

Design and fabrication of the portable artwork preservative device (PAPD)

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ABSTRACT

Traditional artworks not only have a long history but also offer high economic value in the auction market. The artwork is commonly used paper or silk paper as raw material, which needs the relative harsh condition to save. However, there are generally three types of conditions to harm valuable artworks, which are water, fire, and earthquake or stealing conditions. To protect the artworks from irreversibly damaged conditions, the portable artwork preservative device is designed to protect the artworks using rolling up the artwork method and keep it inside the artwork box. Three types of sensor modules have been selected in this study, which is used to detect external conditions. It is concluded that this device shows the valid response performance, and it is automatically rolled up the artwork around 10 s when it detects the signals from three sensor modules. Besides, the joystick module is used to control the artwork movement manually.

INTRODUCTION

It is known that Chinese painting is one of the oldest continuous artistic traditions, which is mainly divided into Gongbi, ink and washes painting techniques methods [1, 2]. Traditional artworks involve essentially the same techniques as calligraphy, which is done with a brush dipped in black ink or colored pigments [3]. Chinese artwork is a form of aesthetically pleasing writing and the artistic expression of human language, which has been widely practiced in China [4]. Calligraphy artwork has led to the development of many forms of art in China such as seal carving, ornate paperweights and inkstones [5, 6]. In recent years, Chinese artworks have been regarded as the art of the nation. Traditional artworks are commonly shown in public or private museum and exhibition, as shown in Figure 1. For different types of museums and exhibitions, there are used to collect, preserve, interpret and display valuable collections of artistic, cultural and historical artworks [7, 8]. The calligraphies, paintings other types of artworks are commonly shown in public or private museum, and there are usually protected by the specific frame with clear glass [9]. The visitors are allowed to have a closed look at the artwork in details. According to the available statistics from Art Market Monitor of Artron (AMMA) in 2017, the market of Chinese painting and

calligraphy had a good result with 269,400 lots offered and 82,400 artworks sold. The high-value and high-quality artworks: over \$ 100 million, have successfully attracted much attention from the art collectors. Therefore, a large number of collectors and investors have concentrated on the artworks with traditional Chinese cultural values, especially with high-quality, rare and authentic artworks [10, 11].

Regarding of high economic value of artworks such as traditional calligraphy and painting, it should be carefully saved and protected. Generally, the artwork is used paper or silk as material to create works, which requires the relative strict environment to keep it [12]. Based on its market survey, there are mainly four damaged conditions to harm the valuable artworks, which involves fire, water, earthquake and stealing conditions. Figure 2 presents the three artwork damaged conditions, which includes the comparison between its original artwork and repaired artwork. Several artworks maybe cannot be repaired due to the variety of materials used and varying degrees of damage. The repairing process has a higher cost compared to its economic value, and the damaged condition of artwork is irreversible damage to some extent. Therefore, it is highlighted that the importance of protective device for valuable artworks.

There are various artwork protection devices, which used different types of sensors to monitor exhibitions, galleries, and museums. The available artwork protection devices have several methods to protect its safety such as laser scanner method, real-time reporting system, IP-based with data monitoring, safe hook, and laser-based security device. The typical artwork protection device has been patented with US8371054B2, which is related to two-dimensional hanging artwork. The device is mounting and spacing a protective cover in front of a hanging piece of artwork [13]. However, the current artwork protection devices are mainly focusing on alarm and monitoring methods, which lacks a sufficient method to protect the artwork itself. The novel idea is from winding method [14-16], and it can roll up the artwork to keep and protect inside the safe artwork box. The device should automatically protect the artworks from the potential damaged condition such as fire, water, stealing, and natural disasters. This paper aims to design, fabricate and test the portable artwork preservative device to protect the valuable artworks from possible damaged conditions, such as fire, water, earthquake or stealing situations. The protection method is to roll up the artwork through the top scroll rotation, which is safely protected in the artwork box. The device is tested and evaluated according to its three damaged conditions, which offers valid respond performance and sufficient method.

