THE CREATION OF PHYSICAL ART THROUGH VIRTUAL REALITY TECHNOLOGY

BY

GOMESH KARNCHANAPAYAP

THIS RESEARCH IS SUBMITTED IN PARTIAL FULFILMENT OF

RESEARCH GRANT SPONSORED BY

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ABSTRACT

Art and Technology have always been evolving alongside one another. From the invention of various paint mediums to photography and computer art, humans embrace technology in pursuit of art creation. Newer technologies such as digital painting and digital sculpting bring about convenience and flexibility to artists while aiming to maximize the artist's creative flow. The objectives of this research were 1) to study and explore Virtual Reality as a creative platform for creating new media artwork, 2) to create and output the new media artwork as a Physical art through the use of additive manufacturing technology, and 3) to compare and analyze Virtual Art and its Physical counterpart in a commercial art exhibition setting. An analysis of audience' survey data concerning the virtual reality art piece and physical artwork in art exhibition setting indicates that 1) virtual reality can be used to deliver a satisfying art viewing experience, 2) most audience would rather purchase physical art piece instead of the VR work because of product tangibility.

KNOWLEDGEMENT

The researcher would like to express his deepest appreciation to Professor Wattana Jutawipat, the advisor for his never-ending support on this research. My beloved wife, Saruta Chanharn for her understanding and support when I needed most.

Lastly, the researcher would like to thank all the audience and participants for their time in the interview.

GOMESH KARNCHANAPAYAP

RESEARCHER

TABLE OF CONTENTS

TABLE OF CONTENTS (CONT.)

LIST OF TABLES

LIST OF IMAGES

LIST OF IMAGES (CONT.)

CHAPTER 1

INTRODUCTION

1.1 BACKGROUND OF THE STUDY

According to Oxford Learner's Dictionaries, the term “Virtual Reality” is defined as images created by a computer that appears to surround the person looking at them and seem almost real (Hornby, A. S., Turnbull, J., Deuter, M., & Bradbery, J.,2017). Although Virtual Reality has been around for many decades, nowadays the term “Virtual Reality” often being associated with the entertainment industry particularly computer gaming.

However, Virtual Reality has a broad spectrum of applications including medical, military, architectural visualization, and even fine art. Since the dawn of Virtual Reality, forward-thinking artists have been trying to incorporate the technology as an artistic medium. Since then virtual reality artworks in the forms of installation arts have begun to appear in galleries and exhibitions all around the world.

As artworks created using Virtual Reality technology require the audience to wear head-mounted display to be transported to the virtual reality art, one cannot easily purchase the artworks and take them home. Hence, for the Virtual Reality artists, the most common revenue streams for this type of virtual reality art are either through exhibition ticket or project sponsorship.

When the exhibition’s over, these types of artworks leave no physical footprints behind as the artworks were created and displayed digitally during the exhibition as visual experience through physical head-mounted display powered by a computer. Oftentimes, one can only trace virtual reality arts in the form of documents may it be documentation videos or news. In this study, the researcher would like to explore the possibility of producing both virtual reality art and physical art as commercial art objects through the qualitative research process.

1.2 STUDY OBJECTIVES

1.2.1 to study and explore Virtual Reality as a creative platform for creating new media artwork,

1.2.2 to create and output the new media artwork as a Physical art through the use of additive manufacturing technology, and

1.2.3 to compare and analyze Virtual Art and its Physical counterpart in a commercial art exhibition setting.

1.3 SCOPE OF THE STUDY

1.3.1 Primary research about Virtual Reality as an art-making platform

1.3.2 Design and develop survey research tool about audience perception of Virtual Reality as an art product

1.3.3 Develop 2 artworks Virtual Reality art and physical art as sellable art objects

1.3.4 Collect and analyze data by comparing the 2 art mediums as suitable commercial art objects. Sample: Art audience age 18-50 years. Sample Size: 115.

1.4 SIGNIFICANCE OF THE STUDY

1.4.1 Understanding of audience factors in appreciating Virtual Reality and Physical Artworks.

1.4.2 The body of knowledge of how to produce Virtual Reality Art through modern computer applications.

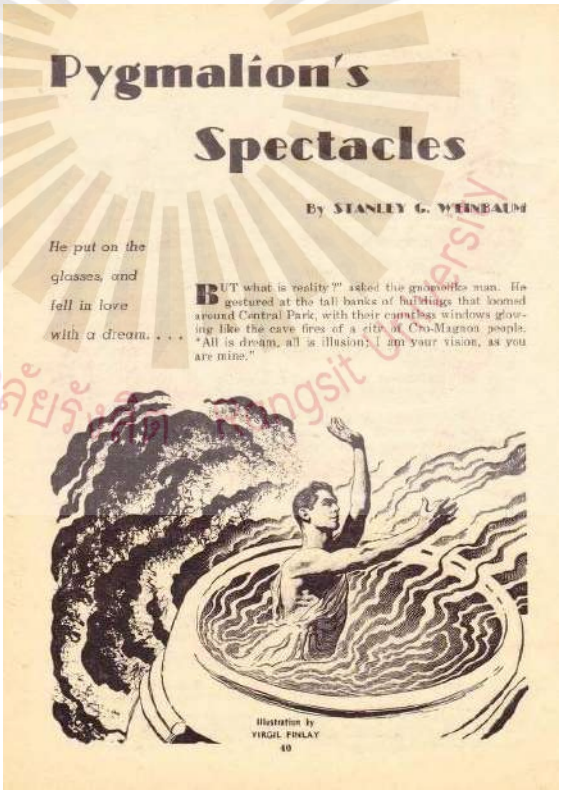
1.4.3 The body of knowledge of how to produce physical sculpture derived from Virtual Reality art.

CHAPTER 2

LITERATURE REVIEW

INTRODUCTION

Virtual Reality technology has come a long way in the past few decades, yet it's still considered an emerging technology. The concept of "Virtual Reality" was first appeared in a science fiction short story "Pygmalion's Spectacle" by Stanley Grauman Weinbaum. The fiction was published in 1935. In this fantasy science fiction, the protagonist meets a professor who invents a pair of goggles that allowed him to view a movie in full senses -sight, sound, taste, smell, and touch (Poetker, 2019).



Pygmalion's Spectacles

By STANLEY G. WEINBAUM

He put on the glasses, and fell in love with a dream. . . .

BUT what is reality?" asked the gnomelike man. He gestured at the tall banks of buildings that loomed around Central Park, with their countless windows glowing like the cave fires of a city of Cro-Magnon people. "All is dream, all is illusion; I am your vision, as you are mine."

Illustration by VIRGIL FINLAY

40

Image 2.1 Pygmalion's Spectacle by Stanley Grauman Weinbaum

Source: Poetker, 2019

It's the power of imagination through science fiction that aspired the realization of virtual reality. It's essential to look back and see how the technology's evolved and how the technology might be applied in the field of creativity.

2.1 VIRTUAL REALITY TECHNOLOGY

Morton Heilig, an American cinematographer and inventor is one of whom scholars often credit as the pioneer of virtual reality. Heilig began the study of attention to examine the relationship between film and viewer in 1955. This famous study reveals which of human's five senses are being used at any given point during the film viewing experience. According to the study senses are being utilized in the following proportions; Sight: 70%, Hearing: 20%, Smell: 5%, Touch: 4%, and Taste 1%. From this study, he began inventing and proposing a device for the cinema of the future. The Sensorama Machine was invented in 1957 and patented in 1962 along with five short films for it to display (Payatagool, 2008).

Image 2.2 Sensorama

Source: Payatagool, 2008

Sensorama is a simulation device that incorporates visual, auditory, somatosensory, olfaction, and taste. The device claimed to stimulate the users' senses with a screen for visual perception, audio speakers for auditory, vibrating fans for somatosensory, and smell emitting device for olfaction. While the device itself was very cutting edge, this device never took off due to the high cost involved in the production of the contents and manufacturing of the device (Payatagool, 2008).

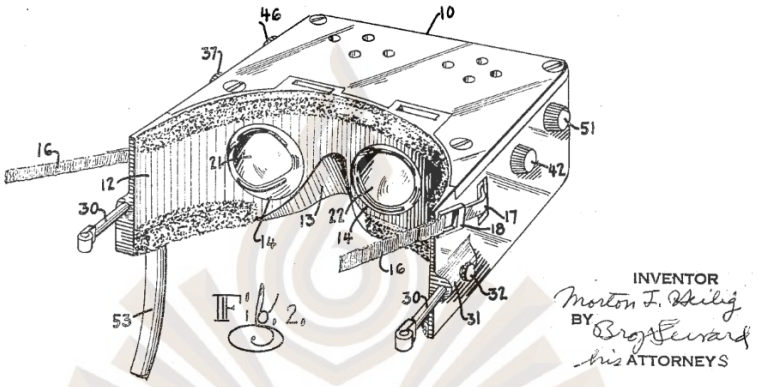


Image 2.3 Telesphere Mask Patent

Source: http://uschefnerarchive.com/morton-heilig-inventor-vr/

Also invented by Morton, Telesphere Mask is the first-ever head-mounted display (HMD). The goggle provides stereoscopic, wide vision, and stereo sound. This marks the dawn of Virtual Reality. The device can truly be considered as the forefather of modern day's Virtual Reality HMDs.

Image 2.4 Telesphere Mask

Source: Source: http://uschefnerarchive.com/morton-heilig-inventor-vr

In 1961, Comeau and Bryan, 2 Philco Corporation engineers developed the first HMD with head tracking ability – the Headsight, by incorporating a video screen for each eye and a magnetic motion tracking system linked to a closed-circuit camera. The device application allows immersive remote viewing by the military. The device would detect wearer's head movements which in turn instruct the movement of a remote camera, allowing the user to naturally albeit virtually look around through the camera lens (BCC Research Editorial, 2018).

Approximately 8 years later in 1968 Ivan Sutherland utilized a computer instead of a camera to connect to a head mounted display. This allows greater computing power to be displayed on the HMD. An early application showed a 3D wire-frame virtual room that users could explore by moving their heads around. Because the HMD's tethered with a large overhead weight support system hung from a ceiling, the machine came to be known as 'The Sword of Damocles' (Sutherland, 1968).

