Re-Creating Judith Beheading Holofernes, Originally Painted by Artemisia Gentileschi, in a Real-Time Rendering System

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RE-CREATING Judith Beheading Holofernes, ORIGINALLY PAINTED BY ARTEMISIA GENTILESCHI, IN A REAL-TIME RENDERING SYSTEM

A Thesis
Presented to
the Graduate School of
Clemson University

In Partial Fulfillment
of the Requirements for the Degree
Master of Fine Arts
Digital Production Arts

by
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May 2021

Accepted by:
Dr. Eric Patterson, Committee Chair
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Abstract

Artemisia Gentileschi is one of the most renowned female artists of her time, best known for her Baroque style paintings of religious narratives. *Judith Beheading Holofernes*, originally painted by Gentileschi in 1620-21, now hangs permanently in the Uffizi Gallery of Florence, Italy, the birthplace of the Renaissance. Many Renaissance artists, such as Leonardo da Vinci and Michelangelo, were dedicated to the arts and sciences. For the first time, artists used scientific techniques to replicate real life accurately, including knowledge of linear perspective and human anatomy. As pointed out in the Hockney-Falco thesis, artists used new inventions like the camera-obscura to achieve this realistic replication of perspective. In a continuation of the Renaissance period, the Baroque era utilized these new discoveries to push new boundaries. In addition to accurate human anatomy and perspective, the Baroque style utilized incredibly dynamic posing and dramatic lighting to articulate highly emotional religious narratives. Artemisia Gentileschi’s works were examples of this technique. An avid follower of Caravaggio, she employed tenebrism and dynamic posing to create some of the most famous pieces of the Baroque period.

Through the re-creation of *Judith Beheading Holofernes* in a real-time rendering system, this thesis explores the impact of these Renaissance-era techniques on present day digital art. Much like early 17th-century European artists, this project utilizes new technological advancements to attempt a hyper-realistic replication of Judith’s biblical narrative. These advancements include techniques for virtual humans such as the *Meet Mike* project and the usage of 3D scanned geometry and textures. Together these modern tools create a different type of artwork that not only challenges the way in which we engage with the visual arts, but also evokes a powerful emotional response from this religious narrative.
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Chapter 1

Artist’s Statement

Figure 1.1: ‘Judith Beheading Holofernes’, Artemisia Gentileschi, 1620
My personal work is inspired by Artemisia Gentileschi, and so it is important to first understand her personal story and its impact on her work. Artemisia is easily the most famous female artist of her time. In a world full of male artists, how did she make her work stand out? The answer is her own personal attachment to the subject of her work. After enduring a rape and subsequent public trial, Gentileschi’s reputation as a woman and an artist were tarnished. Even so, Gentileschi defied the standards traditionally set for female artists in her time period. Best known for her portraits of strong female biblical figures, featuring the likes of Judith, Lucretia, Susanna and many more, Artemisia provided a visual understanding of her own personal narrative. In the last thirty years, Artemisia’s impact has been highlighted by feminist leaders. For female artists such as myself, seeing such strong female figures in classical artwork is an inspiration.

The Renaissance period, meaning re-birth in French, was a time in Eastern Europe dedicated to academia. Starting with the Humanist movement, the Renaissance birthed a multitude of artists dedicated to blending the arts and the sciences. As pointed out by David Hockney and Charles Falco, these Renaissance artists even utilized optical instruments to perfect the perspective in their paintings. With the usage of optical devices, artists were able to paint accurate folds in fabrics and even draw curved objects in linear perspective. In the Baroque era, artists such as Caravaggio and Gentileschi utilized these technological advancements in their work. Known for dynamic posing and contrasted lighting, Baroque artists used high levels of drama to articulate religious narratives in their work.

The Book of Judith was a common biblical narrative in Renaissance and Baroque artwork. Artists such as Giorgione, Caravaggio, and Donatello utilized Judith’s narrative in their work. Artemisia Gentileschi painted this narrative multiple times; her most rendition from 1620-21 (figure 1.1) now hangs in the Uffizi Gallery. Known for its grotesque level of realism, the painting portrays Judith and her maidservant as strong heroines, beheading Holofernes for the sake of the Israelite people. Gentileschi was known to portray many of her female heroines in her own likeness; however, art historians have also pointed out the resemblance of Holofernes in this painting to her rapist. Considering both women in the painting look like Artemisia, it is fair to consider this piece a way of Artemisia regaining control over her own narrative.

In order to effectively translate Artemisia’s painting into a digital, three-dimensional format, I utilized a number of programs, including ZBrush, Mari, Substance, Maya and Unreal Engine for a real-time-rendering platform. The major reference for this project was the Meet Mike project, Epic
Games’ hyper-realistic digital re-creation of Mike Seymour in a Real-Time-Render VR space [10]. Originally presented at SIGGRAPH in 2017, Epic Games released the Meet Mike project as a free downloadable for Unreal Engine 4. Using this project as a reference, I utilized Epic’s technological advancements in digital humans research to create hyper-realistic humans in this project.

Through the re-creation of Artemisia’s “Judith Beheading Holofernes” (figure 1.1), I explored the various ways present-day technological advancements in computer graphics challenge the ways in which we interact with the visual arts. By integrating Judith’s story, as told by Gentileschi, into Unreal Engine, I discovered new ways to interact with this incredibly expressive work of art. Two main levels exist in the project’s final build. The first level allows the user to view the piece as if it is the real-life painting hanging in the Uffizi Gallery in Florence. In the final level, the user is able to move around the piece, as if he is present in the act of Holofernes’ assassination.
Chapter 2

Background Material

Figure 2.1: ‘Self Portrait as Saint Catherine of Alexandria’, Artemisia Gentileschi, about 1615–17
2.1 Artemisia Gentileschi

2.1.1 Who is Artemisia?

Artemisia Gentileschi, arguably the most renowned female artist of her time, is a 17th century painter from Rome, Italy. Born on July 8th of 1593, Gentileschi is the daughter of Orazio Gentileschi, an Italian painter of the Baroque period [51]. Artemisia is named after “Artemis”, Greek Queen of Caria. In Greek mythology, Queen Artemis is described as “a strong woman full of intrigue” and “was ahead of her time, in a man’s world, as was Artemisia Gentileschi” [38].

![Image of Artemisia Gentileschi's painting](image-url)

Figure 2.2: ‘Susanna and the Elders’, Artemisia Gentileschi, 1610-11

Artemisia lost her mother Prudentia Gentileschi in 1605, when she was only twelve years old, leaving her with three younger brothers [36]. During the early 17th century, it was customary for the father to pass his family’s craft to his offspring. Even though most individuals did not teach their daughters, Orazio decided to continue this tradition with all four of his children, including Artemisia [36]. She turned out to be highly gifted in the arts, helping in Orazio’s studio, and by her teens she even helped him with commissions. It is believed that at this age she even produced and sold her own work. In the early 17th century, female painters were not encouraged to attend a formal education and most, similarly to Artemisia, honed their craft at home. When Artemisia was
seventeen, she painted her first notable piece, "Susanna and the Elders." The piece (figure 2.2) was so advanced in technical skill that it was originally considered one of her father’s pieces. However, at a later date her signature was found in a shadowed portion of the painting, leaving no room for further speculation [38].

![Figure 2.3: ‘The Lute Player’, Orazio Gentileschi, 1612/20](image)

It is believed that Artemisia’s father was a friend and colleague of Caravaggio, one of the most influential artists of the Baroque era. As seen in “The Lute Player” (figure 3.3), Orazio was inspired by Caravaggio’s signature artistic styles, *tenebrism* and *chiaroscuro*. As defined in Encyclopedia Britannica, in *tenebrist* paintings, “the figures are often portrayed against a background of intense darkness, but the figures themselves are illuminated by a bright, searching light that sets off their three-dimensional forms by a harsh but exquisitely controlled chiaroscuro” [58]. As later pointed out by art historians, this piece in particular is likely inspired by Caravaggio’s iconic painting, “Lute Player” (figure 2.3) [59]. By the time Artemisia was 13, Caravaggio was forced to flee Rome due to a murder trial [60]. As a result of his friendship with her father, as well as Caravaggio’s impact on the Baroque period, Artemisia’s work is very clearly influenced by Caravaggio. Her work exemplifies many of his trademark styles, much like her father’s work [58] [57]. Furthermore,
Artemisia is notably the only known female follower of Caravaggio [50].

During this time, Artemisia had reached an appropriate age for marriage. Paola Tinagli, a Lecturer in the History of Art and Design in the Department of Humanities at Edinburgh College of Art, points out the importance of marriage in this period, stating “obedience was the main requirement of the ideal fifteenth-century woman, first towards her parents, then towards her husband. Young women were considered by society to be pliable and inherently weak, hence they needed constant moral guidance” [67]. Considering Orazio never re-married, he was met with the reality that his daughter no longer had a motherly figure in her life. Orazio arranged with Tuzia, his married female neighbor, to become a female role model in her life. Tuzia became a companion and chaperon for Artemisia as she began meeting potential suitors. In addition, Rome’s artists were incredibly sociable with one another and, as a result, Gentileschi met many different future colleagues during this time [36]. One of these colleagues is Agostino Tassi, a fellow Italian artist, whom Orazio hired to act as a teacher for Artemisia, considering by this time in her training she had surpassed her father’s skills [36]. In 1612 Tassi took advantage of this situation and raped Gentileschi [50].

In the early 17th century, Rome was a richly animated and rather violent city. The Gentileschi family resided in the ‘rione’ of Campo Marzio, whose members were incredibly diverse in social rank, occupation and nationality [36]. As a result of papal regulation, this neighborhood also housed a large population of Rome’s prostitutes, bringing in “attracted restless young men in search of company, sex, or a good brawl” [36]. In order for a young woman to remain poised for marriage in 17th century Europe, it was imperative that her innocence and virginity stay in-tact. However, in the city of Rome, these moral and social codes of conduct were far more lenient. What remained important, however, was the necessity of a dowry and eligible male suitor. With regards to sexual impurities, it was most ideal that the bride be virgin. However, “when, with or without the woman’s consent, premarital [sex] did happen, the loss could sometimes be made good, if promises of marriage, even words blurted in private, accompanied sex, many understood it as a part of courtship” [36]. Tassi initially promised marriage, leading to a sexual relationship between the two for multiple months. However, Tassi inevitably backed out of the relationship and, after finding out, Orazio launched a prosecution against Tassi and Tuzia for conspiring with one another to deflower his daughter, along with Cosimo Quorli, an officer in the papal household [36].

The trial started nine months after the initial incident and involved multiple witnesses. In Roman trials, it was customary for the accused, the victim, and witnesses to be questioned both
in public and private. If all parties have varying or conflicting testimonies, which occurred during Artemisia’s trial, “the magistrates sorted out conflicting testimonies by face-to-face confrontations between the accused and witnesses or by judicial torture” [36]. Due to Gentileschi’s sexually promiscuous actions, her word was not certifiable; for this reason, she was tortured with thumbscrews, forced to confront Tassi in the formal trial setting, have a gynecological examination to prove she was a virgin prior to Tassi and endure solitary interrogation in order to prove the truthfulness of her testimony [36]. Even though her father initially charged Tassi, Tuzia and Quorli, the court only legitimized his testament against Tassi. The trial lasted seven months and left a permanent negative stain on Gentileschi’s reputation. For the rest of her life, Gentileschi was labelled as a promiscuous woman [60].

After the trial finally ended, she was set up to marry Pierantonio Stiattesi, a fellow artist, and the pair moved to his hometown of Florence. While in Florence, she was given support from the Medici family, Cosimo II, Duke of Tuscany. In 1616, she also became the first female artist admitted into the Florentine Academy of Fine Arts [50]. During this time she was highly esteemed, amongst both the royal family and elite scholars. One of her more famous friendships was with Galileo, an esteemed astronomer, philosopher and physicist [50]. Her time in the academy allowed Artemisia a rare opportunity to exercise independence; for instance, the ability to sign contracts and purchase art supplies without the signature of a male counterpart [60].

Artemisia and her husband had two daughters, both of whom became painters. However, in 1618 she began a love affair with Francesco Maria di Niccolo Maringhi, a Florentine nobleman [50]. As shown through a series of letters, Gentileschi’s husband was very aware of the situation and even wrote to Francesco, himself. It is believed that the nobleman kept Gentileschi and her husband financially afloat, an issue due in part to her husband’s mishandling of their fortune [50]. As a result of these financial difficulties, along with her affair, the couple eventually parted ways and Artemisia returned to Rome without her husband.

In 1638, Artemisia was brought to the court of King Charles 1 of England. Her father, Orazio, had been the King’s court painter since 1926, being the original artist to bring his Caravaggio-style to England [50]. It has been recorded that her father was still working for the court at this time. The two were able to work together on an allegorical fresco, commissioned by Queen Henrietta Maria for their Greenwich residence [50]. Her father passed in 1639, and it is unknown whether they were able to work together to complete the fresco, or if Artemisia finished the project after he passed
on. Little is known about Artemisia’s eventual death; however, it is believed that she died of the plague while in Naples, in 1656 [50].

