





## Implementation of an Augmented Reality Guide: Auto-Presenting Suitable Content to Adults and Young Children about Chen Cheng-Po's Oil Paintings

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**Abstract.** A single painting can be embedded with rich layers of information. However, the information on a painting's museum label remains limited. The growth of mobile computing has facilitated the creation of innovative self-guiding apps. Augmented reality (AR) technology allows for dynamic digital content to be displayed on real-world objects and scenes, thus expanding the explanation of abstract and underlying stories beyond the limitations of static text. An augmented reality art guide application was developed to allow adults and children to access suitable content about paintings with the assistance of a gyroscope, following a case study of Chen Cheng-Po's oil paintings. In this study, four oil paintings of different orientations and sizes were selected for the design implementation to provide threshold suggestions for the gyroscope. This natural user interface AR guide application that can precisely deliver the content to adults and young children offers the potential to create in-depth content for adults interested in art and child-friendly inspiring content for future artists.

**Keywords:** Art Guide Application, Mobile Learning, Augmented Reality, Natural User Interface, Museum Education

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### 1 INTRODUCTION

Art is indispensable for humanity and can be expressed intangibly through music or poetry and tangibly through three-dimensional sculptures and architecture or two-dimensional painting. Individually, a piece of art can reflect an artist's skills and thoughts; collectively, art can represent the culture of its own period. Consequently, a single artwork can be embedded with rich layers of information. Among different art forms, painting can be considered the most influential that reflects the individual artist, as the pictorial space mediated on canvas can be imaginative and creative without limits. Paintings from significant artists can, therefore, be incredibly valuable for collectors but truly invaluable for cultural heritage. Efforts have thus been made to preserve and exhibit significant paintings in museums and galleries to connect the public with the development of

humanity on the one hand while inspiring future art creation on the other as a way of continuing humanity [8].

Typically, a painting is exhibited with a museum label or so-called “tombstone,” on which the name of the artist, the title of the artwork, the year of creation, and the material used are presented. While this is the essential information providing the facts of the artwork, it is less concerned with the intended meaning of the artist and extended appreciation, discussion, and discoveries from critics and researchers [11],[13]. Although more information can be provided, the content remains limited to one or two paragraphs and thus remains fundamental in nature.

The advance of mobile computing has enabled innovative self-guiding applications, and augmented reality (AR) that can be mediated on visitors’ own handheld devices such as smartphones, has enabled innovative and interactive self-guided learning while reviewing the actual artwork [9]. The application of AR can present dynamic digital content overlaid on real scenes and objects, enabling the explanation of abstract and underlying stories beyond what static text can offer. Many AR guides have been implemented in art museums; the digital layer allows museums to offer physical paintings to audiences with different virtual information that cater to the needs of different individuals; however, one challenge is to develop universally suitable content [1],[6].

The widespread use of AR technology brings both convenience and concern. AR applications, with their virtual and real elements, can attract users to view additional virtual information. However, users may become overly focused on the virtual content, disregarding their surroundings or reducing interactions with others. This can lead to safety issues and detract from the direct interaction and observation of artworks, limiting the appreciation and understanding of art [5],[7],[12]. Additionally, when applying AR to sensitive narratives, there is a need to consider potential issues, as simulations and attractive visual and auditory content can minimize and distort the suffering of victims and divert attention from the story itself [4]. Designers should exercise caution in the use of AR technology, ensuring that it provides accurate, respectful, and meaningful experiences in sensitive topics.

The same painting can elicit multiple interpretations, and some content may not be suitable for younger children. For example, *Starry Night* by Vincent Van Gogh demonstrates how to use the static composition of color to illustrate the movements of the presumed static sky scene. However, expressions concerning the artist’s depression that lies behind the creation and value judgments might not be suitable for a younger audience [2]. Children learn about famous artists in galleries and benefit from their paintings.

Solutions for displaying suitable content according to the different ages of users can be achieved by providing a user interface for selection. However, where content might be truly inappropriate for certain ages, stricter control might be desired. In addition, because decision-making has been identified as a factor that induces museum fatigue [3], this study proposes a natural user interface that utilizes the embedded gyroscope of a smartphone to allow AR content to automatically detect the age group of the audience and deliver suitable content accordingly. A prototype of an AR guide project for the oil paintings by Taiwanese painter Chen Cheng-Po was created to demonstrate the feasibility of this proposed new art guide.

