Group Situational Awareness: Being Together

Eyal Dim and Tsvi Kuflik

The University of Haifa, Mount Carmel, Haifa, 31905, Israel
dimeyal@cri.haifa.ac.il . tsvikak@mis.haifa.ac.il

Abstract. In many cases, museum visitors come to the museum in small groups of friends or families. Their level of 'togetherness' may be implied by their proximity and interaction. Position proximity is a basic requirement to enable quiet face to face conversation in a museum, while voice communication is an example of interaction. Group 'togetherness' may be measured to serve two purposes: (1) on the micro level, identifying if the group members are currently together or apart, and (2) on the macro level, identifying group characteristics (such as cohesion). This study focuses on the micro level in a museum environment, presenting observations and analysis that intend to set the foundations for automatically measuring and analyzing 'togetherness' among museum visitors.

Keywords: Group Interaction, Group Model, Cultural Heritage, Users Study.

1. Introduction

The museum world is looking for innovative technologies which may enhance their visitors' experience. Bitgood [2] posits that overwhelming percentage of museum visitors come in groups. He sees the social contact as a very important aspect of informal learning settings, and sometimes as the most important part of the museum visit experience. Interaction between visitors is known to enhance the museum experience, deepen the visitors' involvement and increase the intimacy among group members [14]. When people visit the museum in small groups of family or friends, the social context is different from the case of an individual visitor [4]. In the group visit case people share their attention between the exhibits or the guidance (such as labels, audio guides, handheld computers, etc.) and **the other group members**.

There are several questions that need to be answered: (1) what measurements can a system use to be aware of the situation of the group and its members? (2) can a technology be aware of higher level group characteristics (such as 'group cohesion')? (3) interrupt management question: when should an intelligent mobile device intervene during the museum group visit? and (4) what kind of intervention may such a technology apply? This work focuses on the first question in the light of the others, by trying to measure the group 'togetherness'(the term 'togetherness' refers to a social activity which enables mutual sharing of thoughts, feelings, knowledge, wants and needs, among group members), as a required pre-condition for interaction.

There may be several levels of 'togetherness' that a group has for its members and that the members have for one another [5]. Therefore, understanding group 'togetherness' may allow using technology to better support both the group needs and its members' interests. This study identifies social-interaction as a measure that may be used to identify group 'togetherness'. It measures physical proximity as a pre-condition for face-to-face social interaction and conversation. A group may be together or apart, and its group members may join or leave the group. Assuming that the group members use an intelligent mobile device, the application may, for example, provide recommendations to a group member when he/she is not involved in deep conversation with others (free attention); or it may adapt to the group and its members by making recommendations for those group members who are close to each other, neglecting the separated group members interests. If the application has, for example, information about the level of group cohesion, it also may choose to treat the group differently.

Previous studies focused mainly on exploring the possibility to use novel technologies to support individuals visiting the museum, mainly by improving the ways of information delivery [8]. This included adaptation [13], personalization [11] and various additional aspects such as context awareness [3], support of positioning and navigation [9], and visitors' circulation [7]. Several studies dealt with recommendations that may suit most small group members, based on a variety of strategies [6]. Some applications such as Sotto Voce [1], ARCHIE [12], PEACH [16], PIL [10] and AgentSalon [17] were aimed at using collaborative tools like messaging, voice communication and eavesdropping to enable intra group interaction.

This work focuses on basic measurements that may enable group situational awareness in a museum visits setting. It intends to evaluate the possibility of automatically measuring and analyzing the group 'togetherness' based on proximity and interaction of museum visitors. These measurements, in turn, may be used to predict the group behavior and trigger the adaptation of a system to meet the needs of the small group and its members. Prediction of group behavior is important for better group monitoring and situational awareness. It may lead to actions within the current applications or may be shared with other applications and contribute to enhance the museum visitor's experience. Moreover, these initial results may be applied in different scenarios with similar characteristics, such as cultural heritage sites and tourism in general, large exhibitions, and shopping malls.