Image 2.5 The Sword of Damocles by Ivan Sutherland

Source: www.computerhistory.org

Although the Sword of Damocles was considered an advanced virtual reality of its time, it's too cost-prohibitive to be commercially viable. Not until the early 1990s that VR was made available to the public. This time around, VR reincarnates in the form of games where a head-mounted display could be worn and used to view graphics while playing games. In 1993 a videogame giant, SEGA, revealed and demonstrated SEGA VR. The Virtual Reality goggles were planned to be accompanied by their Sega Genesis console at the Summer Consumer Electronics Show (CES). Due to development difficulties and that it induces motion sickness and severe headaches in users, the headset was never released and remained only a prototype (Horowitz, 2004).

Image 2.6 SEGA VR

Source: https://www.vrfocus.com/2018/05/a-brief-history-of-virtual-reality/

In 1995, another gaming industry titan, Nintendo attempted yet another VR push with Nintendo Virtual Boy. It was marketed as the first console capable of displaying stereoscopic 3D graphics. Even though there was a big hype due to its portability, it slowly fades away. Factors that may contribute to its demise are the very clunky design, its visual performance, and lack of content (Horowitz, 2004).

Image 2.7 Virtual Boy console

Source: www.vrfocus.com

The researcher's still able to clearly recall the experience of trying out Nintendo Virtual Boy at Walmart in 1995. At that time, the researcher was trying out "Mario's Tennis". Upon peering through the Virtual Boy lens, the machine was only able to produce crude red monochromatic display --leaving much to be desired after such a high expectation.

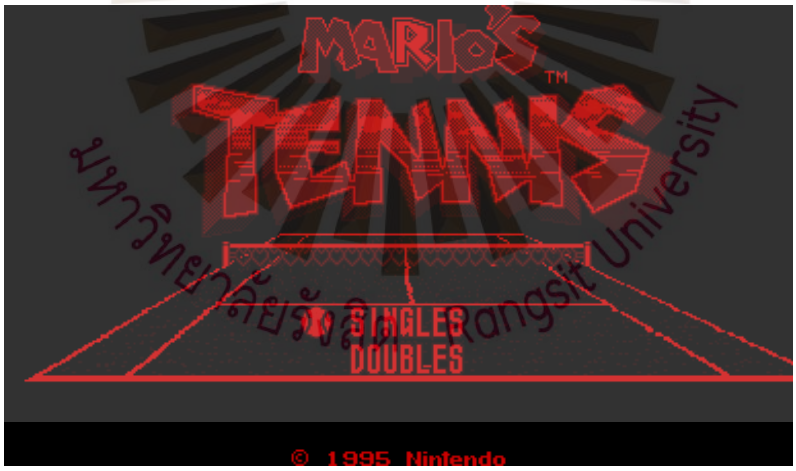


Image 2.8 Mario's Tennis, a Game on Virtual Boy console

Source: www.planetvb.com

Due to the past failures to launch, Virtual Reality was believed to be an unfeasible product for mass adoption. In 2013, Oculus Rift a successfully crowd funded head mounted display project would forever change the landscape and perception of Virtual Reality technology. The Oculus Rift project was a brainchild of Palmer Luckey, who in 2011was only 19 years old.

His aspiration was to invent an affordable VR headset for the indie gaming community. His first prototype was highly praised by John Carmack, a living legend in the gaming industry responsible for multi-million-dollar games such as Doom and Quake. With this heavy momentum, he started a Kickstarter campaign offering game developers a chance to get Virtual Reality technology at US$300-an affordable price point. The project took off and eventually surpassed $2 million in pledges from 9,522 backers (Kickstarter, 2018).

Image 2.9 Oculus Rift CV1

Source: www.oculus.com

The consumer version of Oculus began shipping March 28, 2016. The headset was well received by its patrons for its high quality of display and unprecedented affordability. In the wake of Oculus' success in penetrating the Virtual Reality market, many tech giants such as Sony, HTC, and Samsung began announcing their versions of Virtual Reality headsets. According to Statistica, the Virtual Reality industry is growing at an accelerated pace, with the market size of consumer virtual reality hardware and software projected to increase from 6.2 billion U.S. dollars in 2019 to more than 16 billion U.S. dollars by 2022 (Gordon, 2020). Virtual Reality can truly now gain critical mass adoption for it to propel to the next level. At first, Virtual Reality attracts mainly game enthusiasts. However, the innovative technology also sparks more ideas and it didn’t take long for the world to begin imagining creative applications for Virtual Reality beyond gaming.

2.2 VIRTUAL REALITY ART

Virtual Reality art really began to surface around the early 1990s when artists started to combine visual art and Virtual Reality technology to produce immersive experience. One of the most well-known and worth mentioning virtual reality artworks was “Osmose” by Char Davies.

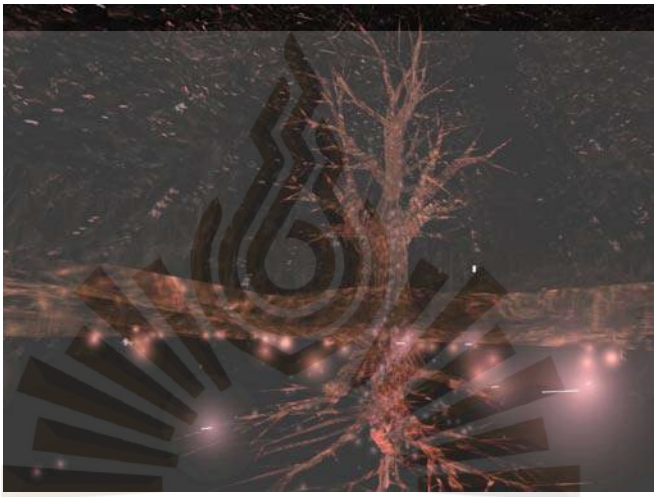


Image 2.10 Osmose

Source: www.immersence.com/osmose

Osmose was exhibited in 1995, the artwork utilized 3D stereoscopic computer graphics and audio with real-time motion tracking. When audience put on the Virtual Reality goggles, they were placed into virtual environments.

Image 2.11 The tunnel Under the Atlantic

Source: Archive of Digital Art

In that very same year, “The tunnel Under the Atlantic”, a Virtual Reality art by Maurice Benayoun was also unveiled. The project was an experimental Virtual Reality art that let users to virtually situate on each side of the Atlantic Ocean able to meet and interact in a virtual space they have created together (Archive of Digital Art, n.d.). The two Virtual Reality artworks helped push virtual reality artwork forward into what it is today.

2.3 TILT BRUSH – VIRTUAL REALITY ART APPLICATION

As Virtual Reality technology’s becoming ever more accessible, there’s a growing need for art creation tools specifically designed to be used in Virtual Reality. Oculus, the company that spearheaded Virtual Reality, also spawned child projects to develop Virtual Reality creative tools such as Oculus Medium and Oculus Quill. These two software titles, however, can only be operated under the Oculus platform. With many brands of Virtual Reality headset available today, the researcher believes opting for a third-party software that can be operated across multiple platforms would allow flexibility for the research.

Image 2.12 Google Tilt Brush

Source: www.tiltbrush.com

Google, an American multinational technology company that specializes in Internet-related services and products, also poised to enter the Virtual Reality arena with its creative software-Tilt Brush. The program was originally developed by Skillman & Hackett. In 2014 the program was nominated for four Proto Awards, an annual awards show organized to reward successful individuals and teams in the field of virtual reality. In that show, Tilt Brush won the "Best GUI" award (The Proto Awards, 2020).

Tilt Brush is designed for 6 Degree of Freedom movement and motion interfaces in Virtual Reality. Users are presented with a virtual palette from which they can select stroke types effects, and colors. Users can manipulate the artwork through the movements of the handheld controllers in the virtual environment. In addition to the ability to capture screenshots, 5-second GIF images, .mpeg videos, or 360-degree videos, the software can also export the creation in a variety of industry-standard formats including. .FBX, .USD, and .JSON. FBX files also known as Filmbox is a proprietary file format developed by Kaydara. Since 2006 this trademark is owned by Autodesk. It is commonly used to provide interoperability between digital content creation applications. USD or Universal Scene Description is a framework for the interchange of 3D computer graphics data, created by Pixar. The framework's main strengths are non-destructive editing and enabling multiple collaboration. JSON, also known as JavaScript Object Notation, is

an open standard file format and data interchange format that uses human-readable text to store and transmit data (JSON.org, 2020). With these 3 standardized file types available during export, the extensibility of Tilt Brush to be used in other programs is limitless.

Another key benefit of using Tilt Brush is its availability across many Virtual Reality platforms. At the time of writing, Tilt Brush is released on all major Virtual Reality platforms supporting the widest range of Virtual Reality headsets including Oculus Rift, Oculus Quest, Valve Index, HTC Vive, and even PlayStation VR (Hackett, 2020).

2.4 PHYSICAL OUTPUT OF VIRTUAL ART

3D Printing is a technology that can transform a virtual object into a physical one through additive manufacturing process. There are many 3D Printing technologies invented.