## 2 METHODOLOGY

The perceived unfriendly atmosphere and lack of child-friendliness in art museums and galleries is a barrier to access that can lead to frustration and can keep children away. One reason is that artworks are displayed at an adult viewing height, discouraging a younger audience from engaging and appreciating the work [1]. Figure 1 shows this typical situation where the adult perspective is level or slightly elevated or lowed, while children have to look upward significantly. This situation is unavoidable as the displaying height of paintings is required to accommodate the average viewing eye level. This difference in viewing angles for different age groups provides the opportunity to implement a natural user interface for AR art guiding. The concept of the natural user interface (NUI) minimizes user operation to promote an intuitive user experience. It is so named because it often employs the user’s natural behaviors as the input and output for the human-computer interaction.



**Figure 1:** Different viewing angles between adult and young child.

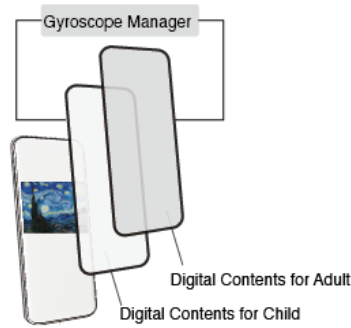
The gyroscope is a sensor that enables a device to sense its state, including its orientation and gravity value. This has become a standard feature of smartphones and, therefore, provides various applications based on variations in orientation and gravity value. The Unity 3D software program was used to develop the AR project. The gravity value has three directions on the x, y, and z axes and is within the range of -1 to 1 in Unity 3D. For the gyroscope, the direction pointing toward the user of the device is referred to as the z-axis, and the direction to the right of the device is referred to as the x-axis. When the device is vertical, and the camera is facing upwards, the gravity value of y is less than 0. Figure 2 illustrates the direction of gravity and each value of the three axes. Hence, when the handheld device scanning the images is rotated, the gravity value of the three axes also changes.



**Figure 2:** Gravity value of x, y, and z.

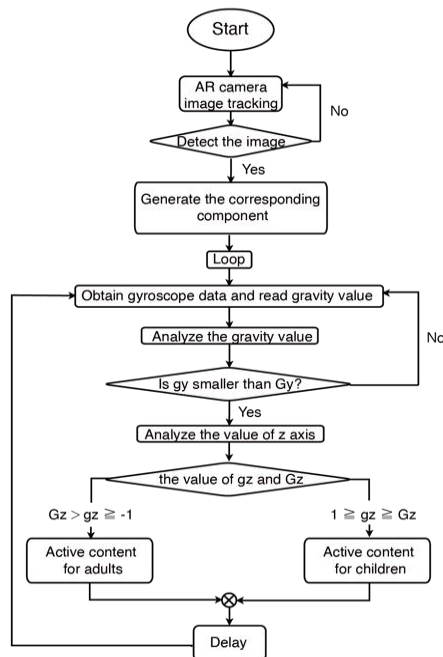
A pilot study was conducted to investigate how to use the current state of handheld smartphones to automatically display three different types of content for adults, teenagers, and young children [15]. Although the prototype successfully functions, the system frequently displays incorrect content for users according to the three different age groups. One major reason is that teenagers' height can be closer to that of either adults or children, making the difference of detected values unreliable. In this study, the algorithm was revised to only target adults and children, enhancing the accuracy in determining whether the user is a child or an adult. Thus, the age-sensitive art guide can be implemented using self-guiding AR.

When the user scans an image with a smartphone, the component with the gyroscope manager and digital content is displayed. The component is shown in Figure 3. Digital content, including information and user interface, is designed separately for adults and children. The component consists of two groups for adults and children and the gyroscope manager, which returns the gravity value of the devices and determines which group to present.



**Figure 3:** There are different digital content for adults and children and the gyroscope manager in the component.

Figure 4 illustrates the operational flow chart for the project. The prototype uses the gravity value of the y and z axes to determine the state of the device. The values detected by the sensor are referred to as "gy" and "gz," and the threshold values are referred to as "Gy" and "Gz." The Gy value is used to recognize whether the device is vertical with the camera facing upwards, with a value of 0. The Gz value is used to recognize the orientation of the device based on the size of the painting and the distance between the user and the painting. If the detected value of gz is above the threshold Gz, the content for children is presented. If the detected value of gz is below that of Gz, the content for adults is displayed. The process is repeated every 0.3 s after the component is generated.