2. Measuring Visitors Proximity as an indicator for Group 'togetherness'

2.1. Setting and Data collection

Proximity and voice interaction data was collected at the "Yitzhak Livneh-Astonishment" exhibition presented in the Tel-Aviv Museum of Arts, where 142 visitors were observed in 58 groups (Table 1), by their random entry order. There was no human guidance at the exhibition hall, and all visitors of this exhibition did not use any other guidance (written, audio, or other intelligent mobile device). This specific data was collected since it represents obvious group 'togetherness' behaviors. Proximity of group members had one of three states (which was the dominant state during the sampling interval of 1 minute): (i) Separated – all group members are separated (at least two exhibits apart or two meters apart). (ii) Joined – Some group members are together. (iii) Left – All group members left the exhibition. On the average, groups were "Separated" 30.2 percent of the observed visit time. The duration of **Voice interaction** was recorded within each sampling interval of the observation (1 minute). Voice conversation provides better evidence of interaction. Data was collected by observations, but in the future such data may be collected by technologies such as the wearable sociometric badge, which collects location, proximity, orientation, human activities and speech features data [15].

Table 1. Summary of group's characteristics

Group Size	# of Groups Observed				Group Gender		
	Couples	Family (Children under 18)	Family - Other	Friends	Males Only	Females Only	Mix
2	23	2	5	10	1	15	24
3	N/A	6	1	4	0	2	9
4	N/A	3	0	3	0	1	5
5	N/A	1	0	0	0	0	1

2.2. Proximity Measurements Analysis

The sampled proximity data created *proximity patterns,* represented as the vectors of "Joined" and "Separated" states over time. Each vector element has a state for every relevant time step (1 minute), and the state vector has 10 elements (10 observation minutes). The position-proximity patterns can be used to describe the level of 'togetherness' of group members, based on a criterion to decide what it means to be together and what it means to be apart during the group visit. The criterion suggested here is a separation ratio (or its complementary criterion - a join ratio), which operates on the group. Let J be the number of "Joined" periods along the group visit (within the proximity patterns), S be the number of "Separated" periods along the visit, and let JR be the "Join Ratio" and SR be the "Separation Ratio" then: JR is defined by equation 1 and SR by equation 2. Of course this leads to equation 3:

$$JR=J/(J+S)\,. \tag{1}$$

$$SR=S/(J+S)\,. \tag{2}$$

$$SR=1-JR\,. \tag{3}$$

This definition enables reorganization of the "Joined" and "Separated" position proximity patterns as shown in Table 2[1]. Columns 2 through 11 are the minutes of measurement – the cells contain the value of "1" for "Joined" states and the value of "2" for "Separated" states while "0" is used for minutes when the group already "Left" the exhibition. Column 12 presents the SR value and column 13 presents the JR value. Columns 14 through 16 respectively show the "Joined" state-count, the "Separated" state-count and their totals. The proximity patterns generated by the "Joined" and "Separated" vectors have been sorted first by the SR value and then by the time the group was present at the exhibition (equals the total of "Joined" and "Separated" minutes as presented in column 16).

[1] Due to space limitations, only sample of the patterns are presented

Table 2. Adaptation decision based on position-proximity patterns

Group ID	Minute 1	Minute 2	Minute 3	Minute 4	Minute 5	Minute 6	Minute 7	Minute 8	Minute 9	Minute 10	SR	JR	Joined Count	Separated Count	Total Count
29	1	1	1	1	1	0	0	0	0	0	0.00	1.00	5	0	5
46	1	1	1	1	1	1	0	0	0	0	0.00	1.00	6	0	6
49	1	[illegible]	[illegible]	[illegible]	[illegible]	1	1	1	1	0	0.00	1.00	9	0	9
48	2	[illegible]	[illegible]	[illegible]	[illegible]	1	1	1	1	1	0.10	0.90	9	1	10
53	1	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	1	1	2	1	0.10	0.90	9	1	10
35	1	1	1	2	1	1	0	0	0	0	0.17	0.83	5	1	6
57	1	1	1	2	1	1	0	0	0	0	0.17	0.83	5	1	6
43	1	2	1	1	1	0	0	0	0	0	0.20	0.80	4	1	5
4	1	1	1	1	1	1	1	1	2	2	0.20	0.80	8	2	10
21	1	1	1	2	2	1	1	1	1	1	0.20	0.80	8	2	10
44	1	2	2	1	1	1	1	1	0	0	0.25	0.75	6	2	8
40	1	1	1	1	1	2	2	0	0	0	0.29	0.71	5	2	7
30	1	[illegible]	[illegible]	[illegible]	[illegible]	2	1	1	1	2	0.30	0.70	7	3	10
54	1	[illegible]	[illegible]	[illegible]	[illegible]	2	2	1	0	0	0.38	0.63	5	3	8
11	2	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	1	0	0	0	0.43	0.57	4	3	7
15	1	[illegible]	[illegible]	[illegible]	[illegible]	0	0	0	0	0	0.50	0.50	2	2	4
18	2	2	2	1	1	2	1	1	2	2	0.60	0.40	4	6	10
55	1	1	2	2	2	2	0	0	0	0	0.67	0.33	2	4	6
34	1	1	2	2	2	2	2	2	1	2	0.70	0.30	3	7	10
16	2	[illegible]	[illegible]	[illegible]	[illegible]	2	1	0	0	0	0.71	0.29	2	5	7
3	2	[illegible]	[illegible]	[illegible]	[illegible]	2	2	2	2	2	0.80	0.20	2	8	10
23	2	[illegible]	[illegible]	[illegible]	[illegible]	2	1	2	2	2	0.80	0.20	2	8	10
45	1	[illegible]	[illegible]	[illegible]	[illegible]	2	2	0	0	0	0.86	0.14	1	6	7
42	2	2	2	2	2	2	2	2	2	0	1.00	0.00	0	9	9
47	2	2	2	2	2	2	2	2	2	2	1.00	0.00	0	10	10

