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Innovative Design and Experience of Arduino-based Interactive Installation: Seaweed Dance

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Abstract: ***This paper introduces the innovative design and experience of the Arduino-based interactive installation "Dance of the Seaweed". The installation aims to rekindle people's attention and reflection on the natural environment through the combination of art and technology. The installation utilizes ultrasonic sensors to perceive the distance between the audience and the installation, and adjusts the rotation speed of the seaweed model according to the distance changes, enabling intelligent interaction between the audience and the installation. The article elaborates on key aspects such as the installation's design, hardware setup, programming, and scene construction, and demonstrates the installation's effectiveness in practical applications. Through this installation, audiences can immerse themselves in the beauty of nature, prompting deep thoughts on environmental protection. Additionally, the paper discusses potential improvements and future applications of the installation, such as in art exhibitions and educational outreach, with the goal of bringing more wondrous experiences to people and contributing to environmental protection and science education.***

Keywords: Arduino, Interactive Installation, Ultrasonic Sensor, Stepper Motor**.**

1. Background of the Study

In today's digitalized era, the link between human beings and nature seems to be weakening. The rapid development of science and technology makes people pay more attention to the virtual world, thus neglecting the natural environment around them. In this context, we need to rethink how to inspire people to pay attention to and think about the current natural environment through the combination of art and technology. In modern society, many art works are inclined to digitalization and abstraction, and lack the integration of natural elements. Digital forms such as virtual reality, digital painting, and computer-generated art dominate, and the lack of natural elements in many art works makes it difficult to arouse the audience's empathy, which leads to the neglect of the natural environment and exacerbates the estrangement between human beings and nature [1]. We can create stunning interactive installations by incorporating natural elements into artworks through technological means. The Arduino-based interactive installation "Seaweed Dance" aims to sense the distance between the audience and the installation through sensors, and adjust the rotation speed of the seaweed model according to the change of the distance, so as to let the audience feel the interaction between nature and human beings. The installation skillfully combines natural elements with technology, and provokes people to think about and pay attention to the beauty of nature.

2. Demand Orientation

In today's fast-paced and digitized society, human beings are increasingly alienated from nature. This alienation is not only manifested in our distance from the natural environment, but also more deeply in our knowledge and emotion of nature [2]. However, it is in this context that some innovative art and technology installations such as "Seagrass Dance" have been created, which attempts to re-inspire people's concern and love for nature through the combination of art and technology. The installation is not only a work of art, but also a medium that brings people into the world of natural beauty through complex interactive features. By simulating the dynamics of seaweed swaying in the water, it successfully integrates natural elements into the artwork, giving the viewer an immersive natural experience. This experience is not only a pure sense of beauty, but also a reflection and experience of natural beauty, which triggers the viewer to think deeply about environmental protection [3]. This experience is not only a pure sense of beauty, but also a reflection and experience of natural beauty, which triggers the viewer to think deeply about environmental protection.

In addition, the Arduino-based interactive device used in this installation provides the audience with a novel way of experiencing the artwork. By interacting with the installation, the viewer is no longer passively enjoying the artwork, but becomes part of it. This interactive nature not only increases the viewer's sense of participation and enjoyment, but more importantly, it reintroduces the realization that nature and technology are not opposites, but can be harmoniously co-existed [4]. The "Seagrass of the Sea" is an interactive work of art. Therefore, "Seagrass Dance" is not only a work of art, but also a vehicle to call on people to re-examine the relationship between nature and technology.

3. Styling

In the design of the interactive installation, the selection and realization of the seagrass modeling is crucial, as it directly determines the audience's visual perception and emotional resonance of the installation. Therefore, in the modeling design stage, we focus on how to create stunning seagrass models and skillfully integrate them into the installation. Firstly, in the modeling comparison stage, we used Rhino modeling software to create a variety of different styles of seagrass models through modeling. These models included seagrasses of various shapes, sizes and styles so that they could meet the aesthetic needs of different audiences and the requirements of the installation's theme. In the process of creating these models, we not only considered the aesthetic factors, but also focused on evaluating their realism and adaptability [5]. The modeling process was not only aesthetic, but also focused on assessing their realism and adaptability. Realism refers to the ability of the model to realistically simulate the appearance and dynamics of natural seaweed, while adaptability takes into account the scenarios in which the model will be used in the installation and how well it will integrate with other elements. Next, by comparatively evaluating the advantages and disadvantages of each model, we chose the optimal solution, i.e., the seagrass model that best fits the theme of the installation (Figure 1).