2.4.1 Stereolithography (SLA)

This type of additive manufacturing technology began in the 1980s. In 1981, Hideo Kodama of Nagoya Municipal Industrial Research Institute invented additive method for additive manufacturing. He created a product that used ultraviolet lights to harden polymers and create solid objects. This was a stepping stone of a widely adopted 3d Printing technology known as stereolithography (SLA). In stereolithography as invented by Charles Hull, the object is printed layer by layer, rinsed with a solvent, and hardened upon exposing to an ultraviolet light. (ISO.org, 2015)

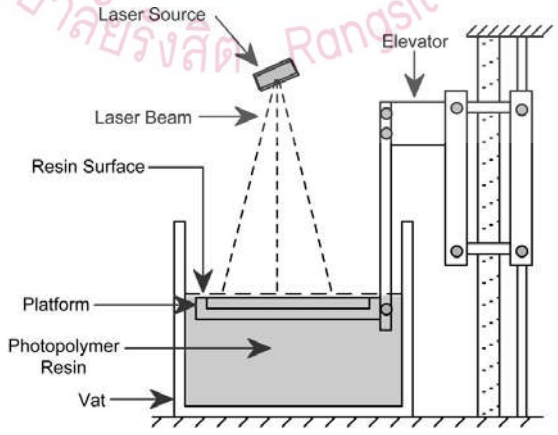


Image 2.13 Diagram of SLA Printing Process

Source: whiteclouds.com

2.4.2 Fused Deposition Modeling (FDM)

Fused Deposition Modeling is an additive manufacturing process developed by Scott Crump. It is the most common form of 3D printing today. To realize an object into a physical form, the printer heats a cable of thermoplastic into liquid form and extrudes it layer by layer (Mongeon, 2017). FDM works with a range of standard thermoplastics, such as ABS, and PLA. According to a whitepaper published by FormLab, although FDM technique is suitable for basic proof-of-concept models, FDM has the lowest resolution and accuracy when compared to SLA or SLS and is not the best option for printing complex designs (FormLab, 2020).

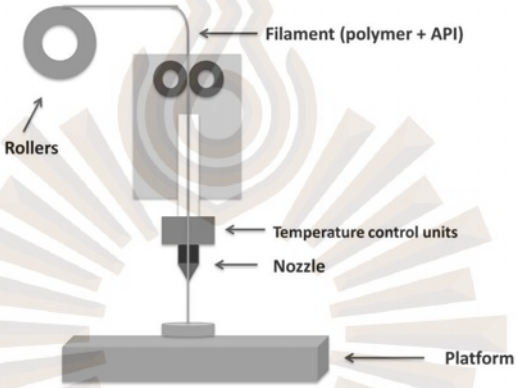


Image 2.14 Diagram of FDM Printing Process

Source: whiteclouds.com

2.4.3 Selective Laser Sintering (SLS)

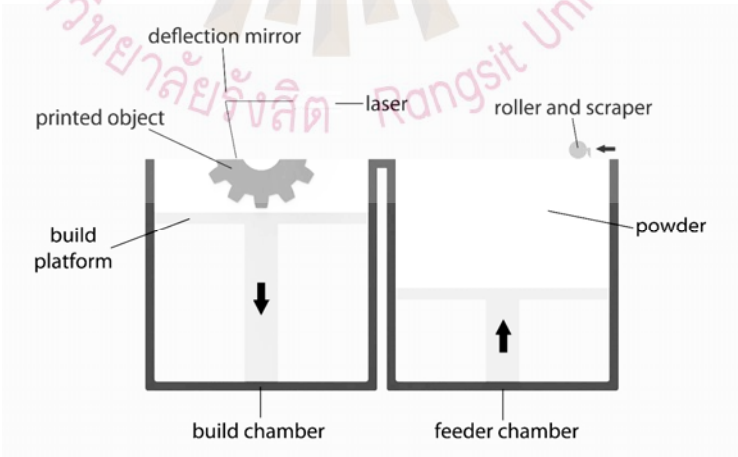


Image 2.15 Diagram of SLS Printing Process

Source: Additive.blog

Selective Laser Sintering is another form of additive manufacturing. It uses a powder polymer to create objects by emitting a laser to fuse the powder together, layer by layer, into solid shapes. Objects printed with SLS technology SLS have a slightly rough surface finish, but almost no visible layer lines (ISO.org, 2015).

Table 2.1 Compare FDM, SLA, and SLS 3D Printing Technologies. Source: FormLab

	FUSED DEPOSITION MODELING (FDM)	STEREOLITHOGRAPHY (SLA)	SELECTIVE LASER SINTERING (SLS)
Resolution	★★☆☆☆	★★★★★	★★★★☆
Accuracy	★★★★☆	★★★★★	★★★★★
Surface Finish	★★☆☆☆	★★★★★	★★★★☆
Throughput	★★★★☆	★★★★☆	★★★★★
Complex Designs	★★★☆☆	★★★★☆	★★★★★
Ease of Use	★★★★★	★★★★★	★★★★☆
Pros	Fast Low-cost consumer machines and materials	Great value High accuracy Smooth surface finish Range of functional applications	Strong functional parts Design freedomNo need for support structures
Cons	Low accuracy Low details Limited design compatibility	Sensitive to long exposure to UV light	Rough surface finish Limited material options
Applications	Low-cost rapid prototyping Basic proof-of-concept models	Functional prototyping Patterns, molds, and tooling Dental applications Jewelry prototyping and casting Modelmaking	Functional prototyping Short-run, bridge, or custom manufacturing
Print Volume	Up to ~200 x 200 x 300 mm (desktop 3D printers)	Up to 300 x 335 x 200 mm (desktop and benchtop 3D printers)	Up to 165 x 165 x 320 mm (benchtop 3D printers)
Materials	Standard thermoplastics, such as ABS, PLA, and their various blends.	Varieties of resin (thermosetting plastics). Standard, engineering (ABS-like, PP-like, flexible, heat-resistant), castable, dental, and medical (biocompatible).	Engineering thermoplastics. Nylon 11, Nylon 12, and their composites.
Training	Minor training on build setup, machine operation, and finishing; moderate training on maintenance.	Plug and play. Minor training on build setup, maintenance, machine operation, and finishing.	Moderate training on build setup, maintenance, machine operation, and finishing.
Facility Requirements	Air-conditioned environment or preferably custom ventilation for desktop machines.	Desktop machines are suitable for an office environment.	Workshop environment with moderate space requirements for benchtop systems.
Ancillary Equipment	Support removal system for machines with soluble supports (optionally automated), finishing tools.	Post-curing station, washing station (optionally automated), finishing tools.	Post-processing station for part cleaning and material recovery.

Based on the study, the researcher selected SLA technology in order to output Virtual Reality art to physical form at its the best resolution.

CHAPTER 3

RESEARCH METHODOLOGY

3.1 RESEARCH FRAMEWORK

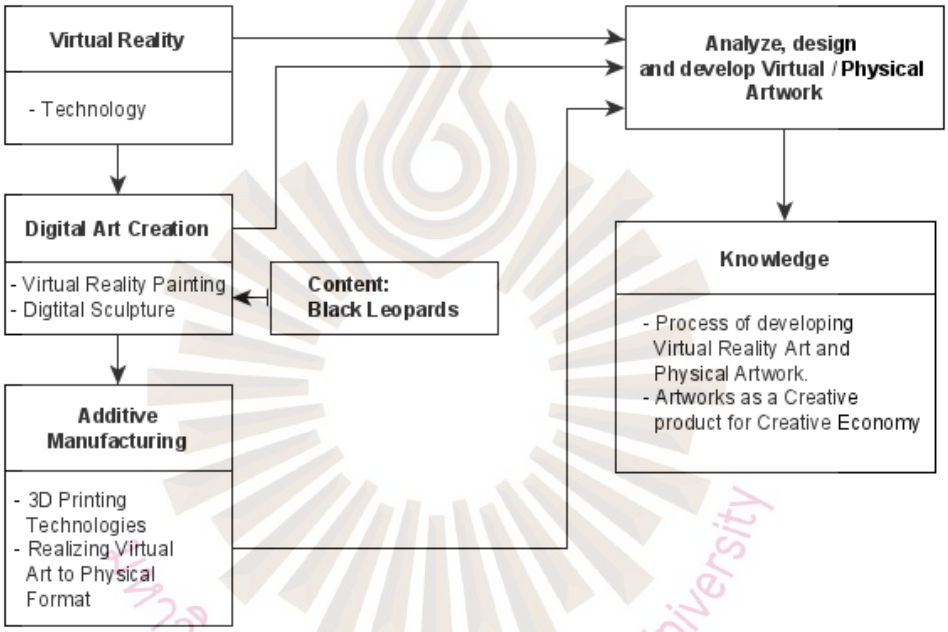


Image 3.1 Research Framework

3.2 CONTENT SCOPE

The researcher would like to use this study to produce artworks on the topic of a black leopard. The researcher aimed to study physiology and ecology of the species in order to produce Virtual Reality new media art and Bronze sculpture respectively.

3.3 POPULATION SCOPE

This research collected field data from 73 samples of volunteers who've viewed and experienced both Virtual Reality and Bronze artworks. The artworks were exhibited as part of the "Ror Sor 238: Zodiac Art" exhibition on October 25, 2019.

3.4 RESEARCH TOOLS

The researcher used data collecting tools as follows: camera, interview questionnaire, electronic equipment such as telephone, computer, and devices to record pictures and data.

3.5 DATA COLLECTION PROCESS

Data were collected from the fieldwork which was conducted by observing the audience and asking survey questions. With this method of data collection, the researcher was able to acquire both qualitative and quantitative data necessary for this study. The research tools used are interview questionnaire, and camera.

CHAPTER 4

RESULT OF THE STUDY

4.1 BLACK LEOPARDS

To gain a deeper understanding of the subject matter, the researcher went on and studied black leopards, their physical forms, activities and ecology. Often black leopards are also called black panther. However, the term “Black panther” is the melanistic color variant of any Panthera including the leopard (Panthera pardus) in Asia and Africa, and the jaguar (Panthera onca) in the Americas. According to the book, “Comparative Genetics of Coat Colour in Mammals”, black leopards are most common in the dense tropical forests of south and southeast Asia. Their coloration enhances their ability to blend with the thick vegetation in the low light of the forests (Searle, 1968).

Image 4.1 Black Leopard

Source: cokesmithphototravel.com

Image 4.2 Leopard Cubs

Source: cokesmithphototravel.com

Baby leopards weigh only about half a kilogram, and are about 13-18 centimeters long. The mother leopard has a gestation period of 93 to 100 days. Leopards, particularly in Asia, regularly give birth to just one cub (Animal Facts Encyclopedia, 2020). The average length and height of a full-grown male leopard are 183 and 66 centimeters. Males are slightly larger than females. The average length and height of a full-grown female leopard are 152 and 56 centimeters. Males can weigh up to 54 kilograms while female average is 40 kilograms. Leopards can live up to 23 years in captivity, but their average lifespan in the wild is around 12 years. Leopards are considered large felines; upon further investigation you can see big cats may have different proportions. As illustrated by Eliot Goldfinger in the book, Animal Anatomy for Artists: The Elements of Form, you can see the proportion of leopard in comparison to other big felines. (Goldfinger, 2004).

