CONTENT 2013

The Fifth International Conference on Creative Content Technologies

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Valencia, Spain

CONTENT 2013 Editors

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CONTENT 2013

Foreword

The Fifth International Conference on Creative Content Technologies (CONTENT 2013), held between May 27 and June 1, 2013 in Valencia, Spain, targeted advanced concepts, solutions and applications in producing, transmitting and managing various forms of content and their combination. Multi-cast and uni-cast content distribution, content localization, on-demand or following customer profiles are common challenges for content producers and distributors. Special processing challenges occur when dealing with social, graphic content, animation, speech, voice, image, audio, data, or image contents. Advanced producing and managing mechanisms and methodologies are now embedded in current and soon-to-be solutions.

We take here the opportunity to warmly thank all the members of the CONTENT 2013 Technical Program Committee, as well as all the reviewers. The creation of such a broad and high quality conference program would not have been possible without their involvement. We also kindly thank all the authors who dedicated much of their time and efforts to contribute to CONTENT 2013. We truly believe that, thanks to all these efforts, the final conference program consisted of top quality contributions.

Also, this event could not have been a reality without the support of many individuals, organizations, and sponsors. We are grateful to the members of the CONTENT 2013 organizing committee for their help in handling the logistics and for their work to make this professional meeting a success.

We hope that CONTENT 2013 was a successful international forum for the exchange of ideas and results between academia and industry and for the promotion of progress in the field of creative content technologies.

We are convinced that the participants found the event useful and communications very open. We hope that Valencia, Spain provided a pleasant environment during the conference and everyone saved some time to explore this historic city.

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Energy Balance:
A web-based Visualization of Energy
for Automotive Engineering using X3DOM

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Abstract—**Automotive systems can be very complex when using multiple forms of energy. To achieve better energy efficiency, engineers require specialized tools to cope with that complexity and to comprehend how energy is spread and consumed. This is especially essential to develop hybrid systems, which generate electricity by various available forms of energy. Therefore, highly specialized visualizations of multiple measured energies are needed. This paper examines several three-dimensional glyph-based visualization techniques for spatial multivariate data. Besides animated glyphs, two-dimensional visualization techniques for temporal data to allow detailed trend analysis are considered as well. Investigations revealed that Scaled Data-Driven Spheres are best suited for a detailed 3D exploration of measured data. To gain a better overview of the spatial data, Cumulative Glyphs are introduced. For trend analysis, Theme River and Stacked Area Graphs are used. All these visualization techniques are implemented as a web-based prototype without the need of additional web browser plugins using X3DOM and Data-Driven Documents.**

Keywords-**scientific visualization; spatio-temporal multivariate; glyph based; trend analysis; web-based.**

I. INTRODUCTION

Scientific visualization is a growing field of research in computer graphics. The enormous amount of measured and calculated data has rapidly grown. To make fast decisions based on the data, scientists and engineers need to interpret valuable information efficiently. The complexity of this data constantly increases and therefore highly specialized and individual visualization methods are needed [1].

Especially automotive engineering encounters the need to develop more efficient energy saving systems to provide longer duration with a given amount of energy. Thus, automotive engineers require specialized tools that support them to achieve this goal. An increasing research field of automotive engineering are hybrid vehicles (e.g., combination of combustion engine and electric propulsion system). As electricity is used for propulsion, several forms of energy can be used to generate electricity [2] (e.g., heat, kinetic energy or sun light). A hybrid vehicle that uses multiple forms of energy can be a very complex system. Every single component that outputs or consumes energy must be considered to ensure highest efficiency. To cope with such

complex systems, engineers need to be able to understand the global behavior of such hybrid systems.

In this paper, several multivariate visualization techniques (two- and three dimensional) are evaluated (see Section II). In addition to that, a prototypical implementation using X3DOM [3] and Data-Driven Documents (D^3) [4] technology is discussed (see Section III). This interactive prototype demonstrates two glyph-based three-dimensional (3D) visualization methods including Scaled Data-Driven Spheres (SDDS) and three different two-dimensional (2D) visualization methods called ThemeRiver [5], Stacked Area Graph and Stacked Cumulative Percent Plots [6] (see Section IV and V). The conclusion in Section VI complete this paper.

II. RELATED WORK

A. Data Visualization

There exist many visualization techniques for multivariate data like Geometric Projection, Pixel-Oriented Techniques and Hierarchical Display [1]. The given data model is not only a general multivariate data set, but it also has temporal and spatial components, which play an important role.

Temporal or so-called time-oriented data has become a separate research field. There are various visualization techniques for temporal data and different purposes (e.g., ThemeRiver, TimeWheel) [7]. Generally, they have in common the depiction of the change over time.

On the other side, previous research also found multiple visualization methods for spatial-multivariate data, which are mostly used for scientific visualizations. These techniques include surface based rendering, direct volume rendering and glyph based techniques [8]. A large field of application for visualization methods for spatial-multivariate data are medical data visualizations (e.g., data from Nuclear Magnetic Resonance (NMR)). In the next section several related visualization techniques are presented, which have been considered for visualizing various forms of energy for automotive engineering.

Quantitative Texton Sequences (QTonS) is a bivariate visualization technique. It maps one dimension to a spec-
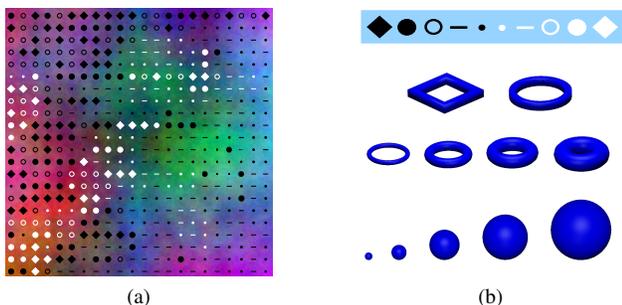
(a)   (b)

Figure 1. **(a)** QToS with both negative and positive values **(b)** from top to bottom: Example of a Quantitative Texton Sequence - Cornered and round supertorus - Supertorus of various thickness - Scaled Data-Driven Spheres of different size.
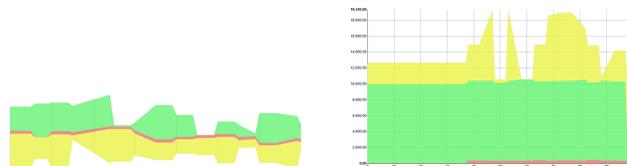

Figure 2. **(a)** Illustration of Theme River with three currents. The width of current represents the corresponding value. It is primarily used to identify trends. Thus, labels indicating the exact value are not essential. **(b)** Illustration of Stacked Area Graph with three elements. The height of stack element expresses the corresponding value.

trum color sequence and the other to a QTonS sequence (see Figure 1(b)). These two corresponding dimensions are distributed over an 2D area [9]. Fundamentally, values are mapped to individual Textons. The higher the absolute value is, the bigger the Textons surface will be. To differentiate negative and positive values, black and white Textons are used. In this case, black Textons represent negative values (see Figure 1(a)).

Superquadrics are a category of geometrical shapes, which basically are derived from ellipsoids and quadrics. Their appearance can be changed by changing their parameters (e.g., roundness of corners, size, color, etc.). This property can be exploited to map values to the glyphs appearance resulting in a glyph-based visualization (as illustrated in Figure 1(b) and 1(b)). Thus, Superquadric Glyphs can be used to visualize up to four dimensions in addition to the glyphs position.

Scaled Data-Driven Spheres (SDDS) is another glyph based visualization technique, which extends the 2D Data-Driven Spots [10] to 3D. SDDS use spheres as glyphs and it implies the properties of superquadrics like color and size. In addition to that, they are easier to interpret due to their simple shape and viewing angle independence. A previous user based evaluation of superquadrics and SDDS revealed that SDDS result to a lower error rate in value estimation and relationship identification [11].

Theme River is a two-dimensional visualization technique designed for trend analysis over a serial dimension (e.g., time) [5], [12]. Theme River enables users to compare different identities, which occur parallel. Every identity is represented by a colored current within the river (see Figure 2(a)). The higher a value is, the wider the corresponding current will be. If a value changes along the serial dimension, the currents width will proportionally change to it. Hence, abrupt changes and long term trends can be recognized easily. If a value equals zero, the appropriate current will disappear until it changes its value again.

Stacked Area Graph represents serial values as areas. The x-axis represents a serial dimension and the y-axis

represents the corresponding value. When values change over a serial dimension, the height of the corresponding area will change as well. If multiple values are depicted, areas are not overlapping. They are arranged as a stack. Thus, the total sum of all depicted values is represented by the total height of the stack (see Figure 2(a)).

Stacked Cumulative Percent Plot (SCPP) is another graphical method for visualizing trends [6]. In contrast to Theme Rivers and Stacked Area Graphs, SCPP depicts the percentage instead of the value as stacked areas. The total graph is always stacked up to 100%.

B. Web Technology

As these visualization techniques have to be implemented with the aid of current web technologies, X3DOM is used to render all 3D visualizations. Generally, X3DOM is a new approach to enable web browsers to render 3D content without the need of further plugins [3]. The current HTML5 standard defines X3D (derived from VRML97) to be used to provide 3D content, but it does not define how this 3D content has to be handled. For that, X3DOM has been approached to connect the web browsers *Document Object Model* (DOM) containing the X3D data, with the internal X3D runtime. The X3D runtime does all 3D tasks, which are needed to render the scene defined by the X3D data. Using X3DOM there is no need to struggle with low-level graphics interfaces like OpenGL provided by WebGL [13]. Due to its observer architecture, it also supports dynamic DOM changes, which effect an analogous update of the X3DOM runtime content. X3DOM has not been declared as a web standard, but like XML3D [14], it runs for it.

III. PRECONDITIONS

A. Data model

Problem-specific visualizations are tailored for specific data. Thus, it is important to know the underlying data structure. In our case, we have a spatio-temporal multivariate data. The data consists of the energy type, the 3D position where the data was collected, the data acquisition time and the measured (positive or negative) value itself.

The multivariate data has 6 dimensions:

- form of energy (one dimension)

- value (one dimension)
- time (one dimension)
- 3D position (three dimensions)

Each value sequence represents the recording of a single sensor (measuring point). All values are measured parallel and it can be assumed that all sensors have been synchronized. Hence, the nth value of every value array represents the same time.

B. Visualization

The visualization must be capable to display five distinct forms of energy and an arbitrary number of sensors in an explorable way. These forms of energy should be easy to interpret, to distinguish and to compare. In addition, the trend over time must be easy to investigate to satisfy the requirements of automotive engineers. To achieve that, both 2D and 3D visualization techniques will be considered.

Summing up, an optimal visualization meets these requirements:

- displaying at least five distinct forms of energy measured by several hundred sensors
- easy exploration of data, especially considering spatial and temporal dimensions
- opportunities to compare measuring points and different forms of energy
- gives a global overview about the data
- opportunities for detailed trend analysis

IV. EXAMINATION

Basically, the human's perception capabilities are limited to a 3-dimensional spatial sense plus a perception of time. This results to a 4D world, in which we live in. This limitation also narrows the possibilities of beneficial visualization methods, while the perception of time can only be used via animations. Thus, a single image can not exploit the perception of time. Regarding this fact, properties of geometrical shapes (glyphs) (e.g., color, size, roundness, pattern and orientation) can be used to gain the feasibility to visualize even more dimensions. This is needed to display multi-dimensional data.

An investigation of existing techniques revealed that a combination of 2D- and 3D visualization techniques lead to a better global insight into the measuring data. Moreover, this allows the user to investigate the data from different points of view.

A. 3D visualization

If the data has a spatial component and it is important to know its location, it is common to use a visualization technique that retains this spatial information. The drawback of this decision is, that every visualized dimension consumes a single dimension in the visualization space. For our problem, all three dimensions of the spatial variable are used

because the cognition of the energy's location is essential. Therefore, no spatial dimension for visualizing time is left. Three-dimensional visualizations also allow more freedom to explore the spatial data in a natural way.

QTonS are considered to be used as a render mode of the three-dimensional space to represent the two dimensions *value* and *form of energy*. While exploring the 3D-space, the view is updated by the QTonS technique to represent the amount of energy in the viewed region. The mapped colors represent the *form of energy* and the texons represent the *value* of the data (see Figure 1). The drawback of this approach is, that the location of the visualized energies is not clearly evident. The user can only perceive how much energy occurred in a specific direction calculated from the viewpoint. Therefore, it is not possible to investigate a single location. This results to an ineffective explorable visualization. Moreover, it is rather suitable for data sets of high spatial density. Such a high density might be reached by some measurements but this is not the common case. It is assumed that common measurements have up to several hundred measuring points distributed over the vehicle.

Torus-based Superquadric Glyphs can be used to encode up to four dimensions using only their shape [15]. A possible setup would map the *form of energy* to the glyphs color; contrasting colors should be chosen [16], [17]. The absolute energy value is mapped to its thickness. To indicate if a *value* is either positive or negative, the roundness of the superquadric is used. However, when glyphs are placed densely, it is difficult to differentiate the glyphs and to identify patterns [11].

Scaled Data-Driven Spheres can be described as a point-cloud with the energy value modifying the radius of the spheres. To be able to display negative energy values, different colors are used (dark color for negative, light color for positive value). As humans perception struggles to differentiate more than 12 color values [17], ten colors remain, which is enough to visualize five energy forms (leaving out black for captions and white for background).

To illustrate change of values over time, a key frame animation is used, which interpolates between the radius of the spheres and its color (if the sign changes).

Due to the ease of interpreting SDDS, their low error rate in value estimation and relationship identification, SDDS are the most suitable visualization technique to display detailed measuring data spatially.

For large amounts of data points it may not be feasible to display all data, but to partition the data set into regions instead. This approach makes it easier to keep track of behavior and dependencies. The Cumulative Glyph (CG) visualization can be used to display the energy emission in these regions. A single glyph consists of several discs with each disc representing one energy form in such a region. These discs are usually depicted using icons identifying those energy forms. The color of each of those discs
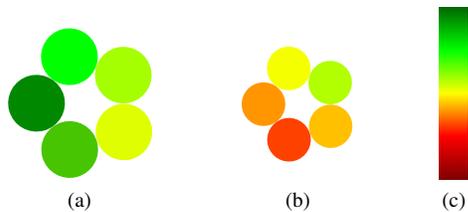
Figure 3. (a) Cumulative Glyph with only positive values (b) Cumulative Glyph with both negative and positive values (c) Color scale used for mapping energy values to colors

shows how much energy of one form is emitted (green) or consumed (red) in total in that region (see Figure 3).

B. 2D visualization

Due to Theme River's properties, it is suitable to depict the trend of measured values. While the serial dimension is the time component of a measurement, every sensor is represented by one current within the river. Currents that represent sensors measuring the same form of energy are of the same basic color and are placed side by side. As a result, these sensors together generate a wide current representing the total amount of one form of energy. Additionally, the total width of the river describes the total amount of energy. This allows users to compare trends of different forms of energies and various sensors at once. A drawback of Theme River is the difficulty of estimating values. Without any labels, users can hardly guess what value is represented by a given width. Moreover, Theme River works only with positive values. Thus, either absolute values should be used (where negative values are represented by darker colors) or two graphs, one for positive and the other one for negative values might be a solution. The latter solution should be preferred, because the former one treats positive and negative equally, which leads to a wrong representation of the total energy occurrence.

Stacked Area Graphs can also be used to examine the energies trend over time. Every measuring point is represented by an area. As implemented in Theme River, measuring points representing the same *form of energy* are placed next to each other. In addition, they are of the same base color to represent the overall occurrence of that specific *form of energy* as a cumulated area. This enables users to investigate the trend and to identify the entire amount of energy in an area (e.g., engine or front wheel). Negative values are represented by stacks below the x-axis. To navigate through time, controls for setting the displayed interval should be provided. Possibilities to set start time and end time independently allows users to *zoom* within the dimension of time.

Stacked Cumulative Percent Plots are very similar to Stacked Area Graphs. Due to the depiction of percentages instead of values, users can easily recognize which energy contributes the most.

V. PROTOTYPE

The aim of this prototype is to test all chosen visualization techniques and to provide a data explorer based on X3DOM and Data-Driven Documents. The resulting web-based application is shown in Figure 5.
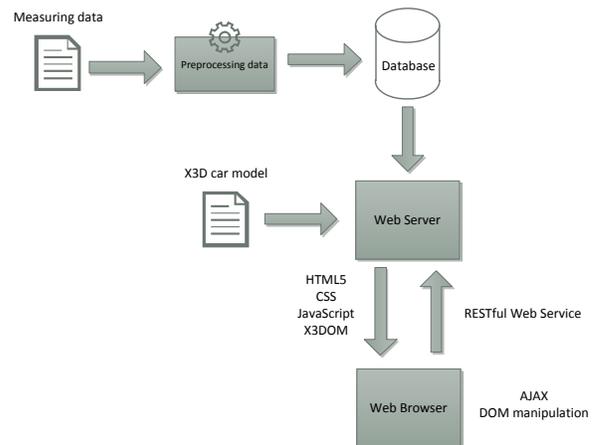
A. Architecture

Figure 4. General architecture of prototypal implementation. Original and reduced approximated values are stored in database. Web server provides HTML content and data to the client. Client performs complete visualization using X3DOM and Data-Driven Documents.

The main parts of the prototype (see Figure 4) are a database, a web server and a client (a web browser supporting 3D within web sites). The major part of the applications logic is run within the client's web browser to provide dynamic visualizations, which respond quickly to user interactions. The web browser requests needed measuring data from the web server via RESTful web services and maps it into a data format that can be visualized by X3DOM or D^3. Hence, the web server primary has to provide the requested data and further visualization-specific calculations are performed client-side.

B. Data Preprocessing

Transferring all data to the client would be very time-consuming. Thus, the data is preprocessed to reduce network traffic. Generally, a measurement with n measuring points and t value acquisitions results to a data complexity of $O(n \cdot t)$. As the amount of measuring data can be massive, the Douglas-Peucker algorithm is used to to reduce the number of values [18]. This algorithm has an expected complexity of $\Theta(nt \cdot \log(nt))$; worst case is $O(n^2 t^2)$. After applying this geometric algorithm, the reduced approximation of the original measurement curve will still preserve the overall structure. In other words, this algorithm filters all non-distinctive values. As users want to navigate through the data using different time-zoom levels, different degrees of approximations are needed, which are stored into the server's database after the preprocessing step.
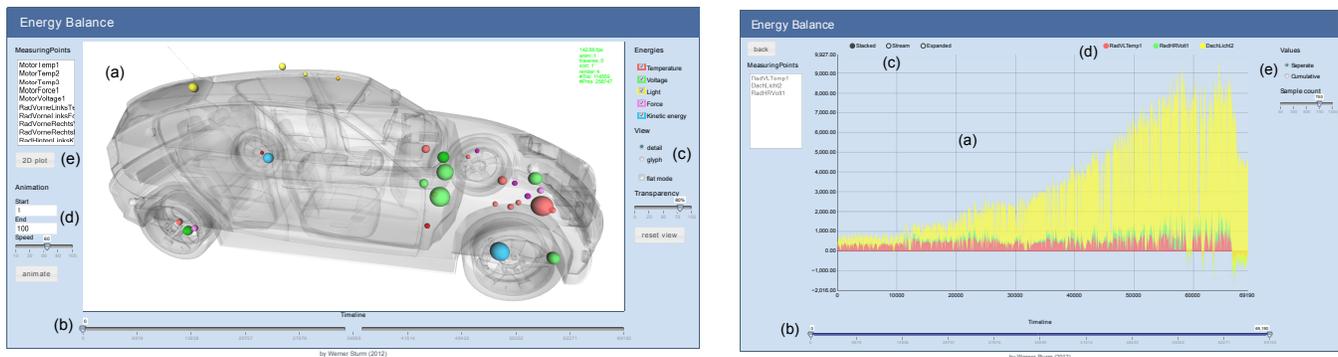
Figure 5. **left** Prototype displaying detailed data using Scaled Data-Driven Spheres. Real time 3D window provided by X3DOM (a). Timeline to navigate through time (b). Possibility to switch between detailed mode (SDDS) and overview mode using Cumulative Glyphs (c). Animated glyphs within specified period for three-dimensional trend analysis (d). 2D plot of values measured by selected measuring points for detailed trend analysis (e). **right** 2D representation of the data using Stacked Area Graphs. Graph is created using Data-Driven Documents library. Plot area for displaying the graph (a). Timeline to select a period to plot (b). Option to switch between Stacked Area Graphs (selected), Streamgraph (very similar to ThemeRiver) and Stacked Cumulative Percentage Graph (c). Possibility to select if measuring point is included in current graph (d). Switch between *seperate* and *cumulative* mode (d).

C. Web Server

Basically, the web server provides HTML content including a static 3D car model (for orientation and navigation purposes) in X3D format, which can be understood by X3DOM. However, the servers main task is to provide measuring data to the client. For that, it offers several RESTful web services, which provide the data in *JavaScript Object Notation* (JSON). Of course, clients do not receive all data at once. For both 3D visualizations (SDDS and Cumulative Glyph) the client commonly requests only data of a single moment. But all time-oriented, two-dimensional visualizations and animations of SDDS and Cumulative Glyphs, used for depicting the trend over time, need a data set of the desired time span. If users select a long period, which would cause a huge amount of data to be transferred to the client, the web server selects and sends the best approximation of the data. This allows the client to request any time span without overloading.

D. 3D using X3DOM

The observer architecture of X3DOM, which connects the web browsers DOM with the internal X3D runtime, allows to modify the 3D scene via the DOM itself. Moreover, X3D predefines simple objects like box, sphere, cone and cylinder. Therefore, a SDDS can be created easily by using a sphere object (see listing in Figure 6).

Cumulative Glyphs can be created analogously using cylinders arranged circularly as depicted in Figure 3(a), (b). To animate glyphs to depict the values change over time, X3DOM implements *TimeSensors*, *Interpolators* and *Routes* defined by the X3D standard. *TimeSensors* provide a timer to trigger steady events within a defined period. *PositionInterpolators* are connected to *TimeSensors* via *Routes*, which provide a 3D vector interpolated between two defined

```
<scene id="scene" pickMode="box">
...
  <transform id="sdds1" class="sdds"
      translation="0 0 0" scale="10 10 10">
    <shape id="sphere1">
      <sphere class="sphere"></sphere>
      <appearance>
        <material id="material1"
          transparency="0.2" diffusecolor="#FF6666">
        </material>
      </appearance>
    </shape>
  </transform>
...
</scene>
```

Figure 6. Listing with X3D tags defining a Scaled Data-Driven Sphere.

vectors depending on the timers progress. These output vectors are passed to the spheres attribute *scale* (which expects a 3D vector) resulting a smooth animation showing a growing or shrinking sphere. Colors of glyphs also have to be changed during an animation. For that, X3D offers *ColorInterpolators*, which works analogously. This concept also supports long lists of key frames and therefore, any animation can be defined.

E. 2D using Data-Driven Documents

An investigation of multiple graphing libraries revealed that D^3 performs very well even with bigger data sets. Moreover D^3 can handle non-equidistant data points, which is needed to depict approximated data (as discussed before) without interpolating them explicitly.

VI. CONCLUSION

This paper investigates two- and three-dimensional visualization techniques to be used to visualize consumed and emitted energies, which have been measured within

a vehicle, to support automotive engineers. In addition to that, a web-based prototypal implementation of chosen visualization techniques based on Data-Driven Documents for 2D and X3DOM to perform real-time 3D client-side is introduced.

Besides the measured value and its type of energy, the multivariate data includes spatial and temporal components. It revealed that Scaled Data-Driven Spheres are most suitable for a detailed 3D visualization of energy. This contributes to this research field that SDDS are also suitable for other scientific visualizations than medical visualizations. In addition to that, Cumulative Glyphs are presented to provide a better overview of the detailed data.

