Mirage: A Real-time Affection Meter via Collaborative Memory Creation and Navigation

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***Abstract*—This paper presents an interdisciplinary study on social science and computing technology to build a novel interactive device Mirage toward presenting the collaborative memories of a place. With the support of social science theory, the locative media builds a strong connection between the participants for sharing similar memories at the same place. Using the metaphor of magic crystal ball, we construct the Mirage coordinate by system calibration to obtain precise 3D directions and distances of hand motions. With the aid of computing technologies, participants use their hands to manipulate and to reverse the memory axis intuitively, and to control the speed of memory stream with the accurate hands positions. Through memory navigation, they contact with each other by affection communication and create the virtual social relationship between them. During the touching process, they gradually turn the world into their world with self-memories through memory creation, and their self-conscious be enhanced. Besides, the experience of attending the digital art exhibition helps us to attract the aesthetic people to be involved in the experiment that raises the diversity and quality of collected data. We also design the affection computation method for analysis the affection amplification effect between the participants, and the experiment proves the interesting social factor influence which we proposed in this paper.**

Keywords-Affective Computing; Collaborative Narrative; Human Facial Expression Recognition; Interactive Device; Locative Media; Memory; Psycogeography

I. INTRODUCTION

Human world has concreted and preserved by many kinds of memories that form diverse cultures and histories of human beings. Ong's extensive work [1] on orality and communication shows many of the characteristics of listening prior to print literacy and the recording and stockpiling of speech/sound. These memories with affections of people are evidences that they ever lived. In the new era of rapidly changing technologies, the types of memory creation have become various and rich, such as email, MSN messages, Twitter, or the social website Facebook. People like to share their life experiences with their families and friends. That is easier for them to contact with others to form a rich virtual social layer upon the real world. But, even from now, the major way of displaying the personal histories is limited by timeline, and the expression form of their feelings is still poor, for example just using the face symbols. That brings the issue how to reveal human affection within the abundant recorded memories intuitively and automatically.

This research focuses on to develop a novel interactive device for collaborative memory creation and navigation. Using the metaphor of crystal ball, participants intuitively enter the magical memory space and control the time axis to reverse the world with bare hands. Through the memory navigation, they sense the strong connections with others who ever had similar experiences at the same place. With the magical power gift, during the touching process they gradually turn the world into their world with self-memories, as in the Genesis the God gives Adam life, and enhance their self-conscious. We also design the affection computation method for analysis the interesting affection amplification effect between the participants.

Figure 1. The Mirage in Being digital artwork exhibition

The Mirage attended Being digital artwork exhibition held by MOCA museum [2] from December 3, 2011 to January 8, 2012 showing on Fig. 1. The experience helped us to collect plenty diverse data for experiment.

This paper starts by revealing a new concept of virtual memory creation to open up a new way of memory navigation. We then propose Mirage as a novel interactive device to realize the collaborative creation and navigation. Section 2 provides pointers to related works, including the social science theory that supports the design principles for Mirage to meet our several expectations. Section 3 describes the system implementation including two models for

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affection computing. Section 4 presents a preliminary study of the system and the analysis on users' feedbacks, followed by the conclusion and future work in Section 5.

II. PRIOR ART

A. The Virtual Social Relationship

For the improvement of new technology, a rich virtual layer has generated upon the physical world which has unique meaning to an individual. As Shotter [3] said, "World as activities and events rather than substances and things," and therefore, the virtual world formed from an individual's cognition is more meaningful than the real world. That brings the topic to discuss the interesting virtual social relationships among the world. SecondLab [4] creates a remote lab that allows students to control a microbot working with real experience in the social 3D-based immersive environment, and creates the novel virtual social relationship. Moreover, the virtual interactive activity has realized in gameplay field. Uncle Roy All Around You [5] [6] held a city game by following online-player's directions to find the mysterious Uncle Roy hidden in the city.

From virtual social relationship creations, we find out that there is a connection within people, content, and location. As Salamensky's theory [7], "a new kind of conversational space opens up… The particular mix of spatial metaphor and the dynamics of instantaneous communication… build a sense of belonging." Under the premise, the digital content is meaningful to people with embedded location information, otherwise it is meaningless for the sense of belonging lost. Milgram [8] defines a Reality-Virtuality (RV) continuum as a way to define how new technologies could form new types of realities in the new age. The virtual layer provides us abundant resources for digging the new type of social relationship and we will further discuss these locative media.

