The Digital Afterlife of Urban Objects:

The Physical and Digital Materiality of Urban Objects Captured through Photogrammetry

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complies with the regulations of the University and meets the accepted standards with respect to originality and quality.

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Abstract

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This thesis provides a comprehensive investigation into digital material and the 3D photoscanning process. It argues for an emotional investment in the treatment of the inanimate through a visual analysis of the material qualities of photoscanned objects. It highlights the photogrammetric process, leveraging it to explore an afterlife of these digitally reconstructed objects, which would otherwise occupy a space of abandon in the digital realm. Contrasting the pervasiveness of high-quality, clean assets, it elevates digital objects wrought with glitches, distortions, and imperfections, all bestowed on them as a product of the processes involved in their creation.

The research establishes a history of the relevant tools and technologies before examining theories on objects and materials of both physical and digital nature. It surveys these theories and concepts through the practice-led computer-generated artwork *Digital Afterlife*, utilizing both the artwork and its creation process, from asset collection to display, to explore a narrative of care towards neglected objects.

Acknowledgements

As I finish writing this section in the hours before submitting my thesis, I realize that this is the last project I will work on after many years as a student in Design and Computation Arts at Concordia. I would like to express my sincere gratitude to my family, friends and colleagues for their support throughout the development of this project and the rest of my studies. I am also deeply grateful to my thesis supervisor, Dr. Pippin Barr, for his valuable insights, feedback and patience in sifting through the multiple drafts of this thesis, with their ever-shifting deadlines. Furthermore, I would like to extend my immense thanks and appreciation to my thesis advisory committee members, Dr. Alice Jarry, Dr. Martin Racine, and other members of the faculty of Design and Computation Arts, who, as my professors, saw the early evolutions of this project and provided so much meaningful guidance throughout my journey in the Master’s and undergraduate programs. Finally, I am endlessly grateful to all those who have created the open-source 3D tools used throughout this project.

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Glossary

This glossary includes terms relating to 3D design, modelling, texturing and animation.

Photogrammetry (photoscanning, 3D scanning)

The extraction of 3D information from photographs to produce textured 3D models. The term '3D scanning' typically refers to a scanning process using specialised instruments to capture an object's interaction with light, while photoscanning and photogrammetry rely instead on images.

3D Assets

Three dimensional digital objects, usually consisting of a mesh with a material and textures.

Mesh & Mesh Topology

The points, edges and faces that construct the geometric surface of a 3D object. Mesh Topology refers specifically to the characteristics of this 3D mesh, its quality and density.

Modifiers (Blender)

Operations that affect a mesh's geometry in a non-destructive manner. This means that the structure of the mesh is not physically altered, and can be easily reverted to its former state at any point.

Remeshing

The process of rebuilding a 3D object's mesh topology, by adding to, or reducing its geometry in order to render it more usable.

UV maps

The projection of a 3D model's surface onto a 2D image, or vice versa. U and V are used to denote the axes of the image. In the context of this thesis, these maps are generated by photogrammetry software algorithms.

HDRI

Referring to High Dynamic Range Image, a 360° image wrapped around the entirety of a 3D scene for lighting purposes.

Rendering

The process of converting 3D data into 2D images, involving complex light calculations and computation.

Vertex(ices)

The individual points that make up a 3D mesh.

Face(s)

A surface connecting three or more vertices.

Normals

A vector in 3D space that is perpendicular to two other vectors. In most cases it is perpendicular to the face of an object. Each face has its own normal, determining the direction that face is 'pointing'.

Shading (Smooth, Flat Shade Auto Smooth)

Dictates how Blender treats the sharp angles of a 3D model, rendering them as smooth below a specified degree.

Baking (not bread)

The saving of information relating to a 3D mesh into a texture.

Empty Object

An 'empty' is a single coordinate point with no geometry. It cannot be rendered, and appears as a basic axis, circle, square or cube.

Chapter 1: Introduction

Digital Afterlife, the creation portion of this project, is composed of 55 individual, photoscanned, 3D objects. Each scan is of a unique object, each captured at varying times of day and weather conditions, and each in a different location. They range from garbage bins, and electrical boxes, to lampposts and concrete barriers. The project consists of two computer-generated videos examining the afterlife of a specific type of objects through their materiality as digital artefacts altered through the process of photogrammetry. These objects are the neglected and ubiquitous things that inhabit the transitory 'non-places' in the urban environment, the infrastructure between places of interest, objects that are commonly seen as lacking interest themselves. Their digital representations are geometrically complex artefacts and assets, wrapped in high resolution textures and deformed through an imperfect technology. The videos juxtapose the scuffs, scrapes and graffiti of human interaction these objects bear, with these resulting digital glitches and deformations of photoscanning, each as a form of material alteration that urges the viewer to compare the material differences of the objects. The 3D objects resulting from the scanning process are themselves another type of neglected object, too dense and flawed for professional use as background of foreground assets. The two sides of the video work in tandem, examining both the captured materiality of the scans, and looking deeper into their digital reconstructions and the distortions that accompany them. The project exists both as an analysis of the photogrammetric process, its strengths and flaws, but also as a way to elevate a class of object that is often neglected and abandoned. The brief, passing interactions and neglectful actions with these objects are challenged with a slow and deliberately directed viewing that lingers on their form and material, positioning them as objects of higher worth than they are typically accorded, and attempting to visually exhaust every present element. The 'afterlife' of these objects within *Digital Afterlife* spans three stages, a digital limbo, where they have been carefully scattered in an array which the viewer slowly explores, a solitary afterlife, focusing on each individual objects in turn, and a final empyrean setting, in which they coalesce in a final, undulating composition.

Outline

Chapter 1: Introduction establishes the aims of the project, covering its objective and relevance to theories on objects, both digital and physical.

Chapter 2: Object and Material provides the reader with necessary contextual knowledge of 3D history, terminology and concepts. It begins with discussion of key literature relating to neglected urban environments and the ontological understanding of objects existing within them. The chapter then explores how these ideas may be applied to digital objects, covering areas that pertain specifically to 3D.

Chapter 3: Context of Methods provides the reader with necessary contextual knowledge of 3D history, terminology and concepts. It offers a history of computer generated graphics and photogrammetry, providing the reader with necessary background to the technology involved in producing the work, aiding in understanding the context in which it was created.

Chapter 4: Observing an Afterlife offers a descriptive observation of the entire animation from its first scene to its last. It explains the intentions behind the various scenes in *Digital Afterlife*, and how each one fits into a larger whole.

Chapter 5: Analyzing an Afterlife breaks down the methodological steps implemented in the creation of *Digital Afterlife*. The methods employed in the project's creation are heavily tied to the theories and philosophies it explores. It examines the photogrammetric process from the state of the initial objects through to that of the final digital artefacts, and how that process informs the inextricable digital qualities of these created objects. It discusses the aesthetic and philosophical intentions behind each creative decision, justifying the steps taken at every stage of the project, from the initial selection of objects, the file format to which the digital scans are exported, composition and the final lighting and animation decisions.

Chapter 5: Afterlife Alternatives surveys a variety of works created with similar philosophical goals to *Digital Afterlife*, and explores past iterations of the project.

Chapter 7: Conclusion describes the final resulting form of *Digital Afterlife* and its contributions. It concludes with an overview of the thesis as a whole, the theoretical and conceptual connections between the final animation and the ideas it seeks to explore.

Relevance & Objective

Online databases and stores of 3D objects are littered with half-finished 3D assets and botched photoscans. Things that aren't considered 'good enough' for professional use, and are too complex and unoptimized for application as background assets, uploaded haphazardly or automatically. These 3D objects will sit, unused, potentially forever, observed by passersby as they search for more favourable options. They may be clicked on and briefly examined, before being passed over once their geometric flaws, texture shearing or high polygon count are uncovered. These repositories, stores and online collections are graveyards for these digital artefacts, the final resting place of objects deemed all but unusable. This project makes use of this type of object, placing things that may only scrape by as background assets in a small scene at the forefront of their own animation, the stars of their own short feature. The typical manner of neglect these assets experience is akin to that of the urban objects that are the secondary subject of this thesis. These ubiquitous objects that occupy every corner of the urban environment, but are never given much thought. The garbage bins, lampposts, electrical boxes, poles and signs that are gradually covered in graffiti, scuffs and dents are analogous to their digital counterparts in their neglect by those who pass them by. This section will solidify the connection between these objects and their representations as 3D scanned assets, exploring the reason this specific categorization of object was chosen to visualize the comparison to this specific type of digital artifact, and address the overall objective and research aims of the project.

Figure 1.1 - Scans from the Polycam 'Explore' page.

This thesis will deal primarily with the photoscanned assets belonging to the aforementioned category of undesired digital objects. Those that are processed or uploaded and typically abandoned for their imperfections. If the goal were only to show that these types of digital objects have their own value, a work could be made with assets pulled solely from photoscan repositories, cobbled and kitbashed together into a piece that highlights their unique flaws and qualities that make them so undesirable to work with. This latter aspect is still a large portion of this project, which will investigate the complexity of their models, the gaps in data that leave them looking damaged or melted, and the high resolution unique textures that are excessive for items only 'good enough' for use as a backdrop or distant object that isn't quite visible. However, the goal of this project does not rely on these digital objects by themselves, but rather seeks to explore its themes through the contrast in the material qualities they share with their real-world counterparts, and those which are unique to the newly created digital objects.

The 3D objects created through photogrammetry do not exist in a vacuum, they have not been modelled in software by a 3D artist, but have been captured directly from a real world object, residing in its own environment, with external qualities that can and do affect its ability to be captured and rendered. Their location and any obstructions can negatively impact the ability to scan them properly. Nearby walls can mean that a certain face of the object cannot be scanned because it cannot be accessed. The lighting of a location can lead to blown out or overly dark areas of an object, resulting in a scan with the same uneven lighting, or creating enough contrast as to confuse the software and distort the produced geometry. These imperfections make the digital objects less faithful representations of their original, and thus unique objects of their own. All of these flaws or errors in the scanning process are unique to this one digital object, just as every bit of weathering, scuff or graffiti is unique to the object from which it originates.

What is the importance of preserving these objects and their states? They are ubiquitous and arguably uninteresting objects that represent a kind of mundane interaction that happens only in passing, repeated every day. This mundanity is the reason they are not thought of for preservation, but are rather replaced when they become damaged beyond usefulness or can no longer keep up with shifting urban aesthetics. This thesis will argue that they are compelling items in their own right, worthy of attention and care, and deserving of more than just passing observation. The specific type of interaction they foster, the continuous, uncaring, contact they undergo with humans who, for the most part, are simply intent on getting somewhere else, creates a unique, encompassing, materiality. They are inconspicuous, neglected and generally disinteresting to most people, having very little attention paid to their appearance, relevance or even existence. There is more to the goal of preserving and displaying these things than simply doing so because it is a treatment they seldom receive. There is an element of pathos within these objects that is exemplified by their external material qualities. They will continue to build up unconsidered wear and grime until they are deemed too damaged and removed and replaced with newer, cleaner alternatives. These spiritual qualities are shared with the botched photoscans and 3D assets of dubious quality that litter 3D creator spaces, both overlooked and replaced.

The final creation objective of this thesis project is a 3D animated short film that highlights the material qualities of photoscanned 3D assets. It specifically examines the qualities they share with their physical precursors, the objects within transitory spaces that have been altered by their environment and human interaction, and those which are physically impossible products of photogrammetry. It is both an examination of the process of photogrammetry and an effort to make viewers more considerate and aware of their treatment of the inanimate by creating a sense of emotional investment through the animated piece. Contrasting the usual interaction and passing perception of these objects, the film urges the viewer to sit with them for a set duration, asking for unwavering attention toward objects they usually pass by without a glance. The particular medium of 3D animation allows the choosing of highly specific points of focus on each object and absolute control over how they are represented and viewed, their lighting, scale, and positioning in reference to each other. It grants the ability to choose where the gaze of the viewer will fall, how long they said gaze will rest on, and examine, each element, and the manner in which they can be made to perceive each object. The control over the presentation of these objects is leveraged to display them in a fashion that positions them as objects of elevated status, things worthy of care and consideration, endeavouring to provoke an emotional reaction from viewers that may stimulate them to be more attentive in their treatment of these things.

The full animation offers applicable knowledge and contributions to numerous fields of design, with relevance across digital, industrial and urban fields. The collected objects have been sourced from a wide range of urban settings, offering insights into their treatment across their life-cycle. They encompass a varied assortment of differing objects, though all of an industrial and urban design origin. The digitized nature of the resulting assets, and the manner of their acquisition, is explored in depth as they are optimized and made more 'usable' through a process of constant care and careful attention.

The data collected through this project is a series of imperfect recreations of the subjects's imagery, texture and geometry, creating an abstracted catalogue of their forms and a two-dimensionalized, visual facsimile material. They have each been scanned with a high degree of care, both as a means of respect towards the objects, and to ensure that they are as high fidelity as possible within the constraints of a photoscanning mobile application. While this care cannot remove the flaws, glitches and distortions that will occur in the digital objects through the photogrammetric process, these resulting flaws present their own form of material artefacts.

Research & Creation

This project aims to build visually on many research papers and literary works published in the last decade and a half. These texts ontologically analyse objects both physical and digital, their forms, representations and perceptions surrounding them. They explore the processes that mediate the creation of digital objects, how they may be understood and what is beyond the grasp of understanding. The most important of these philosophical ideas surrounding physical and digital objects are found in the works of Yuk Hui, Paul Leonardi, Graham Harman and Hamid Ekbia.

Digital Afterlife is the central artwork created for this project. It spans two 26 minute and 38 second CGI HD videos in a 4:3 aspect ratio, intended for display in a full 4K and viewed in gallery contexts or through an online video viewing platform, for which a combined cut was produced. This combined cut shows both video segments side by side in one frame, though they are ideally intended to be shown at a small distance from each other. This allows the viewer to perceive both simultaneously with ease, able to look from one to the other without a great deal of effort, while having them remain separate entities, just as the physical and digital objects, though reflections of each other, may never occupy the same space, and never touch. This separation between the videos mirrors the intrinsic separation between the two types of objects. The project's audio component is intended to be played through speakers or headphones, acting as an accompaniment to ground the viewer with the objects and the space. For installation, it is intended to be shown with a short-throw or ceiling mounted projector on a projector screen, or any flat, white surface. The two portions of the video are ideally viewed in close proximity, either side by side or at a 90° angle to each other, functioning in tandem, while being afforded their own space.

Digital Afterlife features a series of virtual environments, composed of the representations of various urban objects, reconstructed through photogrammetry into digital assets. It uses animation to exhibit the material and forms of these new objects and explore their ontological origins.

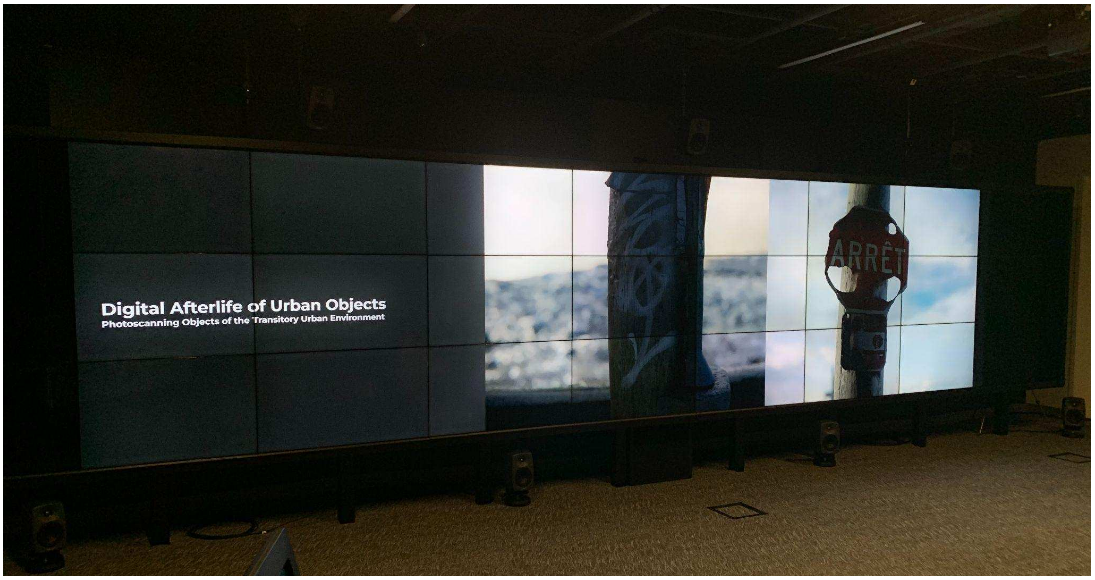

Figure 1.2 - *Digital Afterlife* displayed in Concordia's Visualization Studio, Webster Library.

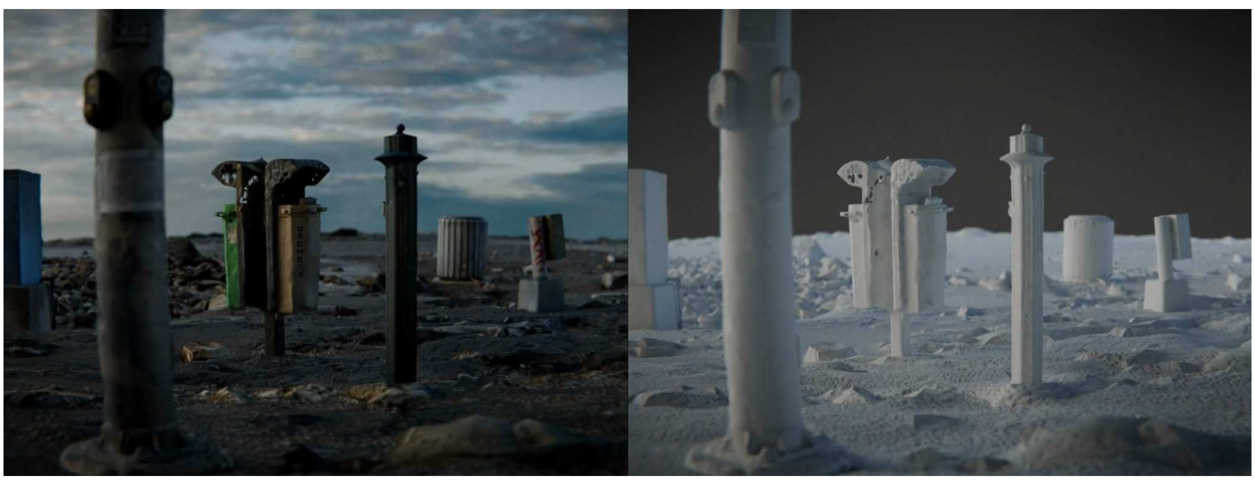

Figure 1.2 - *Digital Afterlife* still.

Chapter 2: Object and Material

"What does it mean to construct digital worlds while the actual world is crumbling before our eyes?" (Odell, 2019)

This chapter will cover the technology and theories that are used and explored in *Digital Afterlife*. It begins with a brief evolution of the technology that led to 3D animation and photogrammetry being possible, both as a method to establish further context around *Digital Afterlife*, and to ensure the reader has a foundational understanding of the relevant philosophy and technologies. This technology was instrumental in processing the photos of the objects into 3D assets, animating them, and rendering them. Beginning with an analysis of transitory spaces and objects, it will continue with an overview of pertinent philosophies surrounding the ontological origins of objects and material. The chapter will then pivot to a chronology of CGI, and one of Blender (the main creative tool), with the subsequent sub-chapter detailing a history of photogrammetry technology, until the point of it being feasible with smartphone apps. This chapter discusses the technologies in chronological order, but this order will be swapped for all following sections, as the photoscanning, and the decisions in asset selection that came with it, took place prior to the creative decisions made about actual 3D scenes and rendering steps. These discussions around the utilized technologies and relevant philosophies will lead into how they were implemented in a creative setting in the following chapter.