Both 3D-based techniques only visualize a single moment of the measurement period at once. Despite animations can represent the change over time, engineers want to analyze the trend in a more convenient way. Therefore, two-dimensional visualizations for time-oriented data are investigated in detail. Depending on the engineers requirement, Theme Rivers, Stacked Area Graphs and Stacked Cumulative Percentage Graphs support engineers to get a better understanding of the trend.

A successful implementation of a prototype shows, that all techniques can be implemented as a web-enabled application without the need of installing third-party browser plugins. It revealed some issues with X3DOM like web browser incompatibilities, but most of them exist because X3DOM does not implement all specified functionalities defined by X3D standard. Despite that fact, web developers benefit from both X3DOM and Data-Driven Documents, which enables them to implement interactive visualization applications without the need to struggle with low-level graphics operations like OpenGL or drawing single lines for 2D graphs. This certainly leads to lower development costs as well.

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Congress and Meetings Tourism and Destination Brand

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Abstract— **Congress tourism has been enforcing its presence in global industry despite recent years of economical hardship and it is becoming more and more important. This tourist field is a high level sector, which involves a lot of people and money. In fact, it is a kind of tourism that requires organization, intermediary, high capacity destinations and high territorial and human resources. Destination management is increasing as a professional way to study congress destination characteristics, meetings requirements and customer satisfaction in order to optimize the hosting process and promote destination brand. The tourism sector offers benefits and impacts in many different ways and completely changes the way we understand tourist destinations. Firstly, we are going to consider this kind of tourism as a tourist segment. Secondly, we are going to focus on what are the factors that influence the choice of a congress destination. Finally, we are going to analyze the demand and the offer in Spanish tourism industry to understand the reason why it is so well located in global ranking.**

Keywords- Congress tourism; Destination management; Congress requirements and impacts.

I. INTRODUCTION

Congress tourism is a subset of the larger field of business tourism. "Business tourism is the provision of facilities and services to the millions of delegates who annually attend meetings, congresses, exhibitions, business events, incentive travels and corporate hospitality" [1]. In this definition, ICCA gives a general perspective of this segment in the tourism industry. In fact, there is no official definition of Congress and Meeting tourism.

From an anthropological point of view, tourist experience is always a special event in the ordinary life of people. The travelers abandon daily life to enter in a different circle of activities and way of life. In fact, tourists change their usual context and experience a new environment organized for leisure time or for other purposes [2]. Actually, event tourism refers to marketing and creating special events that become a way of living the tourism experience itself [3]. In general, event tourism aims to increase the attractiveness of one tourist destination with the purpose of creating tourism demand and satisfy tourist requirements. Another goal is to localize the destination in the marketing field [2]. Generally, events are propulsion factors to create tourism or to enforce tourist destinations and they are preeminent elements in a destination marketing plan. In fact, planned events are a force-factor for destination competitiveness [3].

Events are useful occasions to renew the urban planning of a city and to develop the cultural aspects of destinations. Congress tourism is included in the more general perspective of event tourism and it is one of the level in which tourism and events are connected in a strict relation [2]. Planned events are nowadays a consolidate field of research and study. D. Getz [3] defines 8 fields: (1) Cultural Celebrations, (2) Political and State, (3) Arts and entertainment, (4) Business and Trade, (5) Educational and scientific, (6) Sport competition, (7) Recreational, (8) Private Events. Congress tourism is included in the Business and trade subset, which refers to: meetings and conventions, consumers and trade shows, fairs, and markets.

In this paper, we analyze the element of competitiveness and image promoting of a congress destination brand. We also look at essential characteristics a place must have to be considered as a congress destination and analyze how tourist offer and incoming services are essential in the selecting process. This work helps us understand what are the motivations behind a congress destination choice and why this type of organization requires such a high level quality.

The rest of this paper is structured as follows. In Section 2, we present some works that have analyzed the creation of a congress tourist destination and look at requirements and impact on the branding process. Section 3 explains the different parts a congress is composed of. We discuss both the immaterial and materials parts of the congress process, analyzing destination management activities and tourist requirements. In addition, we analyze the global impact of congress tourism in the tourism industry. The research will be focused on Spain for its qualities and its position in global ranking. The results of this analysis are shown in Section 4. Finally, we discuss these results in Section 5. Conclusions are shown in Section 6.

II. RELATED WORK

This section shows several works on the connection between congress tourism, meetings, events planning and destination requirements.

G. Del Chiappa [4] inquiries into the process in which a congress destination is built as a complex brand, with different kinds of qualities and characteristics. This analysis reveals that a destination is not only a set of goods and services but also includes symbolic images and immaterial qualities. The consequence is that, in this sector, the role of the mark territory has become essential to organize a place in a competitive way. In Del Chiappa's work, the tourist who

uses this kind of travels gives more importance to the previous period of time. In Destination Branding optic, the most important period of time in congress tourism is the selection part. In this, the territorial mark is what tourists and business look at.. Del Chiappa analyzes the main destinations and investigates the process, which concerns the mark creation.

Following this philosophy, D. Getz shows us the destination perspective on event tourism [3]. His work is built on an anthropological point of view, in which he analyzes typologies of event tourism and requirements needed for each one. D. Getz also identifies patterns and processes related to this aspect and tries to identify possible research methods to study how to obtain knowledge about the creation process. The author focuses his work on outcomes and impacts on event tourism by identifying three fields of research: temporal, policy and spatial. D. Getz concludes that congress tourism, in a social and cultural way, can be understood as including a real effort behind organization, a very strong impact on communities and way to live. In his opinion, for this field, "event management" professions are important.

This is a fast growing professional field focused on destination management and marketing of customers' behaviour. This way, it is possible to look at event tourism as a set of actions, with each one of them having a planned work and a predictable effect on the host territory. In Sicily Convention Bureau report, it is possible to see how congress tourism can be a positive resource for an already confirmed tourist destination. This association gives importance to the high costs received from delegates who attend congresses and makes a list of favorable effects in this kind of tourism, which brings visibility outside the simple tourist season. We talk about this work because it is a summary of a critic view of the Sicily territory. The important thing in this work clarifies that the offer needs to unify a territory: a congress destination has to be integrated within a context in which it is located and communicated with other national congress centers [5]. These elements help us identify how we should organize a country's congress destinations. Spain, for example, shows a complex and integrated offer that should be compared with requirements included in Sicily Convention Bureau work.

III. CONGRESS TOURISM AND DESTINATION BRANDING

In this section, we are going to consider some research and literature which can show congress destination requirements and impacts. Spain is taken as a model for its congress destination offer and its tourism demand.

A. Incoming offer requirements in congress tourism

We can identify a few elements of strengths for meetings and conventions, namely:

- High capacity cost of participant (big spenders).
- Destination congress and leisure image promotion.
- Brands enforcement.

To understand how these elements characterize this kind of tourism we can see the complexity in demand and offer

meeting. Demand and offer in congress tourism organization create a meeting which involves different kinds of actors. From the demand side, professional associations, scientific associations, enterprises and organizations are looking for a possible congress experience. They also represent the advertising recipients and it is possible to see them as customers of the tourism industry. From the other side, the offer is composed on incoming services, food and beverage agencies, entertainment agencies, transports companies and public entities [4].

Managing a congress destination means creating a system with different elements, which are connected to each other in order to satisfy customers requirements. The whole phenomenon of acting congress tourism can be resumed in a circle way: Motivation of choice - Planning and managing the event – Tourism - Destination aspects - Impact and effect on territory - Brand and Economic incomes. It is clear that the process can be improved by knowing every element and by connecting events feedback with motivation of choice of future participants [6].

The entire process of planning, organizing events and promoting a congress experience looks like a tourism system. Tourism studies identify a set of economic and social inputs [7]. Distinguishing a pre-congress and a post-congress period, it is possible to look at many sub-factors which are strictly related, such as transport and technical services. Furthermore, it is possible to identify the differences between immaterial procedures and material procedures.

Facilities required in the material part of congress tourism are [6]:

- Conference rooms, offices and exhibition areas and multifunction halls.
- Translation equipment and technological instrument (sound systems, projectors, etc.) to satisfy audiovisual and video requirements.
- High quality hotels (and high quality personnel)
- Protocol events, formal event and activities (excursions and tours)
- Food and beverage related to different countries to satisfy international needs.

Involving local people can help increase the motivation of possible tourists in choosing a destination, by, for example, meetings translators, which are intermediaries with the place. This can encourages congress members to participate actively to the life congress. From another point of view, translators are useful to avoid languages barriers. English is a spread and common language but, in some destinations, different languages are needed and here the role of translators becomes much more important.

These requirements are confirmed by Del Chiappa's survey research [8]. Results data show that different kinds of meetings require different kinds of structure, despite a common need of large incoming space. For example, the availability of large convention centers is important because of the high number of participants. Incentive travels need an informal location to create socialization. The common necessity to achieve spaces has also been evaluated with the

purpose to give delegates the possibility to cooperate. The accessibility, in Del Chiappa's opinion, is one of the most important elements. The survey gives importance to destination branding which improves destination management with the aim to achieve conference kick-off [8]. This is known as the immaterial part of a congress. The immaterial part of congress tourism includes pre-organizing, monitoring and getting congress feedbacks.

We have to distinguish two kinds of destinations:

- Affirmed tourist destination brand.
- Non-affirmed tourist destination which wants to improve it.

These two kinds of tourist destinations are involved in congress tourism because both of them have to increase or change something in their brand to adapt their offer on congress demand. In the first case, we have to change in image promoting: here, we already have activities such as hotel offer and attractions which can satisfy a particular segment of demand. But now, congress destinations have to be prepared to be as multifunctional as possible. In tourist places which have an affirmed brand, the possibility to change their brand consists in performing communication between public and private structures to unify as much as possible the different elements that are included in the tourist destination itself.

Looking at new tendencies and the utilizing of resources to show the destination in different ways, it is important to add congress demand in an already confirmed destination.

Furthermore, a non-affirmed destination which wants to get an attractive perspective to host congress, has to make strong efforts to create structures and optimize territorial characteristics to create a new demand. This kind of reaction includes the possibility to study new tendencies about business travel and to adapt the territory to specific needs. Sometimes, it could be useful to include this kind of destination in a bigger context to show an integrated variety of spaces. In the first case, the offer of the tourist destination is already confirmed, the brand is famous and people have an idea before going there.

The destination management in pre-congress period has to study how to satisfy the pull factors [9]:

- Geographic accessibility: good transport and simplicity to arrive.
- Social-political aspect (affordability): condition in which tourists can live the experience.
- Economical: the entire cost for traveling to a destination and staying there.

Another important thing is to study membership tendencies and their needs. Delegates move the entire congress economy by using economical components such as transports and accommodations, registration fees, entertainments and tours fees, extensions in accommodations and paying for being accompanied [7]. In the last few years, the studies of customers behavior improved the knowledge about congress participants as a social group and we can identify three categories of participants[10]:

1) Functional participant: he/she participates in the congress by professional motivations, for the cultural exchange and for increasing his/her own knowledge.

2) Relational participnat: he/she participates in the congress for getting professional relations and generally interpersonal relationships. He/she also participates in the tourist excursion and leisure offer.

3) Symbolic participant: he/she participates to congresses to reach visibility, notoriety and image. He/she wants to find a high-level revenue, a prefect organization and a good level of representation.

The congress tourist customer has an exigent and informed profile with a middle-high cost and education. The congress tourist customers are keen on travels. In comparison with the leisure tourist, congress tourists look for a different quality of host system and wants a high level of incoming services. The sojourning time is less flexible than a leisure tourist and he/she usually thinks less in prices and costs [10].

It is important to design a planned marketing valuation in the pre-congress phase and it is also interesting to study future memberships needs. The marketing of congress destinations works on four levels [10]:

- Delighting demand market.
- Identifying objective attractions which can attire this sector-aim.
- Defining a positioning strategy and prove destination brand.
- Acting tactics and operations.

Thanks to these points of organization, organism like *Conventions Bureaux* are using more and more often previous studies to identify congress users and knowing the demand. Firstly, it is necessary to identify the social group which should participate in the congress and try to design a customer's satisfaction line. After this, it is possible to adapt the structure and create an inventory of material components needed to reach this goal. It is possible to define the economical impact even as a function of the listing operating cost and the number of expected participants [10].

We have to distinguish another kind of segmentation in this offer. It is related to the difference between hosts and guests. The organizers and the delegates in the congress tourism have a different systemic role. Firstly, organizers have to guarantee services (like food and beverage) which have to be available before conference starts. They also have to prepare documentation (promotion materials, congress announcements, etc.) and have to rent equipment and instruments to support the correct operation of the congress [4].

From the organization point of view, we find connections with the field of information. Communication connections between exterior market and incoming market allows us to plan the visit. It is also important to improve the revenue system. The integrated system of revenue allows guiding and reaching the hospitality in the destination [10].

The process of organizing meetings is a complex work of people but there are different ways to plan this kind of event.

Firstly, a meeting can change its way to be organized from the temporal point of view.

Using a structured approach, it is possible to create a list of congress requirements to give a congress image for a destination. Firstly, it is necessary to connect delegate numbers and create a relation with the destination. The location becomes important for the offer that gives people who come in the country (or region) and it is important to calculate the impact on size attendance. Local speakers are important from the organization point of view because they are intermediary between organizers and delegates and if they are local, they can be also a guide which permits to give importance to the geographical context.

A destination has to be supported by exhibitors and sponsors. So, it is important to connect the destination choice and the sponsors feedback in order to know in which way the location can be useful to support the congress. The value exchange is important to ensure the success in travel organization and customers' behavior. People prefer to have a tourist experience where they can spend a lot time thanks to a favorable value [7].

Finally, we can build a scheme about the entire process of organizing a congress where destination, congress and brand are related.

We should distinguish primary service relationships which are services at the core of the brand experience, such as hotels and hotel associations. This segment communicates with consumers (residents and employee, internal customers and non-conflicting target markets) and communication media (functional communication from one side and induced marketing communications and advertising from the other). These elements are built on brand infrastructure relationship which are composed of access services (external and internal transports), hygiene facilities (car parks and open spaces) and BrandScape. These elements work together and the final result is that Destination Brand is characterized by personality, positioning and reality of place [4].

B. *Congress tourism in global scenery*

In global situation, congress tourism represents one of the fastest developing sectors which are increasing in the tourism industry. This element has been developed very recently and tourist companies are approaching to this segment in different ways, giving to the global scenery a complexity in offer and demand.

In Fig. 1, we can see where Europe is placed in global raking. These observations are strictly related to Europe tourist characteristics which can be derived in this paper and discussed at the end of our research.

A recent survey about congress tourism of future global situation reveals that, in the 2012-2020 period, this tourist sector will have different external factors which will impact it.

Firstly, 71% of industrial managers opinions say that the economic uncertainty would impact this sector strongly. For 49% of respondents, new technologies, including the possibility of pushing on virtual conferences, can be another important element. 47% of respondents think that the most important factor is the economical aspect while 46% think

that Asian policy influences the development of conferences. 91% of respondents say that those industries have to demonstrate a return of investments (ROI) tangible for their customers (first choice for the 76% of respondents). Meanwhile, 59% think that is more important to create personalized events and 51% say that they will assist on a development in interactive-learning experiences. New online Social Networks are strongly considered. 63% of respondents think that social networks such as Facebook, Twitter, Linkedin, etc. will be key elements to promote an event. For 60%, these factors will allow an instantaneous feedback during congresses and events [11].

This survey let us thinking about the importance of ICT in congress tourism. Congress participants need fast connection to the Internet and better access to new technology than other kind of tourists. Consumers' expectations are changing parallel to invention of new technologies and congresses have to be prepared for new applications and innovations. Keeping in mind these factors, we should highlight two words. The first one is "connectivity". A business meeting is a work place which hosts several workers in a period of time. The Internet connection has become important because it allows us to communicate outside the congress context.. Moreover, it is necessary to ensure that participants get information every time they need. The second word is "presentation". The formality and quality are the most important requirements in congress tourism. In fact, a well presented congress and good services will guarantee the presence of high level ICT. The "technological solution" will not replace the real presence of participants. ICT would just strengthen visibility of congresses and give more eases to delegates [12]. Hotels and congress planners have to build connections which allow creating networks between participants. In this context, it is necessary that event planners and hotels look at new technologies in order to be prepared to reach new applications. Lack of these kind of services can create problems in organizing congresses and can decrease the quality of the incoming process. A recent survey about perception of new technologies in convention context reveals that congress palaces managers find Wi-Fi and audiovisual streaming essential, but for 64% of them, organizers and participants have to look at these services in a more realistic way. In fact, providing a speed and free connection is a critical point of discussion in this context. For 76%, the pricing offer should be diversified by different customers. For 54% of respondents, free Wi-Fi access should be sponsored by the event hosted and for 42% of them, connection has to be free only in public spaces. Only 25% of respondents think that Wi-Fi should be free in all of the building spaces. The survey shows us how high is the customers' expectation and how important free Wi-Fi service has become for the participants. In fact, 86% of respondents are interested in having a permanent signage system in the common areas of the congress site and 56% of respondents think that it can give more value to the event, especially if they want to localize the event, advertise and build information [13].

The event web page has to be well planned and with all the information customers need, that is, tourist information, incoming information and congress contents. In experts' opinion, a convention promotion takes 6 steps strictly connected with ICT: (1) not excluding use of social network like Facebook or Twitter to produce a publicity effect; (2) using traditional internet instruments like main listing and social media to collect participants feedbacks after the congress and to stimulate their opinion on the event; (3) utilizing twitter during the congress with the *hashtag* (#name event, for example) to promote the event and suggesting to the event followers to *retweet*; (4) creating a Facebook event page and inserting the "I like" in the congress website page to show the event to people who are not directly connected with the event; (5) publishing the event in on online calendars, hosted by many websites and publishing it on Foursquare or Gowalla; (6) creating a live connection during the event publishing news on real time and photos, for example on Flickr [14].

Another important element is the use of geo-localization. It is an application given to participants due to the necessity of speed and commodity requested by delegates. ICT are also important to promote the congress itself.

Congress planners also have to procure applications which can be downloaded on the new high-tech mobile phones. This is important because enterprises often give to participants these new instruments. An example of this importance is the IPhone and IPad application called
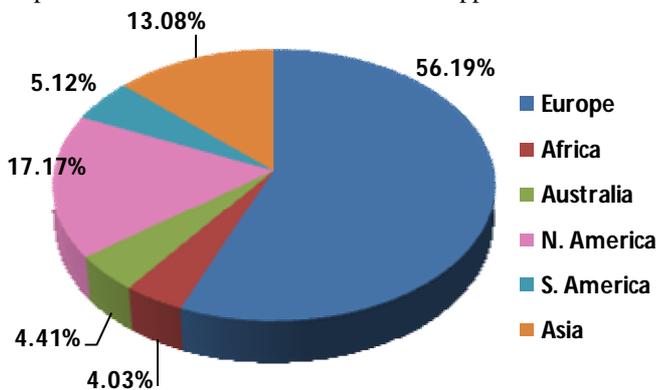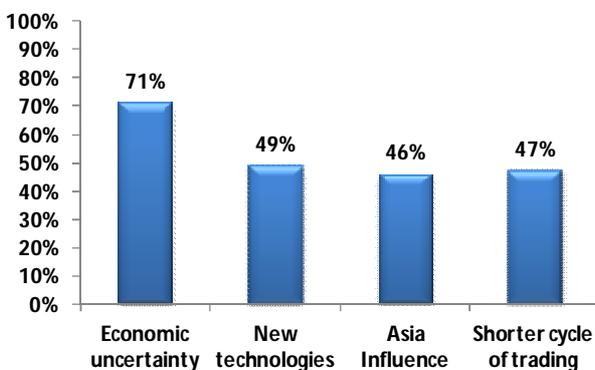
ITCongress 2.1 (the reviewed version), presented by Tecnoconference – TC Group in occasion of BTC, the Rimini event-fairy. This kind of application allows visualizing videos and abstracts of the papers, geo-localization, the building map and the event description [15].

Mobile phone are more and more connected on real time and if they are connected on real time (and here, we can see the importance of connectivity) it allows us to communicate outside the congress building, promoting the event and increasing the customers' satisfaction.

C. *Spain as an increasing congress destination model*

Spain Convention Bureau was created in 1984 and it is composed by 55 destinations. This association works with the Spanish tourism institute (TURESPAÑA) in order to organize events, international faeries, marketing studies, workshops and destination promotion [16]. Nowadays, Spain congresses have a big impact on the economy of incoming tourism. Spain occupies the third position in ICCA global ranking in number of congresses [17]. In 2011, Spain hosted 463 international congresses.

Fig. 2 shows the main external factors which have impact on congress tourism.

Fig. 3 shows the number of meetings per country in the world in 2011. Fig. 4 shows the top ten cities which have organized the major amount of conferences in 2011. As we can see, Barcelona and Madrid appear in this top ten list of cities.

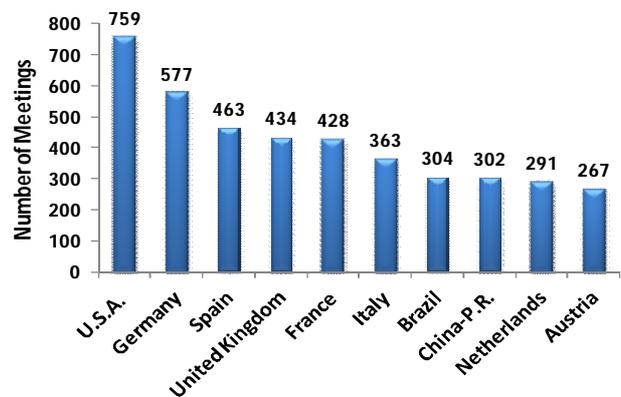Figure 1.   Congresses global distribution in 2011.

Figure 3.   Number of meetings per country in the world in 2011.
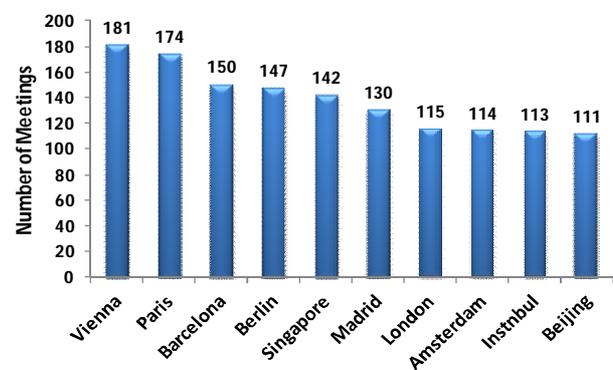
Figure 2.   External factors which influence congress tourism.

Figure 4.   Global ranking: number of meetings per City in 2011.
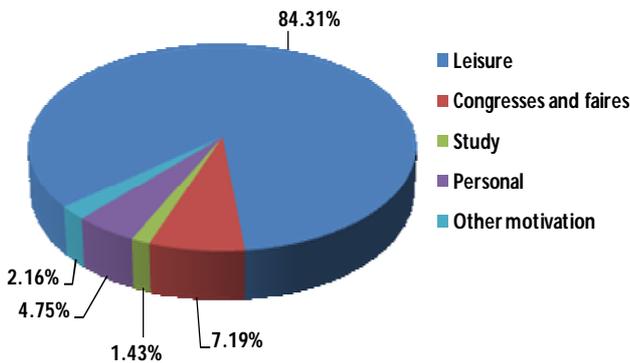
Figure 5.   Motivation of travelling in international Spanish tourism.

Figure 6.   Number of meetings in the main cities of Spain in 2011.

The annual economic impact is about 11% of tourist international introit in 2011. In Fig. 5, we can see the position of this kind of tourism in the international motivation of travelling. The middle-cost for a single-travel-person is about 332 €.