METHODOLOGY

Confirmation Measurement for Wedge Angle of Cutting Blade

The portable artwork preservative device is used the acrylic plate to fabricate the framework, and the device box is manufactured by plastic material using the 3D printing technique. For the control system, it is used Arduino Uno as the main micro-controller. To detect the surrounding environment condition, three types of sensor modules are selected and used. The DC geared motor is used to provide the rotation method, and a joystick is designed to control this device manually. Two limit switches are placed at the top and bottom sections of this device. The relevant components of this device are summarized in Table 1, which includes key specifications and several parameters.

Table 1 Key specifications of relevant components used in this study

Components	Key specification
Arduino uno microcontroller	Operating voltage: 5 V / Digital I/O pins: 14
5 way flame sensor module	Voltage: 3.3 – 9 V / Detecting range: > 120 degree
SW-420 vibration sensor module	Operating voltage: 3.3 – 5 V
Rain sensor raindrop module	Module supply: 12 V / 5 – 12 mA quiescent current
ZYTD520 DC geared motor	Voltage: DC 12 V / Torque: 15 kg/cm
Joystick module shield	2.54 mm pin interface leads / 5 V voltage supply
Limit switch	Supply voltage: 5 V / Dissipation power: 5

Design and Fabrication Procedure

Design Procedure

The artwork paintings or calligraphies are commonly used vertical type, which could be rolled up via top scroll. The device has two basic functional methods, which is shown and protected the artworks in different museums or exhibitions. Therefore, the initial design concept is shown in Figure 3, which is divided into a device box section and framework section. The device box is designed to place the artwork box, transmission system, and control system, which is the main section of this device, as shown in Figure 3 a. The framework section is designed to show the artwork like common protection frame, which still meets the display demand of visitors. The framework size is designed according to the artwork size with top and bottom scrolls. The initial 3D structure is designed using Solidworks software to present its design concept in details, as shown in Figure 3b.

The finalized design structure of this device is presented in Figure 4, which includes the device box and framework. Two types of sensor modules are placed on both sides of the device box, which are water and flame sensor modules. The framework is added to the LED screen to introduce the information of the artwork, such as author, background, style and so on, which is supported by two L-type supports. The vibration sensor module is placed at the single side of the framework. The two sections are connected using the screwed method, which is simply assembled and fabricated. The artwork box is put inside the device box, which is used to protect the artwork in a safe condition. The box cover is designed to replace the artwork inside the artwork box, as shown in Figure 5.

Figure 6 illustrates the structure concept of the device box, which mainly involves the artwork box, transmission system, and control system. The rotatable bolt can rotate to lock and unlock the artwork box, which is designed to ensure its position during the rotation condition. The control system is placed in the control system zone. The DC geared motor is put on the motor stand, which is fixed on the inner bottom wall of the device box. The transmission system is used belt transmission with a closed timing belt and two pulleys. The shaft connector is connected with the top scroll of the artwork and passive driven shaft. The shaft connector is designed to loose and move on the shaft, which is aimed to simply take out the artwork box. Two types of hooks of the framework section are designed to hang the portable artwork preservative device on the wall, which is simply disassembled to reduce the visual impact.

Figure 7 presents the wiring diagram of the portable artwork preservative device, which involves Arduino Uno, DC motor, motor driver, water sensor module, 5-way flame sensor module, vibration sensor module, vibration sensor module, joystick module, power supply connector and two limit switches. The top and bottom limit switches are used to determine the pause location of the device, which is adjusted based on its of the size of the framework. The sensitivity of three types of sensors could be adjusted via its potentiometer, which depends on its external conditions.