2.1.2 What is Her Work’s Impact?

Within the past 20-30 years, Artemisia Gentileschi’s legacy has resurfaced amongst modern feminists. Professionally active from the years 1610-1639, Artemisia Gentileschi curated an impressive portfolio throughout the Baroque period [61]. Mostly known for her usage of dramatic lighting and dynamic posing, Artemisia was originally showcased as the only female follower of Caravaggio. Now seen in a modern light, Gentileschi’s art has been rediscovered and is now seen as work “created by a skillful and independent female artist,” highlighting strong female characters and feminist themes [36]. Most female artists in this period were restricted to portraits of court ladies and still life paintings [44]. However, Artemisia defied these standards by exclusively painting strong females from biblical and historical tales, a feat typically completed by male artists [44]. Gentileschi’s female heroines include Susanna, Judith, Cleopatra, Lucretia and Esther, just to name a few [15]. While alive and working, Artemisia’s reputation was overshadowed by negative judgements of her personal life; however, in recent years she is hailed for her work and branded as a feminist icon.

As previously mentioned (figure 2.2), Artemisia’s first professional piece was “Susanna and the Elders,” completed in 1610 when she was only 17 years of age [61]. The painting is based on a deuterocanonical addition to the book of Daniel [69]. The narrative follows a young woman, Susanna, who is spied on by two male elders while she is bathing. The men have conspired to manipulate her into having sexual relations, threatening her with blackmail if she denies their request. After her refusal, the men publicly accuse her of adultery with a different young man, a crime punishable by death. After crying out to God for help, Susanna is miraculously saved [69]. Artemisia’s decision to recreate this biblical narrative was not out of the ordinary; in fact, this tale has been recreated by a multitude of artists from this period, even highlighted in early Roman catacomb art [69]. However, in drastic comparison to these paintings, Artemisia’s rendition of the painting makes the viewer much more sympathetic to Susanna’s position in the story. In prior renditions of the story, Susanna is turned away from her predators, seemingly unaware in innocent bliss. However, Gentileschi shows Susanna staring directly at her menacing stalkers, cowering away in fear and lifting a dainty arm in self-protection. This image brings discomfort to its viewers, unable to help the distraught woman in need. As a result, “Susanna and the Elders” brings “psychological realism” to the story and, as
described by feminist art historian Mary Garrard, “the expressive core of Gentileschi’s painting is
the heroine’s plight, not the villains’ anticipated pleasure” [61].

Figure 2.4: ‘Lucretia’, Artemisia Gentileschi, 1623-25

During the years 1623-25, midway through her career, Artemisia created the painting “Lucretia” (figure 2.4). Artemisia re-interpreted Lucretia’s story multiple times throughout her career, and her most renowned version was completed in 1623-25 (figure 2.4). The story of Lucretia is a legendary tale from Ancient Rome, following the tragic life of Lucretia, wife of the nobleman Lucius Tarquinius Collatinus [56]. The story is first found in the writings of Fabius Pictor, the earliest Roman historian, whose recordings of Lucretia dates back to 3rd century BCE [56]. Even though Lucretia is married to a nobleman, she is raped by Sextus Tarquinius, son of the King of the Etruscan king of Rome. Following this act, she subsequently takes her own life. As a way of vengeance, an attack was led against the Tarquins, driving them out of Rome. This event is dated back to 509 BCE and is known as the establishment of the Roman Republic [56]. Considering Artemisia, herself, was a victim of rape, her decision to paint Lucretia’s experience is understandable. Much like her other work, “Lucretia” (figure 3.4) exemplifies Artemisia’s usage of tenebrism and expressive posing. Lucretia’s face turns towards the heavens, seemingly in question of her inevitable decision to take her own life. Her facial expression displays severe anguish and determination, invoking sympathy from the painting’s audience [15]. In 1630, Gentileschi revisited the subject matter and created two more versions of “Lucretia.” It is evident that Artemisia felt deep empathy for Lucretia, considering
her own personal connection to the subject matter.

Figure 2.5: ‘Lucretia’, Artemisia Gentileschi, 1630

Figure 2.6: ‘Lucretia’, Artemisia Gentileschi, 1630-35

Keith Christiansen, curator at The MET, stated “it is from the act of self-identification that the painting derives its dramatic intensity: a psychologically neutral exemplum virtutis transformed into a vivid allegory of violation and vindication” [33]. In other words, it is because of Artemisia’s deeply traumatic closeness with Lucretia’s experiences that these three paintings are so emotionally charged. In fact, it is even arguable that Artemisia “modelled the figure of Lucretia on herself” [44]. As seen in ‘Self Portrait as Saint Catherine of Alexandria’ (figure 2.1), Artemisia based many of her paintings’ heroines in her own likeness. Most noticeable in her first two renditions of “Lucretia”
(figures 2.4 and 2.5), Lucretia’s facial features, hair color and body type are very similar to her own. During this period, it was not uncommon for artists to pose for their own paintings. For instance, Caravaggio famously modeled Medusa’s face after his own in his piece “Medusa” (figure 2.7). In doing so, Caravaggio is the only one safe from Medusa’s deadly stare [3]. While Caravaggio’s approach is very tongue-in-cheek, Artemisia’s personal connection to her subject matter indicates something far more serious. The level of anguish in her female heroines facial expressions, namely Lucretia’s, “is almost painfully raw in its emotional treatment of the subject....in part because of its closeness to her own experiences” [44].

![Figure 2.7: ‘Medusa’, Caravaggio, 1597](image)

As a result of Artemisia’s artistically technical proficiency, her representation of various strong-willed female figures and the emotional vulnerability of her work, she “now stands as that rare example of a woman who achieved success in the male-dominated world of seventeenth-century Italian painting” [44]. In doing so, she is seen in recent years as a feminist figurehead in the art community. Further described by Paola Tinagli, Lecturer in the History of Art and Design in the Department of Humanities at the Edinburgh College of Art, “[i]n the fifteenth and sixteenth centuries, a woman artist was a rare phenomenon indeed. Any discussion of the paintings or of the sculptures produced by a woman could not be separated from the sense of wonder at the special talent she possessed, which singled her out from the rest of women” [67]. This narrative has continued into recent decades, hailing Artemisia’s accomplishments first as a woman and second as a painter.
2.2 Renaissance and Baroque Eras

2.2.1 Renaissance Era

Following the “Dark Ages” of Europe, a period of time stricken with war, pandemics (i.e. Black Death) and famine, new waves of thinking started to spread throughout the continent [5]. The first of these waves is known as *Humanism*, a period dedicated to embracing “human achievements in education, classical arts, literature and science” [5]. Originating in Italy during the 13th and 14th centuries, *Renaissance Humanism* is considered the reasoning for this sense of “rebirth” throughout Europe. Professors of these studies were known as *umanisti*, whose name derives from the term *studia humanitatis*, “a course of Classical studies that, in the early 15th century, consisted of grammar, poetry, rhetoric, history, and moral philosophy” [54]. This course of studies is based on the original philosophies of Marcus Tullius Cicero, a Roman writer, scholar and statesmen [53]. Cicero’s original teachings on *humanitas*; defined as the “development of human virtue, in all its forms, to its fullest extent,” *humanitas* worked as the foundation for the humanist movement, which eventually led into the Renaissance period. Thanks to the humanist’s belief that formal education stimulates useful citizens, the Renaissance period blossomed into a celebration of the arts and sciences [32]. According to Jessica Stewart, an art historian and curator, Raphael’s masterpiece “The School of
The Renaissance, meaning *rebirth* in French, started in Italy and then swept throughout Europe between the 14th and 17th centuries [31]. It is a time in history dedicated to science and realism, a time in which artists “were often skilled in both painting and sculpture, and by studying the art of antiquity and adding their theoretical knowledge of mathematical perspective and new painting techniques, they produced truly unique works of art” [31]. Florence, Italy is the birthplace of this revolutionary movement, due in part to the Medici family’s financial support. The Medicis ruled in Florence over sixty years, starting in 1434 with Cosimo de’ Medici, who first gathered wealth through banking and commerce [4]. Cosimo was passionate about the humanities and financially supported a multitude of artists during this period, including Donatello and Ghiberti [4]. As a result of his passion, Florence became a cultural hub throughout the Renaissance period. His grandson, Lorenzo the Magnificent, ruled during the height of Renaissance art history, being a supporter of Botticelli, Leonardo da Vinci and Michelangelo [4]. Continuing until Cosimo II, the Medici family’s ruling over Florence was incredibly prosperous for the field of academia and research. However, after Duke Gian Gastone died in 1737 without a male heir, the Medici’s ruling was passed to Francis of Lorraine [4].

As previously mentioned, a connection between the arts and sciences was formed throughout the Renaissance period. For the first time, artists were following scientific principles (i.e. anatomy, perspective, etc.) to create hyper-realism in their work [5]. This example is most notable in the
works of Leonardo da Vinci, arguably one of the most influential members of the Renaissance period. An artist, engineer and scientist, Leonardo was well known for his dedication to incorporating the sciences into his art. In fact, as described in his notebooks, da Vinci claims that painters must have a strong sense of “mathematical and optical principles,” even more so than sculptors, since a painter is working in a 2D space [55]. He then goes on to emphasize that “the 10 optical functions of the eye (“darkness, light, body and colour, shape and location, distance and closeness, motion and rest”) are all essential components of painting” [55]. Renaissance perspective is based on the original principles of Filippo Brunelleschi, an Italian architect, and Leon Battista Alberti, author of De Pictura, who wrote about these principles and how to use perspective as an artistic technique [26]. For the first time, artists utilize linear perspective in their work, which is a “mathematical system used to create the illusion of space and distance on a flat surface” [26]. As shown in the Linear perspective for The Adoration of the Magi (figure 2.9), a vanishing point is found along the horizon line and, once found, defines visual rays, which help create a sense of depth within the composition [26].

![Figure 2.10: ‘Madame Jacques-Louis Leblanc’, Jean-Auguste-Dominique Ingres](image)

As documented in Da Vinci’s Codex Atlanticus, a bound notebook containing thousands of pages worth of his writings, inventions and sketches, a device similar to what is later known as the camera obscura was utilized by Renaissance painters to create perfect perspective in their work [66].
This concept is extensively described in the *Hockney-Falco Thesis*, a collection of essays spanning over the past twenty years. Written by David Hockney, a British painter famous for his impact on the pop art era, and Charles Falco, an expert in optics and condensed matter physicist [16]. David Hockney’s initial studies on this topic began in his book, *Secret Knowledge: Rediscovering the Lost Techniques of the Old Masters*, originally published in 2001. According to David Hockney, paintings created as early as c1430 used early models of the camera obscura to create realistic perspective in their paintings. Hockney first claimed this evidence after inspecting the 19th century portraits of Jean-Auguste-Dominique Ingres [40]. In *Secret Knowledge*, Hockney describes his first response to Ingres’ portraits in January of 1999 at the National Gallery in London. Initially impressed by the “uncannily 'accurate'” quality of Ingres’ gestural strokes, Hockney mentions the relatively quick speed of their completion, stating that many of the portraits were completed in under a day [41]. He concluded that Ingres must have received aid from a camera lucida, “an instrument made in 1806 for artists, mainly as a measuring device for drawing” [41]. Continuing onto Ingres’ collection of portrait paintings, Hockney immediately noticed the pinpoint accuracy of fabric folds, shown in figure 2.10. According to Hockney, “[t]he fabric draped over Madame Leblanc’s chair could not, [Hockney] believes, have been done without some optical help” [41].

This initial hypothesis spearheaded Hockney’s further investigation into a number of early Renaissance paintings. He quickly realized a distinct accuracy in the quality of fabric folds. For instance, as shown in Jean-Auguste-Dominique Ingres’ painting *Madame Jacque-Louis Leblanc*, the
pattern of the blanket draped over the chair perfectly follows the folds. This detail is almost impossible to free hand draw. As pointed out by Hockney, how could this ‘...advance’ in naturalism have happened? Better drawing skills cannot be the answer” [41]. In other paintings, it is not just the folds that have hyper-realistic accuracy. In Caravaggio’s painting *The Lute Player* (figure 2.12), the lute has perfect linear perspective. It incredibly difficult to replicate curved objects without the help of an optical device. Albrecht Durer’s woodcut *The Draughtsman of the Lute* (figure 2.11) highlights an early version of such optical aids. However, this early device was incredibly difficult to manage and required two users [41]. For this reason, it is very possible that Durer’s techniques were already obsolete by the time of Caravaggio.

