# Light up! Creating an interactive digital artwork based on Arduino and Max/MSP design

**Conference Paper** · January 2011

DOI: 10.1109/COMPSYM.2010.5685506 · Source: IEEE Xplore



**4 authors**, including:

Hao-Chiang Koong Lin
National University of Tainan
**71** PUBLICATIONS **472** CITATIONS

SEE PROFILE

# Light up! Creating an Interactive Digital Artwork Based on Arduino and Max/MSP Design

Yu-Chen Yang
Department of Information and Learning Technology
National University of Tainan
Tainan, Taiwan
e78v03e10eve@hotmail.com

Yi-Jen Tseng
Department of Information and Learning Technology
National University of Tainan
Tainan, Taiwan
melody_winds@hotmail.com

Sheng-Tien Wang
Department of Information and Learning Technology
National University of Tainan
Tainan, Taiwan
tyn037@hotmail.com

Hao-Chiang Koong Lin
Department of Information and Learning Technology
National University of Tainan
Tainan, Taiwan
koong@mail.nutn.edu.tw

*Abstract*—**Recently, digital art plays a more and more important role in various kinds of performance arts. Not only do the performers have more performing forms, but the audiences also receive the performing messages from the stage in completely different ways as compared to before. Moreover, the performers and the audiences can do the interaction with each others. In this paper, we try to establish an interactive system to control the lights of the stage. We wish the user can use the system to create their own stage by themselves.**

**This study is aimed to explore the following two concerns: (1) How can we provide the audiences better interaction by combining music and lights? (2) How to make the audiences emotionally fulfilled by interacting with the system?**

**The experimental results show that the user can enjoy the interaction by his own way and create different light effect with the music. At the same time, the users believe the system can became more useful and expandable and feel satisfied.**

***Keywords-Digital Art; Context Awareness; Interactive Art; Happening; Installation Arts***

## I. INTRODUCTION

### A. Motivation

We can find many films about awards or idol concert on the top ranking on Youtube. We can find that the recent performances are not just excellent singing and dancing. The performance is also use some special effects like varied light or projection on the stage with the background which is composed of big screen with changing images. All the things make up the great show with multiple sounds and visions. And the design of the varied stage light interests us the most.

The way of using new media on performance motivated us to research following things: Can we control the stage light just by sound detection and user directly manipulating but not default setting to create personal work of stage light? It means even using the same song, but different users can get different effects by themselves.

Most traditional art is unidirectional. That is only the audience gets the message from the author. And because of the personal reason and experience everyone get the work levelly. But digital art create a new world by using technology. Especially is interactive art which turn the audience to the author. How does it link the user and the work successfully makes us want to know more.

We also want to know more about happening which increase more fun on interactive art. People cannot expect what will happen next, and the surprise just show up. By interacting with the system, we not only brand new things to the same performance, but also wish that the user can get the message about treat the same thing in different sight.

### B. Research Questions

The critical factor that transforms unidirectional traditional arts into two-way digital art is the appearance of new media arts. New media arts bring a new way for artwork creation. But is technology really everything? When we enjoy the convenience from technology, didn't we lose some sensibility? By using the system we wish the user can enjoy the changing environment of the light and jump out of the stereotype, just try to feel the relationship between user and the world. We will discuss following questions in this paper:

(1) Which parameters will be set in the programming when the sensors read different music?
(2) After finishing the programming and sending the instruction to the hardware, how to present the light effects?
(3) Can the light effects in real time make the user truly feel that they create their own stage?
(4) Does the system provide good interaction between the user and the system?
(5) Does the user feel satisfied about the system?

Technology is more and more advanced and developed. So there are more and more materials can be used in art. By using the materials well, we believe the creation can bring more new experience of sounds and vision for the audience.

Moreover, people can get deeply feedback during the process of interaction.