Fabrication Procedure

The portable artwork preservative device is fabricated, as shown in Figure 8. Based on its fabrication procedure, the device box is firstly designed and fabricated. The artwork box is placed inside the device box, and transmission system is arranged at the left side of the device box. The passive driven shaft is connected with the top scroll with the artwork through the artwork box. The control system is placed in the control system zone of the device box, and the framework is simply assembled. The rest of the space of the device box is filled with fireproof materials. The limited switch is attached inside of the framework at the bottom side. The calibration procedure is performed to test the device response performance according to its design function. There are several parameters should be finalized such as limit switch position, transmission shaft center distance, and sensitivity value.

In short, the device is firstly fabricated using Solidwork software, which refers to structural design, dimension, design concept, and component arrangement. Figure 9 presents the 3D prototype isometric view of the portable artwork preservative device, which is modified according to its initial design concept. Joystick module shield is added to manual control the device motion, and the framework is protected using the external protective frame with yellow color, as shown in Figure 9.

RESULTS AND DISCUSSION

The realized prototype device is shown in Figure 10 b, which is fully based on the 3D prototype structure, as shown in Figure 10 a. It is concluded that the portable artwork preservative device has been successfully designed and fabricated. The device is designed to automatically detect the external condition and roll up the artwork to achieve the protective procedure. The artwork box is placed inside the device box, which can insert and take out for different artworks. It offers much sufficient and handy method compared to the traditional method, and it reduces the man-made damaged factors and fabrication cost.

To ensure the device is working, the response performance of the portable artwork preservative device is studied and tested, which involves water, fire, and vibration conditions, as shown in Figure 11. It is found that the protective artwork is automatically rotated up when the relevant sensors detect the three damaged conditions. For water condition, it is detected the water condition in the rain board with 5 cm × 4 cm. For fire condition, it is tested using the lighter to close to the 5-channel infrared flame sensor with above 120 degrees detection range. For vibration condition, it is detected by knocking on the device using a hand, which is closed to simulate the earthquake or stealing conditions. It is tested that the response time is around 10 s to fully roll up the artwork on three different damage conditions.

Figure 12 presents the manual control method using a joystick module, which is used to relieve the protective method and other purposes. The artwork is manually rolled up by security personnel when the art exhibition is closed, which effectively reduce the artwork imitation and stealing chances. In some cases, the owner of the artwork is particularly shown some sections of it to visitors. This device offers the advanced design concept with different display purposes, and it is highlighted that it can be automatically and manually controlled.

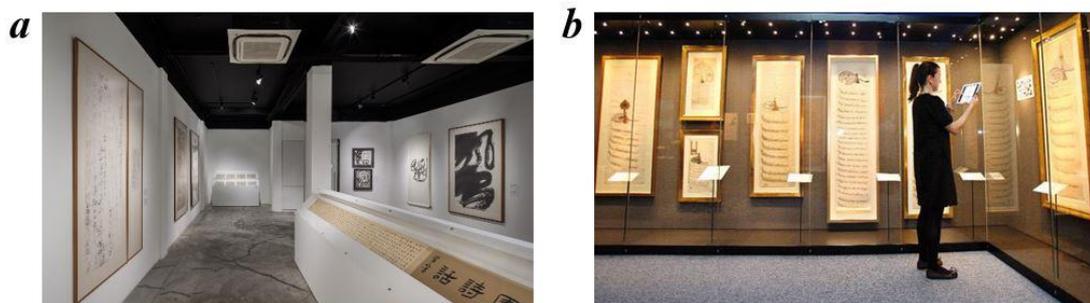


Figure 1 Traditional artworks display condition: (a) private museum or exhibition; (b) public museum (Source: <http://www.theprivatemuseum>; <https://www.sabanciuniv.edu/>)



Figure 2 Three artwork damaged conditions: (a) water condition; (b) fire condition; (c) vibration condition (Source: <http://www.artgallery101.com>; <http://oliverbrothersonline.com>)