Turespaña joined the second IMEX AMERICA Edition in Las Vegas with 31 Spanish expositors aiming to promote the Spanish offer regarding congress tourism. Other associations participate this year in specialized visits as SITE, ASAE or MPI, in Madrid, Pamplona and Tenerife, setting up the platform Spain Meetings & Events Community @i-Meet [18].

Speaking about the rising importance of congress tourism, it is important to mention the case of Farmaindustria. The farm industry has gained a relevant position within the thematic congress sector which brought 5335 events in Spain in 2011, with an increase of 5% compared to 2010. Nevertheless, this industry has been into a radical change this year. In 2011, the new Farmaindustria code (Codigo de Buena Prácticas) observes that congresses and events related with this industry cannot include leisure activities and according to the new auto-regimentation [19], it cannot reserve Golf hotels and Thematic Hotels. This point has brought us to think about the important relation among hotel offer, theme congress and event purpose. In this case, the enterprise seeks to find reasonable locations and adequate sojourns to the quality of scientific program with a hosting place suitable to the new austerity level.

An enterprise prefers to choose a 4-5 stars hotel. However, lots of places mean to start a reclassification. In fact, the 5335 events in 2011 respected this code. In MPI opinion every year more and more enterprises decide to auto-regulating themselves in order to defend their reputation. The consequence is that the whole congress organization is regulated in different ways connected with the political sector. In fact, we can observe the strength of the relation between demand and offer and how a destination can change their brands or their tourist structure. These changes have the aim of satisfying congress customers and participants without damaging the destination brand of the congress [19].

Fig. 6 shows the ten spanish cities which have organized the most meetings throughout 2011. Madrid and Barcelona play an important role as most important congress cities in Spain. In ICCA ranking, these destinations occupy third and
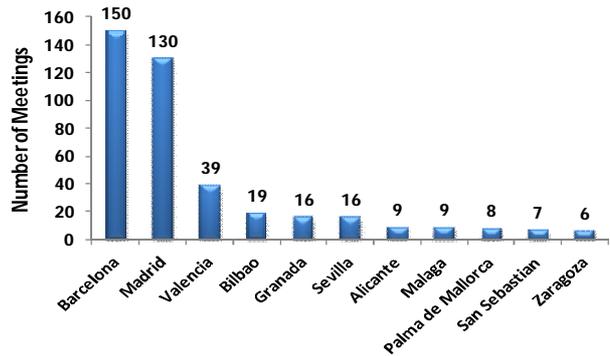
sixth position, respectively [17]. The Spanish offer is complex and includes a lot of destinations. The Spain Convention Bureau (SCB) unifies 38 congress cities and there are several other places not federated into SCN which show us how Spain is a consolidated congress country [14].

Nowadays, Barcelona is living an important moment of prosperity in this kind of sector. In 2011 (See Fig. 6), the segment increased by 5% in participant numbers compared to 2010 [20]. The positive trend is also referred to meeting numbers which these years have increased by 6.8% in relation to 2010 with the total of 2,283 meeting and 647,693 participants (80% of them are foreigners). In particular, the courses and daily meeting subsets increased by 50% more (64.612 delegates) than meetings in 2010. This fact implied 2,523,937 reservations (almost a 2.6% more than 2010) in the Catalan capital. Hence, we can see Barcelona as a perfect model of congress destination city. The Barcelona region presents an important role in ICCA. Barcelona is the second place with the highest number of hotel capacity system. It is also important to consider how this city is well-seen. In many reviews and in many famous newspaper readers opinion (Askmen, Forbes, Monocle's, Time Out) Barcelona appears as a one of the best cities to live in [21].

Despite all these important attributions, the most important seems to be the big capacity of reception.

The high dimension of the incoming offer located in a rich tourist region, amounts on a big set of establishments (more than 1000 spaces which can host meetings, 38 golf camps, high level sport installations and the presence of city) account for the fact that Barcelona (which has a great position in global ranking) would be considered as a strategic position in Mediterranean sea and Europe.

We cannot forget the important role of transport and infrastructures which makes possible reaching the territory by train and plane. Barcelona airport grows every year more and every year it improves its connections with USA, South America and south-east Asia. 29% of the intercontinental air traffic is attributed to this city which means 40% of Spanish traffic to middle-orient and Asia [20].

Catalonia does not include only Barcelona as a city congress. We can identify different places which are important in this sector, for example, Girona. Another place is Lleida which grows itself like a "smart city" and finds its force in its location and in recent years has seen a positive

increase of congresss tourism thanks to infrastructures, new technologies and tourist equipment. Congress activities generated in 2010 7,32 millions of euro in the city economy [21]. Fig. 7 shows the origin of participants in Barcelona congresses.
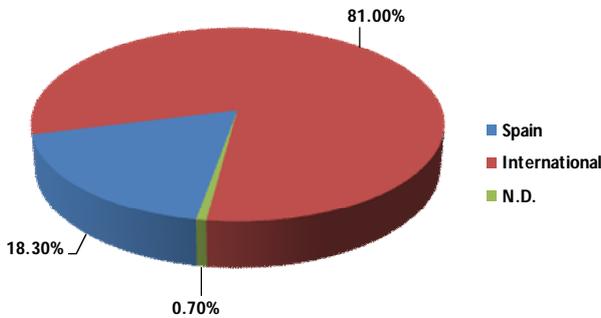

Figure 7. Barcelona congress participants origin in 2011 [16]

The second most important city in Spanish congress tourism is the capital, Madrid. In 2012, this city has enforced its presence in global congress market by participating in many thematic meetings Meedex (París), IMEX (Frankfurt), AIBTM (Baltimore), CIBTM (Pekín), IMEX América (Las Vegas), MICE Place International (París) and EIBTM (Barcelona). The promotional strategy that Madrid Visitors & Convention Bureau is trying to improve the city aspect showing this city as a prefect destination model, opening the market to international demand like China or USA [23].

Another important congress destination which must be included in this research is the Andalusia Region. It presents strength characteristics such as favorable climate and geography (seaside, natural protected spaces), a good golf fields offer, sportive ports, good gastronomy and very-well organized hotel offer (big conference halls and audiovisual technologies). It is important the role of the particular mark called "Asociacion de Palacios de Congresos de Andalucia" which demonstrate the importance of destination promoting. In comparison with Catalonia region, we can identify some points of weakness which have to be considered in a destination management study. Firstly, Andalusia region does not have good airport connection and its infrastructures have not been built with the purpose to create trade meetings. They are old-aged and so it is not possible to increase the incoming market.

These weakness elements do not allow an incoming offer evolution and a re-qualification of buildings and transports would be necessary to improve the incredible territory offer [10]. There are many cities in Andalusia that can host a congress such as Sevilla, Córdoba, Granada, Cádiz and Málaga, capital of the *Costa del Sol*. This last destination is requested for its hotel offer and for its sophisticated resort area fruit of 30 years of tourism development.. Places like Torremolinos, Marbella, Fuengirola and Estepona are good for sports and activities thanks to a very good climate. The point of strength is also the presence of a high nnumber of high-level hotels and restaurants. Costa del Sol is also a strategic point for its perfect position for daily excursions to

other cities of Andalusia. Cadiz and Sevilla are also congress destinations very well positioned. Seville in particular has an airport and it is well connected by train with Madrid.

In the North of Spain, Basque Country is strategically positioned in the transport network which includes boundaries with the south eastern areas of France. We can find high-level infrastructures and its tourist offer is oriented to natural and cultural activities thanks to the presence of museums and parks very well known. Outside Iberian Peninsula, the Canarias Islands represent another part of Spanish congress tourism offer. The force-point of Canarias is the natural landscape and the hotel offer which works all the year thanks to favorable climate and the presence of golf fields [23].

Another important congress destination is Valencia, the third largest metropolitan city in Spain. Fig. 6 shows that Valencia hosted 39 conferences in 2011. With 39 meetings, Valencia is positioned as third national destination. In 2010, the city also occupied the third position in ICCA Europe cities ranking and the tenth position in global ranking.

Unfortunately, its position changed in 2011 because of strong competiveness in congress destination branding and European keen competition. Despite this data, we can look at this city and observe qualities which it presents. In fact, from 1998, Valencia has seen a growth rate of 600%. *Turismo Valencia* approved 2012-2015 strategic plans giving an important role on convention and congress incoming tourism. In these three years, the aim will be to maintain its position in national ranking and include it in the first 25 European positions and in the first 50 in global position. Looking at the permanence of international arrivals to the city, we can understand why the first aim of *Turismo Valencia* is oriented on international congress demand. In fact, the capital of autonomous community of Valencia is getting importance of the international tourist demand in Spain thanks to its tourist offer and the improvements of choice in last years. As we saw before, facilities requirements as conference rooms, offices and exhibition areas and multifunction halls are essential in destination brand promotion [24]. A strong promotion incoming factor is certainly the Valencia Conference Center, which was designated as "World's Best Convention Centre" at Apex Award 2010 by AIPC (International Association of Congress Centre) in Liverpool [25]. This conference keeps on giving the city an improving image. In 2010, the center hosted 114 events with 89,304 participants and in 2011, it hosted 19 international congresses. The conference center is starting up a process of improvement which will be completed on 2014 through the opening of a more multifunctional congress building in order to host a major number of people [24].

Furthermore, Valencia-Manises International Airport is a hub between northern Europe and the Mediterranean countries. In Valencia region, tourism is of essential importance and its airport made possible international arrivals to Costa Blanca beaches. In the last few years, Valencia brand has been growing after having built City of the Arts and Sciences. In autonomous community of Valencia, it is also important to mention Alicante as a new congress destination.

In 2011, congress tourism brought to the city of Alicante 70 events including meetings, conventions and daily congresses. The presence of "*Ciutat d'Elx*" and the Alicante's conference center, is certainly a pull factor. The ACB (Alicante Convention Bureau) is oriented to host a major number of participants thanks to new incorporations in the conference center structure [24].

IV. DISCUSSION

After this research and these statistics, we can talk about the field of congress tourism. Organizing meetings and congresses is a part of business tourism and events tourism. This activity involves a plurality of actors and resources.

We have identified the main elements which are referred to the component in material part of this tourism. In the immaterial part, we have talked about destination branding and its goals. In this part, we have included the analysis of the demand and the offer where we have defined the services in a congress which should have to be very-well positioned in international destination marketing. The most important thing seems to be the accessibility and the high-quality hotel offer. In this sense, there are more and more important modern commodities related with new technologies. We have also distinguished two kinds of destinations. One of them is a destination already famous and confirmed in international scenery. The others are places which want to be considered congress destination but before this, they have to improve many elements. Both of these kinds of destinations are present in Spain and are presented as a great model in global congress demand. In fact, Spanish cities and regions satisfy all the elements which have been considered in these researches.

We have also talked about weakness point in Spain country. We made a critical review about some element, like one present in Andalusia region. As we can see in ICCA statistics, Europe is very well positioned in global ranking. The most important thing, we can achieve thanks to this paper is that congressional tourism has to be included in general tourist offer for its mix of business and leisure.

When a territory is a complex kind of tourist offer, it can automatically become a potential congress destination. This is because, in this segment, the pre-congress moment is the most important element. Brands are becoming the motivation of choicefor congress organizers and participants. Spain and the other European countries present a tourist image, a destination brand which is generally already famous and confirmed. This is a point of strength and secondary destinations can be used to increase the incoming services by destination management studies and re-qualification activities. We can conclude saying that the role of ICT (Information and Communication Technologies) will increase in importance. As a consequence, ICTs are essential for the congress Spanish tourism deal with the ICT and the role played by Spain in regards to this field of study [26].

V. CONCLUSION

We have shown that congress tourism is a complex way of travelling and it creates a very particular relation between demand and offer. In the more general field of event tourism,

planning is the most important moment. In most parts of the hosting congresses work, the act of managing becomes a priority process which involves every part of the destination and the membership expectations. Furthermore, this segment does not impact only in the place where a meeting is hosted. Talking about a congress destination means that we should consider the entire context in the place where the meeting is located. A set of elements motivate the choosing process and most of them are often related with the more general destination location.

The conclusions drawn from this study can be used to mitigate/harmonize the regional tourist requirements. It can also be used to adapt and improve existing portals and web services to new demands of customer needs considering their comments. We believe that this document can help creators and researchers of tourism websites. This work has helped us achieve a better understanding of new ways to understand tourist destinations. In fact, the more general business tourism requires different kinds of quality and necessities. The difference between leisure travel and business travel are essential to understand the selection of destination. Moreover, studying the new business tendencies and customers behavior in working place and meeting aim can help the destination brands to became more attractive not only in this sector but also in every part of its economic offer.

Challenge between destinations will be more competitive and destination management will be a universal useful recognized field to improve or create more attractive destinations. Analyzing Spain as a well-positioned country in global ranking allows us to take it as a model of reference. In this country, general tourist offer and fame have met congress tourism requirements in a very interesting way. When a country has a great diversified offer and high hosting potential, it lets us understand how a congress destination can be built.

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Comparison of Online Platforms for the Review Process of Conference Papers

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Abstract— **Organizing conferences requires the consideration of several aspects, such as the choice of the most appropriate platform to manage the received papers or the conference location, among others. To this goal, we are going to compare some of the most important review platforms, which allow us to host our conferences. In recent years,new systems based on software applications have emerged. This software can be downloaded from the developer websites. These give us more options to choose from. Keeping in mind some of the most important review platforms, we are going to compare the services that each one offers, as well as their advantages and disadvantages. In addition, we are going to show several statistics about the use of these platforms during recent years. This work can help the conference organizers choose the most appropriate platform to manage their conference.**

Keywords- Conference review systems; Online conference platforms; Paper submission; Conferences comparative; Reviewers Assignment.

I. INTRODUCTION

In the beginnings of conferences, when authors wanted to submit a paper to a conference, they had to send it by ordinary postal service or airmail services. After the review process, the paper and the reviewers' comments were returned to the author. Before the deadline, authors had to make the corrections to their papers and send them again to the conference manager. While the papers were traveling, the authors expected that papers and reviews were not lost during the shipment. This method was expensive and it consumed a lot of time. Furthermore, it was difficult to track lost or delayed papers [1].

When the use of computers was more common among the population and especially in universities and research centers, the sending of documents in paper decreased. Instead, the authors sent their work on magnetic supports as floppy disks [2]. The appearance of electronic mail (e-mail) and the extension of its use facilitated several aspects in the organization of conferences. This method improved the process of paper submissions and the revisions of papers. It also saved time and money. However, it was still laborious to organize and distribute the papers to the reviewers [1].

Finally, the development of online web-based systems has made even easier the organization of conferences. Authors and reviewers are now able to track their papers' progress anytime and anywhere, if they have Internet connection.

In addition, the conference Chair can efficiently manage a lot of papers and reviews, as well as respond to comments and complaints from the authors [1].

Since the apparition of web-based services, scientific communities have established several policies and mechanisms to implement electronic conference management. The main reason of these is to reduce the operational and communication costs without reducing the high quality of the revision process. It should also maintain the fairness in the evaluation process [3].

Nowadays, there exist a lot of web-based systems that are able to manage the submissions and other tasks related to the conferences organization. There are mainly two options. On one hand, it is possible to download different software to create our own management system.

On the other hand, web-based systems offer the possibility to order services for a conference. In some cases, these additional services (which can include different options) imply a higher price. In other cases, these services are free. Some features typically provided by these platforms are [4]:

- Submission of abstracts and papers by Authors.
- Submission of reviews by the Program Committee Members (PCM).
- Download of papers by Program Committee (PC).
- Handling of reviewers preferences and bidding.
- Web-based assignment of papers to PCMs for review.
- Review progress tracking.
- Web-based PC meeting.
- Notification of acceptance/rejection.
- Sending e-mails for notifications.

A Web-based solution acts as a communication channel between submitters and organizers/editors.

First of all, a user must register (create an account) in order to gain access to the system, which allows him/her to add/modify submissions and get feedback [2]. The registration process allows users to enter personal details and select his/her username and password. In many occasions additional information may be required [2].

In order to submit a paper to a conference, we should go to the platform that hosts the conference. On most platforms, it is mandatory to introduce the title, abstract, keywords and author names.

These keywords are used to facilitate the allocation of submissions to suitable reviewers. The user can submit an abstract and can check the submitted data, as well as observe

the status of his/her paper. If the abstract is accepted, the user will be able to upload the full text version for review [2]. In other cases, the full version of the paper is sent at the same time with the abstract.

After the submission deadline, the papers must be assigned to several reviewers. Hence, the PC Chair sends the submitted papers with review forms to individual reviewers. The review form consists of a set of questions to assess the quality of the paper that the reviewers must fill in and return it to the PC Chair. Each platform has a specific system to organize the distribution of papers between the reviewers. Each submission is typically evaluated by at least 2 or 3 reviewers.

Generally, the review process ends with the PC meeting where the papers are discussed on the basis of collected review forms, in order to decide their acceptance or rejection for presentation at the conference [4].

In this paper, we are going to compare some of the most important review platforms, which allow us to host our conferences. Finally we have compared the features of the 5 platforms that have organized more than 1000 conferences from their beginnings.

The rest of this paper is structured as follows. Section 2 shows works about some platforms for managing the conferences. Some researches about the improvements of these platforms are also included. Section 3 presents the platforms and review systems available in internet. We also show the number of conferences organized in their history. The evolution of some of these platforms is shown in Section 4. Section 5 presents a comparative study of the five platforms, which have hosted more than 1000 conferences. Section 6 shows our conclusions and future works.

II. RELATED WORKS

There are some works that present new platforms for conference managing and others, which analyze some statistical data about the use of these platforms. In this section we are going to see some of them.

According to the Association of Learned and Professional Society Publishers (ALPSP) [1] on web submission and review systems for journals, among the 442 respondents selected at random from the ISI Web of Knowledge database, we should highlight this:

- 81% of users prefer to use web submission and review systems
- 36% of users would think twice when choosing a journal without online submission for their work.

When the online submission systems were introduced, there was an increase of 25% in submission volumes and publishers reported a decrease of 30% in the administration time. For these reasons the online submission and review systems are playing a significant role in the conferences organization process.

B. Martens et al. [2] discuss the logistics of the submission and review process of conference entries by means of a "free", web-based application. They focus their explanations in the SOPS (SciX Open Publishing Services), a conference application that has been developed. The SOPS

application provides functionalities to support the organization of a conference offering services for the registration of participants, submission and reviewing of abstracts, full-paper submission, reviewing and publishing.

M. Papagelis et al. [3] present an implemented system named Confious. It is a state-of-the-art management system that combines modern design based on a sophisticated algorithm that helps the program committee (PC) Chair perform some of the most difficult tasks in the conference organization. This system improves the efficient management and monitoring of the overall coordination process in conferences.

J. H. Johnson et al. [5] describe a web-based application system that can offer support for conference organizers. It was developed in 1997. WitanWeb offers interactions among program committee members, authors, and reviewers for the refereeing process of conferences. Authors also describe the evolution and changes that Witan Web can admit to adapt its function to several research fields.

As we have mentioned earlier, one of the problems in the organization of conferences is the distribution of submissions between reviewers. In this context, N. Di Mauro at al [4] describe the Global Review Assignment Processing Engine (GRAPE). This system allows the conference management and other tasks, such as automatic assignment of reviewers to papers submitted to a conference, additionally assessing the quality of the results of this activity in terms of profitability and efficiency. Their proposal was evaluated on real-world conference datasets obtaining good results when compared to the handmade ones.

S. Dumais et al. [6] present a new automated assignment method called "n of 2n" that achieves better performance than human experts. This method sends twice as many papers as they are actually asked to review, so they can choose which ones they want to review (the rest are assigned again). This method may also have some motivational advantage over traditional assignment methods where the reviewers have no choice. This method achieved improvement of 48% compared to the random assignment.

D. Yarowsky et al. [7] describe and evaluate a system for the automatic routing of submitted papers to reviewers and area committees. The main characteristic of this method is that the system does not need any human annotation from the reviewers or the program chair. The routing system is based on a profile of previous writings available on-line for the reviewer pool. Authors explore several variations of the core model, "which makes that system accuracy be close to the task of several human judges on the same task.

P. Rigaux [8] presents a simple method, which provides an approximate solution to the problem without requiring each user to rate each item. The method is based on an iterative process. The iterative process is performed by a collaborative filtering algorithm. The system allows users to rate a sample of the paper. Then the algorithm predicts the missing ratings as well as their level of confidence (which is initially 0). A new ballot improves the accuracy of predictions. The administrator of the system is responsible for stopping the iteration when a satisfactory level is reached.

The method presented by P. Rigaux can be used for the assignment of reviewers to papers.

As far as we know, there are no other works similar to ours, where the most important platforms for organizing conferences are analyzed and compared.

III. DESCRIPTION OF EACH PLATFORM

There are several platforms to host conferences. But people usually tend to use only some of them. In this section, we are going to explain the main aspects of each review system according to the information available on their websites. We have also provided a comparative in number of conferences hosted by each platform.

Easy Chair [9] is a free conference management system easy to use. It presents several features to make it suitable and flexible for various models of conferences. It has been designed to help program chairs to cope with the complexity of the reviewing process. The first version of Easy Chair was implemented in 2002. It was used by 12 conferences from 2002 to 2004. During 2005, 66 conferences used Easy Chair to host the conference. Since 2006, Easy chair has become number the one conference management system in terms of the number of conferences, users and submissions.

Microsoft's Conference Management Toolkit (CMT) [10] is a free conference management service sponsored by Microsoft Research. CMT is capable of handling the complex workflow of an academic conference. In last two years, CMT has been used for more than 700 conferences, workshops and various other events. Last year, CMT had been used for more than 400 conferences including several ACM and IEEE conferences.

EDAS [11] manages the paper submissions, review and registration process for conferences, workshops and journals. It is a hosted and supported service, i.e., no software is necessary. The support staff helps authors, reviewers and chairs without any problems. Users can interact with EDAS using standard web browsers. EDAS supports the full conference lifecycle. It includes submission and review processes, discussion and decision about papers, conference registration, copyright elaboration and travel grants. EDAS can offer support for Visa letters, CD-ROM, USB and IEEE Xplore proceedings and conference program brochure. In addition, this platform can host the conference web pages, with a configurable template and system menus. The host of a web site does not incur extra cost and the web pages are maintained indefinitely.

ConfTool [12] is a Web-based event management system developed to support the organization of academic conferences, workshops, congresses and seminars. It is available in several languages. ConfTool offers two versions of services, in function of the event features. On one hand, it has a standard version designed for smaller events with up to 150 participants. The service is an open/shared-source system, which can be acquired under different licenses. For organizing small non-commercial events, ConfTool offers a free license. On the other hand, it has a professional version more flexible than the previous one. It can be used for events with many participants, several contribution types and sub-events.

Open Conference Systems (OCS) [13] was created in 1998. OCS is a free Web publishing tool that allows organizers to create a complete Web presence for conferences. OCS allows to create a conference Web site and compose and send a call for papers. Through OCS platform, it is possible to electronically accept paper and abstract submissions where authors can edit their work. At the end of a conference, organizers can post conference proceedings and papers in a searchable format, and even if the organizer wants, it is possible to integrate a post-conference online discussion forum.

START V2 [14] is an integrated, user-friendly, web-based system for managing peer-reviewed conferences. This interface was designed to follow the typical flow of a conference's editorial process. START V2 can be used in two ways. On one hand, the organizer can download and install the system to run on his server. The other option is to have the server hosted at softconf.com. In both options the license includes the maintenance services, upgrades and installation help, for the duration of your conference process.

Conference Online-Management System (COMS) [15] is a web application for managing the registration, payment, paper submission and paper review. This system tries to accommodate the support to the conference features. The Conference Chair or administrator can perform changes in his COMS profile and see the effects of these changes in real-time. It is possible to achieve a simple user interface disabling some features for the users view.

