COLLA 2020

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COLLA 2020 Editors

Lorena Parra, Universitat Politecnica de Valencia, Spain

COLLA 2020

Foreword

The Tenth International Conference on Advanced Collaborative Networks, Systems and Applications (COLLA 2020), held between October 18–22, 2020, continued a series of events dedicated to advanced collaborative networks, systems and applications, focusing on new mechanisms, infrastructures, services, tools and benchmarks.

Collaborative systems became a norm due to the globalization of services and infrastructures and to multinational corporation branches. While organizations and individuals relied on collaboration for decades, the advent of new technologies (Web services, Cloud computing, Service-oriented architecture, Semantics and Ontology, etc.) for inter- and intra-organization collaboration created an enabling environment for advanced collaboration.

As a consequence, new developments are expected from current networking and interacting technologies (protocols, interfaces, services, tools) to support the design and deployment of a scalable collaborative environments. Innovative systems and applications design, including collaborative robots, autonomous systems, and consideration for dynamic user behavior is the trend.

We take here the opportunity to warmly thank all the members of the COLLA 2020 Technical Program Committee, as well as the numerous reviewers. The creation of such a 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 COLLA 2020. 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 COLLA 2020 organizing committee for their help in handling the logistics and for their work to make this professional meeting a success.

We hope that COLLA 2020 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 collaborative networks, systems and applications.

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Table of Contents

Collaboration through Virtual Teams: Towards an Operational Model for Virtual Project Leadership in the Automotive Industry

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Abstract – **Companies from various sectors of the economy are confronted with the new phenomena of digitalization and globalization and are faced with the challenges of formulating and implementing new business models, updated strategies and different ways of working. In the automotive sector, globalisation has required new developments in project management practices and support technologies, notably those relating to the challenges of collaborating over distance between and within dispersed teams. Researchers and practitioners have started to think more comprehensively about the complexity of projects with dispersed teams, and how best to manage them. This interim paper is the result of the distillation of relevant literature relating to virtual teams. It presents a set of critical success factors for virtual teams and outlines a provisional model for virtual team leadership and management. This model is currently being evaluated and developed through in-depth interviews with field practitioners working in the automotive sector. The confirmed model will provide operational guidance for practitioners and an analytical framework for further research studies.**

Keywords – Project management; virtual teams; virtual leadership; German automotive industry; V-CORPS model

I. INTRODUCTION

The globalisation of automotive companies has brought new challenges for project management, such as projects being led from a distance, with dispersed team members and teams. Lipnack and Stamps [1] noted that twenty-first-century problems require twenty-first-century organisation and innovation. Researchers and practitioners have started to think more comprehensively about the complexity of projects with dispersed teams, and the new possibilities for project management and required changes in processes, technology support and people competencies. This has given rise to the concept of "virtual leadership" or "e-leadership", which are more or less synonymous, focusing on the social influencing capabilities of leaders of dispersed (or "virtual") teams, whereby collaboration and communication technologies are of heightened significance in the pursuit of project goals.

Jugdev et al. [2] concluded that project management can be seen as a holistic discipline for achieving organisational efficiency, effectiveness, and innovation. Team leading plays a key role here. An examination of the extant literature on virtual leadership reveals issues relating to project complexity, social process, value creation, conceptualisation and practitioner development [3]. Virtual teams face a number of issues that can impede effective project delivery – different time zones, different cultures, lack of face-to-face meetings, reduced productivity and increased miscommunication [4].

The current research project has the goal of rethinking project management leadership for dispersed teams in the automotive industry, looking particularly at team leading from a distance and its influence on team members. As recently noted in the National Instruments Research Handbook [5] "within the next 10 years, we will see remarkable change in the automotive industry from improved engine efficiency to autonomous vehicles to electrification" and virtual project management will likely be of increasing importance in an industry undergoing rapid and radical change. Berlin et al. [6] see this as consisting of four main trends - Connectivity, Autonomous Driving, Shared Services and Electric, for which the acronym CASE is often used. This is leading to major changes in many aspects of the industry's operations [7], where issues need to be resolved in parallel and at speed, often in different geographical locations. Effective operation through virtual teams is thus essential.

An examination and analysis of the available literature provides the basis for the development of a conceptual and operational model for future automotive projects led from a distance. This model can act as a framework for the building and leading of dispersed teams, and is currently being evaluated through practitioner interviews. The model will enable the identification of those elements of virtual leadership which can be adapted to the automotive sector, and how such elements can be used to more effectively influence people from a distance.

This paper is structured around five main sections. Following this Introduction, Section 2 outlines the research methodology and positions the two research questions addressed in this paper. Section 3 then reports the Critical Success Factors (CSFs) drawn from current literature relevant to the research aim. This is followed in Section 4 by a discussion of the provisional model for virtual team leadership based on concepts drawn from the extant literature, but amended to reflect the realities of virtual team operations. The final Section 5 provides an overall conclusion to the issues

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discussed in the paper and briefly outlines future work that will be done to further develop the model.

II. RESEARCH METHODOLGY

The research methodology is based on a qualitative inductive approach, using a conceptual literature review and case study methodology employing semi-structured interviews. The epistemological position is interpretivist. There are several stages to the project which are currently ongoing.

Available literature in the automotive industry and in other industry sectors has been investigated to ascertain current thinking on the leading and management virtual teams working on specific projects. This has established whether concepts and ideas can be adopted from other sectors and whether these can be of value for leading virtual teams in the automotive industry. This is a conceptual review which aims to synthesize areas of conceptual knowledge that can contribute to a better understanding of virtual team leadership and management, and lead to the development of an operational model.

A conceptual literature review has many benefits. It can provide an overview of the literature in a given field, encompassing the foremost ideas, models and debates, especially the concept that is not explicitly stated before – in this case the dynamics of virtual team leadership and management. It can provide the basis for a summary of the existing evidence concerning this theme, and identify gaps in the current literature that may highlight possible areas for further investigation. It can also help build a framework or model for new research activities. A conceptual review is particularly suitable when the research area is in the early stages of development, where key questions remain unanswered and an accurate picture of current thinking and evidence to date is required to promote the development of new methodologies [8] [9].

This review has allowed the identification of critical success factors for the successful leading of virtual teams, and the construction of a provisional model for virtual team leading and management. A model of virtual project leadership in the automotive industry does not yet exist, and this research aims to address this gap in the literature and in practice. The Research Objectives (ROs) addressed in this paper are:

RO1. To review existing literature on virtual leadership and virtual teams and identify critical success factors for the e-leadership of virtual teams in the automotive industry.

RO2. Through a conceptual review, to develop a new operational model for the e-leadership of virtual teams that minimises personal contact and optimises project outcomes in the automotive industry.

III. CRITICAL SUCCESS FACTORS

Project management has become more versatile and complex, in terms of people and project leading, over the past few decades, especially when project teams are geographically dispersed. This has been done with the support of a variety of project management methods and concepts and the use of faster and cheaper communication technology, which have facilitated the achievement of project goals and milestones more effectively. Whether these methods would also work for virtually-managed teams in the automotive industry is a gap in the literature. A review of the extant literature suggests a number of factors as critical to the building and leadership of virtual teams (Figure 1). These may be seen as key concepts emerging from the literature search on project management and team development, which the authors have considered of particular relevance to virtual team leadership and management. They are taken from the literature on both the automotive industry and other different industry sectors, and the relevant elements of project management methodologies.

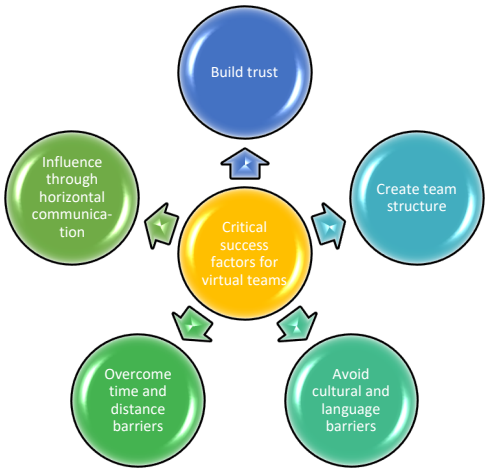

Figure 1. Critical Success Factors for virtual team building and leading

These CSFs are as follows:

Build trust: A number of authors, including Maes and Weldy [10] and Ford, et al. [11], have emphasised that trust between leaders and their team members, as well as among team members themselves, is the most important aspect for leading from a distance, and that it is possible to see trust as a key starting point for working with virtual teams. The building of trust is a pre-requisite for team cohesiveness, and the gaining of trust is part of social influence for distance-led team members, as discussed by Scheunemann and Bühlmann [12]. It is a major challenge in overcoming distance and time barriers, and winning over team members. Building trust is an essential and challenging aspect for leading, and this is highlighted in the literature [10] [13]. Ford et al. [11] describe trust as the key to a capable virtual team.

Create a team structure: Working with team members in a number of locations entails a different work attitude and way of working. To achieve this, the creation of a team structure that can support virtual working is essential, to connect the team members and foster a collective, shared approach to the working behaviour of the team. This structure can be viewed as a contract for team members that allows

 ISBN: 978-1-61208-797-9

them to pursue individual and project objectives effectively. Klitmøller and Lauring [14] note that the team structure is essential when it comes to communication and knowledge sharing, because these are more challenging in a virtual team environment than with face-to-face counterparts.