Transitory and Temporary

This section assesses the philosophical foundation of *Digital Afterlife.* It will first examine ideas surrounding the unseen elements and objects of the urban environment, discussing transitory spaces and their inanimate inhabitants, before moving towards interpretations of objects inhabiting both physical and digital realms.

On Rue De La Montagne, in downtown Montreal, just past the Bell Centre, there is a short underpass that cuts below Gare Lucien l'Allier. It directly connects a mostly urban area with one of the busiest streets downtown. There is absolutely nothing of interest in this underpass, an electrical box, some lampposts, and lots of concrete. Just beyond its darkness, the crowd, bustle, scents from nearby restaurants and visual hum of electronic light from shops vie for attention and overflow the senses with stimuli. This small stretch of road and sidewalk exists in contrast to these other pervasive spaces. This section of De La Montagne, and spaces like it, are transitory environments, equally widespread in an urban setting as the streets lined with shops and restaurants, existing as the "non-places" between these other places. Transitory spaces, referred to as 'non-places', and defined by Marc Augé (Augé 1996, 34), are temporary places intended only for momentary physical dwelling, unconcerned with relationships, history or identity, existing in contrast to 'places'. They are spaces without anthropological origin, where humans remain anonymous, existing in a state of "solitary contractuality" (Augé 1996, 94), and which they are traversing to or through with individual intent, always in the goal of reaching elsewhere. These places are down an alley, through an underpass, or on the sidewalks taken to traverse the mundane. The urban variety of the transitory space is devoid of anything that would ask for our attention, thus seldom receiving it, their contents being ignored. The online asset repositories constitute their own form of transitory 'non-place'. Websites like Polycam, Fab, Turbosquid and Sketchfab are not the end goal, but merely a quick stop in the process of creation in 3D. They do not involve input or creation on the part of those who visit them. They exist for a quick search or download before their required extractions are imported into a 3D scene file.

Digital Afterlife focuses on the individual items that inhabit these neglected spaces, in both physical and digital realms. These are items that are often ignored, passed over or used carelessly, and certainly not tended to or desired. They are unappealing and often invisible to passersby, deemed either unworthy of consideration and attention, or else simply dismissed or wholly unnoticed. A pedestrian on the sidewalk may pass by electrical boxes and garbage bins without notice or care just as a 3D artist searching for assets may immediately overlook those with glaring imperfections. These objects are passed by just as frequently as the spaces they inhabit are traversed through. Granting attention and focus to these spaces and things is explored in Jenny Odell's *How to Do Nothing*. She argues for a resistance to the constant attention economy, the shops and screens that vie for our time, and a focal shift to notice that which often goes unnoticed. She catalogues these acts of 'doing nothing', to sit and dwell, in the detailed observations of these spaces and things which abound with their own interest and intrigue, creating a collection of searches for beauty and interest in things that do not typically garner it. The worn surfaces that have been defaced with layer after layer of graffiti, and the melted deformations of their 3D recreations will seldom receive attention over the clean storefront, cafe or high quality, carefully modelled background asset. This thesis and *Digital Afterlife* place express focus on the regularly unnoticed or rejected, arguing for a wider recognition of their interest.

The hyper-focus on the details of the mundane that this project investigates is similar to the explorations in George Perec's *An Attempt at Exhausting a Place in Paris*. Perec describes, in exhaustive detail, every typically unnoticed element that occupies Saint-Sulpice Square. He chronicles the times of buses, people passing by, market stalls, vehicles and birds, exhausting every element and mundane happening throughout the day. Instead of exhausting an entire transitory space, *Digital Afterlife* aims to exhaust the visual forms of a rather brief collection of the objects that occupy them. While not the literary exhaustion that Perec's work explores, *Digital Afterlife* grants the same service done to the objects in a purely visual manner, covering every scratch, scuff, scrape, dent, chip, glitch and deformation of their digital representations. The project treats each individual object as Perec's work does Saint-Sulpice Square, not over the course of a day, but for the qualities they possess at the moment of their documentation. It cannot not dwell on how these qualities came to be acquired, as the total sum of interactions these objects experienced and the manner in which they occurred extends beyond the possible scope. Digital Afterlife simply observes the presence of what remains from these interactions in the material surface of the objects.

Physical Material Objects

Individual objects exist in constant affectation by their surrounding environments and manners in which they are interacted with by human and non-human elements. Examining these philosophical standpoints is crucial to analysing the intentions of *Digital Afterlife*.

Sociological researchers have defined materiality in different manners, specifically for how a thing's physical properties affect its sociological impact and how it may be perceived. For the purposes of this project, materiality speaks equally to the solely physical properties of an object and to how those qualities can determine an understanding of, and perception towards, it. The materiality of an object denotes its physical properties, those externally visible, and internal, determining how something looks and feels, its colour, durability, hardness, roughness and reflectivity. An object's materiality can encapsulate the entirety of its being, the manufacturing processes involved in its creation, perception, and its specific spatiotemporal qualities. There is a clear distinction to be made between physical and digital materiality, as characteristics of things that occupy entirely different planes, one tangible and one intangible. This section will continue to focus solely on the materiality of physical objects, with the subsequent section transitioning to an elaboration of digital materiality.

The physical originators to the objects that are the focus of this project are whose interactions with their surroundings are incidental, brief or unintentionally impactful. While these objects are not an equivalent mirror of the discarded assets and photoscans of the digital world, they occupy similar spaces in their respective realities. Not quite good enough, each is overlooked because there are more appealing things around every corner. In the context of 3D these are the more optimized assets with clean mesh topology, more manageable textures and undistorted UV maps. In the physical world things and places with higher appeal include stores, benches, or anything that does not occupy a non-place. There exists an implicit object hierarchy to human perception of them that stems from their purpose, aesthetics, and spatiotemporal locations. *Digital Afterlife* explores the urban objects occupying the lower echelon of this hierarchy.

Borrowing the 'object-oriented' from computer languages, object-oriented ontology (OOO) was first coined by Graham Harman in 1999 as a variation of speculative realism, debating the anthropocentric branches of philosophies. Influenced by Heidegger and Kant, yet strongly differing, it counters human-centred worldviews, elevating the importance of objects, and exploring how the human and non-human contact with these objects distorts them in lasting ways. The existence of these objects cannot be solely attributed to other external forces, nor can they be reduced to manifestations of human perception. Objects are not ontologically tied to human perception and interaction, they are independent things whose existence and reality is individually withdrawn from all other things. "OOO is strongly committed to an *anti-literalist* view of objects, meaning the notion that we can paraphrase an object, as if it were truly equivalent to a sum total of qualities or effects and nothing more." (Harman 2017, 257).

OOO endorses Kant's idea of the 'thing-in-itself', and expresses an inability to examine the total sum of experiences of an object. Kant writes; "considering objects of sense as mere appearances, [we] confess thereby that they are based upon a thing in itself, though we know not this thing in its internal constitution, but only know its appearances, viz., the way in which our senses are affected by this unknown something" (Kant, Prolegomena). Observing the material exterior of an electrical box we may see graffiti covering its facets, posters plastered over top of posters, dents from some unknown provenance.

Exhaustively describing these individual objects does not capture their entirety. Photographing these objects from every possible angle does not capture their entirety. Photoscanning and animating these objects does not capture their entirety. Photogrammetry reduces some digital abstractions of them into pixels, vertices and faces, but even this is a new form of object that cannot truly be done justice in its representation. "OOO asks why Kant treated [the thing-in-itself] as the sole and tragic burden of humanity, rather than the ungraspable terms of *every* relation" (Harman 2017, 256). Both physical and digital objects are "ungraspable terms of *every* relation". Their materiality encompasses everything that lead to the totality of their state at any given moment, a sum of interactions that are unknowable. Harman writes that "OOO rescues the non-relational core of every object, thus paving the way for an *aesthetic* conception of things" (Harman 2017). These objects are exhibited in order to observe the aesthetics of the remnants of these relations that remain on every facet of their forms, now digitized and affected once more through new relations.

The objects of *Digital Afterlife* present countless visual marks of interaction across these now digitized surfaces. This visual data is the only thing that is truly documented and semi-preserved from them through the course of the project. Even this visual materiality is deformed and altered as it is captured and processed into a new artefact. There is a level of object-on-object interactions taking place throughout the methodological steps of *Digital Afterlife*. The end state of the scanned objects is the result of the interaction of a software object with a physical one. There is a great degree of human influence that can affect the end result of this process, but this has been mitigated wherever possible, as will be explored in the fifth chapter of this thesis. A series of algorithms have interpreted a physical, three dimensional object, reduced it to two dimensions and reassembled it into a final digital, 3D, form. The digital artefact and the original, the object that still stands in the same spot where it was captured, are different entities. One is wholly unaffected by the creation of the other, while this other relies entirely on the existence of the one.

Digital Material Objects

In the context of 3D, the aforementioned visual material qualities (colour roughness and reflectivity) are divided into individual image textures, plugged together via nodes that form a 3D object's material. There is a clear quantitativeness that now resides in them in terms of vertices, polygons, pixels and file size. Harman's ideas relating to physical objects are still very applicable, but the objects can no longer be touched, their materiality was captured based purely on its interaction with light, extracted from thousands of photographs. They have been flattened into 2D images that are wrapped across the surface geometry of an assembled mesh, no longer having any tactile qualities. The curves, hard edges and bump have been translated into vertices, faces and pixels. The objects in *Digital Afterlife* can very clearly not be used for their physical counterparts' intended purpose. You cannot dispose of physical trash in a digital 3D rubbish bin, nor can an electrical junction box of the same nature protect against short circuits. In a translation of Michel Foucault's response to René Magritte's 1929 painting, *Treachery of Images (La trahison des images),* he writes "the copy predicates its existence (qua copy) upon whatever it submissively imitates" (Foucault 1983, 8). The objects in *Digital Afterlife* are not modelled on, or an artist's interpretation of, what they imitate, they are assembled solely through photography and algorithms to produce a digital recreation, albeit an abstracted one, of these original items. *Digital Afterlife* highlights the material aspects of the objects that make clear the illusion of their imagery, their warped geometry and shorn textures, to clearly indicate that the viewer is observing imperfect representations of objects.

In *Digital Materiality: How artifacts without matter, matter,* Leonardi explores the manners in which the material qualities of digital objects and artefacts may be defined and understood. Referencing the ideas of multiple other authors, including Orlikowski, Pinch and Ashcraft, he covers their definitions and interpretations. These definitions and explorations refer predominantly to organizational software, telecommunication technology and institutions. Expanding these ideas and definitions to 3D software, its components, and various processes, allows for a greater understanding of 3D objects, their material and the lasting effects that their means of production have on them. Leonardi posits that "in the case of digital artifacts, what may matter most about 'materiality' is that artifacts and their consequences are created and shaped through interaction" (Leonardi 2010). The interactions that shape the photoscanned assets of *Digital Afterlife* occur through both the photoscanning process and across the entire existence of the physical objects from which they have been reconstructed. The act of scanning an object does not alter its original state, but creates a new artefact, seriously affected through the very process of its creation. These interactions are unending so long as the objects are in use, altering their materiality and form through rotation, relighting and modifying of their geometry.

Hui Yuk discusses the ever-increasing ubiquity of digital objects in our lives in his paper, *On the Existence of Digital Objects*, exploring how the emergence of new objects and technologies affect those that came before them. "The new can only manifest relative to the old, either as a continuation or as a break or rupture" (Yuk, 49). The process by which the subjects of this project have been captured, preserved or documented cannot be described as a continuation of the old in respect to the new entity they represent relative to their precursors. The physical objects, the tangible bins, boxes and posts, may be the antecedents to the digital scans, but these digital forms do not take the place of, or fulfill the same purpose as, their physical reference. They exist as a "break or rupture", manifested in relation to a 'thing' that came before them, that being "the old". Yuk also introduces Object Oriented Programming (OOP), a paradigm dealing with the concept of digital objects within computer language. Yuk writes; "OOP has three important properties: abstraction, encapsulation, and inheritance, whereby a class can be overridden to generate new classes, which subsequently inherit certain properties and functions from the parent class" (Yuk, 72). While this text deals primarily with a much broader category of digital object than *Digital Afterlife* and this thesis do, these concepts are still heavily applicable to the subject of 3D assets, especially those of a photogrammetric provenance. Each object in *Digital Afterlife* exists as an extrapolation from its parent object, those that exist outside the digital realm. These things are obvious abstractions of their source objects, something less precise than the original, yet still managing to encapsulate its being. It presents the form and material of its precursor, visual materials qualities and imperfections, yet a step removed from the original, undergoing alterations through their method of capture and display. Each geometric and material quality it possesses has been inherited by its real physical variant. There are no objects in *Digital Afterlife* without the existence of their parent objects.

Once an object has been photoscanned, the resulting asset takes on properties that are wholly unique to, and inextricable from, its creation process. These properties are exemplified in the resulting bugs and material distortions that are created through the photogrammetry process, elements which are obviously absent from the original tangible artefacts, which lack vertices and UV maps with which to encounter such glitches. These objects cannot be extricated from the context of their provenance, without which they could not have been created. The original objects are a source of direct reference to their original, and yet, while so tightly linked, their digital counterparts are not perfectly faithful representations of their physical predecessors. Since these new digital artefacts cannot have been created without the direct photogrammetric reference to the physical ones, they become "quasi-objects". This concept of classification is introduced in Hamid Ekbia's *Digital Artifacts as Quasi-Objects*. "Digital artifacts have novel properties that largely derive from the processes that mediate their creation, and that can be best understood by a close examination of such processes" (Ekbia, 1). Ekbia uses the term 'quasi-object' to refer to these digital things who's method of creation is inextricable from their being. While he dwells mostly on the artefacts of bug reports within software, the term quasi-object is aptly applicable to the digital, photoscanned, 3D objects in *Digital Afterlife*. The materials and forms of these objects are inseparable from their method of creation. They are interpretations of the algorithm used to create them, vertices and polygons placed according to hundreds of thousands of images.

When discussing the social media profile as a digital object, Ekbia argues "It has aspects that make it special—an active, immanent, unstable, and loosely bounded entity that meaningfully constitutes and is constituted by, its environment, it is a quasi-object" (Ekbia, 1). The objects presented in *Digital Afterlife* are more than loosely constituted by their environment, they are a manifestation of the multitude of processes that lead to their creation. The physical manufacturing practices, the folding of steel, priming, painting and layers of material, both intentional in their creation, and produced through a continued existence within their environment, are all displayed in an abstracted form in their final 3D scan. This scanning process adds context of its own, a limit on geometry, preservation of external qualities affecting an object in a given moment, and a reduced understanding of unseen elements. They exert a very quantitative limit on the new artefact in terms of vertices, pixels and file size. The digital objects exist as a paraphrasing of their original physical forms, and yet are their own thing-in-itself.

Analysis of these texts reveal that most writing on digital objects and artefacts has revolved around pieces of software, applications, the code that forms them, and the bugs that arise within it. There are numerous papers that discuss the technicalities of 3D objects relating to storage size, optimization and use for preservation of physical artefacts., but little is written on the roles of digital objects in the forms of 3D meshes, their vertices and faces, and materials composed of PNGs, pixels and nodes. While software represents digital objects that exist on one's desktop, the artefacts examined in *Digital Afterlife* are quasi-objects representing a digital manifestation of the tangible, to which each theory on digital objects remains profoundly applicable.

In reference to digital objects, Trevor Pinch writes that "such objects are often treated more in terms of the social or cultural significance they produce or the affect of such objects upon social relations rather than in terms of how the social is integral to the constitution of such objects" (Pinch 2008, 462). The aim of *Digital Afterlife* is specifically to highlight these elements where social relations have affected an object's constitution. The constitutions of the photoscans of *Digital Afterlife* are reliant on the social relations these objects experience across both their physical and digital forms. Each dent, taped poster, digital glitch and preserved shadow represents an unknowable and never fully graspable instance of interaction that has an everlasting effect on the constitution of the object.

Chapter 3: Context of Methods

Moving slightly away from philosophical ideas on objects and material, this chapter will explore the technological basis of *Digital Afterlife.* The advancements discussed in this segment are instrumental to all 3D practices and methods, including those employed in the creation of *Digital Afterlife*. *Digital Afterlife* is built on decades of technological advancements in 3D modelling, lighting physics simulation, animation and photogrammetry. Knowledge of these practices and techniques ensures the reader has sufficient context surrounding the tools used in the creation of the project and the digital world in which it exists. The methodological practice involved in the creation of *Digital Afterlife* is intrinsic to it as a whole, and is crucial to a complete understanding of the digital artefacts it explores.

This chapter will first cover a brief history of computer generated imagery and 3D tools, before delving into a similarly brief history of photoscanning and photogrammetry tools. The final section of this chapter will cover the existence of 3D objects in the digital world, their make-up, and their different types.

A Briefer History of Computer Generated Imagery & 3D Objects

During his 1963 doctoral thesis, Ivan Sutherland wrote 'Robot Draftsman', a computer program that pioneered Human Computer Interaction (HCI) with a revolutionary Graphical User Interface (GUI). HCI is a field of research that encapsulates the front-facing interactions between humans and computers, typically through a specialized GUI. Sutherland's program, which later became Sketchpad, was the first piece of 3D software to ever implement a cohesive GUI. Prior to Sutherland's work, early 3D modelling and animation softwares required the manual input of Cartesian coordinates to place even individual vertices. The existence of a complete GUI rendered a painstaking process intuitive and straightforward, and demonstrated that computer graphics programs could be used for both technical and artistic purposes. His software also introduced the unique use of objects and instances, whereby individual duplicates may exist as instances of a master object that adhere to any changes made to the original, allowing for the creation of multiple copies of an object while lessening the computational burden they would produce. This concept is paramount to the creation of *Digital Afterlife*, and any 3D scene or animation that contains a high number of assets. To create a true duplicate of a geometrically complex object would nearly double its hardware strain in a file, slowing down all processes, increasing render and computation times. Through Sutherland's research, among others, the processes of 3D modelling and animation have been greatly simplified, and the principles and developments he established remain the basis for all computer generated imagery software.

Within 3D softwares, there are a variety of models that now exist to simulate the movement and transport of light. Each of these models has varying levels of fidelity and render speeds. The method used in Blender for the creation of *Digital Afterlife* is referred to as ray tracing. Ray tracing is among the more accurate, but computationally intensive, methods for calculating light within a 3D scene. It treats the light emitted from a source as individual particles that move in straight lights, beginning from their emitter, and bouncing off the objects and materials within a scene (Cook et al 1984). These rays are rendered where they intersect with the view rays emitted from the camera. The first accomplished instance of computer ray tracing was performed by Arthur Appel in 1968, who calculated the distance of points on a surface to the camera in order to determine their visibility (Appel, 1968). Work by Turner Whitted expanded on ray tracing technology to calculate angles of refraction and allow for accurate shading of soft or smooth surfaces (Whitted, 1979). His paper provided the rendering equations that are currently used in 3D software to allow for computer generated images to be perceptually faithful to real lighting physics.

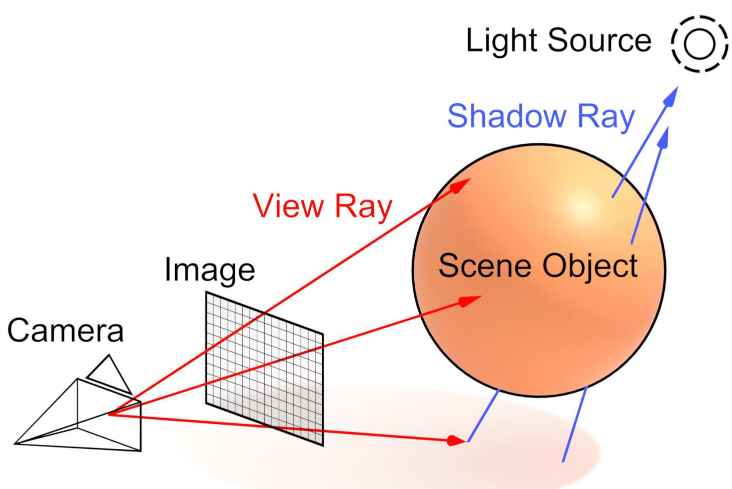

Figure 3.1 - Ray-tracing visualization.

