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**Beyond One Painting: Implementation of An Augmented Reality Guide to Automatically Present Suitable Information about Chen Cheng-Po's Oil Paintings to Adults and Young Children**

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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 culture 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.

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 from the artist and extended appreciation, discussion, and discoveries from critics and researchers [1]. Although more information can be provided, the content remains limited to one or two paragraphs and thus remain 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 [2]. 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 museum 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 [3][4].

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 can demonstrate 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 lie behind the creation and value judgements might not be suitable for a younger audience [5]. Children learn about famous artists in galleries and benefit from their paintings. Art appreciation allows children comprehend the world, strengthen the connection with it and foster a habit of visual observation which encourage them to engage with the world. In addition to acquiring knowledge, art education cultivates children interest in art. "Pick-and-

mix” questions help children how to appreciate at the paintings [5]. In such cases, digital content can be more in-depth and precisely targeted to audiences of different age groups.

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 [6], 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.

#### Main Idea:

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 [3]. Fig. 1 shows this typical situation where the adult perspective is level or slightly elevated or lowed, while children have to looking upward significantly. This situation is unavoidable as the displaying height of paintings are 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.

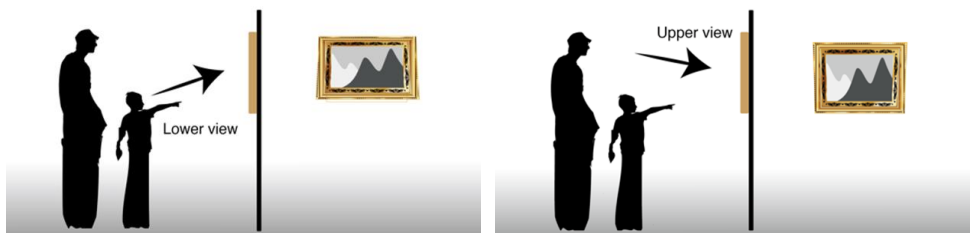


Fig. 1: Different viewing angles between adult and young child.

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 devices 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.

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 [7]. 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 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 are displayed. The component is shown in Fig. 3. Digital content including information and user interface, are 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.

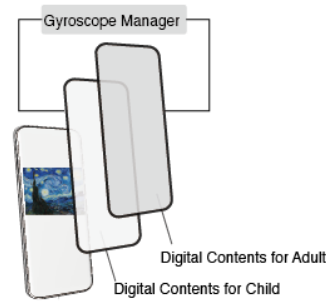


Fig. 3: There are different digital content for adults and children and the gyroscope manager in the component.

Fig. 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 0.1 s after the component is generated.

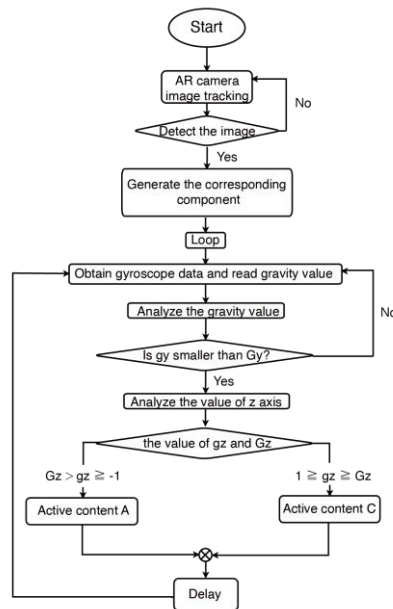


Fig. 4: Algorithm flowchart.

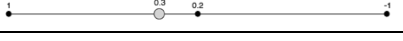

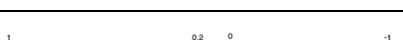
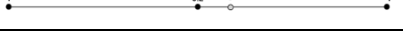
### Design Implementation:

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 past decades, studies have been conducted and valuable discoveries revealed how art can survive under political injustice [8].

In this study, four oil paintings of different sizes and orientation were selected for the design implementation. "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 an important antiquity piece by the Taiwanese government.

During the field test, reproductions of each chosen painting were manufactured in actual size on canvases, and the center of each reproduction was displayed at a fixed position, which is on the wall at a height of 1.5 m. The center of the mobile is 0.5 m away from the wall. Additionally, the test is carried out at the height of 1.2 m and 1.5 m respectively to offer different digital content for children and adults. 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 size and orientation to prevent children from being exposed to sensitive content. When the phone scans images at a height of 1.2 m and then generate 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.

The results for each painting, as shown in Tab. 1, 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 scanning image become larger. Furthermore, the Gz values of portrait orientation paintings with the same size are larger than those of landscape orientation. In addition, large paintings require a greater distance to scan the image completely because the Gz value needs to be detected more precisely to change the digital content.

<i>Oil painting</i>	<i>Orientation</i>	<i>Size</i>	<i>Distance</i>	<i>Gz-Values</i>
Outside Chiayi Street #2	Portrait	65 × 53 cm (Medium)	0.5 m	
Landscape in Tamsui	Landscape	23.5 × 33 cm (Small)	0.5 m	
Chiayi Park	Landscape	130 × 162.5 cm (Large)	1.5 m	
Outside Chiayi Street #3	Landscape	53 × 65 cm (Medium)	0.5 m	

Tab. 1: Basic Information and results for each painting showing the difference of Gz values: (a) Outside Chiayi Street #2, (b) Landscape in Tamsui, (c) Chiayi Park, and (d) Outside Chiayi Street #3.

### Conclusion:

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 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. In this study, we explore the potential of augmented reality (AR) as a medium for connecting artists'

works with diverse audiences. We address the challenge of presenting tailored information to individuals with varying levels of knowledge by developing an interactive system that leverages natural hand gestures, smartphone gyroscopes, and AR. Our system automatically delivers age-appropriate content for both adults and young children, providing in-depth context and fostering a greater understanding of art. Through the implementation of this natural user interface AR guide on Chen Cheng-Po's paintings, we demonstrate the effectiveness of our approach in offering a seamless and engaging experience for art-interested adults and inspiring content for young, aspiring artists.

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