![Figure 2.12: ‘The Lute Player’, Caravaggio, 1595](image)

In early 2000, Charles Falco joined Hockney in his optical research. Falco, an expert in optical physics, casually stated that “a concave mirror has all the optical qualities of a lens and can project images onto a flat surface” [41]. It was in this moment that Hockney realized the type of optical instrument likely used in Renaissance art. To test this theory, Hockney created a makeshift ‘mirror-lens’ (as he calls it) by blacking out a room, covering the doorway with cardboard, cutting a rectangular window in the board and then placing a concave mirror opposite the window. As shown in figure 2.13, Hockney’s subject matter sat outside of the room. By angling the mirror towards his drawing material, Hockney could clearly see his subject-matter’s reflection on the paper. The only issue with mirror-lens projection is that the image projected is always a foot (30 centimeters) wide, no matter how large the lens is [41]. If the length is more than a foot, the image is no longer in
perfect focus, significantly restricting accuracy of the drawing. To remedy this issue, artists collage
together a grouping of drawings, all taken with this mirror-lens projection technique. By the 16th
century, conventional lens became far more advanced in technology, enabling artists to work with
a wider field of view. With this in mind, Caravaggio’s life-like usage of linear perspective in *The
Lute Player* is clearly influenced by the usage of optical help. Even if these optical devices were not
used in all artwork of the period, the initial techniques and understanding of Caravaggio’s mirrors
became a standard quality throughout the Europe, influencing other artists to take note.

Figure 2.13: David Hockney’s Mirror-Lens Projection

In addition to linear perspective, human anatomy was a very important knowledge for
Renaissance painters. In an effort to better understand anatomical structure, Leonardo da Vinci
collaborated with Marcantonio della Torre, an Italian physician-anatomist, who allowed him to
dissect up to thirty different corpses at hospitals in Florence, Rome and Pavia [55]. Through this
experience, Leonardo significantly advanced his interpretation the muscular structure of the human
body, known to Leonardo as the *figura istrumentale dell’ omo*, or the “man’s instrumental figure”
[55]. In addition to Leonardo, a multitude of other Renaissance artists followed pursuit in his
Pollaiuolo, a Renaissance sculptor, painter and printmaker, was the “first master to skin many human
bodies in order to investigate the muscles and understand the nude in a more modern way” [27].
Through the combination of optical science and formal education of human anatomy, 16th century
artists brought hyper-realism to Renaissance art that had never been seen before. Per example, Caravaggio’s *The Crowning with Thorns* (figure 2.14) has excellent examples of anatomical realism. For the first time, paintings were exact recreations of real life. In a time before the invention of photography, this was a major breakthrough in art history.

### 2.2.2 Baroque Era

![Figure 2.14: ‘The Crowning with Thorns’, Caravaggio, 1602-04](image)

Leading into the 16th century, the Catholic Church reigned supreme over Europe. However, its power was compromised when a German monk posted 95 theses to the entrance of Wittenburg Cathedral in 1517 [29]. Martin Luther challenged every negative aspect of the Catholic Church, calling Rome the “‘whore of Babylon’ decked out in finery of expensive art, grand architecture, and sumptuous banquets” [29]. As a result, the Catholic Church found itself in a Reformation period, during which members of the church split into two groups: those who remained faithful to the pope and those who disagreed with the church’s structure [1]. Throughout the remainder of the 16th century, the Catholic Church rid itself of its lavish and overindulgence of the papacy, dedicating itself to austerity and piety [1]. Following the Reformation period, the Catholic Church rededicated itself to “[s]hepherding the faithful— instructing them on Catholic doctrines and inspiring virtuous behavior” [29].

In light of this revelation, the Church underwent severe reconstruction to its infrastructure,
redirecting its focus on the arts. In the beginning of the 16th century, religious artwork and iconography were seen in a negative light. However, following the Protestant Reformation, the church realized the importance of religious art. The Church saw the visual arts as a way to “guide the faithful,” considering its accessibility to the public eye, both with education and without [1]. In order to properly articulate these narratives, religious art had to be incredibly clear, direct and inspire its viewers. The art “had to move the faithful to feel the reality of Christ’s sacrifice, the suffering of the martyrs, the visions of the saints” [1]. The Church re-dedicated itself to “its ancient origins, its beliefs, and its divinely-sanctioned authority” [29]. For this reason, artists began experimenting with more intense and captivating visuals.

![Image](image.png)

**Figure 2.15: 'The Anatomy Lesson of Dr. Nicolaes Tulp', Rembrandt, 1632**

Paintings from the Baroque era upheld the realistic style of the Renaissance era, utilizing its major principles such as proper anatomical proportions and usage of perspective. As shown in fig. 2.14, artists in the Baroque era, such as Caravaggio, adopted a very specific visual style. During the baroque period, artists worked to produce an “ornate, over-the-top aesthetic that evokes ethereality and aims to inspire awe” [63]. The most well-accomplished Baroque artists consist of Caravaggio, Rembrandt and Rubens, whose work best exemplify this visual style. For instance, as shown in Rembrandt’s *The Anatomy Lesson of Dr. Nicolaes Tulp* (figure 2.15), the lighting’s intensity and posing of the figures creates high levels of drama. The drama in Baroque painting stems from the usage of tenebrism, dynamic posing and depiction of religious themes [52]. Tenebrism
is defined as the usage of “extreme contrasts of light and dark in figurative compositions to heighten their dramatic effect” [58]. As shown in Caravaggio’s piece (figure 3.12), *The Crowning with Thorns*, his usage of tenebrism drastically heightens the dramatic quality of the overall composition. The lighting’s placement leads the viewer’s eye directly to Jesus, the clear focal point of the piece. In addition, the figures are seemingly in motion, another notable quality of baroque artwork.

### 2.3 Judith and Holofernes

#### 2.3.1 The Book of Judith

*The Book of Judith*, a deuterocanonical book of the bible, is the story of a Jewish heroine, whose actions save her city from Nebuchadnezzar’s army. Written in either Palestine or Alexandria during the Hellenistic period in the years of 135-78c, the book’s author is unknown. Now commonly retold during Hanukkah, Judith’s tale encompasses “the charter myth of Judaism itself – cultural survival through the commitment to the preservation of the Mosaic Law, with the help of God” [28]. Historians state that Judith’s narrative holds significance in a number of areas, including cultural, political and theological contexts [28]. For this reason, playwrights, sculptors, painters and poets have retold Judith’s tale over the past 2,000 years. As pointed out by Kevin R. Brine, author of *The Judith Project*, “the beheading of Holofernes was an act of war and [the author] uses the celebratory scene of the presentation of the head to establish Judith as a military heroine” [28]. The most climactic point of the story, when Judith severs the head of Holofernes, is most popularly recreated by visual artists. However, in order to fully understand the impact of Judith’s story, it is imperative to study the entire narrative.

The Book of Judith starts with a chronological history of King Nebuchadnezzar’s reign. At the beginning of chapter one, Nebuchadnezzar rules over his land from the city of Nineve [68]. Nebuchadnezzar sends messengers to everyone in Persia and its surrounding cities to the west, asking members to join his efforts in overthrowing King Arphaxad, ruler of Ecbatane. However, the members of these communities refused his offer. Nebuchadnezzar became furious, stating that he will eventually tear their cities apart. After overthrowing King Arphaxad, Nebuchadnezzar calls upon his chief captain, Holofernes, stating “I will go forth in my wrath against them and will cover the whole face of the earth with the feet of mine army, and I will give them for a spoil unto them” [68]. Holofernes obeyed his King’s orders, taking his army through a multitude of cities along the
coastline. Upon the king’s request, they slaughtered anyone in their path, trashed the city streets and even desecrated all the temples. The children of Israel, currently living in Judea, heard of Holofernes’ efforts and feared potential destruction of the temple in Jerusalem. In an attempt to protect their cities, the people fortified their villages on the high hilltops and secured the mountain passes [68]. The Israelite’s began to fast and cry out to God for his protection against Holofernes.

Holofernes heard about the people of Israel preparing for war and was furious. In a fury, Holofernes gathered together a meeting with his committee and demanded further information about this group of people. Achion, leader of the Ammonites, proceeded to warn Holofernes about the children of Israel, stating that they have a powerful God on their side. He went into great detail about God leading his people out of captivity in Egypt and suggested that Holofernes avoid their cities. However, Holofernes is disgusted by Achion’s statements, stating that the only god is King Nebuchadnezzar. Holofernes banished Achion from his camp and proceeded to march his army towards the Israelites. The Assyrian army surrounded the Israelites’ camps for 34 days, depleting their people of water and supplies [68]. The people of Israel complained to their leaders, saying they should just submit to Holofernes. Ussiah, an Israelite leader, declared to his people that they must wait five more days. If God does not save them in that time, they will surrender to the Assyrian army.

Judith, a beautiful widow and Israelite, hears her people’s cries for help and decides to take action. She is greatly disappointed in the actions of the city’s elders, believing that their decision to give God a time limit to save them is incredibly disrespectful. She sends her maidservant to call for the ancients of the city. The three elders, Ozias, Chabris and Charmis, meet with her at once. The elders suggest that Judith, because she was such a devout servant of God, pray for a solution. Judith leaves the elders, puts ashes upon her head and covers herself in sackcloth to beg the Lord for an answer. Once her pray was complete, Judith cleaned herself, put on her finest clothes, brought along her maidservant with a bottle of wine and left the city gates. Judith and her maidservant travel up the mountain to Holofernes’ camp and denounce the Israelites to the guards. In awe of her beauty, the soldiers lead Judith straight to Holofernes. Holofernes allows Judith to stay in the camp, giving her a tent of her own. On the fourth evening, Holofernes called for Judith to enter his tent and share a meal. Holofernes proceeded to drink more wine than intended and passed out on his bed. Judith immediately grabbed his sword and, without any hesitation, severed his head.

Judith and her maidservant placed his head in a bag and escaped the camp. Once they
arrived at the city’s gates, the guards called upon the elders, who came at once. Judith said to the men “Praise, praise God, praise God, I say, for he hath not taken away his mercy from the house of Israel, but hath destroyed our enemies by mine hands this night” and lifted Holofernes’ head from the bag, in everyone’s disbelief [68]. At sunrise, the Israelites hung Holofernes’ head on the wall and gathered their troops. Seeing the Israelite army in the distance, the Assyrians went to Holofernes’ tent. In their astonishment, “one woman of the Hebrews hath brought shame upon the house of king Nabuchodonosor: for, behold, Holofernes lieth upon the ground without a head” [68]. The Israelite army proceeded to rush the Assyrian army out of the mountainside. Judith led the Israelites in songs of praise for God, who once again led them to safety.

2.3.2 Judith’s Story Represented Throughout Art History

Throughout art history, a multitude of artists have depicted Judith’s story in their work. As previously mentioned, the most popular plot points to visualize are the moments right before, during and directly after the beheading of Holofernes. As seen in Donatello’s bronze sculpture, “Judith and Holofernes” (figure 2.16), Judith stands over Holofernes with the sword above her
head in preparation. Giorgione’s rendition, “Judith” (figure 2.17), features Judith directly after beheading Holofernes. Her left foot resting on top of his head, Judith looks down at her victim in the aftermath of her heroics. Both pieces are from the early Italian Renaissance, focusing more so on the quality of the figure’s anatomy than the dynamism of the posing. The lack of facial expressions, from either Judith or Holofernes, results in a lack of emotion or passion. As a result, the true heroics of Judith’s actions are not properly displayed. In stark contrast to these versions, Caravaggio’s famous depiction, “Judith Beheading Holofernes” (figure 2.18), is much more dynamic and emotional. In this Baroque-era piece, Caravaggio paints the most dramatic moment in Judith’s story: the beheading of Holofernes. Caravaggio’s Holofernes contorts in pure agony, looking up at his capture in surprise. As a result of his pose, the painting’s viewers understand the level of anguish Judith’s actions impose upon her captor. Furthermore, Caravaggio’s masterful usage of tenebrism severely heightens the quality of drama throughout the piece’s composition.

Figure 2.17: ‘Judith’, Giorgione, 1504
Following the Renaissance and Baroque eras, a resurgence of Judith’s story began in the 19th and 20th centuries. For instance, in the early 20th century Gustav Klimt created his own renditions of Judith’s tale, titled “Judith and the Head of Holofernes” (figure 2.19) and “Judith II (Salome).” Depicting the moments directly after the beheading, Judith carries Holofernes’ head out of the tent. Gustav Klimt was an Austrian Symbolist painter, best known for his paintings of the female body, often laced with erotic undertones [6]. Both paintings created during his “golden phase,” Klimt portrays Judith in a very ornate setting, utilizing gold leaf as a main material. Judith’s sultry stare pierces the viewer, as she stands carrying Holofernes’ head in the bottom right corner. Judith is clearly the main feature in the composition, as Holofernes’ head is halfway off the canvas. She is seemingly in a moment of ecstasy following the beheading of Holofernes. On the other hand, Franz von Stuck’s “Judith and Holofernes” (figure 2.20) is reminiscent of the early Italian Renaissance. A German painter and sculptor, Franz von Stuck is best known for his work during the Symbolist period [2]. In this piece, Stuck portrays a naked Judith preparing to swing a sword downward onto a passed out Holofernes. Judith’s placement on the left third of the composition accentuates her as the focal point of the piece. Much like Donatello’s piece (figure 2.16), Judith’s posing is not overtly dynamic. Even so, it is still possible to articulate what action she is about to perform. Holofernes’ body hides in the shadows of the composition’s right third. In doing so, Stuck solidifies Holofernes
as a secondary character in this narrative.

