A Field Study on Real-time Self-reported Emotions in Crowds

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***Abstract* – Crowd experience is inevitable in daily life. Crowd managers need tools to accurately estimate the psychological aspects of crowds, an important one being crowd emotion. In this study, we explore the feasibility of obtaining a real-time, dynamic map of crowd emotions through self-reporting by crowd members. To this end, a smart phone application "*EmoApp*" was developed. *EmoApp* allows users to report their emotions without interfering with their on-going activities. We conducted a field study to test *EmoApp* in a music festival. The collected data revealed that the users' movements and emotional changes were consistent with the activities at the festival. This suggests that a majority of the users reported their real emotions. The paper also discussed several aspects of emotion detection, namely, privacy protection, reliability of self-report method, accuracy of positioning users and user-friendliness of the application design. This study is part of the on-going research in understanding the psychological aspects of crowds.**

***Index Terms* – Crowd emotion, crowd management, real-time emotion, self-reported emotion.**

I. INTRODUCTION

Crowd management has been increasingly gaining attention both from academia and business in recent years due to the rapid population growth in big cities and the prevalence of events with a mass of people. Crowd experiences are inevitable in daily life. In a previous study, we interviewed ten crowd experts, most of whom made a plea for developing tools to accurately estimate the psychological aspects of crowds, e.g. crowd emotions or moods [14], since emotion serves as a predictor for human behavior [12]. Several studies clearly indicated that crowd emotion is contagious [2, 6, 11, 13]: meaning that both positive and negative emotions can spread rapidly over a crowd. For example, the ceremony of the Dutch Dodenherdenking (Remembrance Day) in 2010 was disrupted by a person's loud scream, resulting in a panicked stampede among the crowd of 20,000 people. In the audience of the 1986 Mexico World Cup, the excitement was passed on in the famous La Ola audience wave [4]. Through perceiving other people's emotions, people can judge their intentions and predict their behavior so as to act accordingly [12], e.g., most people would want to flee from a crowd when they sense negative emotions, but may like to stay in a crowd with a happy atmosphere. Thus, it is crucial for crowd managers to understand crowd emotions in real time in order to act appropriately.

To date, most crowd management teams have installed video cameras above the crowds for detecting suspicious behavior. Unfortunately, a majority of these surveillance cameras are not automated, and require crowd managers to constantly examine the crowd scenes on dozens of monitors to keep track of the situation [14]. In addition, crowd managers hire security personnel who stay in the crowd to assist in detecting misbehaving crowd members [1]. Such methods are not very efficient and are prone to human error, especially when the crowd size gets bigger. Crowd managers can only observe the crowds from an external point of view. This outsider's view tends to induce managers to put all their effort on monitoring the physical changes, i.e. changes in crowd density and behavior. Crowd members' psychological needs, such as feeling welcomed by a group or feeling respected and taken care of may be overlooked.

Ideally, one would sense the emotions of a crowd from inside the crowd, e.g., by placing sensors on crowd members to measure their emotions automatically. However, for technical and ethical reasons, such solution is not realistic at the moment. As an alternative, this study intends to bring the state-of-the-art one step further by encouraging crowd members to report their emotions via a smart device, such as a smart phone. From these self-reports, we would like to obtain a real-time, dynamic map of crowd emotions to enable crowd managers to rapidly perceive emotional changes.

In this study, we address two research questions: 1) what are the criteria for developing a tool for self-reporting emotions in a fast way without interfering with the activities in the crowd, and 2) how will this tool be used to collect valid reports from crowd members? In order to find answers to these questions, we developed a software program called "*EmoApp*" to allow users to report their current emotion along with their location. The software adds a time stamp as well as the user's unique phone ID to every report. To motivate individuals to use this self-reporting tool, we designed a user-friendly graphical interface along with a playful rewarding mechanism. We tested *EmoApp* with 78 crowd members in a music festival. The collected data revealed that the users' movements and emotional changes were reasonably consistent with the activities at the festival. Furthermore, this experiment also provided valuable insights for developing the self-report tool further.

The remainder of the paper is organized as follows: Section 2 introduces the design of the self-report tool. Section 3 presents the field study. The paper finishes with discussion and conclusion on the lessons learned and some open issues (Section 4).