## II. Literature Review

### A. Digital Arts

"Digital Art" is the word "Techne" that from the ancient Greek. It refers to arts, skills, crafts, and so on [18]. In the process of creation, if the arts were created in digital forms, and methods, that is called digital art. When the traditional forms of arts were recreated by digital methods or tools, it can be called art-digitization. No matter what type of creations, they all can be known as digital art [11].

The difference between the digital art and the traditional art is not the change of the creative spirit, but the use of digital technologies. Therefore, digital art is that can be shown in the way of digital or together with other technologies to display in various ways [3]. In Rui's "Introduction to Digital Art": "Digital Art is different from the OpArt, Minimalism or PhotoRealism. It is not a particular style or idea, it is a tool or a way to show, similar to the sculpture, and photograph. "

In these diverse creations, the influence and change of the science and technology can be seen. We also look forward to the science and technology that progress continuously can lead the digital art into a more brilliant future.

### B. Characteristics of Interaction

Using the computer programs to drive the object around, so that the works of art can interact with the audience. And making the original passive single law of inertia between the creations and the audiences become a community of interactive [24].

The major difference between the digital interactive arts and the traditional arts is that you can let the audience to join the creative process, allowing viewers to create their own world by full use the freedom of digital. Margret Elisabet Olafsdottir, curator at The National Gallery of Iceland argues that interactive art's main objective is to have the spectator actively participate in the creative process. Participation was supposed to stimulate the audiences' creativity as instead of standing in solemn contemplation. This concept is contrast obviously with the traditional arts [25]. "Interaction" makes works of art is not just a one-way creators' tell, the audience is no longer a passive listening. It becomes a dialogue, a two-way communication between the people and the arts.

Now, through the interactive installation art, technology is no longer 0 and 1, the interpretation of digital information. It could also become a bridge between the machines. Through the complex program operations, digital media can be used with the hardware, and allows creation to be copied into many new forms. It gives artists a new creative mode of intermediary to copy images, and also make the audiences interact with the work in the casual condition, or even can create their own unique interactive experience.

New media artist and theorist Roy Ascott said: "The most distinctive characteristics of the new media art are connectivity and interactivity. There are five stages to learn about the creation of new media art: links, merge, interaction, transformation, appearance." First of all, you must link with the work, and let your body merge into the work (not just only watch in the distance). Second, interact with the system or other people, which will lead the work and your consciousness to transform. Finally, the new image, relationship, thinking and experience will appear.

### C. Interactive Arts

The most characteristic about digital art is combine technology and use technology to create art. The more technology progress, the more variety can be show on. Using technology to create art work can help artist present the creativity more vivid. And art work has to express the affection directly. Moreover, should inspire deeply thought. So the work can cause the viewers' feedback in mind. Creative work should be open process but not closed, structured or limited [17].

Wang said: "Interactive has been considered the important characteristics of digital art, but the evolution of the aesthetic point is seldom mentioned. The experience of the participation process is the most important formation of the art-created". This also develops the "interactive aesthetics" gradually, and all of them are major concepts of the new media art. If you add some interactive elements into the work, then you can create a richer interaction between the viewer and the work. And make the relationship between "creator", "audience" and "work" complicate, for example, creators may become the viewer, but the viewer may become creators, and then generate a new route [17].

## III. Digital Arts Programming

Miller Puckette and other designers have developed Max / MSP at IRCAM in Paris since 1988. At the beginning, they started from the control of sound, now has been combined with images and interactive capabilities. As for the technology, it is a specialized art programming language, which is a comprehensive set of development kit to use drag components as part of the program [5][15]. Max/MSP/Jitter uses the software to control the connection between many audio and video hardware of computer, such as sensors, MIDI equipment, sound playback, video output,etc. Max is responsible for controlling the messages between MIDI; MSP, for Audio controlling; Jitter, efforts to dealing with static and dynamic images. Among them, Max is the controlling logic of the core process. Consequently, to learn MSP or Jitter, leaners must first have the foundation of Max. [2][5][15].