Figure 2.19: ‘Judith and the Head of Holofernes’, Gustav Klimt, 1901

Kehinde Wiley is a New York-based contemporary artist, best known for his self-titled “urban-meets-classical” style [8]. His body of work consists of African American portraiture based on the classical Western European style. Wiley’s “Judith and Holofernes” (figure 2.21) is a continuation of his series on female portraiture. Wiley states that this “series of works attempts to reconcile the presence of black female stereotypes that surrounds their presence and/or absence in art history, and the notions of beauty, spectacle, and the ‘grand’ in painting” [8]. In this updated rendition of Giovanni Baglione’s 1608 Renaissance painting, “Judith and the Head of Holofernes,” Kehinde Wiley portrays Judith as an African American woman. In Wiley’s signature style, the background of the painting is a vivacious floral pattern. This renewed rendition of a classical painting “translates this image of a courageous and powerful woman into a contemporary version that resonates with fury and anger” [8].
2.3.3 Artemisia Gentileschi’s Version

Artemisia Gentileschi created multiple renditions of the Book of Judith, all completed within the early 17th-century. In 1611-12, Artemisia completed her first painting about Judith, titled
“Judith Slaying Holofernes” (figure 2.22). In comparison to any other renditions of this narrative, Gentileschi’s painting is vividly realistic. The composition consists of two women, Judith and her maidservant, bearing down on Holofernes with all of their strength. While the maidservant holds down his arms, Judith grabs his hair with her left hand while plunging her sword into his neck with the other arm. Similarly to Caravaggio’s version, Holofernes contorts his upper body in pain, contorting his face in complete disbelief. Blood drips down the side of the bed, adding to the level of brutality in the piece. Nearly ten years later, Gentileschi created an improved version of this work, re-titling it “Judith Beheading Holofernes” (figure 2.23). Dr. Esperança Camara, whose research revolves around the Baroque era, considers Gentileschi’s 1620 version “one of the bloodiest and most vivid depictions of the scene, surpassing the version by Caravaggio, arch-realist of Baroque Rome, in its immediacy and shocking realism” [30].

In this version, Gentileschi keeps the posing almost exactly the same as the original; however,
the overall composition is far more sophisticated. To start, in the original painting from 1611, the framing is cropped in around the women’s heads, showing very little background. The lack of a buffer between the figures and the edges of the painting creates a visually awkward composition, centering the image around the gap in Judith’s arms. In the newer version, the the figures are set in the center of the piece, creating a higher sense of drama and grandiose within the composition. More specifically, the composition is centered around Judith’s sword, bringing the viewer’s eye directly to the most climactic point in this narrative. In addition to the composition, Gentileschi significantly improved the anatomical proportions of the figures. In the original painting, the figure’s arms are too long and the heads of Holofernes and the maidservant are too large. Furthermore, in the original painting, Judith’s sword is cocked at an awkward angle, making it very difficult for her to realistically decapitate Holofernes. However, in the 1620 version Gentileschi revitalized this pose, straightening out the blade so that Judith can put all of her strength into the action.

Gentileschi’s drastic improvements in perspective brings up the potential usage of optical
instruments. Similarly to Caravaggio’s “The Crowning with Thorns” (figure 2.14), the figure’s posing is incredibly dynamic; however, the perspective is perfectly realistic. In accordance with “Madame Jacques-Louis Leblanc” (figure 2.10) by Jean-Auguste-Dominique Ingres, the fabric folds, not just in the blankets but also of the dresses, are almost impossible to draw free hand. As previously pointed out in section 2.2, David Hockney and Charles Falco uncover a multitude of Renaissance artists who clearly used optical resources in their work. Caravaggio was one of these many artists, whose usage of optical aids “enabled him to attempt even more complex and naturalistic images” [41]. In his initial thesis on optics, Secret Knowledge, Hockney talks about the process behind Caravaggio’s Judith Beheading Holofernes (figure 2.18). According to Hockney, “on many of his canvases, [Judith Beheading Holofernes] included, there are a number of incised lines made with the wrong end of the brush in wet undercoat....I believe that Caravaggio used this technique to record the positions of his models so they could take a break” [41]. After the break, Caravaggio could then re-project the model’s image onto his canvas and adjust their pose until it matched his guide lines. This process allowed Caravaggio to work in many different stages and likely work with each model on separate days. Considering Artemisia was a major follower of Caravaggio’s work, it only makes sense that she would also study his process.

Figure 2.24: ‘Judith Beheading Holofernes’, Artemisia Gentileschi, 1620-21

The most shockingly grotesque addition to this piece is the blood spurting out of Holofernes’
neck. Shown in greater detail in figure 2.24, Gentileschi paints the blood with tremendous realism; in doing so, she articulates how dramatically violent Judith’s actions are. In order to achieve this level of realism, Artemisia utilized the scientific discoveries of her good friend, Galileo Galilei. In 1638, Galileo “proved that the trajectory of a projectile traveling through a nonresisting medium is a parabola” [37]. In his final research, Galileo states that “the vertical distance the object falls from rest is proportional to the square of the time elapsed and that the projectile's horizontal velocity will remain uniform” [37]. Following Galileo’s research, Artemisia paints the blood spurts in parabolic trajectories, as shown in figure 2.24. In addition to changes in composition and perspective, Gentileschi gives the women much finer jewelry and dress fabrics, matching up with the popular Florentine Renaissance styles. Dressed in velvets and golden damask, “a firm lustrous fabric (as of linen, cotton, silk, or rayon) made with flat patterns in a satin weave on a plain-woven ground on jacquard looms,” Gentileschi gave Judith and Holofernes the attire of someone in elite status during the Italian Renaissance era [7]. Considering Judith was the widow of a rich man and Holofernes the leader of Nebuchadnezzar's army, this matched their descriptions perfectly. Furthermore, Judith’s hair is far more ornately styled than in the original painting, better matching her description in the biblical narrative [30]. These slight changes in detail made a major difference in the overall quality of the piece, elevating Gentileschi to an even higher standard in art history. To this day, her 1620 version of Judith and Holofernes is her most prestigious and well known work.

In order to fully understand the importance of Gentileschi’s painting, it is imperative to recount her personal attachment to Judith’s story. Gentileschi completed her first version in 1611-12, just a few years after her rape trial against Tassi ended. At this point, Artemisia moved to Florence in hopes of refocusing her life on her work. However, by this point, Gentileschi’s reputation had already been tarnished, branding her as a promiscuous woman. According to Elizabeth Cohen, author of The Trials of Artemisia Gentileschi: A Rape as History, “through rape survival, Artemisia is said to have delevoped a feminist consciousness that expresses itself in her paintings, especially in the striking violence of her repeated renderings of “Judith at Holofernes”” [36]. As mentioned in section 2.1.2, Artemisia is well-known for portraying strong female heroines in her work, such as Susanna, Lucretia and Judith. Furthermore, many of these female heroines strongly resemble her own likeness, as seen while comparing her 1623-25 rendition of “Lucretia” (figure 2.4) with her 1615-17 “Self Portrait as Saint Catherine of Alexandria” (figure 2.1). This same resemblance can be seen in Judith and the maidservant; in doing so, Artemisia uses her work as a vehicle for self-expression.
Art historians have even gathered that Holofernes resembles Agostino Tassi, making this painting a way for her to avenge her rapist. According to the trial transcripts, Gentileschi threatened to kill Tassi with a knife after he first took advantage of her; in a way, this painting stands as an autobiography of that moment.

Artemisia Gentileschi’s grotesquely realistic 1620-21 rendition of Judith and Holofernes (figure 2.22) is arguably the most emotionally tumultuous and visually stunning version of Judith’s story in art history. Firstly, the painting’s compelling posing and melodramatic lighting creates an overwhelming sense of despair within the piece. Furthermore, Artemisia’s apparent usage of Hockney and Falco’s optics research provides hyper-realistic perspective throughout the entire composition. This combination of traits is only rivalled by Caravaggio’s “Judith Beheading Holofernes” (figure 2.18), whose expert usage of tenebrism and perspective creates a visually stunning composition. However, in Caravaggio’s version Judith has an incredibly passive pose, making the possibility of her successfully severing his head a seemingly impossible task. On the other hand, Holofernes’ extremely dynamic posing and incredibly passionate facial expression makes him the main focus of the composition. In direct contrast, Gentileschi paints Judith and her maidservant as active participants in the composition. Both women hover over Holofernes in an aggressive stance, holding down his arms and plunging the sword deep into his neck. The overall formation of each figure’s placement creates a triangular shape within the composition, a common occurrence in Renaissance religious paintings. In Caspar Pearson’s review of The Passionate Triangle by Rebecca Zorach, he states that a triangular composition “is particularly well suited to denote hierarchies of various kinds, and as such could become an image of political and ecclesiastical order” [62]. By placing both woman at the top of the triangle, Artemisia puts them in a status of importance and power, a rare occurrence amongst female figures in Renaissance-era art. Gentileschi’s representation of strong women in her paintings is the major inspiration for my own work. As a female artist, Gentileschi’s work provided a unique perspective in early 17th century artwork. Up until this point in art history, it was rare for women to have such an active stance in art. By re-creating “Judith Beheading Holofernes” (figure 2.23) in a Real-Time digital platform, Gentileschi’s feminist voice is re-told in a modern platform.
Chapter 3

Related Work

In the Renaissance and Baroque periods, artists initiated a blend of the arts and sciences. In doing so, the study of linear perspective and human anatomy bred high levels of realism never seen before in the arts. Leading into the Baroque era, artists were able to articulate melodramatic religious stories with realistic posing and anatomical structures. In present day, technological advancements significantly improve the visual quality of computer-generated content. These advancements include Epic Game’s breakthrough in real-time digital human content, featuring the usage of 3D scan textures and geometry. Through the usage of various modern technological advancements, I explored new and innovative ways to interact with the visual arts.

Figure 3.1: ‘Digital Humans: Mike’, Unreal Engine, 2018
3.1 Unreal Engine Digital Humans

In the past six years, Unreal Engine, a gaming engine developed by Epic Games, has made significant advancements in the creation of digital humans. Unreal Engine released its first look at a “Photorealistic Character” in 2015, accessible in highly descriptive online documentation and accompanied by a downloadable version of the project [23]. The character featured UE4’s new shading model, the Subsurface Profile Shading model. An extension of the Subsurface model, the profile model sets itself apart with its rendering technique [25]. Based in screen space, the subsurface profile model focuses on “a more effective to display the subtle subsurface effects seen in human skin,” focusing less on back scattering than most models [25]. The following year, at the 2016 Game Developer’s Conference, Epic Games’s Unreal Engine unveiled its newest advancements in virtual human development: “Crossing the Uncanny Valley in UE4” [18]. With the help of 3Lateral, Cubic Motion, IKinema, and Xsens, Unreal Engine showcased its newest advancements in a live performance. An actress (dressed in a motion capture suit) acted in the role of “Senua,” from Ninja Theory’s “Hellblade: Senua’s Sacrifice.” Her digital double recreated the moment on screen in real time, shocking onlookers with its realistic quality. At the 2017 SIGGRAPH conference, Epic Games gave a preview of its newest technology in real-time digital humans: Meet Mike. As described in Meet Mike: Epic Avatars, “Meet Mike uses the latest techniques in advanced motion capture to drive complex facial rigs to enable detailed interaction in VR. This allows participants to meet, talk in VR and experience new levels of photorealistic interaction” [48]. Since this breakthrough, UE4 has released two continuations of this research: “Digital Humans” (2018) and “Metahumans” (2021). Unreal’s published documentation and UE4 downloadable projects provide incredibly detailed explanations of these advancements, making it possible for users to test out these techniques on their own projects.

3.1.1 “Creating Believable Characters” Seminar

In 2018, Unreal Engine published detailed documentation about the creation of three different Digital Humans: Mike Seymour, Siren and Andy Serkis. All three characters showcased drastic improvements from the 2016 update: a new and improved specular model, light transmission with backscatter, better contact shadowing for the subsurface profile, higher definition normal maps for the eye geometry, and short-distance, dynamic irradiance for screen-space, indirect-bounce approx-
imation [17]. With the help of 3Lateral, 3D scans were utilized to create 4K texture maps for the characters; the maps were later cleaned up by digital artists to remove any unnecessary shadows or blemishes on the scan. A combination of diffuse, roughness, specular, scatter, and normal maps were used in the final skin material. In addition to the usage of 3D scanned textures, 3D scanned geometry was also used. As shown in the figure below, a clean version of the scan is created with new retopology. The scan is then projected onto the new mesh, transferring over the micro details.

The 3D scans were captured with a combination of efforts, all administered by 3Lateral. The actor’s likeness was captured with a multi-camera and sensor setup, along with dental molds and detailed facial scans. Through the process of gathering over 50 different facial scans, the FACS (Facial Animation Coding System) were gathered. For each, a respective normal, diffuse and roughness map is gathered and assigned to its respective section of the skin material. The FACS is an industry standard in virtual humans research. It defines a number of facial movements and expressions for the purpose of analyzing, originally proposed by Ekman and Friesen in 1978 [43]. By using the FACS system, the Unreal team was able to isolate necessary muscle groups and capture their physically accurate textures.

