Master's thesis

NTNU
Norwegian University of Science and Technology
Faculty of Humanities
Department of Historical Studies

Stian Ingdahl

The Circle View

An analysis of the omnidirectional camera and the possbility of including it into the archaeological toolbox

Master's thesis in Archaeology
Supervisor: Martin Callanan
Co-supervisor: Terje Brattli
November 2021

Photo: Stian Ingdahl

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Abstract

Omnidirectional cameras in archaeology – A study of the potential of omnidirectional camera in the creation of archaeological documentation

The advancement of technology brings new potential ways of conducting archaeology. This has been seen with the usage of drones, LiDAR and ground-penetrating-radar. As the field of archaeology is moving rapidly into a more technological world it is the goal of this thesis to gauge the potential of omnidirectional cameras. By looking at the current practice one might infer new ways to the advance the field practice that are generally accepted and used to document archaeological excavations and investigations. To this purpose I have conducted field testing of the GoPro Fusion omnidirectional camera in several locations containing material heritage. The results were then analysed and compared with existing guidelines regarding the gathering and presenting of photographical documentation.

The results showed that the omnidirectional camera can be used for archaeological purposes, both documentation and otherwise. It presents an opportunity for further research and a possible inclusion of the omnidirectional camera technology in archaeological field practice.

Preface

This thesis has been both the bane of my existence and a joy to work with. I had to go beyond the boundaries of my knowledge in archaeology and explore something completely new and exciting. It has been frustrating and rewarding at the same time. Whilst writing this thesis I have noticed that the subject of VR and omnidirectional cameras have experienced an increased interest which might signify a change of perception and possible inclusion of archaeological field practice.

I want to give my sincerest thanks to my advisors Martin Callanan and Terje Brattli for keeping me grounded when my Icarus reached too high. Their support and belief kept me from giving up on the whole thing and their positive attitude made me realize that maybe I could pull this off. Both professionally and morally they have both been supportive and I am eternally grateful.

I would also like to thank Anja Fløtten Olsen who was kind enough to join me on my escapades to gather data for the thesis. Your company has been greatly appreciated and I hope that we will take to the road in the future looking for new and exciting pieces of the past.

Making a fashionably late entrance, when I have never known him to be anything but, Aleksander Skre. A man of dedication, good natured humour and lightning brilliance who were kind enough to help me gather data for my thesis.

Thank you to all who have been good enough to read my work and helped me improved it. You have all been of great help and support. Last but never least, my fiancé who shall remain nameless. Even if I wrote a thank-you note the size of this whole thesis it would never be enough.

Stian Ingdahl

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Contents

Table of figures

List of tables

1. Introduction

"It belongs in a museum!" – S. Spielberg, (1989)

A society that is ignorant of its own past is susceptible to manipulation and can lead to a warped sense of- or even a loss of identity all together. Examples of the past being weaponized can be found in the plundering of burial mounds from which a local chieftain might derive their right to authority all the way back to the Viking age and all the way up to how Gustav Kossinas research into the languages of the Germanic people were used as justification to Hitler's *lebensraum*. It is important therefore that the past is studied, interpreted and above all, made accessible to the public. The process of which this is done is usually through a mix of archaeological digs and random finds by someone working the soil or hiking. How archaeologists go about studying the remnants of the past is a process that has inadvertently been shrouded in popular culture and misconceptions. The allure and mystery of ages gone is certainly stimulating to the imagination which I'm sure drives many people to try and become archaeologists. Stunning figures such as Harrison Ford in the signature movies of Indiana Jones and the well-known video game character, Lara Croft are very well-known examples of this. However, if archaeologists were to have the same destructive influence on their dig sites as these two seem to have, there would hardly be anything left to study. So instead of running around with whips and guns (although the hat is optional and sometimes recommended in strong sun) the job of an archaeologist is one of preservation. The material heritage left behind by those who came before are preserved. We treat the objects with care, their special conditions in which their deteriorations are severely slowed or even halted. Buildings are cared for in much the same way. However, the preservation of the objects and buildings in question are not the entirety of the job. The location where they were found, how they were collected, and by whom, is vital information to allow for further research and to put the finds into its historical perspective. As such, the archaeological process is intricate and requires decision making and initiative from those who perform it. Knowing how to perform this process is half the battle, while the rest is fought with trowel and buckets.

In this thesis I will take a closer look on a potential new source of collecting information to add to the existing methods of documentation. The method of collecting will be through an omnidirectional camera, also known as a 360 or 360° camera.

2. The questions that needed asking

"That, detective is the right question" – A. Proynas, (2004)

This thesis is centred around the possible incorporation of omnidirectional cameras within the field of archaeology. It does not try to cover every possible angle but instead tries to establish a foothold in which further research may stem from. As such it seeks to answer the following questions:

1. Is the omnidirectional camera capable of producing archaeological documentation?
2. What are the benefits and disadvantages of utilizing an omnidirectional camera in the field?
3. Are there other uses for the omnidirectional camera within archaeology that does not fall under the category of documentation?
4. Should the omnidirectional camera replace the regular digital camera for documenting purposes?

The first question requires a definition of the term "archaeological documentation". Whilst this may at first glance seem obvious, the many disciplines of archaeology means that the question is far broader to what it may seem. In this instance however, archaeological documentation is understood to be documentation taken during an archaeological excavation or examination, for the purposes of preservation, research, and education. Documentation in this instance focuses on photography, which must be mentioned, is only a part of a complete archaeological documentation. A more expanded definition of the term "archaeological" will follow in a later chapter.

The second question requires field testing, to gain an understanding of the how the omnidirectional camera will function in a field setting. By using the camera in an archaeological excavation or examination one discovers the suitability in the field and more specifically, what makes it a good fit and what makes it a bad fit.

The third question requires a thorough understanding of not only the workings of omnidirectional photography, but also the different disciplines within the field of archaeology today. The reason is that by knowing how to best utilize the omnidirectional camera and by also knowing the goals and methods used in the various disciplines of archaeology one might see openings in the practice where omnidirectional cameras might fit. To find these openings one must ask themselves, in what other settings do archaeologists use photography, and in which settings could photographs be substituted for omnidirectional photographs? Are there situations where omnidirectional footage can be of use where traditional photography has little to no presence today?

The fourth question requires an understanding of what omnidirectional cameras can offer comparatively to a traditional digital one. This then implies an understanding of how omnidirectional cameras functions at all. Furthermore, it requires an understanding of what photography is used for in archaeology, how the photographs are obtained, and the methods used to interact with the photographs after they have been successfully taken.

Lastly it requires the understanding of what purpose photography is meant to fulfil and whether both alternatives offer, in essence the same fulfilment of this purpose, or if they are meant for different tasks.

The goal then will be to seek an answer to these questions using scientific methods based on archaeological theory.

3. The way to find answers

"It sounded an excellent plan, no doubt, and very neatly and simply arranged; the only difficulty was, she had not the smallest idea how to set about it" – L. Carroll (2010, p. 35)

To answer the questions presented in the previous chapter, empirical data needs to be collected. Said data are collected mainly by using a GoPro Fusion 360° camera whilst some is gathered with a Huawei P20 Pro using the Street View app from Google. The primary method of analysis for this thesis is qualitative and centres around the footage gathered with the cameras. Furthermore, it is substantiated by what little could be found in the literature regarding the usage of omnidirectional cameras in archaeology.

After gathering data, it is then compared to a list of criteria, which outlines the general understanding and definition of what archaeological photographical documentation should be. These criteria are taken from several handbooks for archaeology and are as much a summation of contemporary practice as literary sources. The goal of the thesis in general is to develop an understanding of the omnidirectional camera, and gauge potential usage within archaeological field practice. To successfully achieve this, there are a few other things necessary to understand. These are mainly the current field practice, how it works, potential needs and why it works as it does. Having then developed this understanding, it is my hope to possibly uncover a niche in archaeology that could be filled by the usage of omnidirectional cameras. A qualitative comparative method is suitable for finding the answers to the questions this thesis asks. The collecting of data was gathered by the person handling the camera in the field, operating it to the best of their ability. No prior practice or standard currently exists on the subject and as such the age-old method of trying and failing have been applied generously.

A qualitative method is defined as a scientific method of examination that uses qualities of selected data (Williamson & Johansen, 2018). It differs from a quantitative method in which a large number of data would be collected and used as a whole. More precisely, this thesis uses a content analysis, by collecting primarily omnidirectional data, in this case photographs, and analysing them with the goal of isolating and identifying parts that correlates with existing criteria for photographs in archaeology. By doing so one might identify situations where one could conceivably use an omnidirectional camera to create data that fulfils the demands of existing criteria. Could this be achieved, the data collected would be able to be used in today's practice of archaeology. Even if this should not be the case however, there is still the possibility of allowing one to discover a niche in which traditional photography and practice are unable to fill, where an omnidirectional camera might. As such, this thesis is as much an analysis of existing methods of archaeological photographical documentation as it is a tentative introduction of the omnidirectional camera to the field.

As a method it is not grounded in any strictly acknowledged archaeological theories. It is instead more focused on existing field practice and methods within archaeology. Mostly concerning itself with the pre-existing notions of what constitutes a "good" field photo. The approach to taking one and the practical aspects of working with it comes after the fact.

One might argue that the methods used to do this, are understood to be subject of some theory or other, but that is at this point, far removed from the down to basics operations of this thesis.

The reason for choosing this method is that a qualitative analysis better suits the amount of data that were available for analysis. Most of the data have been gathered by me, with the rest gathered by another as a part of an experiment that involved sending someone with no prior experience with an omnidirectional camera to use as they saw fit for their own archaeological purposes.

The inclusion of the Google Street View app came late in the development of the thesis, but I have decided to include it due to the availability and cost effectiveness of the app. It forms a natural comparative opposite for the GoPro Fusion. I will expand on this in chapter 10. Suffice to say, the amount of total data gathered were limited. There are several reasons for this. One of the less important ones, although quite critical, was the limited manpower. Two persons can only gather so much data after all. Furthermore, the deconstruction of the current accepted field methodology regarding how to take field photographs and the following analysis of the of pieces mean are required to construct a new method based on the old. As such, the amount of "good" archaeological photographs available for analysis were less than preferable due to time constraints. To guarantee having enough time to analyse them, it meant that a qualitative analysis was the more realistic option. As such, a qualitative analysis of the data that were gathered were considered a suitable method to answer the questions that this thesis is based on.

Having decided a method that could comfortably handle the amount of data gathered, there was also the question of whether the method could answer the questions posed in the previous chapter. I have found during my work with this thesis, that the qualitative method selected is satisfactory in this regard. A full summation of this work will follow in the thesis. At this point I will therefore quickly mention how the usage of the selected method worked to answer the problem in question:

Is the omnidirectional camera capable of producing archaeological documentation?

By utilizing a content analysis of the data collected and comparing the results to the current archaeological practices and methods, one can answer the question. As a content analysis is qualitative or quantitative depending on how it is used, and the usage in this thesis is qualitative, I would argue that it is able to answer the question.

Should the omnidirectional camera replace the regular digital camera for documenting purposes?

This question requires an understanding of the role of photography in archaeological documentation. Therefore, by analysing the current criteria for what constitutes as "good" archaeological photos taken in 2D one might gain the necessary understanding what makes photography a valuable inclusion in archaeology. Taking also into consideration that the criteria for "good" archaeological photographs in 2D is not necessarily the same criteria which constitutes as "good" archaeological photograph taken by an omnidirectional camera, one might infer whether the traditional camera is replaceable at all. The method in question then is a straight comparative analysis between the criteria that either camera adheres to.

This then allows for a discussion around this subject and whether the omnidirectional camera and the digital camera are filling the same roles or two separate roles. If they are filling two separate roles, the method will also discover potential overlap, if any.

> *What are the benefits and disadvantages of utilizing an omnidirectional camera in the field?*

The qualitative analysis at this point is not centred on the data itself, but rather its collection. It is wholly dependent on the data collected. By analysing this data, one gains an understanding of its workings, strengths, and weaknesses. From this one can infer the suitability of the omnidirectional camera compared to the existing criteria for the digital one. Then, taking this as the base one can construct a new set of criteria to follow when using an omnidirectional camera as opposed to a traditional digital camera.

"What are the benefits and disadvantages of utilizing an omnidirectional camera in the field?" is relevant to ask both when compared to the existing set of photo criteria and when compared to the new set of criteria. The difference lies in the changes made when rebuilding the old one to tailor it for the omnidirectional camera. There are then, two qualitative analyses to be performed to answer the question in any degree of satisfaction.

> *Are there other uses for the omnidirectional camera within the field of archaeology that does not fall under the category of documentation?*

To answer this question, one must first establish other aspects of archaeological work. Then, one must establish some form of criteria that pertains to the work in question. Examples of this could for instance be digging, detection or dissemination. Having these criteria as a foundation to conjecture and establish a discussion from, one might approximate other usages of an omnidirectional camera within archaeology that does not fall under the category of documentation. The qualitative comparative analysis works in this regard as it has specific guidelines and goals it can compare with.

