INTERACTING WITH VISUAL POEMS THROUGH AR-BASED DIGITAL ARTWORK

Hao-Chiang Koong LIN, Min-Chai HSIEH
Department of Information and Learning Technology
National University of Tainan, Taiwan

Eric Zhi-Feng LIU (Corresponding author)
Graduate Institute of Learning and Instruction
Center of Teacher Education
Research Center for Science and Technology for Learning
National Central University, Taiwan
totem@cc.ncu.edu.tw

Tsung-Yen CHUANG
Department of Information and Learning Technology
National University of Tainan, Taiwan

ABSTRACT
In this study, an AR-based digital artwork called 'Mind Log' was designed and evaluated. The augmented reality technique was employed to create digital artwork that would present interactive poems. A digital poem was generated via the interplay between a video film and a text-based poem. This artwork was created following a rigorous design flow, including: (1) conceptual formation, (2) prototype design, (3) expert-based evaluation that consisted of both a cognitive walkthrough and a heuristic evaluation, (4) the final artwork design combining a visual poem generator and an AR system, and (5) a series of evaluations from an audience's perspective. The system usability scale evaluation results show that this work achieved positive usability, audiences enjoyed the interaction with the artwork, and most people accepted AR-based digital poems.
Keywords: augmented reality technique, digital artwork, digital poem, virtual poem, system usability scale

INTRODUCTION

Typically, artists present their work using non-interactive visual media. With the ongoing development of information technology (Chang & Lee, 2010; Isman & Celikli, 2009; Liu & Lin, 2010) and interactive technology (Chiang et al., 2011; Lin & Li, 2008; Liu, 2010), people can create art using digital multimedia in addition to the traditional forms; the methods for creating art have changed dramatically. Through this evolution, digital art creation has become more lively and interesting given that the materials/technologies used to create digital art also enhance artists' creativity by allowing them to express their thoughts and ideas in new ways. Today, artists can create artwork with the help of powerful computing technology that incorporates input information in real time. The process of creating artwork is fascinating, as it is a manifestation of an experience and not just a presentation of a phenomenon (Hsieh et al., 2010; Lin & Li, 2009)

This paper presents a way to employ Augmented Reality (AR) technology to create digital artwork to present a series of interactive poems. This artwork is named 'Mind Log'. Audiences can interact with the digital poem via pre-designed postcards that are composed of AR markers. The postcards are real objects, whereas the digital poems are virtual sights. In this way, audiences can situate themselves in an environment that is both virtual and real.

LITERATURE REVIEW

Interaction is an important characteristic of digital artwork. Nevertheless, the evolution of the esthetic viewpoint is seldom mentioned. Participation is essential in the creation of artwork. It gradually forms a kind of esthetics based on interactive design. The concepts discussed here are crucial in new media art (Kirk & Gopnik, 1990; Manovich, 2001).

In "The End of Art" (Danto, 1998a, 1998b), Arthur C. Danto stated that the function of art imitation and reappearance had disappeared. The emphasis on verisimilitude imitation was also redefined in art history (Oliver, 2003). This redefinition included concepts such as having the text be writable and created by readers. Moreover, readers, rather than authors, interpret the meaning of the text. This redefinition is the known as the "writable text" concept (Zucker, 1997).

AR is a new technique of the computer vision application used to facilitate interaction in the digital arts. Recently, many scholars and institutes have conducted research examining AR, which is also called Mixed

Reality (MR) given that it is an extension of Virtual Reality (VR). Using computer graphics, VR can simulate objects in the real world and create an environment in which people can interact with the simulated objects. AR is the image, object, or scene that is generated by a computer to blend with the real environment to enhance the visual experience. To summarize, AR adds virtual objects to the real environment. AR technology must possess three characteristics: the combination of virtual objects and the real world, real-time interaction, and the representation of 3D space.

Milgram and Kishino (1994) treat the real environment and the virtual environment as a continuum. The real environment is on the left end and the virtual environment is on the right end. VR typically replaces the real world, whereas AR augments the virtual images produced by the computer with objects from the real environment. Presently, AR is applied extensively in the fields of education, medical technology, military training, engineering, industrial design, arts, and entertainment (Azuma, 1997; Azuma, Baillot, & Behringer, 2001).

AR combines virtual objects with the real environment and displays the virtual objects generated by computers to users. Milgram and Kishino (1994) define two ways of displaying AR: See-Through AR and Monitor-Based AR. In See-Through AR, the users can see the surrounding environment through a monitor that also displays the virtual image. Accordingly, the effect of the augmented environment is strongest with See-through AR. In Monitor-Based AR, a computer combines images captured by a webcam with virtual images. The final image after this combination is displayed on a Head-Mounted Display (HMD) or on a computer monitor. HMDs are either pure or equipped with a small webcam. The former system is small and can be equipped with a head-mounted tracking instrument that tracks the viewing angle and the direction the user's head is facing. This pure HMD is more suitable for research and for the application of AR. The HMD with a small webcam has an immersion effect (Hsieh & Lin, 2009; Hsieh & Lin, 2010).