![Figure 3.2: ‘Digital Humans: Andy Retopologized’, Unreal Engine, 2018](image)

3.1.2 Digital Humans: Mike Hair Material

A major breakthrough in this new batch of virtual humans is the quality of the hair. This is due in part to the creation of Groom components in Unreal Engine, a way to import XGen-generated hair as Alembic cache files. Up until this point, hair cards were the only format for hair in real-time rendering programs. For instance, the 2016 version of UE4’s virtual humans featured an older version of the hair card shader and its visual quality is nowhere near that of the Mike
model. As shown in figure 3.5, the hair cards are noticeably creating various chunks of hair, rather
than a grouping of individual strands. In addition to the usage of Groom components, the quality
of the hair material is exponentially higher in quality than previous versions. For example, the hair
shader’s ability to approximate primary and secondary specular highlights. As shown in the figure
below, the hyper-realism of this hair material is due to the quality of its specular approximation.
The system is coded to pick up on each Groom as a translucent piece, much like an actual strand of
hair in the real world. The light in the rendering engine passes through the hair, rather than simply
bounce off of the surface, further mimicking real-world light physics [17]. As shown in figure 3.3, as
the light interacts with each individual Groom component, the hair shader is set up to approximate
three different potential paths for the light.

Figure 3.3: ‘Digital Humans: Hair Specularity Diagram’, Unreal Engine, 2018

Based on the original research by Dr. Stephen R. Marschner and associates in “Light
Scattering from Human Hair Fibers”, Mike’s shading model shows “a multiple specular highlight and
variation in scattering with rotation about the fiber axis” [46]. In its Digital Humans documentation,
Unreal Engine defines these three separate paths: reflection-only, transmission-transmission and
transmission-reflection-transmission [17]. Marschner’s study states that “the primary specular peak
occurs at an angle several degrees away from the specular direction...the angular shift is caused by
the tilt of the scales forming the cuticle of the hair fiber. Second, there is a secondary lobe that occurs
on the other side of the specular direction” [46]. In reflection-only, the light simply bounces off of the
surface of the hair, creating the primary specular highlight. While transmission-transmission occurs,
the light travels through the hair strand and out the other side, mimicking the ways in which light
scatters through an entire volume of hair. Finally, the transmission-reflection transmission combines
the previous two, in which light enters the hair, reflects off of the inside strand and then exits,
creating the secondary specular highlight [17]. This attention to minute detail is what sets the 2018
digital human hair shade apart from previous real-time implementations.
3.1.3 Digital Humans: Mike Eye Material

The final noticeable breakthrough in Unreal Engine’s 2018 showcase is the drastic improvements in the eye material. In fact, the 2018 eye material is so technically robust that the engine advises its users to migrate the material and eye geometry to their new projects, rather than attempt to rebuild it from scratch. As shown in figure 4.6, the eye material is anatomically correct, incorporating all five major sections of the human eye. In accordance to the eye diagram, these sections include the sclera (1), limbus (2), iris (3), pupil (4) and cornea (5) [17].

In previous digital human projects, the eye was comprised of two separate pieces of geometry. One contained the sclera, iris and pupil while the other comprised of the limbus and cornea. This combination creates a realistic imitation of the eye’s overall wetness and accurate light refraction.
However, this tactic is incredibly limiting in overall optimization; for this reason, the 2016 and 2018 digital human projects created an eye material dynamic enough to replicate this phenomena with a single piece of geometry. Furthermore, the 2018 version of the eye material contains an exponentially higher number of artistic parameters. Each set of parameters allows the user to control different parts of the eye, such as the radius of the iris or the level of refraction. As shown in figure 3.7, the material has over 20 different parameters and hyper-realistic textures for the iris and sclera. This level of detail brings significant improvements to the overall realism of the character. It is arguable that the quality of the eye material is the most important part of a virtual character. If the eye does not translate as being realistic enough, it does not matter how high of quality the rest of the character is, the virtual human’s facade is already ruined. For this reason, Unreal Engine’s serious advancements in eye material quality is a major breakthrough in the real-time virtual humans field.

3.1.4 Digital Humans: Mike Skin Material

A major resource in this particular thesis project is the Mike Seymour downloadable Unreal Engine project, Meet Mike, initially offered to the public in 2017. More specifically, the skin material included in this particular project. As briefly mentioned in the previous section, the technological advancements of Unreal Engine’s 2018 digital humans projects were incredibly important in the study of virtual humans. Not only in the quality of the visuals, but also in the optimization of the overall unreal project. For instance, the Meet Mike project incorporated a series of material functions, “little snippets of Material graphs that can be saved in packages and reused across multiple Materials,” [19]. Working similarly to functions in a coding project, these material functions can
be reused throughout various parts of the project. This process makes the overall process far more efficient, allowing the artists to spend more time on the visual quality of the materials, rather than their initial creation. In addition, minor edits can be made to just one material function, rather than fixing every individual material. In addition, these material functions can be migrated and then reused in different projects.

There are five major sections within the Mike skin material: diffuse, roughness, specular, scatter and normal. All utilize the 4K texture maps acquired through 3D scans. In addition to the texture maps, a number of mask maps were also utilized in the skin material, used to isolate the textures to specific parts of the geometry. These masks added another level of control to the technical artist, aiding in the overall realism and visuals of the project. These additional maps include ambient occlusion, RGB masks (ear, nose, mouth, etc.) and tileable maps (i.e. micronormals, microroughness, etc.).

Using the “normal to roughness” technique, roughness maps were procedurally generated through usage of the normal maps. As shown in figure 3.8, the normal map is combined with a black image and is displayed using the green channel. Additional functions were used to create finer details, such as Fresnel edge roughness to mimic villus hair on the face. Artists create these additional masks and maps in a variety of programs, such as Mari, Substance Painter and Adobe Photoshop.

An important factor in the overall efficiency and optimization of the Unreal Engine project is the usage of material instancing. Once a material is “instanced,” it becomes a “parent” material and
an infinite number of different-looking instances, or “children” can then be created [20]. Through this technique, changeable attributes of the material (i.e. texture maps, scalar values, etc.) are saved as material parameters. These parameters can be changed quickly and efficiently in the Material Instance Editor. In a project involving digital humans, material instances are most useful for incredibly complex shaders, such as skin materials. For a skin material, parameters include all geometry-specific maps (i.e. diffuse, roughness, normals, etc.) and scalar parameters (i.e. edge roughness levels, specular intensity, etc.).

### 3.1.5 Digital Humans and the Uncanny Valley

Using these techniques, the *Meet Mike* project’s result is a stunningly realistic virtual human. As seen in figure 3.9, Mike’s hair and skin materials are almost indistinguishable from his real-life photograph, shown in figure 3.10. However, it is still possible to tell the difference between the two, mainly due to the eyes. The eyes are arguably the most challenging obstacle in virtual humans research; considered the window to the soul, even the most technically realistic pair of digital eyes can potentially ruin a virtual human’s mirage. The topic of an “uncanny valley” is frequently
thrown around when referencing digital humans. Introduced in 1970 by Masahiro Mari, a Japanese robotics professor at the Tokyo Institute of Technology, the hypothetical concept of an “uncanny valley” studies the relationship between a human-like object, its likeability to a human being, and the emotional response it evokes from onlooking viewers [49]. According to studies performed by Dr. Maya Mathur and Dr. David Reichling, “human–robot interactions may be complicated by a hypothetical Uncanny Valley (UV) in which imperfect human-likeness provokes dislike” [47]. As shown in figure 3.11, the uncanny valley traditionally occurs when the human-like figure is almost
human-like, but some important features are missing. According to Miro, “through robotics research we can come to understand what makes us human. This map is also necessary to enable us to create—using nonhuman designs—devices to which people can relate comfortably” [49].

![Figure 3.11: ‘Uncanny Valley’, ScienceDirect](image)

### 3.1.6 Unreal Engine: MetaHumans

Since their initial release of the *Meet Mike* project in 2018, Unreal Engine has released information about their upcoming installment: “MetaHumans.” Set to be released later in 2021, the MetaHumans is Unreal’s most robust virtual humans project to date [21]. The finished product, named the “Metahumans Editor” will allow users to easily custom create a hyper-realistic virtual human, pre-rigged and ready for animation. A sample project was released in February of 2021, featuring two example virtual humans. In addition to a full body rig, the facial animation portion is particularly impressive. Its extensive list of facial blend shapes allow for a number of expressions, as well as prep the digital human for lip sync simulation. In addition, the Apple ARKit plugin allows the user to live link their phone to the project. With this feature, while the user speaks into his phone, the virtual human automatically lip syncs with his voice. These major technological advancements are just the beginning of the MetaHumans project; once the final version becomes available to the public, patrons can create a custom human, export it as an fbx, and then easily import it into their own project. What originally took a large team of technical artists months of work will be able to be completed in a matter of minutes [22].
Texturing.xyz is a major online hub for texturing artists, specifically for the creation of realistic digital humans. Its library of skin textures and materials are of industry-standard quality. In fact, they have partnerships with a number of major studios including, MPC, Digital Domain and Method Studios. Its high-quality content and affordable pricing makes Texturing.xyz the most popular resource for texturing artists. Their featured skin texturing assets include multi-channel faces, multi-channel irises, faces displacement, micro-displacement, body displacement and faces photoset. Each of these products are derived from 3D scans, providing the highest level of detail possible. The most common Texturing.xyz workflow utilizes the multi-channel face packs. Each pack includes four maps: raw albedo, cleaned albedo, displacement and utility maps.

As shown in figure 4.13, the raw albedo map includes all shadows and highlights captured during the scanning process. This can be used in rendering systems that do not include ambient occlusion [11]. The cleaned albedo has been touched up by technical artists at Texturing.xyz, neutralizing the harsh shadows and spec in the raw version. The provided displacement map includes
secondary, tertiary and micro displacement textures, separated by the three RGB channel layers. A similar channel setup is included in the utility maps which includes a variety of layers best used for “grading, adding, modifying color in some specific areas, but also to derviate it to a specular intensity map” [11]. Extensive documentation is included on the Texturing.xyz website, explaining in detail the possible techniques for the multi-channel packs. A more common approach is re-shaping the multi-channel pack in Photoshop to match the digital human’s UV’s. Once this step is complete, the technical artist can be import the newly re-shaped textures into a texturing program, such as Mari or Substance, and clean any deformations in the map. Once this process is complete, the maps can be imported into a rendering system of the user’s choice. The Texturing.xyz website also provides a free script for an automatic shading network in Arnold, VRay and Renderman, making the shading process incredibly efficient for the technical artist.

If the technical artist does not need the entire multi-channel pack, other texturing options are available for use. For instance, a variety of displacement textures are available in macro and micro-detail options. These textures are provided for a wide variety of human surfaces such as lips, cheeks, hands, arms and many more. This provides highly specific details for the entire human body. For a texturing artist using ZBrush or other sculpting software, they can also choose to hand-sculpt these micro details using the alphaSkin package. This pack provides a wide variety of alpha brushes, ranging from under-eye bags to forehead wrinkles. In addition, the site even provides a full set of reference images in their “Faces Photoset” packages. This wide range of products places Texturing.xyz at the top of the list for everything texturing. As previously mentioned, its products are industry-standard and used by a wide range of VFX studios.

3.2.1 “Saurabh Jethani: Realistic Skin in UE4”

In addition to a wide range of texturing products, the Texturing.xyz website also includes a large quantity of high quality tutorials by professional texturing artists. These tutorials cover a
wide range of material, from the actual texturing process to techniques used during the shading and rendering stages. An incredible resource for this project in particular is the “Creating Realistic Skin in UE4” tutorial by Saurabh Jethani. Saurabh is a game character artist who has provided in-depth tutorials for a number of platforms including Texturing.xyz, Marmoset Toolbag and CG Master Academy. His Texturing.xyz tutorial was specifically helpful because it goes into detail for the texturing process as well as creating a realistic skin material in Unreal Engine. Jethani based his skin material on the Meet Mike project. As previously mentioned in section 3.1, the Meet Mike project was released by Unreal Engine’s development team in 2017 to highlight the power of Unreal Engine’s real-time rendering system. According to FXGuide, the 2017 SIGGRAPH Meet Mike “showcase[d] the latest research in digital human technology, with leading industry figures interviewed live and in real-time by a photo-realistic avatar in a ‘virtual set in Sydney’” [10]. Its groundbreaking visuals became a standard for the quality of rendering realistic virtual humans. Much like the Mike material, Jethani’s skin material is created using a subsurface profile shader. He used a combination of macro normals, micro normals and tileable textures to curate a highly realistic digital human, as shown in figure 3.14.