Having established the method used in the thesis, we need to get some form of clarification to the terminology used in both the previous chapters, and which might be relevant going forward in the thesis. While most terminology would be expanded upon in the chapter it is featured in, I would be remiss to not clarify the most basic, and yet largest terms in this thesis. In the next chapter, we will discuss and clarify the term archaeology.

4. What is archaeology?

"Archaeology is as much about the present and the future as it is about the past"
– J. Sabloff, (2008, p. 16)

To properly analyse the usage of omnidirectional cameras within the field of archaeology, we must first clarify what the term "archaeology" entails. While the term "archaeology" might seem too basic, it is nonetheless an important term to understand, as it directly forms the foundation of the thesis and how documentation, photography and omnidirectional cameras fit into it. The word itself is defined as "the study of cultures of the past, and of periods of history by examining the parts of buildings and objects found in the ground" (Archaeology, n.d.). While this might seem simple enough, the term archaeology has a depth and nuance that belie the simplicity of this short definition. For instance, the definition of the word explicitly states: "found in the ground". This then would exclude the practice of marine archaeology from archaeology at large, considering that the practice focuses objects that happen to be beneath any layer of water. It is however, still very much "archaeology".

Other, similar but different ways of defining what archaeology is includes Reinhard (2018), "Archaeology is the study of the ancient and recent human past through material remains in pursuit of a broad and comprehensive understanding of human culture". One can also infer definitions of "archaeology" through the usage and understanding of terms such as "heritage" and culture (Skeates, 2004, Howard, 2003) or how objects and reading the past are discussed by known archaeologists (Hodder & Hutson, 2003, Olsen, 2013).

The ways of studying the past and the methods used to do so have changed in many ways since its inception. There are also other disciplines of archaeology such as public archaeology which takes into consideration how archaeology is presented to the public, in what form this may be and how to make it as accessible as possible (Merriman, 2004). As such, the artifacts sitting in museums, reaching the public sphere are still archaeology (Barrett, 2012). There is contemporary archaeology, which may sound like a contradiction but assuredly is not. Contemporary archaeology is a way to explore the present through the theories and methods conceived in an archaeological context (Burstöm, 2007). The terminology also changes depending where in the world you practice it. For instance, in most English-speaking countries, archaeology is viewed as a subsection of anthropology. This is not the case in Norway however as archaeology had its beginnings in what is referred to as ethnography and ethnology. It is today its own field of science but are also somewhat regarded as part of anthropology and history (Solberg & Omland, 2019). As it progressed however, it distanced itself from its beginnings and is currently a field in its own rights. There have been written many books who address the evolution of archaeology, its many practices and interpretations. Of these I would like to mention Bjørnar Olsen's "Fra ting til tekst" (From things to text, 1997). As these examples show, "archaeology" means a lot more than the single sentence definition that the Oxford Dictionary offers.

For this thesis however, the fundamental takeaway of what "archaeology" is, is mainly that archaeology is the study of humanity of the past through the lens of human-

object interaction. As we have seen, it is the basest interpretation of the discipline and yet it is undoubtedly a correct one. To study the past, means to study the objects and other material culture left behind. There are many ways of conducting these studies which differ based on the goal of the study itself. I would argue that archaeology is a science that primarily occupies itself on the study of change. One sees the result of actions made by humanity in the past and tries to interpret the intent and meaning behind it. An example is that if one finds slag in the forest, one might interpret a mine of some sort. Following the logic that mines are places to extract metals one might argue that they used the metal for smithing and construction of tools. In this way, archaeologists ascribe agency to the past and by documenting the finds one opens for avenues of interpretation.

It is important to note that archaeology can be used for different purposes. Among these the foremost example is the museums which functions as centres of learning and education. Historical societies use archaeological and historical sources to further a connection to the place where the society is located. And finally, archaeology creates a bond of continuity that connects the modern human to its history and ancestors.

Having now devoted a few pages to the definition and some usages of archaeology, I have chosen to refrain from any further elaboration. This is mainly to keep the thesis concise and on point. An understanding of archaeology as a discipline is peripheral when compared to the actual focus of the thesis. I will therefore elaborate on the theoretical archaeological aspect of the work when relevant and expand upon it when needed. From here however, I will take a closer look on the general role that technology plays in archaeology at large before moving onto a closer look on photography specifically.

5. The role of technology within the field of archaeology

"Archaeologists adopt technology piecemeal" – J, Wallrodt (2016, p. 34).

There is no escaping the fact that technology is firmly entrenched in archaeology. In this chapter, I will expand a bit, on the up until now, rather narrow definition of technology as purely photography whilst also mentioning other branches of technology that are currently in use in archaeology today. Technology as a term is here meant as mechanical, digital, or otherwise in-organic tools created by humans.

The merging of technology and archaeology are by no means a foreign concept. From the inclusion of cameras in the 1800's till modern times, technology has been a staple in documenting and conveying historical significance to the public. Omnidirectional cameras aside, the archaeologist today utilizes a vast array of different tools to aid in their work. Geographic Information System (GIS), tablets, drones, LiDAR, hyperspectral imaging and ROV's are all different pieces of technology that offers invaluable aid to the archaeologist in a variety of tasks. Through them, archeologists have access to and the means to discover and document the remnants of the past much more efficiently than one could do without.

There has been some debate regarding the introduction of technology and how it changes the methodologies of the past. "More specifically, these concerns for digital field recording are about "de-skilling" (after Caraher) of archaeological method, as well as a worry that the efficiency brought about by digital field recording leads mostly-or rather, merely- to the collection/creation of more and more data" (Ellis, 2016, p. 60).

The quote is referencing the supplantation digital recording over that of paper recording; however, I feel the point that is made is equally valid when compared to the digital recording of photography. It is as a general discussion around the subject of a more digitalized archaeology that the possible introduction of the omnidirectional camera can be placed. It is not as easy as all that to just introduce an omnidirectional camera, however.

Technology in general requires training and aptitude beyond the scope of classical archaeological training, which mainly consists of handling a trowel and digging trenches when one discusses the usage of tools in the field. In addition to this, operating the technology is one thing, it also requires further training to be able to read and interpret the data that they create. It follows then that to be an archaeologist one cannot rely solely on methods of digging, but in a manner of speaking must be an adept as a technician as well. This adds to the amount of education an archaeologist is required to undertake before they are allowed in the field proper. So, while technology is bringing a lot to the field of archaeology, it also increases the demands of the archaeologists who tries to wield them. My argument therefore is that digital archaeologists are not "de-skilled" but rather "re-skilled" as they are acquiring new skills and reforming the old.

With the increasing amount of technology used for documentation, and newer and more advanced technology at that, one must consider how one shall access and interpret the documentation created by it in the future. While this opens for opportunity, it also carries a risk for the present documentation created and accessed through that technology.

Data loss is of course a constant worry when talking about technology, but with the advent of cloud-based storage this is somewhat mitigated. However, outdated technology is no longer supported. That means that as time goes on, and more technology finds itself replaced, we might lose access to the documentation.

> "With the rapidly changing pace of advances in hardware and operating system in the mobile space, it is not possible to be certain that specific software will be able to function in even three years. In the past decade, we have already confronted this problem with the change from 32 to 64 bit architecture in desktops and the difficulty of Android devices to upgrade to later operating systems" (Wallrodt, 2016, p. 47).

Furthermore, technology requires added resources to function in an intended manner. Besides the personnel to operate them, which in this case usually are the archaeologist themselves, they also require power, storage, and upkeep. All these play a part to keep the equipment up and running. As such, while technology plays a huge part in how we collect material culture and heritage today, it is also shaping the way archaeologists work and think. It has also worked towards a change in the public perception of archaeologists, who previously seemed to be forever doomed as the people digging for dinosaurs using trowels and toothbrushes.

As we have seen, the usage of technology in archaeology does not come without a price. It is however a price willingly paid as the present field doctrine clearly attests. The disadvantages of working with digital tools are offset by the advantages.

Being a field that specializes in connecting the past to the present, archaeologists first need to find the past. This is done through a variety of methods. Mentioning but not elaborating on the "non-technological" methods, such as digging with trowels or shovels, excavators usually being operated by non-archaeologist personnel, the aforementioned technologies will here be briefly explained in conjunction with existing methods of conducting "archaeology".

Before any excavation can begin, one must identify the area in which any heritage or material culture may be present. The deciding factor of whether any exploration is deemed necessary is usually if any action is to be taken that might damage any material culture or heritage that might be in the area. Usually this is in conjuncture with building projects, such as the establishment of a new road or a housing estate for instance. Depending on the site in question, the landscape and the available history of the area, different forms of exploration will be used. For example, LiDAR is used when a large area needs to be covered. It is primarily a preliminary method of discovery, as it is unable to form the basis of any conclusive evidence of material heritage in the area. Usage of LiDAR will reveal differences in elevation which can show telling signs of burial mounds, production traces of coal or tar and other traces of human interaction.

LiDAR, or Light Detection and Ranging is, in short, an area detection method which uses laser signals cast upon a surface from a high elevation, to read the reflection of the returning lights (Norsk Institutt for Kulturminneforskning, 2016, p. 3). By doing this, the creation of high-resolution maps and three-dimensional objects are made possible. LiDAR is one of the "Remote sensing" techniques used within archaeology to find sites of interest.

When it discovers something that might be of historical value, an archaeologist will usually be sent out to investigate, time and money permitting.

Ground-penetrating radar is another type of technology which have been appropriated for archaeological use. Originally meant to investigate underground without having to intrude upon it, it is perfect to locate certain types of material culture. Deposits of metal for instance are easy to spot using ground-penetrating radar.

By using ground-penetrating radar one can locate areas of interest which might open for excavations. As such, it is, together with LiDAR a method of locating and not documenting. While the data created from both LiDAR and the GPR (ground-penetrating radar) are documented together with the rest of the material its value is scientific rather than historical and is stored to be examined in how the heritage was discovered rather than fostering any direct knowledge of the artifacts. As such, the nature of material discovered, the location where it was discovered, and the depth will be documented as meticulous as any photograph.

Drones are a relatively new inclusion within the field of archaeology, as they are a relatively new invention. Drones can trace their invention and primary usage to military purposes but have increasingly seen usage in the civilian market. By appropriating drones, archaeologists have been able to take photographs easily and quickly from the air. This has been an immense help in getting overhead photographs and eliminated older forms of "air photos" which were taken by an unlucky archaeologist climbing a ladder or stuck in a crane.

Drones then are for all intents and purposes a flying camera. It allows access to previously inaccessible fields of vision and things that are too high up to study normally. The outside of buildings and such are a good example of what a drone can document without endangering a person.

Geographical Information Systems (or GIS for short) is a computer software that allows the creation of maps. Although there are many definitions, (Heywood, Cornelius & Carver, 2011, p. 18) it is for the purpose of maps, that GIS is used in archaeology. These maps are then used for a multitude of reasons. There are maps that simply show the area, elevation, vegetation, habitation, and roads. There are also maps that through GIS are made to show areas of interest, perhaps that show LiDAR results, where elevation suggest burial mounds. Maps are also useful when considering documentation. From a historical perspective, maps show the area as it was when it was made. Changes in landscape and terrain is hardly uncommon and as such, having a factually correct summation of the area as it was, is useful when consulting the documentation regarding any activity, archaeological or otherwise, in an area. Furthermore, maps can show where the focus of an excavation has been centered, where the largest concentrations of finds were, or be used as supplementary documentation for drawings, photographs, or field diaries.

While technology in general is, and are continuing to be, an integrated part in how archaeology is being done today it is important to note that most technology in archaeological use today was included to fill an obvious niche or need. Or to improve existing techniques. Drones for instance saw its induction to replace existing methods of creating overhead photographs. It was safer and more cost-effective comparably to sending an archaeologist up in a crane, ladder or other highly placed trees or objects. As such it was

not a "new" or inventive way of doing archaeology but rather a new way of doing an old practice. The same could be argued for LiDAR which is "just" a very effective way of scouting the landscape. You still need to investigate in person, but now you have a general heading and approximate knowledge for what you are looking for. In the same vein as drone practice, LiDAR is rather a technological solution to the persistence of practical problems.

It is important to consider that while technology offers a lot of helpful solutions it is up to the archaeologist themselves to fulfill this potential. The main reason archaeology in Norway is so heavily dependent on education, training and experience is that it requires the ability to know what you are looking for, recognizing it when it is unearthed and above all, being able to interpret the find and putting it into the larger historical context. By interpreting material culture, the archaeologist puts it into a grander context that is being built and shaped by past, present and future archaeologists. This context is our shared understanding of the past and is an important when it comes to creating and shaping our identity, our knowledge, and our morality. Technology aids in this process of course, and many ways of conducting archaeology today would not be possible without it. As such, technology is an important part of archaeology and as the technological level of society advances, it is likely that further inclusion of technology in archaeology will continue to rise. From here it might be a good idea to take a closer look on photographical technology, its inclusion and development in the field of archaeology.