B. The Locative Media

Locative media has been realized in the new era for the technology improvement. Many smartphones can show the locations of users' near friends, moreover, they also like to share where they currently stay via the Facebook's check-in function. It brings the trend that people start to pay a lot of attention to location information and it has meaning to them with the social aid. Harrison [9] declares the difference between the term "space" and "place." Space is the structure of the world, it is a three-dimensional environment, in which objects and events occur and have relative positions and directions. A place, at the base of previous definition, is a space invested with understanding of behavioral appropriateness, cultural expectations, and so forth. Jacob [10] and Alexander [11] further illustrate that a place is considered including the people's life experience there with deeply-echo social and historical meanings. That starts the investment to find out the connection between people and place they lived. Sonic City [12] is a real-time music creation system that generates different sounds according to the buildings or passenger users met on the street, through the discovery they are aware of their daily routes and the connection of the city is enhanced. However, it doesn't reach to the virtual social layer with the life experiences of residents. Urban Tapestries [13] enables people to leave their path in the city generating a complex network. They provide the geography information on the map, but they can't interact with each other to create virtual social relationship.

Bakhtin [14] gives explanation of human's view through dialogism. He claims that each person organizes the world through his unique experiences. That echoes Shotter's point where the individuals construct their own world by their unique cognition. In prior work, Storylog [15] concretes the Michael Ende's [16] Fantasica, in which people create virtual social relationship via collaborative narrative storytelling. That implies the interaction property of Salamensky's theory. Each avatar they created from their unique cognitions is embedded with their true personalities, and their different cultural background supports Bakhtin's view. Besides, they name the locations of story world creating the relations between people and location echoes Shotter's theory.

The world concreted from the people's thoughts leads the locative media to the mental level and enables them to turn the real world into their own world. The power of turning space into "a sense of place" [17] depends on how deep of the inner mind people inject to the world. For the reason, we focus on how to reveal the inner layer of people intuitively, the memories with their thoughts, minds, and affections.

C. The Human Affections within Memories

Memories contain people's affections and record of their life traces. The early researches still narrow on the memory retrieval how to help people preserve and recall the valuable memories. iRemember [18] retrieves keywords from a huge vocal data recorded from everyday conversations with campus for two years. The transcript text brightness is proportional to recognition confidence that tries to recall people's social experiences. Matthew [19] aims his work physically in the health filed to help people with the EMI (Elderly Mentally Ill) problems. Using the portable device combining with Microsoft SenseCam [20], an off-the-shelf voice recorder, and a GPS logger, he records everyday behaviors of patients then provides the helpful memory cues. But, it still needs the expert knowledge of caregiver to decide which good memory cues are.

The rapid improvement of portable device makes the memory recording easy and brings the researches into lifelogging field. I Like to Log [21] also records data by SenseCam and automatically generates keyfarme images of people's daily lives. It's like diaries with specific names, events and time. The new problem is how to deal with the huge amount raw data recorded day after day, and most researches are disoriented by the huge log information. People keep their memories for sharing their feelings with others to form the meaningful lives. That is why we focus on the inner layer of people, their affections within memories. We try to find out their treasure memory fragments by human affection analysis. It was shown that image is a stronger material than text, or voice to reveal one's affection state. This research identifies the affection state of people by human facial expression recognition and human behavior

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detection, and further analyzes the affection amplification effect between them in the common memory world.

III. PROJECT DESCRIPTION

A. *User Scenario*

The memory flow consists of three parts and shows on the Fig. 2.

- The Chaos: In idle mode, the crystal ball continuously displays a haze through particle generation to turn on people's curiosity. It reveals the Chaos world as the initial state of memory world without any infections.
- The Overture: The participant touches the crystal ball and the haze fades away then the door of memory world opens. It starts with a stream of predesigned images retouched by artist, and brings to participant the experience of passing through the time tunnel. In the meantime, it triggers the camera to capture his face images continuously.
- The Genesis: After the overture, a tinkle sound alerts the participant that he arrives to the territory of memory world. It plays the memory fragments collected form the past visitors. With the magical power gift, he controls the time axis with acceleration speed, navigates in the depiction or flashback way, and continues or temporally stops to view the detail of a memory frame. During the touching process, the memory fragments pass through his fingers and he will be surprised to see own faces showing in the memory flow. The more he involves in, the more he infects the world. The memory creation gives the world new element as God gives Adam life in Genesis, and finally, the world turns into his own world only with his memories. During the interaction process, once participant's finger lefts, the world goes back to the initial Chaos state showing mysterious haze. However, what ever done is irreversible.