II. *EMOAPP*: A TOOL FOR COLLECTING SELF-REPORTED DATA

Since most people own a smart phone today, developing a self-report tool in the form of a smart phone application is more feasible and lower in cost compared to alternatives such as wearable sensors as used in the study by Roggen and his colleagues [17]. In the following paragraphs, we present the requirements for the data collection, and give the design details of this smart phone application, *EmoApp*. Our goal was to collect emotion data from crowd members without abruptly interfering with their activities. For our measurements, we defined the tuple <ID, location, time stamps, emotion> to be sent by each smart phone to a central server. Here, ID is the unique identifier of the smart phone. Location is the physical location of the user, which is defined by two inputs: the user's self-report on a festival map shown on the *EmoApp* (Fig. 1, left-hand panel) and position information based on WiFi signals, with an accuracy of approximately 20 meters. The combination of these two inputs enables the location information to be more accurate, e.g. excluding users who used *EmoApp* outside the festival. As time stamp, we used the digital recording of the time of sending the data to the server. Emotion is the real-time self-reported emotion of the user.

Four types of emotions were applied in this study, adapted from Russell's emotion dimensions [18].

1) Positive-active emotion, such as happy and excited,
2) Positive-passive emotion, such as calm and relaxed,
3) Negative-active emotion, such as angry and frustrated,
4) Negative-passive emotion, such as bored and tired.

While collecting the above-defined tuple from the individuals, we also made sure that the following requirements were met.

Usability. The interface design of *EmoApp* should allow users to intuitively know how to operate it once they installed it, as well as to have the report done within a few seconds. Here, intuitive use refers to the user's subconscious application of prior knowledge [8], like intuitively turning the tap head counter-clockwise to get tap water, and sliding to unlock our smart phone.

Non-intrusiveness. Users should be able to report via *EmoApp* with minimal effort and this should not interfere with their activities in the crowds.

Attractiveness. The *EmoApp* should be aesthetically appealing to the users through a user-friendly interface design and game-like components, such as rewards.

Since Russell and Pluntchik both proposed circumplex models of emotions [16, 18], we decided to apply a circular interface in *EmoApp*, with cartoon characters that can explicitly express the four types of emotions (see above). Two user studies were conducted to inform the interface design: one for defining the positions of the four emotions on the circular interface, the other for verifying that the emotion characters successfully conveyed the intended emotions [15]. Fig. 1 illustrates the circular interface with the designed cartoon characters.

Reward is a key strategy in game design, attracting people to participate [5]. Besides the aesthetically appealing interface design, we rewarded *EmoApp* users with free drinks at the festival. The participants immediately received a free drink once they successfully installed *EmoApp*. A virtual cup would be gradually filled up after each report (Fig. 1, right-hand panel). They could redeem a second free drink when the cup was full after three reports.

Fig. 1 *EmoApp* interfaces.

III. Field Study

In order to test whether *EmoApp* could measure emotions of individuals in crowds and whether we would be able to construct a real-time, dynamic emotion map based on the reports from crowd members, we carried out an experiment at a summer music festival.

A. Setting

The experiment was conducted in a summer music festival at Delft University of Technology, which started June 14 at 9:00pm and ended June 15, 2013 at 6:00am. A total of 78 visitors used *EmoApp*, approximately 10% of the crowds. The procedure included four steps.

1) The participants downloaded and installed the application, which took 30 seconds to 4 minutes depending on the versions of their smart phone systems. They immediately received a free drink as a reward.

2) Each half an hour the app would prompt the participants to indicate their location on a simplified festival map consisting of the six major areas: water stage, entrance square, entrance hall, i.d kafee, studio and main stage.

3) The participants were also prompted to report their emotions at that moment.

4) A virtual cup would gradually fill. Participants could redeem a second free drink when the cup was 100 % filled. They would receive another signal to report in 30 minutes after the last report. The free drink offer stopped at 3:00am.

B. Results

We received a total of 306 valid reports during the festival. Most of the emotion reports came from two areas: the entrance square and the main stage area, which were the two most crowded areas in the festival. In general, the amount of reports per location was representative of the crowd size at that location, but not always. For instance, although the estimated crowd size in the main stage area was larger than that in the entrance square area, the amount of reports in the former location was fewer than in the latter one.

