Research on Interactive Installation Design Centering on Urban Light Pollution Based on Open-source Programming Language

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Abstract. The design of multimedia interactive installations symbolizes the integration of technology and art, and has already become an artistic expression form with distinctive technological beauty of the times. Furthermore, the application of open-source programming language enhances the interactivity and enriches the connotation of the installation itself, as well as creates the aesthetic feeling for the viewers via catering to their sensory needs during the interaction with the installation. This research takes “TURN OFF!!”, an interactive installation as an instance, which focuses on the theme of environmental protection and employs Processing, the open-source programming language and Arduino, the open-source electronic prototyping platform. Also, the research manifests the application significance of the open-source programming language in the design of interactive installations, and discusses the influence of the integration of science and technology and artistic design during the creation of art and the ultimate presentation of the artwork. In the end, the research indicates that future designers should have programming-related technical skills to better display their creativity and imagination.

1. Introduction
The high-speed development of science and technology has enabled an increasingly intertwined relationship between various fields. Thus, the design of multimedia interactive installations represents the fusion of technology and art. Particular to note, open-source programming language features the open-source property and a low threshold for application, thereby it is rather worthy of designers and artists to integrate it into installation art design.

2. Open-source programming technology and its application significance

2.1. Processing, an open-source programming language
Processing stands as a flexible open-source computer programming language (P language, for short), which was first initiated in 2001 by Casey Reas and Ben Fry of the Aesthetics and Computing Group of the Massachusetts Institute of Technology Media Laboratory.

Moreover, Processing is widely employed to create interactive graphics in the realm of digital media art, thus the most intuitive form can visualize the designers’ creative thinking into the interactive creative works. Although based on Java, Processing itself has more design transformations that adapt to the creation of visual information. Compared with Java with the complex language framework, Processing stands as a simplified version and does not require designers to have...
systematic knowledge on programming syntax and high proficiency in English. Hence, its users can shape a creative image with a few lines of code.

2.2. **Arduino, an open-source electronic prototyping platform**

Arduino serves as a convenient and flexible open-source electronic prototyping platform from Italy. Its programming language is based on the C/C++ language and consists of a hardware platform (Arduino Board) and a development tool (Arduino IDE). Users can control the Arduino electronic chip through a relatively simple programming language, connect and receive signals transmitted by various sensors and functional modules at the same time, and control subsequent devices through programs (such as processing) to feedback information, thereby enriching perception and recognition, processing and other functions. For most art students, artists or designers who have no rudimentary knowledge on engineering, the Arduino language is easier to understand, which can promote communication between designers and engineers or write feasible codes after simple learning.

With the combined development of information technology and artistic design, the Arduino-based platform has five features as below. First, it requires low-cost consumption; second, it has high platform compatibility; third, it is a humanized programming language; fourth, it is open-source hardware and software; last but not least, supported by many developer communities.

2.3. **Interactive installation design supported by programming technology**

Interactive installation design is characterized by dynamic aesthetics, different from traditional art design. Specifically, the audience can communicate with the installation by triggering actions and such interaction is often part of the expected effect. Also, the audience can resonate with emotions conveyed by the installation when transmitting visual, auditory, and tactile perceptions via sensors.

The interactive installation fully respects the personal wishes of the participant to convey its connotation. This form of artistic expression is eye-catching for the audience to think about the content behind the installation. Thereby, recognition from the participant will be generated in terms of the connotation of the installation, thus meeting the designer’s purpose. In addition, the employment of programming technology strengthens the interactivity of the installation and diversifies its expression forms. From the perspective of the technical means, supported by the interactive installation, it can be categorized into interface interaction and immersive interaction.

**Interface interaction** primarily depends on the screen or “interactive interface”, requiring the audience to touch or use only the upper limbs so as to obtain direct feedback. **Immersive interaction** is majorly completed through “immersive” interactive detection devices in order to create an “immersive environment”. It requires the audience to participate in the interaction with the entire body movement, so as to experience the interactive environment and obtain indirect feedback. This type of interaction is mainly utilized in art venues, museums, public spaces and other places.

2.4. **Significance of applying open-source programming language in interactive installation design**

The application of open-source programming technology in interactive installations can exert an influence on the external and internal forms of artistic design. First, when it comes the external form, the open-source programming language provides the material foundation for the physical and materialized form of the interactive installation design, which refers to a direct influence. Second, when it comes to the internal form, the open-source programming language has an indirect impact on the connotation of the installation by means of influencing the external form of the interactive installation design. Although such application cannot change the inner nature of the work, it can have an enormous impact on the form of artistic expression.

**External form** A well-designed interactive installation features cross-border, integration, emotions expressing, spatial sense, and publicity for all.