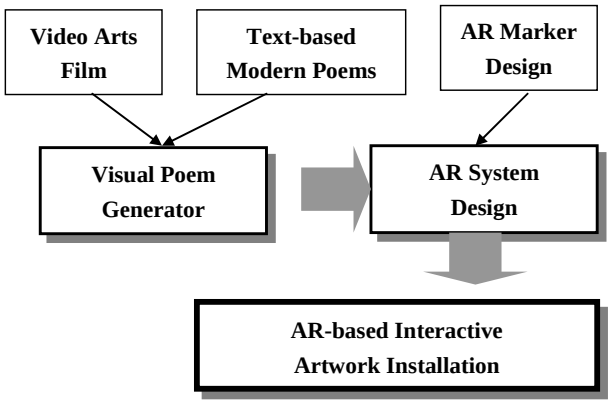

Figure 1 Conceptual Model and System Architecture.

METHOD

Conceptual design

The conceptual model and system architecture are shown in Figure 1. The visual poem and AR system design are introduced in detail in subsequent sections. This section explains the artistic concept behind the creation of this artwork. Given that this concept could be both naive and profound, this work will attempt to expand on fragments from a series on the phenomenology of inconspicuous things. The work describes both doubt and depression, humorously examining life's predicaments and the absurdities of the senses. We are the city wanderers who observe various surrounding symbols without probing into their significance. Subjective regularity helps us gain insight into true cleverness.

This artwork is based on the identical digital space with concurrent portrait and enjoyment. It attempts to elucidate the background of the personal contemporary state through an immersion in "digital vacancy." The author wants the audience to engage in a combination of videos and poetry using interactive media, and further pushes the audience to consider their expectations. As in life, the crowd passes each other in the city while alternating and switching between consciousness and predicaments. Among the images and signs is the image of dust, which generally embodies endless vacancy due to vision and wisdom. People often become immersed in the beauty of ambiguity when thinking about the multiple levels of possibility. This cognitive approach reflects the nature and details of things while estimating the length and scale of seemingly familiar yet strange surrounding sceneries, which offers a taste of such inspiration.

Design and evaluation flow

The creation of this artwork followed a fluent design and evaluation framework, including (1) the conceptual formation discussed in this section, (2) the prototype design, (3) an expert-based evaluation that consisted of a cognitive walkthrough and heuristic evaluation, (4) the design of the final artwork, which combines a visual poem generator and an AR system, and (5) a series of evaluations from audiences members' perspectives. The design and evaluation flow is depicted in Figure 2.

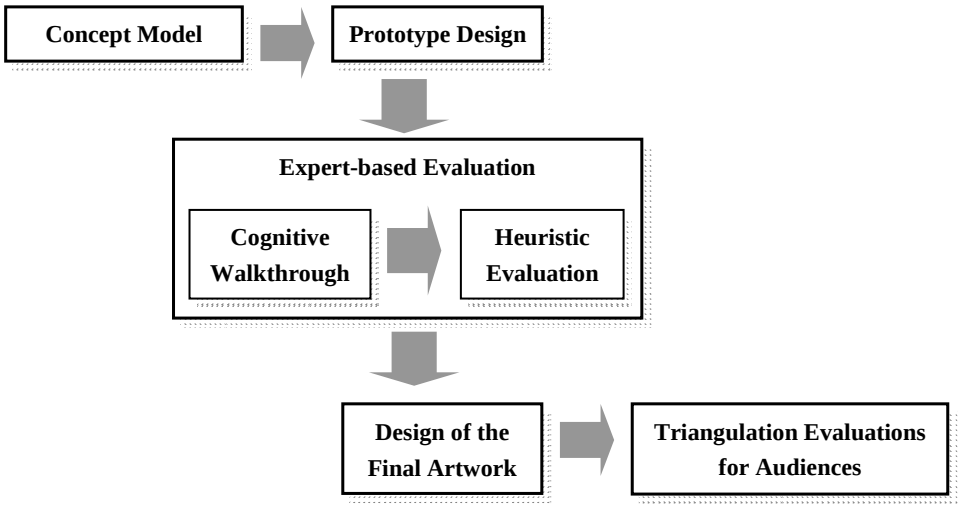

Figure 2 Design and Evaluation Flow.

Research questions

This study investigated the following research questions:

- Is AR-based artwork acceptable?
- Is the AR system designed in this study usable?
- Do audiences feel satisfied with the exhibition?
- Are the visual poems comprehensible?
- Does the exhibition provide a good learning environment for art and design?

