Interactive Device for Publicizing Global Desertification Issues Based on the Open-source Programming Language

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Abstract. This research primarily applies Processing, a framework language for image-processing and Arduino, an open-source electronic prototyping platform to achieve human-computer interaction. The communication between Arduino and Processing completes the combination of software and hardware, thus presenting widespread application and strong visual expression. Moreover, through employing programming languages, designers and artists can create high-quality interactive device art, freely turning their ideas into reality. With the core focus on the global desertification, this research aims to design and produce an interactive device for publicizing the hazards of desertification via connecting hardware (a hand pressure bellow, light strips and wind sensors, etc.) and screen images which can show the continuous spread of desertification across the globe.

1. Introduction

1.1. Processing programming language
Processing serves as a revolutionary and forward-looking new computer language, and represents an extension of the Java language. As an open-source programming language, Processing is suitable for multiple operating systems and is primarily useful for people who are interested in both technology and art. Moreover, combined with its integrated development environment, Processing can transform the received external signals into physical senses, and display interactive works with both sound and light in the form of images or animations.

Processing has gained popularity in electronic interaction and digital visual design for its simple programming syntax. Hence, designers and artists can also utilize Processing to create interactive forms of images or animations without mastering the sophisticated programming skill. The take-off development of technology has unlocked infinite possibilities for interdisciplinary integration. An increasing number of designers have explored the fields of technology and programming via the Processing language, and actually turned their ideas into reality. Meanwhile, the flexible and autonomous programming method provides the potential for artists to explore more artistic creativity and expressions, thus opening up the boundary of art.

1.2. Arduino platform
Arduino serves as a software and hardware platform based on the open-source simple I/O interface, including a variety of hardware and IDE. It perceives the environment through a wide range of sensors (such as infrared sensors, pressure sensor modules, etc.), writes control codes in the IDE, connects the
circuit with the Arduino main board as the centre, as well as receives signals and gives corresponding feedback.

Arduino has gradually boomed as the most popular open-source hardware in the world. Like the Processing programming language, Arduino does not require its users to have a programming foundation and it can be mastered after relatively simple learning. Furthermore, Arduino can be applied cross platforms, and its core file is open, which is convenient for users to refer and modify. By connecting a variety of input sensors and output devices, Arduino can complete independent operation and can also cooperate with Processing and other software to form an interactive system, so as to create more intuitive interactive devices via images.

1.3. Open-source programming language and interactive device art
Interactive device art is based on computer graphics technology, computer information gathering, information processing and computing technology. It takes advantage of information input and output carriers as hardware facilities, uses comprehensive materials to create a space scene as a platform, and applies human-computer interaction to express art [1].

Processing and Arduino languages are often integrated and employed in interactive device art. Arduino connects input sensors to receive information from participants, and produces light, sound, and Processing image feedback via the main board. The fusion of technology and art enhances the expressiveness and appeal of interactive devices, and enables viewers to spontaneously engage in human-computer interaction more enjoyably, so that the inside content can be displayed thoroughly.

2. Global desertification
Due to economic growth and urban expansion, the global ecological environment is continuously deteriorating [2]. In particular, desertification has imposed a major threat on human survival and sustainable development in the 21st century [3]. According to the United Nations Convention to Combat Desertification promulgated in 1994, desertification refers to land degradation in arid, semi-arid and dry sub-humid areas resulting from various factors, including climatic variations and human activities; However, human factors (such as unreasonable use of land and water, overgrazing, and deforestation) are the major contributing causes of modern desertification. Relevant statistics suggest that due to drought and desertification, the world loses 23 hectares of arable land per minute, which is 30-50 times compared with that of the past; the economic loss caused by desertification reaches as high as 42 billion US dollars per year; the International Committee of the Red Cross estimated that half of the world’s refugees are environmental Refugees, such as one-sixth of Niger’s people have moved due to desertification [4]. The sustainable development goals revised by the United Nations in 2015 also put desertification into the list. Furthermore, desertification also poses an enormous threat to biodiversity, food security, air quality and global warming.

Desertification directly threatens about 40% of the world’s land, plaguing 2 billion people. However, people always think that desertification is very far away from life, which means that it is increasingly urgent to raise the public’s awareness of combating desertification. Protecting the environment not only requires efforts at the national and corporate levels, but also requires the public to increase relevant awareness. This research hopes to show the process of desertification expanding through interactive device art, so that participants can understand the various hazards of desertification towards people, society, and the world via interaction. Then, the participants can have a more intuitive understanding of desertification and begin to think about protection and prevention of desertification.