Avoid cultural and language barriers: The avoidance of the possible negative impact of cultural differences is a necessary preventive measure to mitigate possible bias between the different team members. Nader et al. [15] note that cultural barriers are a serious impediment to the effectiveness of virtual teams. It is essential that the general understanding and respect of culture is recognised by the leader, and that neither origin nor gender plays a role in the team, with only ability and merit counting.

Language barriers are an important issue which cannot be underestimated. Due to the fact that the members of virtual teams often do not speak the same language, many companies opt for mutual understanding through English [12]. It is essential that the leader considers this issue and accommodates language differences during complex negotiations. Team members may need to develop agreed procedures for avoiding misunderstandings and time wasting through misinterpreted instructions or information.

Overcome time and distance barriers: One of the most important pre-requisites for successful virtual working is the effective management of time and distance barriers. The "follow the sun methodology" allows the phased deployment of teams around the globe, and the increased use of collaboration and communication tools can facilitate more autonomous work, and yet also allow all team members to be in one virtual space during critical situations. Effective communication across time and distance barriers is essential to give team members a form of security (the feeling that they are not alone), and can be seen as the "project life-blood" of the team. Layng [4] found that communication was a key factor in the success of virtual teams.

There is a range of available technologies to support communication and co-working in virtual teams [16], which have seen increased deployment in the lockdown periods brought in as a response to the coronavirus pandemic. In addition to standard phone, texting and email, there are more sophisticated messaging services like Microsoft Teams, WhatsApp and Facebook Messenger. Video conferencing and meeting tools such as Skype and Zoom support virtual meetings across time and distance boundaries, and many of the standard project and document management tools will be used by virtual teams. Similarly, if virtual teams are interacting with the customer, shared access to customer files (probably via a customer relationship management system) will be necessary. The use of the Cloud to provide shared access to these software systems is an option.

Influence through horizontal communication: Many project leaders work with multi-functional teams drawn from different departments, without direct line management authority. Influencing skills thus come to be of particular importance, especially in virtual teams when there are limited opportunities for face-to-face meetings. The influencing of team members can take place through adopting elements of nonviolent communication (Observations, Feelings, Needs/Values, and Requests) to minimise escalation of disagreements and minor disputes among team members. Alistoun and Upfold [17] discuss how virtual team leaders can be trained to successfully influence team members, deploying computer-mediated communication, building trust, shortening subjective distance, sharing information, processing gains and losses, dealing with feelings of isolation, encouraging participation, and enhancing coordination and cohesion. If the leader can appear to communicate on the same hierarchical level as team members (horizontal communication), the leader is seen to be on the "same wavelength" as the team members, only revealing their true hierarchical position in urgent or emergency situations. Influencing team members is a topic which has an impact on team and work behaviour, and must be considered before and during the project, and constantly being improved upon by getting to know the team members.

To have social influence on team members, virtual team leaders need to use a range different communication technology to ensure a social presence [18]. The use of communication technology makes the virtual socialisation of team members possible, allowing leaders to assess their teams' capabilities, and receive, provide and accept feedback from their team members. For team members, it promotes a sense of connectedness to leaders, as well as allowing leaders to create a social presence [19].

These CSFs suggest the key issues for establishing a successful virtual team, but also indicate which factors are necessary for successful virtual leading. The tendency to work virtually is growing [10], and recent research reports an improvement in the effectiveness of virtual teams from less than 30% in 2006 [20] to 68% in 2016 [21].

IV. DEVELOPMENT OF THE V-CORPS MODEL

Based on the conceptual review of extant literature, this section presents an initial model for virtual leadership of teams in the automotive industry. It builds upon the Tuckman and Jensen [22] model for co-located teams which has been adapted to the realities of virtual leadership through the incorporation of new technical and human working aspects. In addition, elements of project management methodologies are incorporated into the five-stage model (Table 1). This takes into account a number of management challenges for virtual teams, including differences in employment and, occupational health legislation, norms regarding social interaction, a lack of mutual knowledge of context and access to dispersed knowledge, stress and fatigue issues, and data security [23] [24].

It is important to note the differences between co-located and virtual teams, and how they communicate to reach their goals. As pointed out by Berry [25], a co-located team is a group of individuals who interact interdependently and who are brought together or come together voluntarily to achieve

 ISBN: 978-1-61208-797-9

certain outcomes or accomplish particular tasks, and are able to have face-to-face conversations or meetings at any time. Virtual teams could theoretically comprise the same individuals as co-located teams, with the premise of working over the world and communicating through the use of information and communications technology. Virtual team members consist of individuals spread across geographies, cultures and time zones.

Managing virtual teams is different to, and more complex than, managing face-to-face teams. Virtual teams are groups of individuals that still share most of the characteristics and dynamics found in traditional teams. The challenge for virtual teams is in cultural differences, mentalities, work-settings etc., which are of significance for the virtual leader when influencing team members from a distance. Cortellazzo et al. [26] state that when focusing on behavioural norms, it is particularly important for virtual teams to have a clear definition of the norms pertaining to their use of communication tools, through which information flows and activities are performed. Berry [25] suggests that the effective management of virtual teams requires knowledge and understanding of the fundamental principles of team dynamics, regardless of the time, space, and communication differences between virtual and face-to-face working environments.

These considerations and the CSFs discussed above underpin the development of a 5-stage model for virtual leadership and management of virtual teams. The stages in the model (given the acronym V-CORPS) are outlined below.

Creating the team: To support virtual team members in achieving a high level of performance, some key considerations need to be taken into account in the creation of the team. The choice of the appropriate team members is vital – not only those that have the relevant work experience for project requirements, but also those that are able to work remotely, being self-motivated and independent [12]. The project manager has to make a pre-analysis of the team members and speak to their line mangers to get an impression of their ability to work in a virtual environment. This pre-analysis is essential prior to taking the next steps of team member selection, since virtual teams tend to be more sensitive to trust issues and the need for communication [27]. Caulat [20] concludes that people who are very process-oriented and structure-driven might be effective when managing the virtual process of communication between the members during a project, but might find it challenging to facilitate and participate in virtual meetings where spontaneity is required.

TABLE I. CSFS IN THE V-CORPS MODEL

CSF/ V-CORPS Stage	Creation	Organisation	Relationship Building	Performance Evaluation	Sign-off & Closure
Build trust	First impressions – preferably via a face-to-face meeting – are important in building trust.	Clearly define project tasks and responsibilities and assign roles for individual team members.	Conduct the "Big Five" analysis of each team member. Offer support in critical situations.	Performance evaluation underlines mutual dependence of team members in achieving successful project outcomes.	Acknowledgement of lessons learned and reflection on team leading can reinforce mutual trust and respect.
Create team structure	Explain and apply corporate policies for team working. Clarify expected outcomes.	Define and agree terms and conditions, project rules and team composition.	Introduce 'team working contract' and a team chat/forum to facilitate team communication.	Highlight the importance of the team structure in achieving project success.	Team dissolution. Creation of long-lasting relationships.
Avoid cultural and language barriers	Establish whether any cultural or language barriers exist.	Clarify support actions and steps to be taken in the event of language or cultural issues. Provide a common understanding of working posture and customer requirements	Equal treatment and support during breakdown of communication. Explain how and when to escalate properly to avoid time wasting.	Stress the importance of a standard work-culture across the team. Ensure that team performance comes before individuality.	Private contact data exchange (if desirable). Stay in touch with team members after project closure.
Overcome time and distance barriers	Investigate and evaluate implications of geographical differences and discuss how to overcome them.	Define ways of working to accommodate time and distance issues. Establish technology platforms to be used for virtual team operations.	Show dependencies between tasks and team members. Implement simulation procedures to avoid unnecessary product testing.	Review impacts of time and distance differences across the team. Adjust working practices accordingly. Provide appropriate training.	Avoid anxiety about separation and project closure.
Influence through horizontal communication	Round of interviews. Project manager treats team members as equals.	Highlight the importance of teamwork and the value of the project to the company.	Intervene only when necessary e.g., key decisions, supportive role, problem escalation.	Create a relaxed environment while focusing the team on specific project milestones. Avoid coercion.	Project evaluation. Encourage mutual support. Team members leave the project feeling appreciated.

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Cross-cultural awareness is also necessary for team cohesion, influence and trust promotion. It is essential that the project manager be in place as the first team-building measure, with an overview of team member actions and reactions, especially during the team creation period. The project manager can assess how team members score against the project CSFs. Building trust, as Seshadri and Elangovan [28] note, is an interpersonal challenge faced by managers to foster collaboration with team members through communication and building relationships. Caulat [20] argued that, by working with cultures as diverse as Japanese, Indian, Swedish and Russian, she realised that cross-cultural awareness may help in understanding each other, but that it is certainly not sufficient for establishing a sound basis for the development of trust within the team. Although the pre-investigation of team members is essential, it is the first meeting where the project manager meets his team face-to-face, and can leave a positive, lasting impression, which can establish the tone and *modus operandi* for future project procedures [29].

