Improving Large Image Viewing in the Crisis Management System SécuRéVi

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***Abstract*— This paper deals with the processing and integration of images in SécuRéVi platform, a crisis management system, with an emphasis on large images whose handling leads to specific difficulties. Indeed, in the domain of crisis management, images are key elements for understanding and taking proper decisions. Images of different nature (map, aerial view, 360 ° view, etc.) are helpful and adequate solutions that need to be provided in case of sinister. After describing the SécuRéVi platform, we shortly present its images processing approach and establish some design constraints and criteria for the development of a large image viewer. Then, we present our proposal for improving large image handling and its implementation in the SécuRéVi platform. The paper ends by conclusion and future works.**

Keywords-crisis management; image processing; large image; image segmentation

I. INTRODUCTION

Crisis management requires a good understanding of the sinister environment for adopting necessary attitudes for the resolution of incidents. Different prevention measures are provided for this purpose, such as emergency planning.

The SécuRéVi [1] platform is inscribed in this process. It is based on the Global Safety Plan (GSP), which is a knowledge base aimed at gathering all the information needed by preventive approaches dedicated to crisis management. The understanding of a situation is a major challenge for crisis resolution and images are key elements for such understanding (like in geospatial imagery, scientific visualization or immersive application [2]). It is therefore important for a crisis management tool, to provide adequate solutions for images handling. In the context of crisis management, images can come from various sources (such as satellite [3], camera [4] or industrial plan) and are incorporated before or during crisis management. They are extracted from camera shots or shots assembling [5]. The size of the used images goes from tens to hundreds of millions of pixels. The image generation systems offer increasingly higher resolutions, but often, visualization tools do not allow their full restitution because the screen resolution is most often lower than that of camera sensors. Given the large size of images generated, the use of conventional tools quickly becomes problematic and they can't be used by any type of computer [6]. Therefore, we decided to develop a tool allowing a better use of these images.

We start by describing the SécuRéVi Platform (section 2). Then, we show the importance of images for crisis management and explain their handling in the SécuRéVi platform (section 3). Thereafter, we present our proposal for image processing and precise the key elements for a successful implementation (section 4). Afterwards, we describe the implementation of this process and its evolution to obtain better performance (section 5). Finally, we conclude and propose some lines of thought for future works (section 6).

II. SÉCURÉVI PLATFORM

The SécuRéVi Platform [7] is a platform dedicated to communication and understanding, as well as decision making and the workmanship (see Figure. 1). It allows different actors from various professions to communicate and collaborate for a crisis resolution. It is based on the GSP integrated into a Geographic Information System (GIS), as well as various sources of external data (measurement tools, camera, business oriented computer tools, etc.).

The whole interacts with a monitoring and events forecasting system (accident, incident, etc.) with commitment of resources (staff and equipment) in which each object, event or staff, can index data (e.g., description sheet, procedure, user manual, etc.) .

SécuRéVi allows an approach in both space and time. It provides real time monitoring which makes it possible to create recording for replays that will feed the "lessons learned" database associated (feedback). Finally, in the platform, a 2D world can be associated with a 3D world, and this makes it possible to go from the virtual world to the real world and inversely.

SécuRéVi works with a standard computer which can be enriched with other tools (video projector, interactive whiteboard, etc.).

Figure 1. The SécuRéVi platform (crisis management system).

It is used during crisis management operations, during which the in-situ data and GSP allow a better understanding of the context. Any intervention concludes with a feedback that can enrich the knowledge base for future operations. Training will take advantage of the platform which makes it possible to use virtual information while maintaining realistic working framework.

The initial concepts and methodologies of the SécuRéVi platform were developed at the Research and Development Expertise Service (Direction Expertise Recherche et Développement, DERD) of the Departmental Office of Fire and Rescue of Finistère (Service Départemental d'Incendie et de Secours du Finistère, SDIS29) by Colonel Hervé Mahoudo and engineer Gilles Cloarec of SDIS29, and engineer Olivier Danjean, head of the company INOVADYS.

This platform is used by Colonel Hervé Mahoudo and Gilles Cloarec for courses offered at the National School of Firefighters Officers (ENSOSP, Ministry of Interior), in the following areas:

- Classified Installations for the Protection of the Environment
- Chemical hazards (internships RCH4)
- Emergency Planning [8],
- Crisis management.