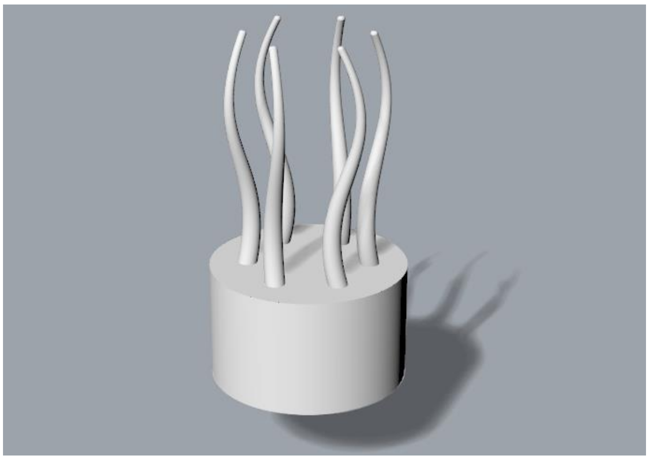

Figure 1: Seagrass model 1

Once the choice was made, the selected model was further optimized to ensure that it would perform better in the installation. These optimizations involved fine-tuning the morphology, texture, and details of the model to finalize the final model design. In order to realize the designed seagrass model, we exported the final design as a 3D model file and made it into an actual seagrass model using 3D printing technology. Through 3D printing, we can ensure the accuracy and details of the model, making it more realistic and beautiful. In addition, 3D printing provides flexibility and malleability, allowing us to experiment with different materials and colors to get the best visual effect.

Overall, these steps in the styling phase go beyond simply choosing a great looking seagrass model; it is a process of integrating aesthetics, technology and practicality. Through careful design and fabrication, we can ensure that the installation's seagrass model will have a deep visual and emotional resonance with the viewer, thus realizing the goals and intentions of the installation design.

4. Hardware Construction

During the hardware construction of the interactive device, we focused on the application of ultrasonic sensors, stepper motor technology and Arduino, aiming at realizing the automatic interactive function of the device, thus bringing an all-around immersive experience to the user.

4.1 Trigger Mechanisms

First, we chose the HC-SR04 ultrasonic sensor (Figure 2) as the distance sensing component of the device. The sensor is able to calculate the distance from the object to the sensor by emitting ultrasonic pulses and measuring the echo time. This allows us to accurately sense the distance between the viewer and the device and adjust the subsequent interaction behavior according to the change in distance.

Figure 2: HC-SR04 Ultrasonic Sensor 1

4.1.1 Introduction to the principle of HC-SR04 ultrasonic sensor

The HC-SR04 ultrasonic sensor is a commonly used distance measuring sensor that utilizes the propagation speed of ultrasonic waves in the air to measure the distance between the target object and the sensor. [6] The sensor is designed to measure the distance between the target object and the sensor. The principle of operation is briefly described as follows: first, one part of the sensor acts as a transmitter, converting an electrical signal into 40 kHz ultrasonic pulses. These ultrasonic pulses are then released into the air and propagate in the direction of the sensor, away from the transmitter. When the ultrasonic pulses encounter a target object, a portion of the energy is reflected back by the target object. Another part of the transducer acts as a receiver and listens for echo signals during propagation. If a reflected pulse is received, the receiver generates an output pulse. By measuring the width of this output pulse, we can determine the time it takes for the ultrasonic pulse to propagate and thus calculate the distance between the target object and the sensor.

The HC-SR04 ultrasonic sensor is characterized by high accuracy, fast response and a wide range of applications, and is widely used in many fields. For example, it can be used for distance measurement, obstacle avoidance, and localization. In this interactive installation, the HC-SR04 ultrasonic sensor is applied as a triggering device to detect the presence of the audience and measure the distance to the audience. By combining the ultrasonic sensor with a motor, the automatic interactive function of the device is realized, allowing the device to automatically adjust the rotation speed of the seagrass model according to the audience's proximity, providing a more immersive experience for the audience.

4.1.2 Experiments with variables

In order to determine the most accurate test range for the HC-SR04 ultrasonic sensor, we conducted variable experiments based on the technical specifications of the ultrasonic sensor and our experience in using it. First, we set a series of different distance ranges from 2 cm to 400 cm, setting different measurement distance points at appropriate intervals. We then performed a series of measurements on the HC-SR04 sensor based on the set distance range parameters. At each distance point, the distance value measured by the sensor was recorded and the experiment was repeated several times to ensure the reliability of the results. After collecting all the experimental data, the measurement accuracy of the sensor at different distance ranges can be evaluated by calculating statistical methods such as mean, standard deviation and error range to determine the most accurate test range of the sensor. Based on the final data analysis, it can be concluded that the most accurate testing range of the HC-SR04 ultrasonic sensor is from 2cm to 50cm, and the subsequent interaction design can be guided by this data.