The combination of Processing, Arduino, sensors and installations brings designers the opportunity to explore fields that are not yet integrated with art, so as to seek artistic beauty from the unknown, and to have the courage to think out of the box for cross-border integration. When the audience and
experiencers are attracted by original installations to have an interest in visiting, a sort of bond established between artists, design works and the audience to convey emotion and aesthetics and that enables the connotation of installation design to be reflected. The installation art itself needs to be displayed in a certain public open space, and the application of new media can maximize the possible limited space to present the infinite artistic charm of installations.

**Internal form** The open-source programming language creates more original and unexpected effect by freeing the display form of the installation, and indirectly enhances the aesthetic value, interactivity and technical content of the work. For the design of interactive installations, interactivity stands as its core feature, and the application of multimedia technology can blend technical charm to the work that is in line with the aesthetics of the times. Furthermore, the open-source programming language expresses the external form of the work step by step, thus helping people to deeply feel and understand the connotation behind the work. The purpose of the interactive installation design is to convey to the audience the artistic pursuit and concepts hidden behind the works thoroughly and appropriately through human-computer interaction.

```c
void loop(){
  if(press1 == LOW){
    digitalWrite(led1,HIGH);
  } else {
    digitalWrite(led1,LOW);
    Serial.write("a");
  }
  if(press2 == LOW){
    digitalWrite(led2,HIGH);
  } else {
    digitalWrite(led2,LOW);
    Serial.write("b");
  }
  if(press3 == LOW){
    digitalWrite(led3,HIGH);
  } else {
    digitalWrite(led3,LOW);
    Serial.write("c");
  }
  if((press1 == HIGH)&&(press2 == HIGH)&&(press3 == HIGH)){
    Serial.write("z");}
}
```

**Figure 1. Code setting of Arduino chip.**

3. **Design concept and intents**

3.1. **Design theme—— the status and consequences of urban light pollution**

The term of light pollution was first proposed by experts in the international astronomical community. They found that the brightness of the sky increased when nighttime lights from cities were illuminated, thus making astronomical observation difficult. Since such night illumination affected their astronomical observations, night lighting was called light pollution. However, nowadays, it is generally believed that light pollution refers to excessive light radiation that has affected people’s normal life and caused harm to people’s health to varying degrees.

Due to the quickening pace of urbanization in China, some cities are enthusiastic about establishing lighting landscapes titled with “internet celebrity attractions” and “night cities”. Consequently, urban light pollution has been worsening recently. In terms of health, the construction of the “night cities” severely disrupts the biological clocks of surrounding residents and causes serious damage to the eyes that are in direct contact with the light source. In terms of ecological environment, a large number of nighttime lights make the starry less and less glittering. According to research, due to urban light pollution, brightness of the sky at night has increased tenfold. As a result, it is not only difficult for people to observe the starry sky with the naked eye on the ground, but even with the help of astronomical observation tools. At present, the brightness of the night sky in the urban area continues
to climb, forcing some observatories to move away from “night cities” to the suburbs away from the lights. Nevertheless, there is still huge room in addressing light pollution, but it has not attracted enough public attention.

3.2. Design intents
In addition to chronic physical health problems brought about urban light pollution, the most intuitive change in the ecological environment that can be really felt by people is the disappearing starry sky. Such disappearance makes many children, teenagers and even adults who were born and raised in urban area have never seen the real starry sky. In consequence, they can only appreciate the starry sky that they have never witnessed in paintings and photography created by some artists.

This interactive installation intends to enable the viewers to actively interact with the installation inspiring them to return a starry sky to the simulated city. The visiting route starts from the simulated city, and then unfolding the scenes of life in their mind, thus enlightening the audience to reflect on light pollution in reality.

```java
while(port.available()>0){
    char input = port.readChar();
    switch(input){
        case'a':
            image(bkg,0,0);
            image(star2,0,0);
            image(star3,0,0);
            image(city,0,0);
            image(light2,0,0);
            image(light3,0,0);
            break;
        case'b':
            image(bkg,0,0);
            image(star3,0,0);
            image(city,0,0);
            image(light3,0,0);
            break;
        case'c':
            image(bkg,0,0);
            image(city,0,0);
            break;
        case'z':
            image(trueSky,0,0);
            image(city,0,0);
            break;
    }
}
```

Figure 2. Code setting of the electronic screen.

3.3. Design scheme
The design theme of publicizing environmental protection determines that all materials used in the installation should be environmentally-friendly and conform to China’s sustainable development philosophy. It is specified before the design plan is formulated. Specifically, the entire installation is primarily composed of model buildings and tables as well as an electronic display screen with two pictures displayed. One picture takes Starry night painted by Van Gogh as its background while the other presents the background of real-life star trails. In order to achieve clear contrast, the installation selects star trail photos with dynamic lines grounded on the brushstrokes of “Starry Night”, after comparing ordinary starry sky photos and long-exposure star trail photos.