SYSTEM DESIGN

Visual poem generator

A system (written in the processing programming language) was established in which a digital poem was generated via the interplay between a video film and a text-based poem. In other words, the system consumed two kinds of inputs: (1) a video file produced by the artist and (2) a modern poem written by the artist. The poem consisted of a sequence of Chinese characters. Figure 3 is the transformation program written in Processing.

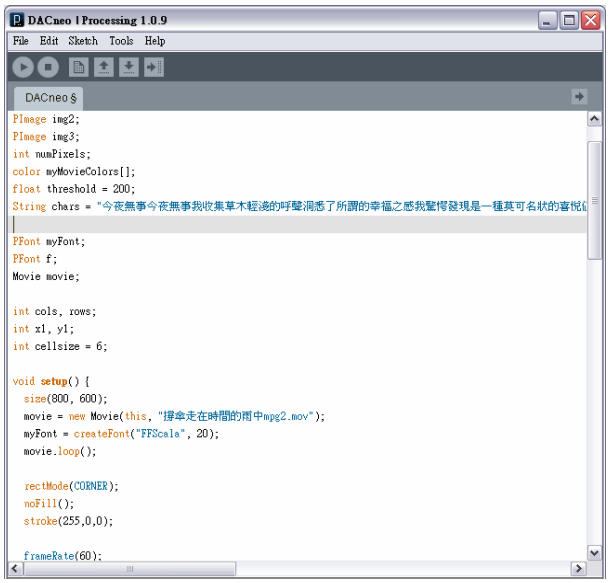

FIGURE 3 The Transformation Program Written in Processing.

Figure 4 The Video File before Transformation.

After these two inputs were fed to the system, each frame in the video was transformed to an image constructed of text. The transformation process was conducted as follows: a “cell size” was defined in the program, and each cell contained several pixels, for example, four pixels. The cell size determined the style of the resulting image. For each cell in the frame, the content was replaced with a Chinese character from the poem. The order of the applied characters was dependent on the characters’ positions in the poem.

The color of the Chinese character was based on the color of the cell in the same position. The designer can also define the font size of the character. If the font size is larger than the cell size, then characters in the image may overlap such that the colors will blur, causing the frame to appear similar to a painting.

An interactive “digital poem” in video form was produced when all of the frames were generated and filled with colors using the process described previously. Figure 4 shows a snapshot of the video in a QuickTime file before transformation. Figure 5 shows a frame following the transformation process in which pixels in this frame were replaced with text from the poem. Figure 6 is a snapshot of the generated film after the transformed frames were combined together. Figure 7 shows a second example of a digital poem produced using the program.

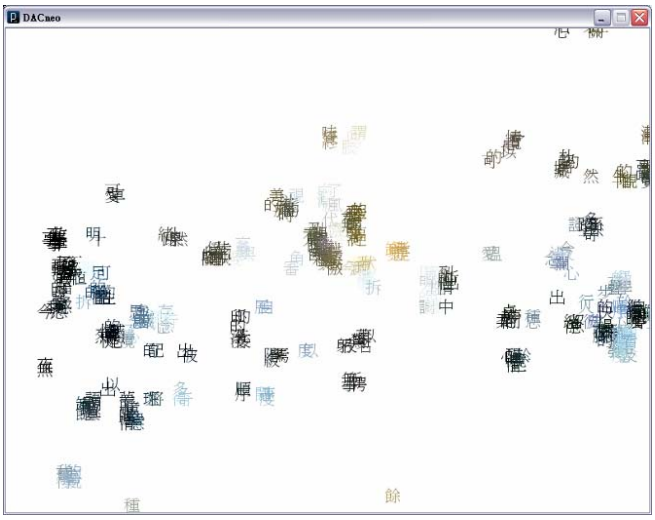

Figure 5 A Frame after Transformation. (Pixels in this Frame Were Replaced with Text from a Poem).

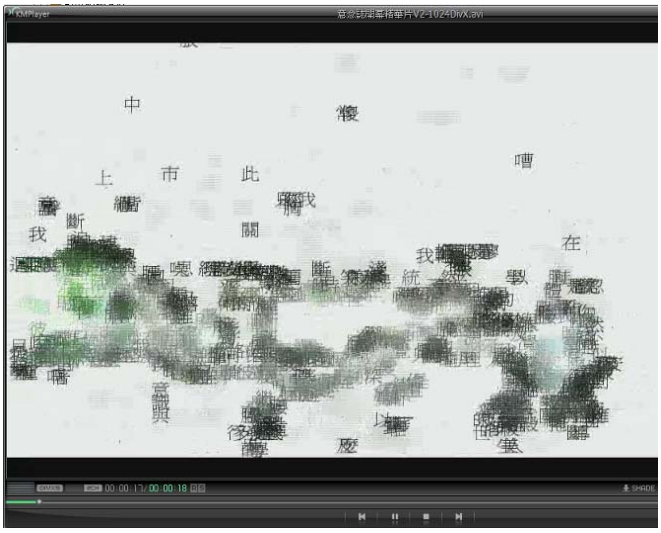

Figure 6 A Snapshot of the Generated Film after the Transformed Frames Were Combined together.