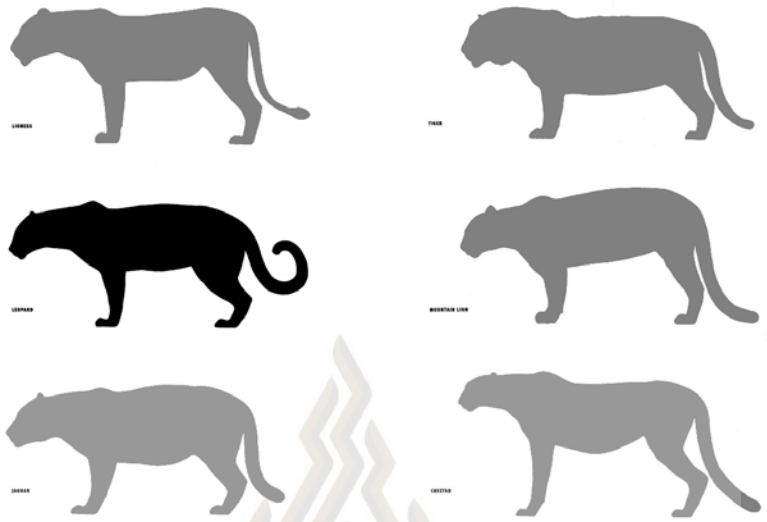


Image 4.3 Proportions of large felines

Source: Goldfinger

4.2 DEVELOPMENT OF VIRTUAL REALITY ARTWORK

The researcher studied Google Tilt Brush application which can be used to create Virtual Reality artwork. In this study, the researcher utilized Oculus Rift CV1 on the Oculus platform to work with. The followings are the steps in the creation of the artwork.

1. Setting up Oculus Rift Virtual Reality Head-mounted display

Prior to getting the Oculus Rift, the researcher must ensure that the PC can handle the high demand of performance the VR headset is going to need. Oculus has released its own recommendations of which graphics cards to use, which as a standard is NVIDIA GeForce GTX 970 and 980. The next step is to download the Oculus installation program that can be found on oculus.com/setup.

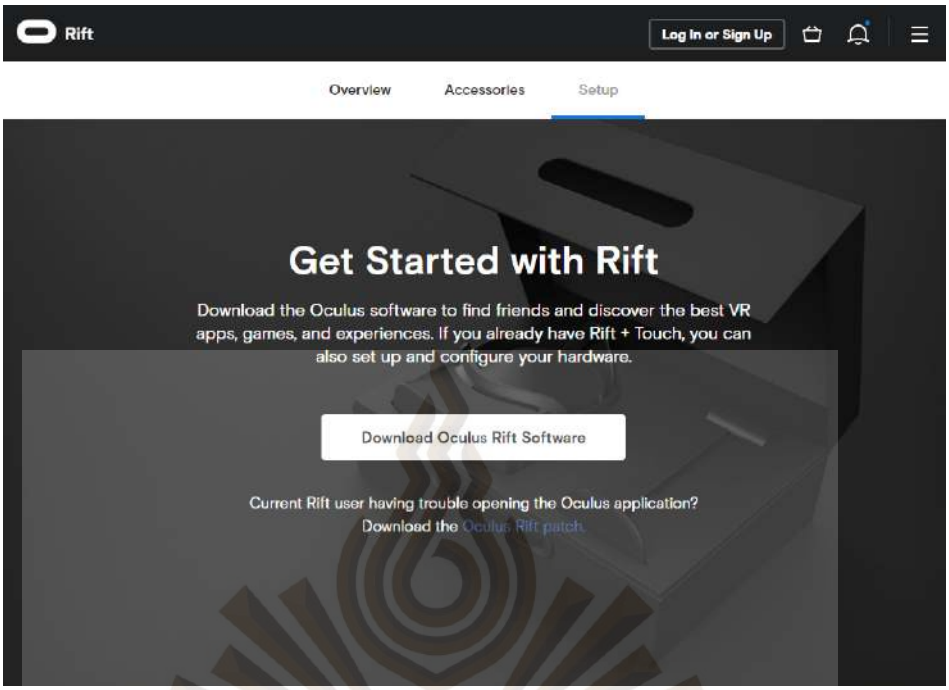


Image 4.4 Oculus Installation Software Download

Source: Oculus

The installation process took approximately 30 minutes and requires 1.22 GB of disk space. Once the installation is complete, the software will ask to set up an Oculus ID. Facebook account can be used as Oculus ID as Oculus is a subsidiary company of Facebook. After Attaching the Oculus HMD and Oculus Sensors to the PC, the installation software will go through the steps including inputting height and sensors' placements. The last step is to calibrate the HMD by picking it up in all directions in front of the sensors until the software confirms correct detection.

2. Acquiring and installing Google Tilt Brush Software

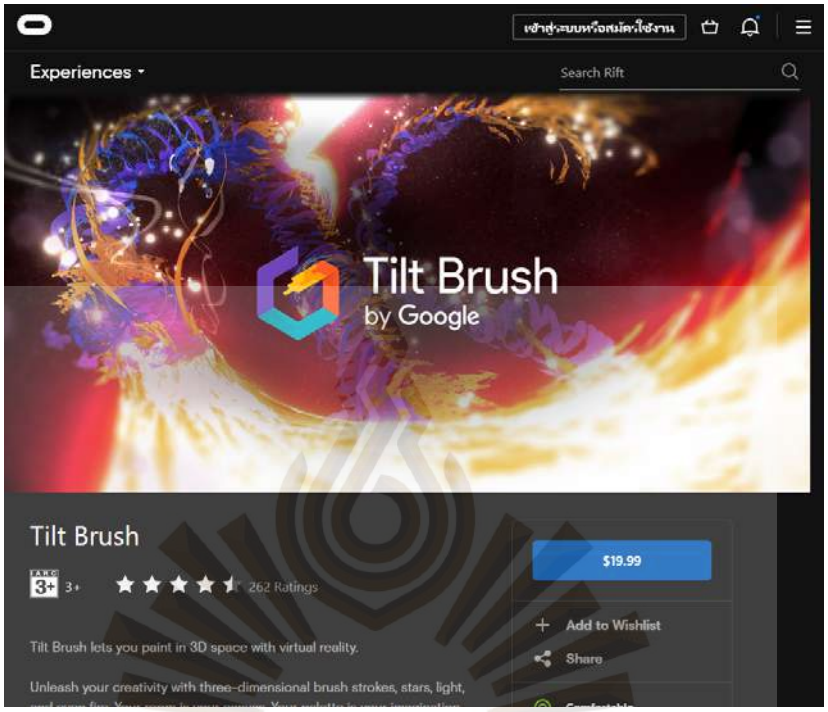


Image 4.5 Tilt Brush on Oculus Store

Source: Oculus

As the researcher chose on the Oculus Platform for the study, Tilt Brush software can be purchased directly on the Oculus store at US$19.99.

3. Familiarize with Touch Controllers

Image 4.6 Touch Controllers

Source: Oculus

As the artwork's created with Virtual Reality, it's imperative to learn how to use the input device. The Oculus Touch consists of a pair of handheld controllers, each comes with an analog stick, three buttons, and two triggers. Rings on the controller contain infrared LEDs that allow the controllers to be fully tracked in 3D space by the Oculus Rift system. With this the movements and actions made by the controllers can be represented in the virtual environment.

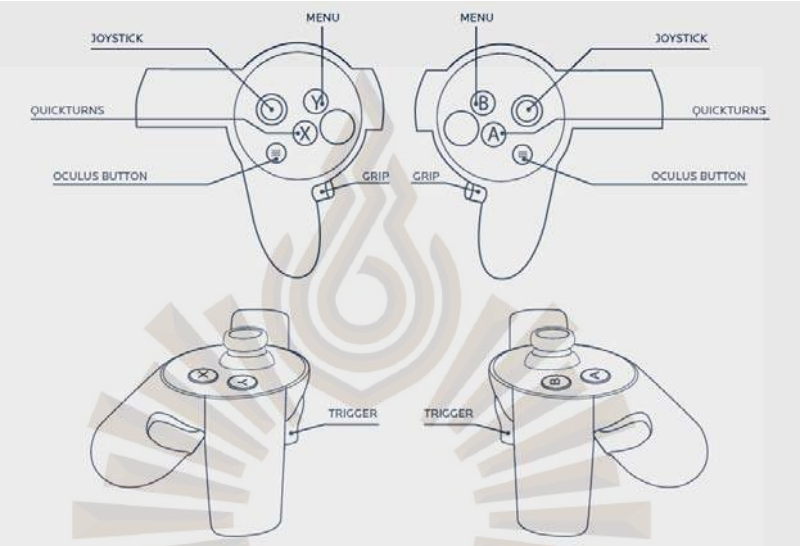


Image 4.7 Touch Controllers Button Diagram

Source: Oculus

4. Familiarize with Google Tilt Brush

Image 4.8 Tilt Brush Loading Screen

The User Interface of Google Tilt Brush is very intuitive. The program requires both hands to operate. The primary hand (right touch controller) is used for painting. Palette containing options are positioned on the secondary hand (left touch controller). To start a new artwork, angle the primary controller towards the palette and clicking on the “New Sketch” area in order to create a new scene.