Congrex [16] is an international management company that offers support and services for meetings, events, conferences, association management, travel and accommodation. Congrex, offers conference bid support, venue sourcing including a destination comparisons, conference logistics management, such as, registration services, program content management and financial management and budgeting, among others. This system can also be in charge of conference promotion and accommodation and conference housing bureau, etc.

CyberChair [17] fully supports all activities comprised in the review process. CyberChair was founded in 1997. According to some statistics, the use of this platform has decreased in the number of conference since 2005. The last conference was organized in 2011. This platform allows authors to send the abstract of their papers and the final version in the camera-ready, follow the status of his paper and the notifications of acceptance and rejection. In addition, the PC chair can control the reviewer assignment based on the reviewers' preferences and expertise and the review submission process, prepare the proceedings (according to the Springer-Verlag procedure) and the abstracts for the conference website and program booklet.

TrackChair [18] is a modern tool for peer review conferences. It has been developed by conference organizers. This platform divides the conference process in four stages: conference setup, paper submission, review assignment and tracking and accepting and rejecting papers. For managing our conference, we can use Firefox or Safari because both of these browsers are much faster than Internet Explorer, especially with large pages.

iChair [19] is another platform to control and manage the submission and review process in a conference. iChair was developed in the third quarter of 2005 by Thomas Baignères and Matthieu Finiasz. The developers tried to make this platform as easy to install as possible. This platform can be used on a Windows based server an in Linux box. It is based on a server software designed to help the program chair of a conference with all tasks involved in the conference organization. iChair can perform the tasks of submission collection, assignment of articles to reviewers, review collection, discussions, mailing to authors and reviewers, among others.

Academics [20] provides customized software solutions and services for academic professionals around the world. Because the conference management can be a complex chain of tasks involving communication, collaboration, job assignment, and decision making between CP chair, authors, reviewers, Academics can facilitate this process. It offers several web-based systems for conferences. Some of them are paper submission and review system, conference management system, and event registration and payment system. Depending on the conference features, these services can be customized without charging over the original price.

Confious [3] is a state-of-the-art management system that combines modern design based on a sophisticated algorithm that helps the program committee (PC) Chair perform some of the most difficult tasks in the conference organization. Confious system is provided as a web service. This means that there is no need for separate installations for each conference served. Confious can support multiple conferences in parallel, transparent between each other. This system improves the efficient management and monitoring of the overall coordination process in conferences.

From the available data on their conference web sites, we have extracted the number of conference that each platform has hosted. Table 1 shows the number of conferences organized by each system until now.

According to these values, we can see that the most important web-based system is EasyChair. It has become very popular between the research communities in last years. EasyChair has hosted more than 21.000 conferences.

Other platforms like EDAS, ConfTool, Open Conference system and START V2 are also very important. All of them have organized more than 1000 conferences.

We can group together the platforms that have organized between 100 (or nearly) and 1000 conferences. This group includes CMT, COMS, Congrex, CyberChair or TrackChair.

Finally there exist some web-based systems where the number of conference is fewer than 50 (or nearly), like Confius, Academics, iChair and SIGCHI. All of them (except the last one) are apparently out of use from conference since 2009 or 2011. SIGCHI has conferences to organize during 2013 and 2014.

IV. EVOLUTION OF CONFERENCES

The platforms evolution we have presented, in terms of the number of conferences organized, can vary greatly depending on the year. The data that each system provides can be very limited. In this section, we are going to show

values of conferences organized considering their relevance. We have tried to show their evolution in different years.

Fig. 1 shows the number of conference in percentage for the 13 platforms that we have cited.

We can see that Easy Chair is the most used system for organizing conferences, even more that the sum of all others. EDAS, OCS, START V2 and ConfTool are also widely used. They have percentages from 10% to 5%. CTM, CyberChair and COMS have percentages from 5% to 1%. The rest of these platforms are less important.

It is possible to perform an interesting analysis by comparing the data of number of conference per year. Unfortunately, all sites do not provide this kind of information. For this reason, in Fig. 2 we have only shown the evolution of sites that offer information per years until 2012. We have grouped in an only group the review platforms with lowest percentages (CONFIUS, Academics and iChair). Because the number of conferences to 2013 can change, we have processed this data separately.

As Fig. 2 shows, START V2 began its trajectory as a conference organizer in 2002. The first years it registered a great increase in number of conferences having its maximum register in 2008 (233 Organized Conferences). In recent years, the number of conferences organized has decreased up to 200 conferences per year.

TABLE I.   RELATIONSHIP BETWEEN EACH REVIEW PLATFORM AND THE NUMBER OF ORGANIZED CONFERENCES.

Review Platforms and their Conferences			
Name	*Conferences*	*Name*	*Conferences*
EASYCHAIR	21.448	COMS	323
EDAS	2.655	CONGREX	123
OCS	1.900	TrackChair	97
START V2	1.778	iChair	51
ConfTool	1.652	Academics	21
CMT	700	CONFIOUS	17
CyberChair	480		
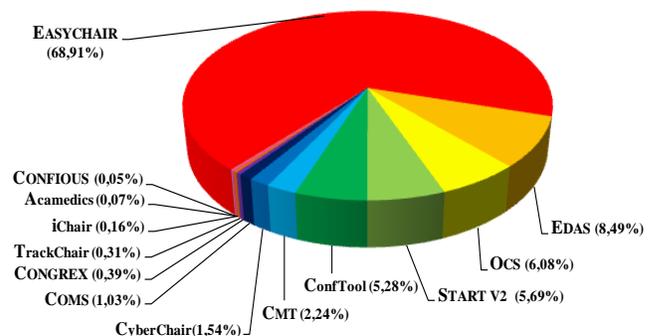
Figure 1.   Conferences organiced by each system

Figure 2. Evolution of number of conferences per site

Figure 3. Number of conferences per dite in 2008.

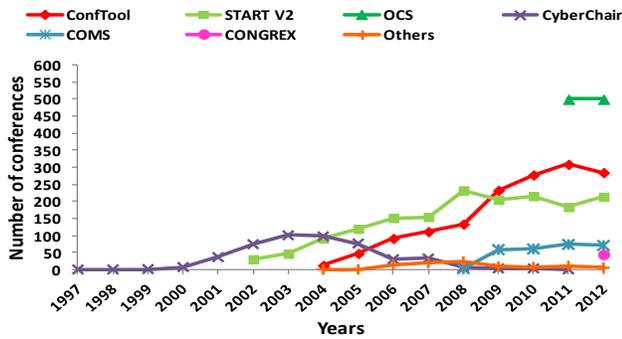Figure 4. Number of conferences per site in 2013.

This value remains constant until 2012. START V2 has (at the moment) 129 conferences for this year.

Although ConfTool started to work 2 years latter (in 2004), this platform, has registered a higher increase than START V2. Its maximum values have reached in 2011 with 309 organized conferences. Since then, ConfTool has had 285 conferences in 2012 and at the moment it is organizing 141 conferences for 2013.

CyberChair was founded in 1997. CyberChair had an increase of use in the following years to its creation. But it evolution has not been so high than others like ConfTool and START V2. CyberChair presents its highest values in 2003 with 101 organized conferences. These values remained stable until 2004. The number of conferences started to decrease since 2011 when CyberChair organized its last conference. In last years of CyberChair (2009), COMS appeared. COMS has organized around 60 conference per year until 2012.

In 2012, CONGREX started to organize conferences. As we can see in the first years the platforms, they experiment an increase in the number of organized conferences. Assuming that this site is still in the first period and that it has already some conferences to organize in 2014, 2015 and even 2016, it is possible that the use of this platform will increase in the next years.

Fig. 3 shows the number of conferences organized by some of these systems during 2008.

In 2008, the number of conferences of ConfTool and START V2 are very different. Both represent more than 90% of the total of conferences organized. iChair, CyberChair and CONFIUS have little representation in the organization of conferences. Its very important to obtain recent data to analyse the actual importance of each platform, because the changes can be high .In 2008, CONGREX had not been created.

Fig. 4 shows the number of conferences that are being organized by the some of these systems in 2013.

From 2008, we can see that these percentages have changed. According to the available data, EDAS will be the most relevant web-based service in 2013. Regarding to information of Fig. 2, ConfTool and START V2 have similar behaviour.

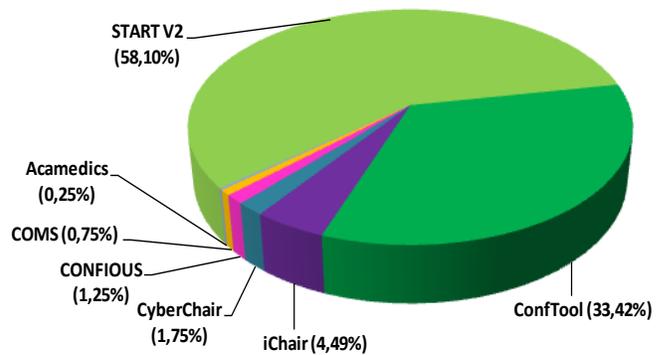In 2013, this behavior still exists and both of them have percentages near 20%.
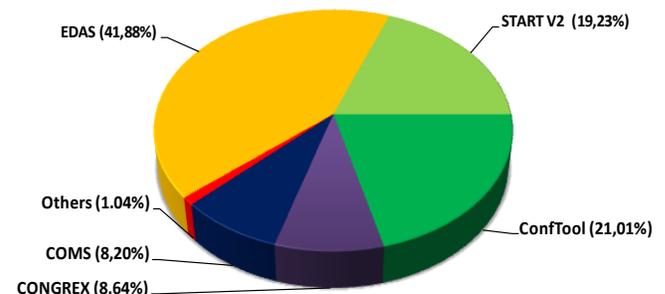
ConfTool has more conferences (12 more than the number of conferences in 2008). COMS has almost half the percentage that START V2 has.

The total number of conference included in the information available is 401 conferences in 2008 and 671 conferences in 2013.

V. COMPARATIVE STUDY

In this section, we are going to compare the five most important platforms, in terms of the number of conferences organized from their beginnings. Table 2 shows the platforms features of systems with more than 1000 organized conferences.

As we can see, all of 5 platforms have similar characteristics. EDAS allows authors to have access to submit works in any conference that EDAS are organizing. The other platforms do not offer this feature. EasyChair, ConfTool and OCS have a demo version that allows organizers to see a preview of the product that they are going to purchase. All of them are relatively easy to use and are very flexible (all of them have am available user guide, except EasyChiar). That means that organizers can customize their final product. In exception of EasyChair and EDAS, the rest of platforms have a friendly point of view to the authors. OCS, START V2 and ConfTool can be used in other languages than English. Only ConfTool permits to select the option to manual selection to send each submitted paper to each reviewer, the other makes it automatically. ConfTool and Start V2 show past conferences and allow searching conferences per year, but neither allows searching conferences per topics or countries.

TABLE II.   PLATFORM FEATURES.

Review Platforms Features					
Name	*Easychair*	*ConfTool*	*EDAS*	*Open Conference Systems*	*START V2.*
Total number of conferences	21448	1652	2655	1900	1778
Add technical/ committee members	✓	✓	✓	✓	n/a
Automatic preparation of conference proceedings	✓	✓	✓	✓	n/a
Automatic reminders	✓	✓	✓	✓	n/a
Blind review	✓	✓	✓	n/a	n/a
Can't submit form the main webpage, must to go to a congress page	✓	✓	No	✓	✓
Conference summary	✓	✓	✓	✓	n/a
Demo version	No	✓	No	✓	No
Easy to use	✓	✓	✓	✓	✓
Flexible	✓	✓	✓	✓	✓
Free	Not all	For small conferences	No	✓	✓
Friendly	No	✓	No	✓	✓
Guide step by steps	n/a	✓	✓	✓	✓
Mail to groups	✓	✓	✓	✓	✓
Multilanguage	No	✓	No	✓	✓
Needs instalation	No	✓	No	✓	Yes/No
Price list	No	No	✓	No	No
Random/ manual reviewer paper assignment	Authomatic	Both	Authomatic	Authomatic	Authomatic
Serch conferencer per countries	No	No	No	No	No
Serch conferencer per topics	No	No	No	No	No
Serch conferencer per years	No	✓	No	No	✓
Shows past conferences	No	✓	No	No	✓
Single track/ multitrack	Both	Both	Both	Both	Both
Supott copyright submission	✓	n/a	✓	✓	n/a
Suport Journals	n/a	No	✓	✓	No
Suport Reviewers discussion	✓	✓	✓	✓	n/a
Suport Visa Request	✓	n/a	✓	n/a	n/a
Templates for mailing	✓	✓	✓	✓	n/a
Well designed	✓	✓	✓	✓	✓

n/a: Information not available.

All of them permit to select a multitrack or single track. Finally, except START V2, all of them can support reviewer discussion.

VI. CONCLUSIONS

When we want to organize a conference, it is very important to consider the use of a platform to submit and review articles. After all the information recopiled, we can see that there are several systems and platforms for organizing conferences, some of them free. Nowadays, the most important one is EasyChair, which are partly free. Almost all systems show similar behaviour. In their first years since their creation, they start to experiment an increase in the number of organized conferences. Some of them get maximums some years later and after that, the number of conferences remains stable for years. Others, after reaching the maximum value, start to decrease in number of organized conferences. That can be caused by the development of new systems with more options. The new options usually present lower price and in many occasions offer easier systems to submit or review papers than the existent options. So the popularity of existent systems that actually are now the most popular can increase or decrease according to the competitiveness against new systems.

Finally, if we want to choose a platform to host or manage our conference, we should keep in mind several features even the price of the service. For example, OCS and START V2 are completely free while EasyChair and ConfTool are partially free and EDAS is not free.

We think that this work can be used by organizers as a guide to choose the most convenient platform for his conference, according to their characteristics, such as number of expected attendees, number of tracks of conference, etc.

Now, we are analyzing the main destinations to locate a conference in function of several factors, such as climate and the use of new technologies of countries, among others. Moreover, we will study if regular virtual learning platforms [21] could be used for this purpose.

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Feasibility of a Camera-Based Instant Feedback System

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Abstract—**The Instant Feedback System (IFS) described in this article is designed to collect students' responses to a series of multiple-choice questions. An IFS enables the educators to improve their teaching by generating real-time feedback from the students about the clarity of the lesson. A number of IFS are known: systems using wired mini-keyboards, infrared clickers, SMS or Internet-based smartphones applications, etc. Our long-term goal is to create an IFS system based on the use of digital camera. In the frames of camera-based IFS implementation, every student attending the class receives a specially designed card containing a predefined number of color markers and a 2D barcode. When the students are asked a multiple-choice question, they answer by physically raising their cards. The 2D barcode on the card is used to encode the student's ID, whereas 2D orientation of the card encodes the number of student's answer. A number of images of the class are grabbed by the IFS camera and processed by a computer, which generates a list of student grades. Reliability of the chosen card design and camera placements is analyzed. We conclude that the chosen card recognition process demonstrates feasibility of the camera-based IFS approach.**

Keywords-image processing; 2D barcode; color recognition; OCR; IFS

I. INTRODUCTION

Instant Feedback System (IFS) is a tool for real-time acquisition and processing of human responses. IFS described in this article is designed to collect student responses to multiple-choice questions in the frame of "active learning" approach. A number of researchers claim that active learning as a concept and IFS as a tool for active learning enable the educators to improve their teaching by generating real-time instant feedback from the students about how clear a specific lesson is for a specific student [1, 2]. A number of IFS implementations are known and every one of these has its own advantages and drawbacks. One of the implementations uses wired keyboards, which are simple and reliable, but wiring requires special rearrangements in the class in accordance with safety rules and this is not always possible. Another implementation uses infrared (IR) clickers, which are used successfully in a number of universities [3, 4, 5]. However, price of the clicker and data collector(s), physical size of the clickers, and the need for periodic battery replacements makes wide usage of IR clickers problematic in low-budget universities and colleges. Another IFS implementation uses Short Message Service (SMS), Internet based smartphones, tablet or PC-based applications to collect instant responses of the students [6, 7]. Simplicity of implementation and logistic advantages of the smartphone-based IFS are obvious to anybody skilled in the art, however, in some classes the use of mobile devices is forbidden (at least during exams). The motivation of this research is to design, implement and test a simple and inexpensive IFS. Considering low prices of modern high-resolution digital cameras, we decided to check the feasibility of a camera based IFS.

The structure of the article is as follows. In the Section II, we present elements of the camera-based IFS, its design and operation. IFS card design is described in the Subsection A. Image acquisition is described in Subsection B, and images handling in Subsection C. Then, in Section III, we describe main elements of the IFS Card recognition software. Section IV is dedicated to results of the camera-based IFS usage in the class. Section V presents a summary of this work, conclusions and possible ways to improve reliability of the camera-based IFS.

II. IFS ELEMENTS, DESIGN AND OPERATION

In the frames of the chosen approach, each student in the class gets one IFS card at the beginning of the semester or at the beginning of the lesson. It is assumed that the class is equipped with a lecturer' computer with a projector (as seen in Fig. 1). It is additionally assumed, that lecturer can operate high-resolution digital camera. During the lecture at one or more times, the lecturer presents to the students a slide containing a multiple-choice question (later referred as IFS exam). After a certain time interval (e.g., 30 seconds) the lecturer asks the students to present their answers by raising their cards. The card design is presented in Fig. 2 and is described in details below. The digital camera grabs a sequence of images of the class and stores those images. Specially designed software processes those images and generates grades list. During November 2012 – January 2013 10 IFS exams were provided in the small-size class of 16 students in the frames of Image Processing Laboratory (later "ImProc") and 10 IFS exams sere provided in the auditory designed for up to 60 students in the frames of TAE course. Fig. 1 presents an exemplary image of the class during ImProc IFS exam. Fig. 3 presents two images of the class during TAE IFS exam. Each student in the class is invited to raise his individual card as an answer to the multiple-choice question asked by the lecturer during the lesson. Callouts of different colors presents results of IFS exam (in the format "Short ID of the Student" / "Number of the Answer"). Relevant technical details follow.

A. *IFS Card Design*

Our IFS card is of size 20cm x 20cm and contains three markers, which are 4cm x 4cm squares having Yellow, Magenta and Cyan colors, and a number of black circles (see Fig. 2). The black circle diameter is 2.5 cm and up to six black circles can be positioned in predefined places on the card. These six positions for black circles correspond to 6 bits of a custom 2D barcode and enable encoding integer numbers from 0 to 63 as specified in Fig. 2. This 6-bits number is used to encode student number in the "class list", and is referred later as Short ID (SID). In the current implementation, the number of answers in the multiple-choice questions is four, which can be considered adequate for most questions of this kind. The number of the answer chosen by the student (#1, #2, #3 or #4) is encoded using the 2D orientation of the card relative to the horizon line. For example, positioning the IFS card so that the "Magenta" rectangle is in the right-bottom corner (as seen by the IFS camera) encodes answer #1, positioning the card so that the "Magenta" rectangle in the left-bottom corner encodes answer #2, etc. Additional "Yellow" and "Cyan" rectangles enable reliable evaluation of the card orientation. It should be noted that the back side of the IFS card contains small-size numbers (1, 2, 3 and 4) positioned at the corners of the card, so that the student orients the card in such a way that the selected answer number (seen by the student) is in the uppermost position (as shown in Fig. 2). IFS Cards are printed on the thick white paper by using specially designed "Printing Utility" (see Fig. 4 left) and folded for the proper rigidity (as shown in Fig. 4 right).

B. *Image Acquisition*

In a small class, one wide angle camera can monitor all the students (as seen in the Fig. 1). However, in most classes even a wide-angle camera cannot cover all the relevant areas of the class. Obvious solution is to make a number of shoots by properly rotating and translating the camera as presented in the Fig. 3: minimum two images of the TAE class were required. Practically, a bigger number of images – typically 3-5 images were collected for every IFS exam. For the internal software tests 5MP Logitech c920 HD Pro Webcam connected to PC was used. Logitech camera was positioned on the rotating stage. Specially designed PC software can control camera rotation and camera parameters for every camera position, so that for every specific class optimal image acquisition sequence can be created, tested and stored [8]. However, at the beginning of the semester, this IFS prototype was not operational. Hence, in this research, all the images were collected by using from-the-shelf digital cameras. Cameras were operated in the simplest "auto" mode without tripod. For example, image presented in Fig. 1 was collected by using a simple digital camera (Canon IXUS 200HS, Image dimensions: 4000 x 3000). Images presented in Fig. 2 were collected by using Samsung Galaxy EK-GC100 Android-4 camera/PDA (Image Dimensions 4608 x 2592).

C. *Image Handling*

Practical Instant Feedback Systems must process raw images stored in the camera memory and present results instantly. In this work, raw images were stored in the camera's flash memory and later copied to the computer as JPG files for the processing. This approach enables to compare different cameras and evaluate if the resolution and image stabilization of the specific camera are adequate. Additionally, intermediate storage of all the images as files enables post-processing of the same image using different algorithms. It must be noted, that from-the-shelf digital camera does not provide access to raw image data. Hence, compressed JPG images were manually "decompressed" to BMP images. In case of the Canon camera, typical decompressed BMP image size was 34.3 MB. For the Samsung camera, decompressed BMP image size was 34.1 MB.

III. RECOGNITION SOFTWARE

A. *Color Markers Detector*

A number of well-known approaches used to detect shapes of different colors were evaluated [9-13]. Additionally, certain elements of the approaches and algorithms described in [14, 15] were used.

Images collected during IFS exams were processed by using specially designed "Image Recognition Utility". Taking into account that colors of the simple printer used to print the IFS cards are not pure "MCY", taking into account illumination differences and differences in the color characteristics of the different cameras, practical values of the "MCY" colors were evaluated from the typical images.

In order to find color markers two algorithms were used. Algorithms #1 was based on "Color Blobs" concept [11, 12]. Algorithms #2 was based on "Pixel Labeling" approach [13].

For most images, both algorithms provided the same results. Fig. 5 presents an example of color marker recognition by using Algorithm #1. It can be seen that all the markers of all the IFS cards are successively recognized as rectangles. Additionally, it can be seen (by manual inspection of images in Fig. 1 and Fig. 5) that marker centers are recognized with nearly pixel accuracy. It can be seen that the Magenta color was detected in other places, e.g., the students' faces and bare areas of their hands. Considering the way the cards were designed, this was not a problem for the images analyzed. However, we plan to provide some card design modifications in the future.

After center of the color markers evaluation, process of "Cards Bounding" was executed. Referring to Fig. 6, first available "magenta center" was set as Point "M" and closest Point "C" and Point "Y" were looked for. Then distances "Y-M" and "M-C" in pixels between above points were evaluated. In case above distances were in the predefined limits, angles "YMC", "MCY" and "CYM" were calculated and compared with predefined limits. In case angles "YCM" and "CYM" were close to 45° , angle "CMY" was close to

90°, then card was considered as "found" and its bounds were considered as known. This process was repeated for all magenta centers and results in the cards bounding (see Fig. 6 right). On this stage card orientation (encoding number of the answer in accordance with Fig. 2) was evaluated by calculating angle between "C-M"/"M-Y" and horizontal line.

B. 2D Barcode Analyzer

By using the row and column, coordinates of the marker centers image registration for the specific card can be easily executed. Considering that the surface of the card is white and the SIDs are encoded using black circles of predefined sizes and positioned at predefined places (as presented in Fig. 2), SID extraction is trivial. Combining SID and the chosen answer number, a final list in the format "student's ID, student's answer, grade" is compiled and presented to the lecturer for the purpose of student achievement analysis. Results of two exemplary IFS exams are presented in Fig. 7.