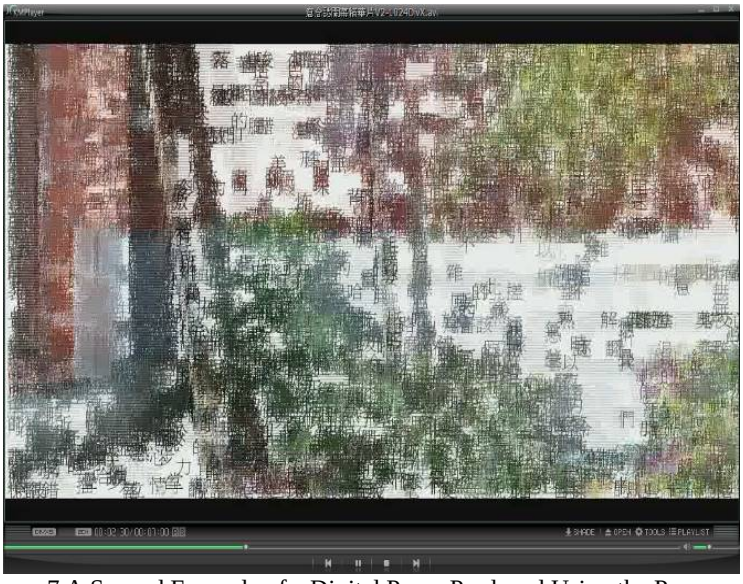

Figure 7 A Second Example of a Digital Poem Produced Using the Program.

Prototyping

When the final artwork was exhibited, the digital poems (as described in the previous section) were displayed using the process of AR interaction. A sophisticated design process was employed in this research; before the final version of the AR-based digital poem was designed, a low-fidelity prototype was developed. In this research, a card-based prototype was employed in which the sequence of screens was depicted as consisting of several cards. These cards simulated how the digital poems might display during the AR interaction. An evaluation of the card-based prototype is introduced in the next section.

EXPERT EVALUATION

Cognitive walkthroughs

Five experts were recruited to collaborate with designers to evaluate the prototype. Two kinds of expert-based evaluation methodologies were used: cognitive walkthroughs and heuristic evaluations (Sharp et al., 2008). The backgrounds and specialties of the experts are listed in Table 1. The advantages of using cognitive walkthroughs are the following: (1) the ability to focus more on identifying specific users' higher-level and detailed difficulties, (2) no real users are needed, and (3) only simple prototypes are used in the process, such that the prototypes are not expected to be able to execute real functions. Nielsen and Mark have stated, "Cognitive walkthroughs involve simulating a user's problem-solving process at each step in the human-computer dialog, checking to see if the user's goals and memory for actions can be assumed to lead to the next correct action" (Nielsen & Mark, 1994, p. 6). Listed below are the steps of the cognitive walkthrough as used in this research:

(1) The characteristics of typical audience members who would attend an art exhibition were identified and documented.
(2) Some sample actions that the audience might take were developed.
(3) The card-based prototypes were designed.
(4) Designers and experts collaborated to perform the analysis.
(5) The analysts practiced the sequence for each sample action that an audience member might engage in during AR interactions with the digital poems. They attempted to answer the following questions regarding typical scenarios:
    - Were the correct actions obvious enough for the audience to engage in?
    - Would the audience notice that the correct action was available?
    - Would the audience associate and interpret the AR response from the action correctly?
(6) The findings were documented with the aim of improving the design of the artwork. These findings are summarized following a description of the heuristic evaluation.

Table 1 The Backgrounds and Specialties of the Experts.

Expert	Specialty	Background
A	Augmented Reality, Multimedia Design	Computer Science and Information Engineering
B	Digital Arts	Fine Arts and Digital Arts Creation
C	Poem Creation, Writing Skills	Literature, Chinese Language Education
D	Usability Engineering, Human Computer Interaction	Human Computer Interaction
E	Usability Engineering, Interaction Design	Visual Communication Design

Heuristic evaluation

The use of experts' suggestions for finding evaluation indicators is feasible (Liu & Lin, 2009). Following the cognitive walkthrough, a heuristic evaluation, as developed by Jakob Nielsen (Nielsen, 1994; Nielson & Molich, 1990), was performed. The evaluation was conducted according to usability-exploring rules, known as heuristics, and whether the user interface elements were based on these rules. Nielsen's research showed that four to six experts could usually discover approximately 75% of usability problems. Therefore, this research included five experts.