Organisational structure implementation: Maintaining a uniform team structure before and during the project is an essential factor in avoiding time-consuming discussions regarding the *modus operandi* of the team. The organisation of virtual team structures needs special consideration, not only for the establishment of working procedures, but also regarding social aspects, and the avoidance of miscommunication or misunderstandings which can affect the entire team's behaviour. It is essential to sensitise each team member to the potential impact of social behaviour. This structure is significant in facilitating communication and knowledge sharing, which is more challenging than with face-to-face counterparts [14]. A clear organizational structure is also of particular importance when dealing with a complicated project environment that includes challenges in language, political climates, organisational policies, time zones, and cultures [30]. To counteract these challenges, it is essential to outline the CSFs for the project through the organisation stage and discuss each of them with the team members, to define rules for working with each other. The project manager may need to act as a moderator between the team members and intervene in critical situations (e.g. escalations between team members).

It is also essential to consider the language skills of the team members before and during the project process, because virtual workers with low language proficiency invoke apprehension and uncertainty in individuals [31]. The organisational structure can be used as the framework, within which issues can be tackled and team cohesion enhanced, and through which the project manager can discuss and explain what he/she expects from team members.

Relationship building: The team organization structure provides the starting point for relationship building between the project manager and the team members. Building relationships is the foundation of all teamwork, especially for virtual teams, and can help counteract the multiple negative aspects of working over distance [4]. It is necessary to confront prejudices about the working performances of the different nationalities of team members.

It is advisable that communication between the individual team members takes place at least two weeks before the start of the project [4], as this will, in the best case, enable the group to become more socially grounded through a personal meeting or by participating in "virtual water cooler communication", thereby increasing their loyalty to the group [32] [33]. This will support relationship building and similarities between the team members can be found before the project starts. It is important for virtual leading teams to create a social environment to promote team cohesion, which will be established through interpersonal challenges for the project manager and ensure that team members communicate with each other, build relationships and foster trust [27]. This builds commonalities, which creates sympathy, trust and encourage team spirit.

In the relationship building phase, a number of techniques can be used, such as Goldberg's Big Five model [34] for assessing and understanding personality traits. Project managers can try to analyse themselves and the team members to find out what kind of leadership is right for each member, and how to employ the right team member in the right position. This model is also useful for relationship building between team members, for working from a distance and improving mutual influencing effectiveness. The leader must not neglect the social behaviour of the team members, and one possible tactic here is to book a short slot at the beginning of each team meeting to speak about non-project themes. This gives an added value of trust, which can greatly improve team effectiveness and relationship building.

Performance evaluation: Leading a team during a project is an evolving and ongoing process. It is essential to update the team regularly and be responsible for enabling communication.

The more team members are up to date, the better their performance is, and the fewer miscommunications and misunderstandings there are. It is advisable to try to bring more personality and dependency to the virtual world.

It is also important to make clear to team members that their performance levels depend on each other, and to get them to consider what kind of impact their performance has on project outcomes and the company.

The quality and effectiveness of information exchange also impacts on team performance – used correctly, it can empower individuals, alter behaviour, and help develop a cohesive team.

The same is true for decision-taking, where team performance counts. Care taken by the project manager (for example in including all team members in certain decisions) can enhance the overall performance of the whole team. In virtual teams, language and mental barriers must be considered. Shared understanding of key decision options is important. Horizontal communication is essential, where team members get the feeling that they are on the same working level and can contribute to a discussion and decision.

Sign-off and closure: The bonding between team members during the project phases can create a form of psychological contract, which will reflect the social team influence of the

project manager, and that of the team members themselves. The dissolution of this contract is a key element of the project sign-off and closure stage, and it is an important aspect for the possible future creation of new virtual teams. King [35] defines a psychological contract as an individual's belief in the perception of reciprocal obligations between that person and another party. For working in a virtual team, this can be considered as a contract between team members, which is unofficial, but essential for the project.

The disbanding of the psychological contract will likely involve a meeting between the project manager and the entire team on site, when project completion meetings can be held with each team member. Project disbandment can be done in a virtual way, but psychological effectiveness, in terms of the appreciation of individual team members, is not as valuable as when there is a local presence face-to-face. In the final discussion, both positive and negative aspects of the project can be reviewed, and the further growth of the team in subsequent projects can be discussed. The project manager should also have their team ready at the end of the project to give some reflection and feedback on the project management process, so that negative aspects can be aired and reviewed.

V. CONCLUSION AND FUTURE WORK

In the final analysis, as Tuckman [36] concluded in his studies of group development, the outcomes from the performance evaluation stage will be critical to final project results. Nevertheless, other stages in the formation of a virtual team – for example, team structure development and promoting team cohesion – are an important part of the leadership process. This means, for the leader, that they have to bring the team to the most effective performance level to fulfil the project requirements [37]. It is also important that virtual teams are equipped with the process capability to respond to changes quickly and effectively [38].

This paper has built upon concepts discussed in the existing literature to identify five critical success factors for virtual teams and develop a provisional model (V-CORPS) for virtual team leadership and management, based on an adaptation of Tuckman's model for co-located teams to the virtual world. The CSFs have relevance to each of the five stages in the V-CORPS model (Table 1), and this can be used as a guideline and point of departure for those assembling and leading virtual teams. Future research will now apply, test and refine this framework. The model is being further developed through semi-structured interviews with 18 interviewees who are experienced project managers in the automotive industry (vice president, director, head of project management) as well as a number of team members (from, for example, purchasing, quality assurance and product development departments) working on international and global projects. In conjunction with the assessment of relevant literature, the analysis of the expert interviews will be the basis for the confirmation of critical success factors and validation of the model for leading virtual projects over distance.

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Social Context Contribution to Group Recommender Systems

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***Abstract*—There are several factors that influence the group decision making process. The individual's personality and the group's social context play a role in the group's decision and the individual's satisfaction with it. Group recommender systems, which offer support to group decision making can offer better results by incorporating such factors. In this paper, we present a social context-aware group recommendation platform which takes into consideration several of the social factors between the group members in the recommendation process. We examined the effect of multiple social factors independently and collectively on the recommenders' outcomes. Our analysis shows the superiority of social-context aware group recommenders compared to a collaborative filtering group recommender baseline approach.**

Keywords–recommender systems; group recommendation; collaborative filtering; social networking; social context; tie strength; social hierarchy

I. INTRODUCTION

The need for recommender systems is increasing as they facilitate decision making processes in multiple domains. They provide users with individualized recommendations or predicted ratings based on different factors such as the preferences to users with similar tastes or domain-based contextual information. There is a growing interest in group recommender systems as they additionally help with group decision making. They provide recommended items to groups or group predictions taking into consideration the preferences of each individual group member. In one variety of group recommenders, recommendations are generated for individual group members and these recommendations are aggregated to form recommendations for the whole group. In another variety, the individual preferences or ratings of the group members are aggregated into a group model and recommendations are then generated to the model. In both cases, an aggregation strategy determines how to aggregate either individual recommendations or individual preferences [1].

Group recommender systems cover multiple domains. Such as music [2] [3], movies [4], and travel [5] [6]. As the group decision making is a complex social exercise, incorporating social factors in group recommenders became an interesting research area. Delic et al. [7] show through an empirical study, how the social relationships between the group members can be used to predict the members' satisfaction with the group's decision. They conclude that social relationships should be included in the preference models used in group recommender systems. Previous research has considered incorporating several social factors in group recommenders. One of these social factors is trust, which was indicated to influence the group recommendation results. Quijano-Sanchez et al. [8] describe a group recommender system based on trust and personality type, while Wang et al. [9] determine the trust factor from more than one source and uses it to determine the group predictions. A trust-based group recommender system is presented in [10], where a movie ratings dataset was created which also includes pairwise user trust ratings.

Social influence is another social factor that has been used to improve group recommenders' performance. In [11], social influence is determined by identifying the dominators and the followers in the group. The group predictions are determined as the average predictions of the group's dominant members. In [12], the social influence metric is introduced to quantify and measure the member's contribution to the group decision.

In this paper, we introduce a social context-aware group recommender for restaurants based on 8 different social factors in addition to the individuals' personality types. We examine the effect of each of the 8 social factors individually on the group recommender's results as well as the effect of combining the 8 social factors together forming a representation of what we call the long-term social context between the group members. We built a platform for the creation and the evaluation of social context-based group recommendation algorithms, and we used our platform to build different group recommenders based on different social factors and compared their results with a baseline item-item collaborative filtering group recommender. Additionally, we built a restaurant rating and social network platform using which we collected a dataset that includes individuals' and groups' restaurant ratings, and – using a pairwise user evaluation feature - a social network that captures the groups' social contexts.

The rest of the paper is organized as follows: Section II provides a description of the social network and the restaurant rating platform we used to collect our dataset. Section III describes our approach to social context-based group recommendation for restaurants and explains our group recommendation platform and the different recommendation algorithms we built with it. Section IV outlines the experiment setup we used to collect the dataset. We present our findings in Section V.

II. SOCIAL NETWORK AND RESTAURANT RATING PLATFORM

"Social context refers to characterizing the social nature of the situation a user is currently in" [13]. It is represented by the models of any aspects of social interaction having a relation

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to IT systems. Long term social context can be described, on a high level, by the dense social network groups the user is part of, and on a low level, by friendship on a social networking platform. Examples of the social factors that contribute to long term social context, which have significance over long durations, are the level of established trust, the duration of the relationship, and the frequency of the interaction. Short term social context, on the other hand, is represented on a high level by social situations whose validity has a temporal scope of minutes to hours and is characterized by social signals and the socially relevant emotions resulting during co-activity social situations. On a low level, the short term social context can be described by sensor data or signals, for example a set of identifiers of persons in bluetooth range.