In order to better verify the accuracy of the HC-SR04 ultrasonic sensor when it is working, we use an oscilloscope to test the waveform of the sensor during normal operation. This experiment aims to accurately reflect the ultrasonic signals emitted and received by the sensor during operation through the clear presentation of the waveform graphs, thus visually presenting the working principle of the sensor and the data acquisition method. Through the waveform graph measured by the oscilloscope (Figure 3).

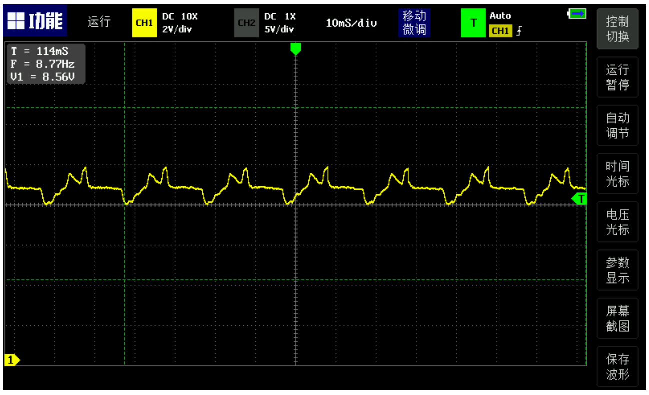

Figure 3: HC-SR04 Ultrasonic Sensor Waveforms 1

We are able to clearly observe the ultrasonic pulses emitted by the sensor as well as the received return signal. In the waveform diagram, we can see the process of transmitting and receiving ultrasonic pulses, as well as the time interval between them. These data intuitively reflect the accuracy and stability of the sensor in operation, providing us with a reliable basis for verifying the performance of the sensor.

4.1.3 Application methods

In the Arduino-based self-motivated interactive installation “Seaweed Dance”, the HC-SR04 ultrasonic sensor is used as a triggering device to detect the presence of the audience and measure the distance to the audience. Based on our experiments, we found that the most accurate range of the HC-SR04 ultrasonic sensor is between 2cm and 50cm, and based on this result, we can apply the most accurate range of the ultrasonic sensor in the interactive installation. When the device is activated, the HC-SR04 ultrasonic sensor is activated and begins to detect the presence of an audience in the surrounding environment. The sensor sends out ultrasonic pulses at a certain frequency and listens for echoes to determine if an object is reflecting the ultrasonic waves, thus determining if a spectator is near. If the sensor detects an echo, it means that a spectator is approaching the device. The sensor will measure the distance from the device to the viewer and convert it into a digital signal. This distance value will be used to control the subsequent behavior of the device. Based on the distance from the viewer measured by the sensor, the device will adjust the speed of the 42 stepper motor. When the sensor detects that the viewer distance is greater than or equal to 50 cm, the motor will rotate at a slower speed to create a gentle motion effect. And when the sensor detects that the viewer distance is less than 50 cm and greater than or equal to 2 cm, the motor will rotate at a faster speed to enhance the responsiveness and interactivity of the device and further attract the attention of the viewer.

In this way, the HC-SR04 ultrasonic sensor plays a key role in the interactive device “Seaweed Dance”, realizing intelligent interaction between the audience and the device. The application of the sensor allows the device to automatically adjust the rotation speed of the seaweed model according to the audience’s proximity, providing a more immersive and dynamic experience for the audience.

4.2 Driving Method

In order to realize the dynamic interaction function of the device, we adopt the stepping motor as the power device. In terms of stepper motor selection, we chose 42 stepper motors as the power unit. 42 stepper motors, as a common motor type, have wide applicability and good programmability, which can meet the needs of the device’s long-time and stable operation, and realize a variety of different rotation speeds and directions, which enriches the device’s interactive functions. Through further testing, it is found that the selection of the 42 stepper motor as the power unit of the device is reasonable and effective, and can provide reliable support for the dynamic interaction function of the device. 42 stepper motor realizes the dynamic feedback mode through the control of the A4988 driver module. According to the measurement results of the HC-SR04 ultrasonic sensor, the stepper motor rotates at different speeds to convey the feedback information of the device to the audience.