IV. RESULTS

Comparing color callouts presented in Fig. 1 and Fig. 3 and tables presented in Fig. 7, it can be seem that while IFS card is properly presented to the camera, recognition of multiple cards is reliable enough even for the current card design and current image processing tools. It is obvious that overlapping cards ruin algorithms used. In order to prevent this, students were asked to use simple optical rule: "If you can see the camera – then the camera can see your card". Senior students attending Image Processing Laboratory were cooperative enough and motivated enough to voluntarily participate in IFS exams and follow obvious exams rules, so that recognition rate in this small group was above 90%. As seen in the Fig. 1, only one card near the window was not recognized. Students of the TAE course were less cooperative. It can be seen that only 30 students of 40 enrolled were present during exam #6 (presence in the lecture is not obligatory). Five students effectively not participated in the exam: by raising cards in the obviously wrong way or by non-raising cards in the due time (Blue callout). In three cases "Image Recognition Utility" failed to recognize cards (Red callout). It can be seen that all those three cards were raised in the last row. Post-exam tests reveals that diameter of the block circles for the problematic cards is about seven pixels only.

V. CONCLUSIONS AND FUTURE WORKS

The proposed camera-based IFS design and the selected image processing algorithms prove feasibility of the camera-based IFS approach. The proposed IFS is extremely inexpensive, simple to implement and requires minimum deployment efforts, thus it can be beneficially used to improve learning and teaching in institutes of education, such as schools, colleges and universities. In the future, we plan to implement fully automated real-time image acquisition and data processing. We expect that using automated image acquisition system utilizing computer controlled camera rotation and computer controlled brightness, contrast and zoom, will improve IFS reliability. Additionally, we plan to implement, test and compare a number of different machine and human oriented IFS cards designs. We plan to use color edges in the future IFS cards design and to use robust color edge detectors [14, 15] to improve practical reliability of the camera-based IFS.

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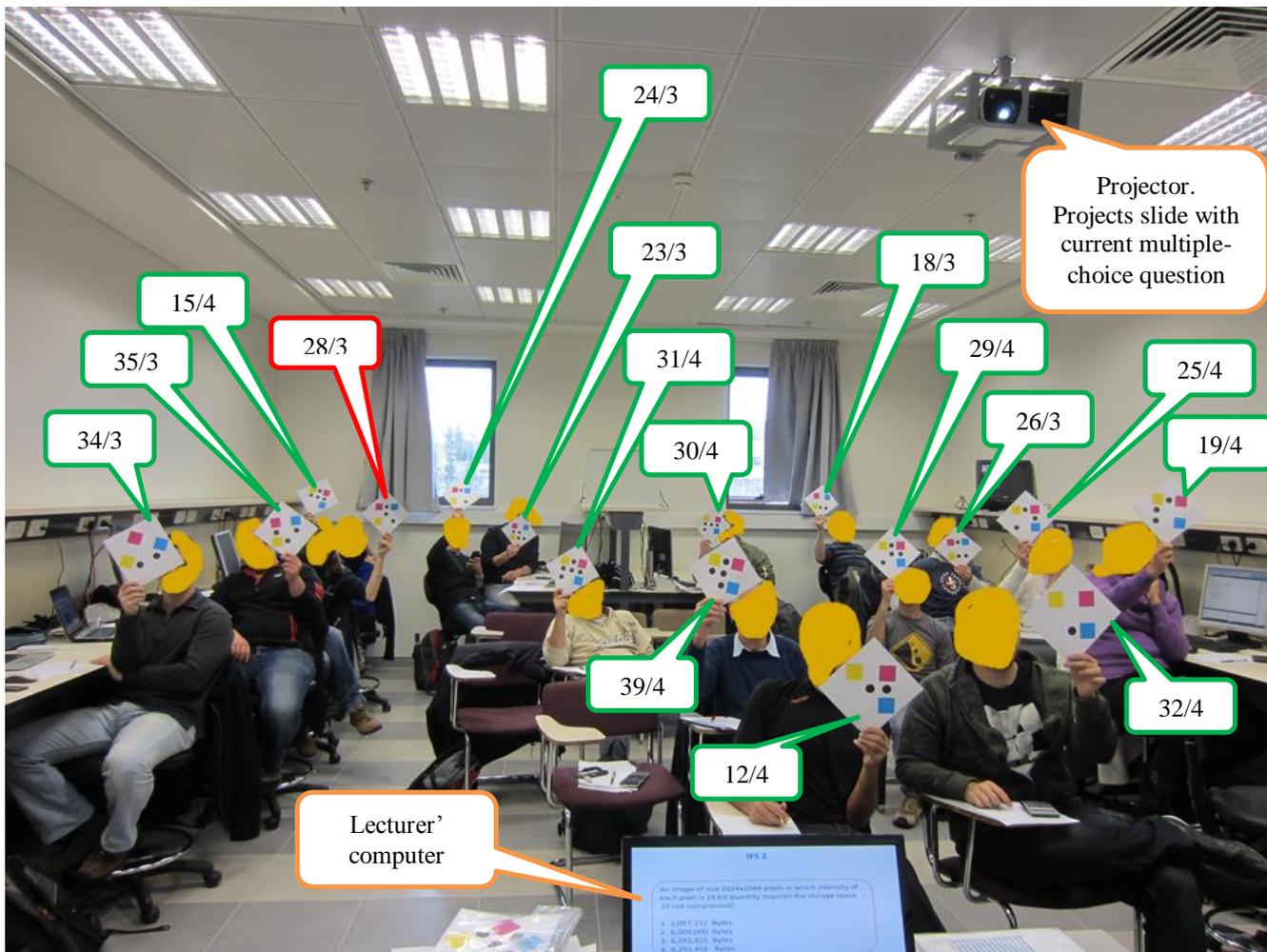
Figure 1. An exemplary multiple-choice ImProc IFS exam #2. See the text and following figures for detailed explanations. The faces of the students participating in the exam were manually brushed.

Figure 2. Left: Front side of an IFS card #63 as seen by the IFS camera (Selected answer number is #1). Right: Back side of an IFS card #63 as seen by the student.
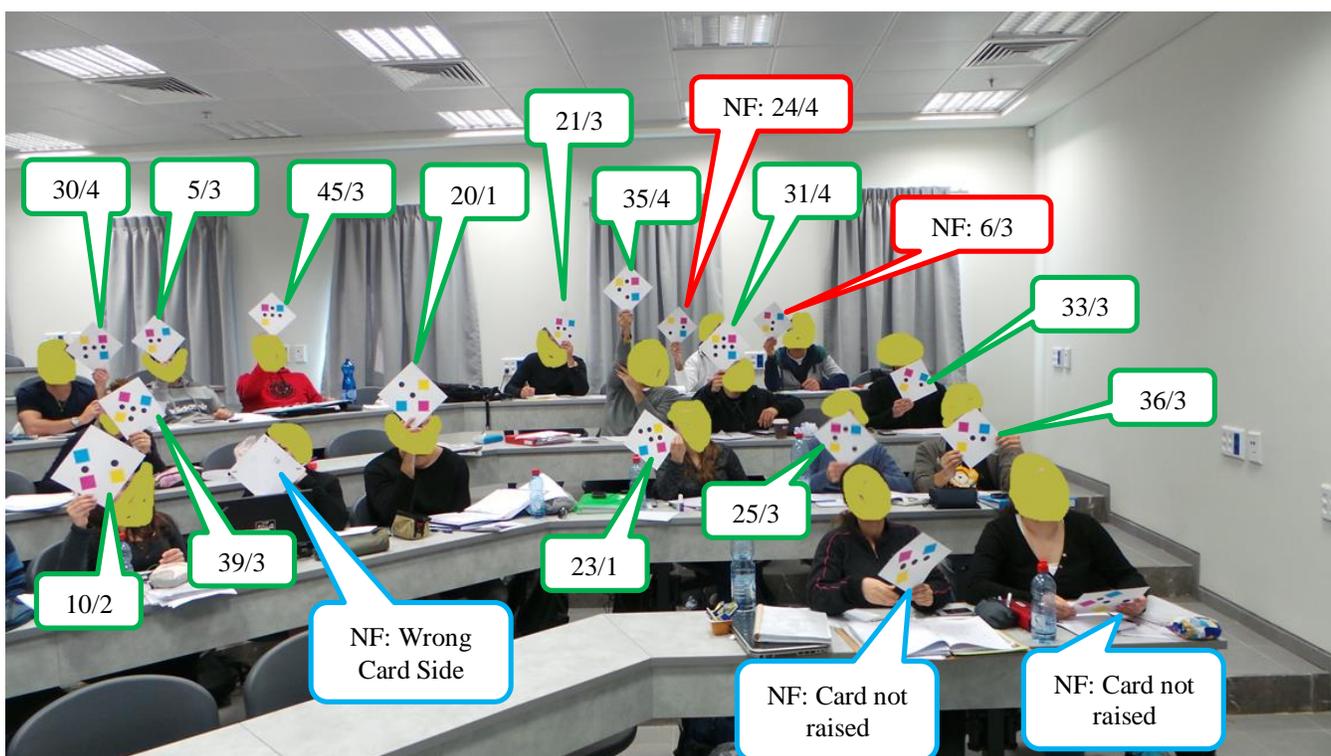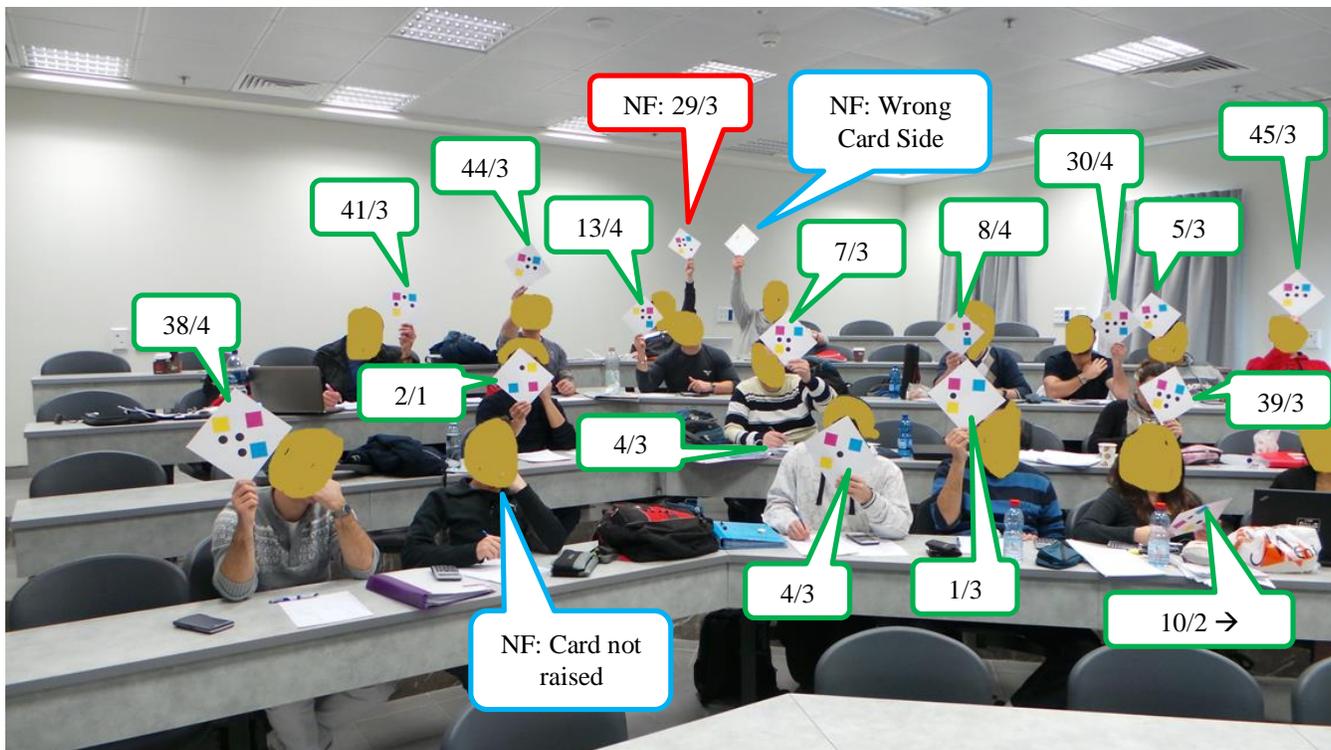
Figure 3. An exemplary multiple-choice TAE IFS exam #6. Minimum two images required to cover the class.
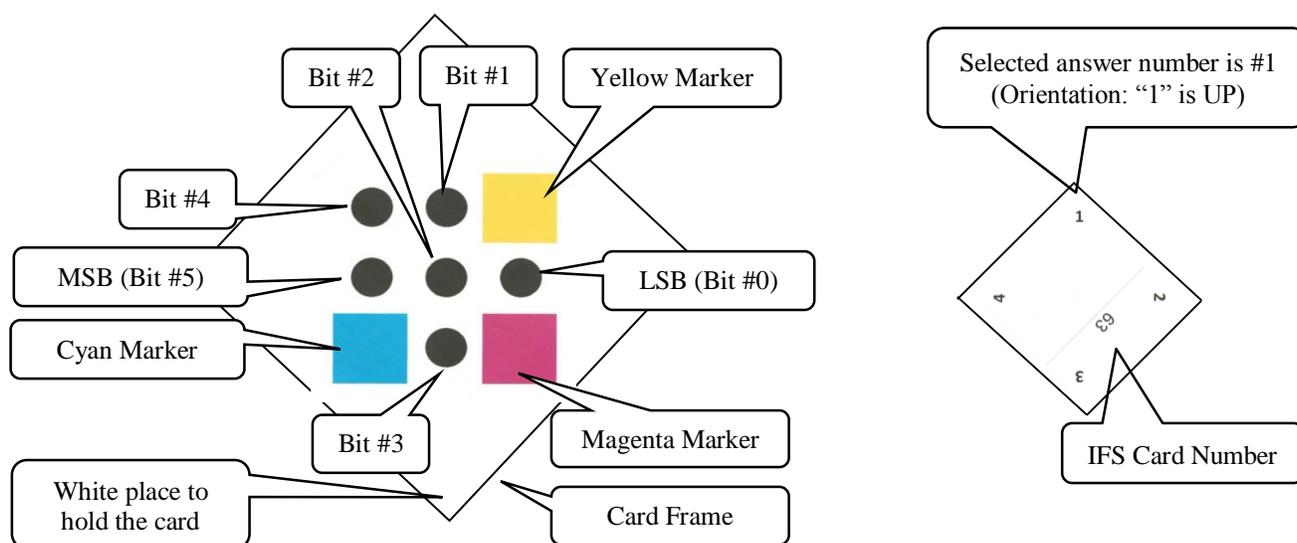See the text and following figures for detailed explanations.
The faces of the students participating in the exam were manually brushed.
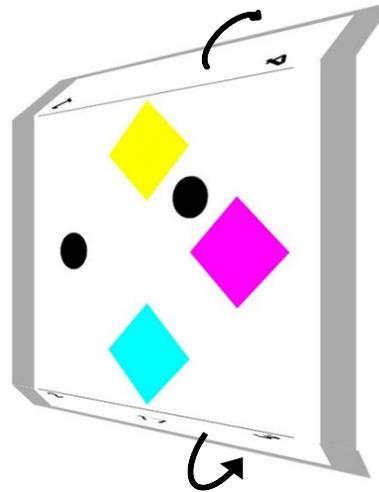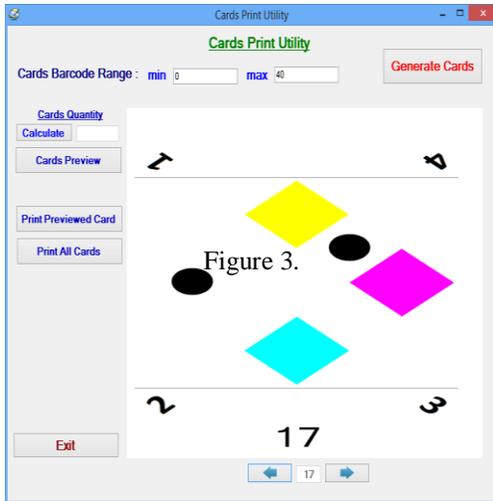
Figure 4. Left: GUI of the IFS Card Printing Utility.
Right: Folding IFS card to create "front" and "back" sides as shown in Fig. 2.

Figure 5. An example of color markers recognition. All the markers of all 16 IFS cards (see Fig. 1) were successfully recognized as color rectangles. The calculated geometrical centers of the rectangles are marked as black dots.
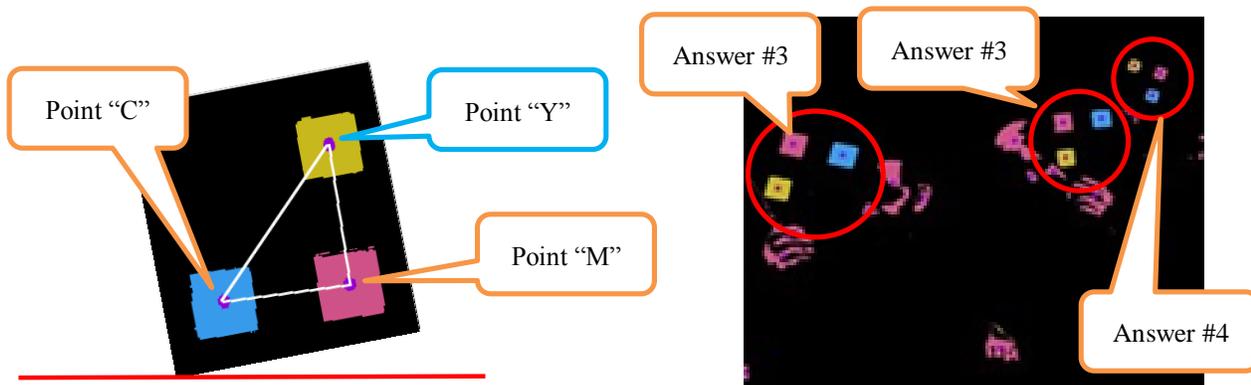
Figure 6. Left: Important angles between Color Markers and horizontal line.
Right: Exemplary bounding of the three leftmost cards (from the Fig. 5) by distances and angles between markers.
Number of the answer is evaluated by the found card orientation.
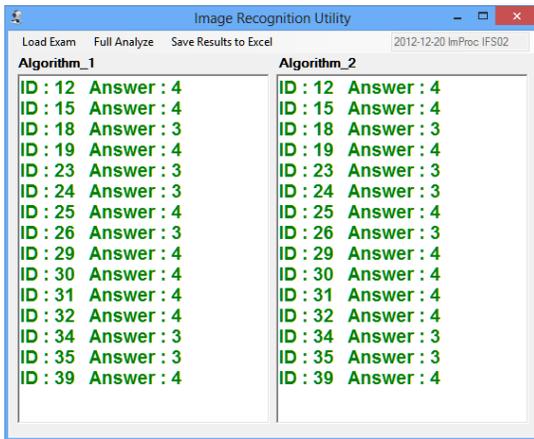
	A	B	C	D	E
1	**2012-01-21 TAE3**				
2	Algorithm1			Algorithm2	
3	******************			******************	
4	ID	Answer		ID	Answer
5	1	3		1	3
6	2	1		2	1
7	4	3		4	3
8	5	3		5	3
9	7	3		7	3
10	8	4		8	4
11	10	2		10	2
12	13	4		13	4
13	20	1		20	1
14	21	3		21	3
15	23	1		23	1
16	25	3		25	3
17	30	4		30	4
18	31	4		31	4
19	33	3		33	3
20	35	4		35	4
21	36	3		36	3
22	38	4		38	4
23	39	3		39	3
24	41	3		41	3
25	44	3		44	3
26	45	3		45	3
27					

Image Recognition Utility

Load Exam   Full Analyze   Save Results to Excel   2012-12-20 ImProc IFS02

Algorithm_1

ID : 12 Answer : 4
ID : 15 Answer : 4
ID : 18 Answer : 3
ID : 19 Answer : 4
ID : 23 Answer : 3
ID : 24 Answer : 3
ID : 25 Answer : 4
ID : 26 Answer : 3
ID : 29 Answer : 4
ID : 30 Answer : 4
ID : 31 Answer : 4
ID : 32 Answer : 4
ID : 34 Answer : 3
ID : 35 Answer : 3
ID : 39 Answer : 4

Algorithm_2

ID : 12 Answer : 4
ID : 15 Answer : 4
ID : 18 Answer : 3
ID : 19 Answer : 4
ID : 23 Answer : 3
ID : 24 Answer : 3
ID : 25 Answer : 4
ID : 26 Answer : 3
ID : 29 Answer : 4
ID : 30 Answer : 4
ID : 31 Answer : 4
ID : 32 Answer : 4
ID : 34 Answer : 3
ID : 35 Answer : 3
ID : 39 Answer : 4

Figure 7. Real IFS Exams Results.
Left: GUI of "Image Recognition Utility". Result of ImProc IFS exam #2.
Image of the class was presented in Fig. 1. Processing time 18 sec.
All 15 presented pairs {ID - number of answer} are correct for both algorithms.
For the card #29 markers were successfully detected, number of the answer was successfully detected; however ID detection was failed (marked by Red callout in Fig. 1) probably because of backlight from the window: central region of the IFS card is more transparent than periphery region (see Fig. 4 right)

Right: Excel table created by "Image Recognition Utility". Result of TAE IFS exam #6.
Two images of the class were presented in Fig. 3. Processing time 35 sec.
All 22 presented pairs {ID - number of answer} are correct for both algorithms.
Some cards are seen as in the first as in the second images of the Fig. 3.
In this case, last result is logged. For example: card #10 is not raised yet in the first image, but is raised in the second image.
Three images from the last row were not recognized by the "Image Recognition utility". (Marked by Red callout in Fig. 3)
Probable reason for failed recognition is the lack of camera resolution.

Video adaptation based on the SVC file format

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Abstract—This paper provides a description of the Scalable Video Coding (SVC) file format standard and its support for the video adaptation in a streaming scenario. The paper shows the advantages of using SVC and its standard file format when implementing server driven and receiver driven adaptation. The organization of information inside the SVC file permits the efficient application of adaptation procedures based on filtering at the server or at media aware network elements, carrying out receiver driven layered multicast and multi-interface transmission. The paper provides an overall description of a tool that supports the creation of files compliant with the SVC file format.

Keywords-Scalable video coding, SVC file format, streaming, video adaptation, multicast and multi-interface transmission.

I. INTRODUCTION

This paper introduces the reader to the ISO media file format [1] and its SVC extension [2] as well as its usage to stream SVC videos over the network in an adaptable way. We expose how to carry out the adaptation executed by the sender or the receiver and describe a tool to ease this process.

The aim of this paper is not introducing the reader to the SVC video codec or the protocols involved in a streaming service. We point the reader to [3] and [4] for a more detailed introduction of those technologies.

SVC is the scalable extension of H.264/AVC. It provides three scalability dimensions: temporal, allowing diverse frame rates; spatial, relative to the picture size; and quality, allowing different values of the signal-noise ratio. In SVC, each feasible combination of these three characteristics is called *a layer*. A layer is recognized by a group of three identifiers (ID): Dependency ID (DID), Quality ID (QID), and Temporal ID (TID). All the layers up to some specific values of these identifiers determine an *operation point* of the SVC stream, that is, a subset of the bitstream that can be decoded to generate a representation of the video with a certain quality. This group of three identifiers will be referred to as DQT from now on in this paper.

As an extension to AVC, SVC defines the Video Coding Layer (VCL) and the Network Abstraction Layer (NAL). VCL is intended to optimally represent video data while NAL provides efficient data formatting to facilitate video delivery or storage. NAL defines the minimum AVC data

0 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30 31

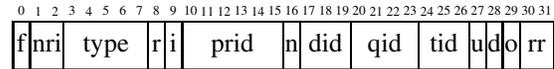| f | nri | type | r | i | prid | n | did | qid | tid | u | d | o | rr |

Figure 1.   AVC NAL Unit header followed by its SVC extension

association, called NAL Unit (NALU). A NALU starts with one octet long header followed by raw byte sequence payload. SVC NALUs extend their header with three more octets, as can be seen in Figure 1. These new fields identify the layer associated to the NALU (DID,QID,TID). The NALU header co-serves also as RTP payload header [5].