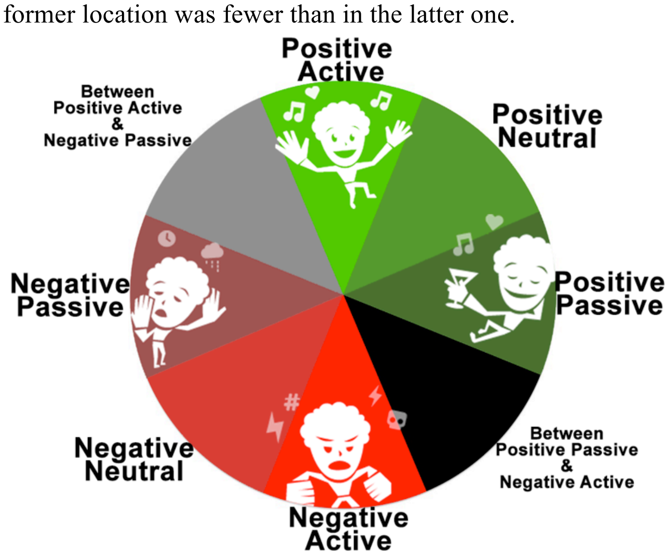

Fig. 2 Eight categories of reported emotions.

We divided the 9-hour festival into 18 half-an-hour time slots, since each participant could only report once every half an hour. The accuracy of the emotion data collected from the circular interface was 10 degrees. We classified them into eight categories as shown in Fig. 2: positive active (PA), positive neutral (PN), positive passive (PP), between PP and NA, negative active (NA), negative neutral (NN), negative passive (NP), between NP and PA. Notice that the black and grey slices are paradoxical, as they represent an emotion state between two distinct ones: positive-passive and negative-active, as well as negative-passive and positive-active. Nevertheless, we still received some reports from these two categories (about 7 %).

We obtained an emotion map of each time slot, where map refers to the six areas. Fig. 3 shows examples of emotion maps based on self-reported emotions of three time slots. Each big square represents a location of the festival, and each colored small square represents one emotion report of a user. As participants did not respond to the prompt for reporting their emotions in all cases, the number of reports per time slot does not add up to the total number of 78 participants. The maps clearly show that the amount of reports in the main stage area increased during the time slot 01:30-02:00 but decreased sharply at 02:00-02:30. At the same time, a few more negative emotions popped up since 01:30.

Zooming in on the users who gave at least eight responses, we were able to track their emotion changes in relation to their locations. Take two users as examples (see Fig. 3): User 1 reported a positive neutral emotion at 01:00-01:30 when at the water stage, then he moved to the main stage during 01:30-02:00 and reported an emotion in between NP and PA. During 02:00-02:30, he went to i.d kafee and felt NP. User 2 did not report during 01:00-01:30. He showed up at entrance square during 01:30-02:00 and reported a PN emotion. Later, he moved to main stage and felt NA in between 02:00-02:30.

IV. Discussion and Conclusions

We developed a list of requirements for collecting emotions from crowd members: 1) usability, 2) non-intrusiveness and 3) attractiveness. The *EmoApp* we developed fulfilled these requirements. The users largely accepted the circular interface and the free-drink rewards, and found the *EmoApp* useful and accessible. A lot of them continued reporting even after the free drink offer stopped at 03:00. The collected information reflected the real situations as we observed it. For instance, people's movements and emotional changes were consistent with the activities at the festival. This made us confident that a majority of the users reported their real emotions.

A. Lessons learned

Feedback about the interface design. In general, users were positive about *EmoApp*. They felt more aware of the surroundings. They were also excited about expressing their dissatisfaction about bad performances at some moments during the festival. Furthermore, the gradually filled virtual