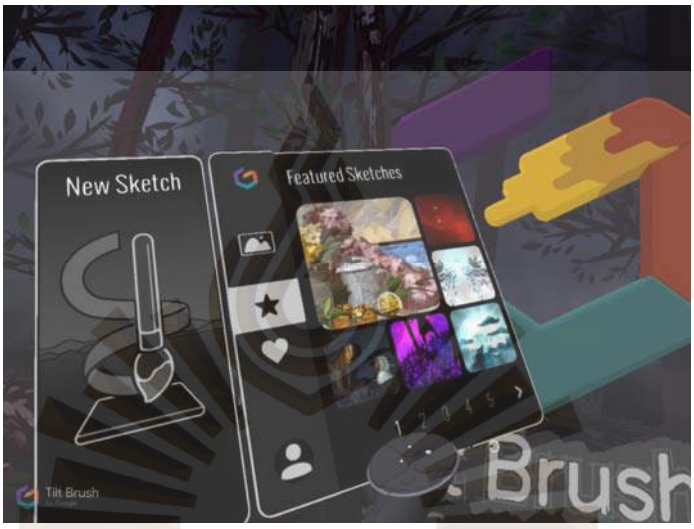


Image 4.9 Creating New Sketch in Tilt Brush

Once the program finished initializing the new sketch, the user will be prompted with a blank area. The palette will now be tools. On this palette controller, user can swipe left or right across the thumb stick to scroll through all available options. This will rotate between the three faces of the palette

Image 4.10 Palette Controller

Swipe across the thumb stick to find the Brush palette, then click on a brush to select brush type for painting.

Image 4.11 Brush Selection in Palette Controller

To select a color, use the same motion- swipe across the thumb stick to find the Color wheel, then click on the color of choice.

Image 4.12 Color Selection in Palette Controller

5. The Virtual Reality Artwork Creation Process

The researcher practiced by testing out paint stroke types available in Tilt Brush. The Final result of this is “Silence Roar: The Last of Us”, a Virtual Reality painting and animation of black leopard family in stylized format.

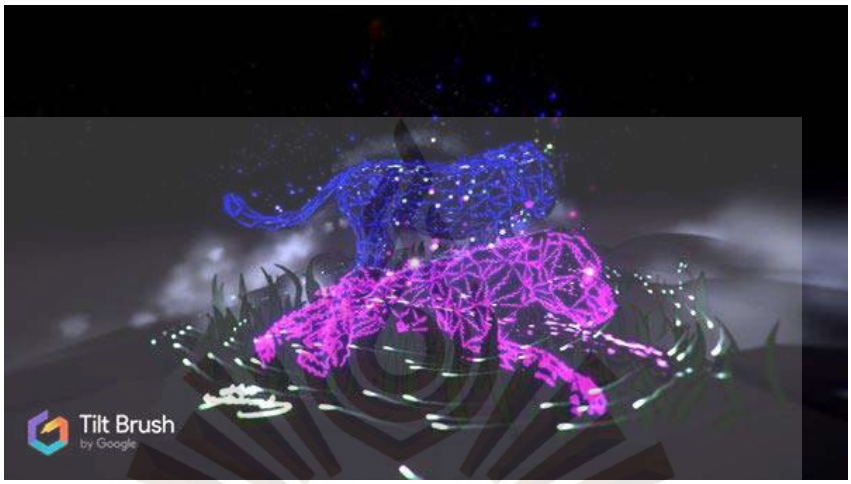


Image 4.13 “Silence Roar: The Last of Us” VR Artwork

The researcher started by using tube brush to create the overall form of mass of the leopard. With dark blue color selected, the tube brush provides gleaming effect to the artwork.

Image 4.14 Step 01 Form the first Leopard with Tube Brush

Image 4.15 Step 02 Paint electrical sparks

Image 4.16 Step 3 Repeat the process on the rest of the painting

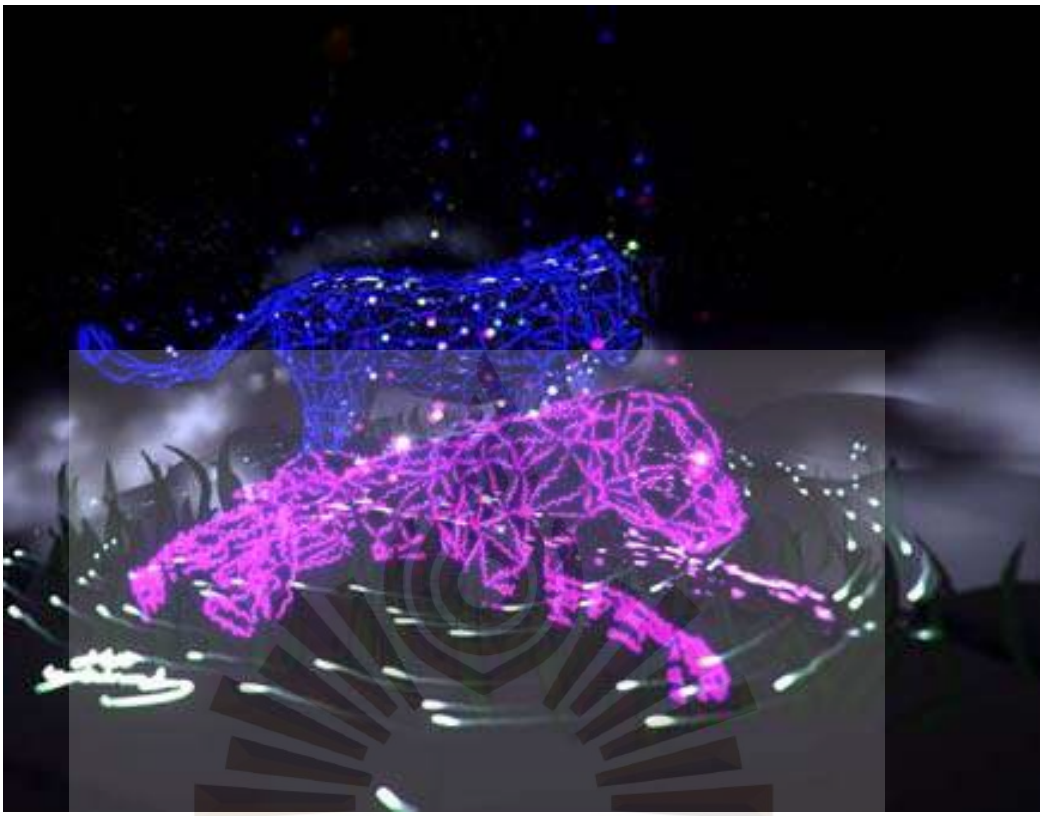


Image 4.17 Add animation with animated brushed

To add animation, the researcher utilized “Trail brush" with light green color to the base of the artwork and "Evaporate brush" set to blue and magenta color to create dispersed movements.

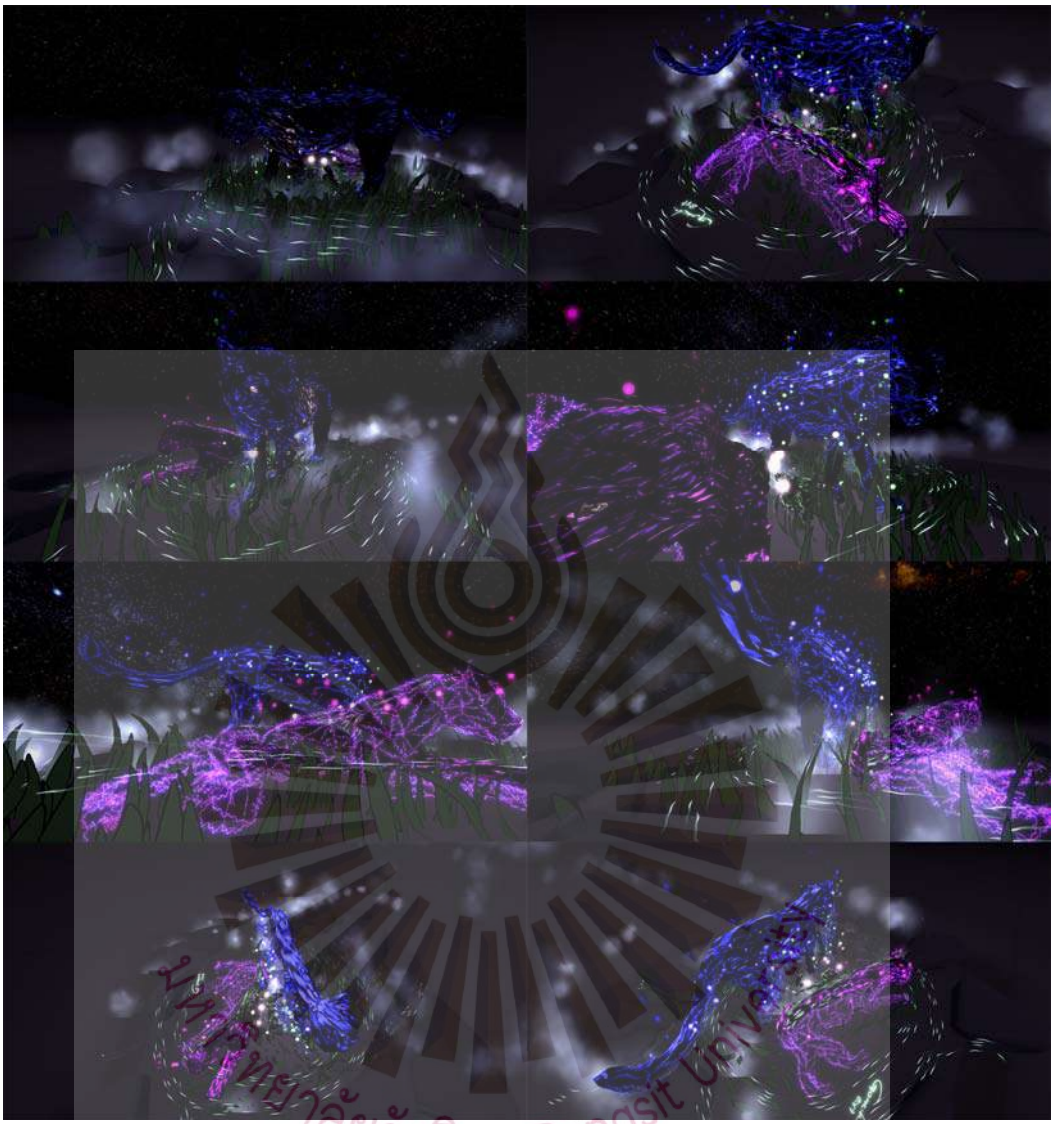


Image 4.18 “Silence Roar: The Last of Us” as viewed in Oculus Rift CV1

4.3 DEVELOPMENT OF PHYSICAL ARTWORK

4.3.1 DIGITAL SCULPTING

The artwork completed in Google Tilt Brush was then export in FBX format. This file format allows the artwork to be interchanged with other major applications. The researcher imported the file to Pixologic ZBrush in order to sculpt details on the artwork.