The interactions between the users of modern social networking platforms either establish or describe long-term social contexts between them. In this paper, we study the influence of long-term social context awareness on the quality of group recommendation. Therefore, the first step is to collect a dataset of individual and group ratings, which also includes the groups' long-term social context information.

Building a real dataset for group recommendation is often regarded as a challenging task [14]. We built our social network and restaurant rating platform to collect the aforementioned dataset. The main requirements for our platform were to:

1) capture the user's personality traits, which may influence how the user may behave during a decision-making process that involves several participants
2) store social network and long term social context information by allowing users to form groups among themselves and perform pairwise social attributes' evaluations
3) elicit the users' individual preferences in restaurants, by allowing the users to rate restaurants as individuals
4) elicit the group preferences in restaurants, by allowing the users to rate restaurants as groups

Our social network and restaurant rating platform is a web application whose use cases and interactions are explained as follows:

Personality Test: The Thomas-Kilmann Conflict Mode Instrument (TKI) [15] quantifies the behaviour of an individual during a conflict, by identifying five different styles of personalities: competing, avoiding, accommodating, collaborating, and compromising. TKI was successfully used in the context of group recommendation as the personality type was shown to be a significant factor in determining the social influence of each of the group members in the decision-making process [16]. After registration, the user answers the TKI personality questionnaire which is composed of 30 double statements in the form of two columns to choose from: A or B. For each statement, the user has to choose between either column A or column B depending on which statement of the two columns she finds more descriptive of her behaviour or personality.

User Rating: In the next step, the user can choose other users of the platform and evaluate them according to 8 social context attributes. The social context attributes are: relationship, social capital, tie strength/trust, social similarity, social context similarity, social hierarchy, and domain expertise. Table I describes each of the social context attributes. As shown in Figure 1, the relationship attribute is a free text

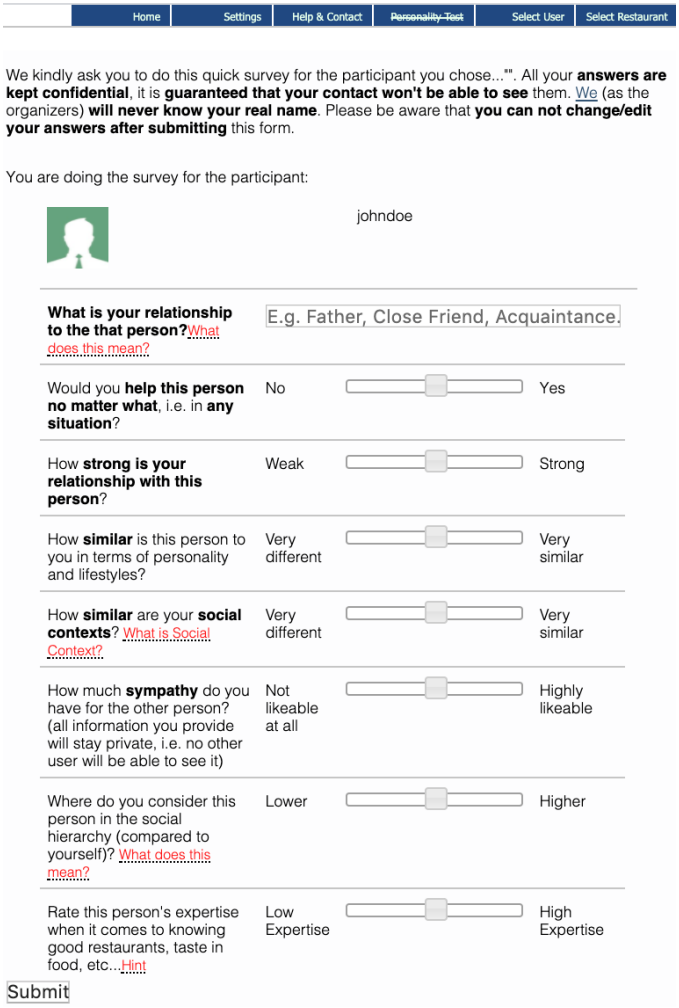

Figure 1. User can rate another user according to eight different social context attributes.

where the user freely enters a description of the nature of her relationship with the rated users. For the other social context attributes, the rating is done using sliders.

Individual Restaurant Rating: In the next step, the user chooses restaurants that she knows and rates individually. To facilitate the process to the user, we integrated a Google Maps widget [17] to our platform. The user can search for restaurants and pick them from the map, as shown in Figure 2. The user is invited to rate at least 5 restaurants, but there is no upper limit to the number of restaurants that a user can rate. When the user picks the restaurants on the map, some metadata about the restaurant will appear in a small popup, which also contains a button to review the restaurant. The restaurant review screen is shown in Figure 3, which provides the user with 8 metrics to rate a restaurant: Hipness, price, order, service, food taste, location, social overlap (which means: to which extent the user and the user's friends share the same opinion about this restaurant and how it suits them as a group), and finally enabling the user to write additional comments. We chose to provide the user with several metrics to rate a restaurant as opposed to a single rating because it captures more accurate opinions.

 ISBN: 978-1-61208-797-9

TABLE I. SOCIAL CONTEXT ATTRIBUTES CAPTURED BY THE SOCIAL NETWORK AND RESTAURANT RATING PLATFORM.

Social Context Attribute	Description
Relationship	A free text description of the relationship with the rated user
Social Capital	Identifies to which extent the user will be willing to help the rated user, which we consider an accumulation of a social capital built from the interaction between the two persons over time.
Tie Strength/Trust	Represents how the user sees the strength of the relationship with the other user. It's also an indication of how much the user trusts the rated user in general.
Social Similarity	Identifies how the two users are socially similar in terms of interests and lifestyle as perceived by the rating user.
Social Context Similarity	Social context is defined by the social setting the users are living in, e.g. sharing the same workplace, school, course, friends, etc. with a friend would imply similar social contexts.
Sympathy	indicates the level of sympathy towards the rated user.
Social Hierarchy	A person who holds a higher position in the social hierarchy is a person who is held in greater respect. For example: a parent, an older person, a person who has some influence, excels at something, or regarded as a role model.
Domain Expertise	A rating for the other user's expertise when it comes to knowing good restaurants, or that this person is famous for having a good and trusted taste in food.

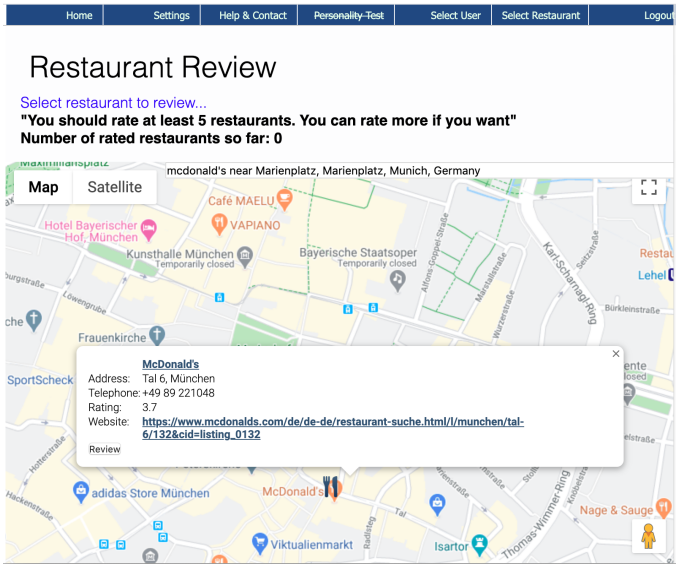

Figure 2. Restaurant picking tool. User/Group can search for any restaurant to review.

Group Formation: A user can instantiate groups with other users of the platform. The user who creates the group is called the group master. The group members should evaluate each other according to the 8 social context attributes described in Table I.

Group Restaurant Rating: Similar to individuals, groups should also rate restaurants. The group restaurant rating is a collaborative process. The group members have to meet, either in person or via a communication medium, search for restaurants and discuss on how to rate restaurants as a group. The group master, finally, executes the group decision and enters the group ratings to the platform. The pairwise user evaluations and the instantiated groups data is a representation of a social network where the nodes are the users and the edges are the relationships between the users in the groups. The weights of the edges are identified by the ratings the users gave each other according to the eight social context attributes. This social network also stores information about the users' personalities as described by their answers to the TKI questionnaire, as well as information about their personal preferences in restaurants represented by their individual restaurant ratings and their group preferences in restaurants represented by their groups' restaurant ratings. The data collected by our social network and restaurant rating platform serve as ground truth data which can be used to evaluate restaurant group recommenders in general, but especially our social context-aware group recommender system.