In 1974, in his doctoral thesis, Edwin Catmull pioneered texture mapping, a method for painting 2D textures onto 3D models (Catmull, 1974). This technique is now one of the fundamentals of 3D texturing and material creation, evolving over the decades with the advent of multi-pass rendering to allow for the same texture mapping process to cover a wider range of functions, beyond Catmull's initial diffuse mapping. Diffuse mapping wraps an image's pixels over an object, passing on its colour data to that object's surface. U and V are used to denote the axes of the image that is wrapped over the 3D surface, with this technique becoming known as UV mapping. To achieve successful mapping, the desired mesh is unwrapped along specified seams and unfolded to conform to the size of and texture of an image. For the creation of most 3D assets, these maps are created after the completion of the modelling phase, when an asset's mesh has been finalized. It is ideal for there to be as little distortion of the mesh's faces as possible, so that an image texture may be cleanly represented on its surface. In the context of this thesis, these maps are automatically generated by photogrammetry software algorithms. The process of mesh and image texture creation in photogrammetry take place simultaneously, as the software's algorithms piece the various photos together. The nature of photoscanning leaves the resulting UV maps with sharp edges that appear to have been cut out haphazardly, relying on the data within the images to determine mesh geometry. The figures below show an object from *Digital Afterlife* with its geometry unfolded into two dimensions, and placed over one of the image textures which control its material properties, with the latter showing its UV seams identified in red on the 3D mesh. Advancements of Catmull's technique make it possible to use multiple image textures to control different properties of a material surface, allowing for more realistic materials.

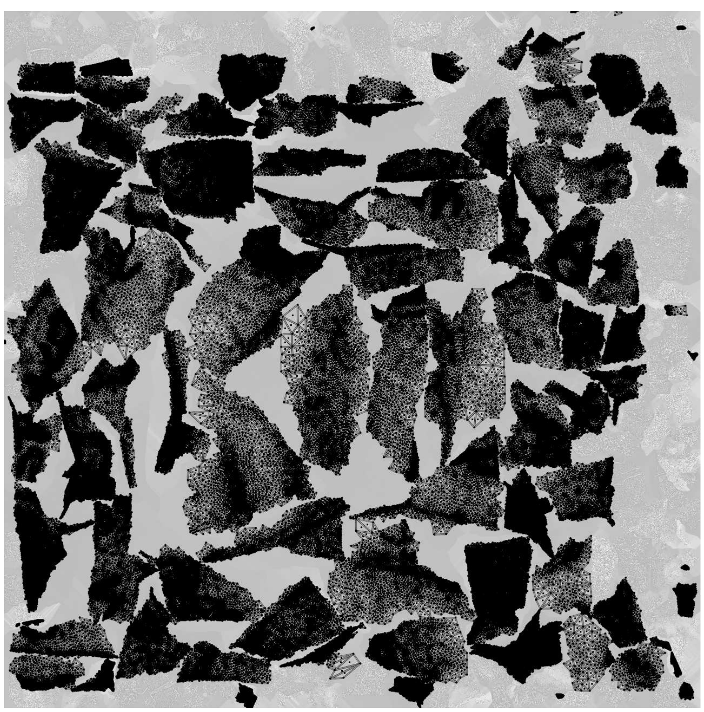

Figure 3.2 - *Digital Afterlife* object UV unwrapped onto its 2D texture.

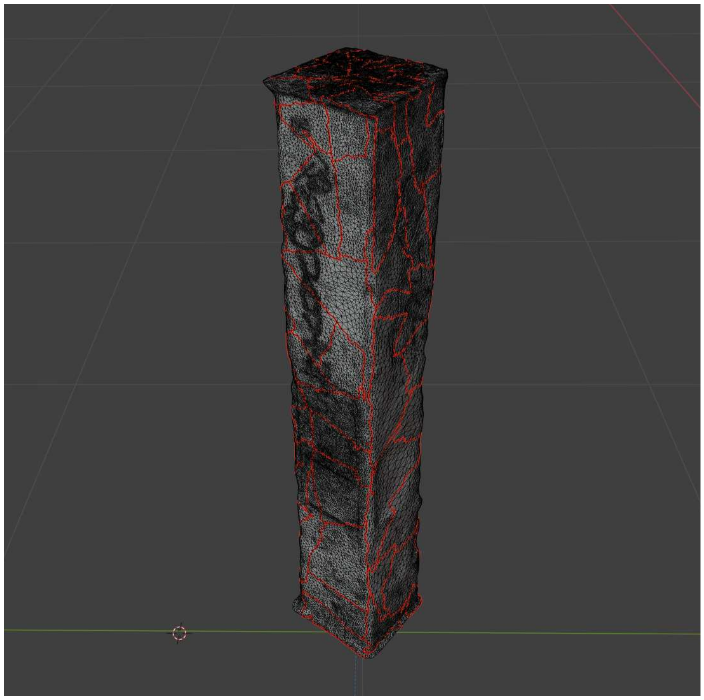

Figure 3.3 - Previous object with its UV seams marked in red.

Physically based rendering (PBR) is a method of shading and rendering in 3D software that is used to simulate and represent the interaction between light and materials in an accurate manner. Its aim is to quickly create an approximation of the bidirectional reflectance distribution function and rendering equations (Rusinkiewicz 1997). These equations define how light is reflected off, and emitted by, a surface. To achieve this, they use different textures and materials to recreate a surface's roughness, refraction, occlusion and normal map. Assuming these different properties are accurately replicated, it is possible to create a material that perceivably mimics real-world interactions with light.

In 3D software, materials commonly fall into two categories, based on whether they use procedural textures or image textures. A procedural material is a term used to refer to any 3D material with customizable texture parameters, allowing it to be continuously and minutely altered in the process of its creation while replicating mathematical patterns that appear in nature (Ebert et al 2003, 10). They automatically stretch over a 3D object's geometry rather than relying on UV maps. The second category of materials are those that employ image textures, and require UV maps for a software to understand their placement on an object's mesh. These are used in photoscans, video games and film assets, and are much more ubiquitous in the general 3D world. These materials use a combination of different textures, each serving a different function in order to simulate the interaction of light with a material surface. A 3D object's colour may be specified through an albedo or colour node, determining the colour of specific areas based on their placement within the UV unwrap. An object's level of reflectivity comes from a roughness texture, determining the scattering of light, which areas are glossy and which are matte, from a scale of 1 to 0. A normal map may be used to determine the amount of bumpiness a material has, or, in models will lower polygon counts, to specify the curvature of the surface, both of which can add finer details than what the resolution of the object's mesh can support. An occlusion map determines which areas of a model ought to be darker than others, regardless of external lighting conditions, which is used to enhance the shadows that an object may cast on itself in the creases and folds of its surface. As described earlier, the image textures and channels that photogrammetry softwares export are created simultaneously to the 3D geometry over which they are UV mapped, tying them inextricably to the mesh geometry of each object.

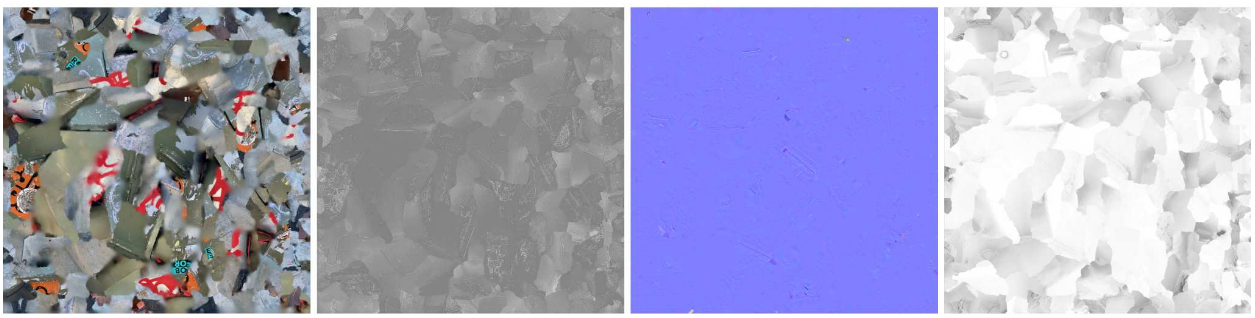

Figure 3.4 - Albedo, roughness, normal and ambient occlusion material passes.

Using a combination of ray tracing's high fidelity light mapping and multiple texture channels within materials ensures that the objects and scenes of *Digital Afterlife* are depicted as accurately and realistically as possible within a digital render engine. Ray traced lighting capable of multiple accurately simulated light bounces allows for their materials to be displayed in the most realistic lighting possible, emphasizing all of their details and providing a high degree of care towards them in the manner of their exhibition.

The creation of *Digital Afterlife* was achieved entirely in the Blender 3D software. All scenes were created in Blender, and the footage was rendered through Blender's ray-tracing engine, 'Cycles'. The first source files for Blender were written by Ton Rosendaal in 1994. It was initially built on a series of pre-existing tools, assembled into one cohesive application. It was intended to be highly configurable, and built for individual creatives. It was built from Rosendaal's love of the "magical ability to create a whole world in a computer". In 2002, Blender was taken open-source under the Blender Foundation under the terms of the GNU General Public License, ensuring Blender and its source code would remain free forever. It is now developed and iterated on by a core team of developers and volunteers alike, allowing for nimble updating and feature implementation.

3D to 2D to 3D, Genesis of Photoscanning

The American Society for Photogrammetry and Remote Sensing defines photogrammetry as “ the art, science and technology of obtaining reliable information about physical objects and the environment through processes of recording, measuring and interpreting images and patterns of electromagnetic radiant energy and other phenomena.” (American Society for Photogrammetry and Remote Sensing, 2019). This section will elaborate on photogrammetry technology, which was touched on briefly in the previous section, explaining its UV unwrapping process. It will cover a short history of the technology, and delve deeper into its functions and the reasons for choosing Polycam as the capture tool for *Digital Afterlife*.

Aimé Laussedat first envisioned the possibilities of the newly invented camera for terrestrial mapping purposes in 1851, and the term ‘photogrammetry’ was later independently coined by Prussian architect Albrecth Meydenbauer in 1867 in his article “Die Photometrographie”. Meydenbauer also proposed a “Denkmälerarchiv”, an archive in which cultural heritage objects could be documented in metric images and stored in case they need be reconstructed in the event of destruction. Meydenbauer’s experiments dealt mostly with architectural structures, using photographs with specialised crosshairs and a variable axes tripod to extract measurements. Laussedat’s method involved the collection of aerial photographs which would be scaled and stitched together into a mosaic. This was done by aligning recognizable points that existed across multiple overlapping images. While, at the time, this would be a lengthy manual process, a very similar operation is now performed by complex mapping algorithms and computers. A spiritual combination of these two methods is now the basis for all forms of modern photogrammetry and 3D scanning, which calculate distances between the camera and object, accurate measurements of the object, and use a point system to stitch photos together into a 3D mosaic.

The form of photogrammetry that has been employed in this project, and will be referred to throughout this thesis, is the method of extracting three-dimensional models and measurements from two-dimensional data. In 1985, Marc Levoy and Turner Whitted published a paper exploring the use of representing 3D geometry with individual points, which could be used to extrapolate a mesh (Levoy, Whitted, 1985). Following this, the first true 3D scanners capable of extrapolating 3D geometry from images were created. These early scanners used contact probes, based on the premises established by Levoy and Whitted, which had to physically touch every point of an object that was to be recorded, requiring a high level of precision and a very long time to complete scans. Optical technology breakthroughs of the late 80s eliminated the need for contact probes, with the only limit now being computational power to actually extrapolate the data and create the model. These new scanners would use pre-existing or manually placed points on an object and examine where they overlapped between images. Advances in storage, memory and computational capabilities in computers in the 90s led to massive breakthroughs in 3D scanning technology.

Today, this technology is available across a number of smartphone apps, highlighting the efficiency of new algorithms, and the greatly increased processing powers of common devices. Accurate and high quality photogrammetry of objects is still best performed with a digital single-lens reflex camera (DSLR) and a desktop application. Some of the most popular applications in the field for capturing 3D geometry from photos include RealityCapture, Metashape or Meshroom. While there are numerous photoscanning apps available on the market, this project used Polycam, a photoscanning mobile app with a free limited trial and paid yearly subscription, which offers unlimited scans. Polycam was founded and launched in 2020 by Chris Heinrich and Elliot Spelman. The app uploads all scans to the user's account, making them accessible from the cloud on any device, and offering a large selection of downloadable model formats. The most prominent reason for choosing a mobile app over a desktop application, and higher resolution photo capture method, is time. The objects that have been scanned for this project exist in transitory areas of heavy foot-traffic. It is not tenable to remain in these areas, blocking parts of this traffic, for extended periods. Additionally, since a smartphone camera does not produce images in a raw format, the processing time for each scan is greatly reduced, allowing for an object to be scanned, processed, examined, and re-scanned if necessary, all within a relatively short period of time.

Photogrammetry software outputs the four main channels listed above, albedo (colour), roughness, normal and ambient occlusion. The UV channels and image textures are created in tandem. As the software builds a 3D model, it is simultaneously unwrapping and positioning its geometry on a UV map within an 8K (8192x8192 pixels) square, building the textures as it constructs a mesh. The final output is one mesh with up to four textures within its material.

Polycam is currently pushing towards increasing the presence of generative AI for filling in missing data in scans. This would render its outputs significantly less faithful to the original objects from which the scans were taken, more so than the inclusion resulting glitches and flaws of the scanning process would. These glitches and deformations in each scanned object would be smoothed over with the guesses of an AI, filling in the gaps of data with whatever it determines would fit best. While this may help create a more cleanly finished 3D model and texture, it would be through the use of data that does not originate from the source object, lowering the actual fidelity of the final model. This implementation of generative AI would make the intent of this project unachievable, since the mistakes and missing data would be replaced with whatever an AI determines might be suitable in its place. It would be a perversion of the actual essence of each object, an attempt to create a perfect 3D asset to the detriment of capturing what is real and physical. As distorted, misshapen, and glitched as each captured object presented in this project might be, they are created entirely with images originating solely from the source object. To approximate its form and appearance for the sole intention of creating a more appealing digital object would distort the model and textures further from the source than the digital flaws of an imperfect process.

Figure 3.5 - Imperfections of a scan viewed in Polycam.

Objects as Assets

Populating any 3D scene, be it for film or video games are '3D assets'. Assets are digital files representing an object in three-dimensional space, consisting of a 3D model and a material, data which will define their shape and appearance for use across various softwares. 'Asset' as a term can be used to refer to any 3D object that is textured and ready for use. In this thesis, the term '3D model' will be employed to refer solely to the geometric qualities of an asset or object, and 'asset' will be used to denote the totality of its mesh and material qualities. Numerous elements are involved in making a digital 3D asset complex enough to appear deceivingly photoreal. The vertices, faces, shading and image textures are all data that factor into how a rendering of an object may be perceived, be it as deceivingly photoreal or an obvious digital assemblage. The vertices are the core of an object's geometry, with each material pass and texture serving a unique purpose in the shading of a surface.

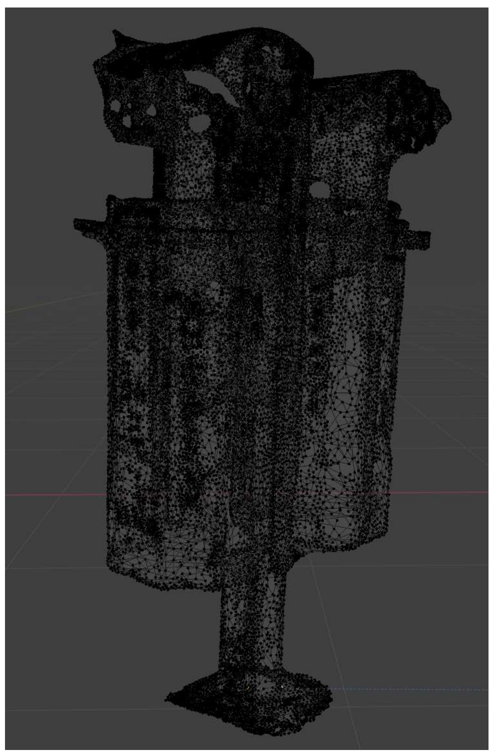

Figure 3.6 - Wireframe view in Edit Mode of a *Digital Afterlife* asset.

This section discusses two categories of assets that are commonly used to refer to those of different detail classes. The first are called 'hero assets', and are items that viewers or players will be experiencing up-close and in great detail. These present themselves similarly in films and video games, as the MacGuffin of the plot, a main quest item, a full CG character or player model or anything that will be viewed in a close-up. They are typically geometrically dense, with high resolution textures to achieve as much detail as possible. They receive high amounts of attention throughout both their creation and the animation, game or render for which they are made, as they will be a centerpiece for this piece of media. On the opposite end of the detail and attention scale lies the background asset. This asset type includes anything that will only be viewed or interacted with from a distance. These are the objects occupying the edges of a scene, the areas players are unlikely to wander, or anything whose detail can be sacrificed without being obvious to the viewer. When building a 3D scene, these are by far the most numerous assets, helping a space to feel busy and real, creating the illusion of habitation by people who may use or rely on the existence of these things.

Figure 3.7 - *Blues Mallard*, Teague Riordon. A 3D scene using many background assets.

In the physical world, we view and interact with the tangible counterparts of objects considered background assets on a daily basis. These objects can be anything beyond those which garner focus and ongoing use or are an intentional focus of daily activities. They fill the edges of every human environment, next to sidewalks, on street corners, hidden below underpasses, under the sink, in the corner of a room, the clutter on a desk or random cars on the street. They are necessary and utilised items that will often go unnoticed by passersby or those preoccupied. The objects inhabiting transitory spaces are the tangible background assets chosen for collection and exhibition in *Digital Afterlife* as foreground assets.

In the 3D creator space, countless asset packs exist in a huge variety of styles, and range from custom made models and textures to photoscanned plants and buildings. These are mostly created by individual professionals, studios or corporations, resulting in a elevated standard of asset quality, some of which go on to be used in films or high-level animation projects. These packs most commonly contain objects that will be used in repetition as background assets, as games and animation will typically feature custom focal assets designed specifically for a given project. These asset packs are designed to be used in many different projects without the viewer recognizing that they may have seen them before, as their contents will rarely be used as the focus of a piece. Their intended use for repeated assets that exist only at a distance also leaves them with a fairly low resolution, as the repetition and frequent use of them within a scene requires optimization. For these reasons, they are typically unfit for use up close or as hero assets, having reduced resolution and potentially easy recognizability as assets from a pre-made pack.

The ubiquity of so many high quality objects has sent the 'lower quality' end of 3D assets to this graveyard of neglect, where they sit unused. This perceived low quality may be determined by bad textures, deformed meshes, or simply unseemly mesh topology, making each of them unpleasant for professional use, with more agreeable options available. *Digital Afterlife* showcases objects that would likely dwell in these digital background asset graveyards, removing and repositioning them into an ethereal limbo, an afterlife comprising these objects. These spaces have been filled with 3D scans that would be discarded and declared unusable for the vast majority of projects. It readjusts the background and forgotten into the foreground, now placed centre-stage as the main focus of their own project.