Cheng thinks: "This system has made progress from the original MIDI controlling functions (Max part) to the immediate processing of voice message (MSP part) in recent years. This has shorten the distance between composers and computer music technology. And it even devoloped to integrate real-time image processing (Jitter plugin). The role of computer in the musical works' roles and functions has aready changed from sound editing, musical instruments, sound simulation, and further into the role of a jam [5][15][21].

The Arduino is an open source Simple I / O board, as long as we write codes within a integrated-development environment, and use the program to control the Arduino board, and burn it into the chip (microcontroller) of the Arduino board in the end, the link can be developed through the bread plate to complete the electronic components such as Switch, sensors, controllers, LED or other output devices. It also allows Arduino and the electronic components linked with it work independently as an interfaces with other software program [1].

Having this in mind, we use Cycling '74 Max / MSP / Jitter 5 with Arduino to develop and design an installation system in this study. When users interact with the installation, the system will capture the audio and sensor values, and input the codes we design, and then users can get the feedback as flashing lights in order to reach the stage of writing personal and exclusive research purposes. Refer to the system architecture diagram in figure 1.

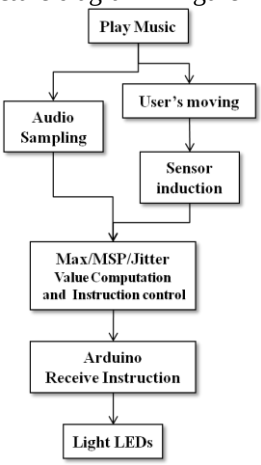


Figure 1. System Architecture Diagram.

## IV. METHOD

### A. *Audio Detection*

We mainly study the volume and pitch of the music. When we play the music, the Max/MSP can analyze the audio by using its build-in objects. We use the object of peakamp~ to capture the max value during a certain period of time. The object of pitch~ is used for detecting the hertz. In figure 2, the yellow block shows the part of read-in audio file, and then the object: pitch~ and peakamp will analyze the audio information. After calculating the parameter, we can get the audio value which will be used later.

### B. *Sensor Combination*

We will use different sensors to do the test, such as pressure sensors or buzzers. As the user dances with the music, the sensor can detect synchronously the pressure during the operating time, and transforms it into a useful value. Next, the system will combine the value with audio value and operate the two values. After that, system will send messages to Arduino according to the variations of the values. In the end, the user can interact with the system, triggering multiple LEDs by using different ways. The system of flow chart presentation is shown in figure 3. Figure 4 is the code that Max/MSP and Arduino can communicate with each other. In the figure 5, we can observe the twinkling LEDs by the object-toggle.

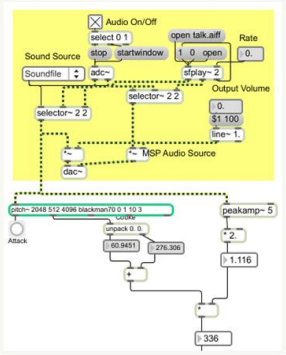


Figure 2. Read and analyze the audio in Max/MSP.

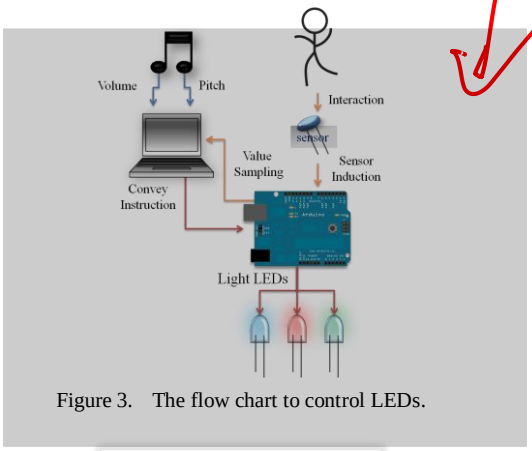


Figure 3. The flow chart to control LEDs.