From a certain point of view, the easiest way to control urban light pollution is to turn off the lights. Only by this way, can the night lights go dark, and will the starry sky return.

4. Practice of the Multimedia Interactive installation Design

4.1. Preparation for conducting the design scheme
Key programming technology principle: the interaction of the multimedia installation is completed through connecting the open-source electronic prototyping platform (Arduino chip) and interactive programming software (processing3) via external hardware tools (press sensors, a light string, an electronic screen, etc.).

Design of interactive process: the audience presses the sensor according to the reminder. Then, the Arduino chip recognizes the signal and transmits the relevant codes to the processing program. After the program reads the code, it uploads and transforms the visual content displayed on the screen as well as provides the audience with visual feedback by turning the lights on or off.

Installation structure and interaction principle: the audience or the experiencer presses a certain building model to “turn off the lights” for the city, and presses the sensor to transmit information to the Arduino chip. Then, the chip receives the pressing information and outputs the signal “a” to the computer program processing. Later, the program receives that signal and send subsequent signals to change the screen display. When the audience or experiencer presses the building model once, the corresponding building displayed on the electronic screen will also “turn off the lights”. Meanwhile, the background of starry sky painting will have a starlight dimming. In accordance with the number of presses, the Arduino chip will output a signal “b” or a signal “c”. When “building model” is pressed three times, the chip will output signal “z”, thus switching off all buildings on the screen. Simultaneously, all the stars in the background will be darkened, and a real star trail picture will be presented in the end.

Material selecting: in alignment with the original intention of popularizing environmental protection knowledge, the material selecting upholds the concept of green design. Specifically speaking, the material of the building has selected biodegradable plastics, the lights are powered by rechargeable batteries, and the glue served as an adhesive is the commonly-used environmentally-friendly glue, called epoxy resin glue.

Symbolic meanings in the installation: “TURN OFF!!”, meaning turn off lights, refers to the interactive action of the audience or experiencer with the installation. Its capitalized letters and two exclamation points give people a sense of tension and eagerness, which indicates that urban light pollution has been urgent to address and requires immediate action. In addition, the luminous building model represents the excessive lighting of the city at night in real life; the experience of pressing the model to “turn off the lights” suggests that the participant actively abandon the false starry sky in the seemingly beautiful paintings, but to pursue the real and natural star trails in reality.

4.2. Installation process of the design
First of all, the layout of the building models and artificial plants in the sand table is line with that of our real daily life. In detail, small holes are made below each building model in advance, so as to arrange the light string. Then epoxy resin is used as an adhesive to fix the house modules and plug light bulbs in the building models. After that, the sensors will be installed on the bottom end of the specific buildings, in order to connect the Arduino chip and the computer program processing. The ultimate part is to connect this installation with the display screen.

After building up the installation, use tablecloths and other decorations are applied to hide the wires, batteries, and data cables, in order to ensure that the interactive installation platform remains clean and good-looking. In the end, all irrelevant items will be removed from the display desktop, so that the audience can see the interactive mode of the installation at a glance.

4.3. Design significance
This research aims to provide the audience with the most intuitive appreciation of the real starry sky through interactive installations. Such simple interactive way can tell people that the prevention and control of light pollution can start with a simple action, like switching off lights, so as to arouse people’s attention to the pollution. Meanwhile, the theme of environmental protection is demonstrated in this installation itself from its materials to functions, thereby securing the spread the concept of environmental protection. The interaction echoes the environmental protection theme contained in this
installation since the intuitive visual and tactile experience can instantly bring direct shock of the disappeared urban starry sky due to light pollution. Unlike the traditional graphic works for publicity, “TURN OFF!!” installation allows the audience to become citizens in the model city, and figure out whether the city night sky shows the artist’s oil painting or the real star trails, so that the audience can understand the current situation of light pollution prevention and control. By this way, people can easily associate the world built by the sand table with real life seamlessly, and then bring interactions in “TURN OFF!!” into real life, like switching off the lights.

5. Conclusion
With the constant booming development of science and technology, it is the integration of art, science, and technology that will build up an inevitable new trend in the future. Additionally, the open-source programming languages provide convenience for designers to create visual information. Moreover, the application of open-source programming language enhances the interactivity of the design and enriches the connotation of the installation itself, as well as creates the aesthetic feeling for the viewers via catering to their sensory needs during the interaction with the installation. Particular to note, the concept of designers should be advanced or leading the era, because their cutting-edge designs can not only reflect the technological beauty of the times, but also seek possible directions for the development of future technology. Contemporary designs are inseparable from the power of science and technology, since they give flight to creativity and imagination. That situation requires future designers not only to have the capability to analyze and create ideas, but also to master certain programming skills.

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