Joined zone

In between zone

Separated zone

Table 2 is divided into three sections, based on SR (or JR) values: thresholds of SR=0.7 (JR=0.3) for being apart and SR=0.2 (JR=0.8) for being together. These SR/JR thresholds have been selected only for demonstration purposes and need further study to be properly adjusted. However, this example shows how position proximity may be measured and then analyzed for gaining some insight about group 'togetherness'.

Even though it seems that position proximity may help in understanding groups, what if group members in close proximity do not interact at all? This is where voice interaction comes into play. The *voice proximity* is based on a threshold for cumulative duration of conversation within each predefined time measurement period (a minute in this case). For example, if the threshold is set to 10 seconds, a group having 15 seconds of conversation within a minute, is considered "Joined" (15 > 10 seconds), and a group having 5 seconds of conversation within a minute is considered "Separated" (5 ≤10 seconds). By setting such a Voice Duration Threshold (VDT) we can select our definition for quantified interaction. In addition we exchange the position proximity patterns above with voice proximity patterns, based on "Joined" / "Separated" states that were defined by the VDT.

By measuring proximity we may infer interaction while by measuring voice data we can prove interaction. As the VDT grows, groups are more "Separated". Detailed investigation of the groups' voice interaction reveals that even a requirement for a VDT of 10 seconds is enough to significantly change the SR of a specific group and transform it from position proximity "Joined" to voice proximity "Separated". Table 3 exemplifies this change in behavior. It presents information about 5 groups. Each cell presents the "Joined" or "separated" state based on proximity to the left of the arrow symbol ("→") and "Joined" or "Separated" state based on VDT of 10 seconds to the right of the arrow symbol. "J" represents a "Joined" state and "S" represents a "Separated" state. Darker cells represent minutes where the state changed. If the group left the exhibition the cell is blank. The collected data shows that if the VDT is high enough (>5 seconds), any voice-based separation would also mean position-based separation (i.e. the change when the VDT increases is always towards more separation). For example the VDT changed the state of group 25 from "Joined" to "Separated" for the total time of presence at the exhibition. Such a change in the determination of "Joined" and "Separated" states could affect the decisions about 'togetherness' or cohesion, if they were based on voice proximity "Separated" criterion rather than on position proximity "Separated" criterion.

Table 3. The Change from "Joined" to "Separated" States for a VDT of 10 Seconds

Group ID	Minute 1	Minute 2	Minute 3	Minute 4	Minute 5	Minute 6	Minute 7	Minute 8	Minute 9	Minute 10
21	J → J	J → J	J → J	S → S	S → S	J → J	J → J	J → J	J → J	J → J
22	J → J	J → J	J → J	J → J	J → J					
23	S → S	S → S	J → J	S → S	S → S	S → S	J → S	S → S	S → S	S → S
24	J → J	J → S	J → J	J → S	J → J	J → J	J → J			
25	J → S	J → S	J → S	J → S	J → S					

This study tested several values for the VDT. Higher values of VDT (i.e. longer conversations) mean that the group members are more occupied with sharing the visit experience with each other (only 3% of the conversations didn't relate to the museum). The selection of VDT=10 above considered the following: (1) it was the first value to have only 'J → S' changes (no 'S → J' changes), higher VDT values kept the same transitions' direction; and (2) it was close to the position-proximity measurements, which means that conversation-proximity may replace the position proximity as a measure.