The platform and the concepts it includes are also the subject of education provided by Colonel Hervé Mahoudo and Gilles Cloarec, during courses at the University of Western Brittany (UBO), at the University of South Brittany (UBS), at the University of Bordeaux (in the QHSE field) and at the University of Rennes 2 (in master of GIS).

On-site implementation consists in achieving the institution's GSP, installing tools for management, monitoring and forecasting of situations and deploying hardware interfaces.

SécuRéVi constitutes a multidisciplinary and multiservice digital knowledge database for daily operations, training, intervention and communication. It is usable by the rescue operations commandant, the leader of internal operations, site safety manager, trainers and all other internal persons authorized by the company.

In the next part, we show the importance of images for crisis management and explain their handling in the SécuRéVi platform.

III. IMPORTANCE OF IMAGES IN CRISIS MANAGEMENT AND THEIR HANDLING IN SÉCURÉVI PLATFORM

The decision making in crisis management needs different types and amount of information depending on the complexity of the situation. Usually, a rapid-mapping is the first task needed to understand the overall situation. More the

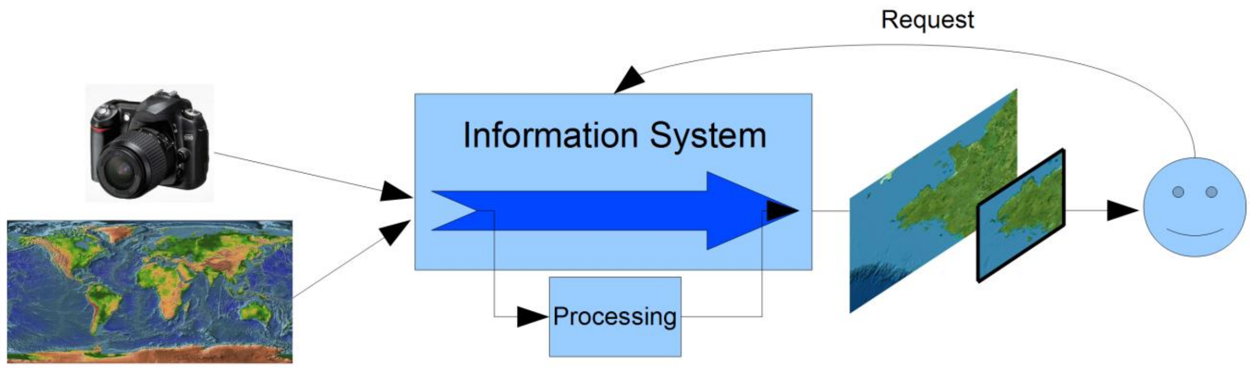

Figure 2. From integration to viewing.

decision process progresses, more the need of detailed information is important.

Images are certainly the most appropriate media for these tasks. For example, satellite images can provide a rapid and overall comprehension of a site, plans allow to see the structure of the building and 360° view help to understand the reality of a room including its content. The use of high definition images improves these tasks.

Therefore, the SécuRéVi platform allows intensive use of visual representations as images: 8 large images (as satellite views, plans and aerial views) and 130 pictures of 360° views were required for a supermarket whose surface is about 21 000 m^2.

The general working principle of image handling in SécuRéVi is shown in Figure 2. Image sources range from camera to GIS and the formats of the images generated are varied. JPEG has established itself in the field of digital photography while there are several commonly used file formats, such as ECW format, in the domain of GIS. The integration of original image files in the Information System (IS) was the process in place before the work presented in this paper. In this initial process, the user connects to the IS and displays the file directly. The IS is typically local to the machine but may be incorporated within a remote storage area. The "processing" part of Figure 2 represents the processing incorporated for large images, which will be discussed in the next section.

IV. PROPOSAL OF A TOOL FOR LARGE IMAGES HANDLING

The hope in decision making in crisis management is to get all the data instantaneously. Obviously, this is not possible in practice due to hardware and software constraints. Moreover, the handling of large images adds new constraints (storage, processing).

The design challenge is then to manage the contradiction between the hope and the reality and to find an acceptable solution in terms of delay, despite the huge size of images.

In this section, we start by presenting the design constraints of the tool, then we precise our design criteria. The solution proposed is then described, as well as its implementation.