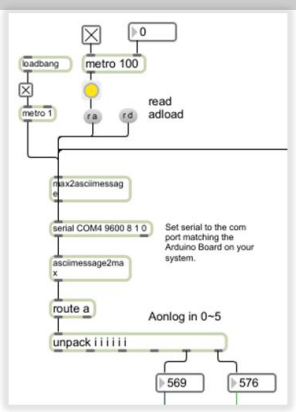


Figure 4. The code which communicates with Arduino.

Figure 5. The situation of LED trigger in the code.

### C. *Research Processes*

As introduction about software and hardware before, this research will develop the system step by step like figure 6.

1. Use Max/MSP to get the parameter about volume and pitch of the sound which the research need.
2. Choose different sensor to take a test and use Max/MSP to analyze the parameter.
3. Use the parameter we got before to execute the program. After evaluated the parameter, program makes the LED reaction finally.
4. Do the questionnaire about the system. Then improve the system in according to the analysis of the questionnaire.

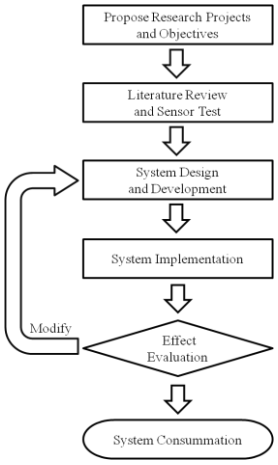


Figure 6. System construction flow chart.

## V. EXPERIMENTAL RESULTS AND ANALYSIS

After the system finished, we invite 35 users to play it and fill 3 questionnaires which are System Usability Scale, Questionnaire for User Interaction Satisfaction [20], Interaction and Satisfaction Scale. And we interview 5 users from them. The whole process is depicted in figure 7.

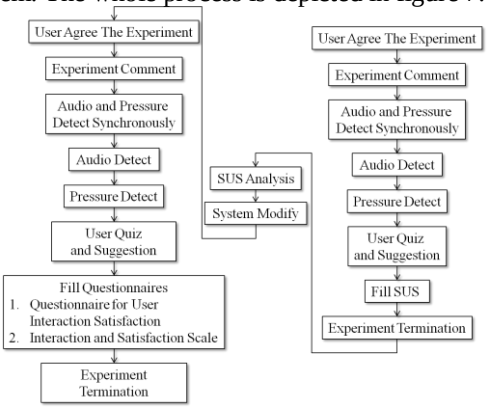


Figure 7. Experiment flow chart.

### A. Experiment

First, we introduce our system to the user. We only use the sound detection to control the system. Just show them the system is reacting in real time but not setting before. Second, we let the user try to control the system by directly manipulation without sound detection. Finally, we encourage the user to interact with the system by directly manipulation with the sound detection. In the end, the users fill the questionnaires and some of them accept the interview.

Figure 8. Users intertact with the system.

### B. User Satisfaction Analysis

Among the 35 participants, there are 4 younger than 19 years old, 29 between 20 to 29 years old and 2 between 30 to 39 years old. 13 were female, and 22 were male.

TABLE I. EXPERIENCE ABOUT DIGITAL ART WORK

| **How many times have you interacting with digital art work before?** | | | | |
|---|---|---|---|---|
| ***None*** | ***Once*** | ***Twice*** | ***Three times*** | ***More than three times*** |
| 4 | 4 | 9 | 5 | 12 |

Table I shows that most people have experience about digital art work before this time.

#### 1) System Usability Scale

SUS is a questionnaire to estimate users' subjective feelings of the system and further know their degrees of satisfaction. In the aspect of system usability evaluation, the SUS is an efficient, time-conserving, and labor-saving way of subjective estimate. At present, it is widely applied in the system usability. After users finishing answering ten questions, the scale offers a formula which transfers the subjective feelings of users into the objective data information for analysis. That is, the score of SUS is used to evaluate usability of the system. The range of estimate score is from 0 to 100. The higher the score is, the more useful the system is and the more easily users can interact with it[11].