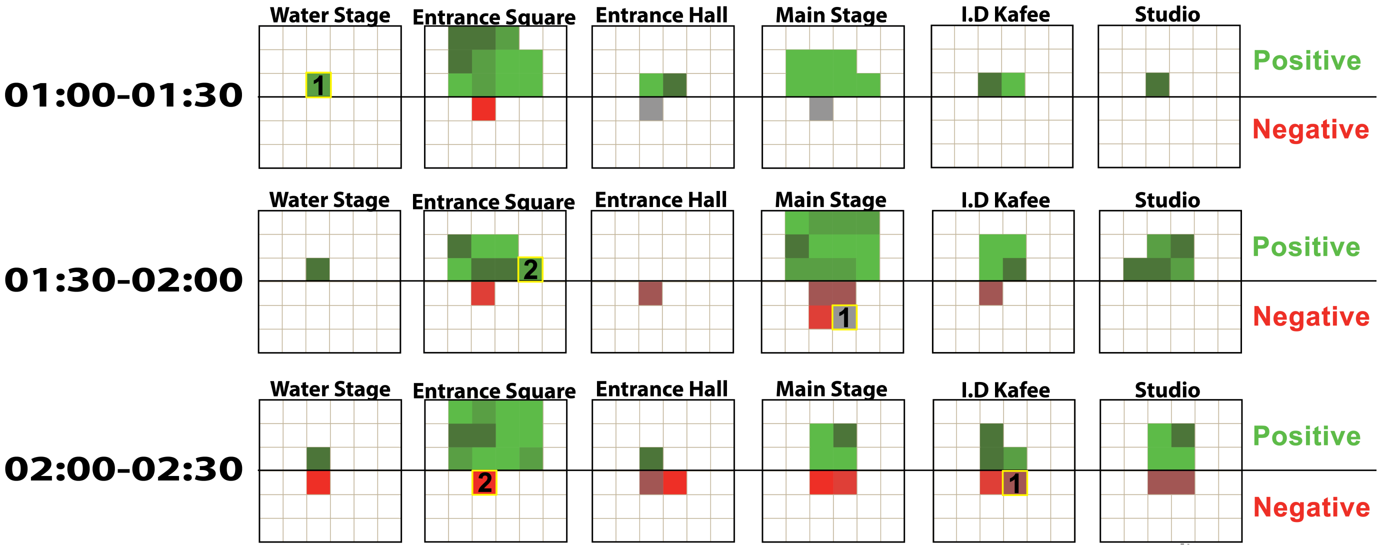

Fig. 3 Emotion maps of three time slots.

cups felt like winning a game, which even made them more excited than actually getting a free drink. On the other hand, we are concerned about the framing effect of this reward mechanism, which might bias the users' judgment of emotions [19].

Mixed emotions. 75 % of the responses were in the positive categories and 18 % were in the negative categories. The remaining 20 reports fell into the paradoxical emotion categories: the black and grey categories in Fig. 2. These categories may be interpreted as mixed emotions. Several studies indicated that happiness and sadness can co-occur [7, 10, 20]. So-called bittersweet situations can make people feel mixed: people have to leave the festival, so they feel sad; however, at the same time, they feel happy as well since they have enjoyed this festival very much. This probably can explain why the users report in this way.

Most crowded area is not always receiving most reports. Even though we could roughly estimate the crowd size of an area based on the amount of reports, the area with the highest number of reports was not necessarily the most crowded area. For instance, the entrance square area was much less crowded than the main stage area, but we received 44% more reports in the former place. The possible explanation is that the entrance square area had many sofas and was less noisy than the main stage area. Probably people felt more relaxed there, and then tended to check their mobile phones and use *EmoApp*. At the main stage, people were engaged with dancing and the performances on the stage, so the probability to play with their mobile phones and notice the prompts for reporting declined.

B. *Open issues*

Privacy. Since *EmoApp* can track users by their location defined by a WiFi positioning system during and even after the events, many users were concerned that *EmoApp* would invade their privacy. Moreover, in other cases, users could worry about their privacy when such an application links their identity to their reported emotions. For example, this could especially be true when the event involves political or personal issues such as a demonstration where some people want to stay anonymous and conceal their identity. Invading privacy can bring another problem: it increases the chance that users send false data in the self-reports. Fan et al. [3] pointed out that "inaccurate responders" (e.g., provide false responses due to confusion) and "jokesters" (e.g., provide intentional false responses due to fun or privacy concerns) do exist in self-report studies, which may seriously bias the results if the sample size is not large enough. Notice that in our study, mostly statistical data are considered rather than individual data. Therefore, scientific solutions that hide the individual data from the data collector can be deployed. One such approach is to use cryptography-based solutions [9], but this approach requires more computational resources since computations have to be performed on encrypted data. We leave such a privacy-preserving emotion detection mechanism for future work.