6. The development of photography and its role within the field of archaeology; a brief summary

"Archaeology is fast becoming a strange amalgam of hand tools and high technology, and photography stands somewhere midway between the two" – P. Dorrell, (1989 p. ix)

Going from generalities around technology and their influences on the documentation practices practiced in Norwegian archaeology, it is important to note that they are all grounded in the following principle: That to excavate heritage is also to disturb the context in which the material culture is found (Gaukstad, E., Bjerck, H., Arisholm, T., Eriksen, H., Holme, J., Norge Miljøverndepartementet, & Riksantikvaren. 2005), (Riksantikvaren, 2018). To excavate is to take the pristine materiality out of its proper context, and while it may sound strange to describe a dirty object covered in soil as "pristine", it is considered thus because of the amount of time it has spent without further human interaction. It forms a direct link to the past and the humans who inhabited it. This leads to the assumption that every object lies there for a reason, which may sound exaggerated, until you consider the fact that objects do not travel on their own. They are made by and travel with humans. Thus, the location where the object is found forms a contextual link to the humans who brought it there. For example, a large number of objects laying in the earth together with human remains is usually interpreted as a burial site. Burial sites have traditionally been found near settlements. By linking location and object agency a clearer picture of life in the past becomes apparent. Combining the smaller contexts of objects and remains creates a larger, more comprehensive context. Corroborating material culture with written historical sources may tell you whom the inhabitants of the grave used to be, or at least what line they belonged to.

However, piecing together the contexts, reading up on sources and researching in general takes time. As such, the materiality needs to be recorded and documented whilst still in the field. By doing this one can preserve the context found in location. Once the material culture is taken from the ground, its context is lost unless otherwise recorded, and then only exists as that documentation. The quality of the documentation then is important. This is only further underlined by the fact that material culture is not a renewable source. In the terms of material culture as a resource when it is removed it does not grow back.

To minimize the loss that occurs when we excavate, meticulous documentation is made during any excavation. This includes writing a field diary, filling out forms, drawing, writing rapports and taking photographs. However, this was not always the case. During the early development of archaeological field methods, documentation was deemed of lesser importance, than it is today. Among the methods of documentation, photography was implemented relatively early, although that does not mean that it is not undergoing changes even today. The world's first successful photograph was taken by Nicéphore Nicépe on a pewter plate in 1826, using his first professionally made camera supplied by the Parisian optician Charles Chevalier (Gernsheim 1965, p. 20). It would only take 24 years until the first documented usage of photography within the field of heritage studies would appear. In the 1850's a man named W.H. Fox Talbot captured images of manuscripts, excavations and

busts. At this stage, photography was considered by archaeologists to be a catch-all solution to any documentation of archaeological interests (Dorrell, 1989, p. 1).

It was at the time of Fox Talbot no uniform guidelines or standard methods of photographical documentation. Each archaeologist did what they thought best. This is different today, where there are several methods to produce high quality photographs and with better technology, we are afforded more options. Examples of this are clarity, motive, and lighting.

Although we have more options today than they did back then, it was still a solid job to produce archaeological photographic documentation. There might be several reasons for this. Taking photographs were a more exhaustive process then, than it is today. This is mainly because the size of a camera has shrunk considerably since its inception. It required a lot more to take the photo as a lot of the automated processes that happens inside a modern camera required manual effort back then.

Considering too the effort in making the picture appear on the paper after, the cost of materials and general quality of the photos, it is no wonder that there were no agreed upon uniformity in standards back when the camera was first introduced. It does not however, mean that any sort of ideal was not sought after.

> The idea that site photographs should reveal every detail of the excavations as they proceeded, with sections precisely cut and meticulously cleaned, was, characteristically, propounded and insisted on largely by Mortimer Wheeler, and carried out by his photographer, M. B. Cookson, during their long association. However, rarely achieved, this ideal remains central to the practice of archaeological photography today. (Dorrell, 1989, p. 7)

From its somewhat humble beginnings, the art of photography and the technology associated with it have experienced rapid development. From cameras that could only take a single photograph and relied on flash powder to create light, to cameras that can capture imagery in a circle, photography has in many ways, never been simpler and never been more advanced. The ideal that Dorell is speaking of, is at this point much more achievable as the mobility of the handheld camera allows for a more dynamic documentation process. Photography on its own however, is far from the catch-all solution archaeologists of Fox Talbot's time made it out to be.

"The camera is a key aid to recording, although archaeologists believe that it is less comprehensive in the detail it can show than the drawn record" (Grant, Gorin & Fleming, 2005, p. 50). Going back no further than around 2000 the usage of photography in archaeology was still analogue in nature. Any photograph an archaeologist would take in the field would need to be developed as the pictures were captured and held in the film. Further, they mention that "most archaeologists continue to use conventional black and white film for recording" (Grant, Gorin & Fleming, 2005, p. 50), which shows that black and white recording was still in practice in 2005. They then go on to explain that slide photography is being replaced by digital recording. "However, the superior quality of slide film it is increasingly being replaced by digital photography and video, particularly as a support to the site diary" (Grant, Gorin & Fleming, 2005, p. 50).

In the 2nd edition of The Archaeologist's Field Handbook North American Edition, which was published in 2009, under a section that explains how to protect your field gear, there is mention of "[…] a Pelican case with the following gear in it: a digital still camera, a digital movie camera, a standard Olympic SLR camera (for taking color slides) […]" (Burke, Smith & Zimmerman, 2009, p. 23). From this we can infer that not only do they use two cameras, one digital and one for slides, they also have a dedicated digital video camera. The digital camera being employed in the field today will usually have several different modes of image capture, among them a video mode. The development of camera technology is continually becoming more advanced, which is mainly why I have chosen to study the omnidirectional camera as a potential inclusion into the archaeological toolbox.

There are also other advantages to the digital camera. Among these are, firstly, the creation of instant images, which you can check before you move on. Secondly, the minimal cost of producing the images as compared to film cameras. Thirdly, the capture and storage of digital images is considerably cheaper than traditional photographs (Drewett, 2011, p. 69).

As for the role of photographs in archaeology, it remains largely the same as it was for 200 years ago. Photography is used to document excavations, examinations, objects, and locations, for a wide variety of use. Photographs are used to show where an object was found and what it looks like. It is also used to show methods and progress, to share with the public or create promotional material for museums. By using it together with written records, a photograph helps the archaeologist to create the context of the past. It is a supplement as it is not very telling on its own, but an important one as it relays the motive in a photorealistic manner. At its core it is there to allow people from the present and future to look at a moment captured in the past. This is not changed since the beginning.

Today, the photographic gear that archaeologists carry with them in the field is limited to a regular digital camera or in some cases a phone with a camera. The aforementioned slides have now become digital in nature which eliminates the need for the film camera. Overhead projectors have become replaced by PowerPoint and other presentation devices that are wholly digital in nature. Photographs taken in the field as documentation are stored in databanks to be used for research, museum banners, rapports and preserved for the future. The role of photography within the field of archaeology has changed very little. The usage of the photographs, how they look, and the general quality have all underwent changes since the 1850's but at its core, photography is still regarded as a staple of archaeological documentation. Of course, not every photograph taken on an excavation will be used afterwards. Much hinges upon the quality of the documentation and the context in which it might be used. In the next chapter then, we will discuss what makes a photograph suitable for archaeological documentation.

7. What constitutes as a "good" archaeological photograph?

"Basically, photography is a combination of visual imagination and design, craft skills and practical organizing ability." (Langford, 2000, p. 1).

Knowing how photography has been traditionally used, we will in this chapter take a closer look at how archaeological photographic documentation is created in practice. Archaeologists depend on photography a great deal. As mentioned in the previous chapter, the usage of photography is mostly a supplement to other forms of documentation, although it can stand on its own in certain situations. It is natural then that an archaeologist is expected to be able to take "good" archaeological photographs. What this means however is another beast altogether. An archaeologist is not a photographer. Whilst a photographer will in many ways construct a photograph to suit their goals: "There is always the need to make decisions on picture structuring" (Langford, 2000, p. 128), the archaeologist is working to create authentic photos that contribute to the overall context of the excavation at large. As such, the usage of props and models is frowned upon and are more considered to be clutter whilst props and models are essential tools for the photographer to capture the motive they aim to capture (Langford, 2000, p. 128). They both however make good use of the lighting to obtain the best photographs.

The archaeologist will indeed construct their photograph when creating their field documentation. However, the goal is to create a photograph that rings with authenticity. Any photo taken in the field should strive to depict as close to an objective truth as possible and as such any photomanipulation after the fact is discouraged, if not actively forbidden. So, the question must be asked; what are the criteria for a photograph to be regarded as "acceptable" documentation?

Whilst striving for the standard of: "revealing every detail of the excavations as they proceeded, with sections precisely cut and meticulously cleaned" (Dorrell, 1989, p. 7) it is important to note that

> A good archaeological photograph is not the same as a "good" artistic photograph. Because archaeological photography has a particular and quite narrow aim (to document a site or an artifact in the necessary technical detail), it is much more analytical and precise than taking snapshots. (Burke, Smith & Zimmerman, 2009, p. 290).

Burke, Smith & Zimmerman goes on to detail the "three elements to all archaeological field photography" (p. 292). These are as follows:

> 1. Learn enough basic technical skills to ensure you can take photographs that show sufficient technical detail.
> 2. Always include a scale, because there is no point in photographing a site or artifact without also indicating how big or small it is, and a north arrow for orientation. Pointed trowels often are used if no formal arrow is available.
> 3. Always record the details of every photograph on a written recording form. Because all photographs ultimately become part of the permanent site archive, written descriptions of each photograph are always noted on recording forms, so that no detail of any photograph is lost. (Burke, Smith & Zimmerman, 2009, p. 292).

Take into consideration as well that any photograph captured, is done so for a reason. What the photographer wants to show, how they want to show it and why they want to show it are all factors to consider when capturing archaeological documentation. Furthermore, what is the photographs being used for, is it useable for someone other than you? Are you communicating the message you want to send, and can a potential recipient understand what you are trying to convey? All these are important things to consider when documenting in the field (Burke, Smith & Zimmerman, 2009, p. 292).

One of the authorities on archaeological excavation, research and education in Norway, is NTNU University Museum through The Department of Archaeology and Cultural History. They are also hosting the cultural history collections of artifacts and material. NTNU is an abbreviation for Norwegian University of Science and Technology (NTNU University Museum, n.d.a).

As one of the museums responsible for archaeological excavation, NTNU have created a short document which details the important facets to include when creating archaeological photographic documentation. It details generally what needs to be documented and why. However, it is important to keep in mind that these were written as a guideline for the quality of the work produced by the museum. The information was obtained from NTNU University Museum (n.d.b). The full document is attached in appendix 1.

Photographic field documentation from the viewpoint of NTNU University Museum then, has several requirements to it:

1. Photographic documentation should occur before, during and after examination.
2. Include in the process, photographs of the process as this can give information about the methods used and make it possible to "recreate" the processes used in the afterwork (might also be used for dissemination purposes).
3. When it comes to structures at least one photo should include a scale and north arrow for orientation while keeping both as unintrusive as possible. The scale should lie parallel to the photo if this is not intrusive for the motive.
4. Strong sunlight can create unwanted contrasts which either distracts or distorts the motive. Shading can solve this issue.
5. Overview photos are important, before, during and after an excavation. These photos are used to place the location in the landscape, progress in the process and landscape features that may get destroyed or removed by the process or after. Usage of drones might be applicable here.
6. Photo lists are important, especially when several people are liable to take photos. Keeping the lists digital on iPad makes it easier to transfer to a PC after.
7. Finding a system to keep track on different types of photos and differentiating between different cameras (digital cameras) is important. Cleaning up the cameras between each time makes it easier to keep lists (NTNU University Museum, n.d.b).

From these points, we gain insight in how the process work, not only what makes for a good field photo. Having now established an understanding of what constitutes a "good" archaeological field photograph, the part photography plays in the documenting process and technology at large, we will now move onto a more philosophical, but nonetheless an

important direction of how the human experience changes when viewed through the filter of technology.