To start, Jethani downloaded a number of resources from Texturing.xyz including the tileable Microskin library and multi-channel face maps [12]. His initial steps took place in ZBrush, where he imported the red and green channels of the multi-channel face displacement maps. After applying a generic noise to the map, he applied the macro and micro displacement textures. An important step in creating an even more realistic look is slightly inflating the pores [12].

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completing the texturing in ZBrush, he exported the high-poly details as a normal map. In order to isolate the micro details and wrinkles, a cavity map was also exported. This cavity map will be incredibly useful in a number of ways; most notably, saving the micro textures lost with the shader’s subsurface profile [12]. As shown in figure 3.15, a number of masks and tileable textures were also utilized in the Unreal Engine skin material. The first of these is the roughness zone RGB mask, used to isolate various areas of major fluctuation in roughness levels. For instance, the nose will have a much different roughness level from the lips. This same mask will also be used to control the size of micro textures (i.e. pores, wrinkles) that will be procedurally created with the unreal engine material. For instance, pores created with the tileable normal map will be larger on the nose than the forehead.

![Image](image.png)

Figure 3.15: ‘Saurabh Jethani / Texture Maps’, Texturing.xyz

A specific topic Jethani notes in this tutorial is the importance of the subsurface and specular levels in a skin material. It is imperative that the values of both are balanced in order to ensure proper realism. The dual-lobe specular portion of an Unreal Engine skin material ensures extra specularity surrounding porous areas to ensure the representation of an oily surface [12]. This is shown in figure 3.16, which uses a combination of the dual spec with the cavity map. Without the cavity map, the specular map is too strong; however, without any specularity the material looks like rubber. The blending of the two creates a much more realistic representation of human skin.

Lastly, the microskin tileable textures are used in conjunction with the existing normal maps to further enhance the micro details [12]. In order to ensure a cohesive quality between the normals
and displacement levels, Jethani extracted a normal map from the blue channel of the multi-channel displacement map. He completed this process using the program “CrazyBump”; however, this same procedure can be done in Photoshop. Shown in figure 3.17 is a screenshot of Saurabh Jethani’s finalized skin material. After its creation, he then adjusted specific levels (i.e. spec, micro strength, etc.) to make sure the material looked right in different lighting environments.

The technological advancements utilized in Epic’s *Meet Mike* project and Saurabh Jethani’s *Texturing.XYZ* tutorial provided terrific information on the creation of hyper-realistic real-time
digital humans. By studying the industry’s most recent breakthroughs in digital human technology, I was able to curate my own pipeline process for the re-creation of Gentileschi’s painting.

3.3 Digital Recreations of Art History

The re-creation of popular Renaissance artwork in a computer-generated format has been done by multiple artists in the past few years. A few of these digital pieces were the initial inspiration for my re-creation of “Judith Beheading Holofernes”. This list includes “Disproportionate Marriage” by Chen Jiangtao, “The Lady of Shalott” by Olivia Obiora, and “King” by Lu Yaoan. All three pieces were created using ZBrush, Substance, Mari and then rendered with Arnold in Maya.

3.3.1 “Disproportionate Marriage”, Chen Jiangtao

Figure 3.18: ‘Disproportionate Marriage’, Chen Jiangtao
Chen Jiangtao’s digital recreation of “The Unequal Marriage” by Vasili Pukirev was the initial inspiration for this thesis project. His entire project was modeled in ZBrush, textured in Mari and Substance, and rendered with Arnold. When comparing his digital version (figure 3.18) with the original painting (3.19), it is almost indistinguishable upon first glance. Its impressive detail includes hyper realistic skin textures, hair, cloth simulation and fabric shaders. In addition, the lighting perfectly replicates the harsh highlights, pulling the viewer’s focus to the couple in front.

Figure 3.19: ‘The Unequal Marriage’, Vasili Pukirev

3.3.2 “The Lady of Shalott” by Olivia Obiora

Olivia Obiora’s rendition of John William Waterhouse’s iconic painting “The Lady of Shalott” is another impressive example. This piece was also sculpted entirely in ZBrush, textured with Mari and rendered with Arnold. Much like Jiangtao’s work, it is very hard to tell the difference between the original painting (figure 3.21) and the digital recreation (figure 3.20).
Figure 3.20: ‘The Lady of Shalott’, Olivia Obiora

Figure 3.21: ‘The Lady of Shalott’, John William Waterhouse
3.3.3 “King” by Lu Yaoan

Lu Yaoan’s digital rendition (figure 3.22) of “The Baptism of Vajk” by Gyula Benczur (figure 3.23) has impeccable detail and seemingly identical to the original. The artist used ZBrush for modeling, marvelous designer for clothing, textured in Mari and Substance Painter, and rendered using Arnold.

As previously mentioned, all three of these digital paintings were rendered with Arnold in Maya. Using this approach, the viewer is limited to a 2D image of the finished piece. I decided to take this approach a step further, creating multiple viewing levels of the digital painting in Unreal Engine. By utilizing a real-time rendering engine, the viewer is fully immersed in the painting.
In doing so, the user can move around the painting in real-time. This viewing experience blends together the technology and high quality textures utilized in *Meet Mike* and Saurabh Jethani, with the processes used in these digital paintings.
Chapter 4

Research Design

Figure 4.1: “Thesis Pipeline Design”

Modeled after a traditional studio pipeline, the research design process took place in five major stages: modeling, texturing, surfacing, rendering and UI design.

4.1 Modeling

The modeling stage took place in ZBrush and Maya, depending on whether the asset was organic or hard surface. Five major asset types required creation: female and male anatomy, cloth simulation, hair groom effects, soft material assets (i.e. blankets, mattress, clothing) and hard surface (i.e. weapon, accessories). This wide variety of asset types required a dynamic mix of techniques and procedures including the usage of 3D scanned models, Marvelous Designer for clothing creation, nCloth for cloth simulation, hair generation with xGen and Maya for retopology and UV’s. Prior to
the initial modeling process, a collection of reference images were collected to ensure a realistically accurate representation of the assets. The most references were collected for the three human figures: Holofernes (male), Judith (female wielding the sword) and her maidservant (secondary female). Even though the painting is based on a biblical narrative, in which the characters were of Jewish and Assyrian descent, the painting’s figures are clearly representative of Italian heritage. As shown in figure 4.2, the reference images have a variety of portraits of men with facial structures most similar to the painting. Figure 4.3 shows reference images for the male body. The same process was completed for the female characters, as shown in figure 4.4. Once this pre-visualization process was completed, I began the sculpting process in ZBrush.
4.1.1 Modeling Realistic Humans: Usage of 3D Scans

During the sculpting process, I had two main goals: create photo-realistic digital humans and make them accurately replicate the figures in Gentileschi’s painting. As mentioned previously in section 3.1, a major resource for this thesis project is the Mike Seymour downloadable Unreal Engine project, *Meet Mike*, originally released by Epic Games and others in 2017. In this project, a major reason in Mike’s realism is the usage of 3D scanned models and textures. For this reason, I utilized two 3D scanned heads, a male and a female, to kick-start the sculpting process. The scans were downloaded from “3dscanstore.com”, an online hub of scanned assets for digital artists. Both models were included in a downloadable package, including the original scan, texture maps, teeth geometry and a re-meshed head. As shown in figure 4.4, the female scan’s texture maps have the correct skin tone for the painting’s recreation; however, the overall facial structure needed major changes to better match the reference images. For this reason, both scans were used as base meshes in the initial sculpting process. In addition to the head scans, I also utilized a 3D scan package for realistic teeth geometry and textures. Downloaded from “3dscanstore.com,” this package included scans of human teeth, gums and tongue. Following the posing process, I imported the scanned geometry and textures directly into Unreal Engine.

4.1.2 Modeling Realistic Humans: ZBrush

After bringing the scanned geometry into ZBrush, I dynameshed the scans into a mid-poly mesh and mirrored it using “mirror and weld” to have exact symmetry. As shown in figure 4.6, all micro-details initially picked up in the scanning process were lost after the dynameshing process.
However, I sculpted new alpha details later in the texturing process. In these early stages, the most important task is sculpting the basic facial structure and matching the reference images as close as possible. After dynameshing and mirroring the 3D scans, I started the sculpting process on the rest of the body. In order to speed up this process, body base meshes were used to create the initial anatomy. As shown in figure 4.7, this male base mesh has very basic structures and had to be re-sculpted to better match the reference photos. The figure on the right is the newly dynameshed full body in early stages of the sculpting process; at this stage, the head has been resized to fit the body proportions, and the muscular structure has been re-sculpted to better match Holofernes’ physical build. This same process was completed for the female characters. Considering Judith and her maidservant have identical body types and basic facial structure in Gentileschi’s painting, Judith’s body sculpt was duplicated in the texturing stage after making modifications to the facial
structure (i.e. tweaking the nose length, Judith’s jawline is less defined, etc.).

![Figure 4.7: “Holofernes Sculpt with Initial Base Mesh”](image)

4.1.3 Modeling Realistic Humans: Retopology and UV

After finishing the initial full-body sculpt, I began the remeshing process. This was completed in two separate ways; for the male body, I used a combination of ZRemesher and then retopologized the mesh in Maya to clean up the ZBrush topology (figure 4.9). For Judith’s body, I utilized a retopologized female mesh from a previous project. After resizing this mesh to match Judith’s body, I projected the details in ZBrush, as shown in figure 4.10. Following the retopology process, I completed the texture layout of both meshes in Maya, using its UV toolkit (see figure 4.11).
Figure 4.9: “Holofernes Sculpt Retopologized”

Figure 4.10: “Judith Sculpt Retopologized”

Figure 4.11: “Male and Female Body UV”
4.1.4 Modeling the Characters’ Assets

A variety of techniques were utilized in the modeling pipeline for the character’s assets. Depending on the type of asset (i.e. hard surface, clothing, etc), a combination of Maya, Marvelous Designer, and ZBrush were used. Starting with the hard surface pipeline, I first modeled Judith’s sword entirely in Maya. After bringing it into ZBrush, I had to slightly resize the blade to better match the proportions with the painting. The maidservant’s head wrap was created entirely in ZBrush, rather than using a cloth simulation program. I first matched the silhouette to the reference, then hand-sculpted the wrinkle details. A similar process was completed for the additional dress sleeves and collars. The dresses required a much more dynamic process, combining Marvelous Designer, Maya and ZBrush. The entire dress was constructed in Marvelous Designer and simulated...
on a figure similar to Judith’s. After the simulation was finalized, it was exported with a quad-based mesh; as shown in figure 4.12, the mesh was very messy (hence the bumpiness) and needed to be reconstructed. The retopologized version is shown in figure 4.13, showing a much cleaner mesh, ready to be posed in ZBrush. The finalized dresses are shown in figure 4.14, following the posing process. All wrinkles and posing in the sleeves were hand-sculpted, attempting to best match the sleeves in the reference painting. Finally, the blood spurting out of Holofernes was completed entirely in ZBrush. Through a combination of dynameshing, the snake-hook brush, and ZRemesher, I attempted to match the silhouette in Gentileschi’s painting.

Figure 4.14: “Character Assets”

Figure 4.15: “Environment Assets”
4.1.5 Modeling the Environment

Multiple environment assets required modeling for this composition, including three mattresses and four blankets (figure 4.12). A combination of Maya, Marvelous Designer and ZBrush were used in the creation of these assets, each for a specific purpose. The mattresses were initially modeled in Maya, used to create an initial low-poly version without any details. Then the mattresses were brought into marvelous designer for realistic cloth simulation. After this process was complete, the resulting geometry was brought into ZBrush for additional wrinkles. A similar process was executed for the blankets; however, instead of Marvelous Designer, I used nCloth in Maya for the cloth simulation. Much like the mattresses, the blankets were then brought into ZBrush to create any additional wrinkles or details. For instance, the lining on the comforter was created with a custom insert brush. Following their creation in ZBrush, the assets’ texture layout was completed with UV Master and imported into the Maya Reference file.

4.1.6 Posing the Assets

Following the completion of the modeling process, I began posing the assets. After initially posing the three characters, I then posed their clothing and other assets accordingly. The result is shown in figure 4.16.

4.1.7 Hair Generation

After the posing was finalized, I began the hair generation process with XGen in Maya. As shown in figure 4.17, I used hair splines to generate the hair, rather than utilize the interactive grooming method. The splines provided far more control over each hair description, especially when creating complex styles, such as Judith’s braid crown. After the initial spline creation, I used a variety of hair modifiers to make the hair much more realistic. This list includes clump, noise and coiling modifiers. The clumping modifier groups together hair strands; in order to push the realism even further, I added a “rand” clump variance. The noise and coil modifiers create natural randomization in the natural irregularity of hair strands. The coil modifier adds a slight curl to the hair, whereas the noise modifier makes each stand of hair frizzy. An identical process was utilized for Holofernes’ beard, along with the character’s eyebrows. Once the hair generation process was complete, each hair group was exported as a “mel” file, converting the strands to curves. Unreal
Engine 4.25 has a plug-in option called the "groom editor." Used in the "Meet Mike" project, this new feature reads curves as grooms instead of hair cards, creating a far more realistic render.
4.2 Texturing

Based on the reference painting, a wide range of material types are needed: skin, cloth, metal and blood. For this reason, a wide variety of programs and techniques were used for the texturing process. This list includes: 3D scanned textures, Mari, Substance Designer materials, Substance Painter, and Photoshop. The textures were then implemented in the Unreal Engine Material system.