TABLE II. DESCRIPTIVE STATISTICS OF SUS QUESTIONNAIRE

| **N** | **Mean** | **Median** | **Min** | **Max** | **SD** |
|---|---|---|---|---|---|
| 35 | 71.1 | 70 | 35 | 92.5 | 13.5 |

From table II we know that the mean SUS score is 71.1, the median is 70, the minimum and the maximum is 35 and 92.5. The scores mean the system is usable and valuable to continue developing.

TABLE III. SUS QUESTIONNAIRE AND STATISTICS OF EACH ITEM

| | **System Usability Scale** | **Mean** | **SD** |
|---|---|---|---|
| ***1.*** | ***I think that I would like to interact with this work*** | 2.14 | 0.99 |
| ***2.*** | ***I find the work unnecessarily complex*** | 3.03 | 0.91 |
| ***3.*** | ***I suppose the work is easy to use*** | 3.23 | 0.86 |
| ***4.*** | ***I think that I would need the support of a technician to help me use this work*** | 2.60 | 1.18 |
| ***5.*** | ***I find the various functions in this work are well integrated*** | 2.43 | 0.87 |
| ***6.*** | ***I suppose there is too much inconsistency in this work*** | 2.57 | 0.90 |

| | System Usability Scale | Mean | SD |
|---|---|---|---|
| *7.* | ***I would imagine that most people may learn to use this work very quickly*** | 3.17 | 1.08 |
| *8.* | ***I find the work not very user-friendly*** | 3.26 | 0.77 |
| *9.* | ***I feel very confident while using the work*** | 2.94 | 0.86 |
| *10.* | ***I need to learn a lot of things before I can get used to this work*** | 3.09 | 0.10 |

Table III is scores about SUS questionnaire and statistics of each item. The 8th item gained the highest mean. And the 2nd, 3rd and 7th items also gained higher scores. It indicated that most users felt the system easy to use.

The most important is that participants are willing to accept and use this system. The system has potential for installation arts use.

*2) Questionnaire for User Interaction Satisfaction*

Questionnaire for User Interaction Satisfaction [20] is provided from Human-Computer Interaction Lab. Score users' satisfaction with the view of user interface. The content of the questionnaire can adjust for the research. Our research concentrates on the response about manipulating the system and the scene about present the light effects. A 7-point scale ranging from 1 as strongly disagree to 7 as strongly agree was used for the measurement[14].

TABLE IV. DESCRIPTIVE STATISTICS OF THE RESPONSE ABOUT MANIPULATING THE SYSTEM

| Question Items | Mean | SD |
|---|---|---|
| ***Simple to Use*** | 5.63 | 1.20 |
| ***Easy to Use*** | 5.34 | 1.33 |
| ***Great*** | 5.23 | 1.22 |
| ***Multiple*** | 4.94 | 1.45 |
| ***Interesting*** | 5.03 | 1.52 |
| ***Efficient*** | 4.77 | 1.17 |

According to table IV, each items get the score higher than 4. It means the user felt satisfied about the system. But the efficient about the system get the lowest score. Because some users felt they cannot make sure about either they control the light up or the music did.

The interesting about the system gets the highest SD. We found that some user enjoyed the interaction with the music and touch the sensor in their mind. They were success to interact with each other. But the other just focused on the changing light. They do not care about the music. So they feel bored about just saw the light.

TABLE V. DESCRIPTIVE STATISTICS OF THE SCENE ABOUT PRESENT THE LIGHT EFFECTS

| Question | Mean | SD |
|---|---|---|
| ***Multiple LED*** | 5.29 | 1.32 |
| ***Colorful scene*** | 5.20 | 1.19 |

Table V shows that the participants gave mean score higher than 4. It means the participants feel satisfied about the light

*3) Interaction and Satisfaction Scale*

About the Interaction and Satisfaction Scale, we use Likert scale to score the system. A 7-point scale ranging from 1 as strongly disagree to 7 as strongly agree was used for the measurement. 1 mans terrible, 4 means no judgment and 7 means satisfied.