8. Authenticity in digital archaeology

"When we take a picture of a landscape or create a map using GIS we are abstracting the original phenomenal experience, taking it outside its initial context to view the world differently" – Crystal, D. (2018, p. 300)

Archaeology is an interpretive science. By studying the past, we study something that does no longer exist. It is no surprise then, that our methods of obtaining knowledge is interpretive as well. Technology becomes another framework of interpretation, a way to view the world in different angles and perspectives. How one experiences the world through technology differs from how one experiences the world through one's own senses. In example, a 3D printed object cannot be an authentic archaeological artifact. It can be based on one, but a 3D printed resin model has never been formed by the hands of a pre-historic human. At least not directly. While a copy is just that, a copy, it can be identical to the original object in every other way, except what to an archaeologist really matters, its history. However, we must consider the implications of perfectly rendered copies. Olson (2016) mentions how using image-based modeling software can create 3D models that can be used as a stand-in for the original artifact. "Rabinowitz, however, cogently points out that digital renderings, and by extension their printed outputs, are not true "surrogates" of the original because their creation, unlike drawings and sketches, lacks an interpretive framework" (Rabinowitz, 2015: 34 in Olson, 2016, p. 240).

3D printing aside, the authenticity of photographical archaeological documentation is no longer as secure as it used to be. While painting and drawing which are in some ways the precursor for photography insofar that it was a visual representation of reality, photography has been lauded for its ability to depict reality. "Photography and the cinema on the other hand are discoveries that satisfy, once and for all and in its very essence, our obsession with realism" (Bazin & Gray, 1960, p. 7).

With the advancement of technology, photography has come a long way from the pewter plates in the 1800's. They are remarkably sharp in detail, can be ported to a computer where you can subject it to all kinds of manipulation to turn a bad photo into a good one. The question is then, how does this affect our experience of the photograph? For a medium that is so firmly connected to "realism", there are a lot to consider when photomanipulation have become so easily accessible in programs like photoshop. Indeed, one need not go further than the internet phenomena "memes" to understand how prevalent basic photomanipulation has become.

Figure 1 *- "I told my uncle about Photoshop. He sent me this a week later". Retrieved from 9gag.com.*

With photomanipulation so readily available it does pose the question of what position archaeology, a discipline in which authenticity has long been lauded as an integral part, should take regarding photo manipulated documentation. In what ways will this change our perception of the motive? These are but two of the questions one must consider when interacting with archaeology through the filter of photographic technology.

That is not to say that we should refrain from using photo technology. Orthophotos with georeferencing, spatial recording and 3D modelling all have their uses within archaeology (Olson, 2016, p. 242). My point is that interacting with archaeology through technology is to create another layer of interpretation which ironically puts the archaeologist further removed from the object in question. Olson have, as we have seen, argued that an exactly rendered 3D printed model are able to stand-in for the original for the purposes of study (Olson, 2016, p. 240) but I would argue that this is dependent on the accuracy of the technology. While one cannot hold archaeology through the lens of technology to the same standards of authenticity as genuine artifacts, one can at least keep it secondary. A 3D printed model that is made in a 1-1 scale with all details included, or an unmanipulated photograph is as close to authentic as technology allows and as long as we stay aware of this fact, we should be able to keep working with it. The advantages are larger than then the disadvantages. "Through technology, we, therefore, abstractly experience a place – yet our subsequent sense of time has now become fractured into direct temporal and indirect temporally abstract avenues within our analysis" (Crystal, 2018, p, 302).

9. What is an omnidirectional camera and how does it work?

"I won't bore you with tech, but…" – Kenneth Donnelly (Mass Effect 2, 2010)

Having expanded a bit on the role technology plays within archaeology today, how omnidirectional cameras have been utilized previously, I feel I need to expand on what exactly an omnidirectional camera is and how they work. While technology in general is, and are continuing to be, a huge boon to the field, the omnidirectional camera in particular is as of yet, fairly unproven and I believe this is partly because of the perceived similarity to regular photography and the difference in both perspective and the skillset required to operate it effectively within archaeology. To begin with, there are different kinds of omnidirectional cameras. I will in this chapter expand on the different types that are available to the public at this time of writing. As with many other technologies this one is in a constant state of development and in the future new types of omnidirectional cameras may be available.

Firstly, there are a few types of omnidirectional cameras on the market today. While most omnidirectional cameras operate within the same principle of multi-angle light capture to a wider angle than what is customary for a non-omnidirectional camera, there are some minor differences between the omnidirectional cameras themselves which are worth a mention. Note too that omnidirectional cameras come in several different price ranges and forms. As they are intended for a specific purpose and designed with this in mind, some might not be suitable for archeological field work. This may be because of their size or fragility. Any action camera that are intended for outdoors activity might be usable in an archaeological context.

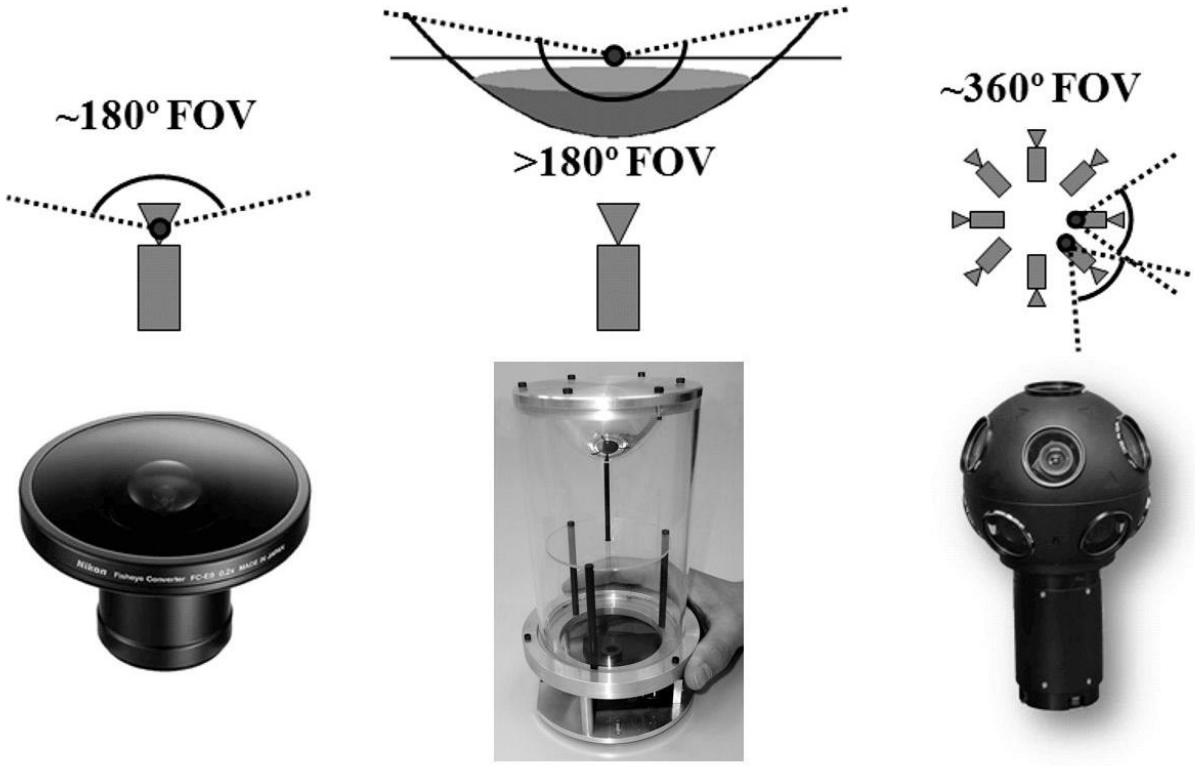

Figure 2 *- (a) Dioptric camera (e.g. fisheye); (b) catadioptric camera; (c) an example (Scaramuzza & Ikeuchi, 2014, p. 2)*

The first camera to mention is the dioptric camera. They use shaped lenses which give what we call the fisheye effect. While generally, all omnidirectional cameras get this effect there are some exceptions. The fisheye effect is named after the bulbous, round eyes typically found on fish, which gives a distorted form of vision compared to the human eye. The lens can in theory capture more than a 180° angle in its imagery, but because of how it captures, it will to a certain degree distort the image that is not directly in focus.

Figure 3 - *Picture taken from an archaeological excavation on Vinjeøra, Trøndelag.*

When the image is presented as shown above (fig 4), the fisheye effect is diluted and can hardly be spotted. However, the observant viewer might see several distorted lines in the image, especially noting the thumb on the left side which seems to magically disappear. The same effect is also noticeable on the right side, and bottom line of the photo.

Note as well, that the camera I had available for my thesis was a GoPro Fusion which has now been discontinued and replaced by the GoPro Max. The GoPro Fusion works with two dioptric fisheye lenses, one on each side of the camera. As such they do overlap in

certain areas which are noticeable in the finished product, as the camera are unable to fully capture itself.

Figure 4 *- Note how there is a blur near the fingers of the photograph. The actual motive of this photo was a sectioned structure which is not shown. The focus of the picture has been moved for the purposes of showcasing the "other" side of the picture.*

To go into some detail concerning the GoPro Fusion specifically, the layout is as follows:

It has two buttons on the camera itself which allows you to control the functions. You press the button that has a large red circle on it, and the camera will either take a picture or start recording a video depending on which setting you have set it to. The other button is to change which setting you are currently using.

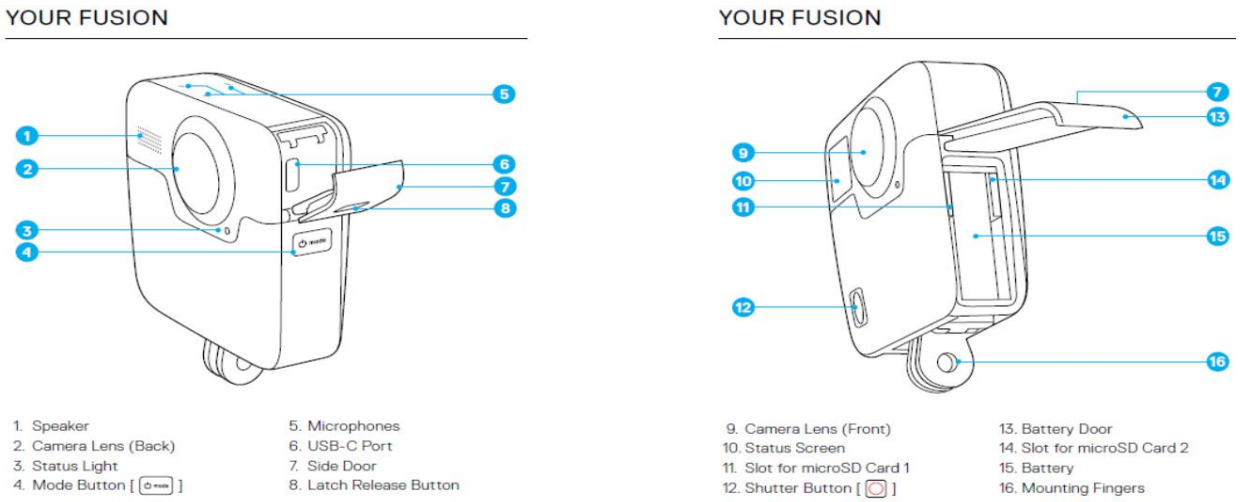

Figure 5 *- An overview that shows the functionality of the GoPro Fusion*

Expanding a bit on the point above, the GoPro Fusion also comes with a set of voice commands. With them, you can make your GoPro perform a number of actions.

5. GoPro Fusion Voice Commands

GoPro Fusion was released in November 2017. It has since been replaced by the GoPro MAX in October 2019.

Here are the 13 voice command settings for the Fusion:

1. **GoPro Video Mode**
2. GoPro Start Recording
3. GoPro Stop Recording
4. **GoPro Time Lapse Mode**
5. GoPro Start Time Lapse
6. GoPro Stop Time Lapse
7. **GoPro Photo Mode**
8. GoPro Take a Photo
9. **GoPro Burst Mode**
10. GoPro Shoot Burst
11. GoPro Turn Off
12. GoPro HiLight *(Adds a HiLight tag while recording video)*

Figure 6 *- GoPro Fusion voice commands*

By using these voice commands, you do not have to press the button on either the camera or in the companion app to start capturing footage. This is ideal when you are unable to do so, for instance if you need both hands to keep the camera steady. As this is dependent on the camera catching your voice however you may find yourself screaming at a camera, trying to document something in a 20-mph windstorm. Note too that other omnidirectional cameras might not have this functionality.

While there are other forms of omnidirectional cameras, I have elected to simply mentioning them, as I have not been able to test them, and are therefore unable to form an educated opinion on their effectiveness in the field which is what this thesis is focusing on.

Two of the other forms of the omnidirectional camera is the catadioptric: "Catadioptric cameras combine a standard camera with a shaped mirror – such as a parabolic, hyperbolic, or elliptical mirror – and provide 360-degree field of view in the horizontal plane and more than 100 degrees in elevation" (Ikeuchi, 2014, p, 2). Finally, the polydioptric cameras function by having several overlapping lenses to create the spherical field of view that allows for omnidirectional vision.