A. Design constraints

In the context of crisis management, the machines used for image visualization have various processing capacities. A machine with a limited performance x86 processor (as Intel Atom), 1 GB of RAM and a hard drive's capacity of 200 GB was defined as the minimum hardware requirement. A 400 Megapixel JPEG (common for a GIS document) uses several GB of RAM and becomes difficult to use on this type of machine. However, on a machine with sufficient memory, the opening time of a file remains problematic.

The tool must accept files from different sources and optimize the use of available resources.

There are different means, like the conversion to a specific format. For example, the use of a wavelet image compression format has been considered as one of the possibilities. It has not been adopted because the conversion with existing tools needs too many resources.

B. Design criteria

For our process, we define an Ideal Final Result (IFR) [9] as a target. This IFR needs to take into account user and computer. We define 3 measuring elements: display time, memory usage and CPU time. These elements need to be as lower as possible. The display time is the time between the user request and the display of the image on the screen. A value less than 100 ms can be considered as a coherent value with the human physiology. We determine the memory usage value like the product between the total number of pixels of the screen and the color depth. The CPU time needs to be near 0%.

Other criteria have been taken into account, including:

- no disturbance of the working of the other parts of SécuRéVi,
- the friendliness when using the tool proposed.

C. Proposed solution

The proposed image processing tool has two parts, one for the pre-processing of images and the other for their visualization. The pre-processing is inserted at the beginning of the restitution chain. Visualization transparently replaced

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the tool previously used. So, the integration of the new tool does not disturb the working of the other modules of the SécuRéVi platform.

The pre-processing aims at optimizing the use of resources. It relies on the use of cutting tiles which is a known technique with different implementations [10]. It is popularized by online mapping services [11]. It minimizes the memory use: only visible tiles are loaded (which are used to generate a new image by assembling and extracting the final visualization). However, when viewing the whole image, the entire tile need to be loaded in memory and the video card need to downscale it before the display. So in this case, the gain is zero in comparison to the initial viewer. In order to improve the gain, we have integrated the management of multi-resolution into the process. This allows to display only the paving tiles whose resolution is directly above the output's display resolution (see Figure. 3). Data formats such as JPEG2000 [12] allow this type of cutting but neither their production nor their return meet our requirements as far as memory use is concerned.

From the pixel array, we generate new images (tiles) organized in predefined zoom level. This data tree is packaged in an archive. The viewer selects the tiles to be displayed according to their level of zoom and resolution. It loads tiles on the fly and releases the useless ones when necessary.

The resolution of a tile was defined empirically: the longest side must have a size of 512 pixels, the value of the second one keeps the ratio of the original picture. Different values were tested. Multiples of 2 show the best performance in terms of processing, but less than 512 pixels value generates too many files (which can be problematic in a FAT32 file system) while a higher value will not make optimal use of memory visualization module (in the "worst case" a display resolution lower than 512x512 pixels will require an image of 2048 x 2048 pixels where our choice divides by 4 the resolution required). In practice, an image of 12100 per 6050 pixels (and weighted 10,8MB in Jpeg), needs the generation of 510 tiles (for a weight of 23,5 MB).

Regarding performance, the software (processing and visualization) needs less than one hundred MB (before it was necessary to have several GB). The CPU load is maximum during processing but minimal during playback. When the processing is done beforehand, the minimum required configuration can be used in good conditions. Finally, one of the consequences of pre-processing is the almost instantaneous loading compared with the tens of seconds of the old loading method (on the minimum performance machine).

V. IMPLEMENTATION

Two versions of the image processing software have been developed. The first version has been tested and integrated into the SécuRéVi Platform. The second version is an optimized version of the first one. We start by presenting the first version software and tackle its testing, then we present its second version.

A. First version of the image processing software

1) Principles and working

In this version, before any use of an image, its entire pre-processing is done and an archive of the result is created as a single file. This use matches a company specific request: generate spherical view. Generating a spherical view consists in assembling photographic images each having a different rotation around a central point. These views are rectified and merged according to specific criteria. The integration of the initial photographic views directly into the IS is maladjusted and the addition of the pre-processing is not detrimental. In contrast, pre-processing does not match the dynamic integration of new data during use (for example, for a crisis management). This problem was solved by storing the images/archives on external transportable disks, such as to be able to use them on the intervention site. Nowadays, data transport by external device is less used and replaced by an access through the network. As a consequence, it is no more interesting to use a single archive. Indeed, the entire file must be downloaded before viewing. Since the archive is heavier than the original file, the interest is therefore diminished. For these reasons, two main changes have been done:

- Archives have been replaced by simple data trees. This change limits the network use negative impact (the amount of data transferred is smaller).
- The pre-processing has been replaced by a processing on request: the pre-processing is only called if the tiles required are not available.