TABLE VI. RESULT FROM INTERACTION AND SATISFACTION SCALE

| Question | Mean | SD |
|---|---|---|
| ***Challenge and Curiosity*** | 4.63 | 1.17 |
| ***Inspiring*** | 4.00 | 1.04 |
| ***Satisfaction*** | 4.74 | 1.10 |

Table VI tells us about the Interaction and Satisfaction of the system. Besides the inspiring, the other got the score more than 4. Most users can not be inspired in their mind through the interaction.

## C. Interview

We have interviewed 5 participants. All of them agree the system is easy to use. If we could increase more light effects it would be better. The most important thing is to advance the efficient. Make the responding time shorter to enhance the user control. Finally expanding the system let user make sure the lights up for them in advanced.

# VI. CONCLUSION AND FUTURE WORKS

We hope that when a user stands before the controlling system, play music, the computer detects the audio, and then the user swings with the music, and through the use of sensor and the judgments of programs triggers out lighting transformation. With the changing light and shadow effect, the system allows users to remove the defensive interaction with the unfamiliar machines, immersed in their own light art and enjoy dancing and singing in a brilliant dancing arena, just like a superstar. The Moments of interaction with the installation system, users can not only quietly achieve an impossible dream, but also expanding the perspective to see the world and enrich the connotation of their own, and stimulate imagination in the repeatedly changing sound and light environment. Finally, they will leave with a happy smile and great satisfaction.

(1) Which parameters will be use in the programming when the sensor catches different music?
While reading the audio, we use the volume and pitch to judge. The volume will use peakamp ~ object, the system will capture the peak of its strength during a certain period of time(in milliseconds). The pitch is based on pitch ~ package to reads Hz value.

(2) How to present the light effects after finished the programming and sent the instruction to the hardware?
In the program, we will set a threshold for each LED, as long as the value is calculated over the threshold, it will light the LEDs indirectly.

(3) Can the immediate light effects make the user really feel that they create their own stage?
Although the hardware is limited, but through the design of the program, we can still have various changes, and

the system can produce different changes based on the user's creativity. Some users will try hard to press on the sensor to make every LED light up, or hit LEDs to make the lights go with a rhythm, and some users even trigger the lights by blowing. The Users use their own ways to make LEDs light is a kind of creation, a unique communication and interaction of art. Therefore, we believe that most of the users who can really feel this interactive work of art is the outcome of personal interaction.

(4) Does the system provide good interaction between the user and the system?

The study provides three variables: music, users, and lights. These three changes of parameters will indirectly influence the interaction among them. Experiment found that some users swung in a unique way because of the speed of music rhythm, and this triggers different lighting effects; some of the users controlled their own actions carefully to observe the regularity of lights flashing. Whether the users were listening to music or watching the light; no matter how they interact naturally or carefully, all the users were enjoying the interaction. Therefore, we believe that this controlling system can provide a good interaction.

(5) Does the user satisfy about the system?

From the interaction and statistical analysis of the Pleasure Scale, overall average is 4.74, standard deviation of 1.10, Skewness and kurtosis is slightly closer look at the left side of the low broad peak, more representative of high scores low marks less. In depth interviews, some respondents give some suggestions and ideas. For example, add more light, play their favorite music, etc. Users not only feel appreciation for creativity about this controlling system, but also affirm the utility and scalability of this controlling system. However, this controlling system still has room for progress and improvement, but we believe that users are satisfied with the controlling system.

Through this research experience, we can understand the interpretation of "Interactive Artistic". The narrow sense refers to the audience's personal participation shows the whole concept of art, a broad sense, we view the process of the audience who sees, identify the concept of mind, and convey the conception as an interactive act. However, the implementation of the whole plan, not just a professional academic research and presentation of digital art, we also hope that this system can be effectively utilized in the commercial sector or entertainment career. In the future, this research work to further the development to the video presentation, by using the capabilities of Max / MSP which can combine the videos and interaction, it can generate a random drawing out of nothing. And then, we can cooperate with the stage design cooperation, through more powerful hardware support, this work of art features and effects will reach more extreme play. We believe in the stunning and unique backdrop of lighting, not only show the professional performer's perfect performance, but also let the audiences feast their eyes on the scene.