2.3. Prediction of Behavioral Patterns

Being able to predict visitors' behavior may allow selection of a course of action, hence the question presented here is: how can the position-proximity pattern from the last several minutes be used to predict the position proximity in the next minute? The data gathered during the observations is used to assess the feasibility of prediction. Table 4 presents an example which summarizes all the sequences of 4 consecutive minutes. The observed state in the 4^{th} minute is compared with the pattern of the preceding 3 minutes. For 3 minutes we have 8 options of patterns (comprised of 3 components selected from a {Joined, Separated} set) starting from "Joined-Joined-Joined", and ending with "Separated-Separated-Separated". These patterns appear in columns 1 through 3 of the table. Each row presents a different pattern. In column 4 we have the number of cases, where the pattern on the left was followed by a "Joined" minute. In column 7 the results are presented in percentage with the same three preceding minutes. In column 5 we have the number of cases where the pattern on the left was followed by a "Separated" minute. In column 8 the results are presented in percentage with the same three preceding minutes. Column 6 presents the total number of cases with the same three preceding minutes. The bottom row presents the total number of cases analyzed, showing that even for the conservative measurement that we used (groups were considered "Joined" even if only a sub-group was together), still 33% of the time groups were "Separated".

We can cluster the results in Table 4 into four major categories: (i) All three "Joined" preceding minutes in the pattern are the same (i.e. "Joined-Joined-Joined") – in this case the probability is high (≥90%) that the next minute would be the same. (ii) All three "Separated" preceding minutes in the pattern are the same (i.e. "Separated-Separated-Separated") – in this case the probability is quite high (≥79%) that the next minute would be the same. (iii) The three minutes in the patterns are alternating between "Joined" and "Separated" (i.e. "Joined-Separated-Joined" or "Separated-Joined-Separated") – in this case again, the probability is quite high that the states in the first and third minutes repeat in the next minute (≥83%). (iv) In the four additional cases the probability is not conclusive. It should be noted that the majority decisions for cases (iii) and (iv) are the same while the prediction probability is totally different. The interpretation is that a consistent group in cases (i) and (ii) would probably continue its behavior for the next minute. A group which deviated for a minute and returned to its previous behavior would probably continue with that behavior for the next minute, as in case (iii), and a group that changed its position proximity and kept it for the next minute would be unpredictable. Please note, that in all cases, if the first and the last minute of the three minute sequence are the same the probability is high (≥87%) that the 4^{th} minute would be the same.

Table 4. Actual results of the next minute position proximity compared to the preceding three minutes position peoximity

Previous 3 Minutes Pattern			Next Minute Actual Results		Total	Next Minute Actual Results Percentage	
			Joined	Separated		% Joined	% Separated
Joined	Joined	Joined	121	14	135	90%	10%
Joined	Joined	Separated	9	13	22	41%	59%
Joined	Separated	Joined	10	2	12	83%	17%
Joined	Separated	Separated	8	11	19	42%	58%
Separated	Joined	Joined	11	6	17	65%	35%
Separated	Joined	Separated	1	8	9	11%	89%
Separated	Separated	Joined	9	6	15	60%	40%
Separated	Separated	Separated	7	26	33	21%	79%
Total			176	86	262	67%	33%

This is an example of a possible analysis. Future analyses (using tools such as the Hidden Markov Model [18]) may assess the contribution of various lengths of proximity patterns history and the impact on the prediction of the next minute. Other variables, such as the location of the group in relation to the exhibits, may also have an impact on the prediction.

3. Conclusions

This work focused on the possibility to use technology for tracking small groups 'togetherness' in a museum environment. Proximity hierarchy has been shown: position proximity is a precondition for voice proximity. Position proximity and voice proximity patterns can serve as criteria for group 'togetherness' or even group cohesion. The proximity patterns are group related aspects that may be measured and monitored automatically by available technology. These measurements, in turn, may be used to predict the group behavior and trigger the adaptation of a technology to meet the needs of the small group and its members. Prediction is important for better group monitoring and improved situational awareness.

Acknowledgements. The work was supported by the collaboration project between the Caesarea-Rothschild Institute at the University of Haifa and FBK/irst in Trento and by FIRB project RBIN045PXH.