Chapter 4: Observing an Afterlife

Digital Afterlife can be viewed at a reduced resolution at the following link: https://t.riordon.ca/digitalafterlife

Digital Afterlife is a fully computer generated video constructed to simultaneously evoke an emotional investment in the treatment of the inanimate, and to question the nature of digital, photoscanned objects, and their relationship to the real objects they represent. Its subjects are the dirty, banged up and graffitied inhabitants of the transitory urban environment. These objects are reconstructions of things most often overlooked and neglected, and, simultaneously, assets that are inherently flawed or suffering from glitches of an imperfect photogrammetric process. They would be discarded or ignored in the 3D world in favour of more optimized, well textured and glitch-free alternatives. Spliced together from multiple thousands of still images, *Digital Afterlife* forms a lengthy video containing a series of three different settings through which the objects transition, these being ‘Limbo’, ‘Afterlife’ and ‘Empyrean’. Every frame has two distinct versions that play out simultaneously and in synchronicity with each other. One half of the video piece exhibits the objects in full colour, with their extracted materials, roughness and normal data on display, while the other replaces these high fidelity image textures with stark white, washing away any additional detailing that is not otherwise present in the geometry of each object.

The following sub-chapters will delineate how each scene unfolds, their content, and a breakdown of their individual elements, organised into their distinct segments. *Digital Afterlife* contains three main settings, each displaying the scanned assets in a different environment, and serving to illustrate different aspects of them. These settings will function to organise this chapter, covering both versions of the scenes.

Asset Limbo

Digital Afterlife opens to two sprawling ‘limbos’ of roughly twenty digital objects. They are scattered, seemingly haphazardly, in a liminal environment. Water ripples slowly at the edges of the scene as a vast, flat island stretches into the horizon. This setting is nowhere, a nondescript digital limbo created solely for its current inhabitants. The clouds overhead remain fixed in the sky, unmoving as time unfolds. The camera is positioned lower to the ground than an average eye-level. The scale of every object is true to the dimension of their physical counterparts, but nearly all appear taller than the viewer. This viewing angle is suggestive of the photoscanning process, wherein one must squat close to these shorter objects, capturing them from low angles to extract the desired details. This also has each object appearing more imposing, occupying the centre of frame and thus more demanding of the viewer's attention. Having each object occupy the centre of the frame allows them to be less distorted by the angle of the camera, and permits each detail to be more clearly visible. As many of the objects are shorter in stature, it is a more neutral manner in which to view them, rather than looking down on them from a truer eye-level.

To more effectively guide the viewer's focus, a shallow depth of field blurs the background elements of the scene, shifting from object to object as the camera passes by them. The camera shakes slightly, gradually bobbing forward in a straight line, never turning, but consistently looking forward. This slow movement is deliberate, allowing the viewer to linger on each bit of detail as the scene unfolds. The constant motion of the camera and the slow lapping of water at the edges of the frame are the only moving components in the animation. This is no digital spectacle or excess of commotion to distract from the subjects positioned about the landscape.

A post with an electrical box affixed to it occupies the right side of the frame, with a graffitied bin and post beyond it. The camera pushes onward through the imposing field of digital reconstructions, as the focus shifts from one item to another as it travels on its undeviating path. A few seconds in, the post to the right flashes to white, and gradually the entire right video begins to lose its colour, slowly deviating from the left video as the camera progresses through the environment. The ground loses all colour as the sky begins flashing to grey and white. We see now, as colours are gradually removed, that the cohesive island is made up of multiple planes, different objects stitched together to create the illusion of one surface. The entire right side of the video is now slowly pulsing between full texture and a stark colourlessness wrapping around the forms of each object.

Figure 4.1 - *Digital Afterlife* stills in a 'limbo' scene.

The colours to which the sky and objects transition were chosen to represent Blender's default viewport of an unrendered scene. This viewport view displays objects surrounded by a grey void of hex code 2E2E2E. This even grey is the default backdrop of all projects in Blender in the wireframe and solid viewports, in which objects are untextured, represented only by a light grey which covers their entire surface. This lighter grey of the untextured objects has been replaced in *Digital Afterlife* with white to allow their unevenness to be made more prominent by the shadows each object casts on itself. The right side of the *Digital Afterlife* is designed specifically to exemplify an enhanced version of the working view of a project in Blender. This motif continues for the 'afterlife' and 'empyrean' scenes which compose the rest of the animation.

Figure 4.2 - An object in Blender's solid viewport, with default settings.

The camera continues pushing forward, extending deeper into the scene to reveal more objects. Some of these white objects contain remnants of the colour data that used to be present on them. They have ridges and bumps, outlining graffiti, stickers, posters and scuffs. Since the photogrammetry process is imperfect, some of an object's colour may be incorrectly interpreted as geometric data, this can be caused by a different in reflectivity, a harsh shadow cast by the sun coming through a chain link fence, confusing a black sticker as a hole, or seeing a scratch as a raised surface defect. The colour data may be removed from a 3D item, but even when viewed without it, the interpreted indents of a dark sticker, the raised surface of a poster, or melted geometry of a bright sun spot will remain. These imperfections have been irreversibly calculated into the mesh of each object. The unevenness and misrepresentation of their surfaces becomes even more obvious when it is no longer hidden by shades of colour and other detailed data. To remove the colour data lays bare these faults of the scanning process, exposing the unique geometry of each scan, and making more apparent how this geometry differs to the source they were scanned from. Highlighting these areas exposes certain inner workings of the photogrammetry process, and how it functions as a whole. It displays where this preservation method has harmed the fidelity of the object, where it has bent, twisted or shorn the geometry to create something apart from its precursor. The creation of geometric deformations through each change in colour is substantially more obvious when that colour is absent, when there is no longer anything to mask the geometry. As the long track of these scenes approaches the end of the scatter, everything in the right scene has lost its colour, now made up of shades of white and grey. They are just their geometry, ridges, holes and warping revealed by the shadows cast on them from above.

As the motion of the camera slows, it returns to the start of the scene, the camera placed in a closeup of the opening object. This segment shifts its focus to shorter close-ups and pans of each object in turn, cutting every dozen seconds to a new detail or subject. The two sides of the video remain in sync, but the angles and positioning of the cameras are no longer identical to each other. In lieu of the contrasted textured and colourless views of each object, the left video focuses on the material imperfections of the physical objects, those present in both the photoscans and their real world counterparts, while the right side concentrates on the generated deformations and distorted geometry. This juxtaposition contrasts more directly the imitation of the real with the obviously digital, demonstrating the areas that have been distorted in their capture, the flaws caused by lack of understanding of each object's material and form. It shows, up close, the effect that photogrammetry has had on the mesh and texture together, where one has influenced the other, accurately or inaccurately to their physical counterparts. It contrasts where the software has correctly understood the difference between form and material, and the areas of struggle in replicating a portion of the physical into its digital reconstruction.

Figure 4.3 - *Digital Afterlife* stills in a 'limbo' scene (close-ups).

After the completion of the following scene, which will be discussed in the next section, the animation returns to another 'limbo'. This scene features a new set of objects, comprising the half that were missing from the earlier collection. The animation plays out identically to the first, maintaining the same frame count and camera trajectory as the previous 'limbo'. The videos begin as mirrors to each other before diverging to textured and untextured variants. The two scenes have been separated in part due to the limitations of hardware, as it is exceedingly difficult to work with up to sixty objects all containing numerous 8K resolution textures and dense mesh geometry. They have also been separated into two spaces to allow the viewer to maintain a frame of reference when the close-ups begin. The objects from the 'limbo' should remain relatively fresh in their minds as they see these significantly more isolated shots. This section of the animation continues into its own close-ups as discussed before, now focusing on the qualities of the new objects present in this 'limbo'.

*Digital Afterlif*e features an audio component that carries through for the duration of the piece. This audio is composed of a series of lengthy recordings within transitory spaces. It has vehicle noises, honking, pedestrians and trains, all layered with an eerie ambience or wind and light synth. This audio exists more than anything to ground the viewer in the experience of the animation. The layered sounds, while slightly off-putting, are also meditative, occupying another sense and helping the viewer to block out other distractions.

An Afterlife

Having completed the trek through the limbo, the video now displays solitary objects, mirrored on both sides of the video. These electrical boxes, garbage bins and lampposts float in voids of orange and grey. They have ascended above their previously grounded setting and cast off the deception of photorealism to occupy their own digital space. Each asset now levitates in solitude, unimpeded by any surrounding elements.

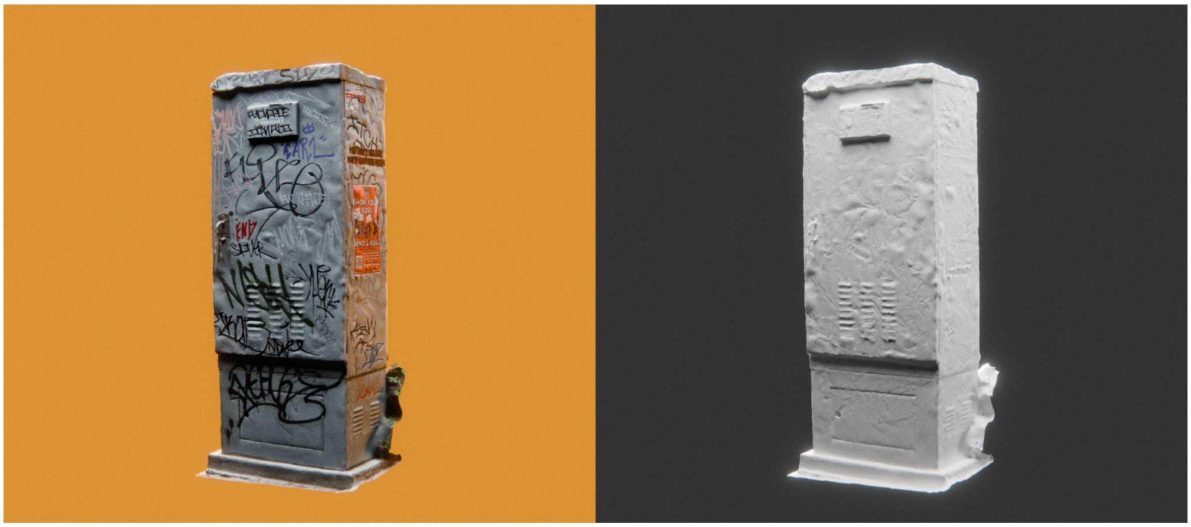

Figure 4.4 - *Digital Afterlife* stills in an 'Afterlife' scene.

These high bloom scenes exhibit each asset in its full form, picked from the limbo scenes for detailed display by themselves, no longer in situ with their peers. On one side of the video each asset is fully textured, while the other portrays stark white, textureless geometry. The monochromatic backgrounds and high levels of digital bloom ensure that these scenes stand apart from the more muted tones of the others, while adding an obviously 'enhanced' element to them. The bloom surrounds the objects in a highlight, glowing around their edges, basking in the surrounding light as they rotate. The plain backgrounds allow each asset to command the full attention of the scene, uninhibited without other elements present to distract from their forms in the scene. The previous limbos were populated with many different objects, some hiding portions of others. Here they are allowed to breathe individually, set apart from each other.

As in the wandering of the limbo sequences, the objects depicted on either side of the animation are alternately in full colour and a flat white. The white displays only their geometry, stripped of all colour data, roughness maps and normal data. This fully untextured view of the objects highlights their raw geometry, no longer hidden beneath layers of image textures. This full view of the white objects makes even more obvious than before how photogrammetry has altered their structure. The areas where the graffiti, chipped paint and discolourations have been baked into the geometry of each object can be viewed in full. Every displaced vertex, scuff, distortion and glitch that may have been hidden in the previous scatter can be seen as they spin slowly before the viewer.

The orange surrounding the left screen's specific HEX code is F39A00. This represents the default outline colour of an object when it has been selected within Blender. It surrounds the contours of objects as a visual indication that it is the most recently selected object, onto which all operations will be applied. Similarly, it is utilized here to highlight the currently 'selected' object on display in the video, calling attention back to the processes employed throughout the piece's creation. As mentioned above, the grey of the right side of the video mirrors the working view of a project while it is still in Blender, with the white referencing the untextured objects existing within the default solid viewport.

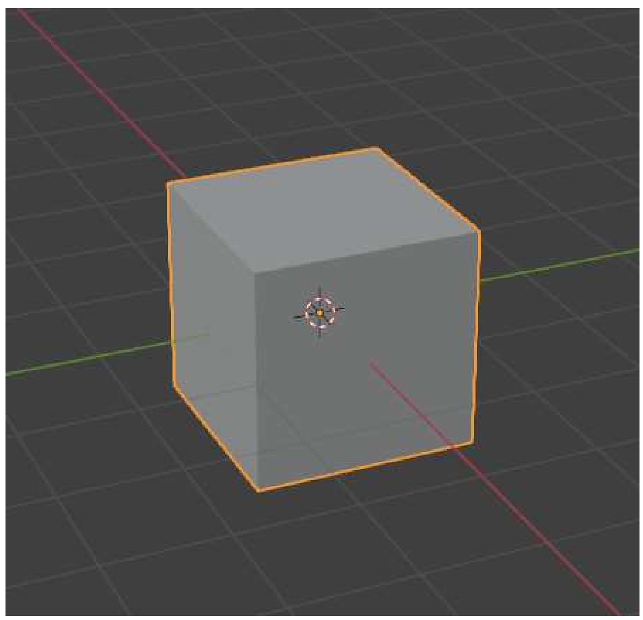

Figure 4.5 - Selected default cube in Blender.

The camera remains fully static for the duration of this scene, the only motion being the slow spinning of each object as they cycle through the total collection. This collection mirrors all of the objects previously showcased in the 'limbo'. Every object receives the same duration of screen time, each completing a full revolution before moving on to the next. As with the previous scene, there is a second 'afterlife' that follows the subsequent 'limbo'. This scene once again features the same assets included in this second 'afterlife', with each rotating in turn, mirrored on either side in their textured and untextured versions.

Empyreal Array

Featured at the end of the two videos, the ‘empyrean’ scenes form the final step in the journey which these assets undergo. The empyrean is the highest heavenly sphere in medieval cosmology, an ultimate paradise of light (Case 2022). The objects here have completed their ascension from the previous ‘afterlife’, and are now elevated to this empyreal plane, lifted far above the grounded limbo, shifting as one larger piece. These scenes feature arrays of collected objects, coalesced and interlocking, expanding and contracting to create massive, imposing structures. This is the culmination of the previous scenes, every object now assembled into their final configurations within the animation, an artwork composed of the neglected to build on their individual forms together. It demonstrates the beauty that these artefacts can hold beyond their own forms, focusing on the collection as a whole, rather than analyzing them for their individual qualities, as has already been done for the duration of the piece.

These scenes take full advantage of a 3D creation process to produce physically impossible floating formations, offering a sharp break from the simplicity of the previous scenes and their focus on individual objects. These sequences are a celebration of the mundane through angelic formation. The initially static camera allows the full majesty of these configurations to be absorbed before slowly pushing closer. The assets are arranged to afford each one some amount of individual space amidst the larger form, having a clear view of its surface at some point as the structure evolves.

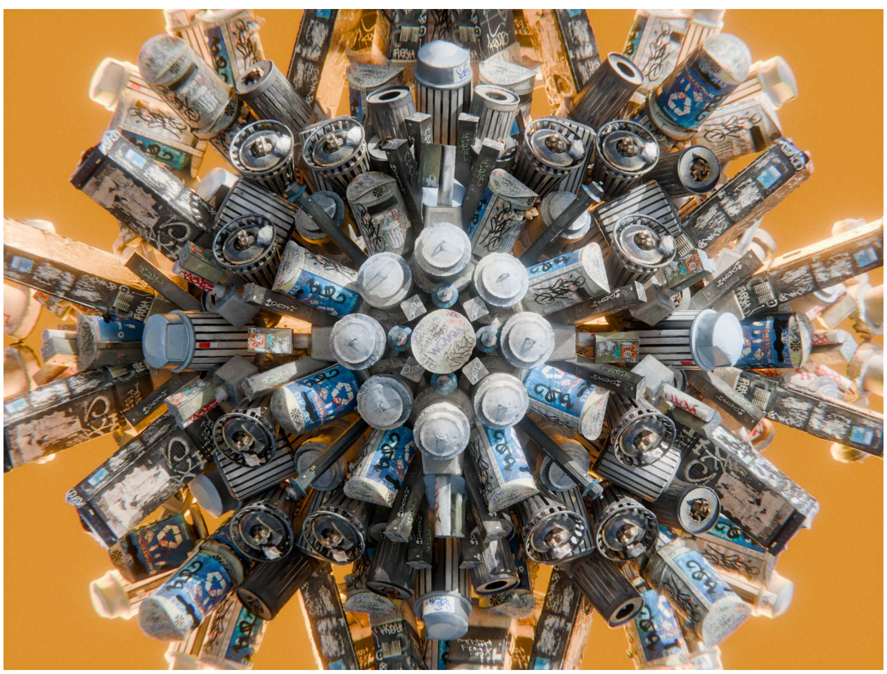

Figure 4.6 - *Digital Afterlife* still from an ‘empyrean’ scene

Throughout these scenes, the composition and camera movements of both sides of the video remain mirrored, the two configurations ebbing and flowing in sync with one another. As has been the case throughout, the right side of the video is devoid of colour data, surrounded in a grey expanse, while the left side is set on a backdrop of bright orange, with objects displaying the full colour of their captured material. As the camera slowly pushes through the surrounding void, the immense shape is gradually pushed out of view, until it is inches away from the central object. The camera rests at its destination, sitting in front of the central asset before this object is then instantaneously replaced with another. The camera now begins pushing outwards, away from this form. As the extremities of this formation come into view, until it is once again viewed in full. Here again, the camera rests, admiring the full view for a moment. Each object has been completely replaced with another, forming a new structure with a new composition. After the brief pause the camera once again begins to move closer. It pushes closer to the formation, mimicking its prior movements. Reaching a few feet from the centre, it stops for the last time. It rests here a bit longer than before, lingering on this last object. If viewed in a gallery, it now cuts abruptly back to the start of the piece, or ends, if viewed online.

Figure 4.7 - *Digital Afterlife* still from an ‘empyrean’ scene close-up.

Chapter 5: Analyzing an Afterlife

By the end of the empyrean sequences, the assets have embarked on their full journey through *Digital Afterlife*. Beginning in a strange transitory limbo, they entered an afterlife as individuals, each displaying their own unique imperfections and deformations.

Digital Afterlife is composed of 55 individual, photo scanned, 3D objects. Each scan is of a unique object, all captured at varying times of day and weather conditions. They range from garbage bins, to electrical boxes, lampposts and concrete barriers. This chapter will document every methodological step taken, covering the entire journey from tangible objects in a physical world, to the intangible assets seen in *Digital Afterlife*. It records the collection, repairing, and optimizing of these objects, their placement into their scenes, the animation and post-processing, and the reasoning and relevance of each of these steps. The methods employed in the creation of *Digital Afterlife* are essential to the final forms of the objects it catalogues.

Foraging for Urban Assets

As with traditional and historical foraging, photogrammetry requires that certain seasons and weather conditions be observed, requiring even light and a lack of wet or snow for optimal scanning practices. This section details the preparatory and active operation of photogrammetry, beginning with the steps involved in selecting objects for scanning, and those necessary to complete a successful scan.

To begin a project based around a collection of urban 3D assets, that collection must first be created. The very first step in starting work on *Digital Afterlife* was to establish a framework for selecting appropriate objects for scanning. What qualifies as a 'neglected urban asset' in a transitory space? The qualifiers determined for this project relate to the nature of an object's use, the feasible length of time across which said use would transpire. They should exemplify the "spaces formed in relation to certain ends, and the relations that individuals have with these spaces" (Augé 1996, 94). It is not enough for an object to simply exist within a transitory space, it should also epitomize the relationship that individuals have with these spaces and the manners in which they interact with them. They must be objects utilized in a manner that would ensure no prolonged close attention is given to it, just as the imperfect products of photogrammetry and neglected 3D assets see little use or notice. This removes certain objects like benches and bus stops from inclusion, which are more likely to be cared for in cleaning and repairing as a product of their regular and semi-extended use. This extended use, seen by objects made for momentary human occupation, also removes them from qualification for the purposes of *Digital Afterlife*.