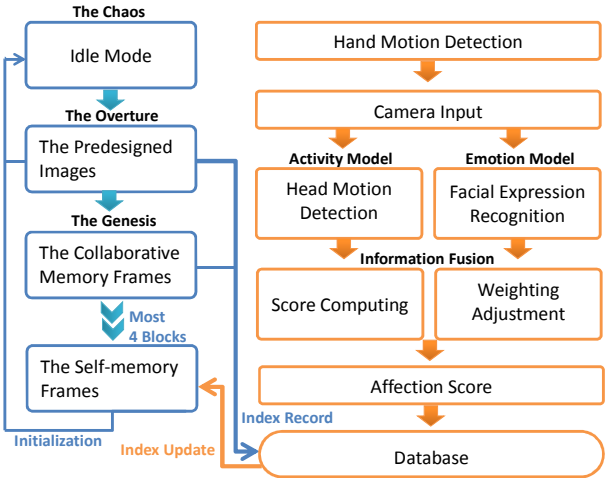

Figure 2. Mirage system architecure

B. *Mirage System*

Mirage is an interactive device for collaborative memory creation and navigation. After alpha blending processing, the 3D virtual memories fragments are reflected through a Fresnel lens and then are projected in a transparent acrylic ball. Using two cameras, we construct Mirage coordinate by system calibration to obtain precise 3D directions and distances of hand motions. With the specific information, users control memory axis and modulate memory stream with acceleration speed according to their hands positions. Besides, another camera is embedded for ambient capturing of their faces during the interaction.

The system architecture of Mirage shows on Fig. 2. Once it detects the user's hand motion, it triggers the camera to continuously capture one block of 60 memories frames. By recording the block index, we know the start and end points of the user's memory creation. After one period capturing, the block index is updated. In the meantime that adds new elements to the current memory world by shifting and replacing a block of 60 memories frames. The continuous updating maintains the transition in the memory world and user can see the evidence of his influence.

We display one block of past 240 to 180 frames to form the past memory stream, and the four blocks of past 240 to 1 frames to form the current memory world. The interval was tested in the design phase and it creates best connection between the current and previous users that allows him almost to see the previous one's memories. Therefore, there is the best chance within couple friends seeing each other's memories and occurring to the interesting interaction with social meaning. Besides, the transition is a skill displaying the delayed memories instead of showing them simultaneously. That achieves the spirit of slow technology [22], which inspires the audiences to discover the meaning of artwork by themselves, not teaches them in advance.

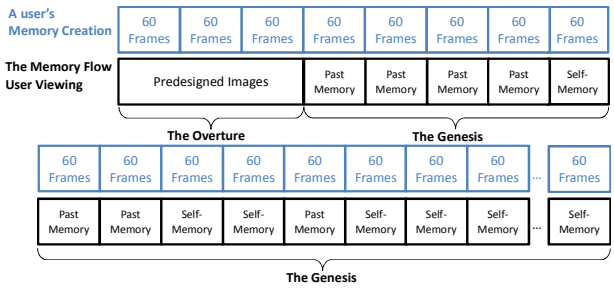

Figure 3. The components of a user's memory creation

The correlation of user's memory creation and the memory flow is shown on Fig. 3. A user's memory blocks will be added one by one to the memory flow by the updating mechanism. The first three blocks of memory creation capturing in the Overture period are the baseline of a user's affection. The record blocks correspond to the predesigned images by the artist for the art aesthetic. We only consider the next four blocks to analyze the previous one's affection influence on a user, and ignore the rest blocks

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corresponding to repeated memories. For the first time, the user sees the content and it causes him strongest feelings. For the same reason, we choose the next eight blocks which contain both previous one's memories and self-memories, and analyze the social factor influence among them. The number of rest blocks is without limitation until the end of a user's interaction. We propose a real-time affection analysis method to measure the user's affection level and to verify the affection amplification effect.

C. The Affection Analysis Method

We consider the facial expression and gesture classes from Argyle's [23] six clues of people's positive communication behaviors and define the human affection by emotion model and activity model. In emotion model, we define the positive degree of affection by facial expression recognition method, and in activity model we identify the strong degree of affection by head motion detection. Fig. 4 shows the four possible affection states of a user. In low emotion condition, user is bored within low activity state, and is suddenly out of patience with high activity state. In high emotion condition, a user is immersed within low activity state, and is excited with high activity state.