As mentioned, the camera I used during the gathering of data for my thesis were the GoPro Fusion camera. The GoPro Fusion works with two dioptric lenses which are both in use, any time you use the camera. In the case of the GoPro this means that the camera actually functions somewhat like two cameras taking two photographs at the same time, and then stitching two photographs together into one. The GoPro Fusion requires two SD cards for storage, one for each lens and by accessing them on a medium such as a PC or Mac you are able to see the photographs individually, before the camera has stitched them together. Example:

Figure 7 *- A photograph of what was speculated to be a stone path. The area was sectioned, and the camera placed within. Example of a pre-stitched omnidirectional photograph.*

Having looked at how the omnidirectional camera works it is fitting then to take a look at examples of usage. While there have been precious few instances where omnidirectional cameras have been used in archaeology there are instances where this has been the case. However, none as far as I can find have been solely focused on the omnidirectional camera. Of the few examples I have been able to find, the underwater examination of a sunken ship named Gnalić, the research team outfitted an AUV with omnidirectional cameras to map the inside of the ship. The data found within were used to build 360° panoramic videos, topological panoramic maps and 3D optical reconstructions. Further reading can be found in the Third Iberian Robotics Conference, "Immersive touring for marine archaeology. Application of a New Compact Omnidirectional camera to mapping the Gnalić shipwreck with an AUV" (p. 183-195).

An experiment was also performed on land, in London during the Crossrail excavation that began in 2015 and which aims to add to the London underground network. The experiment itself was just a part of the bigger project in which the construction of a new subway line opened for new archaeological possibilities to discover the history of London. New ways to document and convey the documentation to the public was considered, and the advent of omnidirectional cameras was at the time considered a worthwhile addition. The key example of omnidirectional documentation can today be found on YouTube by following this link: https://www.youtube.com/watch?v=fHSLW2K8ZjM in which the archaeologists are digging out what they suspect to be a plague pit from 1665. The experiment was overall a minor addition to a larger project. I have been unable to access the data collected about the usage of the camera itself. However, I have based parts of how the data collecting process from the video they released on YouTube.

In the video the archaeologists have placed the camera to allow visual access to the methods used for excavation. It shows how they work in the pit itself, and the surroundings in which the pit has been found. The goal, however, does not seem to be to document the find as I try to do, but rather to allow the general public some sort of insight in how it is to be an archaeologist. "Using an innovative 360 degree video capture, the short film lets viewers step into the shoes of archaeologists from Museum of London Archaeology (MOLA) who are carefully excavating the burial" (Crossrail Project, 2015).

The Norwegian Institute for Cultural Heritage Research (NIKU) is in their own words an "independent institute for applied R&D (research & development) and for services within the wider field of Cultural Heritage in Norway and beyond (Norsk institutt for kulturminneforskning, n.d.). This being the case, it is not surprising that they have made forays into the omnidirectional world https://www.youtube.com/watch?v=QSZTvqQHrl8&t=143s. This video shows how NIKU in cooperation with Oslo Ladegård and Tidvis Utvikling AS has made a virtual representation of Oslo in 1324. While not directly connected to the omnidirectional camera per se, it is nonetheless a good example of the "applied R&D" that they are working with. Furthermore, in this video, https://www.youtube.com/watch?v=y1T9CdT0Z5U one can spot at the time 1:28 the usage of the GoPro Fusion. The results from this excavation have not been published but one might speculate in what ways they have elected to work with the footage.

While not a very extensive list, I do feel like they exemplify some of the possible ways to utilize the omnidirectional camera within archaeology. None of the examples

however focuses solely on the omnidirectional camera itself. It is used in conjecture with a specific goal. In the case of marine archaeology, the omnidirectional camera has already been embraced as it offers a mobility and field of vision that can be hard to attain in any other way whilst underwater. The usage of omnidirectional cameras in the Crossrail project showcases clearly a potential of the omnidirectional camera but is too short and lacks any real context to draw any conclusions from it.

The existing examples of usages of omnidirectional cameras within archaeology is rather sparse when compared to other forms of technology used within archaeology. It is, however, important to acknowledge their contributions as it gives an idea on the status on the usage of omnidirectional cameras within archaeology today.

Having now put omnidirectional in an archaeological context we can move on to looking at the data collected for this thesis.

10. Empirical data collection

"And Tiffany had thought – Where's the evidence?" – Pratchett, T. (2003, p. 37)

Before we go into any detail on the data itself, we need to take a closer look at the method of collecting, where it was collected, by whom and when. This is mainly to construct a context and structure to make it easier to categorize the finds. To gather the data needed to answer the questions posed by this thesis, several trips into the field with the GoPro Fusion were required. Included in the data, there are also some tentative trials of the Google Street View app, which is an app that allows your phone to take pictures, stitch them together and make an ad-hoc omnidirectional picture. The gathering of data was performed primarily by myself, although one experiment were performed by another student at the master's programme, who were sent out with the omnidirectional camera and told to use it to the best of their extent. A short guide on how the camera functions was provided but no instruction in any method or practical tips. The goal was to see how a "learning by doing" process would differ from my own as we both started at the same point of understanding.

The initial attempts of collecting data were performed without any omnidirectional methodology. This was mainly since there are no standard methodology concerning omnidirectional photography, but also because I wanted to test the intuitiveness of the omnidirectional camera. By personally experiencing the shift of perspective that comes with using an omnidirectional camera comparative to a regular digital camera I could lay the foundation of understanding needed to possibly create a new methodology when gathering omnidirectional documentation.

Whom	Where	When	Size
Stian Ingdahl	Ireland	Spring, 2020	769,5 MB
Stian Ingdahl	Flatanger	Summer, 2020	1.51 GB
Stian Ingdahl	Melhus	Fall, 2020	22.3 GB
Stian Ingdahl	Vinje	Fall, 2020	2,47 GB
Aleksander Skre	Rein Kloster/Skaun Kirke	Fall 2020	17,62 GB
Stian Ingdahl	Flatåsen	Fall 2020	229 MB
Stian Ingdahl	Kvikne	Fall 2020	194 MB
Stian Ingdahl	Melhus Kultursti	Fall 2020	10,2 GB

***Table 1** - Data collected*

Maps depicting the different places can be found in appendix 2. The table above is depicting the different areas where footage has been gathered, when it was gathered, and the size of the material gathered. I have also included the person responsible for gathering the data. There is no separation of which are photographs and which are videos as the

method of presentation requires a filtering of traits that makes it irrelevant regardless. As a side note, due to the restrictions imposed on 2D media compared to the 3D media, there are some loss of functionality when translating the footage from the GoPro Studio and how they are presented in the thesis. After rendering the footage, whether they are stills or videos they offer the ability to move around the screen, looking around. The videos retain this ability when uploaded to YouTube, however the stills do not. This is because stills are unable to be uploaded directly to YouTube. YouTube after all is a video platform and as such is not made to show stills in the manner of which I needed it to. The solution to this was simply to make a video of my screen while I was looking around the photographs, edit it into a video format YouTube would accept and upload it that way. Since the purpose is to showcase what one can do with an omnidirectional image it does work towards its intended objective, although in a more roundabout manner than I would have liked. Nonetheless, videos taken with the omnidirectional camera can be rendered in the accompanying program, GoPro Fusion studio, and be uploaded directly without losing any functionality.

Chronologically the first imagery captured and used in this thesis, were captured in the early phase of the thesis and took place in Ireland.

1. https://youtu.be/VHz5CXbCpeo - Newgrange Wall
2. https://www.youtube.com/watch?v=n_b87qxCxJE - Carrowkeel
3. https://youtu.be/xLDSyDi9ZOc - Midden on Omey Island

These videos are from the Ireland footage. The Newgrange Wall footage was taken by placing the camera on the ground, close to the wall. As can be seen in the footage, there is no north arrow, nor any true indication of scale. One might infer scale from the person standing in the footage, but this is unreliable at best since the size of humans can differ wildly. The camera captures the wall construction, a few mounds in the background as well as a few people.

The Carrorwkeel footage shows the inside of a passage tomb- By imagery was captured by placing the camera on the floor of the central chamber. The three secondary chambers were lit up by three people using their cellphones as flashlights whilst the photographer stood in the opening with their backs against the light.

The Omey Island footage were taken by holding the camera up to the intended motive. The camera was held because the foundation was unstable and the camera would fall over. Again, there are no north arrow or scale included in the photo. The footage is closer than the one in Newgrange. Omey Island also had ruins of a church which were documented.

Going forward I will no longer point out the lack of north arrow and scale, as this will primarily not be a feature. There are some exceptions on the inclusions of a scale, but this will become apparent when watching the footage. Having said that, the ruined church footage gives an idea of scale. One can use the length of the camera to calculate approximate scale as compared to the environment it is placed. This is only possible when one knows how tall the camera is and when it is placed securely on the ground.

https://www.youtube.com/watch?v=Dtl7iwx1G_g - Omey Island ruined church

The footage displays the ruins of a church, the photographer using the GoPro companion app to take the footage and the nearby environment of the ruins. The footage was captured by placing the camera on the ground, making sure it would not fall over. Furthermore, it was taken where the photographer could keep an eye on the camera to make sure it did not lose connection with the phone. This was in the early stages of testing and usage of voice commands and app control were still somewhat foreign concepts.

The second set of imagery were captured in Flatanger, Trøndelag. Taking the opportunity to bring the omnidirectional camera with me in the field when hired to investigate the area for possible sites of material heritage and cultural heritage. More familiar with the camera at this point, I set out to explore other avenues of usage for the camera.

https://www.youtube.com/watch?v=UFgWYv-GpgY – Flatanger space

This footage shows the inside of a small cave/overhang. The camera is placed on a rock inside the space and the imagery is captured using the companion app. At this stage, no photographer is in the image. By taking a quick photograph and rendering it, I can inspect the inside of the cave/overhang with a single picture.

https://www.youtube.com/watch?v=uyTsz0afXcw – Flatanger Overview

By holding the camera high and either pressing the button on the camera or by using the companion app one can take a photograph that gives an impression on the landscape in the area. This is useful for capturing imagery with focus on a broader perspective or context.

https://www.youtube.com/watch?v=QD01VRw-F0g – Reins Kloster

This footage was captured by another student who were given access to the camera and some rudimentary explanation on how it worked in exchange for testing it out. Their intention was to look for marks left by the mason in the building and by using the omnidirectional camera they gained access to areas that would otherwise be unavailable. The imagery was captured by taping the camera stand to an even longer stick to increase the length.

The omnidirectional camera was not the only instrument for collecting data. To gather a small basis of comparison for other alternatives that offered omnidirectional footage I downloaded and used the Google Streetview app. The Google Street View app is capable of allowing someone who might not otherwise have access to an omnidirectional camera to take omnidirectional photos. The app functions by using a cellphone with a camera to take a series of pictures in a 360° angle around yourself. It then stitches the images together to create a rudimentary omnidirectional image. In this way the Google Street View app functions by the same principle as the GoPro Fusion omnidirectional camera, however the result is rarely as good. This is mainly because the app requires you to take several photos in a row, connected by different points. These points serve as connectors in which the app will use to stitch the image together. Comparatively to the Fusion which takes everything at one press of the button the process with Street View is

tedious, inaccurate and unsatisfactory. Example of a photo taken with the Google Street View app: https://youtu.be/kXf-5DeUFPM – Brekkberget.

To summarize; the data collected for this thesis were done by two persons. I collected the majority of the content, with some assistance from another student. The data consists of photographic imagery, both stills and videos captured in several different places and at different times of year. These include, but are not limited to: passage tombs, middens, churches, ruins, and landscapes.

Other data were collected in a cultural trail, using the Google Street View app. The app in question is primarily an add-on to Google Maps, in which Street View allows a view from street level.

Figure 8 *- An example of a Google Street View image*

The Google Street View app is meant to take photographs, among them 360° photos that will better the street view experience as shown above (fig 9). The intention is then to take photos and upload them to Google Maps. Which brings up the question of ownership. While the photos you take with this app remains legally yours as per the Google Street View guidelines (Google Maps, n.d.). It also states that they do not allow photos which may infringe upon the legal rights of another. As this might be quite vague, especially in the matters of ownership of cultural heritage, it makes it unsuitable for institutions like museums as the photos can be removed at any time by Google's discretion.

11. How the method started and how it developed over time

"Surely no man would work so hard or attain such precise information unless he had some definite end in view" (Doyle, 2011, p. 9)

In the previous chapter I mentioned some of the methods tested and the ways I collected the data by travelling to a lot of different places, taking a lot of different imagery, both stills and videos. In the beginning I was under the assumption that the omnidirectional camera would function in the same way as a regular digital camera. As such I also assumed that the method of taking photographs would be the same. This would quickly turn out to not be the case.