Digital Afterlife specifically showcases urban things that are engaged with over a very short window of time, or passed by without any notice. These things are the garbage bins into which litter is tossed into on the sidewalk, the lamppost that lights the path to the metro but whose base or greater form is never really observed, the random short post outside the bus stop that you don't quite know the purpose of, or the electrical box in an underpass that houses some unknown electrical mysteries. Each of these represent a category of object that inhabits every urban setting, often necessary to the greater functioning of that area, but whose state, forms and material exteriors are perpetually unnoticed, neglected, uncared for or totally disregarded. These are the objects that have been chosen for scanning, preserving and exhibiting within *Digital Afterlife* through means of a fitting yet imperfect process in order to create digital reconstructions that mirror their physical precursors. Each 3D representation of these objects will inherit its own sets of flaws, bestowed onto them by a method of imperfect photogrammetry.

Creating a 3D object from a series of photographs requires a hefty amount of data. The minimum number of photos recommended by the Polycam app is 200 images, though most of the scans done throughout this project approached 1000 or more, with an imposed limit within the app of 2000. When taking these images, it is important to orbit around the object slowly and deliberately, capturing it from low, high and frontal angles. Capturing it from afar will ensure that the software has a good sense of its general shape, but it is also necessary to capture it from up close to extract the most minute details. Another key practice while photoscanning is to take photos consistently and in constant sequence. If the camera's location or angle is changed too drastically, and there is not enough data in between its current and previous position, the processing software may not be able to comprehend where things are in relation to each other. Polycam will automatically take photos when it detects that the scene angle or content has changed sufficiently, but this is not always accurate enough to rely entirely on. It is sometimes necessary to tilt the camera slightly after shifting its position to guarantee it takes a photo. The meticulous circling and attention taken to capture every facet of each object goes far beyond the forms of attention these things generally receive. In lieu of being ignored fully or perceived briefly from one angle, they are carefully documented from every possible perspective so that their digital reconstructions may thoroughly represent their material surface to the fullest extent.

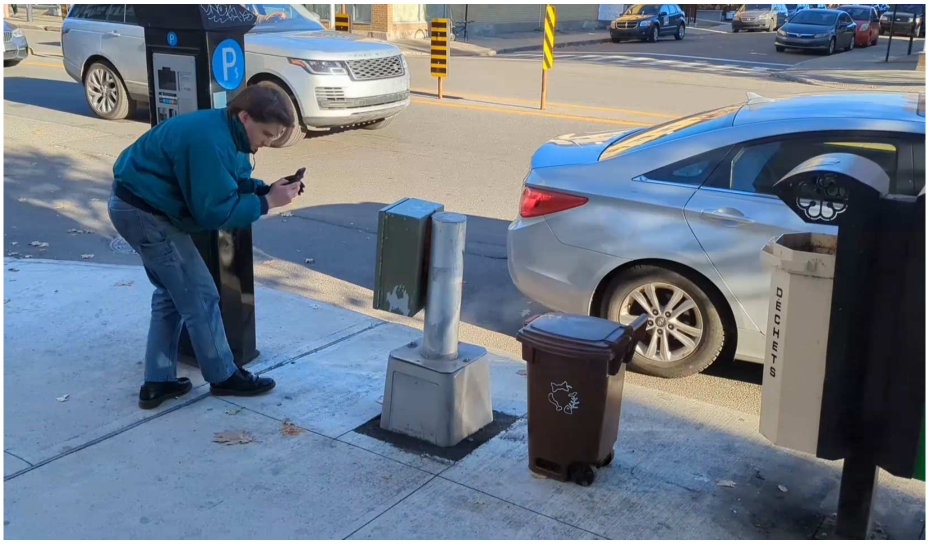

Figure 5.1 - Scanning of a small electrical box on Rue Jean-Talon.

Unlike with most digital cameras, a smartphone, which was the capture method for this project, cannot easily be put into a manual mode. This means that the phone is constantly attempting to even out the exposure and contrast of an image, adjusting the focal point and trying to ensure that it is easily visible, neither too bright or too dark. This change in exposure can greatly affect the quality of a scan without care. It can create splotches that are aggressively bright, or areas that are in total darkness, losing all detail and becoming a solid wall of black in the object’s material. Avoiding this requires constant awareness and care when performing a scan, readjusting the focal point to even out the lighting and guarantee that the area currently being scanned is properly exposed. Express care must also be taken in avoiding all external factors that may disrupt a scan, beyond just the processes occurring within the camera and scanning software. Depending on the lighting conditions of the target object, the scanner’s body may block light, projecting their shadow onto the object they are attempting to capture, and embedding it into the resulting scan. Mindfulness of the position of one's body in relation to light and the target object must therefore also be maintained. The camera can be angled, extending it away from the body, or rotated to avoid the capture of these shadows. The viewing angle can also aid in eliminating the reflection of harsher light. Capturing a surface at an acute angle may cause the light reflecting off the object to be blindingly bright, erasing all detail. Maintaining an oblique angle when capturing surfaces of an entity ensures an even reception of light. While this project works with unavoidably imperfect scans, these imperfections are not meant to be intentionally generated by the user of the scanning software, but are simply a ‘natural’ occurrence as part of the scanning processing. Any actions that can be taken on the user end of photoscanning to mitigate the glitches in a scan have been, be this an excess of source images, exhaustion of capture angles, attempts at balancing light or simply maintaining focus. They are all captured with diligent care and attention.

Figure 5.2 - A garbage bin photographed and viewed in Polycam after processing.

Such a large quantity of images, across multiple scans, takes up no small amount of storage. Each individual scan may require up to 3GB to store and process (Polycam 2024). The meticulousness with which each prospective object is captured results in thousands of images, each important to an individual element of an object and necessary to its larger coalescence into one 3D creation. Each additional image increases the total storage requirement and processing time of a 3D mesh and texture, making it essential that every image in a batch serves a purpose . Polycam will automatically remove the images that it deems to be most unusable, be they too blurry, out of sync with other images, or over-exposed. This, nonetheless, does not absolutely prevent these types of imperfections from entering the final batch of photos selected for processing. It is not impossible for blurry or overexposed images to be selected to build a model from. These imperfect images can lead to glaring errors and material distortions, disrupting the quality of the final model more than the scanning process would by itself. Additional care must be given to weeding out bad photos from the captured batch, which involves sorting through them manually and removing those that may confuse the algorithm. *Digital Afterlife* explores the physical imperfections, those arising through photogrammetric capture, and their intersection, where a flawed capture can result in the imperfect preservation of existing imperfections.

Imperfect Imperfections

The level of fidelity of each of the 55 scanned objects to their original sources varies substantially, being heavily affected by the external conditions surrounding the object, including weather, time of day, and, importantly, environmental obstacles. Each of these additional variables affects the photoscanning process, possibly leading to the imperfect capture of an object's imperfections. This section will continue the previous discussion regarding the photoscanning process, expanding on the material output of the software, while using individual objects to exemplify the circumstances that lead to their production. It will discuss the material and external conditions that lead to the varying quality of scans, and how these circumstances caused certain digital imperfections to be produced. These factors may include lighting and weather conditions, highly reflective material surfaces, obstacles near the objects and the quality of photos used for scanning.

The most ideal weather and lighting conditions for photoscanning are the slightly overcast, dry middays in summer or autumn. These conditions avoid any strong directional lighting that would lead to harsh shadows, and any unnecessary reflections brought on by rain or wetness. The goal is to capture a form of each object that is undisturbed by external factors that would cause frequent and impermanent visual changes to its material, in order to capture those that are more permanent as faithfully as possible. Weather conditions such as rain, snow and different lighting conditions can cause an object to take on a temporary alteration that detracts from its otherwise 'neutral' state. The more even the lighting on an object, the more faithful the resulting scan will be to its original, so it is best for the sun to be coming from directly above, while being diffused through clouds, not reflected off of nearby snow or causing glare from a recent rainfall. However, when the goal is to capture a large number of objects across many settings, it is not always tenable to note down their location to return to at a later date with weather or lighting that are more favourable to the scanning process. The lighting conditions present when the object is initially discovered are usually the lighting conditions under which it will be captured. For this reason, a number of the scanned objects have these harsh lighting conditions, shadows, rainfall and reflections irreversibly baked into their material and geometry.

Figure 5.3 - *Digital Afterlife,* garbage bin asset with chain-link pattern.

The above figure of a scanned garbage bin has the pattern of a chain link fence baked into one of its sides. The garbage bin was positioned on the sidewalk, with a fence blocking off a park behind it. Captured around later afternoon, the low sun shone through the fence to create harsh shadows on the back side of the bin. These shadows are inextricable from the resulting digital object, creating patterns that appear in both its image texture and geometry.

Lighting issues in photoscanning are not limited solely to external obstacles. The surface qualities of a target object can create their own multitude of problems, exemplified most prominently through highly reflective surfaces. The reflections of light off these surfaces can result in the scanning algorithms misinterpreting the form of an object, leading to anything from a slightly imperfect surface to a large concave dent or a massive protrusion. While the human brain can make sense of reflections in a surface as separate entities viewing it with external context, algorithms are not always so clever, and may interpret the reflected images as geometric deformations of the object itself. This struggle applies to any objects that have a polished or glossy surface. The figure below is a lamp post with a highly reflective black painted surface. The surface is missing large sections, as if parts of it had been melted away. This is caused by the physical surface picking up new reflection angles in every photo, their positions changing as the camera is rotated around the object. A material that more effectively diffuses light would not encounter such issues. A strong example of this is also illustrated in the same figure. The graffitied area of the lamppost stands out in sharp relief to the melted surface around it. The more diffuse material of the paint contributes to the higher fidelity as much as the sharp colour contrast between the two materials. The contrast provides the photoscanning software with clear points of reference for constructing a model and texture, points which it cannot accurately produce in the high reflectivity of the material surrounding the graffiti.

Figure 5.4 - *Digital Afterlife* lamppost with albedo, colourless and normal texture renders.

The imperfections produced through photoscanning are not limited to gaps or large scale distortions that lighting and surface reflectivity can produce. Objects that have areas of high contrast and diffuse surfaces can still result in deformations. The image below depicts an object from *Digital Afterlife* rendered with and without its colour data applied. The right side maintains some of the details that should logically only be visible through inclusion of colour. The graffiti spread across its surface has created conspicuous protrusions and indents in its mesh, permanently baking these details into the geometry of the 3D asset and inextricably linking its geometry and colour data together. This can once again be attributed to both the stark contrast in colour and the differing reflective qualities of the two materials. This phenomenon is replicated across numerous assets in *Digital Afterlife*, imperfectly preserving the details in each tangible object at the moment of their scanning.

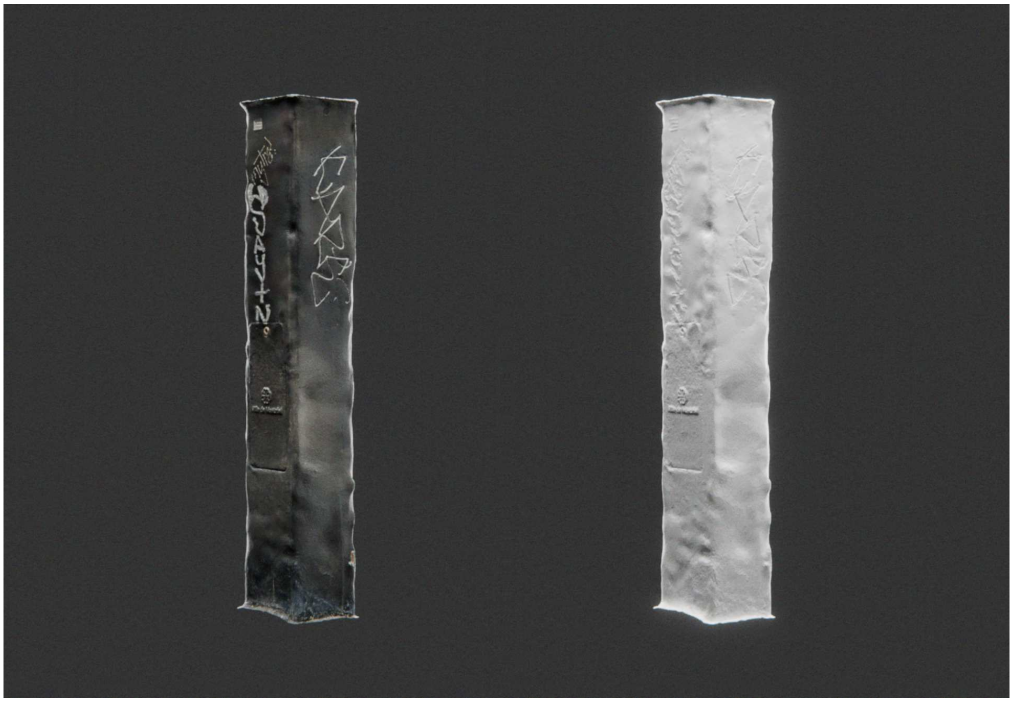

Figure 5.5 - *Digital Afterlife,* post with and without colour data.

The following paragraphs will continue to delve into the possible and present imperfections that may result in a photoscan. A handful of objects have been selected as examples of the various material conditions that can increase or decrease the ensuing geometric deformations. The qualities of form and material of the physical object, and some environmental factors, will be explored as an aid to explaining these phenomena. They will cover reflectivity, thickness of material, colour, external obstructions, and environmental lighting. The selected objects explore some common shortcomings of both the scanning practice and the software. Each object presents unique challenges to capture through photogrammetry, and a full exploration of the entire catalogue would present endlessly unique circumstances. This brief exploration into written descriptions of material qualities also emphasizes the care shown to each individual object. By describing how digital imperfections may arise from specific physical elements, it further stresses the steps that were taken to capture each object as faithfully as possible. There is care shown towards these objects in every step of *Digital Afterlife*'s creation, from the initial capture of each asset to their treatment within 3D software and within the resulting animation itself. The resulting inaccuracies of process and practice that are left on each object are examined in *Digital Afterlife* itself. The following objects have been selected to provide the reader with additional context as to the nature and involvement of their capture.

Figure 5.6 - *Digital Afterlife,* recycling and garbage receptacle asset.

The physical original of this conjoined recycling and garbage bin object is created from thin, folded steel sheet metal, painted in black, cream and green, and is covered in an exceptional amount of dirt. Despite this grime, the surface maintained a fairly high level of reflectivity, bouncing the light of the bright overcast day off its surface and creating numerous confusing areas for the scanning software to interpret. These reflections caused a number of holes to appear in certain areas of the model, and caused the sharp edges of its metal form to become distorted and uneven. This was exaggerated on the black surface, being mostly devoid of contrasting surface details, as the darkness of the dirt, and detail markers that it would leave, blended almost fully into the dark paint, leading to numerous gaps and protrusions from its surface. The city of Montreal logos punched into the upper sides of the black painted metal are its most distorted feature, warped by the imperfections of the capture process. The high gloss on this surface, combined with the relatively small details compared to its larger overall size makes it a great struggle for the software to decipher. The result is a very straight and flat surface rendered warbled and uneven. Detail is preserved but also heavily distorted.

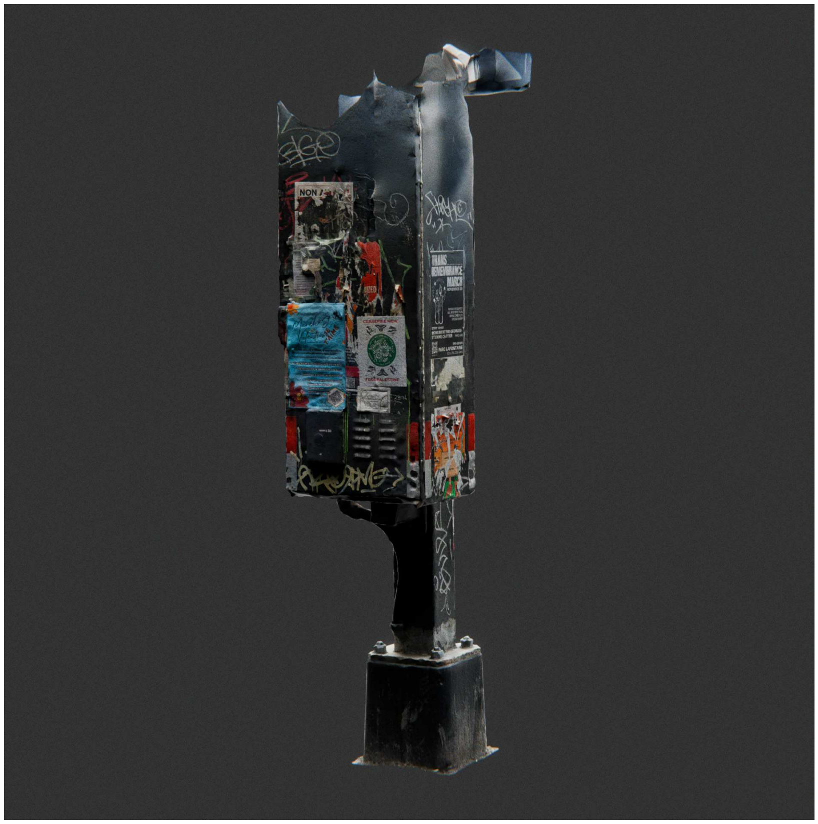

Figure 5.7 - *Digital Afterlife,* tall electrical box asset.

The remnants of posters plastered over posters cover the sidewalk-facing surface of this electrical box. Each of these posters causes its own protrusion from the geometry of this digital object's surface, leaving a warbled texture covered in small, overlapping rectangles, yet also produces a wealth of points from which the scanning software can interpret details. This asset presents the best example to illustrate the importance of scanning a surface at an oblique, front-facing, angle. Positioned higher up on a post, its top could not be scanned effectively from ground level, and is left cut open, only hinting at what was mounted above through the mangled forms at its peak. The inability to properly scan these surfaces at a proper angle forced the software to use images of them that caught harsh reflection rays, masking much of their detail. This lack of data left the material not only with a significantly lighter shade than what lies below but made them appear melted and misshapen.

Figure 5.8 - *Digital Afterlife,* small electrical box asset.

In contrast to the previous electrical box asset, this is a mostly successful photoscan in terms of fidelity to its precursor. The light olive green box of the physical object is highly reflective, which makes that surface of the asset uneven, especially where stickers have been partially ripped off. Polycam interprets the sharp changes in reflectivity and colour as changes in geometry, leaving the stickers and graffiti slightly extruded from the surface. The base of the object, though having a very smooth surface, was captured in remarkable fidelity. This is due in large part to the colour variance that comes from its light scuffing, and the diffuse material. Each easily discernible point of discoloration or material change gives Polycam a distinct point of reference to connect images across. This small asset maintains a wealth of interaction preserved on its surface, despite its imperfections. From a technical perspective this is the most successful scan of *Digital Afterlife*'s collection.

Import > glTF 2.0

This section covers the steps involved from the initial exporting of a 3D object from Polycam, to the broader processes of optimization for their use in a large 3D scene within Blender. It will explain the choices behind formatting and each individual steps of optimization and alteration applied to the objects that precede the creative phase of *Digital Afterlife*. Each step in the optimization of these assets is made with purpose and thoughtfulness in how it will affect the object's final form. The steps are diligently detailed to supply the reader with additional context to the level of care they have received.