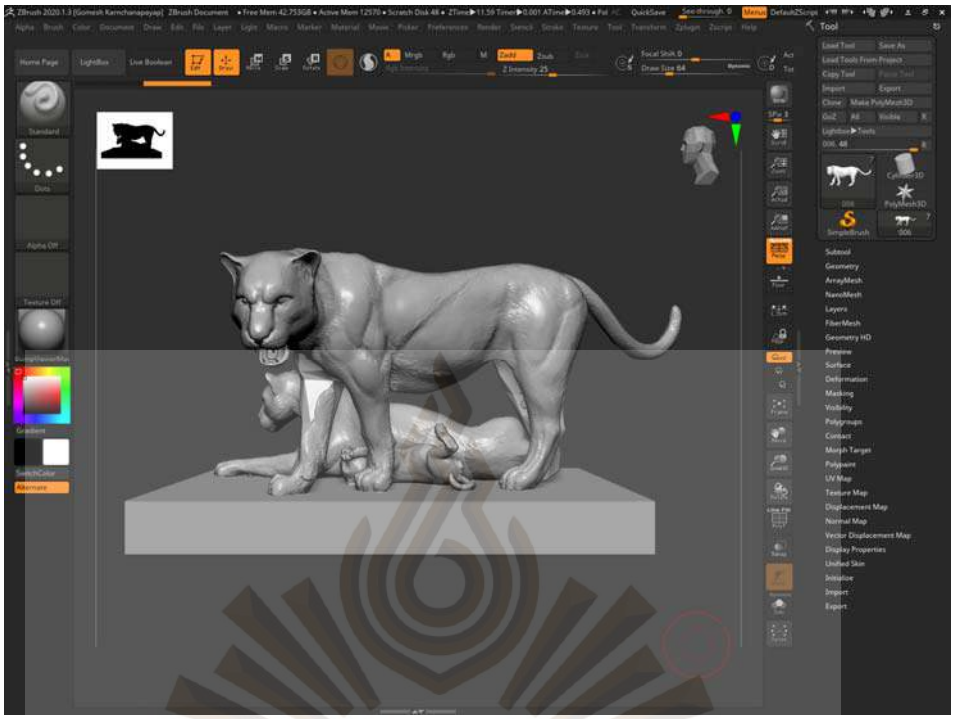


Image 4.19 Digital Sculpting of “Silence Roar: The Last of Us” (Left View)

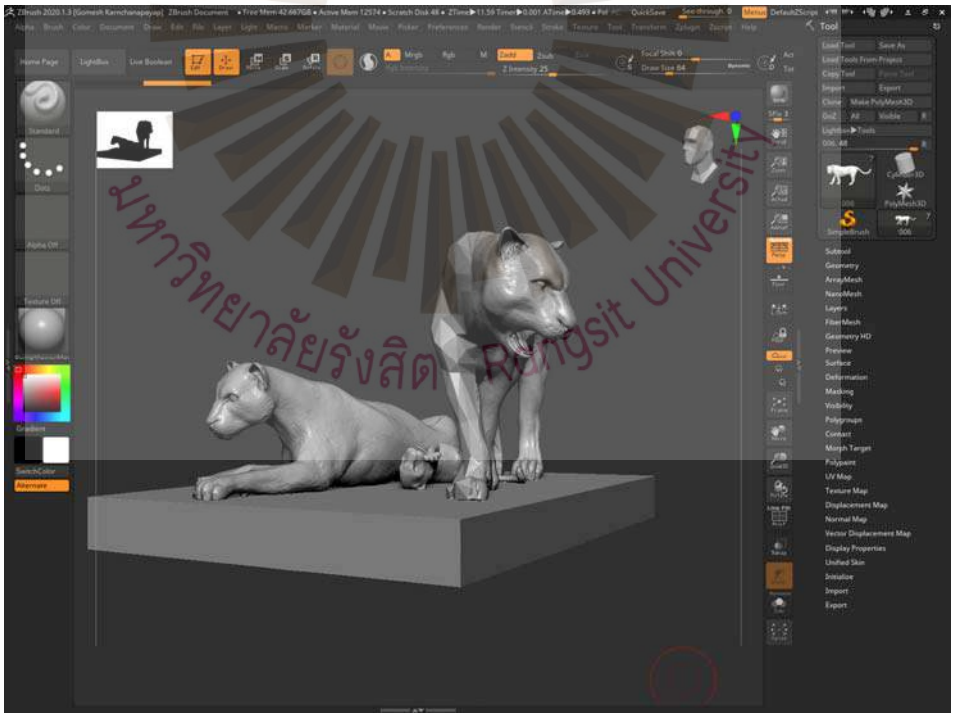


Image 4.20 Digital Sculpting of “Silence Roar: The Last of Us” (Front View)

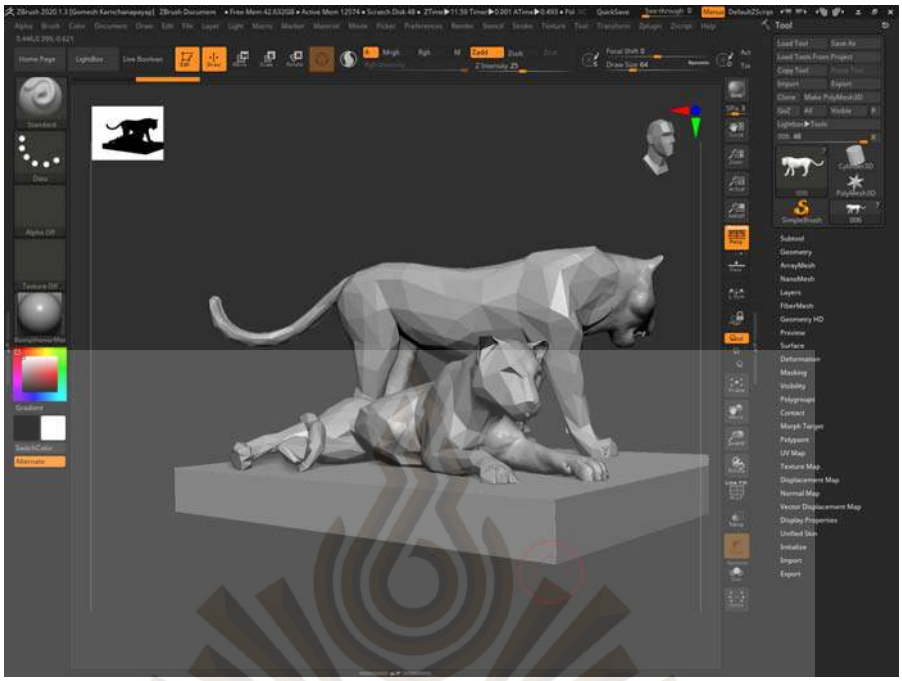


Image 4.21 Digital Sculpting of “Silence Roar: The Last of Us” (Right View)

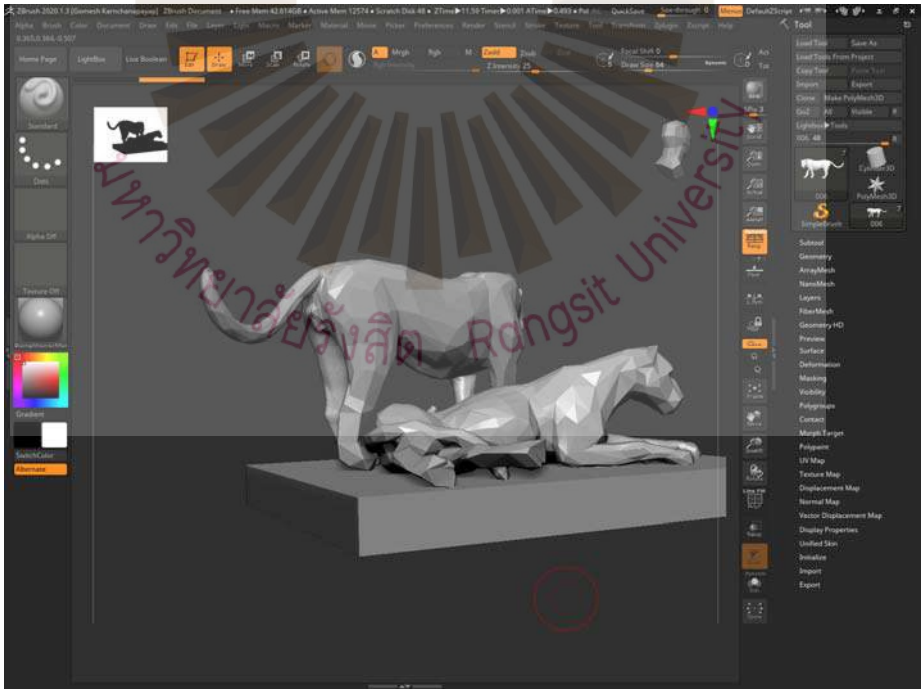


Image 4.22 Digital Sculpting of “Silence Roar: The Last of Us” (Rear View)

4.3.2 3D PRINTING AND BRONZE MAKING

The researcher exported the sculpt from ZBrush in STL format which allows the model to be physically printed with additive manufacturing process. For this step, the researcher employed OctoPrint, a 3D printing service in Thailand.