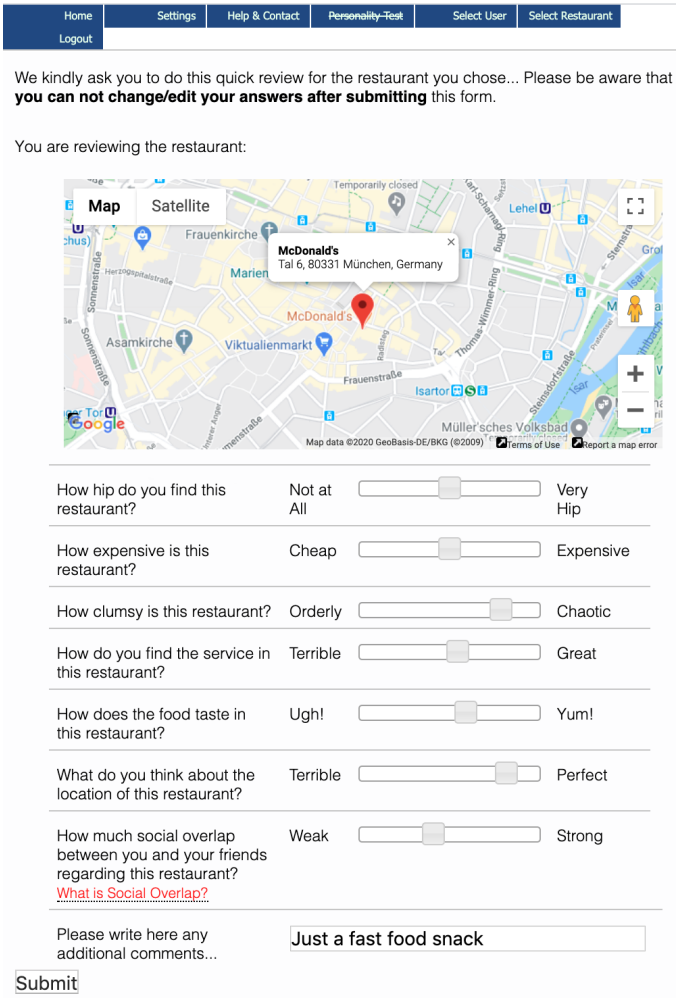

Figure 3. User/Group rates restaurants according to eight different rating metrics using sliders

III. SOCIAL CONTEXT-AWARE GROUP RECOMMENDER SYSTEM

Deciding what to recommend to a group of individuals is a challenging task. Not only individuals' preferences should be taken into consideration during the recommendation process, but also how to aggregate those preferences using a model

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that collectively represents the group's preferences should be considered. Such an aggregation should reflect the group decision making process, so that the list of recommended items to the group results in the highest satisfaction to the majority of the group members. Group decision making is a complex process that is largely influenced by the group dynamics characterized by the individuals' personalities and the degree of influence they may impose on each other either generally or during the decision making process [18]. The social influence is part of the group's social context, which is in the long term defined by the history of the members' relationships and in the short term resulting from the group formation and the social dynamics surrounding the decision making process. In this paper, we introduce a framework to build long-term social context-aware group recommenders that incorporate different social context attributes together with the individuals' personalities to improve the group recommendation results.

The social choice theory which has been studied in many disciplines such as economics, politics, and sociology covers the group decision making process or the study of what is best for a group given the opinions of its members [19]. There are different strategies to aggregate individual user preferences into group preferences and presenting a list of recommended items to the group accordingly. Those strategies which are based on the social choice theory can generally be classified into 3 categories [20]:

1) *Majority-based Strategies:* strategies that focus on recommending to the groups the most popular choices among the individuals. The Plurality Voting Strategy [19] is a an example of this category.
2) *Consensus-based Strategies:* which generally attempts to average the individuals' preferences into group preferences. E.g. averaging strategies [19]
3) *Role-based Strategies:* where the group preference is determined based on the preferences of some of its members, depending on their roles or how influential they are in the group. For example, dictatorship strategies [20]

The group recommendation process consists of three main steps. The first step is to generate predicted ratings to the individual users (group members) using a single-user recommender system. The second step is, using one of the mentioned social choice theory-based aggregation strategies, to aggregate the individuals' predicted ratings into group predicted ratings. Finally, the list of recommended items which consists of the items with the highest predicted rating values is presented to the group. The choice of the aggregation strategy largely depends on the group recommendation problem and domain. For our use case, which is group recommendation of restaurants, we built and evaluated our recommenders based on 4 different aggregation strategies: *Average, Least Misery, Most Pleasure, and Dictatorship.*

For the *Average aggregation* strategy, the individuals' predicted ratings of an item are calculated, and the average is taken of all predicted ratings of that item for all the group members. The average value will be the group's predicted rating for that item.

For the *Least Misery* aggregation strategy, the degree of group satisfaction of an item is be determined by its least satisfied member. For each item, the group predicted rating for the item will be the smallest predicted rating for that item among the group members.

For the *Most Pleasure (Maximum Satisfaction)* aggregation strategy, the group predicted rating of an item is the highest rating for that item by any of the group members. Hence, the group's predicted rating for the item is dominated by the most satisfied member of the group of that item.

For the *Dictatorship (Single User)* aggregation strategy, the group's predicted rating for an item is the predicted rating of the group's dictator. The choice of the dictator can be based on different factors. For example, the group's dictator can be chosen to be the most influential member, the oldest or the most respected member of the group, etc..

We built our group recommendation and evaluation framework based on Lenskit [21]. Our framework is largely configurable and highly extensible, which easily allows to add new recommendation algorithms, aggregation strategies, and evaluation methods. Using our group recommendation framework, we built different group recommender systems for restaurants based on a dataset that we collected with our social network and restaurant rating platform.

We built different social context-based group recommenders and compared each with a baseline group recommender. The baseline group recommender is based on an item-item collaborative filtering single user recommender [22] [23]. For both the baseline recommender and the various social context recommenders, we applied the 4 aforementioned aggregation strategies.

The social context-aware recommenders are based on the 8 different social context attributes described in the previous section. The social context attributes are used either individually or collectively in the recommendation process. We define two types of social context-aware recommenders. The first is the *single social context attribute-based group recommender systems*. Those are the recommenders that are based on single social context attributes such as: trust or social hierarchy. For this type of group recommenders, we generalize the delegation-based method [8] which employs both the personality type and the trust in the recommendation model so that we can weigh the single user predicted rating by any of the social context attributes:

$$pred_{soc}(u,i) = \frac{1}{\left|\sum_{v \in G} attr_{u,v}\right|} \sum_{v \in G \wedge v \neq u} attr_{u,v} \cdot (\mathrm{pred}(v,i) + p_v) \quad (1)$$

where $pred_{soc}(u,i)$ is the social context influenced predicted rating of item i for user u. $attr_{u,v}$ is the social context attribute value rated by user u towards user v (e.g. the value of tie strength or sympathy rated by user u towards user v). $pred(v,i)$ is the predicted rating of user v for item i. p_v is the personality value of user v. We created 8 recommenders based on each the 8 social context attributes.

The second type is the *full social context recommender*, where the single user predicted ratings are influenced by all of the 8 available social context attributes present in the social network. The single user full social context predicted rating in

this case is calculated as follows:

$$pred_{fullsoc}(u,i) = \frac{1}{\left|\sum_{v \in G}(\sum_{attr \in soctxt} attr_{u,v})\right|} \cdot \sum_{v \in G \wedge v \neq u} \left[\left(\sum_{attr \in soctxt} attr_{u,v} \right) \cdot (\mathrm{pred}(v,i) + p_v) \right] \quad (2)$$

Where $soctxt$ is the set of the 8 social context attributes in the social network, $attr$ is a social context attribute value rated by user u to user v. As in the previous equation, p_v is the personality value of user v

For both types of social context-aware recommenders, group predictions are generated according to the 3 aggregation strategies: Average, Least Misery, and Most Pleasure. For the Dictatorship strategy, the social context is not used to generate single user predictions, instead they are generated, as for the baseline recommender, using the single-user Item-item collaborative filtering algorithm. The group prediction is calculated as the dictator's predicted rating for the item. The social context attributes are then used to elect the dictator. For example: if the Dictatorship recommender is based on the social context attribute "domain expertise", then the dictator of the group will be elected as the group member with the highest total domain expertise value as rated by the other group members.

We used our group recommendation platform to build and evaluate 38 different group recommender systems. They represent the combination of recommendation algorithms based on different social context attributes and aggregation strategies. They are classified as follows: The baseline recommender, 8 social context-aware recommenders based 8 different individual social context attributes, and a full social context recommender based on the aggregation of the individual social context attributes. Each of those algorithms is combined with the 3 different aggregation strategies: Average, Least Misery, and Most Pleasure. For the Dictatorship aggregation strategy, only the individual social context recommenders are combined with it and they are compared with a baseline item-item collaborative filtering recommender that uses the Average aggregation strategy.

IV. Experimental Setup

We set up an experiment using our social networking and restaurant rating platform with the goal of building a dataset of restaurant ratings both from individuals and groups and capturing the participants' social contexts. The dataset serves as the ground truth against which we can evaluate our social context-aware group recommenders.

Our experiment participants are the students of the Social Computing class offered by the department of Informatics at the Technical University of Munich [24]. We asked our students to participate in the experiment as part of the course activities so that the students could test social computing concepts using their "own" data. The experiment consisted of the 4 following phases: In Phase 1, the students register to the social networking and the restaurant rating platform and answer the TKI personality questionnaire. In Phase 2, we asked the students to use the platform's restaurant search tool to choose and rate restaurants as individuals. We instructed the students to balance their selections between restaurants they favoured and those which they didn't have good experiences with. In phase 3, we asked the students to form groups among themselves, and use the platform's user evaluation tool to evaluate their co-group members. These evaluations are elements of the social context as discussed below. During the same phase, we encouraged the students to invite external participants to the experiment, e.g. their family members, partners, relatives and friends. The external participants were also asked to answer the personality questionnaire, rate restaurants as individuals, and evaluate other users - normally the members of their inviting students' groups- according to the social context attributes. In phase 4, the students were instructed to create the groups – they already formed offline - in the platform. The students were instructed to sit together, choose and rate restaurants collaboratively as a group using the restaurant search and rating tools. The group restaurant ratings are entered into the tool by the group master, which is a role that any group member can assume. Students formed groups with the external participants whom they invited to the experiment, this constellation resulted in two types of groups and restaurant ratings.