Location accuracy. Creating more precise emotion maps is another goal of our future work, which requires improving the accuracy of the positioning system. The system we applied in this study could achieve a maximal accuracy of 20 meters indoors, which would drop dramatically to 700 meters when the users were outside. Due to this inaccuracy of the positioning system, users were asked to indicate their locations on the *EmoApp*, which introduced an additional step in using the application. This reduced the respond speed of each report. Accurate location information is necessary particularly for managing crowds in real time: i.e., the organizers and emergency staff should be able to detect and react to incidents as quickly as possible. However, there is a technological challenge in terms of determining the exact location of individuals with current devices, but if that becomes feasible, then we face another issue: knowledge of people's exact locations can be privacy threatening. This introduces a dilemma, which requires substantial research in the future. One emphasis in the future studies must be on providing proper privacy protection to boost the trust among users and improving self-reporting of emotions further in term of usability.

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REFERENCES

[1] J. L. Abbott and M. W. Geddie. Event and venue management: Minimizing liability through effective crowd management techniques. *Event Management*, 6:259–270, 2001.

[2] C. A. Bartel and R. Saavedra. The collective construction of work group moods. *Administrative Science Quarterly*, 45:197–231, 2000.

[3] X. Fan, B. C. Miller, K.-E. Park, B. W. Winward, M. Christensen, H. D. Grotevant, and R. H. Tai. An exploratory study about inaccuracy and invalidity in adolescent self-report surveys. *Field Methods*, 18(3):223–244, 2006.

[4] I. Farkas, D. Helbing, and T. Vicsek. Mexican waves in an excitable medium. *Nature*, 419(6903):131–132, September 2002.

[5] J. Hamari and E. Veikko. Framework for designing and evaluating game achievements. In *Proceedings of Digra 2011 Conference: Think Design Play*, Hilversum, The Netherlands, September 2011.

[6] E. Hatfield, J. T. Cacioppo, and R. L. Rapson. Emotional contagion. *Current Directions in Psychological Science*, 2(3):96–99, June 1993.

[7] P. G. Hunter, E. G. Schellenberg, and U. Schimmack. Mixed affective responses to music with conflicting cues. *Cognition and Emotion*, 22:327– 352, 2008.

[8] J. Hurtienne and L. Blessing. Design for intuitive use-testing image schema theory for user interface design. In *Proceedings of International Conference on Engineering Design*, ICED'07, pages 386–397, Paris, France, August 2007.

[9] R. Lagendijk, Z. Erkin, and M. Barni. Encrypted signal processing for privacy protection. IEEE Signal Processing Magazine, January 2013 2013.

[10] J. T. Larsen, A. P. McGraw, and J. T. Cacioppo. Can people feel happy and sad at the same time? *Journal of Personality and Socail Psychology*, 81:684–696, 2001.

[11] G. Le Bon. *The crowd: A study of the popular mind*. Batoche Books, Kitchener, Canada, 1896.

[12] R. W. Levenson. The intrapersonal functions of emotion. *Cognition & Emotion*, 13(5):481–504, 1999.

[13] M. Lewis, J. M. Haviland-Jones, and L. F. Barrett, editors. *Handbook of emotions*. The Guilford Press, 72 Spring Street, New York, NY10012, USA, third edition edition, 2008.

[14] J. Li, H. de Ridder, A. Vermeeren, C. Conrado, and C. Martella. Designing for crowd well-being: Current designs, strategies and future design suggestions. In *Proceddings of 5th International Congress of International Association of Societies of Design Research*, IASDR'2013, pages 2278–2289, Tokyo, Japan, August 2013.

[15] J. Li, H. de Ridder, A. Vermeeren. *EmoApp* Experiment on IO Festival 2013. *COMMIT EWiDS Internal Report*, July, 2013.

[16] R. Plutchik. *Emotions and life: Perspectives from psychology, biology, and evolution*. American Psychological Association, 2002.

[17] D. Roggen, M. Wirz, G. Tr¨oster, and D. Helbing. Recognition of crowd behavior from mobile sensors with pattern analysis and graph clustering methods. *arXiv preprint arXiv*:1109.1664, 2011.

[18] J. A. Russell. A circumplex model of affect. *Personality and Social Psychology*, 39(6):1161–1178, December 1980.

[19] A. Tversky and D. Kahneman. The framing of decisions and the psychology of choice. *Science*, 211(4481):453–458, 1981.

[20] P. Williams and J. L. Aaker. Can mixed emotions peacefully coexist? *Journal of Comsumer Research*, 28:636–649, 2002.