Once Polycam has completed the process of converting hundreds of images worth of data into a three-dimensional, textured model, they are ready to be exported into a format that can be read by 3D software. While there are many different file formats for 3D models, the scans exported from Polycam for use in this project were all converted to the 'glTF' format. The 'Graphics Library Transmission Format' is a standardised file format for three-dimensional models developed by the Khronos Group (The Khronos Group). The official Khronos PBR specification supports alpha channels, colour data, ambient occlusion, roughness, normal data, refraction indices, and all other relevant PBR material properties. This format minimises the storage size of 3D assets and decreases the time needed to process them by losslessly compressing their mesh and texture data. The compression algorithms that store this are highly efficient without sacrificing image resolution or the geometric density of the unpacked models. When working with files that contain upwards of sixty highly detailed scanned models, every possible amount of optimization and efficiency must be taken advantage of, all without sacrificing detail and fidelity to the original object. The glTF format ensures that when an object is exported, it maintains all of its data so that it can be efficiently imported into a project file as faithfully and seamlessly as possible.

Working with dozens of these assets in one scene leads to the necessary allocation of a significant amount of memory and storage, greatly slowing down workflow and increasing render times. This high amount of data would pose no problem if not for the inescapability of hardware limitations. This section details the steps taken to decrease the size and unnecessary complexity of these assets, both in their geometry and textures, while maintaining the a level of detail that does not sacrifice any elements that they share with they precursors, or eliminates aspect of them that denote them clearly as imperfectly captured digital objects. Maintaining small, complex details is desirable, especially those that are present as a direct result of errors in the photoscanning process. The aforementioned unnecessary complexity arises from overlapping vertices, which is extra geometry that cannot be seen in the final product, and makes the assets more cumbersome to work with. Further optimization eliminates geometric details that simply will not be seen in any finished product. This is most commonly exemplified with multiple vertices being used to divide a flat plane, when only those on its boundary are necessary. The initial output of photogrammetry software tends to have a proportionally consistent geometric density. Areas with high amounts of detail will contain many more vertices than long stretches of completely flat surface area. These flat areas may still be more dense than is necessary or practical, with many of their vertices having little to no surface variation. This added complexity does not create more visible detail in the object's mesh, but requires extra processing power to maintain. Removing these invisible details improves the workability of the file and reduces render times. Maintaining the maximum resolution of each individual 3D object would be ideal if not for the very real limitations imposed by the available hardware. As such, simplifying these meshes allows for more objects to be placed within a single scene, furthering the ease with which they can be subsequently displayed and shown care, while increasing how many can be included in a single scene.

To begin optimizing each photoscan, the processed assets were first imported, in small groups, to a specialised Blender scene, with a layout created solely for the purposes of optimization and clean-up of photoscans. Until the photoscanned models were brought into this scene, it contained only a cube and an 'empty'. The first of these objects had a number of modifiers applied to it, each geared towards geometric optimisation. The modifiers were set up so that they can be quickly copied onto the photoscanned objects to create an efficient workflow. The empty object will be used to place the origin point of each asset. The origin point is essentially the 'centre' of an object, and the point around which it will move and rotate. Keeping this consistent across each asset is essential for placing them in scenes later on, and ensures that they can be accurately positioned on surfaces and rotated accurately and efficiently.

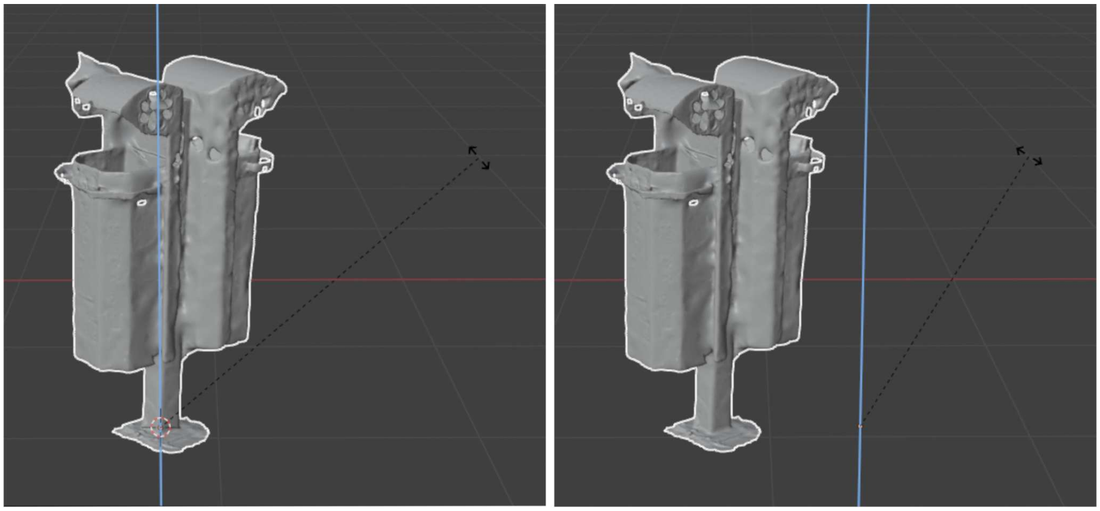

Figure 5.9 - Rotation around differing origin points.

While glTF may be an optimized format, Polycam's output does not always share that quality. The algorithm used to stitch the images and geometry of a scan together does so in tiles of varying size, all fitting together like pieces of a large 3D puzzle. These tiles, while part of the same object, do not always share closed or connecting geometry, they are not actually connected to each other in one mesh. This results in potentially tens of thousands of duplicate vertices and many overlapping geometry segments. The first step in optimising the geometry of a photoscan from Polycam was to merge this duplicate geometry. Depending on the density and scale of the asset, this can result from anywhere between a hundred to ten thousand vertices being merged together. Merging geometry works with a distance factor, which dictates the distance that can exist between two points before they are merged into one. In most cases, this distance can be left at its default setting of 0.0001m, or one hundredth of a centimetre. Every asset used throughout this project has a high degree of variance in their geometric density, each containing at least one area in which its vertices are less than a centimetre apart, while also having larger spreads of up to ten centimetres between vertices. If the distance is too high in the merging settings, there is a risk of combining geometry that represents not only key details in the denser portions of the model, but could also distort the UV map output by Polycam across its entire surface. All of the overlapping and duplicate vertices represent the borders of the tiles that Polycam has used to assemble the model and UV map, and as such, merging them does not affect its UV unwrapping. The goal of optimisation and clean-up at this stage is to make the photoscans easier to work with while avoiding sacrificing any detail in the asset.

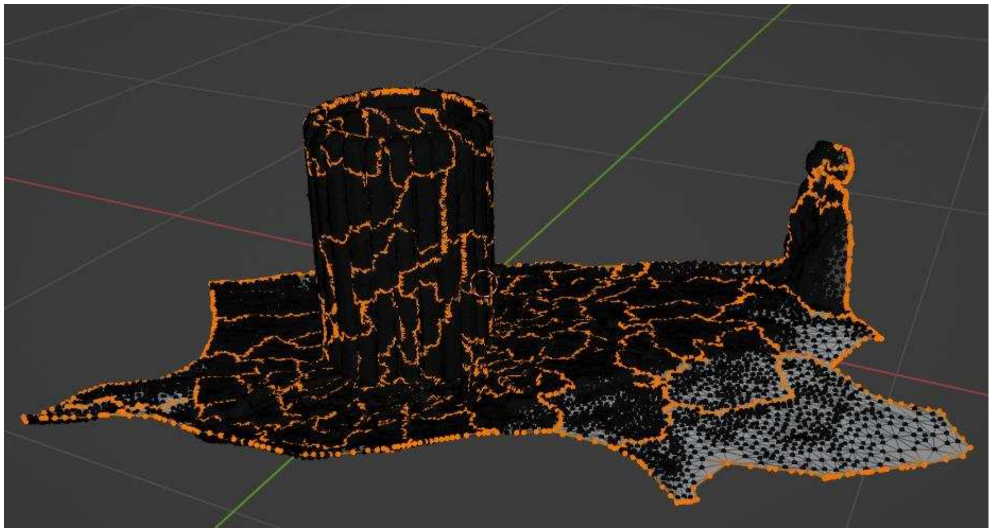

Figure 5.10 - Highlighted overlapping edges of each tile, which are not connected.

Merging duplicate geometry or other serious alterations to the geometry of a mesh can lead to problems with pre-generated normal data. Split normals are geometry data outside of the 'normal' image textures that affect how light interacts with a 3D model through baking, specifically for cases in which the geometry of those models is split into large tiles. It ensures that the splits do not show up as unfavourable errors or seams in the normals of the model. These custom normals are automatically applied by Polycam in order for the models to look cohesive and realistic under the unrealistic lighting conditions of the app's preview. When this split geometry is merged, the geometry that the custom normals were mapped to no longer exists, and Blender struggles to understand how to map them onto the new geometry. This results in the normals of each face essentially pointing in random directions, leading to massive distortion in the shading of a model. To fix this, and re-establish consistent normals in a model, the custom split normals must be cleared. These normals by themselves are also not always conducive to getting realistic lighting results in a render. They have been designed to make the resulting scan look more realistic within Polycam, which uses a rudimentary real-time render engine for lighting, and will usually create unneeded contrast and unrealistic reflections when viewed in a raytracing engine. The normals generated by Polycam exemplify a level of care within the algorithm to understand the interaction that certain faces of the physical object have with light. They provide additional detail to the shading of the model that extends beyond its geometry. This care needs to be somewhat reformulated to work within a different render engine with different constraints. Clearing these custom normals and recalculating them based on the final geometric form of each model allows them to work in tangent with their normal maps to accurately reflect light within a raytracing render engine.

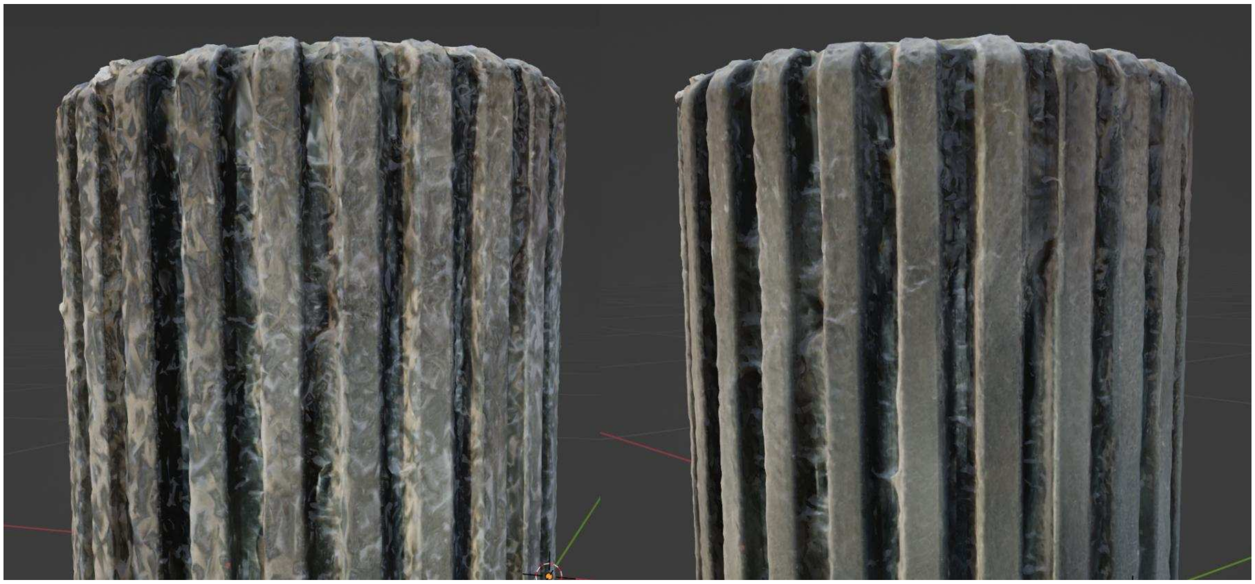

Figure 5.11 - After vertex merging. Custom split normals (left), custom split normals cleared (right).

Following this merger of potentially thousands of duplicate vertices, the remaining steps do not offer quite the same level of geometric reduction or optimization. Within Blender's properties panel, there is an available modifier called 'decimate'. The decimate modifier allows for remeshing of 3D objects, deleting and reforming their geometry with an available slider. Using its base settings, this modifier would distort the UVs of any textured mesh, resulting in stretching and shearing of image textures, as previously mapped geometry is reshaped or removed altogether. To avoid this distortion, settings are chosen better preserve the texture mapping and geometric details of the objects. The 'planar decimation' option attempts uses the existing planes and faces within the mesh as points of reference, maintaining their general integrity as much as possible. In essence, it attempts to remove extra vertices in parts of the mesh that are already flat surfaces. This can usually be successfully accomplished with a level of 5°, meaning the modifier will only remove geometry if its surface angle falls below this. Exceeding this level of decimation may remove desired detail from the mesh and reduce its integrity, causing extra surface distortions. The UV subset of this setting follows a similar principle to that of planar decimation, but instead of just the faces of the mesh, it uses the preexisting seams in the UV unwrap as guides when reducing geometry. Keeping this setting below 5° also avoids any textural distortion as the software attempts to preserve its UV unwrapping. The figure below illustrates an example of what an object's mesh undergoes through planar UV decimation. The example shown below has been exaggerated to more clearly demonstrate the results of the process, with the modifier being set to decimate beyond 15°. This level of decimation reduced the vertex count of the mesh by 38,139 vertices, resulting in nearly forty thousand individual points that no longer need to be accounted for by a computer when handling and rendering this particular file. The need for using this modifier also stems from increasing the workability of each model. Without any hardware limitations, each model could be kept as geometrically dense as Polycam could produce. To put these objects on display with each other, and not each be rendered in very small groups, they need to be optimized to some extent, made easier to work with so that they can be shown.

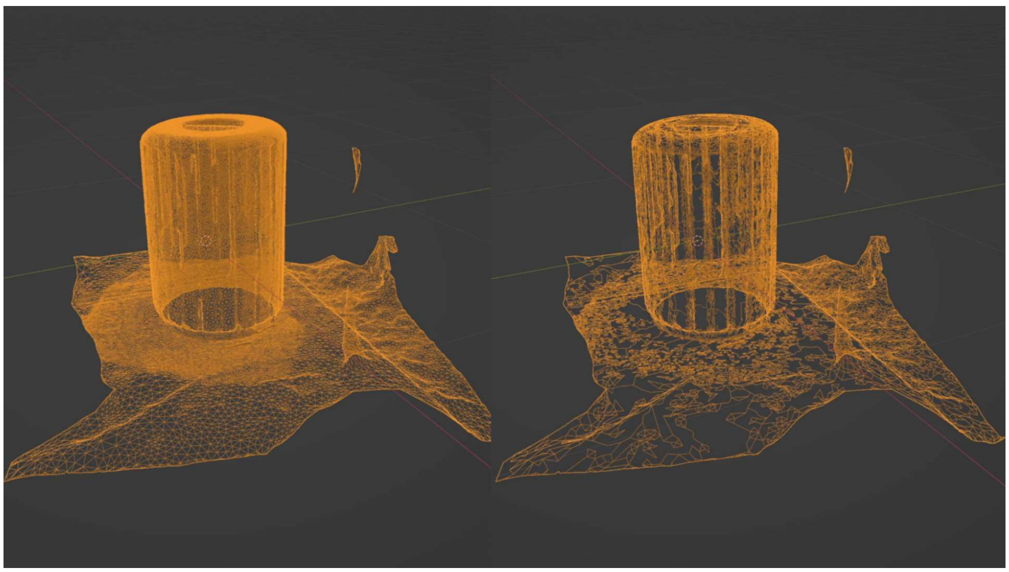

Figure 5.12 - An exaggerated example of geometry decimation.

Every version of an asset in *Digital Afterlife* keeps the highest level of geometric density and texture resolution possible within the constraints of the hardware. This is assisted through the use of instanced objects instead of creating duplicates to fill the composition of a scene. As discussed in Sutherland's work, instances maintain linked geometry and materials between each other. The changes that are made to one instance are made to them all simultaneously, making the instances essentially identical objects in multiple positions, able to be viewed from different positions within one scene. No matter the number of times an object is duplicated, as long as it continues to share the same material as its original, the image textures that lie within the material need only be loaded once. Were this object to be duplicated, and a new material, with a lower resolution of image texture, applied to it, it would still take up additional resources that would otherwise go unused were it to continue sharing the same material. This means that it is counterintuitively more efficient to keep the higher resolution textures for every instance of the objects.

File > New > General

The decisions made throughout the broader scene creation and animation process will be examined here. The choice of the three main styles of shots throughout the project (photoreal, red/white, and the array sequences), will be studied for how they reflect the philosophical theory and research behind them. This section will go on to analyse the individual scenes and how they were created, on both a technical and creative level, exploring the environment of the 3D files themselves. This methodological process, the decisions made in how to display the digital representations of physical objects, and how to connect their materiality is inextricably intertwined with the essence of the thesis. Care is taken throughout this creation process in ensuring each object is displayed in a manner through which each facet, dent, glitch, shorn texture, scratch and geometric deformation, can be seen. They are visually exhausted for every element there is to see, and are afforded the space and the time necessary to be presented and seen in full. The project will always fall short portraying the “ungraspable terms of every relation” (Harman), but it strives to allow the viewer to come as close as the medium allows. *Digital Afterlife* seeks to display as much of the endless layers of interactions that shaped the current state of each object as can be seen. This section will focus on the core of the creative decisions in *Digital Afterlife*, those involving overall scene composition, lighting treatment and the reasoning behind them.

A blank Blender file was the starting point of *Digital Afterlife*, into which each asset was imported through Blender’s asset library to begin blocking out a scene. The traditional method of scene blocking in 3D is to use primitive shapes (usually rectangular prisms) to establish composition and create an outline for where to place or model assets. In *Digital Afterlife*, all the assets have already been acquired, as such the blocking phases were done using the assets themselves. Careful consideration was given to each object receiving an equal amount of time as the focus of exhibition, ensuring they can be fully observed, superseding a merely aesthetic scene composition. While the placement of the assets may appear haphazard to an external viewer, care was taken to allow each object space to breathe and exist in its own space. There should not be too much masking of any individual object, and there must be enough physical distance between the objects that their details can still be properly seen as the camera passes through the scene.

As the objects are positioned throughout the scene, the camera’s movement was determined with them. The movement of the camera is the viewer’s lens into the scene, and every element of these scenes was specifically designed around what the camera would see at any given moment. The placement of each asset was dictated by the perspective of the viewer throughout the extended shots of the piece. Each object is carefully placed along the path of the camera to ensure that it is experienced in full. Objects having space to exist on their own from a top-down view is not enough, this sense of individuality must also be felt as the camera navigates the whole. Consideration was also given to the scenes as experienced through the eyes of the viewer and the camera, their composition determined by its specific angles. A duration of approximately two minutes was chosen for the longer tracking shots. This allows the camera to keep steady pace, and for each asset to have a fair amount of time allotted to it to be the temporary focus.

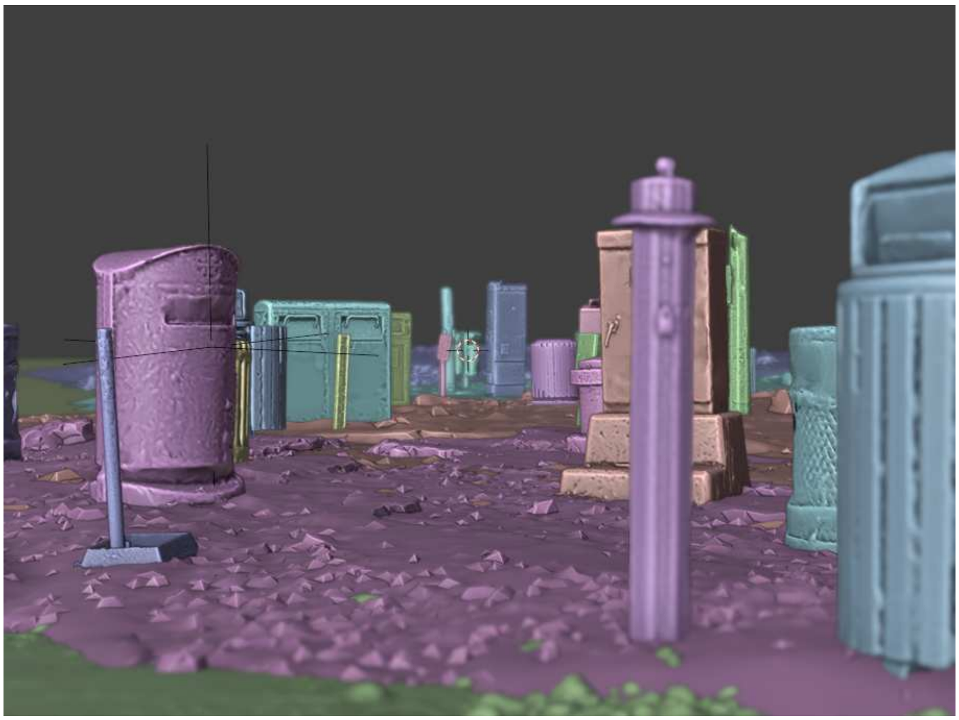

Figure 5.13 - Working view of a limbo scene in the viewport, untextured.