Internal Groups: are the groups that exclusively consist of students. Since the number of participants in this class is rather large and the students do not necessarily know each other very well, these groups are characterized by relatively weaker social ties or weaker long-term social contexts. The second type is the *External Groups*, which are the groups that contain both class students and external participants. Stronger social ties between the groups' members or stronger social contexts generally characterize this type of groups. We isolated external groups in our analysis to evaluate the effect of stronger social contexts on the social context-aware recommenders results.

Each phase of the experiment's 4 phases lasted for about one week. The overall number of participants was: 363. 178 participants were students and the rest were externals. 246 of them were males and 117 females. Participants were from 37 different countries; 235 participants were from Germany (about 64.5%). 356 of the participants submitted their birthdates, among them, 101 participants were less than 25 years old, 171 participants aged between 25 and 35 years, 4 participants were between the age of 35 and 45, and 80 participants were older than 45 years. 340 participants (about. 93.7%) have answered the TKI personality questionnaire. The participants submitted 1480 individual restaurant ratings. 137 groups were created, 45 of them were students' groups (internal groups) and the rest (92) were external groups which contain both students and the students' external invitees. The maximum number of participants per group is 5, the minimum is 3, and the average group participation is 3.2 participants. The groups submitted 656 restaurant ratings, where 218 ratings were submitted by internal groups, and 438 ratings by external groups. The anonymized dataset we gathered from the experiment consisted of the following:

Personality Data: The participants' TKI personality test scores. Each record consists of a user Id and a personality score with the value between 0 and 1. The smaller values describe more cooperating personality types while higher values describe more competing ones. The mapping of the TKI questionnaire answers single value on the cooperativeness-competitiveness scale was presented in a previous work [25] and is implemented according to Recio-Garcia et al. algorithm [26].

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Social Contexts Data: Captures the participants' social context, as it contains the user-to-user ratings values according the 8 different social context attributes. Each record consists of two attributes: from (user Id) and to (user Id) which indicate the rating direction. The values of the social context attributes are in the range from 0 to 1. As mentioned earlier, the social context attribute "relationship" is presented as a free text field. We manually mapped the textual descriptions to values between 0 and 1. To do that, we clustered all the textual descriptions entered by the users into 8 different categories. We assigned each category a value between 0 and 1. The higher the value the more intimate is the relationship. We mapped each of the user descriptions to one of the 8 categories and therefore a numerical value. The categories are:

- *Unknown:* A person barely known. Value: 0
- *Adversary:* A person identified as a competition by the rating person. Value: 0
- *Acquaintance:* Value: 0.25
- *Strong Acquaintance:* A person who is well known or admired by the rating user, yet is not considered a friend. Value: 0.5
- *Friend:* Value: 0.5
- *Close Friend:* Value 0.75
- *Partner:* Life partner or spouse. Value: 1.0
- *Family:* Family member. Value: 1.0

Individual Ratings: Contains the restaurant ratings by individual participants. Each record consists of a user Id, restaurant Id, and a single valued restaurant rating between 0 and 5. The rating value is calculated as the average of the 7 numerical restaurant rating metrics values described earlier. *Group Ratings:* Similar to the individual ratings, but for groups. Each record consists of a group Id, restaurant Id, and a single valued restaurant rating. *User/Groups:* Contains the membership information of users in the groups. Maps user Id to a group Id. We ran our group recommender algorithms both on the full dataset and on the external group ratings dataset. The next section provides a detailed description of our experimental results..

V. Experimental Results

We compare the results of our social context-based group recommenders with a baseline item-item collaborative filtering group recommender. For both types, we experimented with 4 different aggregation strategies: Average, Least Misery, Most Pleasure (Maximum Satisfaction), and Single-User (Dictatorship).

For the social context-based group recommendation, we built a group recommender based on each of the social context attributes separately and compared each with the baseline using the restaurants' dataset. We built a social context recommender based on the aggregation of all the social context attributes and we call it the *full social context recommender* and compared it to the baseline. We ran the full social context recommender on two different datasets: the full dataset and the external groups' dataset. As explained earlier, the latter dataset is characterized by stronger social relationships.

Since recommendation is often interpreted as a ranking problem [27], we chose classification metrics and ranking metrics to compare our recommenders. We used 3 different evaluation metrics to compare the results: Precision@n, and Recall@n as classification metrics, and the Normalized Discounted Cumulative Gain (NDCG) as a ranking metric. We define "n" as the number of the recommended items, and we ran the recommenders and evaluated the results for 4 different values of n: 100, 10, 5, and 3.

The NDCG takes into account the order of the item in the recommendation list so that the items that appear lower in the recommendation list have less relevance value compared to those that appear on the top [27]. We used the DCG implementation in the Lenskit package [21]:

$$\mathrm{DCG@n}(g) = \sum_{i=1}^{n} \frac{r_{gi}}{\log_2(1+i)} \tag{3}$$

Where g represents the group for which the recommendation list is generated, *i* is the ith recommended item, *n* the number of recommended items, *rgi* the predicted rating of item *i* for the group g. The normalized discounted cumulative gain is calculated by comparing the DCG to the ideal DCG represented by the ordered list of favourite items by the group according to the groups actual rating list, which is shown by the following equation: [27]

$$NDCG@n(g) = \frac{DCG@n(g)}{iDCG@n(g)} \tag{4}$$

The Precision@n is calculated as the ratio between the number of relevant items in the recommendation list to a group and the total number of recommended items. It is calculated as follows [27]:

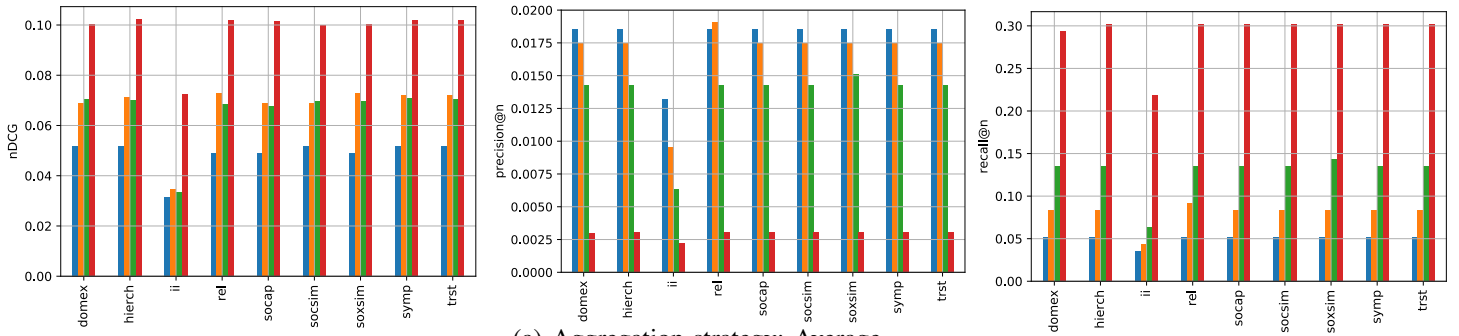
$$\text{precision@n}(g) = \frac{\text{predicted }_n(g) \cap \text{ relevant } (g)}{n} \tag{5}$$

And finally, the Recall@n is calculated as the ratio between the number of relevant items in the recommendation list to a group and the total number of relevant items for that group. The following equation shows how Recall@n is calculated [27]:

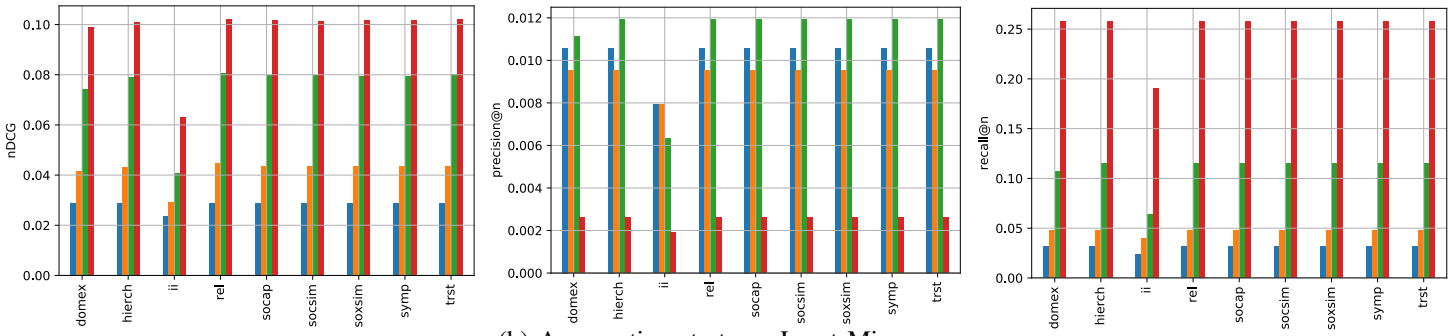
$$\text{recall@}n(g) = \frac{|\text{predicted}_n(g) \cap \text{relevant}(g)|}{|\text{relevant}(g)|} \tag{6}$$

For both Precision@n and Recall@n, the set of relevant items $relevant(g)$ are the items that were actually rated by the group.