Figure 4. Four possible affection states of a user

From the observation, no matter which activity state is, it reveals a user with positive affection in high emotion condition, and with negative affection in low emotion condition. The difference is that the strong degree of affection that people's motions generates stronger affection than the expressions. Therefore, the flow of affection computation is shown on Fig. 2. We combine the detection results into emotion and activity scores through information fusion, and dynamically adjust the emotion score by the activity score as weighting adjustment to enhance the previous result. Finally, we come out with the affection score A (1).

$$A = S_e \times S_a \text{, where } S_e \geq \text{threshold} \quad (1)$$

$$A = S_e \times (-S_a) \text{, where } S_e < \text{threshold}$$

The parameters S_e and S_a are emotion and activity score, respectively. The positive value represents the positive affection of a user and the negative value means the negative affection. The threshold of emotion score 0.65 has been tested with best identification to distinguish the expressiveness and blank faces in the design phase. We further describe the adopted methods in each model.

In the emotion model, based on our previous work [24], we consider local and holistic face components. Besides, both local facial components and global face are adopted. We divide face into seven components including left eye (LE), right eye (RE), middle of eyebrows (ME), nose (NS), mouth and chin (MC), left cheek (LC), and right cheek (RC), and add upper face (UF) and holistic face (HF) components to the classification. Then we adopt manifold learning and fusion classifier to integrate the multi-component information. Given a face image I, a mapping M: $R^d \times c \rightarrow R^t$ is constructed (2), where c is the number of components, $m_i(\cdot)$ is an embedding function learned from the manifold of component i, and I_i is a d-dimensional sub-image of the i-th component.

$$M(I) = [m_1(I_1), m_2(I_2), \cdots, m_c(I_c)] \quad (2)$$

The multi-component information is encoded to a t-dimensional feature vector $M(I)$, where $t \geq c$. To characterize the significance of components from the embedded features, a fusion classifier F: $R^t \rightarrow$ {Positive, Negative} is used based on a binary classifier SVM. After the LDE and SVM models construction, we do face registration and feature extraction of each component. Then we project each component's feature to the corresponding manifold models and calculate the belonging probability of each class. Finally, we combine all probabilities as a new feature vector, and use it as the input of SVM classifier to come out the final result. Through the method, the positive affection degree of each memory frame can be recognized.

In the activity model, for the continuous capturing, we adopt face tracking and head motion detection methods in each memory block. We run each memory frame through a face detection algorithm [25], and come out with the locations and sizes of all faces in the image. Then we detect face and calculate its movement to find the adapted mapping of face movement and head motion score by adjusting the variance of a Gaussian. For computing the activity score, firstly, we consider the persistent property of a calm state. We calculate the calm value of current frame inheriting from the previous adjacent frame (3).

$$S_c(t) = S_c(t-1) + V_{UP} \text{, if static head} \quad (3)$$

$$S_c(t) = \alpha \times S_c(t-1) \text{, else (where } \alpha<1)$$

The initial value of $S_c(t)$ is zero. The calm value increases stably without any head motion detection within

one second sliding window, otherwise it rapidly decreases α time (α=1/3 in experiment). Then we use its reciprocal as the activity score and define the strong degree of affection. When S_c is 0, we set S_a to 100 to avoid the zero divide error and define the range of affection score from -100 to 100. The higher affection score means more positive affection feedback to the corresponding memory blocks in the current memory flow; otherwise, the lower affection score represents the lesser responses. The method we proposed quantifies the affection level of a user and enhances the affection by weighting adjustment.

D. The Mirage Elements

From the social science support, the elements of Mirage are listed as following.

- Time: The memory navigation is a narrative way that echoes Ong's viewpoints and memories which are collected from the visitors is with time sequence embedded. Besides, the updating mechanism keeps the transition with attractive and magical powers, always with unknown things to be discovered.
- Location: Nowadays the huge amounts of data are contributed without location information embedded. They drift on the internet without any meaning to others and cause the phenomenon of sense of place lost. On the contrary, the locative element binds all of the residents and forms the universe of Mirage.
- Interaction: In Mirage, the participant gives the world meaning through memory creation and changes the architecture of universe via turning it into his own world. The architecture will continue changes for another participant involving, and will turn into a new world to flatter its new master.
- Affection amplification: Through memory creation, the residents of Mirage are contacting each other even they are not really presented here in the reality. Their affections are amplified by the virtual social relationship, and it's more obvious with the "familiar elements factor," the self-memories and their friends' memories.