The advantages of using a heuristic evaluation are that it saves both time and money and is easily conducted. A heuristic evaluation also offers suggestions for improving the system design and helps system designers find and fix problems. The disadvantage of using a heuristic evaluation include the difficulty in choosing experts because researchers define experts differently and because experts may influence the design project progress based on personal preferences. Experts were provided with a set of heuristic evaluation rules based on the "Usability Principles" applied to the rules (Nielsen, 1994; Nielsen & Molich, 1990), including (1) the visibility of the system status; (2) the match between the system and the real world; (3) user control and freedom; (4) consistency and standards; (5) error prevention; (6) recognition rather than recall; (7) flexibility and efficiency of use; (8) esthetic and minimalist design; (9) the ability to help users recognize, diagnose, and recover from

errors; and (10) help and documentation.

Each expert examined the prototype twice over the course of one to two hours. First, the experts learned the background and procedures regarding the manipulation of the whole interactive interface. Then, the experts checked for usability problems in the design. Finally, the experts discussed their evaluations in a group, prioritized the problems, and offered solutions.

Results of expert evaluation

A set of prioritized findings and suggestions was collected according to the experts' opinions regarding the interface design of the AR-based artwork "Mind Log" prototype following the cognitive walkthroughs and the heuristic evaluations. The qualitative method was employed to qualitatively analyze and derive relevant information (Glaser & Strauss, 1967; Strauss & Corbin, 1990). Twenty-six chunks/subcategories were determined, which led to the five main categories listed below:

- **Audio/Video Integration:**
  Background music or sound should be incorporated into the film that showed the digital poems.
- **Usage Assistance:**
  "Mind Log" lacked instruction as to how to use it. The audience may not be certain about how to manipulate the artwork. It would be better to display manipulation instructions some time before the audience begins to interact with the work.
- **Webcam Installation:**
  The position of the webcam should be determined carefully.
  The webcam should be decorated so that the audience can become more immersed in the exhibition environment.
- **Artwork Exhibition and Installation:**
  It would be better to project the video film on a wall instead of displaying it on a computer monitor.
- **AR Marker Design and Recognition:**
  The accuracy of the AR marker recognition system should be improved.
  The visual design style of markers should be consistent.

Design improvement

After reviewing the experts' feedback, the prototype was improved in the following manner:

- A famous sound artist was invited to join the design team. He composed music for each film.
- Some instructions that hinted about how to interact with the work were placed on the wall of the exhibition hall.
- The angle and position of the webcam were adjusted according to respective experiments.
- The webcam was decorated to look like a lamp. Moreover, the exhibition hall was designed to look like a study room.
- The visual poem was projected onto the wall in the study room, taking on the characteristics of a large mirror.
- The AR markers were re-trained on site by the ARtoolkits utility software to improve the recognition accuracy.
- All of the AR-based postcard markers were re-designed so that their appearances were more consistent.

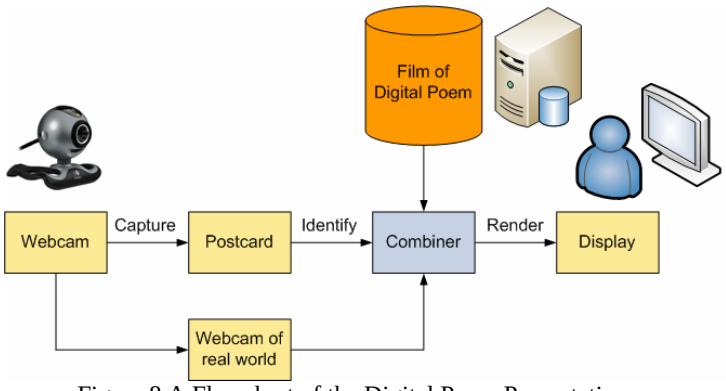

Figure 8 A Flowchart of the Digital Poem Presentation.

Final design: AR-based digital poems

The digital artwork was created for presenting interactive poems by taking advantage of AR technology. This work was implemented in the Processing programming language and developed based on ARToolKit. Figure 8 depicts a flowchart of the AR-based digital poem presentation.

A webcam captured video of the real world and sent it to a computer. The system searched through each video frame for any black squares. If a square was found, the system used mathematics to calculate the position of the webcam relative to the black square. Once the position of the webcam was determined, a film of a digital poem was drawn from that same position on top of the video of the real world in such a way that it appeared to be stuck on the square marker. The final output was shown on the wall via a CCD projector so that when the audience looked through the display, they saw a film of digital poems overlain onto the real world. Figure 9 shows the digital poem presentation based on our system as it is written in processing language. First, the image textures and corresponding vertices were created. Then, the four vertices of a film were matched with the four vertices of an image texture and the film was drawn on the image texture. The four vertices in the image texture were expressed as vertex x, y, u, and v. The x and the y were coordinates of the vertex, the u was a horizontal coordinate for the texture mapping, and the y was a vertical coordinate for the texture mapping.