## REFERENCES


[1] Arduino.TW (2008). http://www.arduino.tw/

[2] Cycling74(2007). http://www.cycling74.com/

[3] Chen Li-Chiu (2009). From the global trend of digital art on modern art ed.ucation in Taiwan.

[4] Chen, Yun-Ru (2009). Non-Mexican Dance - Interactive multimedia and interdisciplinary writing and study dance. Master thesis, Department of Multimedia and Animation Art, National Taiwan University of Arts.

[5] Cheng, Chien-Wen (2004). Computer Music Notes http://w3.nctu.edu.tw/~u8642524/ComputerMusic.htm

[6] Chin, J. P., Diehl, V. A., & Norman, K. L.(1988). Development of an instrument measuring user satisfaction of the human-computer interface. In CHI '88 Conference Proceedings: Human Factors in Computing Systems, (pp.213-218).New York: Association for Computing Machinery.

[7] Graph. Image. Process, vol.21, pp.345-367.

[8] Grout, Catherine (2002). Art spaces: all in the arts. Meng-Yin Yao translation. Taipei: Yuan-Liou.

[9] Han. Bao-De (2000). Show Planning: Theory and Practice. Taipei: Garden City Culture

[10] Harpe, S. M. (1993). Improving User Satisfaction: The Questionnaire for User Interaction Satisfaction Version 5.5.Mid-Atlantic Human Factors Conference, pp.224-228

[11] Hsieh, Min-Chai, Hao-Chiang Koong Lin, Jin-Wei Lin, & Mei-Chi Chen (2010), "The Establishment of an AR-based Interactive Digital Artworks", GJCST, Global Journal of Computer Science and Technology, Volume 10 Issue 6 Version 1.0: 37-46: August..

[12] Ives, B., Olson, M. H., & Baroudi, J. J.(1983). The measurement of user information satisfaction. Communications of the ACM, 26, 785-793.

[13] Levin, Golan (2006). Computer vision for artists and designers: pedagogic tools and techniques for novice programmers, AI & Society, 462-482.

[14] Likert, Rensis (1932), "A Technique for the Measurement of Attitudes", Archives of Psychology 140: pp.1-55

[15] Lin, Hao-Chiang Koong, Zheng-Zong Li (2008). Using Max / MSP / Jitter programs and the Sobel operator and combine images, sound, MIDI music to create an interactive digital art, Science and Technology Research ,15-28.

[16] Lin, Pei-Tun, Digital Art Lab Group Show. Transboundary Perspective. The art center of Providence University.

[17] Lin, Pei-Tun, Yin-Xia Fan (2004). From the interactive concept of Digital Arts, Media and Aesthetics, Art Journal.

[18] Luo, Song-Ting, Yu-Sheng Su, Wei-Fu Zhuang (2009). Your mood with the trash in the digital art creation and research.

[19] Pelletier, Jean-Marc (2004). A Shape-Based Approach to Computer Vision Musical Performance Systems, International Academy of Media Arts & Sciences, 3-95.

[20] QUIS(2006).http://lap.umd.edu/quis/, Retrieved 2006.

[21] Toner (2006). Where to Use MaxMSP? http://home.guestbook.com.tw/b2/viewtopic.php?t=188&mforum=cwcheng

[22] Ye, Jin-Rui (2003). Art in the digital age. Taipei: artouch.

[23] Ye, Si-Yi (2005). Game Master on digital interactive script writing(Chris Crawford on interactive storyetling). Taipei: GOTOP.

[24] Ye, Yu-Tian (2000). About "Digital Art", Art ideas.

[25] Zhang. Bai-Ling (2007). JOURNAL OF AESTHETIC EDUCATION, NO.157