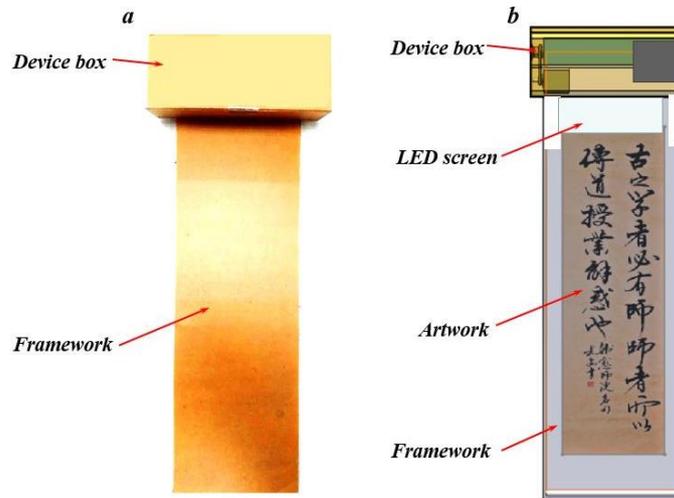


Figure 3 The initial design concept: (a) initial prototype structure; (b) initial 3D prototype structure

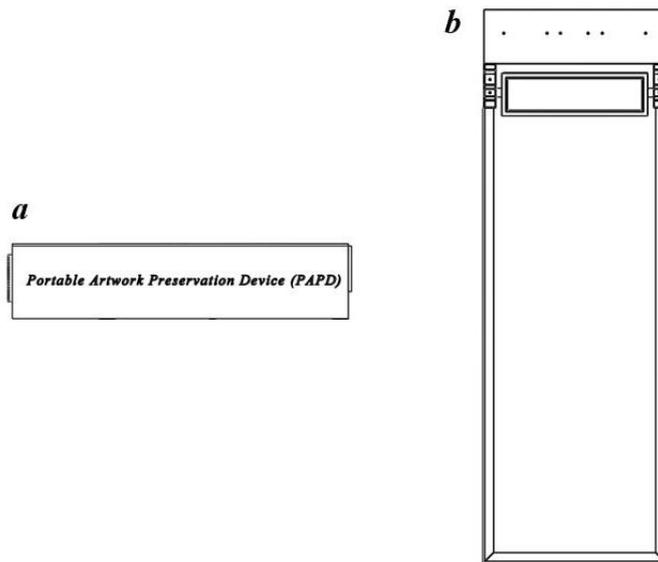


Figure 4 Schematic structure of the portable artwork preservative device: (a) device box; (b) framework