References

1. Aoki P.M., Grinter R.E., Hurst A., Szymanski M.H., Thornton J.D. and Woodruff A., Sotto Voce: Exploring the Interplay of Conversation and Mobile Audio Spaces. CHI 02, Proceedings of SIGCHI Conference on Human Factors. In: Computing Systems, New York, NY, USA, ACM Press, 431-438 (2002)
2. Bitgood Stephen: Environmental Psychology in Museums, Zoos, and Other Exhibition Centers. In: R. Bechtel & A. Churchman (eds.), Handbook of Environmental Psychology, John Wiley & Sons., 461-480 (2002)
3. Davies N. Cheverst K. Mitchell K. Efrat A.: Using and Determining Location in a Context-sensitive Tour Guide. Computer 34, 8, 35-41 (2001)
4. Falk J.H., Dierking L.D.: The museum experience. Whalesback Books, Howells House, Washington (1992)
5. Johnson, W. David, Johnson, F.P.: Joining Together: Group Theory and Group Skills. Pearson Education, Inc. 9th edn. (2006).
6. Kay J., Niu W.: Adapting Information Delivery to Groups of People. Proceedings of the First International Workshop on New Technologies for Personalized Information Access, at the Tenth International Conference on User Modeling, Edinburgh (2005)
7. Klein Hans-Joachim: Tracking Visitor Circulations in Museum Settings. Environment and Behavior, Sage Publications (1993)
8. Kray Christian and Baus Yörg: A Survey of Mobile Guides. In conjunction with Fifth International Symposium on Human Computer Interaction with Mobile Devices and Services (2001)
9. Krüger Antonio, Baus, Jorg, Heckmann Dominikus, Kruppa Michael and Wasinger Rainer: Adaptive Mobile Guides. The Adaptive Web, LNCS 4321, Springer, Berlin Heidelberg New York, 521-549 (2007)
10. Kuflik T., Stock O., Zancanaro M., Sheidin J., Jbara S., Goren-Bar D., Soffer P.: Supporting Small Groups in the Museum by Context-Aware Communication Services. Proceedings of the 12th International Conference on Intelligent User Interfaces, Honolulu, Hawaii, USA, 305-308 (2007)
11. Kuflik Tsvi, Busetta Paolo, Penserini Loris, Bresciani Paolo and Zancanaro Massimo: Personalized Information Delivery in Dynamic Museum Environment by Implicit Organizations of Agents. In Workshop on Environments for Personalized Information Access, 22-33 (2004)
12. Luyten K., van Loon H., Teunkëns D., Gabriëls K., Coninx K., and Manshoven E.: ARCHIE: Disclosing a Museum by a Socially-aware Mobile Guide. The 7th International Symposium on Virtual Reality, Archaeology and Cultural Heritage, VAST 2006, M. Ioannides D. Arnold, F. Niccolucci, K. Mania (Edts.) (2006)
13. Masthoff Judith: Selecting a Sequence of Television Items to Suit a Group of Viewers. User Modeling and User-Adaptive Interaction vol. 14(1), 37-85 (2004)
14. McManus P.: Towards Understanding the Needs of Museum Visitors. In B. and G.D. Lord (eds), Manual of Museum Planning (London: HMSO), 35-51 (1991)
15. Olgu´ın Olgu´ın Daniel, Waber Benjamin N., Kim Taemie, Mohan Akshay, Ara Koji, and Pentland Alex (Sandy): Sensible Organizations: Technology and Methodology for Automatically Measuring Organizational Behavior; IEEE Transactions on Systems, Man, and Cybernetics—Part B: Cybernetics, vol. 39. no.1, (2009)
16. Stock Oliviero, Zancanaro Massimo, Busetta Paolo, Callaway Charles, Kr¨uger Antonio, Kruppa Michael, Kuflik Tsvi: Not Elena, and Rocchi Cesare: Adaptive, Intelligent Presentation of Information for the Museum Visitor in PEACH. User Modeling and User-Adapted Interaction, Vol. 18(3), 257–304, (2007)
17. Sumi Y. and Mase K.: Interface Agents That Facilitate Knowledge Interaction between Community Members. Springer Verlag (Cognitive Technologies Series) , 405-427 (2004)
18. Russell S. and Norvig P.: Artificial Intelligence a Modern Approach; 2nd edition, Pearson Education, Inc, New Jersey, USA, (2003)