The generation on request allows to optimize storage: only image sections needed are generated and stored. This feature opens a new possibility for analyze like the detection of point of interest [13].

For example, more than 3,5 GB were generated for all of the 360° views (with the pre-processing process) and about 80MB for the large images (with the on request process) for the supermarket site mentioned in section 3.

2) Testing and results

The table below (Table 1) is used to compare the processings. The measurements were performed on a machine equipped with a i5-2520 M processor and 8 GB of RAM and the processed image resolution was 16384 x 8192.

After several on-site deployments, we have chosen to accept only JPEG format as input. Third-party software can often export to this file format, otherwise screen printing can be used (at the expense of resolution).This allows to exploit their expertise in their respective fields but also allows great flexibility of workflow for users, and this is very useful in dynamically changing settings [14] as it is the case in a crisis context.

However, we encounter limitations due to software that allow the export of pictures. High resolutions (over 20 000 x 20 000 pixels) are poorly supported. JPEG format accepts a

Figure 3. Multi-resolution tiles organization.

maximum resolution of 65535 in width and height. Format as JPEG2000 would achieve higher resolutions as input. The tiles format seems not to need to evolve: the JPEG covers all needs and viewing, despite the loss of information during processing (rasterization, compression, etc.). The data produced were not intended to return to their original business domain so, the loss of information doesn't have any consequence.

One of the services made possible by the use of the network is the unsupervised distributed computing. One of the conditions of its implementation would be a reasonable network throughput. The current algorithm is not optimized for this type of use. However, this operation is already operational but not optimal.

B. Optimized version

The optimized version generates a tile by the assembly of 4 tiles of the lower level (the first method uses the original image for every tile). It reduces the time needed by 20 compared with the original pre-processing method. The limit is the need to generate all of the tiles of the lower levels before visualizing the highest level tile. It is not optimized for our on request process but we are working on the integration of intermediate operation in order to reach better performance.

VI. CONCLUSION AND FUTURE WORK

In this paper, we have proposed a solution for the handling of large images in a crisis context. The solution proposed has been integrated in the crisis management platform SécuRéVi. Existing tools such as JPEG2000, were not adapted to our needs due to some constraints such as restricted resources (memory, CPU rate, display time), dynamic integration of images (on the fly).

The solution proposed has been tested and evaluated according to 3 criteria: image display time, memory usage and CPU time. The result shows that the new software tool has good performances. After the first viewing, the image display time has been divided by twelve and the CPU time is lower in comparison to that of initial tool. The percentage of memory used has decreased from 100% to 14%.

In operation, the major contribution to the business experts is the ability to update the IS by adding image during planning or operation. The new process allows to use new data very quickly and updating data is a very important feature in a crisis management system [15].

Our industrial partners (EDF, Total, Jeddah airport, industrial and port area of Le Havre, etc.) frequently use our viewer and their returns are positive.

An optimization of the tool has been proposed in order to reduce the time needed for tiles generation by a coefficient of 20. We plan to integrate it in the SécuRéVi platform. This will be helpful especially for tasks needing complete generation like 360° view.

It is very important to take into account the evolution of the technological environment (such as a GPU integration [16], the use of an UHD display or new services like indexing files) to respond quickly and efficiently to users requirements. One of the future works is the investigation of the use of innovative methods such as TRIZ to adapt our solution accordingly.

We also plan to study the use of grid computing to fasten the tiles generation process and to formalize the determination of the size of tiles (currently defined empirically).

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TABLE I. COMPARATIVE PERFORMANCE VISUALIZATION LEVEL

	Initial method		Pre-processsing		Processing on request	
	1st viewing	Next viewing	1st viewing	Next viewing	1st viewing	Next viewing
Display time	6 s	6 s	> 20 min.	< 0.5 s	30 s < t < 70 s	< 0.5 s
Memory usage	580 MB		< 20 MB	80 MB	80 MB	
CPU time	100 %	100 %	100 %	<15%	100 %	< 15 %

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