Figure 5 The artwork box of the portable artwork preservative device

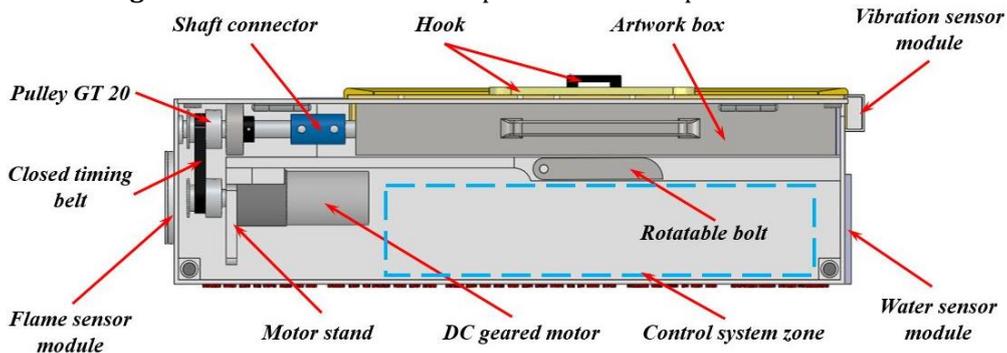


Figure 6 The device box of the portable artwork preservative device

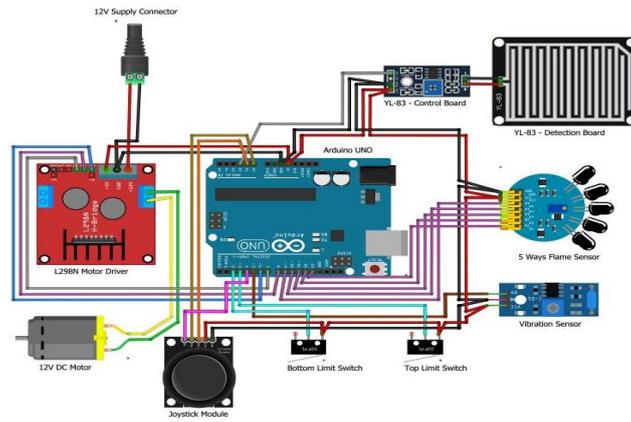


Figure 7 Wiring diagram of the portable artwork preservative device

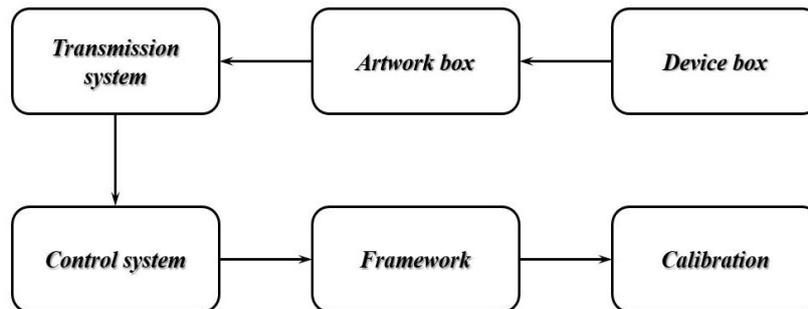


Figure 8 Flowchart of the portable artwork preservative device fabrication procedure

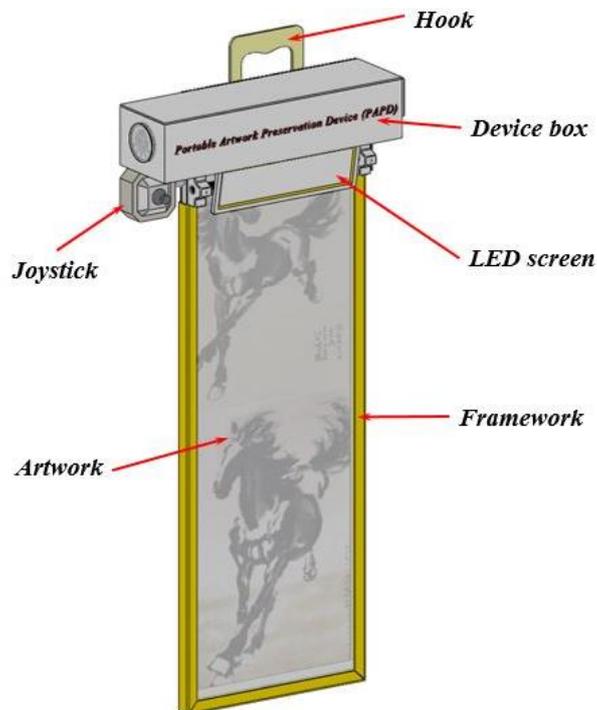


Figure 9 The 3D prototype isometric view of the portable artwork preservative device