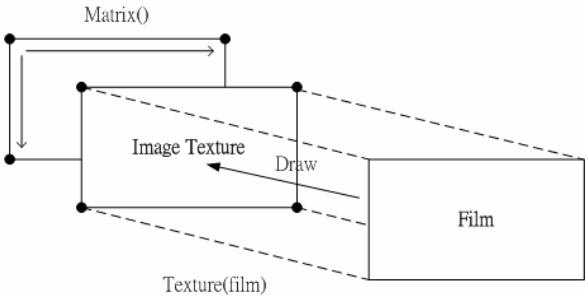

Figure 9 The Film Draws on Image Texture.

With regard to the development environment, we used a PC with Pentium(R) Dual-Core 2.6GHz CPU and a Logitech Orbit as the webcam, which captured 30 frames per second. The frame size was 640×480. The distance between the webcam and the postcard was 50 centimeters. The AR marker on the postcard was 4.55 cm in length and width.

The interactive content of the work was with the video form. Each poem from the postcard matched a virtual digital poem. The audience could interact with the postcard by directly manipulating it. Figure 10 provides an example of the front and back of a postcard. Each postcard corresponded to a video film of digital poems. There were twelve postcards and twelve video films. Figure 11 presents the twelve postcards.

(1) (2)

Figure 10 (1) The Back of the Postcard Has an AR Marker. (2) The Front of the Postcard Has a Poem.

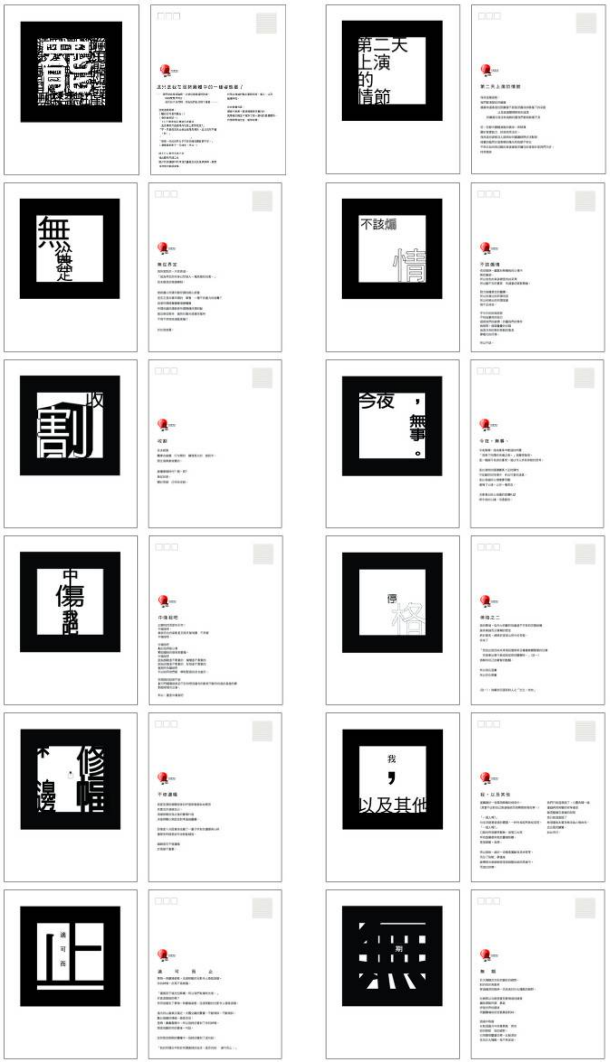

Figure 11 The Twelve Postcards.

The necessary elements of the ‘Mind Log’ exhibition included a webcam attached to a lamp, a reading desk, a projector, and a white wall. Figure 12 provides a picture of the installation of the artwork. There were several postcards on the reading desk, and the lamp was installed at a higher position to present a broad view.

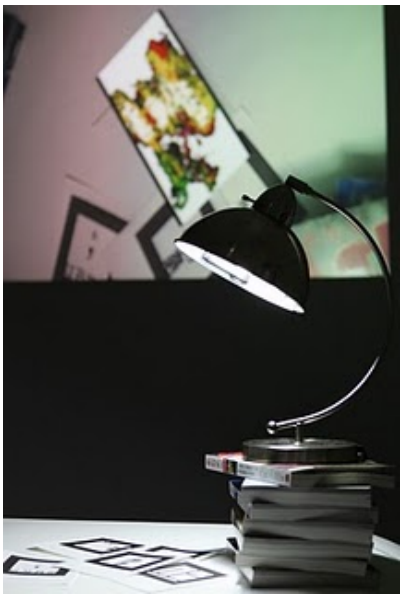

Figure 12 The Installation of Artwork.

EXHIBITION EVALUATION

An evaluation of the interaction between the audience and the artwork was conducted using the triangulation method, which included questionnaires, observations, and interviews.