The SVC file format specification defines how SVC streams are stored in any file container based on the ISO Base Media file format [1] (e.g., MP4 files [6]). It is a specialization of the AVC file format [7] that incorporates some new structures to enable SVC specific features, including *adaptation operations* and *erosion storage*. Adaptation operations consist in discarding SVC data, according to an adaptation decision based on the context in which the file is used, whereas erosion storage is the reduction of SVC storage space with a controlled video quality degradation. A recommended reading about the SVC file format can be found in [8].

In order to provide a representation of the video specified by a certain operation point, an adaptation service is used. The service removes any SVC NALU over the desired operation point simply looking at their SVC NALU extension header. Taking into account the location where the adaptation decision is made, there are two possible strategies to perform the adaptation of the SVC video: sender driven adaptation and receiver driven adaptation.

Sender driven adaptation is interesting when using unicast streaming (video on demand). The adaptation is done at the streaming server itself or at a media aware network element (MANE) [9] in charge of thinning the bitstream. The operation point is selected by an integrated function of the server or MANE, or in a separate module responsible of the decision logic.

Receiver driven adaptation is more appropriate when using multicast or multi-interface reception. In these cases, the client is the entity in charge of selecting the best operation

point. When multicast is used, the adaptation is performed by means of the well known receiver driver layered multicast [10]. On the other hand, if multi-interface reception is available, the receiver starts as many streaming sessions as needed, with different interface endpoints in each session. The whole set of active streaming sessions deliver the layers of the selected operation point.

The remainder of this paper presents the file management procedures that support the sender and receiver driven adaptation. Section II presents an overview of the MP4 file format and the specialization of this file format to store SVC bitstreams; section III describes the storage of SVC bitstreams into tracks in MP4 files and the creation of extractor and hint tracks. Section IV describes the use of SVC files for sender driven adaptation, and section V presents the use in receiver driven adaptation. Section VI introduces a tool and show some results. Finally, in section VII we conclude this paper and provide future work plans.

II. File format

A. Overview of MP4 file format

The MP4 file format is an extension of the ISO Base Media file format designed to store MPEG-4 multimedia presentations. This standard defines a generic and codec agnostic multimedia container based on an object oriented design. Files are made up of objects, called *boxes* or *atoms*, and every piece of data in the file is stored in a box. Inheritance and composition relationships are commonly used in the definition of boxes.

The standard defines three coordinated arrangements of information: a logical structure, a time structure, and a physical structure. The logical structure reflects the components of a movie, that is, a set of time-parallel tracks. The time structure represents the sequence of samples of each track, according to the timeline of the overall movie. And the physical structure of the file defines the location of the information, including the boxes that contains the logical and time structure description, and the media data samples themselves. An interesting aspect of this file format is the separation of the media data from the metadata. For example, the length and timestamp of a video frame are not stored adjacent to the frame itself, but in boxes in the metadata part. Additionally, to facilitate editing, timing data is relative and media data is stored as it is, without any kind of transformation. When data must be streamed, special instructions are stored in hint tracks to support servers in the process of data packetization.

The main top level boxes of the MP4 file format are the movie atom *moov*, which is the metadata container, and the media data atom *mdat*, which is the data container. Inside the movie atom there is a movie header atom *mvhd* and a set of *trak* atoms. The movie header stores media independent information relative to the whole media. Regarding the *trak* atoms, each of them contains the metadata related to a time series of media. The most important boxes included inside *trak* are:

- A track header atom *tkhd* that contains the track identifier and duration.
- A track reference atom *tref* that contains the identifiers of other tracks with which this one has some type of dependency ('hint' and 'scal' are examples).
- A media atom *mdia*, explained below.

The media atom includes several boxes that permit storing efficiently the information of a media stream. First of all, the handler box *hdlr* specifies the nature (audio, video, hint, etc.) of the media in the track. Additionally, the sample table box *stbl* contains all the information to obtain the physical location and timing of each sample. This information is structured in a set of boxes that are formatted as compact tables.

The compact representation of the physical location is based on the observation that groups of frames from the same track are often stored contiguously in the *mdat* box, even when multiplexing various tracks. The concept of *chunk* of samples represents this grouping of contiguous samples from the same track. Several levels of indirection are used to locate a sample: the sample to chunk box *stsc* permits to find the chunk that contains a sample; then, the chunk offset box *stco* specifies the offset of each chunk from the beginning of the file; finally, the sample size box *stsz* stores the size of each sample, and therefore, using the chunk offset and the sizes of the preceding samples in the chunk, it is possible to find the offset of the sample from the beginning of the file.

Regarding the timing information of a track, the sample table box contains two tables that provide a relation between decoding time and sample number *stts*, and composition time with sample number *ctts*. The decoding time of a sample is stored as its duration (or delta from the preceding sample) to obtain a compact representation, whereas the composition time is stored as a time offset from the decoding time of the sample.

We have previously mentioned that the MP4 file format is codec agnostic. To facilitate the storage of different media types, there are track specializations for each media nature parameterized by the *description of sample entries*. The sample description box *stsd* included in sample table box gives detailed information about the coding type used, and any initialization information needed to configure the decoder. The standard enables the use of several sample descriptions per track, although usually there is only one. Each chunk has an index that specifies the sample description of all the samples included in the chunk. The AVC and SVC file formats are not, strictly speaking, truly file formats on their own, but specifications of new sample descriptions and additional boxes to describe specific metadata for the AVC and SVC codecs. We will go over these additions in following sections.

When media is delivered using a streaming protocol, the characteristics of the transmission system may force to reformat the media data, stored in its natural form, in order to perform the communication. This is especially evident when the transmission is done on a packet based network like Internet. One of the particularities of Internet is the Maximum Transfer Unit (MTU) that establishes the maximum packet size that can be transmitted without fragmentation from a particular source to a particular destination. If this value was not taken into account during the media production, some aggregation or fragmentation would be needed to fit the media chunks into packets. The RTP protocol [11], the universal protocol for real-time media transmission, was designed in an extensible manner forcing the definition of different payload format or profile documents for each media to be transported, e.g., H.264/AVC Payload format [9]. This document defines the way media data has to be fragmented and signalled when transported over RTP.

A streaming server may calculate the packetization at streaming-time. However, the MP4 file format defines special tracks that help during the packetization process. So called *hint* tracks contain instructions to assist media-independent streaming servers in the generation of packets. Such instructions contain references to sample data fragments from one or more media tracks, listed as hint-type references in the *tref* box of the hint track. Special authoring tools called hinters have the payload format specific knowledge required to generate hint tracks after the editing process of the media tracks is completed. Hint tracks are structured like media tracks, and as a result, a file may contain both the original media and one or more hint tracks referencing the media track. Each hint track can support just one streaming protocol specified in the sample description of the hint track.

Streaming servers using RTSP [12] usually employ SDP [13] as the description format of the presentation. The MP4 file format defines a set of boxes to store SDP information during the hinting process, to assist the server in forming a full SDP description. SDP boxes are stored at both the movie and the track level. The movie SDP box contains the session level description, whereas track SDP boxes keep the lines corresponding to media level descriptions.

B. Overview of the SVC file format

The SVC file format is designed to be back compliant with the AVC file format, and consequently we start with a quick review of the latter.

The AVC file format defines extensions for the ISO Base Media file format to cope with three interesting features of the AVC codec: switching pictures, sub-sequences and parameter sets. Switching pictures and sub-sequences are AVC mechanisms for video adaptation that have been superseded by SVC, so they will not be addressed in this paper. Regarding parameter sets, the AVC codec defines sequence and picture parameter sets to convey infrequently changing

decoder configuration. These parameters are usually transmitted out of band to the receiver, and more specifically, inside the SDP presentation description. To support the decoupling of parameter sets from coded video data, the AVC file format permits two possible mechanisms to store AVC data in tracks:

- A single video elementary stream: in this case a unique track contains samples that store video coding related NAL units; the track may also store non-video coding related NAL units such as SEI messages and access unit delimiter NAL units. Sequence and parameter set NAL units are stored in the sample description box of the track (*stsd*).
- Video and parameter set elementary streams: in this case one track contains samples that store the same type of NAL units indicated in the previous option, but sequence and parameter set NAL units are not stored in the sample description of this track; instead of that, they are stored as data samples of a second track. This option may be interesting when there are unusual frequent changes in the parameter sets of the video stream.

Samples in AVC tracks correspond to access units in AVC terminology, that is, complete video pictures. Each access unit is made up of a set of NAL units, that usually contain complete picture slices. To identify the limits between NAL units of the same sample, each NAL unit is preceded with a field that specifies its length in bytes. The length field can be of 1, 2, or 4 bytes. The definition of AVC samples specified in [7] is:

```
aligned(8) class AVCSample {
    unsigned int pictureLength = sample_size;
    for (i=0; i<pictureLength; ) {
        unsigned int ((LSMO+1)*8) NALUnitLength;
        bit (NALUnitLength * 8) NALUnit;
        i += (LSMO+1) + NALUnitLength;
    }
}
//LSMO stands for Length Size Minus One
```

A video elementary stream is stored in a track identified by means of a sample description that has the coding name 'avc1'. Sample descriptions of this type have a special box called *avcC* that contains the AVC decoder configuration record. This record includes the list of sequence and parameter sets, specifies the AVC profile and level, and the amount of bytes (LSMO) used to represent the NAL units length. On the other hand, tracks that store parameter sets have the coding name 'avcp'.

After this short description of the main features of the AVC file format, we can continue the discussion of the SVC file format. In addition to a specific sample description, there are three special constructions defined in the SVC file format to support scalability: *extractors*, *tiers* and *temporal metadata statements*.

Extractors are the first and simplest instrument to support

SVC adaptation. An extractor contains special NAL units (with type 31), which enable the extraction of SVC data from other tracks by reference. The extractor can represent a concrete operation point of the SVC stream, identified by the top value of the DQT triple in the NAL units referenced by the extractor. In section III-B there is a more detailed discussion about this adaptation instrument.

Tiers are a more complex mechanism that permit to select operation points with more flexibility. A tier can represent a set of operation points using special boxes to group samples in an SVC video elementary track and to map groups of samples to scalable layers. The characteristics of the operation points (spatial resolution, bitrate, etc.) are stored in the tier definition, and can be used to take the adaptation decision.

SVC metadata tracks represent the more flexible and complex adaptation mechanism defined in the SVC file format. This type of tracks contain time parallel metadata associated with the SVC media data. Metadata is structured as statements that describe the scalability features of the video data, and can help in the implementation of complex extractors, specially when working with irregular SVC streams.

III. SVC TRACKS

A. SVC video tracks

In this section we describe the procedure to store SVC video elementary streams in SVC tracks. The file format specification permits to split the stream in several tracks. For instance, it could be interesting to store the base layer, AVC compatible, in one track, and the rest of enhancement layers in a second track. However, we have chosen to use a single track to store all the SVC stream, because extractor tracks (introduced below) can be employed to obtain similar results.

To keep back compliance with AVC file format, a track with a complete SVC stream must be described with the coding name 'avc1'. An AVC player can open this track and feed the decoder with all the SVC stream; the decoder must discard all the not understandable NAL units, in this case the SVC NAL units.

Regarding the sample description box *stsd*, the SVC file format makes use of the inheritance mechanism of the ISO Base Media file format to define a new sample description atom that contains, in separate sub-atoms, the AVC configuration (sequence and picture parameter sets) and the SVC configuration (sequence, subset sequence and picture parameter sets). An AVC player can retrieve the AVC configuration as usual, whereas an SVC player can use the SVC configuration to prepare the decoder. Additionally, this box stores a SEI NAL unit containing only a scalability information message. The scalability information includes the spatial, temporal and quality dimensions of each operation point as well as its bitrate requirements. This SEI message is fundamental to take decisions on operation point selection.

Samples in the SVC track correspond to SVC access units, that is, each sample contains information of a complete picture, including all the spatial and quality enhancement layers. NAL units of the access unit are stored in the order found in the original SVC stream. Usually, the access unit starts with a SEI NAL unit containing a sub-sequence information message, followed by a set of AVC VCL NAL units containing the base layer data (each one preceded by an SVC prefix NAL unit), and finally concludes with a set of SVC VCL NAL units representing the enhancement layers of the picture.

B. SVC extractor tracks

Extractor tracks permit the pre-filtering of SVC streams in order to reduce the server overload due to adaptation during streaming time. An extractor track is identified with the coding name 'svc1', and points to the original media tracks in its *tref* box with the 'scal' reference type. The samples in the extractor have a format similar to samples in AVC tracks, except for a special extractor NAL unit (type 31). Below we :

```
aligned (8) class Extractor () {
    NALUnitHeader();
    unsigned int(8) track_ref_index;
    signed    int(8) sample_offset;
    unsigned int((LSMO+1)*8) data_offset;
    unsigned int((LSMO+1)*8) data_length;
}
```

where NALUnitHeader() is an extended NAL unit header as specified in [14] and represented in Figure 1.

The track_ref_index in the extractor specifies the index of the 'scal'-type reference in the *tref* box of the extractor track, that points to the SVC media track from which data is extracted. The sample_offset gives a relative index of the sample in the SVC media track to be used as source in the extraction process. The relative positioning expressed in this field corresponds to the decoding time line of the extractor track. Usually it has value 0, indicating that the sample in the media track to be used has the same decoding time as the sample in the extractor track containing the extractor NAL unit. The extractor NAL unit is completed with the data_offset field, that indicates the offset of the first byte in the referenced sample to copy, and the data_length field, that contains the number of bytes to extract. The values in the SVC NAL unit header are obtained from the values in the original SVC media sample. The most important fields are did (dependency identifier), tid (temporal identifier) and qid (quality identifier). They contain the lowest values of the fields in the extracted NAL units.

The extractor track is created with a user selected interval of operation points, specified by a pair of DQT triples: DQT_{min} and DQT_{max}. Obviously, the DQT_{min} value

```
0  1  2  3  4  5  6  7  8  9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30 31
```
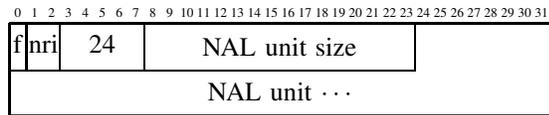| f | nri | 24 | NAL unit size | |
| NAL unit $\cdots$ | | | | |

Figure 2.   RTP payload field format

can specify the $\{0, 0, 0\}$ value, indicating that the extractor selects the SVC video from the base layer up the DQT_{max} operation point.

The sample description of the extractor track stores an SVC configuration box and a scalability info SEI box. This two boxes are filled with data extracted from the original SVC media track. More specifically, the SVC parameter sets included in the extractor sample description are those used by the NAL units pointed from the extractor track. Regarding the scalability info SEI box, the extractor contains a new scalability info message that describes only the layers in the interval of operation points specified by the user.

C. SVC hint tracks

The Network Abstraction Layer for AVC was defined having in mind the use of transport protocols to convey AVC data. In fact, the RTP payload format for AVC establishes that the first byte in the payload field of RTP packets mimics the first byte of a NAL unit. In the most simple configuration of the RTP packetization, each NAL unit can be transported in a single packet, so that the payload is exactly the complete NAL unit. This procedure is convenient when NAL units have an amount of bytes that is nearly the MTU parameter of the network (e.g., 1500 bytes in Internet, including RTP and UDP headers). Nevertheless, this choice is not always available, because the control of NAL unit size is done during the encoding process (usually by limiting the size of slices), but the encoding and hinting stages could be done by different agents.

If small size NAL units are transported individually in RTP packets, the protocol overload will be unacceptable. To cope with this situation, the AVC and SVC RTP payload formats define the use of a special type of RTP packets, called aggregation units. Two type of aggregation units were considered, Single-Time Aggregation Units (STAP) and Multi-Time Aggregation Units (MTAP). In this document we will focus on STAP in which all the NAL Units within a packet pertain to the same decoding instant.

Single Time Aggregation units are identified with the type field in the first byte of the RTP payload: its value is equal to 24. In this case, the RTP packet can contain several NAL units corresponding to the same access unit. Figure 2 shows the format of the payload field in these RTP packets.

The f field in the packet header is set if any of the aggregated NAL units has this field set. The nri field has the greatest value of the corresponding fields in the aggregated NAL units. Following this byte there is a sequence of NAL

units, each one preceded by a 16 bit field that specifies its length.

It is also possible to have NAL units whose length exceeds the MTU parameter. In this case, the hinter is obliged to fragment the NAL unit into several consecutive RTP packets with identical timestamp. Each RTP packet carries a fragment of the original NAL unit. These RTP packets have the structure shown in Figure 3.

The Fragmentation NAL unit header has a type value of 28. The following 8 bits contain a special header with the fields:

- f: has the value of the same field in the fragmented NAL unit.
- nri: has the value of the same field in the fragmented NAL unit.
- s: start bit. Is set when the RTP packet carries the first segment of the fragmented unit.
- e: end bit. Is set when the RTP packet carries the last segment of the fragmented unit.
- r: reserved. Must be 0.
- type: contains the type of the original NAL unit.
- FU payload: contains a fragment of the NAL unit.

To finish this section, we discuss the inclusion of SDP presentation descriptions in SVC hint tracks, because it is a basic piece of information to carry out the adaptation. As mentioned previously, there are two levels where SDP data can be stored: the movie level, and the hint track level. When an RTSP client sends a DESCRIBE operation to an RTSP server, specifying an MP4 movie, the latter returns the complete SDP description of the file. The complete description joins the movie level SDP with the hint tracks level SDP (there could be more than one).

It has to be taken into account that the streaming scenario (RTSP) calls for a declarative use of session descriptions, that is, the SDP description sent from the streaming server as a response to the DESCRIBE operation represents session properties that can not be modified by a client counter proposal. In this context, the SDP description of a hint track contains three parameters that have a special importance during the adaptation process of the RTP stream generated from the track: *packetization-mode*, *sprop-parameter-sets* and *sprop-scalability-info*.

The packetization-mode parameter specifies the type of packets used in the hint track. If this parameter takes the value 0, RTP packets must carry single NAL units. When the value is 1, aggregation and fragmentation packets can be

```
0  1  2  3  4  5  6  7  8  9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30 31
```
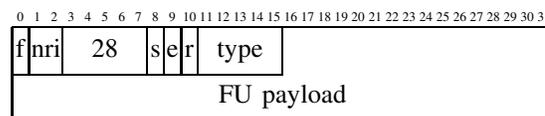| f | nri | 28 | s | e | r | type |
| FU payload | | | | | | |

Figure 3.   Fragmentation Unit payload field format

used, with the restriction of carrying information of a single access unit. When the value is 2, NAL units of multiple access units can be transported in the same RTP packet. As said above we will consider up to mode 1.

To include sequence, subset sequence and picture parameter sets in the SDP description, the hinter uses sprop-parameter-sets [9]. The value of this parameter is a comma separated list of these parameter sets represented in Base64 format. This list of parameter sets is collected from the sample description boxes of the extractor track or SVC media track.

Finally, the sprop-scalability-info is used to convey the scalability information SEI message in Base64 format. Again, the SEI message is retrieved from the sample description boxes of the referenced track.

IV. SENDER DRIVEN ADAPTATION

With the support of the SVC file format described in the previous sections, it is relatively straightforward the implementation of the server driven adaptation in the context of video streaming. In this scenario the server takes the adaptation decision based on static and dynamic context information. Static context information refers to the information relative to the whole session and stays immutable during it, such as client screen size. On the other hand, dynamic context is considered as the mutable information to be altered during the streaming time, such as the instantaneous available bandwidth.

It is important to consider that the MP4 file could have extractors for some (not all) of the possible intervals of operation points $[DQT_{min}, DQT_{max}]$. The server performs the selection in two steps: first, the scalability information message located in the single SVC track, which contains the complete representation of the video, is analysed to find the best operation point that complies with the static context. This operation point is called DQT_{target}; then, the server searches the best extractor (with greater DQT_{max}) that fulfils the conditions:

$$DQT_{min} = \{0,0,0\}$$
$$DQT_{max} <= DQT_{target}$$

Once the server has selected a hint track for the streaming session, it prepares an SDP description that includes only the media level SDP sub-string corresponding to the selected hint track. This implies that the client is forced to ask for the SETUP of the unique hint track proposed by the server.

Dynamic fluctuations of the context (like network conditions) can oblige to perform a thinning of the RTP stream obtained from the selected hint track. To accommodate to the new conditions, the streaming server periodically renews the target operation point. If the operation point moves below the value of the hint track selected during the session setup, the RTP stream is forced to cross an SVC filter [15]. The filter de-packetizes the NAL units, removes those whose DQT

identifiers aren't between the dependencies of the selected operation point, and re-packetizes the NAL units that pass the filter.

Dynamic adaptations can be performed at a MANE between the server and the client. The procedure to implement the dynamic adaptation is similar to the one described previously for the streaming server. It is important to note that the MANE has access to the scalability information that describes the input RTP stream, because this information is included in the SDP sprop-scalability-info parameter that is intercepted during the RTSP conversation between client and server.

V. RECEIVER DRIVEN ADAPTATION

To implement the receiver driven adaptation, some additional information must be included in the SDP boxes of the MP4 file: the dependencies between hint tracks created from extractors. As mentioned in section III-B, extractors can be created using intervals of operation points $[DQT_{min}, DQT_{max}]$. Suppose an administrator creates n SVC extractors in an MP4 file with intervals defined by:

$$I(i) = \left[DQT_{min}^i, DQT_{max}^i\right] \quad (1)$$

such that:

$$\bigcup_{i=0}^{n} I(i) = [\{0,0,0\}, \{D_{max}, T_{max}, Q_{max}\}] \quad (2)$$

where D_{max}, T_{max} and Q_{max} represent the maximum scalability dimensions of the complete SVC stream. Then, the streaming client must be able to detect the decoding dependencies between extractors with $DQT_{min} \neq \{0,0,0\}$ in order to be able to setup enough RTP streams to convey a certain overall operation point.

The SDP extension defined in [16] is the choice of the RTP payload format for SVC [5] to describe the decoding dependencies between media elements defined in an SDP session. The signalling of dependencies proposed by the IETF is described with the following example:

```
v=0
o=john 2890844526 2890844526 IN IP4 10.10.0.1
s=SVC Receiver Driven
c=IN IP4 10.10.0.1
t=0 0
a=group:DDP L1 L2
m=video 20000 RTP/AVP 96
a=control:trackID=4
a=rtpmap:96 H264/90000
a=fmtp:96 profile-level-id=4d400a;
   packetization-mode=1;
   sprop-parameter-sets={sps0},{pps0};
   sprop-scalability-info={si0};
a=mid:L1
m=video 20002 RTP/AVP 97
a=control:trackID=5
a=rtpmap:97 H264-SVC/90000
a=fmtp:97 profile-level-id=53000c;
   packetization-mode=1;
   sprop-parameter-sets={sps1},{pps1};
   sprop-scalability-info={si1};
a=mid:L2
a=depend:97 lay L1:96
```

At the session level, the grouping type 'DDP' specifies the labels of the video tracks that have a decoding dependency. Labels are assigned to media identification attributes ('mid') at the media level. When a specific media can be decoded only when other media it depends on are available, the 'depend' attribute specifies this dependency (called layered dependency) listing the labels and payload type values of the required media. In the previous example, the first media section describes the base layer of an SVC video (AVC compliant). The second media section specifies an SVC enhancement that depends on the base layer.

The control attributes in the media sections specify the track identifiers that the client can use to setup independently each stream. Thus, a multi-interface scenario can be implemented using different client addresses (i.e., network interfaces) during the RTSP setup of each hint track. The receiver must inspect the complete SDP description of the file and infer the set of sessions that must be started to receive the best possible operation point, that is, the operation point nearer to the target operation point that can be obtained with the addition of one or more tracks. The scalability information obtained with the combination of the sprop-scalability-info parameters can be used in addition to the static context in order to calculate the target operation point. A receiver driven layered multicast scenario follows a similar procedure, but in this case the media level SDP contains the multicast address to which the receiver can subscribe in order to receive the corresponding SVC media.