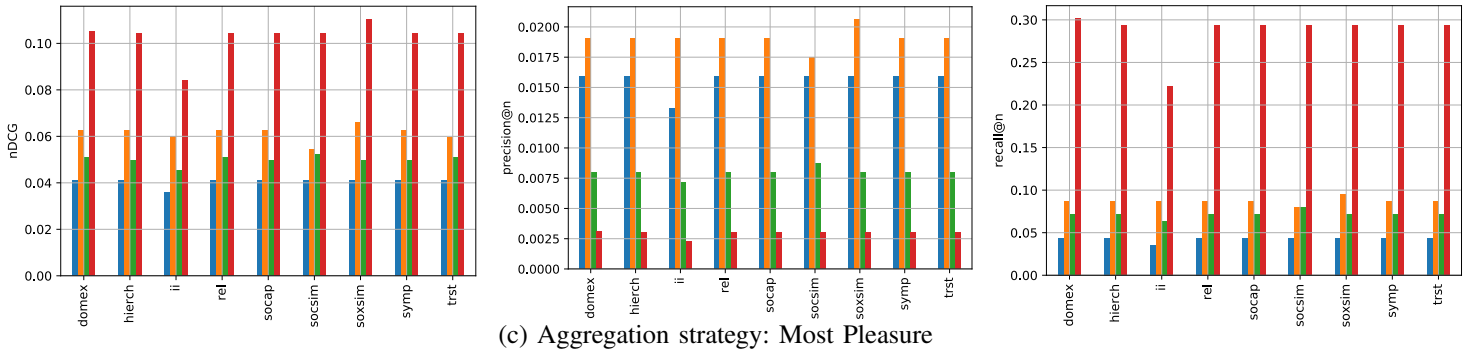
Figure 4 shows the results of comparing individual social context attributes-based group recommenders to the baseline using each of the aggregation strategies. The social context-based recommenders are named after their corresponding social attributes: domain expertise (domex), social hierarchy (hierch), relationship (rel), social sapital (socap), social similarity (socsim), social context similarity (soxsim), sympathy (symp), and trust (trst). The baseline recommender (ii) is named after item-item collaborative filtering. The social context-based recommenders outperform the baseline for all the metrics for all the aggregation strategies except for the Dictatorship strategy where the performance of the baseline is comparable to the social context recommenders. At n=10, however, the social context recommenders still outperform the baseline for the Dictatorship strategy. While we cannot conclude that there is one social context attribute that consistently outperforms all other attributes for all metrics and for all strategies,



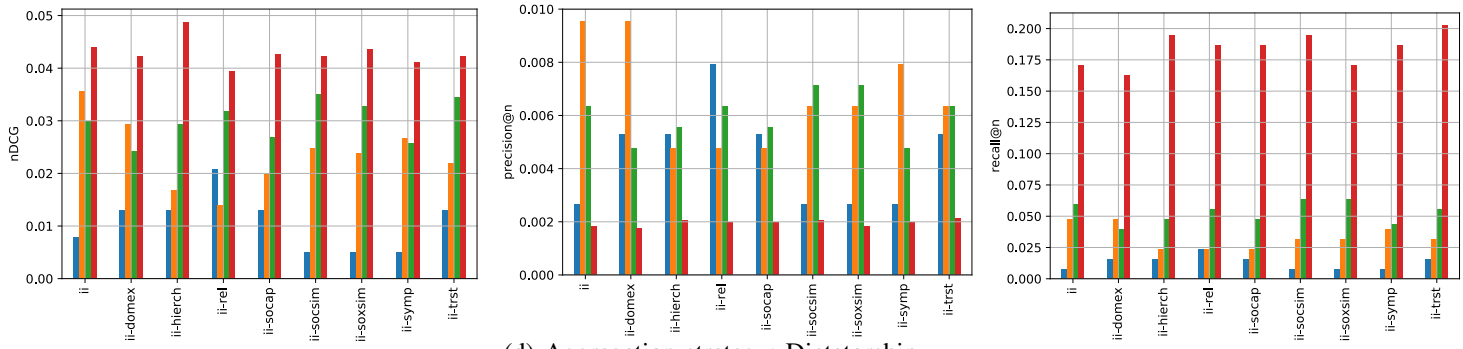
(a) Aggregation strategy: Average



(b) Aggregation strategy: Least Misery



(c) Aggregation strategy: Most Pleasure



(d) Aggregation strategy: Dictatorship

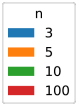


Figure 4. nDCG, precision@n, and recall@n resulting from group recommenders based on the baseline item-item collaborative filtering algorithm and the prediction algorithms based on 8 social context attributes. Group recommendations are generated based on the aggregation strategies: Average, Least Misery, Most Pleasure, and Dictatorship

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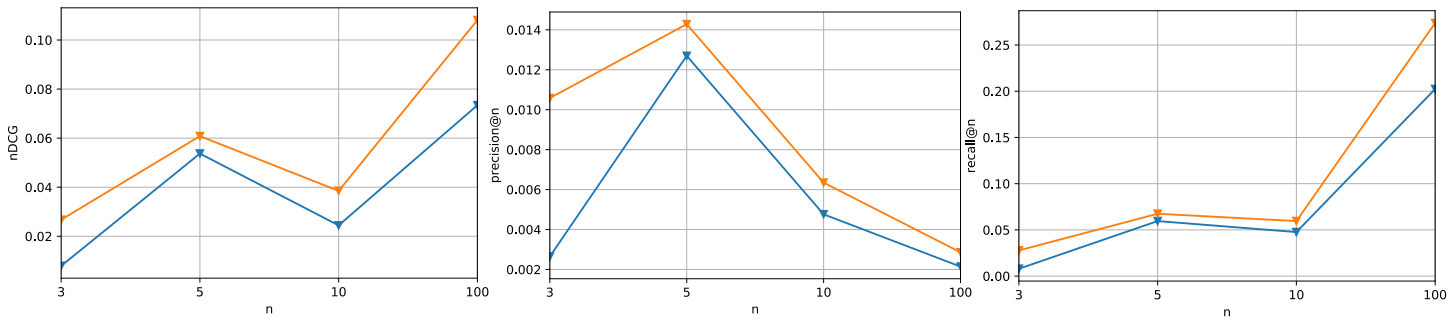
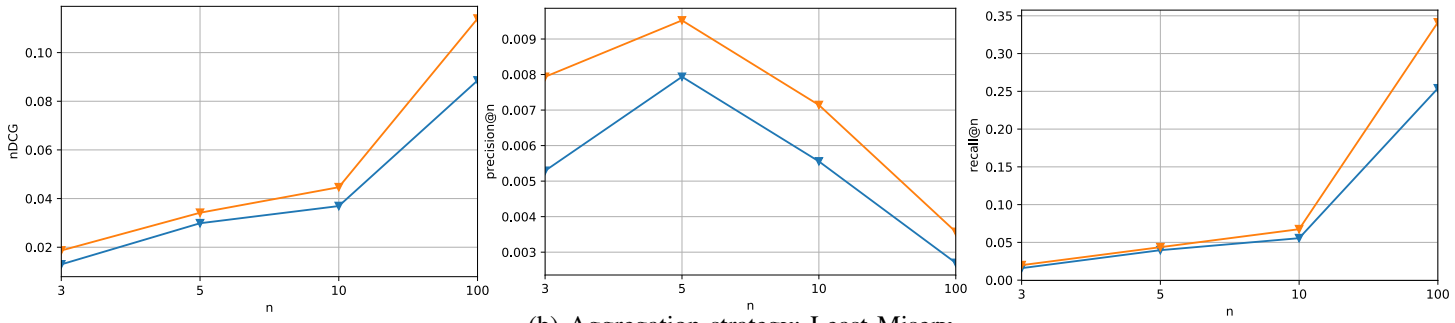
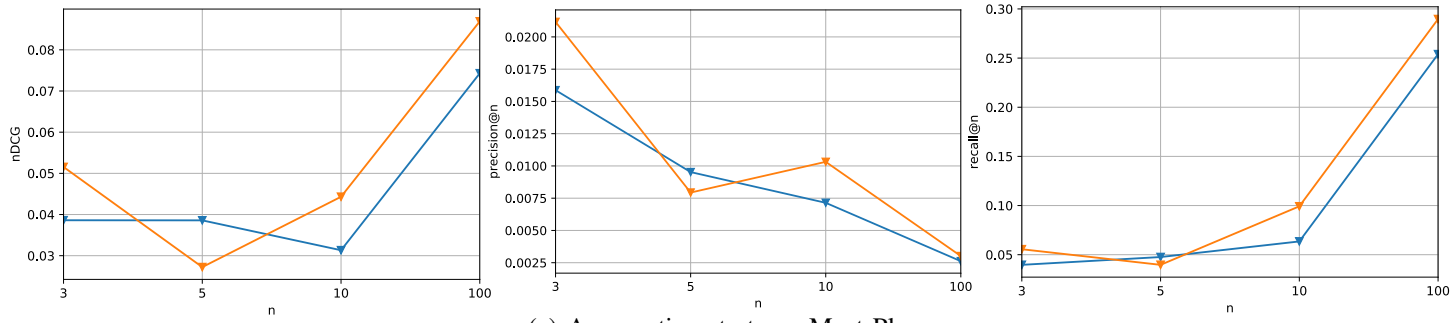