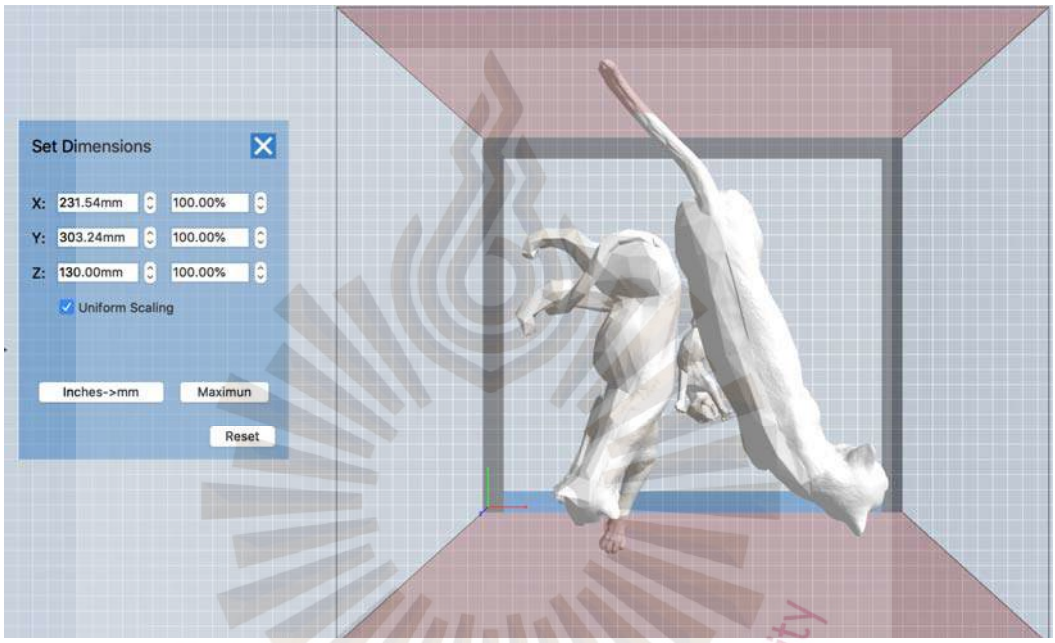


Image 4.23 Preparing 3D Print of "Silence Roar: The Last of Us"

The researcher aimed to create this artwork as a table top collectible with artwork footprint at approximately 23 cm (Width) X 30 cm (Length) X 13 cm (Height). The printed model was then molded and cast in Bronze as a final physical product.

Image 4.24 Wax cast ready to be cast in Bronze

Image 4.25 Bronze Cast before artwork assembly

Image 4.26 Bronze Cast before artwork assembly

Image 4.27 Bronze Cast of “Silent Roar: The Last of Us”

A patina is a surface coating on a metal surface formed by a chemical reaction. Patina can be a natural process or man-made as the process of applying patina to a metal sculpture can add to the final look of an artwork. For this study, the researcher chose jet black patina as the surface finish to emphasize the subject of the study – Black Leopards.

Image 4.28 Bronze Cast with Finished Patina of "Silent Roar: The Last of Us"

4.4 VIRTUAL AND PHYSICAL ARTWORKS EXHIBITION

During the course of creating the artworks, the researcher was invited by an art curator Mr. Yuttana Phongphasuk to exhibit the artworks at "Ror Sor 238: Zodiac Art". This is a moving exhibition which take the artworks to 4 art-centric locations; Fortune Town, Sathorn 11 Art Space, the Seven Art Gallery, and the Combine Café & Art Gallery.

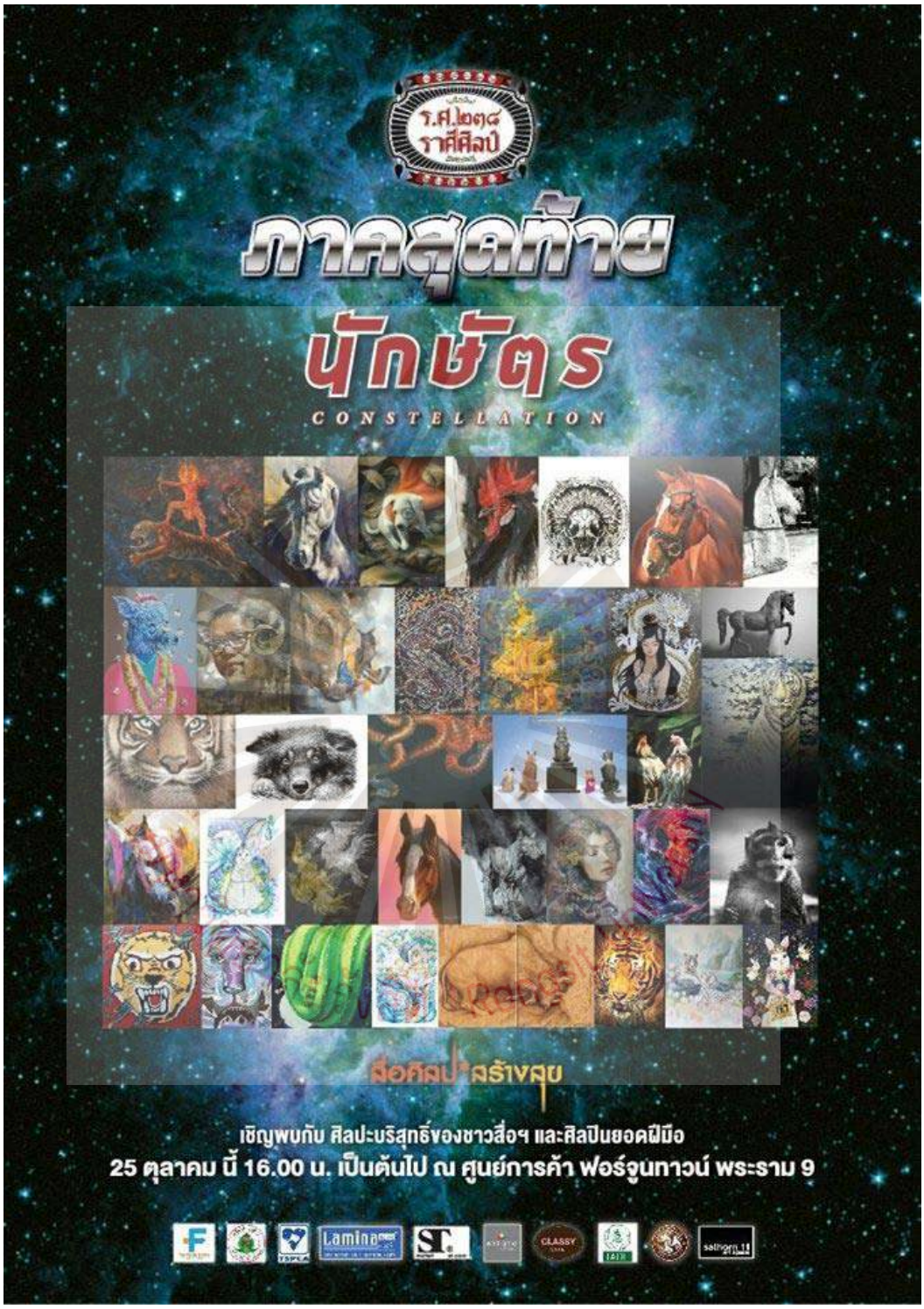


Image 4.29 “Ror Sor 238: Zodiac Art” Exhibition Poster

Image 4.30 Mr. Yuttana Phongphasuk and the artwork

Image 4.31 The Physical version of the artwork @ Fortune Town

Image 4.32 The Setups of both Virtual Reality and Physical artworks @ Sathorn11 Art Space

Image 4.33 An audience @ Combine Café & Art Gallery

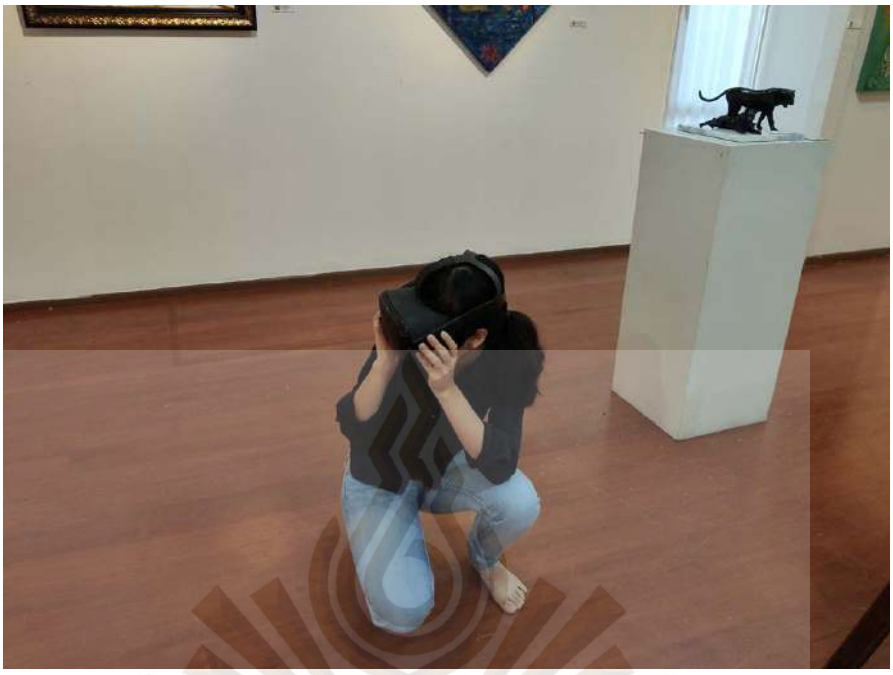


Image 4.34 An audience @ Combine Café & Art Gallery

Image 4.35 An audience @ Seven Art Gallery

4.5 ANALYSIS OF VIRTUAL REALITY ART AND PHYSICAL ART

Due to the nature of the exhibition, the artworks were shown in 4 locations; Fortune Town, Sathorn 11 Art Space, the Seven Art Gallery, and the Combine Café & Art Gallery. This provided exposure of the artworks to a large amount of audience. Through volunteer sampling, the data were collected from 115 participating audience.