First, when the device is activated, if the ultrasonic sensors do not sense the presence of the spectator, or if the spectator’s distance is more than equal to 50 cm,42 the stepper motor will start to rotate at a smaller speed. This slower rotation speed is intended to create a soft, static motion effect for the device, so that the audience can feel a quiet and comfortable environment. When the ultrasonic sensor senses the presence of the viewer and the viewer is less than 50cm and greater than or equal to 2cm away, the 42-step motor will rotate at a faster rate. This speed of rotation is more active and dynamic and interacts more closely with the audience. Through this feedback method, the device is able to sense the presence of the audience more sensitively and actively interact with the audience, which enhances the audience’s sense of participation and immersion, and creates a more quiet and serene ocean atmosphere for the audience [7] The installation is a great way to create a more tranquil and serene ocean atmosphere for the audience.

5. Programming

Programming plays a crucial role in the realization of Arduino-based interactive devices. We chose to use Arduino IDE as the programming tool because it is designed specifically for Arduino development, supports C/C++ language, and is easy to get started and use. When writing the code, we need to consider the ultrasonic sensor and stepper motor control. First of all, the writing of the ultrasonic sensor code is very critical. We use Arduino IDE to write the code to read the data from the ultrasonic sensor and adjust the speed of the stepper motor according to the distance measured by the sensor. The stepper motor control code is also an integral part. We use the A4988 motor driver module to control the rotation of the stepper motor and write code to realize forward and reverse rotation, speed control and stopping of the motor. Next, we have to perform device integration to connect the circuit. Connect the ultrasonic sensors and stepper motors to the Arduino board to ensure that the circuits are connected correctly and that the sensors and motors can work properly. Immediately after that, we integrate the code for the ultrasonic sensor and stepper motor into an Arduino project. During the code integration process, we need to make sure that the code logic is correct and the sensor data can accurately control the movement of the motor to realize the automatic interaction function of the device. Finally, we need to test and debug. Upload the written code to the Arduino board and test it to ensure that the functions of the device operate normally and stably and realize the expected interaction effect.

6. Scene Building

In this installation, we focused not only on the combination of technology and art, but also on the integration of the installation into a realistic marine environment to enhance the user's sense of immersion [8] The installation is a very simple and simple one, and it is a great way to enhance user immersion. Specifically, we used 42 stepper motors as the main hardware device, skillfully assembled with 3D printed seaweed models. However, we did not stop there, but placed the installation in an elaborate scene of marine elements (Figure 4).

Figure 4: Application Scenario Diagram 1

In this scene, we have arranged underwater rocks to create the texture of the ocean, allowing the audience to feel the depth and stability of the ocean. The presence of shells and corals adds to the realism of the installation, reminding people of the rich diversity of the ocean. The soft blue light simulates the light environment of the ocean, which not only enhances the visual effect, but also gives the user the atmosphere of being in the ocean. Through these designs, we have created an immersive marine environment that allows the user to interact with the installation in a way that is not only technologically appealing, but also immersive in the beauty of nature. This integrated design makes our installations more appealing and better communicates our original intent.

7. Conclusions and Outlook

In our research, we have successfully designed and implemented an Arduino-based interactive device "Seaweed Dance". By sensing the distance from the human body through ultrasonic sensors, we were able to automatically adjust the speed of the stepper motor to make the seaweed model rotate as the audience approached and moved away. The installation not only achieved good results in terms of artistry, technology and user experience, but also provided us with a direction for future improvement and expansion. After collecting feedback from users, we actively took improvement measures [9]. Some users suggested improvements, such as optimizing the speed curve of the motor and adding more natural elements to the model. We see these feedbacks as opportunities for improvement and plan to further enhance the performance and user experience of the device in our future work.

In addition to the current applications, we also explored future possibilities and more application directions. Firstly, we can apply this installation in art exhibitions, museums or other interactive scenarios so that more people can experience the beauty of the fusion of nature and technology. Secondly, we can also use this installation for educational and science popularization activities to convey to the public the importance of environmental protection, ecological preservation and natural beauty, and to stimulate people's attention to nature. In addition, in the future, we can further improve the device by adding more sensors to realize more complex interactive functions, such as audio response, light changes, etc., so as to provide a richer and deeper experience for users! [10] The

In conclusion, the Arduino-based interactive installation "Seaweed Dance" is not only an artwork, but also an innovative interactive experience. We are looking forward to continue exploring the organic combination of nature and technology in future research and application, to bring more wonderful experiences to people, and to make greater contributions to environmental protection and science education.

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