![3D Scan – Male Albedo Map](image)

Figure 4.18: “3D Scan – Male Albedo Map”

4.2.1 Usage of 3D Texture Scans: Male and Female Texturing

In order to create hyper-realistic textures, a range of techniques using 3D scanned images and tileable textures were utilized in this texturing pipeline. I used a combination of the processes utilized in the “Meet Mike” project and techniques covered in the “Texturing.XYZ” tutorials, both covered in chapter 4. The original 3D scan packages from “3Dscanstore.com” included a scanned albedo map for the male (figure 4.12) and female characters (figure 4.13). I decided to treat these maps as if they were in a multi-channel pack from Texturing.XYZ. As covered in Saurabh Jethani’s tutorial, I first used a provided Photoshop workflow to reshape the maps for the male and female UV’s in figure 4.11 [13]. As shown in figure 4.13, I first used the puppet warp tool to fit the original map to Judith’s Uv’s. The middle image (figure 45.13) is the map that I then imported into Mari and the last image is the map exported from Mari.
4.2.2 Usage of 3D Texture Scans: Mari

After importing the warped texture map (figure 4.17) into Mari, I began the texturing process on the rest of the body. An identical process was used on the maps for Holofernes, Judith and her maidservant. I imported a variety of other skin texture 3D scanned images, from which I pulled a number of references for image projection. Using this image projection method, I painted these scanned images onto the model, while simultaneously blending in these new textures with the original albedo map. The resulting image is shown in figure 4.17, in the far right picture. Once the initial image projection process was complete, I created an additional layer for the under painting process. In this stage (shown in figure 4.18), additional red, blue and green tints are added to various portions of the face, such as reds in areas with heavy blood flow (i.e. chest area, hands, sides of the head, etc). As shown in figure 4.19, the under painting is eventually placed in a “multiply” layer and set to a very low opacity, so that its impact is subtle. However, the result has a very high impact on the realism of the resulting albedo map. In order to further differentiate the texturing for Judith from her maidservant, a few additional layers were added to the project. The maidservant, whose resulting color map is on the far right in figure 4.19, has a slightly darker skin tone than Judith. In addition, an additional under-painting layer was added to further accentuate the color in her cheeks.

4.2.3 Normal Map Creation: ZBrush

Once the initial sculpting phase was completed, as well as the retolopoly stage, I started the texturing stage in ZBrush. Using a combination of alpha texture brushes and surface noise, I created an assortment of skin textures. As described in the Saurabh Jethani’s tutorial, the best way
to provide realistic skin textures is by starting with a layer of noise to create an organic-looking surface. Another helpful tip from the tutorial is adding a slight "inflate" deformation to the skin pores after providing an initial layer of alpha textures. The result is shown in figure 4.22.
4.2.4 Additional Texture Maps: Photoshop and ZBrush

Following the Meet Mike shader outline, an additional number of texturing maps and masks were necessary for the resulting Unreal Engine skin material. This list includes: albedo map, normal map, roughness map, cavity, AO mask, RGB mask and mesonormals mask (figure 4.23, from left to right). I created these texture maps in a variety of ways, depending on the specific type of map. As previously mentioned in section 4.2.2, the albedo map was created in Mari. After its export, I created the roughness map in Photoshop by converting the albedo map to black and white, then modifying the contrast and brightness parameters. The normal map consists of any high-poly details created in ZBrush. Once the texturing stage was completed in ZBrush, as described in section 4.2.3, the normal maps were exported. I also exported the cavity map from ZBrush, using the “export cavity map” function in the multi-map exporter section. The cavity map highlights reveals all pores, wrinkles and other crevices in the model. This map will be used in a variety of places in the finalized skin material. The remaining maps, AO (ambient occlusion), RGB and mesonormal, were then converted into masks in Unreal Engine. The AO and RGB masks were painted in Photoshop and then exported as png images. The mesonormal map was created in Unreal Engine by compositing a black image with the normal maps, creating the resulting mask with the green channel.
4.2.5 Substance Designer and Painter

In preparation for texturing and surfacing the environment assets, I created a number of tileable materials in Substance Designer. These materials are used for hard surface (i.e. gold frame) and soft surface assets (i.e. blankets, dresses, cloth, etc). Depending on the asset type, the tileable Substance Designer textures were either imported directly in the Unreal Engine material or used in a Substance Painter file. For instance, I first created a simple Designer file for the picture frame asset. In order to create this material, I utilized a variety of noise nodes to create a generic frame-like texture (figure 4.24).
I then imported this Designer material into Substance Painter and applied it directly onto the frame geometry. I then created two separate types of cloth materials in Substance Designer: velvet (figure 4.25) and a generic fabric weave (4.26). For both materials, I referenced tutorials to help start the process, as both materials required complex procedures. For the velvet material, I referenced a tutorial by Filip Hodas, a texturing artist whose YouTube channel provides some great insight on Substance Designer [42]. Using a “shape” node, I first created a cylinder shape, which will resemble each fiber in the overall texture. A blend node multiplies this shape with two directional noise transform nodes, transforming the cylinder’s silhouette into a fiber-like shape. Additional noise nodes make this shape even more organic-looking and the gradient linear node gives the shape depth. By connecting this resulting shape into a “tile sampler” node, the fiber is scaled down and when combined with the Clouds 2 texture, the fibers change directions in a realistic velvet texture. From this Designer project, I exported a roughness map and a normal map and imported the maps directly into Unreal Engine to use as tileable textures.

![Figure 4.25: “Velvet Material – Substance Designer”](image)

A similar process was completed for the weave texture, which was derived from a Pete Sekula tutorial, another terrific resource for texturing [64]. Similarly to the velvet texture, the process begins with shape nodes to create the initial weave pattern. After tiling the weave pattern with tile nodes, I added some variance to the pattern using a variety of noise nodes. From this Designer project, I exported roughness and normal maps, then imported them directly into Unreal Engine, similarly to the velvet texture.

The only asset fully textured in Substance Painter (i.e. used Substance Painter materials) is the sword (figure 5.27). The Substance material “gold pure” is applied to the sword’s handle,
whereas “Iron Rough” is on the blade.

4.3 Surfacing

Utilizing all maps created during the texturing process, I created a wide range of materials in the surfacing process. As shown in figure 4.28, there are 19 different materials and 15 material instances. As briefly mentioned in section 3.2, material instances are children of parent materials, meant to speed up the surfacing process in Unreal Engine. For instance, there is a parent skin material and three material instances branching off of this material. The only different is the maps connected to specific parameters.

4.3.1 Skin Materials

As previously mentioned in chapter four, this skin material is based on the Meet Mike project. Utilizing all seven maps referenced in figure 4.23, the entire shader can be broken down
into six different sections: base color, specular, roughness, opacity, normal and ambient occlusion.

The base color section is broken down into two major sections: the albedo map and the AO mask (figure 4.29). The calculations made between the albedo map and AO mask are directly based on the skin material in "Meet Mike", even using the “CheapContrast” which was migrated into this project. In summary, the albedo map is divided by the alpha channel of the AO mask. The “CheapContrast” node heightens the mask’s contrast levels by 0.2, further accentuating the pores and wrinkle details in the mask.

The specular section is broken down into three major areas: cavity map, RGB mask and AO mask. Firstly, the cavity map is used as a specular map and similarly to the base color, the calculations are identical to the ones used in the "Meet Mike" skin material. The AO mask’s red channel is multiplied by the cavity/spec map’s calculations. The RGB mask isolates the eyes (blue channel), nose (red channel) and mouth (green channel): for the specular map, only the red channel
is multiplied. It is then multiplied by the “BaseSpecularValue.” I added one more parameter, “spec-control,” to have even more control over the resulting specular value.

The roughness section is the most complex part of the overall shader, based not only on the mesoroughness map, but also on micro-roughness details. To start, the micro details derive from a
tileable normals texture used in the *Meet Mike* project. In the mesoroughness sections, the maps are initially multiplied by a “BaseRoughness” value, then the micro and macro details are combined using an “add” node. The mesoroughness value is then multiplied by the original roughness map, which is controlled by the “Roughness0” and “Roughness1” nodes. The EdgeRoughness section is derived directly from the *Meet Mike* skin material, meant to mimic the natural peach fuzz on the edges of an individual’s face. After being multiplied by the resulting “RoughnessVariation” section, it is then multiplied by the additional micro-roughness details. Similarly to the micro-meso textures, this tileable texture came from the *Meet Mike* project.

![Screenshot of Opacity/Scatter in Unreal Engine](image)

Figure 4.32: “Screenshot of Opacity/Scatter in Unreal Engine”

The scatter section controls the control of subsurface scattering in the skin material and is identical to the calculations performed in the “Meet Mike” project. Firstly, the skin material uses a Subsurface Profile shader, identically to the “Meet Mike” project. The RGB mask isolates the impact of scatter on the eye, nose and mouth. Additional parameters such as “ThickScatter”, “ThinScatter”, “LidScatter” and “UpperLidScatter” give the technical artist even further control.

The overall setup of the normal section is almost identical to the mesoroughness portion of the skin material. The micro-normals consist of a tileable texture, identical to the one used for roughness, is initially multiplied by numerous parameters to control the level of normal strength. After the strength is calculated, the macro-normals are combined with the micro-normals using a
blend normals node. The normals are then normalized and connected to the overall skin material.

Finally, the ambient occlusion section is purely based on the AO map, as shown in figure 4.33. Three Material Instances were created for the three different characters. All three used different maps and parameters, who were controlled within their respective material instance editors.
4.3.2 Hair Materials

There are three different hair materials, each assigned as a hair shading model. These materials have a very simple setup, as shown in figure 4.35; the constant node controls the color whereas the numerical constant controls the roughness levels.

![Screenshot of Hair Materials in Unreal Engine](image)

Figure 4.35: “Screenshot of Hair Materials in Unreal Engine”

4.3.3 Fabric Materials

In order to create a realistic fabric material, I first gathered a variety of reference images for Renaissance-era fabrics and textile (figures 4.36-7). This greatly helped in the texturing and surfacing process, not only in creating accurate textures, but also created realistic fabric materials. As previously mentioned in section 4.2.5, I created two separate tileable fabric textures in Substance Designer (i.e. generic weave texture, velvet texture) which were then imported directly into the Unreal Engine materials.

A terrific reference for building a photo-realistic cloth material in Unreal Engine is the cloth shading online tutorial by Ben Cloward, a texturing and shading artist [34]. His technique is based on John Hable’s original cloth shader development, first used for Uncharted 2 [39]. During his presentation at SIGGRAPH 2010, John used the graphic in figure 4.38 to describe the shader’s fresnel rim lobe, inner lobe and the remaining diffuse. The first image isolates the rim lobe, highlighting the silhouette of the woman’s shirt. The inner lobe reflects the center of the material, specifically based on the camera viewpoint. I used Ben’s Unreal Engine cloth material method for all the fabric in
this project, just adjusted the parameters depending on the type of fabric. Shown in figure 4.38, the calculations are dependent on the camera vector and normal map. The power and multiply nodes control the amount of fresnel in the inner lobe (bottom two nodes) and rim lobe (top two nodes) of the material.

The resulting calculations are then added together and multiplied with the color maps and ambient occlusion maps, then connected to the “base color” portion of the shader. A material like velvet requires much higher fresnel values than the simple cloth material shown in figure 4.39. Three major fabric materials exist in this particular project: cotton material for the bed sheets, velvet for the maidservant’s dress and Holofernes’s blankets and the taffeta fabric used for Judith’s dress.

The mattress material (figure 4.39) has a very similar framework to the shader used in
Cloward’s tutorial. Two separate normal maps are utilized in the mattress material. The micro-texture is the basic weave tileable texture from Substance Designer. It is combined with the normal map from ZBrush, labeled as the “Mattress-Wrinkles” parameter in the shader. The “grunge” parameter darkens the overall color of the mattress; utilized in the material instance editor, this parameter allows for slight variance between the mattresses. Similarly to the skin material, three material instances were created, one for each mattress. In addition, almost identical materials were created for the bed sheets as well as the maidservant’s head wrap.

In order to create the velvet material, I used a very similar framework to the shader in Figure 4.38. However, the velvet tileable textures from Substance Designer were utilized along with a red albedo map. In addition, the power and multiply nodes were increased to values of (3, 5, 7, 5) instead of (2, 1.5, 1, 2), drastically increasing the fresnel quantity. Two material instances were
created based on the velvet texture: one for Holofernes’s blanket and another for the dress sleeves.

The maidservant’s dress required a similar material setup to the velvet material; however, similarly to the mattress material it incorporated an additional normal map from ZBrush. The fresnel values are at a mid-range levels (2, 2, 3, 2) rather than the boosted levels in the original velvet material. In addition, its color value is a mixture of two blue tones; the "color-sat" parameter allowed for more control over the color, dependent upon the asset’s lighting environment.