VI. SCALNET SVC FILE FORMAT TOOL

During the SCALNET project [17], a file format tool implementing the features described above was developed. The *mp4creator* open source software was extended to support the creation of SVC media tracks, SVC extractor tracks and SVC hint tracks. In addition to this, modifications to Darwin Streaming Server and MPlayer were carried out to implement the sender and receiver driven adaptation scenarios, respectively. In the server side, these modifications included the implementation of an adaptation decision-taking engine to adapt the streaming sessions to the adequate operation point dynamically. An SVC filter was included in the Darwin Streaming Server to do fine-grained rate-shaping at the server side. Additionally, the filter was also employed in a MANE implemented as an RTSP proxy.

In comparison with other MP4 file creation tools, the SCALNET SVC file format tool includes the capability to create extractor tracks and dependency descriptions in the SDP metadata. Hint tracks permit to perform a coarse-grain off-line adaptation with a low overhead in the space occupied by the MP4 file. Without the availability of extractor tracks, the administrator of the streaming server has to create one media track for each offered operation point, and its corresponding hint track. To exemplify this, consider an SVC stream that occupies 69058031 bytes, with 1500 frames, two spatial layers with QCIF and CIF resolutions, five temporal layers, and three quality layers. The following list shows some of the values of each combination:

Layer	Resolution	Framerate	Bitrate	DTQ
0	176x144	1.5625	0.40	(0,0,0)
1	176x144	3.1250	8.30	(0,1,0)
2	176x144	6.2500	13.50	(0,2,0)
3	176x144	12.5000	17.40	(0,3,0)
4	176x144	25.0000	21.00	(0,4,0)
5	176x144	1.5625	61.10	(0,0,1)
6	176x144	3.1250	88.50	(0,1,1)
7	176x144	6.2500	103.00	(0,2,1)
8	176x144	12.5000	286.80	(0,3,1)
9	176x144	25.0000	551.20	(0,4,1)
10	176x144	1.5625	208.10	(0,0,2)
11	176x144	3.1250	318.70	(0,1,2)
12	176x144	6.2500	420.20	(0,2,2)
13	176x144	12.5000	1246.40	(0,3,2)
14	176x144	25.0000	2439.00	(0,4,2)
15	352x288	1.5625	317.20	(1,0,0)
16	352x288	3.1250	447.00	(1,1,0)
17	352x288	6.2500	558.10	(1,2,0)
18	352x288	12.5000	1570.40	(1,3,0)
19	352x288	25.0000	3090.00	(1,4,0)
...	...	...	...	...
29	352x288	25.0000	9206.00	(1,4,2)

Using the MP4Box tool with the following command:

```
MP4Box -add svcfile:svcmode=splitall mp4file
```

we create a media track per spatial and quality combination. This means six operation points, each one stored in a media track. Using the MP4Box -hint option we obtain the corresponding six hint tracks, one per media track. The result is a file with 73840255 bytes, representing a 6.2% overhead with respect to the original file.

Now we use the SCALNET SVC file format tool with one media track, and six extractor tracks and hint tracks, to provide the server with exactly the same offer of operation points. These are the commands used:

```
mp4creator -rate=25 svcfile mp4file
mp4creator -x=0,0,0-0,4,0 mp4file
mp4creator -x=0,0,0-0,4,1 mp4file
mp4creator -x=0,0,0-0,4,2 mp4file
mp4creator -x=0,0,0-1,4,0 mp4file
mp4creator -x=0,0,0-1,4,1 mp4file
mp4creator -x=0,0,0-1,4,2 mp4file
mp4creator -hint=2 mp4file
mp4creator -hint=3 mp4file
mp4creator -hint=4 mp4file
mp4creator -hint=5 mp4file
mp4creator -hint=6 mp4file
mp4creator -hint=7 mp4file
```

The first call creates a new mp4file starting with an SVC media track with the complete sequence at 25 frames per second. Each call to mp4creator with the -x option performs the creation of an extractor track with the range of layers specified. Take into account that the tool employs a DTQ triple instead of DQT. The subsequent calls with the

`-hint` option create a hint track for each extractor. The value indicated in this option specifies the track to hint. We obtain a file with 72953209 bytes, which represents a 5.6% overhead. The save in disk space depends on the characteristics of the SVC sequence, but such reduction can represent a big amount of space when the server provides an large collection of files.

In order to generate a file suitable for a receiver driven adaptation scenario, we can create extractors with :

```
mp4creator -x=0,0,0-0,4,0 mp4file
mp4creator -x=0,0,1-0,4,1 mp4file
mp4creator -x=0,0,2-0,4,2 mp4file
mp4creator -x=1,0,0-1,4,0 mp4file
mp4creator -x=1,0,1-1,4,1 mp4file
mp4creator -x=1,0,2-1,4,2 mp4file
# Hint tracks as in the previous example
mp4creator -R=6,8,9,10,11,12,13 mp4file
```

We have changed the extractor intervals and issued an extra command to create the DDP dependencies as explained above, where 6 is the number of hint tracks to be taken as source and 8, 9, 10, etc., are the hint tracks to be used to create the dependencies in the SDP description at the file level. The result is a file with 71135866 bytes, only a 3% overhead, which is lower than the sender driven adaptation approach as a consequence of the use of fewer pointers in the extractor tracks.

VII. CONCLUSIONS AND FUTURE WORK

This paper provides an overview of how to use the SVC file format to implement two types of adaptation, server and receiver driven, in scalable video streaming services. A SVC file format tool is presented, incorporating new features with respect to previous ones, and some results demonstrate the reduction in the amount of disk space overhead obtained with the use of extractor tracks. The usability of the tool was tested in a complete streaming architecture.

The SVC file format tool can be improved to include other adaptation aids proposed in the standard, including tiers and metadata statements. The intention of partners involved in the development of this tool is to offer it as open source software in order to support the research and dissemination of the SVC standard.

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idAnimate: A General-Purpose Animation Sketching Tool for Multi-Touch Devices

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Abstract— **Creating animations is a complex activity that often requires an expert, especially if results need to be obtained under time pressure. As animations are potentially relevant in many different contexts, it is interesting to allow more people to use them for communicating ideas about time-varying phenomena. Multi-touch devices create opportunities to redesign existing applications and user interfaces, and new classes of animation authoring tools that use gestural interaction have therefore started to appear. Most of them focus on specific applications, such as cartoon and puppet animation. In this paper, we present *idAnimate*, a low-fidelity general-purpose animation authoring system for sketching animations on multi-touch devices. With *idAnimate,* the user can intuitively manipulate objects with his fingers, while the system records the trajectories and transformations and uses them to build animations. Next to describing *idAnimate,* we also present a comparison study with an alternative state-of-the-art animation-sketching tool, called *K-Sketch*. The experimental results lead us to conclude that *idAnimate* is easier to understand and learn, and that it is significantly faster for certain types of scenarios, at the cost of a reduced precision and detail in the outcome.**

Keywords-Animation; Multi-Touch; Creativity-Support-Tools; User-Study; Design

I. INTRODUCTION

If a picture is worth a thousand words, then a movie is worth a thousand pictures. Compared to static images, animations and motion pictures more explicitly illustrate the course of actions and reactions that constitute an inherently dynamic situation. This can lead to improvements in communication and understanding [[3], especially when describing complex concepts that involve a chain of events [5]. As animations are of interest in a variety of contexts, from education to business, and can support both information transfer and artistic expression, it is worthwhile to explore how they can become more widespread.

Despite the potential interest, it turns out that non-expert animators hardly ever use animation-authoring tools. A number of animation tools exist today, the most popular one being Adobe Flash [4]. However, as argued more explicitly in the next section, for many contexts and users, such professional animation tools lack two important characteristics; (1) they are not easy to learn and use, and hence only adopted by expert animators who can afford the initial investment, and (2) they are insufficiently sketch-like,

requiring an effort and commitment to detail that is quite substantial and often not needed.

In an attempt to bridge this gap between existing tools and user requirements, a number of animation tools and techniques that feel more natural and intuitive in the hands of non-expert animators have been developed. Recent developments in input devices, in particular the increasing popularity of multi-touch interfaces, have opened up new opportunities to develop easier to learn and faster to use animation techniques, but there is as yet no consensus on what is the most effective approach.

In order to explore and test how animation tools could profit from the benefits that multi-touch interfaces have to offer, we have developed a specific animation tool, named *idAnimate,* for them. To better understand the consequences of the design trade-offs adopted in *idAnimate*, we have conducted a small experimental study to compare *idAnimate* with an existing state-of-the-art animation-sketching tool, called *K-Sketch*. This latter application was developed for tablet devices and hence does not incorporate multi-touch.

This paper first describes the related work and the *idAnimate* tool. The description of the tool includes the design goals and the main characteristics of the user interface and animation technique. The paper continues presenting the comparison study, which includes a brief description of *K-Sketch*. The paper subsequently presents and discusses the experimental results, and draws lessons for the future.

II. RELATED WORK

In 1969 Ronald M. Baecker presented Genesys [17], the first computerized animation system that recorded dynamic changes in the position, orientation and shape of visual objects as they were applied by the animator (usually with the help of a stylus). Since then, many systems have followed, introducing a variety of additional animation techniques. Using the flipbook metaphor, GIF animations grew popular during the 90's, partly because they could be easily distributed digitally. Adobe Flash and Director popularized the key-frame technique, in which the animator creates two frames and the system interpolates in between. Another important technique that is commonly used in video games and film production is procedural animation, where computer algorithms define the motion and position of visual objects over time [2]. However, while obviously very useful

in the hands of skilled animators, these tools do not explicitly address novice (or infrequent) users.

Some newer systems have focused on developing techniques that feel more natural and intuitive to non-experienced users. Two specific examples are: a) articulating 3D figure animations based on 2D figure sketches [9] and b) sketching the motion of a character [14]. While non-expert animators can use such tools, they offer interaction mechanisms that are tuned to a specific application, i.e., articulating the motion of a character, and are therefore not necessarily suitable for general-purpose animation.

More interesting in view of general-purpose animating is the motion-by-example technique described by Moscovich. This technique, in which the user can drag an object around the screen while the system records the location trajectory as a function of time, has been widely adopted in animation tools that target novice animators, such as *K-Sketch* [16], *Sketch-n-Stretch* [8], or *Sketchify* [19]. *Sketchify* (which was co-developed by the second author) is primarily intended for quickly creating prototypes with real-time input from a diversity of sensors, and therefore its interface is simply too sophisticated and complex for rapidly sketching animations. The tool *idAnimate* that we present in this paper shares similarities with *K-Sketch* and *Sketch-n-Stretch*, as it extends the motion-by-example technique, which tracks an object's position, to also include orientation and size. The extension to multi-touch devices (specifically, the iPad) can potentially speed up an animation process, as the user can transform multiple properties at a time instead of consecutively. An additional advantage of multi-touch devices is that multiple users can potentially cooperate on a single animation, although the full potential of this idea is only likely to emerge on multi-touch surfaces that are larger in size than the iPad that we used in the current case study.

Ceylant and Capin [6] developed a multi-touch interface for animating 3D Meshes that produced a sense of movement in objects by deforming and reshaping visual objects through the fingers, which is similar to the multi-touch technique by Takayama and Irigarashi [11] for manipulating the shapes of 2D characters. While both techniques share some features with our own prototype, mostly due to the common use of a multi-touch interface, they are mainly intended for character animation, and are hence fairly specialized. To the best of our knowledge, the most similar existing tools to *idAnimate* are *Toontastic [1]* and *Photopuppet HD* [15], which use multi-touch gestures for creating animations. The latter tool is mostly intended for cartoon animation in a professional studio, as it offers many sophisticated and dedicated features, while *Toontastic* has a very specific application domain, i.e., storytelling for children.

III. IDANIMATE

A. Overview

The primary goal of *idAnimate* is to allow users to rapidly author simple but expressive animations. The concept of *idAnimate* was inspired by a series of studies that were carried out within the design teams of diverse companies. These studies aimed more generally at collecting requirements for tools and methods that can support design communication [7, 10]. The need to author dynamic visualizations in a sketch-like way emerged quite naturally in this context study.

As the aim was to create a tool that could support creativity, discovery and innovation, we drew inspiration from the design guidelines proposed by Shneiderman [20] and Resnicks [21], to assist us in mapping the general objective of sketch-like animations into more specific design goals that can potentially also be verified in subsequent observational studies.

B. Design Goals

1) Low Threshold

In order to make the process of creating animations easily accessible to non-experienced animators, the threshold for using the tool should be extremely low. This means that novice users, including those using the tool for the first time, should be able to create simple animations with no or minimal instruction.

2) Speed

The tool should allow users to rapidly create animations. Ideally, the cost of creating an animation should be similar to that of creating static sketches, so that they can just as easily be discarded and replaced by alternatives.

3) Support Exploration

The tool should allow users to try out different alternatives and examples, and should make it easy to roll back to past situations.

4) Flexibility and wide walls

The tool should not limit its users to a predefined set of patterns or prescribed scenarios. The tool should ideally allow the majority of users to describe most ideas that they can think of, within the reasonable boundaries of what animations can describe.

5) Simplicity

Besides having a low threshold, the tool should feel simple and intuitive to use after a prolonged period of time. Instead of providing an extensive set of highly configurable features, the tool should provide only those that are strictly necessary to achieve the desired flexible outcome.

C. Tool design

The aforementioned design goals led us to select tablet devices as the platform for the prototype, mainly due to their form factor, portability, and the affordances that such multi-touch devices provide.

Multi-touch interaction paradigms such as resizing and rotating make it possible to extend the existing motion-by-example method [18] to the more general transformation-by-example method that is at the heart of *idAnimate*. This latter technique essentially allows users to freely manipulate objects using a multi-touch surface while recording the changes in position, size and orientation over time.

Commonly accepted multi-touch gestures are generally perceived as highly intuitive thanks to the direct manipulation of objects through the tip of the fingers, which effectively maps the finger movements to the geometric parameters that are being controlled by the system.

Since our technique complies with common practice, it should be perceived as easy to learn and easy to use. As stated before, next to being engaging and inviting, multi-touch gestures are potentially faster, as three different transformations can be applied simultaneously.

The projects produced with the tool are called Animated Sketches. An Animated Sketch consists of a group of visual elements (objects) and their associated transformations (position, orientation, size) over time. It is possible to import visual elements from different sources into the application, including attachments in emails, images resulting from internet searches (Bing, Google or Flickr images), photographs taken with the built-in camera (if the device has one), or images already available in the users library. The tool also includes a simple sketching application that can be used to create new visual objects, or to modify existing ones.

Figure 1 shows a screenshot of the animation editor. Mark 1 shows the list of objects that are contained in the current animation. By modifying the order of objects in the list, they move in front or behind each other. Mark 2 shows the controls for adding a new object, editing the images associated with an object, duplicating, inspecting, deleting or clearing the animations of the selected object. Mark 3 shows the animation controls including the timeline and the play, pause, record and rewind buttons. Mark 4 shows the canvas where the objects are displayed and where the user interacts to define the animations. Mark 5 shows the inspector, which allows users: 1) to change between the different images that an object can display, 2) to manage the geometrical properties of an object that can be transformed, and 3) to specify when an object is visible or invisible.

D. The animation technique

Animated Sketches are composed of one or more visual elements called Animated Objects. An Animated Object is a region of varying position, size and orientation that can at any instance display one of a set of possible images, where most often the image reflects the state of the object concerned. This way an object can be moved, rotated and scaled while its visual appearance (image) changes.

1) Transforming through gestures

Multi-touch gestures are the key to intuitively defining the transformations on Animated Objects. In order to animate an object, the user has to select it from the list of available objects in a scene. Using two fingers, a user can translate, rotate and scale simultaneously the selected object in a single action. While recording, all of the transformations performed on the device are registered and time-stamped relatively to the animation start time. When the user initiates the record action, a three second countdown is displayed to give him time to prepare the position of the fingers.

In order to provide control over small objects, despite the limited size of the tablet display (9.7 inches in diagonal), the user does not necessarily need to touch the actual object, but instead he can interact anywhere on the device. This way the user can also avoid blocking his view on the selected object. However, the consequence of this design choice is that it is currently not possible to animate two or more objects simultaneously, which is something that will probably need to be reconsidered when migrating to large-sized multi-touch displays that are operated by several users at a time.

2) Synchronization and Concatenation

Complex animations are accomplished by adding new object transformations to existing animations, effectively concatenating transformations. In order to coordinate the animations of different objects, we use the record-while-playback technique. The user can replay a previously created animation, and meanwhile new transformations can be applied on other objects. These additional transformations are recorded, time-stamped and synchronized with the existing animation.
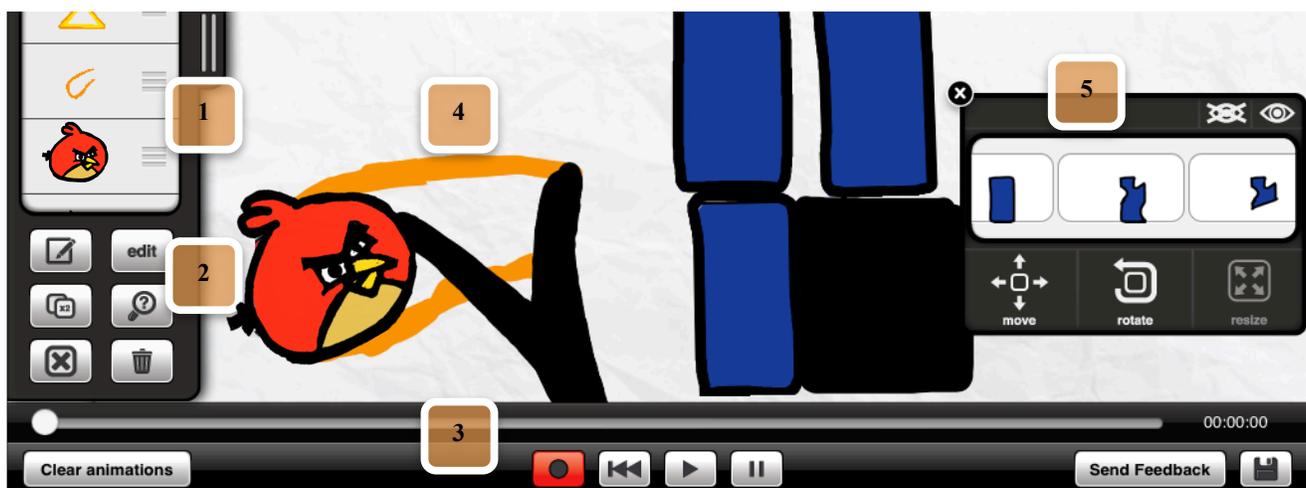

Figure 1. *idAnimate* being used to animate a game concept (Angry Birds). Mark 1 shows the list of objects, mark 2 shows the possible actions on an object, Mark 3 the record and playback controls, mark 4 the canvas and Mark 5 the object inspector.

If a user animates an object that was already animated previously, all existing object transformations, from the moment that he starts to interact, are overwritten. Therefore the user can easily and intuitively refine or redo part of the animation of an object without compromising earlier parts.

3) States

The user can dynamically change the image associated with a visual object. In order to change states, the animation can be replayed, and during the playback, the user can select the desired state from a menu, and consequently the image to be displayed. The changes in the state are recorded and time-stamped with the rest of the animation. An alternative way is to change the states not while recording, but while the animation is stopped, which allows for more time and precision. Specifically, users can navigate to a particular point on the timeline and select the desired state at that time.

Switching states allows to change the visual appearance of a region, for instance changing the color of a light from red to green, the text displayed on a screen, or the different expressions of a character. Flipbook animations can easily be constructed in this way.

E. Implementation

A software prototype of *idAnimate* has been implemented for *iPad* multi-touch devices, using the Objective-C programming language and the Cocoa Touch Framework.

IV.   COMPARISON STUDY

In order to increase our understanding of the trade-offs incorporated in the aforementioned animation system, we have conducted a comparison study between *idAnimate* and *K-Sketch*, a state-of-the-art general-purpose animation-sketching tool that relies on a similar technique (motion-by-example), but that does not require or use multi-touch.
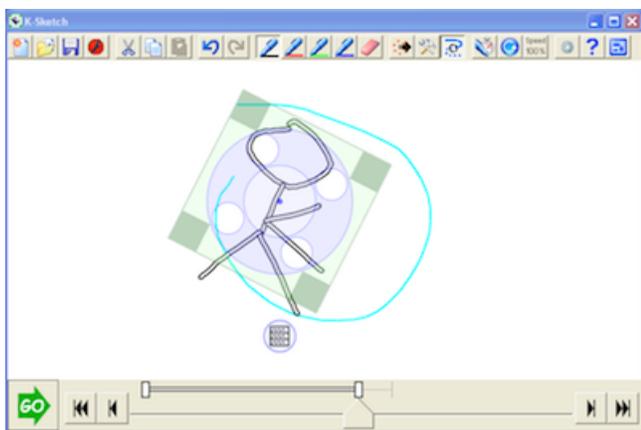

Figure 2.The *K-Sketch* animation tool, showing a selected figure together with its manipulator. The different tools are at the top, while the animation and playback controls are at the bottom.

Figure 3. The *idAnimate* animation tool, with the object selector displayed on the left, the object inspector on the right, the canvas in the center and the animation and playback controls at the bottom.

A. MATERIALS AND METHODS

B. The Tools

1) idAnimate

Please refer to the *idAnimate* section of this paper for more details, as well as figures 1 and 3 for the interface.

2) K-Sketch

K-Sketch (see Figure 2) is a general-purpose animation-authoring tool for Windows computers that is intended to be used with a keyboard and mouse or stylus. *K-Sketch* starts with an empty canvas where objects can be drawn. Objects are selected by drawing a loop around them while holding down the Alt key. When an object is selected, a manipulator (see figure 2) is displayed on top of it.

The manipulator allows users to apply distinct transformations on the object, such as translation, scaling, rotation or skewing, or to modify the orientation of the object relative to the movement direction. The manipulator can be repositioned on the object, effectively changing the center of rotation. To record, the user has to hold down the Alt key while transforming one of the above properties, and the system records the changes over time. *K-Sketch* also supports flipbook animation. At any moment in time the user can erase or draw something new, or decide to show or hide an object.

To record simultaneous motions of two or more objects, the user has to rewind and record new motions while the existing ones are playing. The user can add various transformations to a single object, such as a translation and rotation (like a spinning ball). In order to accomplish this, he has to first record the translation, rewind and subsequently record the rotation. By default the system overwrites the old motion with the new one. Alternatively, the user can select the "Fix Last Motion". This option shows a menu with the different alternatives for combining the existing motion with the new one. For example, if we first translate and then rotate an object, *K-Sketch* will show three different ways to combine them: (1) overwrite, (2) translate
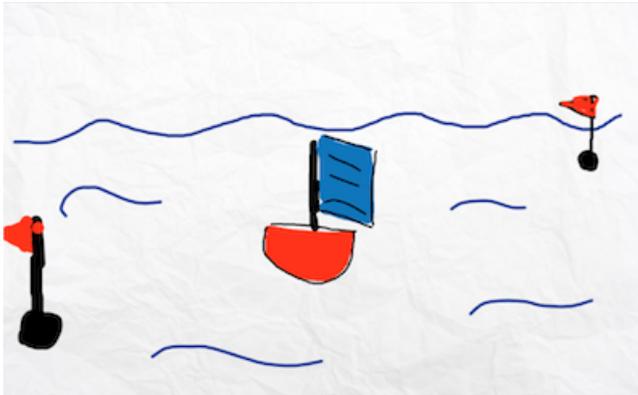
Figure 4. Scene for the sailing boat animation task.

and rotate around the center of the object, or (3) translate and rotate around the initial center. The user can preview all three options and make a choice. Last but not least, *K-sketch* supports recursion or animating of subparts (called Move Relative). To accomplish this, the user needs to select a subpart of an object that is already animated, and animate it with its independent handler. Unlike other features, this latter one is not available in *idAnimate.*

C. Study Approach

Two representative animation tasks were selected (see more details ahead) to allow for an explicit comparison. Each participant was asked to perform both tasks with both tools, randomizing the order across participants of which tool to use first. Before using each tool, participants were given a brief tutorial. The tutorials followed a script that was based on a slightly extended version of the car-exploding example [12] in the demonstration videos of K-Sketch. During the tutorial, participants were allowed to ask clarifying questions to the experimenter.