The first method tried was simply to use the omnidirectional camera as a regular camera, whilst adhering to accepted practice as set out by the NTNU guidelines and the generally agreed upon method of conduct found in archaeological handbooks. In the process of collecting the data for this thesis, I at first made the error of assuming that just because an omnidirectional camera is a camera, the approach would be the same as a digital camera.

Example: https://youtu.be/VHz5CXbCpeo - Newgrange Wall. Once again, we look at this photo at Newgrange. The motive shows the side of a wall and its construction. The intended motive was the wall. As can be seen in the example, the motive was indeed captured. However, the photographer, unrelated landscapes and other people were captured as well. By having the intended motive straight in front of the camera without thinking about the rest of field of vision I unintentionally created imagery with 25% motive and 75% clutter. This is a very common occurrence during the earliest stages of testing the omnidirectional camera.

As I realized I had to shift my thinking and abandon the mindset that I began with, the photographs started to change character. By no longer thinking of the omnidirectional camera as a regular camera, but rather something different, I became able to control the photographs in a larger degree. As I evolved my thinking, I started to become more aware of my surroundings. I was still capturing large open areas but more focused. In this example: https://youtu.be/Dtl7iwx1G_g - Omey Island ruined church, the motive is the ruins of a church on Omey Island, Ireland. There is, however, evidence of the slow shift from traditional field methods when taking archaeological photographical documentation into the potential lying in the omnidirectional camera. Although there are, once again, unrelated clutter in the photo that detracts from the motive while also lacking a north arrow, it is still a "better" photograph when compared to the previous example as it has reduced the clutter and having more of the motive shown.

Simply by using the omnidirectional camera and trying my way forward I shifted my thinking. Familiarity with the camera enabled a progression which has led me to the conclusion of this thesis, which will be discussed more in-depth later. For now, it is enough to say that the extended usage of the camera afforded me an ever-expanding perspective of the potential uses of the omnidirectional camera.

As the method of capture was evolving it also began to branch out. I found that doing something a certain way could be beneficial in certain situations but not in others. I could not find a uniform way or a method that would work 100% in every situation, however. In this way the omnidirectional camera shares an important aspect with the traditional digital camera; the best way to use it for archaeological purposes is simply to play it by ear and make the situation work for you. By knowing how the camera works you can make it show what you want it to show. Acknowledging that the omnidirectional camera gives you a different perspective to the one afforded you by a traditional digital camera is vital to make use of it in archaeological purposes. They do not function in the same way and should not be used as if they did. To show what I mean, I will include examples of different ways of using the omnidirectional camera in different situations:

https://www.youtube.com/watch?v=KUnk1CBel80 – Imagery from a Ward. In this video one can see the surrounding landscape from the perspective of a small stack of rocks. Stacking of rocks can be used as a landmark as when it is done at the top of a mountain like this, they are very visible in the landscape. In the chronology of the thesis, this photograph was taken during the summer of 2020, which is comparatively early in my process of discovering the best way to use the camera. The idea behind the photo was to show the perspective of a rock stack on a mountain top. However, instead of placing the camera from the perspective of the ward, I should have instead held the camera in head height, approximate to how tall people from the suspected age would be. By doing that I could have captured a semi-phenomenological experience of how it is to stand on the mountain top and what they would have seen.

Instead, the camera was placed too low to the ground which negates the point that I was trying to convey. The context of the surroundings is not clearly shown because I did not place the camera higher up, or even held it high. Having said that, I would still argue that it was a sound idea in theory as capturing the landscape could be used as a secondary documentation to support maps of the area. Gaining that context with omnidirectional imagery could potentially have some value.

This is one example of where the omnidirectional camera functions differently from a digital camera. By using the omnidirectional camera to document the landscape, one gains the ability to conduct an analysis of the landscape at the time the photograph was taken. The added 3D aspect to a photograph will make it easier to draw conclusions on the landscape as you get a more complete image than if you would just take a series of regular photographs taken with a 2D camera.

The next example is one which I personally feel embodies the strength of the omnidirectional camera: https://www.youtube.com/watch?v=QD01VRw-F0g – Markings in a stone church. This video showcases the southern portal in the ruins of Rein Klosterkirke. The church was built around 1200 AD and belonged to the noble family, Reinsætten and is mentioned in the historical fiction, Kristin Lavransdatter by Sigrid Undset. The imagery was captured with two goals in mind; to gauge the state of the arch and to look for masons' marks. The video showcases tight spaces high above the ground. In this instance it differs from the footage shown previously. Instead of a large open landscape it is focused on details in tight cramped spaces. Immediately a new avenue of potential has opened. Previously inaccessible places, which would have required a personal investigation have now

become accessible to scout and perform preliminary investigations without having to climb up or remove any layers which may be restrict access. In the case of this church as seen in the footage, the usage of the omnidirectional camera is not primarily as a documentation instrument, but rather one of investigation and "sensing". While you could reach the same height by using a drone you would not be able to fit a drone within the space behind the arch. However, clever use of a selfie-stick, some tape and the companion app, the photographer creates imagery that allows for minute inspection of the arch. The omnidirectional nature of the imagery allows for movement within the footage, with the option to pause the video if there is anything that catches the eye. While a digital camera would be able to reach the same heigh, you would not gain the same flexibility of footage, nor would you be able to capture the imagery with the same ease.

To summarize: my approach to working with the omnidirectional camera changed from focusing on the "camera" part and instead to focusing on the "omnidirectional" part. This shift in perspective meant a change in motives, figuring out the strengths of the camera which primarily lies in reaching inaccessible and cramped spaces and gather information.

Having talked a bit about the development of the methodology from the beginning it is time to discuss how it looks today.

12. Current methodology

"There were a million stars fighting for prominence and for a moment he seemed intent on nothing less than studying them all […]" (Goldman, 2008, p. 160).

In this chapter I will outline my current methodology, how it differs from the practice generally accepted for the traditional digital camera and why. Furthermore, I will also outline how the methodology created here can answer questions posed in the beginning of this thesis.

Although it lacks any real substance when compared to NTNU's guidelines for photographic documentation and the generally accepted field practice outlined in archaeological handbooks, the method is nonetheless tested in the field. It has not been enough for me to have any finely polished guidelines and methods, nor for me to be considered in any way as an "expert" on the subject, but what follows is my interpretation regarding the "correct" usage of the omnidirectional camera for archaeological use. These are primarily suggestions as to how to draw out some of the potential of the omnidirectional camera that I have discovered. Undoubtedly some other creative soul can find other, untapped sources of use for the omnidirectional camera.

12.1 **Documentation**

To be able to use the omnidirectional camera as tool for creating archaeological documentation, there would have to be a process of subjective assessment. In the same way that regular photographical documentation must meet a certain criterion, so too must the omnidirectional documentation. Going by the criteria set out by Burke, Smith & Zimmerman (2009, p. 292), the approaches would differ in small but significant ways when using the omnidirectional camera for documenting (See chapter 7 "What constitutes as a "good" archaeological photograph?" for the three elements of archaeological field photography):

1. Learn enough basic technical skills to ensure you can take photographs that show sufficient technical detail.

This point remains much the same as Burke et al. when using an omnidirectional camera. The only real change is that the amount of "sufficient technical detail" changes together with the amount of general detail increased in the photograph. In other words, you must make an increasing amount of judgement calls as the field of vision is drastically expanded over a regular camera. However, the work is the same, it is just more of it.

2. Always include a scale, because there is no point in photographing a site or artifact without also indicating how big or small it is, and a north arrow for orientation. Pointed trowels often are used if no formal arrow is available.

A proper introduction of a scale in omnidirectional documentation is more challenging than just throwing in a scale in the photo and calling it quits. In a regular digital photograph, this would be simple. A small inclusion of a scale does not clutter the photograph after all.

Indeed, a single motive which does not require you to look around to grasp the entirety of it would not require an omnidirectional camera in the first place. A motive which extends beyond the reach of a traditional digital camera, however, means that you have to decide the best place for the scale to appear. Here we must make a call between what is feasible and what is optimal. For instance, if you were trying to apply this in omnidirectional documentation, it would be optimal if you could always have a scale in your field of vision. However, this simply is not feasible, as a 360° field of vision that is also maneuverable, it becomes complicated and unnecessarily so. The inclusion of scale then, should only happen in one frame, which can be used as a framework for the rest of the photograph. Another possible outcome would be to have a camera that can calculate scale when taking the photograph, either from calculating it from the scale included in the photo, or from native software. A north arrow on the other hand is a simple step to include and can be done with whatever is at hand, i.e., trowels, persons or other pointy things that happen to be on hand.

> 3. Always record the details of every photograph on a written recording form. Because all photographs ultimately become part of the permanent site archive, written descriptions of each photograph are always noted on recording forms, so that no detail of any photograph is lost.

This is a criterion that is much the same as with point 1. The amount of work related to the photograph increases but is essentially the same. However, I would argue that omnidirectional documentation does not require the same ratio of data needed to be recorded on the written form. While you would need to include more detail, it would not have to be equally as detailed. The omnidirectional data are more open to interpretation simply because there is more photo to interpret. As such, you should include on your written form the basic descriptions that are the norm today, include a few extra details but then allow your photograph to speak for itself in a higher degree than is possible for the regular photographical documentation.

Having now looked at the criteria put forth by Burke et al. and made small alterations to suit the difference in media, we can conclude that the omnidirectional camera would primarily be used for specific scenarios and situations. It should not be used to document the same things and situations that a regular digital camera is used for. Although some overlap is probable, the two are not interchangeable and should be considered as different tools for different tasks. An example of a scenario or situation where the omnidirectional camera could be considered is when one would document the landscape in an elevated position. By taking photos or videos of the landscape with high elevation one could allow for landscape analysis and orientation as secondary documentation to maps or field diary. To do this, hold the camera high, preferably above the head of the one taking the photograph, filming for at least 10 seconds without moving. Audio is unnecessary and should be removed while working with the data unless dissemination of the video on social media or the like, is the intended usage. By filming for at least 10 seconds one can comfortably pause the video and look around the landscape for as long as one would want. Just taking a photo is also an option, although I have had mixed results when trying to present the imagery documented in this way. Expanding on why filming is currently the better alternative to simply taking a photo. It has been my experience that a video is easier

to work with in post. It takes longer to render, but the process of getting it online is still more efficient and does not lose any functionality which is a major advantage.

12.2 **Close sensing**

While the omnidirectional camera does record and thus creates documentation merely by performing its intended task, it is as a tool for finding traces of cultural heritage in tight spaces where it really shows potential. The design of the camera, how it works with the companion app and the general sturdiness of it all, means that it is easy to reach or insert into inaccessible areas, capture the details within and study them, all without having to return to base to do so. It is therefore quite suitable for investigative and preliminary purposes. This being the case, I am using the term "close sensing", in direct correlation to the term "remote sensing" which is used about tools like LiDAR. As the term suggests, it allows archaeologists an extension of senses to discover and investigate possible sites of interest. Whilst "remote sensing" could be an applicable term for the omnidirectional camera in the sense that you are "sensing" the site through the filter of technology, I would argue that "close sensing" makes more sense since other examples of "remote sensing" includes LiDAR which are literally several hundred meters off the ground and drones which are several meters above the ground. "Close sensing" then, which only reaches as far as the hand-held device and a stick can take you, would be a better term.

The reason the omnidirectional camera works as a "close sensing" tool is that it requires a very small amount of additional effort for a potentially high gain. To carry the omnidirectional camera with you in the field is not a problem, considering the diminutive size on the average omnidirectional camera. The same size also allows it access to areas which would be very difficult to enter otherwise. A good enough camera will also have light-adjusting lenses or even night-vision, so even if it is a dark space, it could still potentially pick up details that would otherwise be hard to spot. Working as well on a solution to make an omnidirectional camera work with known technology such as DStretch can make finding rock art easier.

The GoPro Fusion can provide a live feed on your phone when connected, not unlike the small screen that digital cameras come equipped with. You use your phone to see the motive, and by utilizing the phone's internal gyrator you can turn around in real time and look around using the camera. You can also click and drag using your finger to shift the view. The view the camera is currently capturing will be shown directly on your phone. This then means that the camera does not necessarily need to be recording to be useful. The option of using the camera to explore and discover hidden details in walls, mountains or other flat and hidden surfaces without having to enter is an enticing one. Not unlike a colonoscopy, it works by inserting the camera into an otherwise inaccessible opening to see what is inside/behind/beneath/at the side and looking at it through the camera feed on your phone. The auto adjusting light settings on the camera means that you will also be able to see, even if there is no light inside said opening. This specific method has been tested and can be seen in these examples: https://youtu.be/QD01VRw-F0g - Markings in a stone church. In this example you can see a testing of the aforementioned method; inserting the camera into a cramped space using the GoPro Fusion. https://youtu.be/OAHxIJiTJyE - Reins Kloster GoPro Fusion recording. In this example I would like to point out the method of

investigation. By carefully scanning the surface of the wall, we are able to reach new heights to investigate. This method means that we do not need to use ladders, cranes and are safer than using drones. Ladders or cranes are well and good when operating in proximity to cities or towns in which they might be readily available. It is something quite different when you have trekked into the mountains or valleys for which Norway is so famous.