Triangulation refers to the use of more than one approach to investigate the research questions to enhance the confidence in the ensuing findings (Liu et al., 2008). Often, social science research is conducted using a single research method and suffers from limitations associated with the single method or from the specific application of the method. The term triangulation is derived from surveying, which uses a series of triangles to map out an area (Webb, Campbell, Schwartz, & Sechrest, 1996) and describes one of several methods of conducting multi-method research.

Questionnaire

The well-known questionnaire, System Usability Scale (SUS), was utilized to evaluate system usability (Isman & Isbulan, 2010). The questionnaire was revised with recommendations from experts who had significant experience in related fields. A 7-point scale, ranging from 1, meaning strongly disagree, to 7, meaning strongly agree, was used for this measurement. The revised version of the SUS questionnaire is presented in Table 2 (Brooke, 1986; Tullis & Stetson, 2004). The revision mainly focused on making the SUS more suitable for artwork evaluation.

Table 2 The SUS Questionnaire and the Statistics for Each Item.

System Usability Scale	Mean	SD
1. I think that I would like to interact with this work more frequently	3.20	0.82
2. I find the work unnecessarily complex	2.38	0.93
3. I suppose the work is easy to use	3.28	0.83
4. I think that I would need the support of a technician to help me use this work	2.17	1.17
5. I find the various functions in this work are well integrated	3.28	0.70
6. I suppose there is too much inconsistency in this work	2.31	0.61
7. I would imagine that most people may learn to use this work very quickly	3.22	0.75
8. I find the work to be not very user-friendly	2.22	0.67
9. I feel very confident while using the work	3.41	0.71
10. I need to learn a lot of things before I can get used to this work	2.67	0.99

The SUS is a questionnaire to estimate users' subjective feelings and their degree of satisfaction with regard to the system. Concerning usability evaluation, the SUS is an efficient, time-conserving, and labor-saving way of gaining a subjective estimate, and it is widely applied to system usability. After users answer ten questions, the scale transforms the subjective feelings of the users into objective data for analysis. That is, a score on the SUS is used to evaluate the usability of the system. The range of estimate scores is from 0 to 100. The higher the

score, the more useful the system is and the more easily users can interact with it.

Population

Participants in this study were 162 audience members who attended the opening ceremony of the Mind Log artwork exhibition. The majority of audience members were students, and the rest were professors, artists, journalists, reporters, and other visitors.

Sample

There were 458 audience members in total who attended the opening ceremony. In this study, 162 subjects were randomly selected from among the audience members who entered the exhibition room of Mind Log and were issued the SUS questionnaire. Subjects completed the questionnaire on site with a 100% response rate. The age of the subjects ranged from 18 to 43 years of age (97 females and 65 males). The ratio of males to females was close.

Table 3 Descriptive Statistics of the SUS Questionnaire.

	N	Mean	Median	Min	Max	SD
Stat	162	75.4	72.5	55	100	10.5

Listed in Table 3 are the SUS scores with regard to the AR-based artwork. The mean SUS score was 75.4, the median was 72.5, the maximum was 100, and the minimum was 55. Given that the mean and the median were 75.4 and 72.5, respectively, these scores indicate that the Mind Log AR system is usable. This result means that audiences accept this kind of artwork and that there is potential for installation art use.

In addition to an SUS score that showed the usability of Mind Log, the survey presented in Table 2 also revealed the following findings:

- The 9th item had the highest mean, which indicates that most audience members felt very confident while using the AR system.
- The next three items with high ranks were the 3rd, 7th, and 1st items, indicating that this work had positive characteristics, including being easy to use, quick to learn, and attractive to interact with.
- The standard deviation of the 4th item was relatively high, which indicates that some audience members were familiar with AR techniques before attending the exhibition and some members were not. Thus, some members needed technical support and others could use the work without outside assistance.
- The 10th item revealed that some audience members were not confident about understanding the poems. Therefore, they thought they should learn how to analyze poems before visiting the artwork exhibition.

Observation

During the exhibition, the interaction between audience members and the AR digital poems was video-recorded and the members' behaviors were analyzed. According to our observations, the audience members were very interested when there was a dynamic film presented from the postcard. One possibility is that people had never seen this type of interactive device before. During the observation, it's found that the audience members were curious about what was hidden in the postcard. However, most of the audience members accidentally occluded the black frame of the postcard or left the black frame outside of the camera's capturing area. They may have blocked the black frame purposefully out of curiosity. Moreover, some audience members turned the postcard at certain angles that then made it difficult for the postcard to display its film. These manipulations resulted in difficulties that were common among audience members. It's also observed that audience members "read" the content of the poems by manipulating the postcards, so that the digital films "hidden" behind the AR markers could be displayed. Examples of audience members interacting with the installation during the exhibition of this artwork are shown in Figures 13 and 14.

Figure 13 An Audience Member Interacting with an AR Digital Poem.