After the brief tutorial, the participants were shown a static image of the scene to create, and were explained verbally the script and details of the animation. The choice to use a static image instead of an actual animation was motivated by our objective to direct participants towards a specific outcome, while allowing them freedom to decide what exactly to create and which features to use.

The participants were given a tool with a blank canvas, and were asked to sketch the visual objects and animate them. They were encouraged to not spend time on creating good-looking and detailed graphics, but to create sketchy looking ones instead. Once a participant had finished completing both tasks with one of the tools, he or she would be given the brief tutorial on the second tool, and would be asked to repeat the same tasks but with this second tool.

D. Surveys and Interview

After completing the tasks with one of the tools the participants were asked to fill out a slightly modified Usability Satisfaction Questionnaire [13] (see more details in the results section). Upon having completed both tasks with both tools, participants were asked to complete a final survey. In this third survey, they were asked to directly compare the two animation techniques by specifying their preference (for various aspects of the techniques) on a scale from -3 (*idAnimate*) to +3 (*K-Sketch*), including 0 as the neutral or no preference. The aspects on which to compare included intuitiveness and playfulness (see the Results section for more details).

A five to fifteen minute semi-structured interview concluded the experiment. Subjects were asked to characterize the differences between the two tools, starting from the attributes used in the comparison survey.

Up to now, the quality of the animations that were produced has not yet been explicitly graded by either the participants themselves or an external reviewer. We are still considering whether or not this is worthwhile doing. Instead, within the comparison survey and post-session interview, participants were asked to argue why they would choose one or the other tool to create better quality animations, or to create them in less time.

E. Data collection

The participants were video-taped during the execution of the tasks, their responses to the questionnaires were collected on paper, and the semi-structured interviews were audio-recorded. As the focus of the study was on comparing both animation techniques, the participants were encouraged to answer mostly in terms of the animation techniques themselves and less in terms of the user interfaces of the tools (which were obviously different).

F. Subjects

Twelve subjects participated in the study, 4 female and 8 male. The age of the subjects ranged from 21 to 34 years. Six participants were PhD students, one an assistant technician in an immunology laboratory, while the rest were bachelor, master or recently graduated students. Table I provides detailed background information on the participants. None of the participants were expert animators, nor did they create animations on a regular basis. Two of the participants with a background in industrial design had minimal experience with Adobe Flash, while one had used Adobe After Effects (video special effects software) once. One of the Computer Scientists had created stop-motion animations in the past, while another had used Flash occasionally.

TABLE I. PARTICIPANTS

Background	Current Position	Participant count
Computer Science	PhD Candidate (3), Postmaster Student (1), Bachelors Student (1)	5
Bio molecular Sciences	Laboratory technician (1)	1
Pharmacy	PhD Candidate (1)	1
Industrial Design	PhD Candidate (1), Bachelors Student (1), Masters Student (1), Recent Masters Graduate (1)	4
Mechanical Engineering	PhD Candidate	1

G. The tasks

Unlike in other fields of research, there is no agreement or standardization in the domain of animations on what constitutes a representative task for comparing animation techniques or systems. For the purpose of the study we looked at common tasks as identified in the preliminary studies conducted by Davis et al. for K-Sketch (specifically, Translate, Scale, Rotate, Set Timing, and Move Relative), and selected two representative tasks.

1) Task 1 – Angry Birds Game

The scene is composed of three objects, an angry bird, and two rocks or blocks. The bird has to fly towards the first block and hit it. As a result of the collision, the bird flies away modifying its original trajectory, and the first block falls down. While falling down, the falling block hits the second block, which in turn falls down, like a falling domino. See figure 1 for more details.

2) Task 2 – Sailing boat

There is a boat on the sea that has to travel from point A to point B. Point A is in the bottom-left corner, close to the observer. Point B is in the top-right corner of the screen, closer to the horizon. The boat has to travel from point A to point B. Because point B is further away, the boat has to become smaller as it progresses along the path. Since it is a boat floating on water, the boat has to rock slightly as it moves. Finally, the flag on the boat has to wave. See figure 4 for more details.

H. Devices

K-Sketch runs on Windows and *idAnimate* on an iPad. To compare both tools in the most similar way possible, we used a Fujitsu-Siemens Stylistic ST-6012 Tablet PC equipped with a stylus for *K-Sketch*. The Tablet PC had buttons around the display, one of which was mapped to the Alt key, since *K-Sketch* requires frequent use of this key. For *idAnimate,* an iPad 2 was used.

V. RESULTS

A. Task Analysis

1) Data Analysis

The time spent by each participant in each of the tasks was divided into the time used for drawing graphics and the time actually used for animating, both measured in seconds. For the purpose of the study only the time used for animating was considered. As the distributions of the observed times were clearly skewed, we used the logarithm of the observed times in the statistical analyses, as they more closely followed a normal distribution, which is required by traditional statistical procedures such as the t-test. Although the original intention was to include measurements of error rates, we found this too difficult to operationalize, as it was too hard to decide on what constituted an error and what did not. It was not straightforward to determine if a user was correcting an error, refining an animation, or just playing
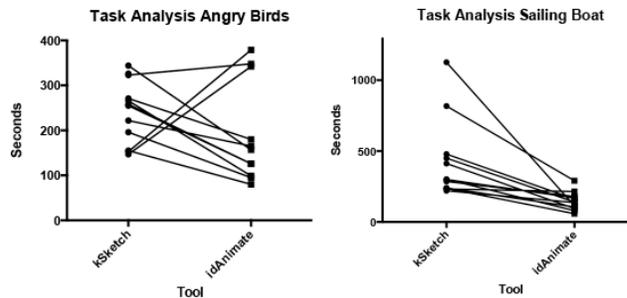

Figure 5. Observed times for the Angry Birds and Sailing Boat tasks

around. Asking them explicitly would obviously have disturbed their process.

2) Task 1 – Angry Birds

All of the participants were able to complete the Angry Bird task with both tools. Table II and Figure 5 show that the animation times were very similar on average. Some subjects performed faster with *idAnimate* than with *K-Sketch*, while for other subjects it was just the other way around. The participants obviously did not perform as a homogeneous group.

TABLE II. TIMING STATISTICS FOR THE ANGRY BIRDS TASK.

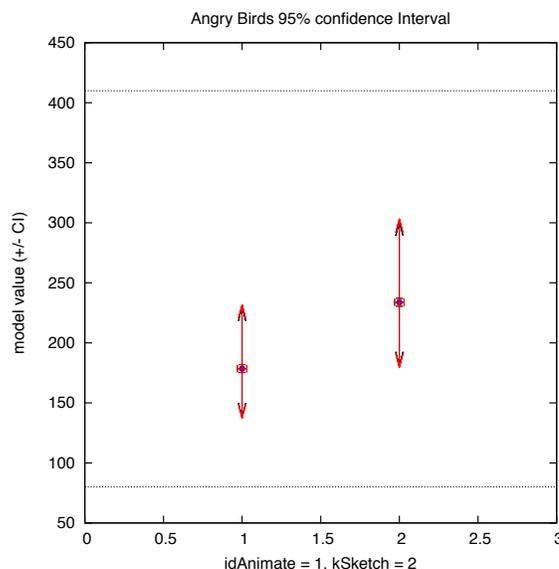| Tool	Min/Max	Std. dev.	Mean	Std. Error of the Mean
K-Sketch	147/344	69.335	243.0	20.015
idAnimate	80/410	123.327	208.916	35.601

Figure 6. Overlapping 95% confidence intervals for the time to complete the Angry Bird task for both tools.

TABLE III. T-TESTS FOR THE RESULTS OF THE COMPARISON SURVEY

Aspect	Mean Difference	Significance	95% confidence interval (min/max)
User Satisfaction	-1.25	0.009 (Yes)	-2.112/-.387
Pleasant Experience	-1.33	0.020 (Yes)	-2.067/-.599
Easiness	-1.750	0.000 (Yes)	-2.522/-.9778
Intuitiveness	-1.916	0.000 (Yes)	-2.704/-1.128
Playfulness	-2.000	0.000 (Yes)	-2.605/-1.394
Animate Rapidly	-1.666	0.009 (Yes)	-2.826/-0.506
Animate Precisely	0.667	0.255 (No)	-.555/1.888

Assuming unequal variance and performing a T-test, we obtained: $T(21) = 1.4108$ (p=0.171326). There is hence insufficient evidence to reject the null hypothesis that both tools require the same time to complete the task. Figure 6 shows the estimated 95% confidence intervals for the untransformed average times. Note that the intervals are not symmetric since they were determined on the logarithm of the time, and then reverted to actual seconds. We observe that both intervals overlap, which agrees with the fact that the difference in average performance is not significant.

3) Task 2 – Boat Animation

All participants were able to complete the boat animation with both tools, except for one participant who after trying a number of times to merge two motions with *K-Sketch*, needed help from the experimenter to do so. Table IV shows the descriptive statistics, while the individual times are plotted in Figure 5. Figure 9 displays the 95% confidence intervals for the average times, while Figure 8 shows the 95% confidence interval for the time difference**.** We observe that the average times are considerably different in this case, being smaller for the multi-touch tool. Assuming unequal variance we performed a T-test on the transformed times with the following result: $T(21) = 5.1248$ (p=3.89654e-05), with $|T| > 2.0748$ (p=0.05), indicating a significant difference. Because of the size of the effect, and the agreement between the subjects, the power of the test was estimated at $\beta = 0.999$, despite the small number of participants. The multi-touch tool is significantly faster for this task. After reverting the time back to seconds, we find a 95% confidence interval for the time difference between 116.5 until 404.9 seconds (see Figure 8).

TABLE IV.   TIMING STATISTICS FOR THE BOAT TASK.

Tool	Min/Max	Std. dev.	Mean	Std.Error of the Mean
K-Sketch	220/11260	227.703	425.250	80.166
idAnimate	59/291	63.981	145.833	18.469

TABLE V. WILCOXON SIGNED RANK TEST RESULTS FOR THE SUS QUESTIONNAIRE.

Dimension	Significance	Positive / Negative / Ties.	Standardized test statistic
Overall Easiness Satisfaction	0.046 (Yes)	1/9/2	-1.996
Intuitiveness	0.043 (Yes)	2/8/2	-2.019
Learnability	0.070 (No)	2/8/2	-1.813
Playfulness	0.007 (Yes)	0/9/3	-2.687
Comfortable	0.088 (No)	2/5/5	-1.709
Simplicity	0.117 (No)	1/7/4	-1.567
Pleasantness of the interface	0.026 (Yes)	1/9/2	-2.228
Recover from Mistakes	0.454 (No)	6/3//3	.749
Efficiency	0.796 (No)	3/4/4	.258

B. Analysis of Subjective Ratings

1) Standard Usability Questionnaire

Figure 10 shows a summary of the results of the modified Usability Satisfaction Questionnaire, including the mean, the standard error of the mean, and the questions asked.
We performed non-parametric repeated measures Wilcoxon Signed Rank Tests on the observed ratings in order to identify significant differences (see Table V). We observe that users have a preference for the multi-touch technique in terms of Intuitiveness, Overall Easiness, Satisfaction, Playfulness, and Pleasantness of the interface. There are some trends mentioned in Table V that cannot be decisively concluded based on our limited experiment, more specifically, *idAnimate* tends to be preferred in terms of Comfort and Learnability, while *K-sketch* tends to be preferred in terms of Efficiency and Recovery from Mistakes. The observed differences for the subjective attributes that are not included in the table were not significant.

2) Comparison Questionnaire

The comparison questionnaire asked users to indicate for a number of aspects which tool they preferred. If they selected -3 that would mean they had a strong preference for *idAnimate* for such an aspect, while +3 would imply a similar preference for K-Sketch. The 0 was included as neutral or no particular preference for any of the tools. As shown in Figure 7, *idAnimate* was preferred over *K-Sketch* on all attributes except one, i.e., Precision. All participants but one would use the multi-touch technique to animate something rapidly, but when judging precision there was no clear agreement. Eight out of the twelve users would select *K-Sketch* for animating something with precision, two would

select *idAnimate*, and two did not have a preference. See Figure 7 and Table III for additional details.

VI.   DISCUSSION

A.   Speed versus Accuracy

The quantitative data allows to conclude that the multi-touch technique (*idAnimate)* is significantly faster then K-Sketch in case of the Boat animation, but not in case of the Angry Birds animation. This is due to the fact that the latter task mainly required users to synchronize the animations of different objects, while the required animations for each object individually were rather basic In most cases, users only moved the bird, and barely changed it's orientation as it flew through the air. Most subjects used only a single rotation of the boxes to make them fall down. Therefore, this task did not reveal differences in performance between both animation techniques. The observed differences in animation times can be attributed largely to the differences in user interfaces, and to how easily objects could be selected.

The sailing boat task, on the other hand, discriminated very well been the two tools. In this task at least three parameters of the boat had to be animated, including the location, the orientation and the size. In this task participants performed significantly faster with the multi-touch animation tool. This was due to the fact that it was possible to animate these three parameters simultaneously, as opposed to having to change these parameters individually and in succession. This task posed different challenges for both techniques.

With the multi-touch tool users had to act out a complex movement with one hand, and they would not always get it right the first time. In fact they would normally perform an initial attempt just to see how it looked, and then refine it on a second or third attempt. Using a single hand to move, scale and rotate an object simultaneously in a controlled way is quite difficult, and very often the accuracy suffered, which had an evident influence on the quality of the output. This was described in the following way by one of the participants during the interview:

"*It's definitely a downside of the iPad app, you have to do everything in one go… …three things at a time can be quite challenging.*"

"*With idAnimate you can do it more fluently, but you have to practice your movements… … to act out something with your fingers is something new and you have to get used to it*".

"*idAnimate felt more easy to drag things, especially to make the boat. The multi-touch was easier even though it didn't create the exact result that I wanted because it was less precise*"

Despite this drawback, the technique proved to be sufficiently accurate for "quick and dirty" animations.

Participants were slower with *K-Sketch* but in general more accurate. There are two factors that influence this tradeoff. First, the stylus is simply more accurate than the finger, as the finger gets in the way, is thicker, and essentially provides less fine control, both for sketching and for animating. But also the animation technique itself had an effect. With K-Sketch the user animates each property
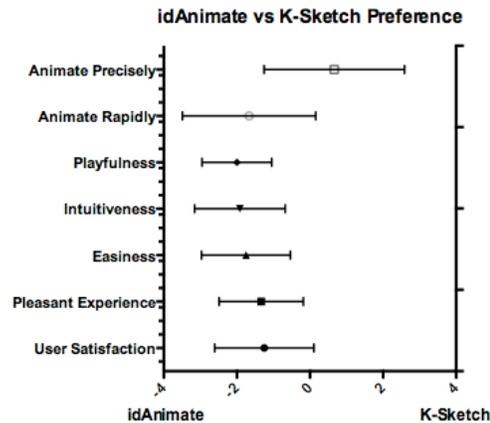

Figure 7. Results from the comparison questionnaire between *idAnimate* (on the negative side) and *K-sketch* (on the positive side) (mean and standard error of the mean).

successively, building the animations step by step. Consequently, the user has more precise control over each of the independent gestures.

"*The quality was certainly higher with the second application (K-Sketch), because of the pen especially, and because of the complexity of the movements*"

"*With K-Sketch you have all the gestures, like the resize, the scale or the rotation separately, and you can control them also independently, and that also gives you a little bit more control*"

"*Your expressive power with K-Sketch is finer. You can combine the movements better, you can make more movements at a time, and be more precise, but especially because you can do it step-by-step*".

But this can also backfire. When animating a particular property, it was not possible to observe the animation of the previous property, implying that users had to act blindly. To assist in such a task, *K-Sketch* displays the trajectory of the previous motion path that gets filled up as the time goes by, showing the time-varying position of the object. This was often found hard to interpret. Additionally, when a user had completed the animation of a particular property, he had to
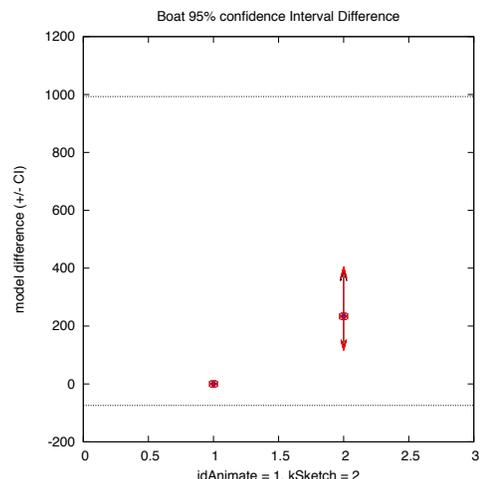

Figure 8. Sailing boat task 95% confidence intervals difference.

merge it with the previous one by selecting an option from a number of alternatives, for example with different centers of rotation. Users often felt unsure of which option matched their expectations best. As more and more motion paths and transformations were applied, the process became more and more difficult to predict. This was found overwhelming to some novices, especially those without a design-related background. Furthermore, in some cases the expected choice was not even there, and participants had to undo and try again because they could not figure out what went wrong.

"*The frustrating part of K-Sketch is that when you want to combine animations, the more you make the more scenarios you get, and that is a bit confusing*"

K-Sketch also offers the possibility to animate a subpart of an animation. This feature was found really useful, and most participants used it to animate the flag on the boat. With *idAnimate* most participants used the flipbook technique instead of animating the flag as an independent object. However, sub-animating with *K-Sketch* was sometimes also found confusing, due to the fact that the larger animation moves continuously as you animate the subpart, and you do not follow it with the stylus, but instead remain in the same place as where you begun animation as if the object was not actually moving.

"*With the pen there is a moment that you are animating and the object continues moving and this is a little bit chaotic.*"

B. Intuitiveness and Playfulness

Certainly, animation-sketching tools are all about making animations quickly, and about minimizing the trade-off between quality and speed. The threshold for embarking on the task and the simplicity to achieve it, how funny and engaging the overall experience is, are also important. This can be particularly influential in certain contexts, such as using animations to facilitate workshops or brainstorms, and for certain users such as children, seniors, or non-animators in general.

Participants found the multi-touch technique to be significantly more intuitive and easy to use. This was
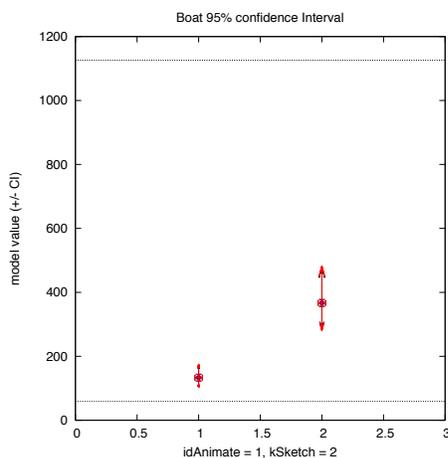
because the underlying conceptual model was easy to understand and very direct, a result of the mapping between the multi-touch gestures and the properties of the objects. Such mapping resembles object manipulation in the physical world. By manipulating objects with the hands directly, users are able to very easily prepare a plan of actions to achieve a desired result.

"*With the multi-touch tool you make the entire movement, it's easier, as you do not have to think, you just let yourself go*".

Furthermore, the multi-touch tool was significantly more playful and more fun. In fact, it was so playful, that three out of the twelve participants created additional content in the animations, such as flying birds around the boat, or making the floating buoy move as if it was actually floating.

"*I animated the floating buoy with idAnimate because it was attractive, it was like a game, it facilitated the act.*"

"*idAnimate felt easier, more fun, more like a game. You can start to do silly things with your own fingers, while the other one feels more professional*".

We believe that this perception of playfulness was due to the combination of how tactile and physical the multi-touch interface feels, together with the simplicity of the technique, its immediate feedback and the attractive graphical design of the tool.

In the case of *K-Sketch, u*sers had to decompose their actions into a series of steps that the system supported in order to carry out their goal. They had to think ahead which motion path they were going to apply, which transformation would follow, how they would be combined, etc. This required more cognitive effort, and relied on a good understanding of the underlying conceptual model. This model was difficult to understand and operate by some users.

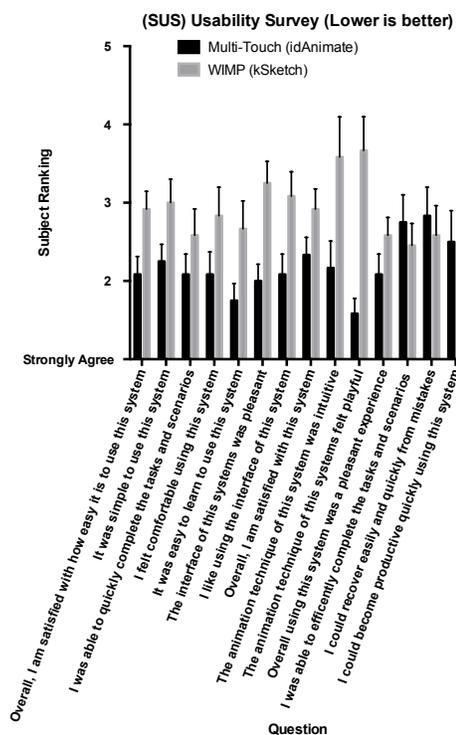"*The interaction style of K-Sketch was more complex,*

Figure 9. Non-overlapping 95% confidence intervals for the time to complete the Sailing boat task with both tools

Figure 10. SUS results, mean and SEM.

less direct or so… …I had to think more often with it."

However, for experienced users this may actually be an advantage. If you are able to plan the actions based on this decoupling of transformations, the technique provides more control.

C. Different contexts

In summary, we argue that the preference for either tool depends on the context. *idAnimate* is most suited in case animations must be created and discarded quickly, if the details are not important, and has the potential to be extended to a situation where multiple people work simultaneously on a single animation. *K-Sketch* is better suited for individual activities, where the level of detail and control required is more substantial (although still significantly below that required of professional animation tools). Both techniques can support novice users with minimal instruction, although *idAnimate* appears to have a lower threshold since its underlying conceptual model is easier to understand.

"I would pick the second one (K-Sketch) if I had to make an application for a corporate setting or something like that… …For a brainstorm the iPad application is more convenient. You just draw it and move it."

VII. CONCLUSION AND FUTURE WORK

In this paper, we have presented a general-purpose animation-sketching system for multi-touch devices, called *idAnimate.* We have presented a comparison study aimed at increasing our understanding on what trade-offs and differences this multi-touch animating system poses when compared to system that does not rely on multi-touch. The experiment supports the conclusion that the multi-touch animation-sketching system (*idAnimate)* is perceived as significantly more intuitive, playful and easier to learn. Additionally, we have observed that *idAnimate* may be significantly faster in cases where the user has to apply multiple simultaneous transformations on objects, and that in comparison to K-*Sketch* it generates animations with lower precision.

These results and observations are being used to guide the next iteration of the tool. From the study we have learned that it is really difficult to isolate specific aspects of the tool in order to benchmark the technique, which has lead us into using for the follow up study a longitudinal approach, focused more on qualitative aspects of the experience.

VIII. ACKNOWLEDGEMENTS

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