Judith’s dress material is far more advanced than the maidservant’s, incorporating multiple tileable textures and RGB masks. Similarly to the Maidservant’s material, a normal map from ZBrush is combined with the initial micro-normal texture. This time, instead of the velvet normal map, it is the generic weave texture. As seen in Gentileschi’s painting, Judith’s dress is made up of separate patterns. The sleeves are a solid color whereas the rest of the dress has a brocade pattern, a common occurrence in Renaissance fashion. In order to create this look using solely tileable textures, I created an RGB mask in Photoshop for the dress UVs. The sleeves are the blue channel while
the rest of the dress is the red channel. By attaching these channels to the lerp node, the tileable brocade pattern does not apply to the sleeves. The additional lerp node attaches the lighter gold color to the pattern and the darker tone to the rest of the dress.

The comforter material is very similar to the material for Judith’s dress. I created an RGB mask for the comforter’s UV’s, labeling one side with the red channel and the other side with the blue channel. This applies the brocade pattern to the bottom half of the blanket and keeping the top half a solid dark navy tone. The weave pattern is used instead of the velvet texture, giving the comforter a cotton-based texture.
4.3.4 Hard Surface Materials

The two separate sword materials were very simple in comparison to previous materials. After importing the albedo, metal and roughness maps, I attached them to the respective areas of the shader.

Similarly to the sword materials, the frame material also consists solely of its base color, metal, roughness and normals maps from Substance Painter.

This simple background image material was created with an imported paintbrush-stroke alpha texture I created in Photoshop. I used the image as an alpha mask and lerped in three different brown values. After scaling the texture, the resulting texture is an abstract painterly-looking texture.
4.3.5 Additional Organic Materials

Blood is a liquid with a thick viscosity and is red, not clear. For this reason, the blood material consists of a single base color and multiple scalar parameter values. The spec value is set to 1.0, while the roughness and metallic parameters are set to 0.1.

The tongue, teeth and gum materials integrate the 3D scanned textures, as described in section 5.1.1. For the teeth, base color, roughness, specular and ambient occlusion maps are connected to the shader. In the tongue shader, the base color and a provided tileable normal map are
4.4 Rendering

In order to ensure a realistic representation of Gentileschi’s painting, a variety of lighting types were utilized in the rendering process. The Unreal Engine project includes two separate viewing levels: a 2D render and a 3D turnaround. In the 2D level, the user is in a locked position and views the “painting” as if it is hanging in the Uffizi Gallery, where the real painting currently hangs. In the 3D turnaround level, the user has the opportunity to move around the piece, as if he is seeing catching Judith in the act. For both levels, the lighting goal is to best match the original
painting; however, the turnaround view hosts far more lights, allowing the user to see far more
details of the overall piece. In addition, I used the Real-Time Ray Tracing lighting plug-in, further
accentuating the photo-realism of the final piece. In comparison to the traditional lighting feature
in UE4, Real-Time Ray Tracing effects “look more natural, producing soft shadowing for lights,
accurate ambient occlusion (AO), interactive global illumination, reflections and more” [24].

![Figure 4.50: “Rendering Setup in Unreal Engine”](image)

### 4.4.1 Lighting Types

In the 2D level, I attempted to re-create the lighting in Gentileschi’s piece with a variety of
digital light types. A total of eight lights are in the entire scene. Of those lights, seven are directed
at the actual painting and one is directed at the front wall and frame. A variety of lighting types are
used, including two point lights, two rectangular lights and three spotlights. The light aimed at the
front wall is a directional light. As shown in figure 4.50, the main lighting comes from the spotlights
from the left side of the screen. The three lights directly in front of the painting, one point light and
two rectangular lights, provide additional subtle bounce lighting to the right side of the piece. For
instance the bottom left bounce light specific aims towards the sword and the bottom right light is
aimed towards the comforter blanket. The third spotlight is located behind the wall and casts light
onto Holofernes’ legs.

In the final level, I used tenebrist techniques to further accentuate the details of this sculpt,
while also utilizing a HDRI lightmap to mimic a real-world environment. The turnaround level also
has eight different lights within the level. The grouping consists of three point lights, one skylight
and four spotlights. Of the eight lights, five lights are aimed towards the actual sculpt. One spotlight
Figure 4.51: “2D Lighting Setup in Unreal Engine”

is aimed towards the background and two point lights highlight the floor in front of the sculpt. The skylight utilizes one of Unreal Engine’s HDRI lightmaps, Sunset Ambient Cubemap, to light the entire environment. The three remaining spotlights highlight the left, right, and center areas of the sculpt.

Figure 4.52: “3D Lighting Setup in Unreal Engine”
4.4.2 Lighting Channels

In order to have better control over the lighting, I utilized lighting channels to determine which assets are affected by specific lights. In the 2D level, the front wall is only impacted by the main directional light (both assets are in channel 1). In addition, the sword is lit by channel 0 and, similarly to the rest of the sculpt, channel 2. This way, it is the only asset impact by the rectangular light directly in front of the sculpt, as well as the other major lights. In the turnaround level, the sculpt, ground and almost all of the lights are in channel 0. The background wall and back spotlight are in channel 1.

4.5 User Interface Layout

As mentioned in the previous section, this UE4 project consists of multiple maps: welcome level, 2D viewing level and the 3D turnaround level. In order to navigate these levels within an executable, I used multiple level blueprints to code a way to move throughout the project. To help with Blueprint design, I referenced a CodeViper tutorial on widget design and implementation [35]. Utilizing this tutorial, I coded a number of navigation parameters to move throughout the final level. For instance, by holding down the left mouse button and gliding the mouse forward, the user moves forward towards the figures. If the right mouse button is held, the user can rotate the camera position. Hold down both buttons and glide the mouth forward, the user can look up and move forward simultaneously.

4.5.1 Level One: GUI Design

The first level acts has a main menu and welcomes the user into the project. Inspired by the CodeViper tutorial mentioned above, the widget titles the project and has a button to start
navigating the project. As shown in figure 4.53, the start button triggers an “open level” node, which opens the level title “Judith Beheading.” In the level one blueprint, the “Set View Target with Blend” and “Create Widget” nodes allow the widget to take up the entire level view port. In addition, the “Get Player Controller” node allows gives the player control over the widget and trigger the ”Set Input Mode” node at the end of the blueprint. This exact blueprint design is based on the CodeViper tutorial [35].

4.5.2 Level Two: 2D View Design

As shown in figure 4.54, this level and widget design is the exact same as level one. The only difference is that the view comes from the camera inside the level instead of the “player controller,” like in level one. The camera has its own blueprint, which is referenced in the level blueprint (as shown in figure 4.54). The camera is set at a focal length of 85mm and 16:9 digital film.
4.5.3 Level Three: Turnaround Navigation Design

As a result of its navigation blueprint, level three has a much more complex blueprint infrastructure than the previous levels. Similarly to Level Two, its view port is set to a camera blueprint. Since the camera is utilized in the navigation blueprint, it has a “GameModeBase” and “PlayerController” assigned to its CharacterMovement class. The camera’s event graph blueprint is based on a tutorial from The Lonely Lynz, who provides great tutorials on Unreal Engine blueprints [45]. With this blueprint structure, the user is able to navigate the level with his mouse. This is defined by the "Set Input Controller" node, as shown in figure 4.55. Holding down the left mouse key and gliding the mouse forward, the user moves forward within the space. Shown in figure 4.56, the inputAxis node defined “MoveForward” if the player holds down the left mouse button (LMB) and moves along the “ForwardVector.” Holding down the right mouse key, the user can rotate the camera in place. This is set in both figures 4.57 and 4.58, where the PlayerController pitch and yaw inputs are defined. If just the right button (RMB) is pressed, the user simply rotates the camera in place. If both buttons are pressed simultaneously (BMP), the looks up.

Figure 4.56: “Level Three Design in Unreal Engine – Define Controller”

Figure 4.57: “Level Three Design in Unreal Engine – Move Forward”
Figure 4.58: “Level Three Design in Unreal Engine – Look Around”

Figure 4.59: “Level Three Design in Unreal Engine – Look Up”
Chapter 5

Final Renders

Figure 5.1: “Level Two Final Render”
Figure 5.2: “Level Three Final Render”

Figure 5.3: “Detail Render – Holofernes”
Figure 5.4: “Detail Render – Judith”

Figure 5.5: “Detail Render – Maidservant”
Chapter 6

Conclusions and Discussion

Through the re-creation of Artemisia’s “Judith Beheading Holofernes” (figure 1.1), I discovered a variety of ways in which present-day technological advancements in computer graphics challenge the ways in which we interact with the visual arts. Furthermore, by re-discovering the techniques of Renaissance masters, I was able to further understand the ways in which traditional artwork has impacted present-day digital art. Throughout the Renaissance period, artists utilized new advancements in scientific technology to heighten realism in their work. As later discovered by David Hockney and Charles Falco, the usage of optical aids allowed artists to perfect linear perspective, allowing for realistic accuracy in anatomical proportions, fabric folds and curved objects. Leading into the Baroque period, artists like Gentileschi and Caravaggio utilized these technological advancements to further articulate the religious narratives in their work. In comparison to the Renaissance period, Baroque artists used overly dramatic poses and lighting to convey the emotional depth of religion. A common biblical narrative amongst artists is the Book of Judith. In this deuterocanonical story, a brave woman’s heroics save her Israelite city. Giorgione, Caravaggio, and Donatello are just a few artists who brough Judith’s story to life. However, the most grotesquely-realistic version is Artemisia Gentileschi’s “Judith Beheading Holofernes”, completed in 1620-21. In this piece, Gentileschi combines the elements of Baroque artwork with her own personal narrative. In doing so, Artemisia treats this painting as a form of catharsis, taking out her revenge on her rapist, Agostino Tassi. In doing so, Gentileschi places her female figures in a position of power, rather than passiveness. This visual is rarely seen in classic art, especially in the early 17th century.

In order to re-create Gentileschi’s painting in a real-time digital format, I utilized a multitude
of references, each instilling the newest advancements in virtual human technology. First inspired by the digital renders of “Disproportionate Marriage” by Chen Jiangtao, I decided to take his project a step further, utilizing Unreal Engine 4’s real-time render platform instead of Arnold or Renderman. In doing so, the user has the ability to fully immerse himself in the program, rather than view a rendered image. Projects released by Epic Games such as Meet Mike and Saurabh Jethani’s Texturing.XYZ tutorial showcased significant technological advancements in real-time digital humans. I utilized a blend of both projects in the pipeline structure, then focusing on a multi-leveled user interface. In the final executable, the user first enters a welcome level. This includes a title of the project and a button to start the viewing process. The second level showcases the digital painting in a two-dimensional format, allowing the user to view the piece as if it is Gentileschi’s painting hanging in the Uffizi. The final level immerses the viewer into the painting, allowing him to move around the painting. Due to the dynamic posing of the Baroque style and the realistic models and textures, the digital viewing seems like a moment frozen in time, rather than a piece of art.

Following the digital re-creation of Gentileschi’s piece, a major question needs to be answered. How does Gentileschi’s rendition of Judith and Holofernes hold present-day significance in this modern format? Unfortunately, the themes covered in the vast majority of Gentileschi’s paintings are still relevant in present-day society. Her body of work covers a wide variety of themes, including sexual assault and suicide. Gentileschi’s self-expression in “Judith Beheading Holofernes” features significant undertones of her past traumas, involving sexual assault and the subsequent negative aftermath of her public rape trial. According to RAINN, America’s largest anti-sexual violence organization, “1 out of every 6 American women has been the victim of an attempted or completed rape in her lifetime” and “About 3 percent of American men—or 1 in 33—have experienced an attempted or completed rape in their lifetime” [9]. By bringing Gentileschi’s painting into this contemporary format, necessary conversations about the present-day issue of sexual can start within the community. Furthermore, this re-creation’s digital format provides the potential for larger audiences.

In the Renaissance era, individuals had to be physically present in a museum to see artwork. However, since the beginning of the Coronavirus outbreak in early 2020, all of society has been forced to see the world through a virtual lens. As a result, museums have been forced to create new ways of viewing art. This list includes virtual tours, augmented reality and other forms of technological immersion. For example, the Metropolitan Museum of Art released a project with
Verizon in January of 2021 titled “The Met Unframed” [14]. This virtual project showcased over fifty pieces from the MET’s collection on the user’s 4g or 5g mobile devices. Its five-week span showcased what can be the potential future of the way we view traditional artwork. This is just one example of art museums utilizing technological advancements to provide unconventional ways of interacting with visual art. Unreal Engine provides a wide variety of rendering possibilities for this project. It is currently built for PC viewing, but it can also be used in Virtual Reality or even packaged for a PlayStation or XBox console. This way, viewers can even engage with Judith’s visual narrative in their home. As shown through this project, digital art has the potential to change the way in which we view and interact with the traditional arts and, in doing so, provide a larger platform for even larger issues.
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