**Figure 4:** Algorithm flowchart.

### 3 DESIGN IMPLEMENTATION

#### 3.1 Chen Cheng-Po

Chen Cheng-Po (1895–1947) is a well-known Taiwanese artist who was born in Taiwan during the Japanese occupation period and later went to Japan in 1924 to study Western painting. His work entitled "Outside Chiayi Street" was the first Taiwanese artwork chosen to be displayed at the 7th Imperial Art Exhibition of Japan in 1926. He was highly regarded as the pioneer of Western painting in Taiwan's art history. Unfortunately, he was arrested and eventually executed by the Kuo Min Tang (KMT) government after they regained control of Taiwan. Consequently, his works were banned for decades until 1991. Over the past decades, studies have been conducted, and valuable discoveries revealed how art can survive under political injustice [10].

However, the themes depicted in the artworks may involve sensitive issues or complex historical backgrounds, which may be challenging for children to fully comprehend and grasp [10],[14]. Therefore, it is important to select and adjust the information accordingly, taking into account the children's age and cognitive level, to ensure that they can understand and appreciate the artwork while avoiding discomfort or confusion.

In this study, four oil paintings of different sizes and orientations were selected for the design implementation. The title, dimensions, orientation, and intended messages for adults and young children are presented in Table 1. "Outside Chiayi Street #2" is in portrait orientation and has been exhibited at several shows, while "Outside Chiayi Street #3" is in landscape orientation of equal size. "Landscape in Tamsui" is a small landscape painting, and "Chiayi Park" is the largest of his oil paintings and has been regarded as an important antiquity piece by the Taiwanese government.

<i>Oil painting</i>	<i>Orientation</i>	<i>Size</i>	<i>Message to Adult</i>	<i>Message to Young Children</i>
Outside Chiayi Street #2	Portrait	65 × 53 cm (Medium)	Background of the artist, color, and topic	Asking open-ended questions
Landscape in Tamsui	Landscape	18.8 × 23.6 cm (Small)	Background of the place, composition, color, style, and technical details	Focusing children's attention on a particular aspect of the artwork
Outside Chiayi Street #3	Landscape	53 × 65 cm (Medium)	Background of the artist, composition, perspective, and topic	Hypothesizing to spark curiosity and encourage further exploration
Chiayi Park	Landscape	130 × 162.5 cm (Large)	Perspective, technical details, topic, and the cultural value	Prompting with cues to support divergent thinking

**Table 1:** Basic information of paintings selected for design implementation.

Studies have observed challenges that children face when visiting art museums and galleries and provided recommendations for improving their experiences [1]. During conversations with children, Weier suggested incorporating visual arts language and concepts at appropriate times [1]. Additionally, two strategies are recommended in the field of art education for inspiring children while viewing artworks: the first is to guide children in exploring the painting's subject and details with general questions, and the second is to guide children in thinking about the painting techniques used and their corresponding effects [2]. In this study, the adult content for each piece will focus on information from different perspectives, while the content for children will focus on providing information in simple language, encouraging exploration and connecting with life experiences, supplemented by natural sounds related to the artwork.