Interview

The audience members were interviewed to explore their ideas about AR digital poems after they had interacted with the artwork and completed the SUS questionnaire. The approach was qualitative, and the method was a semi-structured face-to-face interview. A series of in-depth interviews with various audience members were conducted to examine the usability of our design.

Eighteen audience members were interviewed. Ten members were female and eight were male. The members were between the ages of 21–42. Interviewees included professors, artists, journalists, reporters, students, and members of the general public. The interviews, which lasted 5–12 minutes, were recorded in both video and written form.

Many of the interviewees attempted to illustrate how the artwork was presented, with some members describing their feelings. The Ground Theory was employed again to synthesize useful information methodically. Thirty-four chunks/subcategories were determined, which lead to seven main categories. The following were the feedback categories created from the interviews:

- **Interaction:**
  Some audience members thought that the AR interaction was quite attractive.
  They hoped that we could add more appealing elements to the artwork, such as more interaction and content from the audience members' perspective (ex: 010, 012).
- **Technology Acceptance:**
  Some members said it was their first time interacting with this kind of advanced technology, but that they felt excited when attending the exhibition (ex: 010, 012).
- **Learning on Artwork Design :**
  Many audience members, especially professors and students, said that this exhibition provided a learning atmosphere that could improve their appreciation for esthetics and arts design (ex: 004, 011, 016).
- **Satisfaction:**
  Many audience members said that they felt emotionally fulfilled and mentally satisfied when interacting with the visual poems and the AR-based artwork (ex: 009, 018).
- **Inspiration and Instructiveness:**
  Most audience members found the digital artwork instructive.
  Most audience members responded that they had feelings while interacting with the artwork (ex: 007, 008).
- **Exploration and Comprehensibility:**
  Most of the interviewees said that they were very willing to explore the artwork.
  Most interviewees gained more comprehension through the combination of the AR cards with the presentation of the poems (ex: 011, 013, 018).
  It is remarkable that interviewee-017 thought that the artwork was not comprehensible and that interviewee-002 thought she should learn more about poems before attending the exhibition, which was equivalent with the 10th SUS item previously mentioned.
- **Imagination:**

Some audience members conveyed their feelings about the exhibition through the metaphor of the AR markers providing "passwords" to the virtual world, which inspired them to associate artwork, poems, and their imaginations (ex: 008, 014).

Figure 14 Audience Members Interacting with the Exhibition.

RESULTS OF TRIANGULATION

According to the triangle evaluation that included questionnaires, overviews, and observations, the results showed that this work achieved positive usability, the audiences enjoyed the interaction with the artwork, and, most significantly, AR-based digital poems were acceptable. Listed below were some results and findings from audience members using the triangulated evaluation:

- It was interesting to interact with this artwork.
- The exhibition provided a good learning environment for designing artworks.
- AR-based artwork was easy to interact with.
- The new AR technology was well accepted.
- The artwork and AR system were well integrated
- The design of AR markers and postcards were consistent.
- This work was easy to learn and instructive in creating imaginative associations.
- The AR system was user-friendly, and this made audiences feel confident when using it.
- The visual poems were comprehensible for most audience members.
- This work provided a high degree of satisfaction in that audience members were emotionally fulfilled.

CONCLUSION AND DISCUSSION

In this paper, a type of artwork that combined visual poems, an interactive installation, and an AR system was introduced. The development of this work incorporated both experts' and audience members' perspectives with regard to design and evaluation. The results of the experimental evaluation using the SUS questionnaire, observation, and interview revealed that audience members thought that AR digital poems were interesting and novel devices for creating artwork. Given that audience members had never interacted with this type of artwork before, this research suggests that they accepted this kind of interactive installation artwork.

According to both expert-based and audience-based evaluation, the research questions can be answered as follows:

- AR-based artwork is acceptable.
- The AR system designed in this study is usable.
- The audience felt satisfied with the exhibition.
- The visual poems were comprehensible.
- The exhibition provided a good learning environment for art and design.

From education and learning viewpoints, this study suggests the following benefits, which are seldom mentioned in previous research:

- Digital art provides different kinds of esthetic experiences, which is remarkable for art and design educators.

- AR techniques are helpful for the creation of art. Therefore, AR design and implementation skills should be included in digital art related courses.
- AR is an important learning technology for arts education.
- AR can make artwork more immersive, which is not easy to achieve in the traditional art appreciation process.
- The issues regarding interaction and usability should be emphasized when training visual designers.
- This study shows that the development of visual poems is promising. Thus, literary works can be complemented with digital artwork.

In the future, this work will be uploaded to the Internet and apply it more creatively so that audience members can manipulate and interact with AR digital poems on web pages. The setting and operation of this artwork will be made easier to interact with in such a way that the audience simply has to set up a webcam without additional hardware. In comparison with other AR equipment, the cost of this work is quite low, so it may be a new trend for creating AR-based digital art in the future.

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