3. Materials and Methods
For the purpose of igniting the public’s awareness of desertification prevention, this research designs an interactive device grounded on the Processing and Arduino open-source programming languages. Unlike traditional photography or sand table works, interactive devices can achieve information communication with the audience in a dynamic form, turning the audience from one-way information transmitter to two-way communicator. Hence, participants can more deeply feel the speeding-up
desertification under the influence of human factors. Such devices will guide the participants to build up a connection between their own behavior and desertification, so that they will spontaneously realize the necessity and urgency of combating desertification, and enhance the public’s awareness.

3.1. Implementation of key technologies
The interactive device carries out human-computer interaction by combining the Processing, the image-processing framework language and the Arduino, the open-source electronic prototyping platform. Arduino can establish a link among external input and output hardware such as pressure sensor modules and light strips. Additionally, it can also connect with the Processing. With the Arduino main board as the center, the device gathers, processes and transmits information as well as partly provides feedback (such as light flow). With the application of Processing on screen images, the received signals will be processed and displayed in the form of images or animations to provide screen feedback.

3.2. Interactive device design and operation
The design is immersed with creativity and it can be evidenced by the name of the interactive device “Wind Blowing Sand Falling”. With desertification spreading globally, this research focuses on raising the public’s awareness of desertification prevention, employs Processing and Arduino programming languages, along with external hand-pressure bellows, meteor lights and screen images. With great curiosity for exploration, the audience can be drawn to complete interaction. The screen image presents a huge picture scroll, visualizing the spread of desertification by zooming in and out, so that the participants can realize that human beings are responsible for desertification and think about the hazards of desertification during the process of “wind blowing and sand falling”. In this way, the participants can associate desertification with their own behaviors. As the increasing number of people are conscious of the urgency for desertification prevention and control, more thoughts inspired from the device will become real actions in daily life, such as actively using less paper and selecting low-carbon transport. In accordance with the fact that from small steps comes huge process, these actions will progressively shape a new lifestyle for people. Stronger awareness of the public definitely quickens the pace of combating desertification.

In light of its appearance, the device is mainly composed of two parts, respectively operation area and screen area, with dark yellow as the main hue that echoes the desertification. The operation area is dominated by a hand-pressure bellow, which is connected to the screen through light strips. The hand pressure bellow is all made of environmental-friendly materials (the upper and lower panels are filled with collected waste paper and wrapped with recyclable fabrics). Pressure sensor modules are positioned in the bellow. After the participants press the bellow, the pressure signal is conveyed while blowing out the wind. Arduino receives and processes the signal, and controls the light strips to transmit the light from the operation area to the screen in a flowing way, indicating the running track of the wind. The screen image is to express the threat of desertification via the yellow particle effect. The Arduino main board and main circuit are installed behind the screen, and the circuit linking the operating platform is attached to the light strips to connect to the operation area. The device does not utilize additional accessories but presents attractive appearance. The overall device’s interaction involves the participant’s visual sense, thus enriching the interactive experience.
3.3. Operation of interactive device on desertification

First, information-gathering process. The device connects the pressure sensor modules to the Arduino main board to collect external information. When the participant presses the bellows, the pressure sensor modules installed inside the bellows will be driven to start. Then, the signals will be transmitted to the Arduino main board through the circuit, thus further passing down the information to the light output device and the Processing module for image processing.

```cpp
int press1 = 9;
int ledchain = 10;
void setup() {
    pinMode(press1, INPUT);
    pinMode(ledchain, OUTPUT);
    Serial.begin(9600);}
void loop() {
    if (press1==HIGH){
        digitalWrite(ledchain, HIGH);
        Serial.write("a");};
}
```

Second, the interactive process. After the participant presses the bellow, the pressure sensor will transmit relevant signals to the Arduino main board. Also, the yellow particles on the screen will continue to flutter with the wind. The screen image is only a small area on the edge of the desert at first. With the image continuously expanding, sand particles will begin to invade farmland, and then gradually expand to villages, towns, and cities. Finally, the entire earth will be enveloped by yellow sand particles, signifying that the growing demand of people is driving the rapid spread of desertification.

```cpp
import processing.serial.*;
Serial port;
PImage map1;
PImage map2;
int sand=0;
int a =1;
void setup(){
    size(600,400);
    map1 = loadImage("map1.jpg");
    map1 = loadImage("map2.jpg");
    port = new Serial(this,"COM4",9600);
    mPhysics = new Physics();
}
```
Gravity myGravity = new Gravity(0, 30, 0);
mPhysics.add(myGravity);