In summation, by using the omnidirectional camera as a "close sensing" tool you essentially gain a retractable eye that can look around, conceivably look through color spectrums humans usually cannot (DStretch) and poke their eyes in areas which would usually be unavailable, even with drones and ladders.

While there are quite possibly many other ways to utilize the omnidirectional camera in archaeology, these are the two ways I have discovered whilst writing this thesis. I have encountered many challenges while working with the GoPro Fusion, however. The easy part was taking the photographs and videos. The challenge lay in presenting them in a manner that utilized the omnidirectional functionality inherent in the camera.

13. Working with the GoPro Fusion; presenting the imagery

"Photographs were taken with digital cameras; despite being "born digital", they still required secondary processing" (Motz, 2016, p. 80).

Having now discussed some forms of usage for the omnidirectional camera and how I chose to approach the issue, I will here talk about the immediate issues when it comes to presenting the material captured. To be able to present the photographic imagery as seen in the examples already presented, I had to render the photos from the camera to my computer through the GoPro Fusion Studio app. This app allows the user to regulate the resolution and size of the photos as well as changing the file type of the photo.

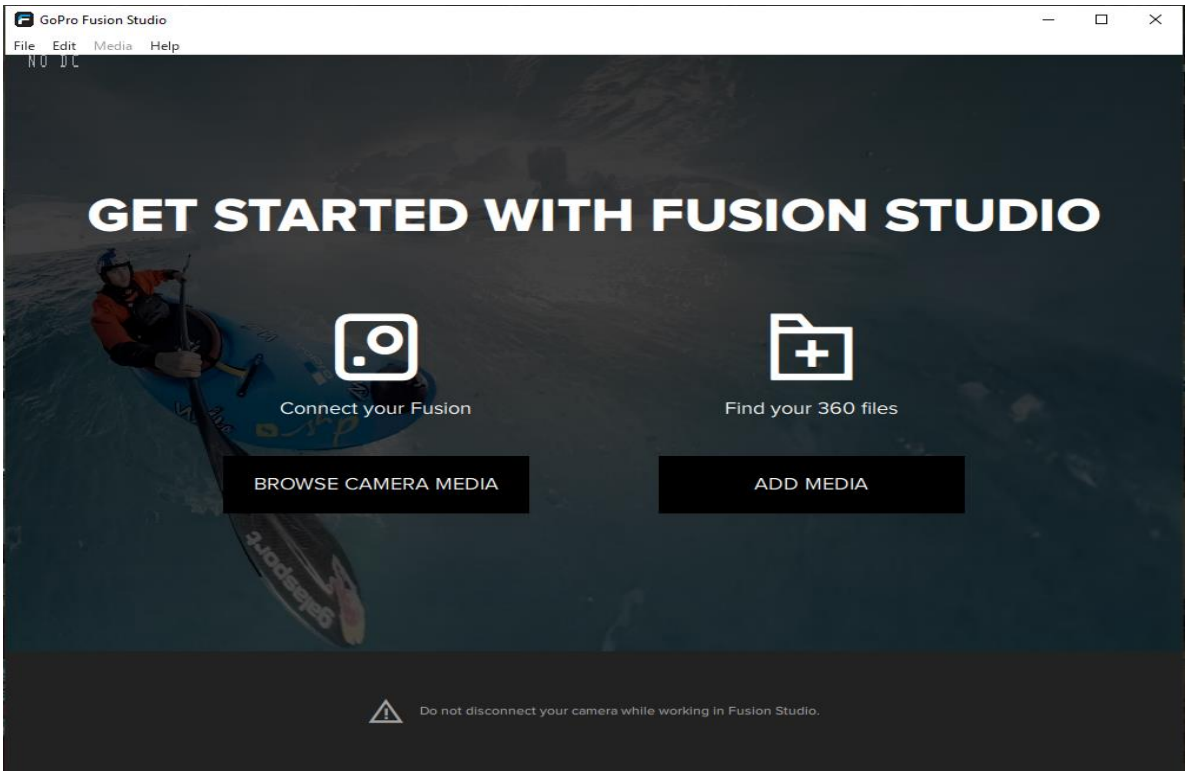

***Figure 9** – Start screen for the GoPro Fusion Studio*

This photo shows the start screen for the GoPro Fusion Studio app. It features two buttons in which you can browse the media directly on your camera, or you can access your files from a directive on your computer. By storing your files on your computer or in a backup area such as an external hard drive or a cloud you remove the need of having the omnidirectional camera plugged into the pc whilst you are working with the media. The size of the media files can be a problem if your choice of storage is not adequately equipped to handle them, however, working with the files directly from your camera is not a problem whatsoever.

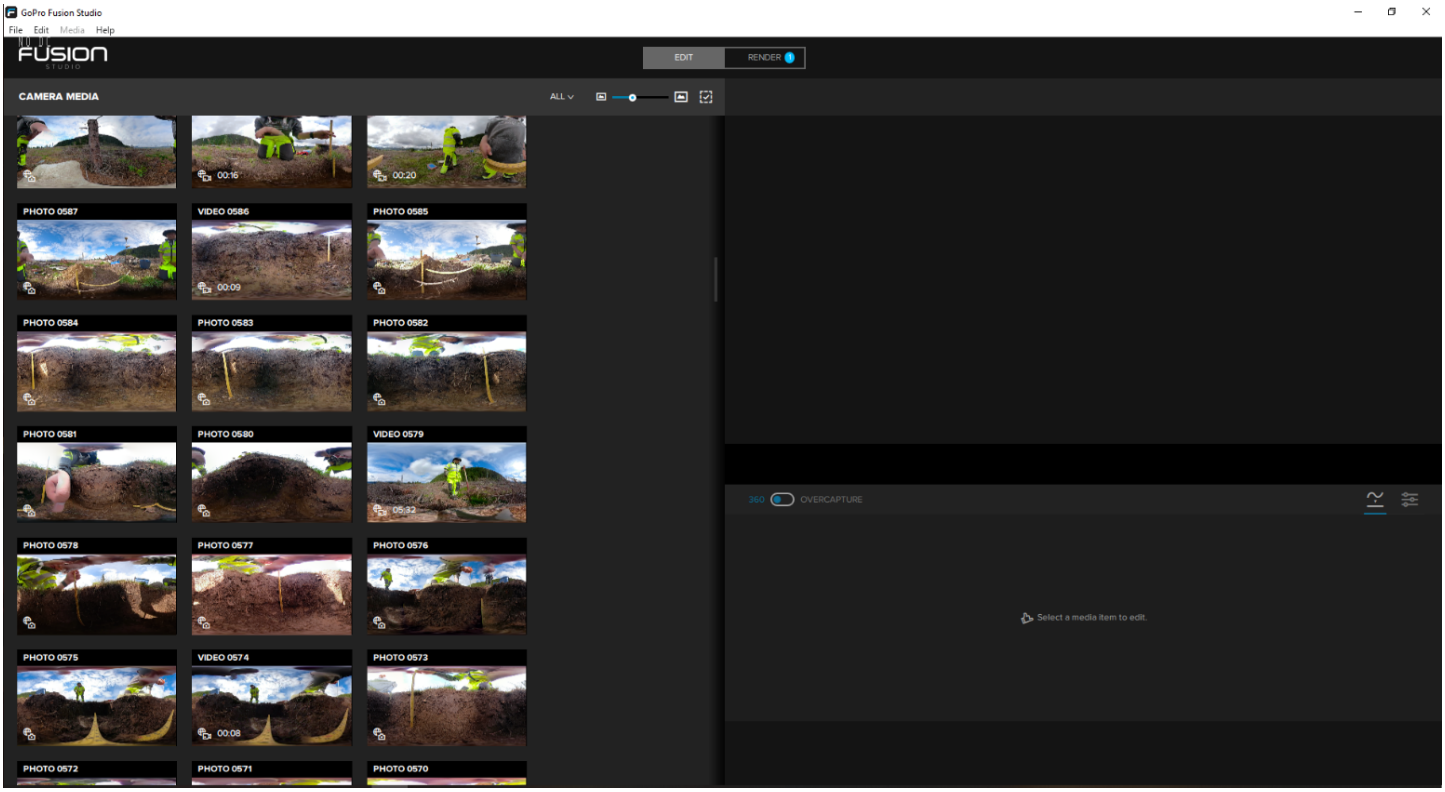

Figure 10 *- Screenshot of the GoPro Fusion Studio*

This photo shows the interface that allows you to render the files. Rendering is a process in which a photograph or video are made into a ready to view format. By selecting the photo or video you wish to render you get several options which will make the media ready for your selected platform of choice.

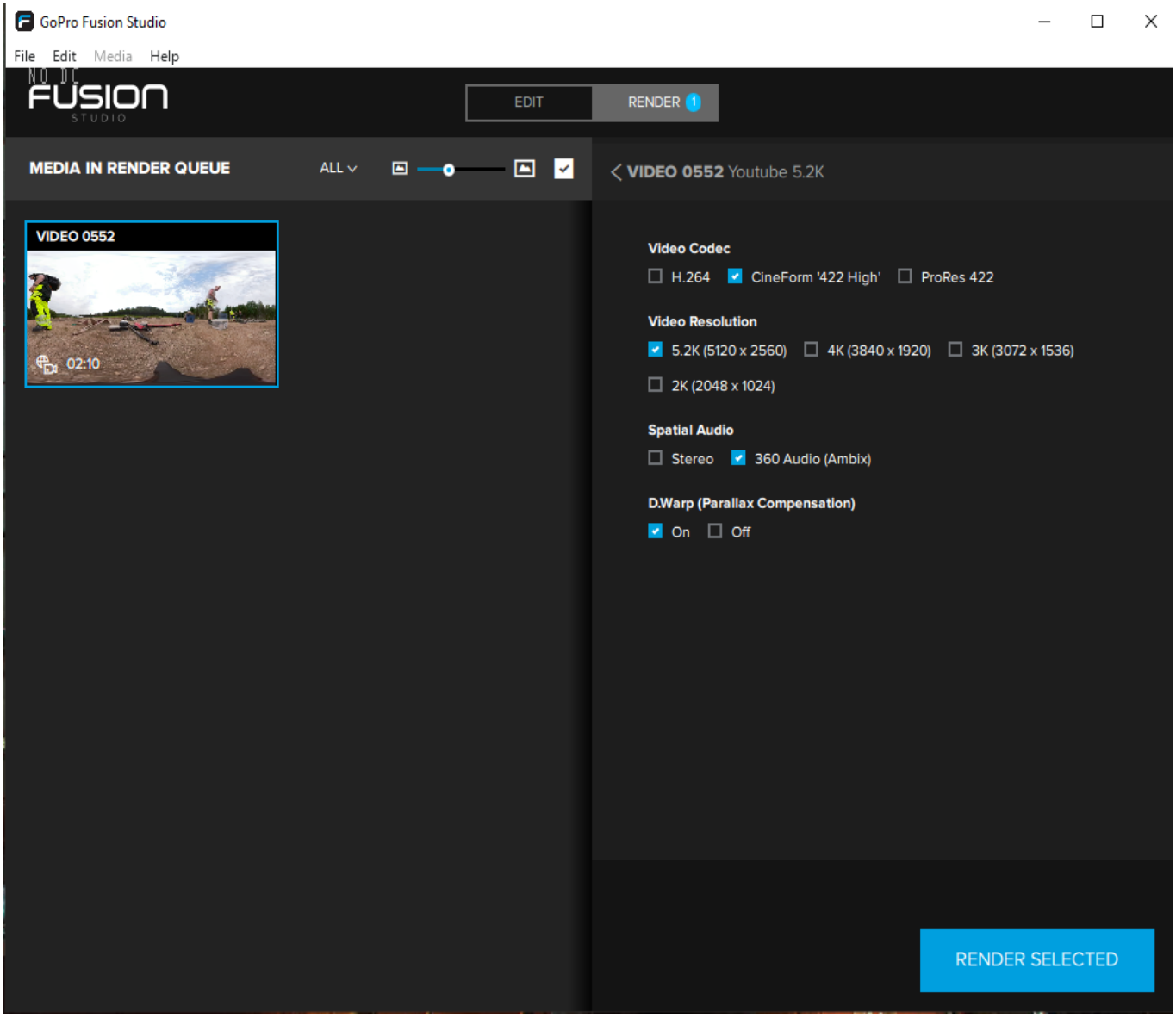

Figure 11 *- In the case of a video, resolution, audio and video codec are all available to configure.*