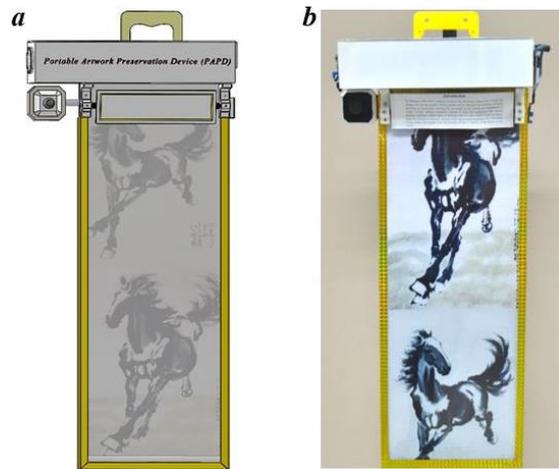


Figure 10 Schematic structure of the portable artwork preservative device: (a) 3D prototype structure; (b) realized prototype device

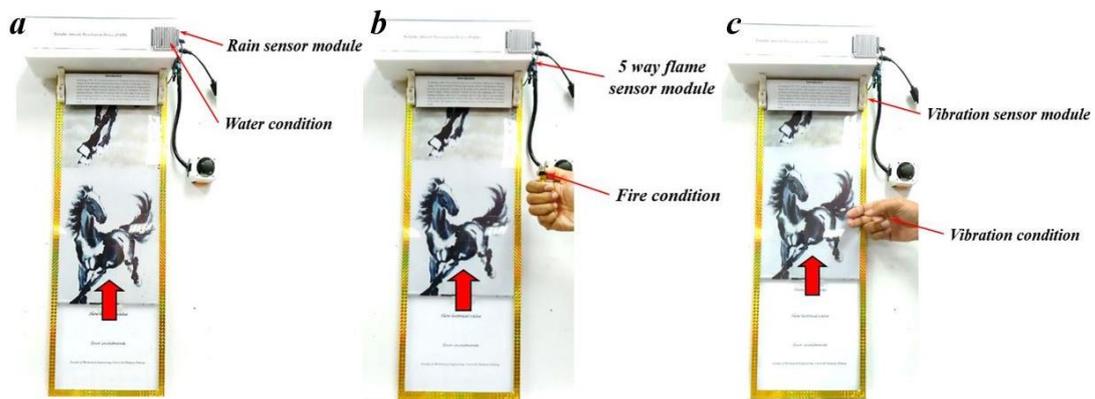


Figure 11 Response performance of the portable artwork preservative device: (a) water condition; (b) fire condition; (c) vibration or stealing condition

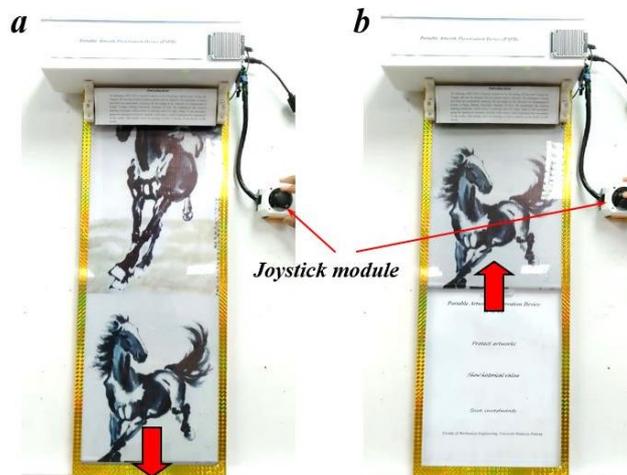


Figure 12 Manual control method using the joystick module: (a) rolling-down condition; (b) rolling-up condition

CONCLUSION

The portable artwork preservation device (PAPD) is successfully designed, fabricated and tested according to fire, water, and vibration conditions, which is used to simulate possible damaged or stealing conditions. Based on its tested results, it is concluded that this device offers valid response performance, which is automatically rolled up the artwork using around 10 s. It is used the joystick module to manually control the artwork movements such as rolling up and down and pause at a certain position. The artwork box is placed inside the device box, which is simply to take out and replace another artwork. Besides, this device provides sufficient procedure to protect the artwork, which offers the new potential method to reduce the irreversible damaged of valuable artworks.

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