Ground assets were brought in from a photoscanned asset pack, but as they are not the focus of the animation, importing them from alternate or previously collected photoscan asset libraries does not conflict with the core ideas presented in the animation. These planes serve to ground the objects, and viewer alike, on a physical surface, adding both a sense of realism and context to the animation. The surfaces represent the uninviting landscape which the physical objects inhabit, the concrete sidewalks and street corners replaced with a rocky and uneven terrain. This setting is a ‘nowhere’, a digital limbo that the objects occupy in both the animation and the blender scene file. Where the ground ends, a calm body of digital water begins. This simultaneously masks the abyss of the skybox below the horizon, and helps create a sense of uneasy calm. The entirety of the environment is crafted to avoid diverting attention from the scanned assets, while capturing the essence of their ‘natural’ habitats that is devoid of the other elements contained within. The buildings, sidewalks, and people are nowhere to be seen. What remains is an undisturbed space devoid of interaction, things and places of common interest, forming the home for these digital representations of the overlooked and mundane.

The ‘afterlife’ scenes of *Digital Afterlife* have a less intensive composition and animation process. Each ‘afterlife’ shot has a near identical set-up to the others. The asset content of the files themselves are divided similarly to the ‘limbo’ scenes, being split across two individual Blender files. An empty was added to the file, and keyframed to complete a full rotation on the Z axis every 400 frames. Each object was then given a constraint to copy the rotation of this empty, ensuring an even and consistent rotational speed. The objects were then themselves animated to enter and exit the line of sight of the camera at 400 frame intervals. At 24 frames per second, this grants each object 16.6 seconds of individual screen time.

The large arrays of the ‘empyrean’ scenes were created with Blender’s geometry nodes system. This allows the distribution and manipulation of geometry with a node-based workflow. The geometry nodes were used to distribute different collections of the photoscanned 3D assets onto the corners of a series of polygons. Their assigned rotation was made to match the directions of the normals of these polygons, ensuring the objects were always pointing outwards. The shapes were then animated to move their geometry, shifting the objects attached to them for the duration of the animation. The camera was animated to slowly push inwards or outwards.

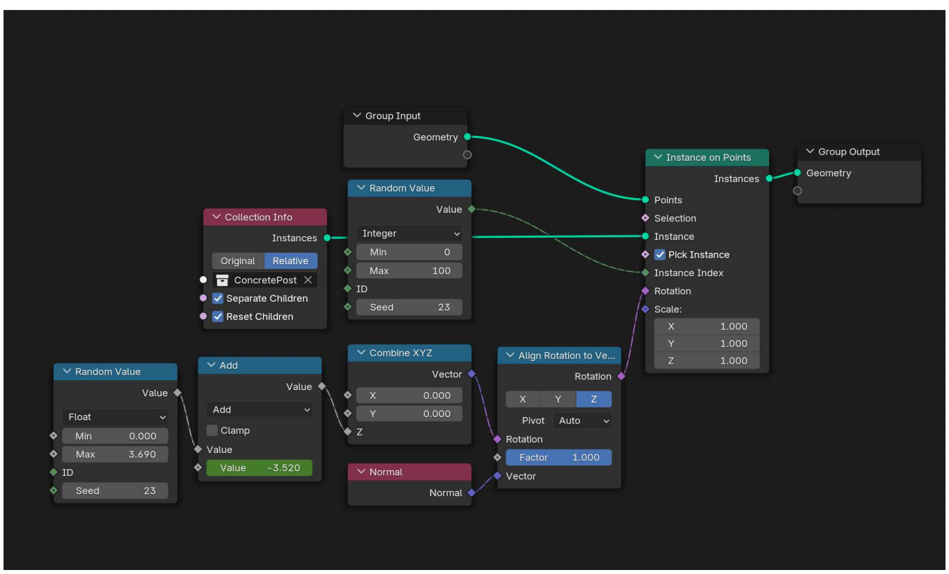

Figure 5.14 - The geometry node group of a *Digital Afterlife* empyrean scene.

The ‘limbo’ scenes were lit with a single HDRI, creating a semblance of realistic lighting. An HDRI is a texture that is attached to the background node in Blender’s ‘world’ shader node group, creating lighting conditions that affect the entirety of a scene, regardless of their placement. The chosen HDRI mimics an early evening sky above a road, a transitory space in itself, casting a dim light over the scene while maintaining directional shadows. The elements of the HDRI that would tie it to its original space are unseen, it exists only as the sky above. The shifting of the sky colour in the right video is achieved with a 'light path' node. This node is used to maintain the lighting effect of one node on objects within a scene while replacing the background with another. In the 'limbo' scenes, this is used to maintain the lighting of the HDRI while displaying a solid grey.

The later 'afterlife' and 'empyrean' scenes forego an HDRI for a complete lack of global lighting. The fully textured half of the video features an orange backdrop, previously specified, which was mixed with a solid black through use of a 'light path' node. This node mixes the orange and black so that, while the orange is visible in the scene, it is not actually reflecting any light onto the assets. Two plane lights were then placed into the scene, one directly behind the locations the objects appear, and one directly in front. This front plane light is the main source cast on each asset. It was set to a neutral white, while the rear plane light was given the same orange as the background. These two lights together bathe the front of every asset in this afterlife in a completely neutral white. This combination of lighting and background colouring allows the colour data of each object to be exhibited undisturbed, while their edges maintain a subtle orange glow. The textureless half of the video uses the same process, replacing every instance of orange with a grey.

The final step before moving to post-processing and rendering of a 'limbo' scene was the addition of a slight camera shake. This helps sell the realism of a scene, especially in 3D, where things are always more 'perfect' than reality. This unsteadiness is another step in creating the deception of believable footage, so that the unrealistic properties, the glitches and contorted forms of the digital artefacts offer a sharp break from the illusion, being at odds with their environment. The camera shake for *Digital Afterlife* was kept low, so as not to disorient the viewer.

Render > Render Animation

Throughout the development of *Digital Afterlife*'s limbo scenes, many steps have been taken in crafting a realistic setting through lighting and post processing, but regardless, it remains imperfect. The actual content of the project is inherently non-photorealistic, and flawed to a degree that immediately betrays them as digital scans. The resulting video is off-kilter and not quite right, there is something amiss in the un-altered, distorted, misshapen and glitchy photoscans in contrast to every other parameter being geared as strongly as possible towards photorealism. Amidst the 'realistic' lighting and material qualities of the scenes, these distortions stand out and demand attention. They make obvious the deception of the digital images that could otherwise deceive the viewer into the perception of viewing real images. If every element of the scenes was filled with unbelievable materials, physically impossible lighting and floating objects, the material qualities that make these artefacts so interesting would blend into the farfetched cacophony of digital spectacle. *Digital Afterlife* instead opts for a digital realism that allows the distinct properties of its subjects to stand out from their environment.

This section covers the final steps of the animation process, those that inform the format and details of the final product. The depth of field, glare, contrast and other post-processing steps are completed here. This section covers these post processing steps and final creative decisions made to create a final product. Throughout this step of creation, efforts are taken to create images that are perceptually photoreal. This is not in an attempt to have the viewer believe, through illusionary tactics, that these are in actuality the real, physical objects, but rather to create a contrast between them and the manner that has been chosen to display them in an effort to make their flaws more discernible. Unnatural lighting, no post-processing, and a perfectly stable camera would all aid in divulging the digital nature of the project, but the goal remains for the clear digital nature of the objects to be the focus. Crafting a passably realistic environment, lighting and post processing ensures that the digital distortions of the scanned assets stand apart.

In striving for this false sense of realism, some creative decisions were made or adjusted after the actual 3D work within a scene was completed. Many of these post-processing elements were only added to the 'limbo' scenes, as the 'afterlife' and 'empyrean' settings are intended to fully divulge their 3D nature, while there is an attempt to mask this in the limbos for the reasons stated above. These decisions are made to mimic the output of a real camera, and not necessarily what is seen with the naked eye. While this may seem counter-productive, we are much more easily fooled into thinking something displayed in 2D looks real if it appears more faithful to the output of a camera instead of the manner light is interpreted by our own eyes. These post-processing additions include glare, a depth pass, lens distortion, film grain, and colour grading.

The first additional setting enabled was directly within the camera itself. The depth of field setting works to mimic the 'f-stop' and aperture of a real camera. It determines how much of a scene is in focus, spanning out from the central focal point. The f-stop of the scene's camera is set to 2.0, which translates to things beyond the focal point rapidly becoming quite blurred. To control the actual location of the focal point itself, an empty object is added to the scene and is selected as the continuous focus object of the camera. This empty is animated independent of the movement of the camera. It is keyframed to shift from object to object as the camera travels through the scene, directing the focus and attention of the viewer towards the object currently in focus.

A depth pass was added in the post-processing phase. Serving as more than just a clever way to obfuscate the horizon, it hides the farther objects in a shroud of mist, working together with the depth of field to help the viewer focus on those objects closest to them. On the clearest day, the human eye can see as far as the curvature of the earth will let them. To replicate this distance in 3D would involve a level of extra rendering that is not viable for any project. A depth pass assigns a gradient value to every surface in a scene based on its proximity to the camera. Those closest to the camera will be black, gradually lightening as the distance increases. These passes, by themselves, do not add anything to the output of a render until they are properly mixed with the image output. This is done with a 'mix' node. The render image output is plugged into one of its image inputs, while the other is kept white. The depth or mist pass is then attached to its 'factor' input, determining the level of white that will be mixed into the original image. Where the factor is black they will not be mixed at all, and the image texture will be seen in totality, while any lighter value will become gradually paler. This factor value is then controlled with a color ramp, used to determine the amount of mist visible in the scene.

Figure 5.15 - *Digital Afterlife,* 'limbo' scene depth pass.

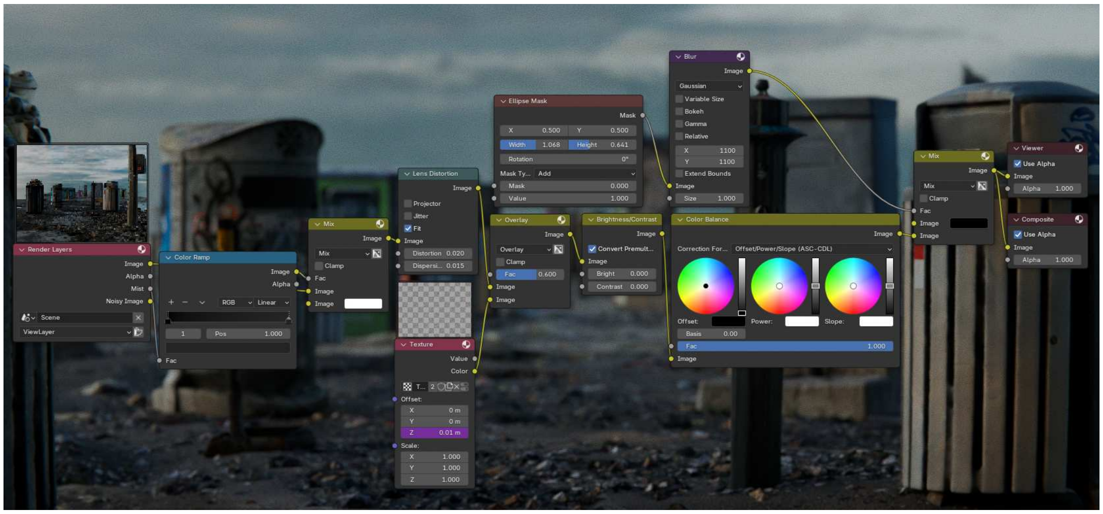

Figure 5.16 - *Digital Afterlife* compositor nodes, mist pass color ramp second to the left.

Paired with the depth of field on the camera, the depth pass helps ensure that the viewer will look where they are meant to, focusing on one object at a time as they pass by the lens. Within a rendered 3D scene, the viewer's gaze is obviously controlled by the creator. Scenes and composition are more akin to that of actual films than a virtual reality space, in which someone may look wherever they wish. In *Digital Afterlife*, the viewer is intended to observe each bin in turn. For the later scenes, this is more easily accomplished by the lack of other elements. Each portion of 'afterlife' and 'empyrean' have one main focus at a time. The limbos are littered with numerous assets, all exposed and shifting past the camera at different intervals. While the journey through this strange beach is underway, the location of the empty to which the depth of field is tracked is the intended trajectory of the viewer's attention. At any given moment there is one specific bin of electrical box that is meant to be the current subject. This not only mimics the real focal qualities of a camera as its focus shifts, but indicates to the viewer precisely where their attention is meant to be. Each asset has its moment being in focus in this limbo, a span of time wherein it is the object meant to be observed. This affords them a level of intentional attention that they do not receive in their natural environment. The observer is now being indicated which item to look at within the frame of the video.

The final post-processing step is the addition of noise, or film grain. Beyond an aesthetic choice to mimic recorded footage, film grain aids with the visual cohesiveness of shots. No matter the changes in lighting, there is an overlay of something that ties them together as one piece. It helps to hide where the algorithmically reduced render noise is imperfectly calculated. Digitally rendered scenes can be 'cleaned up' to increase their quality. Without this denoising, a high number of render steps would need to be calculated to reduce the 'noisiness' of each image.

These steps are the number of times the lighting of a 3D scene is calculated, with each additional step requiring a longer time to render a final image. Reincorporating an amount of noise over top an image or animation masks where this denoising algorithm may not have been enough to produce a clean image.

Digital Afterlife is a combined edit of several different rendered videos from several Blender scene files. This is fairly obvious when viewing the animation, containing lengthy tracking shots intercut with shorter segments with drastically different lighting. While being a creative decision made to allow for a greater variety and aesthetic of scenes, it was also made for a more technical reason. Using multiple video segments greatly eases the render times and iterative processes. Any mistakes or glitches that may only be visible when watching the completed animation do not require a re-rendering of the entire project, and can be rectified segmentally. This also allows for certain scenes to be completed and rendered while others are still in progress. Each frame of *Digital Afterlife* was rendered as an individual PNG image, which were then combined in the Blender video sequencer and exported as a cohesive MP4 file.

Chapter 6: Afterlife Alternatives

Iterations of an Afterlife

This section will explore previous iterations of *Digital Afterlife*, relating them to the earlier theories on material relationships across the different versions of an object, and how animation may engage in these discussions visually. Two previous iterations of this project were realized in the form of *Stagnation: Transitory Spaces* and *Poubelle Mundane*.

Figure 6.1 - The first concept render made for *Digital Afterlife*.

Stagnation was created as an exploration of transitory spaces, for which five scenes were produced. It aimed to determine how convincingly photorealistic a 3D environment could be made while solely employing photoscanned objects from Polycam. These assets were sourced entirely from Polycam, either captured specifically for the project or collected from the 'explore' page. The project put emphasis on the spaces, and not the individual objects. These spaces were intended to be geographically ambiguous, existing anywhere and nowhere. Every space was intended to elicit a vague sense of familiarity, as if this could plausibly be somewhere that the viewer had at one point been. At the same time there exists a feeling of unease across the spaces, something that is slightly off kilter. It featured piers, underpasses and alleyways, and served as an exploration into the specific lighting and render properties that may convince a viewer, even momentarily, that the compilation of photoscanned objects which they are perceiving represented recorded footage of real, physical locations.

Figure 6.1 - Two scenes from *Stagnation: Transitory Spaces*.

Poubelle Mundane is an early exploration of *Digital Afterlife*, on a smaller scale. The goal was the same, eliciting an emotional response throughout the viewing of their deformed surfaces, both as a product of human interaction, and subsequent photoscanning, and examining these material qualities up close. It aimed also to call attention to the unique material qualities that arise in photoscanned assets, and how these qualities are shared with, and differ from the real world counterparts of these objects. The uneasy traversal through limbo was the dominant scene, though its scope was limited to garbage bins, which were the predominant type of asset that had been collected for the project by that point. *Poubelle Mundane* shared many of the same goals as *Digital Afterlife*, emphasizing the digital traces of the photogrammetry process that are intrinsic to the new assets. In lieu of the split visuals of *Digital Afterlife*, all of *Poubelle Mundane*'s scenes were contained in one frame.

Figure 6.2 - *Poubelle Mundane*, shot prototype of the limbo scenes in *Digital Afterlife*.

Figure 6.3 - *Poubelle Mundane*, close-up scene.

There are many possible alternate iterations of *Digital Afterlife* that could have come about over the course of the project. There are elements of these digital assets that are not fully explored across the piece's runtime. Visualization of their wireframes, the connections that link each individual vertex, is absent, representing a far more technical aspect of these objects that was not portrayed. While their geometry, stripped of colour data, is a core component of the artwork, there is no such inclusion of their separated image textures. While this would not have fit within the confines of the piece's aesthetics, these textures represent areas of equal interest to that of their bare geometry, existing as a three dimensional object flattened and rendered two dimensional. Furthermore, the viewer's position and viewpoint is under constant restriction throughout the animation, presenting an argument for the sake of their total display that the viewer ought to have control over finding areas of interest upon these objects themselves. The reasoning for choosing a restrictive perspective and non-interactive animation has been outlined and explained throughout this thesis, but these objects may still see empyreal forms beyond this iteration of *Digital Afterlife*. There remain endless variations to the final forms that the project may have taken, and may still yet take.

Glitches & Objects

This project exists with many others that ponder the nature of digital materiality in relation to physical counterparts. It is also not first to broach the topic of forgotten elements or urban or digital environments. Both of these topics have been around as long as these forms of objects have. Many works that delve into these ideas have been cited here already, as research papers and articles. This section will briefly explore a handful of creative projects that cover digitization of the physical, urban assets and 3D animation, and their relations to *Digital Afterlife*.

Public Bins, by Atelier HOKO, explores the sociological relationship we have to garbage bins that occupy urban environments. The project describes each object, accompanied by a series of photographs, examining their treatment by humans, while analysing how their past treatment may affect their future perception of and interaction by humans. The project cites their existence in the 'non-place' of the street as the explanation for the type of interaction they experience, uncaring and without thought for treatment of, or lasting effect on, these objects. "The public bin falls somewhere between infrastructure and object" (Atelier Hoko 2022, 9). They are residents of the 'non-place' while also being an integral part of it. The bins are almost personified into possessing their own personalities that are brought on through interactions with them. Contrarily, the role of *Digital Afterlife* is not to describe, or assign to these objects, but to allow them to stand apart from their usual surroundings, and to be the central figures on stage. Existing in a state already removed from their precursors, describing these objects through text would not further the ability to grasp the ungraspable nature of their relations and beings.

Figure 6.4 - Pages from *Public Bins*, Atelier HOKO.