IV. EVALUATION RESULTS

During the 37 days exhibition, we collected 347,400 useful images from 1014 participants which consisted of 5,790 memory blocks. The camera set were close to the user to capture the images with clear faces and expressions of participants, and the detail information also helped us to compute the affection elements. The special location in the culture region of Taipei city easily brings in many artists or those who are interested in art and being involved in the work. Besides, the nearby Metro station also brings a lot of travelers that also expands the diverse and dense properties of our data collection. The statistics result of the length of participants' memory blocks is as follows: 38.06% users with less than 3 memory blocks reveal the slow technology property of the interactive device that they discovered the device by themselves and caused many small memory flows; 39.05% users with 3 to 7 blocks reveal that many of them were interested in the past memory navigation and were aware of they are part of the memories in the memory flow; 18.34% users with 7 to 15 blocks and 4.14% users with over 15 blocks mean many users' behaviors with high interaction properties and often with social factor influences. We observed the users interaction behaviors and found out interesting circumstances where people changed postures to find out the correlation of the delayed memory frames and played with their friends to see each other's faces showing in the memory flow. These memory blocks often contain more than one face or interchange with the same several faces showing on Fig. 5. The virtual social relationship between the avatars in virtual memory world and them in the reality causes the interesting affection amplification. Therefore, we make two assumptions. One is that others' affections amplify an individual's affection. The other is that the familiar element generates strong affection amplification.

Figure 5. The memory fragments with social factor influence

We are interested in the positive influence within the virtual social relationship. Therefore, we only consider the positive affection state to define our positive affection detection rate (4), where the unit is frame.

$$\text{Positive Affection Rate} = \frac{\#\text{of frames that user is detected positive affections in memory blocks}}{\#\text{ of frames in memory blocks}} \quad (4)$$

Using the affection method to analyze the collected data from three stages we mentioned before, the statistics results shows as follows. We calculate the original affection state of all users from the average of the first three memory blocks as the baseline for comparison, and the 63.5892% average rate shows that participants are curious about the device with high participation. Then from the average of the next four blocks we get the affection state after others' affections influences, and the 70.5610% average rate proves the first assumption that most of the users' affections are amplified by others' positive affections through the memory navigation. Finally, from the average of the next eight blocks define the affection state after the social factor influence, and the 74.4864% average rate reveals the evidence of the "familiar elements" influences from the self-memories or the last visitor's memories. That reveals the evidence of social factor intervention and proves the second assumption. That is why even with the showing memory flow with low positive affection, it also amplifies the users' affections with obvious influence. We also interviewed the participants how they felt about the memory navigation, all them thought it is interesting and they liked the novel

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experience of seeing themselves, and especially people whom they know being shown in the memory flow.

V. CONCLUSION AND FUTURE WORKS

We designed and built the interactive device Mirage to create an open, infinite and agnostic memory world. Using the metaphor of crystal ball, the users navigate the memory world intuitively to sense the connection of the past visitors. Moreover, with the magical power gift, they influence the world and become part of it through memory creation. The collaborative behavior concretes the universe of Mirage, which consists of the memories belonged to all of the residents in the memory world. The locative media property also creates the connection of the preserved memory fragments, and forms virtual social relationship between all of the participants by sharing common memories.

We proposed a real-time affection computation system for analysis the affection amplification effect among the participants. The basic virtual social relationship constructed by the locative media plays an important role in the experiment. Their affections are amplified each other by sharing the similar experiences at the same place. Besides, the familiar elements provide obvious evidence of affection amplification. From the real-time affection meter mechanism, it enables us to add the memory fragments with high positive affection simultaneously to the showing memory flow in the next version. However, in the current version we keep the sequence of memory creation in the memory flow for observing the social factor influence.

This work can be viewed as a pilot study in the field that first focuses on the place memory, the collaborative memory creation, and the affection amplification effect. During the exhibition, we observed the interaction behaviors of the participants. Most of them really liked the novel memory navigation experiences and felt that the memory creations are indeed interesting. Besides, they were not aware of the ambient recording that ensures the accurate and authentic properties of collected data in the experiment.

The virtual social relationship can be expanded in our future work. For example, a crowd generate stronger atmosphere of a place than just single one, therefore, we can track every faces in the image to count the numbers as an affection adjustment factor. Besides, with the recent growth of number of smartphones, it's common that people take a shot and share it to the internet immediately. For the reason, the affection analysis method can be applied to the internet photo album or the social website with locative information tagging, and provides a new display rule by human affection. With this pilot study, we believe that the development of collaborative memory brings new possibilities in the social computing field, and the human affection as the calendar of memory world helps to solve the problem of huge amount of raw data in the lifelogging field.

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