void draw()
{
    image(map1,-200,-200,800,600);
sand();
    if(port.available()>0)
    {
        char input = port.readChar();
        if(input == 'a')
        {
            sand = sand +1 ;}
    if(sand == 1)
    {
        image(map1,-100,-100,700,500);
sand();
    if(sand == 2)
    {
        image(map1,0,0,600,400);
sand();
    if(sand ==3)
    {
        image(map2,-200,-200,800,600);
        image(map1,100,100,500,300);
sand();
    if(sand == 4)
    {
        image(map2,-100,-100,700,500);
sand();
    if(sand>=5)
    {
        sand();
        image(map2,0,0);
delay(50000);}}
}

void sand()
{
    if (a==1) {
        Particle mParticle = mPhysics.makeParticle();
mParticle.position().set(random(-20, 200), random(0,200));
mParticle.velocity().set(random(-20, 20), random(-20));
    }
    for (int i = 0; i < mPhysics.particles().size(); i++)
    {
        Particle mParticle = mPhysics.particles(i);
        if (mParticle.position().y > height * 0.9f)
        {
            mParticle.dead(true);}
    }
    float mDeltaTime = 2.0f / 60;
mPhysics.step(mDeltaTime);
    background(255);
    fill(211,187,116);
    noStroke();
    for (int i = 0; i < mPhysics.particles().size(); i++)
    {
        Particle mParticle = mPhysics.particles(i);
        ellipse(mParticle.position().x, mParticle.position().y, 5, 5);
        stroke(0, 63);}

void sand()
{
    if (a==1) {
        Particle mParticle = mPhysics.makeParticle();
mParticle.position().set(random(-20, 200), random(0,200));
mParticle.velocity().set(random(-20, 20), random(-20));
    }
    for (int i = 0; i < mPhysics.particles().size(); i++)
    {
        Particle mParticle = mPhysics.particles(i);
        if (mParticle.position().y > height * 0.9f)
        {
            mParticle.dead(true);}
    }
    float mDeltaTime = 2.0f / 60;
mPhysics.step(mDeltaTime);
    background(255);
    fill(211,187,116);
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    for (int i = 0; i < mPhysics.particles().size(); i++)
    {
        Particle mParticle = mPhysics.particles(i);
        ellipse(mParticle.position().x, mParticle.position().y, 5, 5);
        stroke(0, 63);}

Figure 3. with the increase of blows and the non-stop spread of desertification.

Figure 4. Particle Effect.

Third, producing results and feedback. During the whole interaction, if the number of blows that
the participant makes is relatively small and even becomes zero when the screen involves the entire
earth, the screen will no longer spread. After maintaining the existing screen for a few seconds, it will
gradually return to the original screen (sand grains only existing in the desert area). However, if the
participant keeps blowing and the image has been expanded to cover the whole earth, after the
blowing stops, the screen image will not come back to the original. Instead, it will gradually become deserted. Ultimately, it will all drift away in the wind and nothing is left. These two different results represent two trends of desertification as below. If the public realizes the seriousness of the desertification in time and actively addresses the issue before the desertification goes too far to control, desertification will be reversible and it can be controlled or even partially restored. Nevertheless, if it is not taken seriously and the issue worsens further and further, this will become irreversible and the whole world will be never saved anymore.

3.4. Prospects
The research’s design aims to demonstrate how threatening and severe desertification is to the public via the interactive device. In order to raise the public’s awareness of environmental protection and desertification prevention, the device can inspire the audience to enhance their awareness of desertification prevention. To a certain extent, it is to publicize desertification, enlighten the public and influence the society. Different from traditional artworks or lectures for popularization, participants in this device can have a more direct understanding over desertification through the interaction of this appealing interactive device. Hence, it serves as a down-to-earth approach to let people know more about desertification which might impresses the audience profoundly, thus, enhancing the public’s awareness of desertification prevention and control, and turning their reflections into practical actions in everyday life.

4. Conclusions
The interactive device mentioned in this research interacts with participants through the form of “wind blowing and sand falling”, which is intended to appeal to the public to pay attention to desertification. In addition, this device’s design presented an integrated thinking mode that combines technology, art and social issues. However, there are still some shortcomings in the device’s design and operation. The research merely acts as a starting point, and expects that more designers and programmers will enter the realm of interactive device art. In the end, integrating technology and art to present social issues will also become a mainstream for the development device art in the context of fast-developing technologies.

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