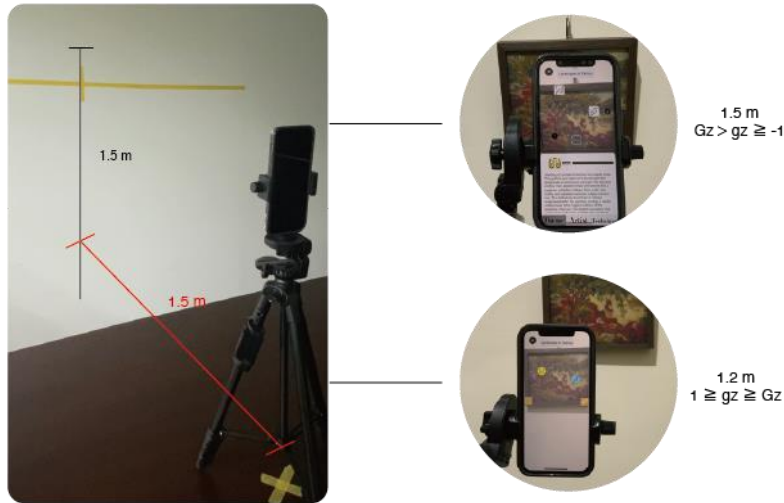


**Figure 4:** Different digital contents for adults and children are activated by the gyroscope manager.

### 3.2 Set-up

During the field test, we selected four paintings of different sizes and orientations. With authorization from the Chen Cheng-po Cultural and Educational Foundation, we manufactured reproductions of each painting in their actual size on canvases. The center of each painting was positioned on the wall at a fixed height of 1.5 meters. The mobile device was placed at distances of 0.5 meters and 1.5 meters from the wall. The distance of 1.5 meters was specifically used for testing large-scale paintings to ensure that the entire artwork could be recognized. Based on publicly available data from the Taiwan Ministry of Education, the average height of 6-year-old children in 2021 was 117.0 cm for males and 116.6 cm for females. To account for individual variations and cover the height range of most 6-year-old children, we used a reference height of 120 cm in the field test. This ensured that sensitive information would not be obtained when the majority of children scanned the images. Therefore, the tests were conducted at heights of 1.2 meters.

After establishing the basic parameters, including the Gz value of 0.2 in the lab, we modified and tested the four paintings of different sizes and orientations and further adjusted the respective Gz values for each painting of different sizes and orientations to prevent children from being exposed to sensitive content. When the phone scans images at a height of 1.2 m and then generates the component, the gz value, which means the gravitational force in the z-axis direction of the phone, can always be greater than the Gz value.



**Figure 5:** The set-up of the field test: (a) the distance between the wall and the tripod (b) the content for adults at 1.5 m height (c) the content for children at 1.2 m height.

### 3.3 Result

The results for each painting, as shown in Table 2, demonstrate how the size and orientation of the paintings influence the parameters. The size of the painting influences the  $Gz$  values: As the size of the painting increases, the  $Gz$  value must be set to a larger value because the orientation of the scanning image becomes larger. Furthermore, the  $Gz$  values of portrait orientation paintings with the same size are larger than those of landscape orientation.

<i>Oil painting</i>	<i>Distance</i>	<i>Child</i>	<i>Adult</i>
Outside Chiayi Street #2	0.5 m	1 ——— 0.3 — 0.2 ——— -1	1 ——— -1
Landscape in Tamsui	0.5 m	1 ——— 0.2 — 0.1 ——— -1	1 ——— -1
Outside Chiayi Street #3	0.5 m	1 ——— 0.2 ——— -1	1 ——— -1
Chiayi Park	1.5 m	1 ——— 0.2 — 0 ——— -1	1 ——— -1

**Table 2:** Results for each painting showing the difference of  $Gz$  values.

## 4 CONCLUSION

To deliver multiple pieces of information about art, the guides are designed in various types, including augmented reality. As an important medium for connecting the artists' works with the audience, guides play a crucial role in resonating with viewers and communicating the artist's ideas and emotions. It was noticed that the challenges of guides presenting information to people with various levels of knowledge exist. To strengthen the connection between the works and the audience, the museums should determine what information would be presented to the audience with different knowledge levels.

This paper demonstrates an interactive system that can respond to natural hand gestures and movements while using a handheld smartphone to scan an image to initiate appropriate digital content for adults and young children with the use of a gyroscope. The multiple layers of digital content are designed to offer detailed context for adults and keep children from inappropriate material. Children who appreciate art with suitable information are encouraged to develop their understanding of the world and art.

The combination of AR and the gyroscope makes the user interface switch automatically and smoothly, which is confirmed by the design implementation of four paintings of different sizes and orientations by the artist Chen Cheng-Po. However, as the field test was conducted at a fixed location, future research should consider conducting user tests in various settings and collecting feedback from the users. With this natural user interface AR guide application that can precisely deliver the content to adults and young children, we believe that in-depth content can be created for art-interested adults and child-friendly inspiring content can be developed for our future artist children.

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