Clement Valla's 2010 work, *Postcards from Google Earth*, is a collection of images taken directly from Google Earth. The 'postcards' highlight the areas across the digital globe where "the illusion of a seamless representation of the Earth's surface seems to break down" (Valla 2010). They show the guesswork done by algorithms to produce an acceptable approximation of the data they have been fed. They explain that these glitches that we perceive as errors are moments in which the inner workings of Google Earth are exposed. As in *Digital Afterlife*, the project does not explain each glitch, but rather allows their visual qualities to stand for themselves. The multitude of image sources from which the digital map is pieced together cannot always be automatically mapped seamlessly, they represent an imperfect database sourced from a myriad of cameras and stored across droves of devices, constantly updated and fit together like puzzle pieces by algorithms designed by engineers and map-makers. The photogrammetry method employed in the creation of *Digital Afterlife* is analogous to a small-scale, localized, version of these processes. The many images, taken by one camera, are combined into a small object, but it still bears the glitches and shearing that are present across the digital globe that Google has created. The geometric deformations and textural mishaps reveal the digital nature of the objects, which are otherwise shown in as photorealistic a manner as possible, thus breaking this illusion. As with commercial photogrammetry, these seams and anomalies in the generated maps will gradually be made more invisible as the technology with which they are created advances.

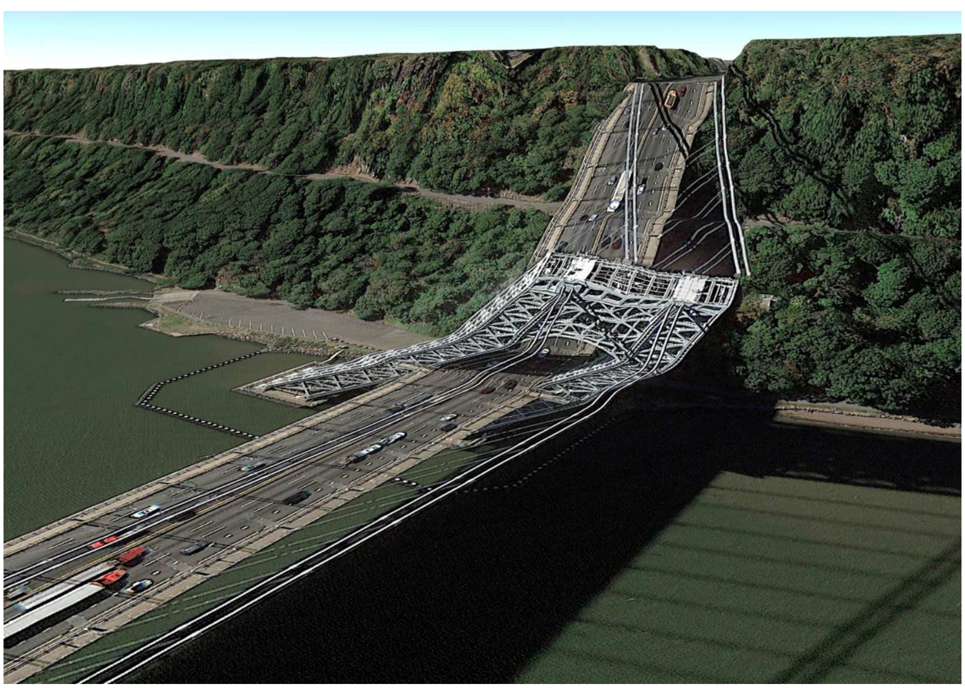

Figure 6.5 - *Postcards from Google Earth*, Clement Valla.

Ian Hubert's ongoing web-series, *Dynamo Dream*, makes ample use of photogrammetry for the collection of background people and object assets. Photogrammetry offers a relatively quick way to capture complex objects and people, things that would require more time than is feasible when they will only be occupying the backgrounds and edges of scenes. These assets, people and objects alike, are used to build the world in which the story exists, and provide additional context to footage that would be nigh impossible to capture in-camera. To avoid the computational burden that a large collection of unique photoscans would pose to a 3D scene file, he uses instances of each object, repeated numerous times when required, each linked to the geometry and material of their original. The scans are imperfect, with strange geometry, uneven lighting and occasional gaps in their forms, but they are well suited for use in the background after undergoing brief optimization. The process of creating, optimizing and animating these assets is detailed on his YouTube channel, which explores a plethora of 3D creation techniques in Blender.

Figure 6.6 - Salad Mug - DYNAMO DREAM, Ep1, Ian Hubert, 2021.

Figure 6.7 - CyberExtras asset pack, Ian Hubert, 2022.

Slow Track: Slowness and the Virtual Moving Image, a thesis within the Design and Computation Arts department of Concordia University by Timothy Thomasson explores slowness as an aesthetic in 3D animation. His creation piece, *Slow Track*, explores meticulously detailed scenes at a deliberately relaxed pace, allowing the viewer to sit with each carefully modelled, placed and animated object. The project aims to illustrate how slowness may be used in 3D projects in contrast to the constant digital spectacle, flashy effects and – busyness that is commonly associated with the general public's understanding of CGI. The project unfolds through a linear camera movement, never rotating, but pushing in or out of a scene at a constant pace, as events unfold around it. *Digital Afterlife* makes use of similar techniques in its animation and timeline. It is similarly slow and meticulous in its determination of what the viewer experiences, and for how long. While *Slow Track* uses its slowness to explore carefully crafted scenes, *Digital Afterlife* utilizes it to examine the individual objects.

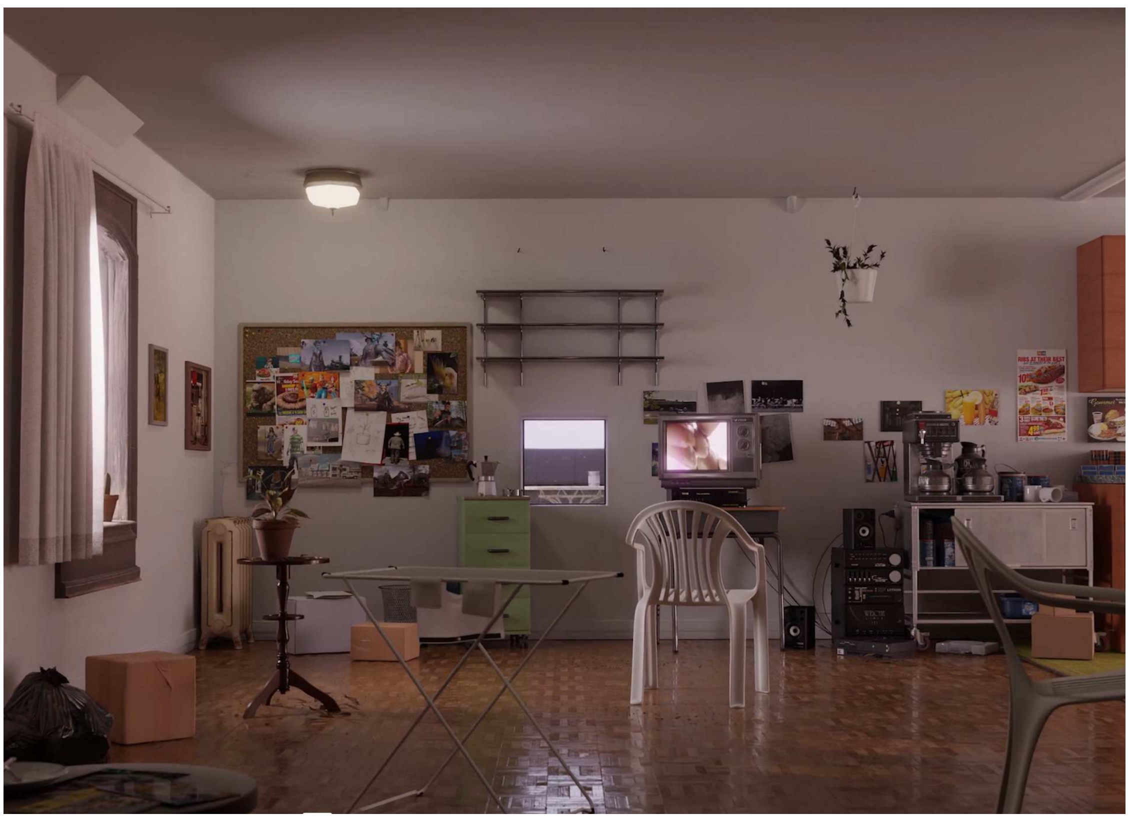

Figure 6.8 - Slow Track, Timothy Thomasson, 2021.

Catalogues & Preservation

While not discussed at length throughout this thesis, and not the main intention of the project, there is an element of *Digital Afterlife* which functions as a form of flawed archaeology. The photoscans represent a snapshot of the immediate state of an urban artefact, within a very specific spatiotemporal frame, but provides no additional context to its being. The scans almost entirely strip these objects of their surrounding environment, there is no reference to any specific location, beyond what is present on its material surface. Additionally, the actual method of preservation results in serious inaccuracies and deformations to the form and material of each artefact. The new digital assets obfuscate data from their precursors that would be highly relevant to a truer form of archaeology.

Photogrammetry represents a fully unintrusive method to capture accurate geometry and textures of archaeological sites and objects. In 2014, Colleen Haukaas's graduate thesis explored the benefits of using low-cost photogrammetry for 3D documentation of objects from archaeological sites (Haukaas 2014). Her research concluded that the process was not without flaws, only being effective with smaller objects, and having a minimum capturable geometric resolution of 5 cm. However, the technology made these assets easy to disseminate to a wider audience, and greatly increased their accessibility. Similarly, in 2015, faculty of various Universities in Lithuania and the United Kingdom proposed the use of photogrammetric software and high resolution cameras to document and track the deformations induced in architectural heritage sites by environmental factors (Sužiedelytė-Visockienė et al, 2015). More recently, in 2021, members of various university faculties in Spain and Tunisia published an article examining advancements in archaeology across the last two decades that have been made possible through photogrammetry (Marín-Buzón et al, 2021). The paper argues that the technology is an incredibly viable and valuable tool for close-range and aerial photogrammetry of individual objects, heritage and excavation sites, and virtual reconstruction.

Digital Afterlife preserves a flawed state of its subjects, heavily altered through its 'on-the-go' capture method. Nonetheless, it is a form of archaeological documentation, not of historically significant objects, but of current things that occupy the urban environment. It preserves the specific manner of relations these objects experience, all of which tell a story of not only the varying significance of these objects, but of human interaction with items inhabiting areas that do not concern them. While neither *Digital Afterlife* nor this thesis dwell on this perspective, it is worth noting the relevance of the project to this digital archaeological viewpoint.

More intentionally than the relevancy to archaeological documentation is the act of cataloguing that persists throughout. The assembled objects in *Digital Afterlife* represent a collection of artefacts of a specific type, each named, recorded and organized within their respective files. Institutes like the Cleveland Museum of Art have undertaken initiatives to upload massive swathes of their collections to online repositories, such as Sketchfab, under open access initiatives (Cleveland Museum of Art, 2019). These collections have also been photoscanned, although professionally, in studios with balanced lighting and using manual camera settings. The resulting assets are of high quality, and high geometric complexity, not optimized, but highly detailed, more than suitable for close-ups or reference. These digitized artefacts are free to copy, modify, and distribute for both personal and commercial use. Similarly, the assets of *Digital Afterlife* will be uploaded to their own repository, for free use by anyone and everyone who sees a use or need for them.

Chapter 7: Conclusion

Outcomes & Contributions

Digital Afterlife comprises 55 individually photoscanned objects, 29 garbage bins, 14 electrical boxes, and 12 posts of various kinds. Each digital asset contains unique structure and texture, attributed to the qualities of its physical precursor, and altered through its capture and digital transformation. The final animation, with a runtime of 26 minutes and 38 seconds per half, asks for patience in which to sit with these assets as they trek through a mirrored journey of three scenes. The viewer sees an opening limbo of scattered objects in an uneasy balance, slowly travelling through them. As the camera gradually moves through these spaces, mirrored in the two halves of the video, they gradually shift to colourless objects, opening into an 'afterlife' with orange and grey variations. The objects in these videos rotate slowly in turn, allowing a complete view of their forms and materials before they are combined in the imposing, undulating forms that occupy the 'empyrean' scenes. *Digital Afterlife* was reworked numerous times across longer and shorter formats, each with more intentional and comprehensive creative decisions. The final version is discussed and exhibited throughout this thesis.

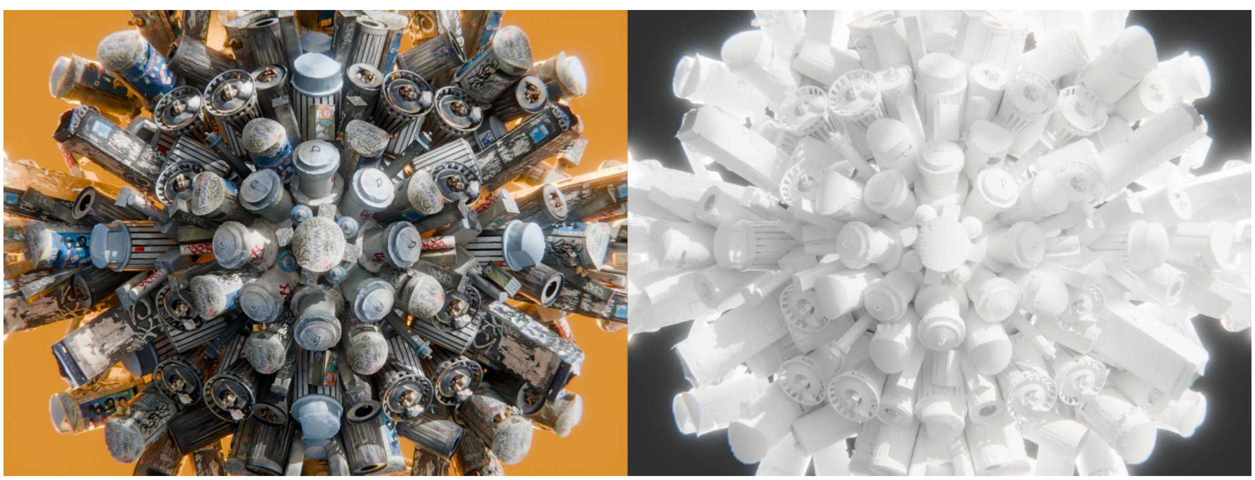

Figure 7.1 - *Digital Afterlife* 'empyrean' scene.

Digital Afterlife's explorations into the material qualities of neglected objects, which have been sitting in a single place for numerous years, and their digital counterparts, which similarly languish in repositories and libraries, offer a contribution to a diverse range of relevant fields. Foremost, *Digital Afterlife* as an art piece, and this thesis itself, provide related explorations into the application and treatment of imperfect photoscanned assets. The animation explores not only a transformative journey across which the material qualities of each asset are exhibited in full, but also one specific use-case for objects of their category. It demonstrates a way to use these often discarded assets, working with their perceived flaws and imperfections, those which may prevent these objects from being utilized more frequently. Additionally, this thesis itself, through its methodology chapter, offers a detailed technical analysis of an efficient manner in which to optimize photoscanned assets in order to lessen their computational load and make them more amenable for use in projects. It illustrates a treatment and process of care for imperfect digital assets, and a manner in which these neglected assets may be utilized and appreciated.

In relevance to a more physical practice, *Digital Afterlife* contributes to the works of industrial and urban designers. It displays a snapshot into the lives of each object in which they have been used considerably, and demonstrates a multitude of manners in which they may experience wear through environmental and human factors. Designers of such objects may view a wide collection of industrial objects, sourced from a variety of urban locations, and examine the wear, damage and vandalization at the hand of environmental and human elements. While this thesis does not focus on the origins of these elements, treating them as a coalescence of the total sum of relations each object had experienced at the time of its capture, they offer insight into how each object is used and affected. Industrial and urban designers may make more informed design choices through an examination of the material qualities of these digital recreations, frozen in time at the moment of their capture, and containing ample information about their relations with their environments.

Upon completion of this thesis, this project's collection will be divided back into individual 3D assets and uploaded online as a free resource, its objects creating their own form of Denkmälerarchiv of the ignored urban objects, made monuments in their own right through *Digital Afterlife*. This represents another form of contribution to the potential work of 3D artists, supplying them with a free collection of assets for use in any multitude of projects. While these assets will undoubtedly see use in my own practice, this will mark the true completion of the journey of these assets on my end, at least in the context of *Digital Afterlife*, extending beyond the artwork to be used or altered as seen fit by anyone in need of a collection of imperfect industrial urban object assets. However they may be seen fit to use, it will hopefully be with their past treatment and care in mind.

Throughout every step of *Digital Afterlife*'s creation and for the entire duration of its runtime, there is an unfailing application and sense of care towards these objects. Their collections have been carefully fostered, their geometry meticulously tended to, and their display mindfully looked after. They have been treated respectfully, nobly and with an attention to their being that goes beyond anything common to their past iterations. The project's main contribution, above those to design disciplines or asset collections, is the service rendered to these objects. These physical objects, abstracted, condensed and reconstituted into digital forms, are the results of an unfathomable number of relations and experiences. The visual exterior of their momentary states are forever preserved in these new manifestations, regardless of the eventual fate of their physical precursors. *Digital Afterlife* seeks to provide not only a platform for these objects on which to be observed and admired, but to elevate them to a place of importance within its context. Its contribution to these objects aims to be an alteration of perceptions towards both the physical and digital forms they hold. To create investment into their treatment through their animated representations and methodology of ceaseless care. These things are flawed, damaged, misshapen and far from perfect, seeing wear and distortion through their physical existence and digital recreation, resulting in their discardment or general neglect towards them. It is in these marks of past relations that their most interesting elements lie. These portions of them that hint at the wider embodiment of ungraspable interplay they have experienced with their environments and the processes of their creation. They represent a wealthy catalogue of interaction that makes these objects worthy of much greater consideration and attention than they receive. The core contribution of *Digital Afterlife* is to the neglected objects of the transitory urban environment, and the 3D assets often discarded for their imperfections and unwieldy geometry.

Conclusion

Digital Afterlife has been created as an artwork that exhibits a select collection of the forgotten objects of both the physical and digital worlds, intended to leave an emotional impact on the viewer through its display of these assets and the care given to them. This thesis has explored the ways in which writings on the ontology of objects have influenced and been integrated into the final creation piece. The various chapters of this research-creation thesis have sought to provide an overview of the many theories surrounding the ontology of objects both physical and digital. *Digital Afterlife* builds on these ideas through its use of a collection of digital assets from the transitory urban environment. By contextualizing the work amidst a theoretical, historical and methodological framework, *Digital Afterlife* seeks to make a visual contribution to the discussions on the understanding of digital objects and materials, most notably those of photogrammetric origin.

The narrative and application of care used throughout, and its accompanying aesthetics, illustrate a metamorphic journey undertaken by each object to transform and exhibit them across carefully curated animations. This methodological application of constant care and attention is employed as a means of creating empathy for the inanimate and an emotional investment in their treatment. This thesis documents the process of their creation in full, cataloguing each instance of alteration they experience from the moment of their capture to their display in *Digital Afterlife*, divulging a tale of intentional and constant care shown towards them.

Digital Afterlife idealizes imperfect objects, wrought with glitches and deformations bestowed unto them through their creation, captured from neglected urban environments. The physical and digital origins of its assets are juxtaposed across two synchronous videos, through which the viewer journeys with these objects. It elevates these assets beyond their common treatment and status, showing them a high degree of care throughout the scanning and creation processes. Each asset experiences increased ennoblement as the animation progresses, being elevated across the three thematic scenes. It examines every facet of the visible material surface of its assets, these quasi-objects affected by a plethora of physical and digital relations. It explores where these interactions have left visible marks on their constitution, exposing the methods of their creation. *Digital Afterlife* asks the viewer to reflect on the nature of them as both things-in-themselves and a product of the numerous relations that created them, to see them as more than habitually neglected background assets. It invites viewers to consider these objects as wholly unique entities, and to ultimately consider their own relation to them through this perspective.

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