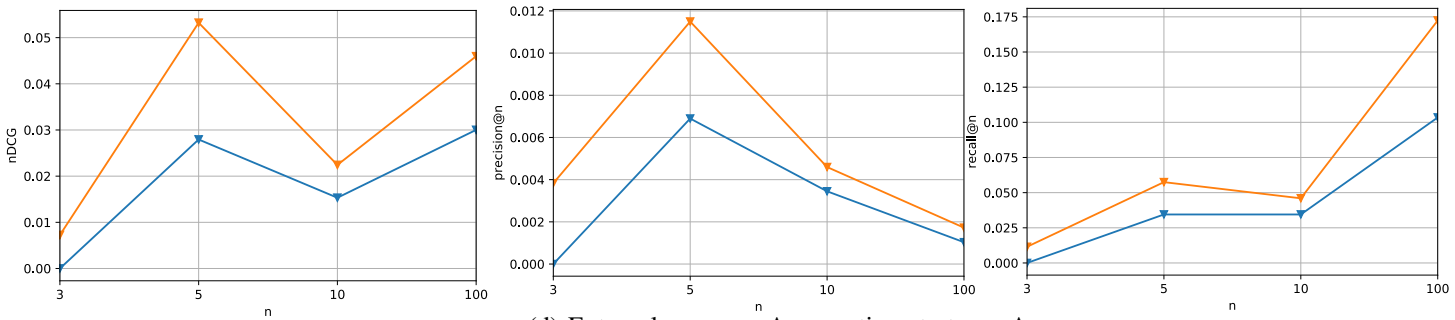
(a) Aggregation strategy: Average



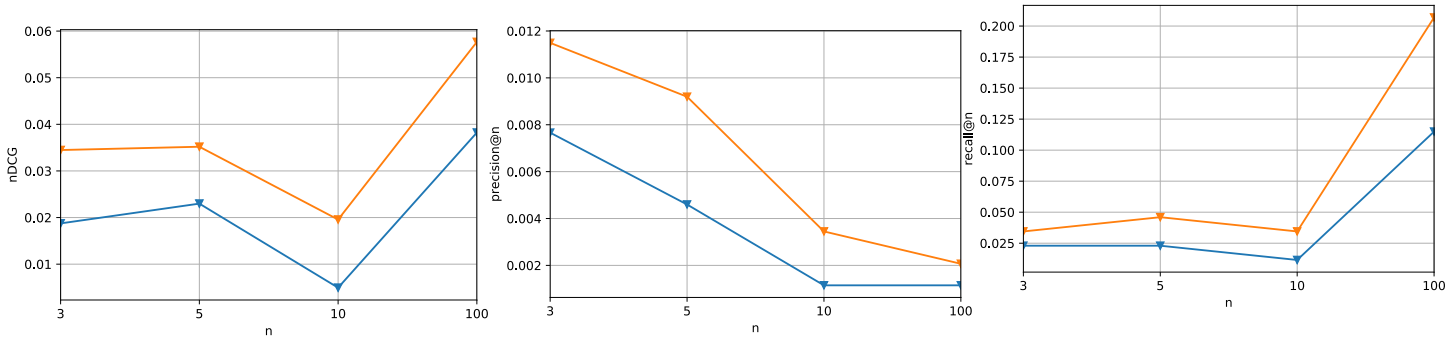
(b) Aggregation strategy: Least Misery



(c) Aggregation strategy: Most Pleasure



(d) External groups - Aggregation strategy: Average



(e) External groups - Aggregation strategy: Least Misery

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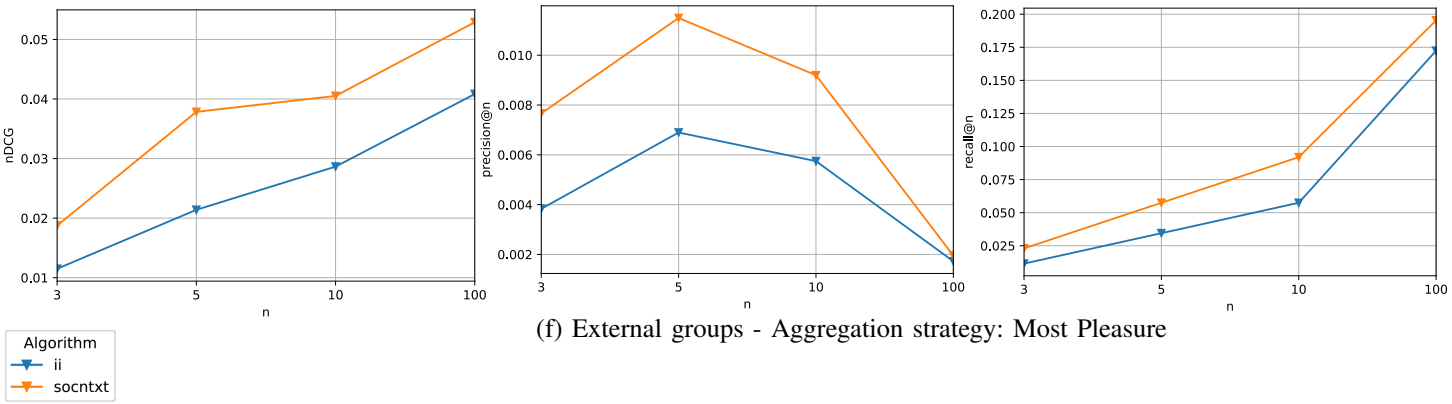

(f) External groups - Aggregation strategy: Most Pleasure

Figure 5. nDCG, precision@n, and recall@n resulting from group recommenders based on the baseline item-item collaborative filtering algorithm and the full social context prediction algorithm. Group recommendations are generated based on the aggregation strategies: Average, Least Misery, and Most Pleasure. Sub-figures a, b, c are the results of the full dataset, and sub-figures d, e, f are the results of the external groups' dataset

the noticed trend is that trust and relationship-based social context recommenders are generally performing better than the other recommenders. One of them is among the top 3 performing algorithms with respect to the average values of NDCG, Precision@n, and Recall@n for all values of n and for all aggregation strategies. The social context similarity-based recommender has on the average the best values of all metrics for the Most Pleasure aggregation strategy. And we notice that for the Dictatorship strategy, the baseline's average NDCG value is higher than all that of the social context-based recommenders and it ranks third for the average Precision@n.

Figure 5 compares the *full social context recommender*, which is based on the aggregation of all the social context attributes, to the baseline recommender. The evaluation is for both the full data set Figure 5 (a, b, c), and for the subset of external groups (d, e, f). For both datasets, the *full social context recommender* consistently outperforms the baseline for almost all aggregation strategies at all values of n. The only exception is for the full dataset with the Most Pleasure strategy at n=5 where the baseline outperforms the *full social context recommender* for all the metrics. For the full dataset, the *full social context recommender* with the Average aggregation strategy performs better than all other strategies with respect to the average NDCG, precision@n, and recall@n for all values of n. It is also the most outperforming *full social context recommender* compared to the baseline with 57.16% higher average NDCG, 72.41% higher average precision@n, and 57.83% higher average recall@n.

For the external groups' dataset, the *full social context recommender* with the Most Pleasure aggregation strategy has the best metrics values by comparing the average NDCG, precision@n, and recall@n for all n values. In terms of outperforming the baseline, the *full social context recommender* based on the Average aggregation strategy performs best with 75.87% higher NDCG, 90.23% higher precision@n, and 66.67% higher recall@n. We notice that the outperforming percentages of the full social context recommenders for the external group's dataset compared to the baseline are significantly higher than those for the full dataset. This behaviour is consistent with our hypothesis that for groups characterized by stronger relationships, the social context influence on the results of group recommendation is relatively stronger.

VI. Conclusion and Future Work

In this paper, we presented a platform that incorporates the long-term social context in group recommendations. The presented platform allows to easily configure, implement and evaluate social context-aware recommenders using different social choice theory aggregation strategies. We also present a social networking and restaurant rating platform using which we raised an experimental dataset of individuals and group ratings of restaurants. The dataset also includes the participants' long-term social contexts by allowing them to evaluate each other according to different social context attributes.

While previous research shows the influence of social factors such as trust and behavioural factors such as the personality type on group recommendation quality, in our research we investigated 8 different social context attributes together with the personality type. We examined the effect of each attribute alone on the recommendation quality and also aggregated the 8 attributes together in what we call the full social context. Our analysis shows the superiority of the social context-aware recommenders in general over a baseline recommender. This was proven both for the *individual social context attributes-based recommenders* and for the *full social context-aware recommender* using most of the group recommendation aggregation strategies. We evaluated the group recommenders on the full dataset, and on a subset of groups characterized by more intimate relationships. We prove that for the latter dataset where the group members have stronger social contexts, the influence of the long-term social context on the quality of group recommendation is even stronger.

As a future work, we intend to continue exploring the contribution of the social context to group recommendation by studying the effect of short-term social context. We intend to build a solution that detects the group members spatial-temporal social situations before the recommendation act. It will also allow the system to interactively get users feedback on the results. Such a setup will enable us to build a larger and denser ground truth dataset The incorporation of both long-term and short-term social contexts into group recommendation as well as the live user feedback will help to build a more real-life application and will allow for a larger study of the social context contribution to the group recommendation.

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