Table 4.1: Gender of the samples

Gender	Count	Percentage
Female	28	24.3 %
Male	83	72.2 %
Not Specified	4	3.5 %
Total	115	100%

Table 4.2: Age of the samples

Age Range	Count	Percentage
Less than 15 years old	5	4.3 %
16-20 years old	12	10.4 %
21-30 years old	32	27.8 %
31-40 years old	35	30.4 %
41-50 years old	15	13 %
50-60 years old	9	7.8 %
More than 60 years old	7	6 %
Total	115	100%

Table 4.3: Occupation of the samples

Occupation	Count	Percentage
Student	25	21.7 %
Employee	46	40 %
Business Owner	15	13 %
Government Official	14	12.2 %
Unemployed	4	3.4 %
Retired	11	9.6 %
Total	115	100%

Table 4.4: Monthly income of the samples

Income Range	Count	Percentage
Less than 15,000 Baht per month	26	22.6 %
15,000-20,000 Baht per month	7	6 %
25,000-40,000 Baht per month	41	35.7 %
40,000-60,000 Baht per month	21	30.4 %
60,000-80,000 Baht per month	15	13 %
80,000-100,000 Baht per month	3	2.6 %
More than 100,000 Baht per month	2	1.7 %
Total	115	100%

Table 4.5: Virtual Reality Experience of the samples

Experience in VR	Count	Percentage
No experience prior to the exhibition	105	91.3 %
Have played VR in the past	9	7.8 %
Utilize VR for work	1	0.9 %
Total	115	100%

One of the questions in the research tool was the Virtual Reality experience of the audience in order to measure the level of familiarity with the technology. The majority of the audience for this study had no experience prior to the exhibition. Only 7.8 percent of the samples have used Virtual Reality in the past. This indicates that the technology is rather novel to the audience especially in the area of Art.

Table 4.6: Satisfaction level of the samples

Format	Very Satisfied	Satisfied	Fair	Dissatisfied	Very Dissatisfied
Physical Artwork	17%	80%	3%	0%	0%
Virtual Reality Artwork	45%	55 %	0%	0%	0%

The study reveals that the audience had a high level of satisfaction while viewing the Virtual Reality artwork. Comparing between the two formats of the artwork, 45 percent of the audience rated as very satisfied with Virtual Reality and for the physical artwork at 17 percent. Through an in-depth interview, the audience informed that the Virtual Reality platform brings excitement and expands the horizon in art-viewing experience. Not only can Virtual Reality technology be used as a new and emerging format for displaying artwork, but it can also able to transport the audience into the center of the artwork itself providing an unprecedented level of audience immersion.

Table 4.7: Pricing Suitability Level with the artworks

Format	Very Suitable	Suitable	Fair	Unsuitable	Very Unsuitable
Physical Artwork	7.8%	75%	15%	2.2%	0%
Virtual Reality Artwork	0%	4.3 %	22.7%	73%	0%

The listing prices for the artworks were determined by the cost of developing the artworks factoring in the material fees. For this exhibition, the Bronze statue was listed at 25,600 Baht and the Virtual Reality artwork at 36,000 Baht (the Oculus head-mounted display alone costs US$399 which is approximately 12,000 Baht). In this aspect, however, the audience considered the pricing of the Virtual Reality is less than suitable when compared to the physical counterpart.

Table 4.8: Number of purchased artworks at listed prices during the exhibition

Format	Count	Percentage
Physical Artwork	3	100 %
Virtual Reality Artwork	0	0 %
Total	3	100%

During the course of the exhibition, 3 Bronze statues were purchased while the Virtual Reality Artwork yielded no sale. According to the interview, although the Virtual Reality art shown in this exhibition was extremely attractive, most of the audience do not deem it as collectible artwork. Many believe physical artworks are tangible and have their direct usage as decorative items. Although Virtual Reality artworks may be new and exciting, they also require quite an expertise to handle and cannot be displayed easily. Making Virtual Reality a less favorable choice as an art object in the eyes of art collectors.

CHAPTER 5

CONCLUSION

5.1 MAJOR FINDINGS AS RELATED TO THE RESEARCH

In “The Creation of Physical Art Through Virtual Reality Technology”, the researcher focused on 1. studying and exploring Virtual Reality as a creative platform for art-making, 2. creating and outputting physical art through the use of Virtual Reality and rapid prototype technologies, and 3. to compare and analyze Virtual Art and its physical counterpart in gallery display setting as sellable art pieces.

Through this study, the researcher was able to create a process for producing artworks with the use of Virtual Reality. The process is not only allowing the artist to create Virtual Reality artwork, but when combined with additive manufacturing techniques can also export Virtual Reality art into a physical one. Virtual Reality arts, in the cases around the world, are normally deployed as special exhibitions earning revenues through ticket sales. This means once the exhibition period’s over, the Virtual Reality arts would also vanish along with the event. The physical realization process of the Virtual Reality artwork in this research allows the Virtual Reality derivatives to live on as physical artworks adding additional economic value to the artwork aside from ticket sales.

As shown in Table 4.6, the majority of the audience had a high level of satisfaction while viewing the Virtual Reality artwork. The technology brings a new sensation of viewing artwork by placing the audience at the center of the artwork itself. However, as sellable art objects, physical artworks are still more favorable among art collectors. Virtual Reality artworks require electronic devices to operate while physical artworks are exhibit ready. This makes physical artworks more tangible and accessible in the eyes of art patrons.

Virtual Reality arts may not be suitable as standalone purchasable artworks. Virtual Reality can, however, be used to complement physical artworks. While deploying alongside physical artworks, Virtual Reality can provide engaging activity during the exhibition which ultimately brings a memorable art-viewing experience.

FURTHER RECOMMENDATION

1. Expand the research to include various art style both in Virtual Reality and Physical formats.
2. Focus group study of Virtual Reality as an emerging art platform among art collectors.

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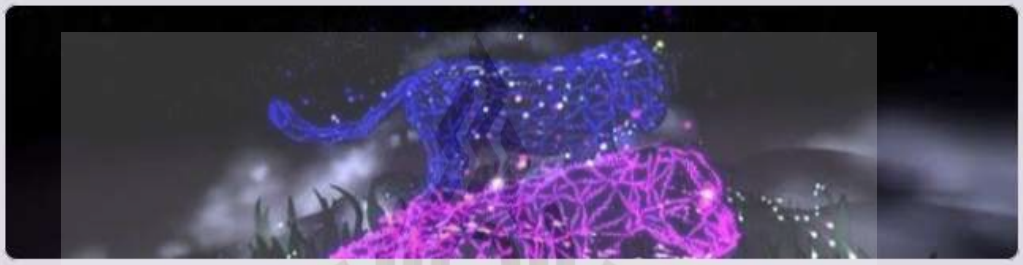
APPENDIX

A. RESEARCH QUESTIONNAIRE



Research Questionnaire for THE CREATION OF PHYSICAL ART THROUGH VIRTUAL REALITY TECHNOLOGY

Directions

1. This Questionnaire is considered a form of User Interview used to collect Quantitative data in the Research The Creation of Physical art Through Virtual Reality Technology
2. This Questionnaire aims to evaluate the suitability of Virtual Reality as a sellable artwork when compared to traditional Physical art format
3. Data collected in this questionnaire is confidential. Your sincere responses are highly appreciated in order for the researcher to further refine the artmaking process.
4. This Questionnaire has 3 part as follow
   - Part 1 General Information about the interviewee
   - Part 2 Evaluation of the Virtual Reality Artwork and Physical Artwork
   - Part 3 Other Suggestions

* Required

1. Gender *

- ◯ Male
- ◯ Female
- ◯ Not Specified

2. Age *

- ◯ Less than 15 years old
- ◯ 16-20 years old
- ◯ 21-30 years old
- ◯ 31-40 years old
- ◯ 41-50 years old
- ◯ 50-60 years old
- ◯ More than 60 years old

3. Higest Level of Education *

- ◯ Primary School
- ◯ Middle School
- ◯ Highschool
- ◯ Vocational School
- ◯ Bachelor's Degree
- ◯ Master's Degree
- ◯ Doctoral Degree
- ◯ Other: _____

4. Occupation *

- ◯ Student
- ◯ Employee
- ◯ Business Owner
- ◯ Government Official
- ◯ Unemployed
- ◯ Retired
- ◯ Other: _____

5. Monthly Income *

- ◯ Less than 15,000 Baht per month
- ◯ 15,000-20,000 Baht per month
- ◯ 25,000-40,000 Baht per month
- ◯ 40,000-60,000 Baht per month
- ◯ 60,000-80,000 Baht per month
- ◯ 80,000-100,000 Baht per month
- ◯ More than 100,000 Baht per month
- ◯ Other: _____

6. Experience Using Virtual Reality *

- ◯ No experience prior to the exhibition
- ◯ Have played VR in the past
- ◯ Utilize VR for work

7. Satisfactory Level with "Silent Roar: The Last of Us" Virtual Reality *

	1	2	3	4	5	
Very Dissatisfied	○	○	○	○	○	Very Satisfied

8. Satisfactory Level with "Silent Roar: The Last of Us" Physical Bronze Sculpture *

	1	2	3	4	5	
Very Dissatisfied	○	○	○	○	○	Very Satisfied

9. Pricing Suitability of "Silent Roar: The Last of Us" Virtual Reality *

	1	2	3	4	5	
Very Suitable	○	○	○	○	○	Very Unsuitable

10. Pricing Suitability of "Silent Roar: The Last of Us" Physical Bronze Sculpture *

	1	2	3	4	5	
Very Suitable	○	○	○	○	○	Very Unsuitable

11. Other Suggestions

Your answer

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INTERNATIONAL CONFERENCE ON INNOVATIVE DIGITAL (ICID2019)
Bangkok, Thailand

2019 Virtual Reality Sculpting– the Quintessential Sculpting Medium of the Digital Era.
THE 7TH BURAPHA UNIVERSITY INTERNATIONAL CONFERENCE ON INTERDISCIPLINARY RESEARCH
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