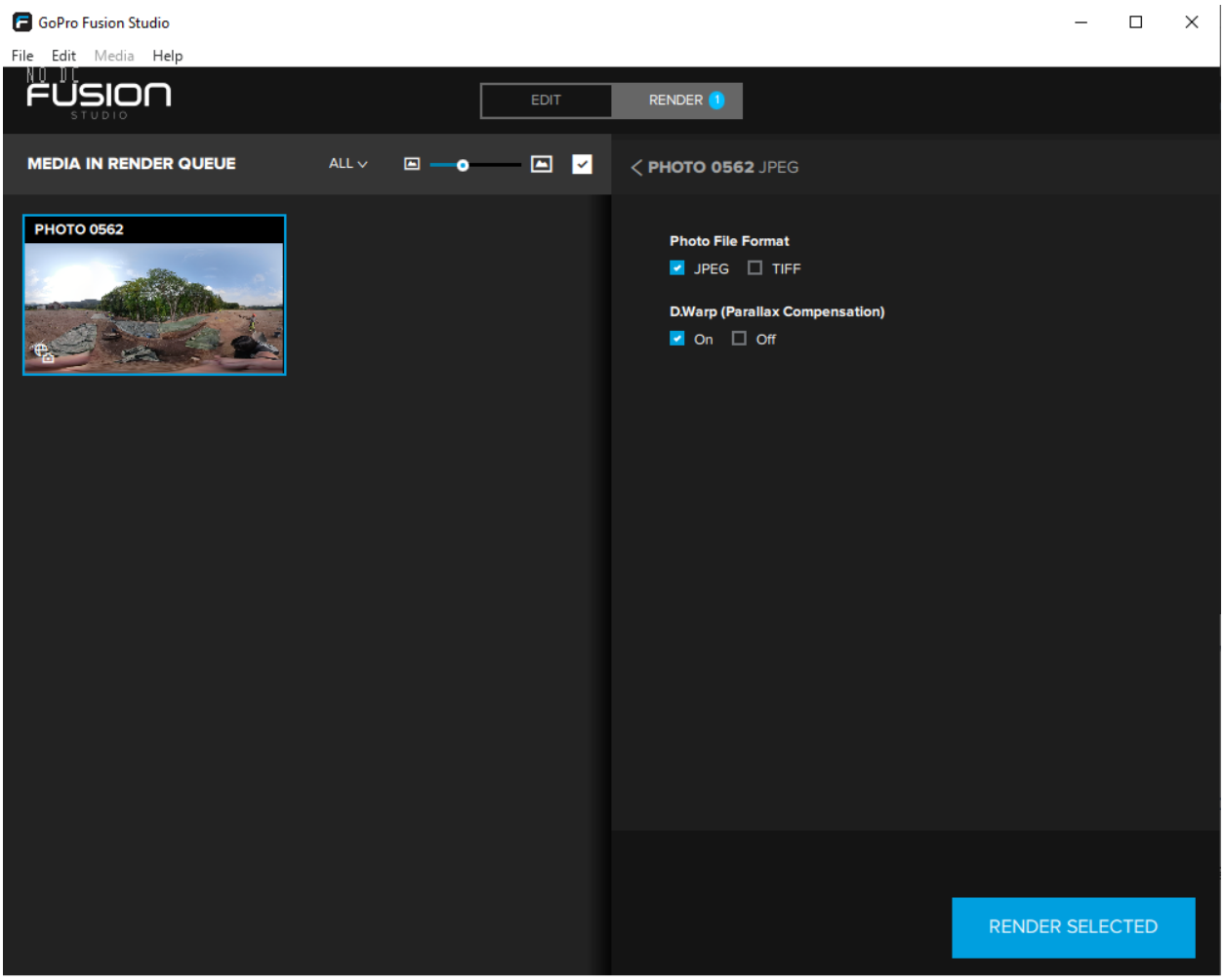

Figure 12 *- In the case of a photo to render, there are less options; file format and D.Warp.*

After rendering the media, to make it presentable I needed an online hosting platform to make it accessible. Since the thesis is in the form of a written document, I needed a way to show the imagery in a way that allowed for the three-dimensional format of the omnidirectional camera. After exploring several avenues, such as Facebook, Sketchfab and Imgur I decided to put the imagery on YouTube. Although there was some loss of functionality on the stills, they are still functional as to underline my points. Considering as well that the videos retain their full functionality of mobility, I decided that YouTube was the best platform to host the imagery.

Having come to this conclusion I set out to try uploading the imagery to YouTube straight from the computer. This did not work however as the file formats were not supported. They had to be rendered through the GoPro Fusion Studio app and then the images had to be further edited and rendered through video editing software (the one I used for my thesis were Sony Vegas Pro 18). To showcase the movement and depth of the omnidirectional imagery I used the GoPro VR Player, which allows for omnidirectional

movement. This was necessary for two reasons. Firstly, the native Photo app on my computer would only show an image that looked like this:

Figure 13 *- Photo taken with the Google Street View app and a Huawei P20 Pro*

Secondly, by using the Go Pro VR Player I could take a screen video of movement within the image. After doing this, I could edit and render said video through Sony Vegas Pro, then uploaded the resulting video to YouTube.

It follows then that a certain amount of discretion when choosing what imagery should be shown had to be made. As shown in the table of collected data, there were a large amount of data to be considered for presentation in this thesis. The effort of making the imagery viewable combined with the sheer number of videos and photographs to choose from meant that I had to be very picky. As there were over 700 images and videos, which had a combined size of over 55,29 GB worth of data I had no other choice. While many of these would never be even considered for inclusion in any archive, it has nonetheless taken a lot of effort and consideration to gain the necessary experience and knowledge to even approach the bare minimum of what *could* be considered the standard for archaeological documentation.

14. Current possibilities of the omnidirectional camera

"Things are reinterpreted, repeatedly used in unexpected ways, in a present they had not been intended for" (Reinhard, 2018, p. 31).

Having touched briefly on the omnidirectional camera, I will in this chapter discuss weaknesses when trying to use the omnidirectional camera within current archaeological documenting practice. Returning for a moment to the questions posed by this thesis:

- Whether the omnidirectional camera is capable of producing archaeological documentation?
- What are the benefits and disadvantages of utilizing the omnidirectional camera in the field?
- Are there other uses for the omnidirectional camera within archaeology that does not fall under the category of documentation?
- Should the omnidirectional camera replace the regular digital camera for documenting purposes?

We will now discuss all these from the basis of understanding outlaid previously in the thesis, analyze omnidirectional imagery compared to the criteria of archaeological standard practice and indulge in some mild speculation of the potential inclusion of omnidirectional cameras in archaeology in the future and how it could be used.

To begin at the top, "Is the omnidirectional camera capable of producing archaeological documentation?" To answer this question, we must define what archaeological documentation is. With the previous established understanding that in this thesis, "documentation" refers to photography and photography being the ability to capture on film or digitally, a version of reality that can be viewed. Having also established that archaeological in this thesis as referring to a study of the past through human-object interaction we can infer that archaeological documentation is photography capturing either the practice and performance of the study of the past or the objects subjected to the study. Plainly speaking, archaeological documentation is photos of people performing archaeological excavations, explorations, or study and/or photographs of the objects they are studying.

14.1 Is the omnidirectional camera capable of producing archaeological documentation?

As per the definition of what "archaeological documentation" is the objective answer is that the omnidirectional camera can produce archaeological documentation. Example: https://www.youtube.com/watch?v=lG45Fdcr6UQ – The Inside of a trial pit. This video shows two archaeologists documenting trial pit that they have dug to investigate the layers of the soil for traces of material heritage. As per the definition used in this thesis, what the video shows in undoubtedly archaeological documentation. However, one might argue that this is not "good" archaeological documentation, as the existing criteria stands. To provide a

brief reiteration, a "good" archaeological photograph should at the least include these points:

1. Technical detail
2. Scale and north arrow
3. Written documentation to go with the photograph

As can be seen in the video, any technical detail suffers from bad camera technique. Although this could be rectified by moving the camera slower in the transitioning phases, there are places where the camera does not correctly stitch the view from the two lenses together. This creates an awkward overlapping effect which takes away from the overall quality of the documentation.

The video does include a scale, although for the numerical value of volume, secondary documentation should be consulted. As this is the standard for regular digital documentation, and scale in photographs are there to give a rough estimate rather than an exact value, I would argue that it does not detract from the current criteria.

The lighting is a problem in the beginning of the video as the day it was filmed was a sunny, no clouds in the sky kind of day. This means that the top part of the pit in the beginning of the video is impossible to see and all details are lost. The camera adjusts for this in the bottom of the pit however, and a slower approach or starting the recording from the bottom up might have remedied the issue with lighting.

Another example of omnidirectional archaeological documentation is this: https://youtu.be/w9tFh5mimIA – Tar production site. This video shows a tar production site. By the aforementioned criteria for "good" archaeological documentation, this video lacks both scale and north arrow. The lighting is good and offers no real issues however the size of the original video file in 5K was approximately 3.16 gigabytes. Because of this, or possibly some unrelated issue that I failed to find, the program used to render the video file could not do so in the highest possible resolution. However, the video shows the basic features of a tar production site such as this and in higher resolution would be able to make out technical details of import. Other angles and close up would be possible to explore on site with no issue, however this was not thought to be important while filming.

As such the video is another example of archaeological documentation, although one could argue what necessitated the video in the first place. As this video serves more as an example of camera technique and how to operate the camera rather than as a guide for documenting tar production mounds it is somewhat irrelevant to the goals of this documentation.

So, the omnidirectional camera can produce archaeological documentation. With steps taken to adjust for three points of technical detail, lighting and scale with north arrow, the archaeological documentation might very well hold up to today's standard documenting practices. By including a portable scale that would be in-frame at all times, together with a north arrow (which could be made as a compass feature in the video, added in post) the omnidirectional imagery would find itself on equal terms to todays practice with a digital camera.

14.2 What are the benefits and disadvantages of utilizing an omnidirectional camera in the field?

Now that we've established that the omnidirectional camera is in-fact capable of producing archeological documentation, we need to take a closer look at the process of doing so. How easy or hard to use is the omnidirectional camera, what benefits does it have above a digital one and in what ways is the omnidirectional camera inferior?

How easy or hard the omnidirectional camera is to use is dependent on a few factors. These are:

- The level of innate technological knowledge the user possess. While not all omnidirectional cameras are the same, most are made with the general public in mind. As such they are usually not dependent on a high level of technical skill to operate.

How fast you get used to this and how simple or difficult this is, is largely a personal thing, but all cameras have a limited number of features to learn and as long as you are willing to be patient you should be able to operate any sort of omnidirectional camera without any trouble. **If you are the type of person who picks up technology fast, it is easy. If you are the type of person who does not, it is hard, but it is never impossible.**

- The level of technology you pair with the camera. The GoPro Fusion comes with its own companion app that you install on your phone. This means that you need a smart phone to use the app and it has its own requirements. Furthermore, the app connects to the camera by setting up a local wireless network in which you connect to via your phone's WiFi settings. In addition to this, the camera connects directly to the phone via Bluetooth. All of this means that there are certain requirements for your phone to fill to be able to handle the amount of data the camera requires. This too is a factor that is largely dependent on the person in question and the gear that they bring outside the camera itself. This does not change whether the camera is easier or harder to use necessarily, however it does mean that the functions you are able to access in the field might be limited. **If you have a smart phone with lots of memory, ram and storage together with an understanding how it works, it is easy. If you do not have a smart phone or normally do not change any settings it might be easier to edit the imagery in post.**

- The weight and space the camera occupies. The camera itself is quite light with its 220 grams and should not overburden someone when brought in the field. It can be carried in a backpack until needed or stuffed into a pocket for easy access. The expandable stand might feel a bit unwieldy but can be detached and put into a backpack until needed. Omnidirectional cameras are usually not large or unwieldy and should not present much of a problem to be taken into the field.

So, the question whether the GoPro Fusion is easy to use would in this case be yes, depending on how willing the user is to learn. After learning how it works however it gets increasingly more intuitive which leads to the conclusion of yes, it is easy to use.

Now that we have established that it is easy to use, it is time to take a closer look at the benefits of using an omnidirectional camera compared to a digital one. The first and foremost reason is that the omnidirectional camera captures omnidirectional footage. The benefits of this are that it affords the viewer of the footage a lot more freedom in deciding where to put their focus. The footage will naturally usually have an intended focus from the view of the photographer to begin with, but this can be negated with omnidirectional footage. Furthermore, it increases the agency of the viewer. Rather than being completely passive and taking in the motive intended for them, they can see details that are included but not highlighted. The increased agency is not necessarily something that will be exploited every time, but I would argue that the option to do so in the first place is beneficial. The shadow side of this is that you might spend time and effort to look for something that is not there, but even this can be turned positively. Disproving something can be just as valuable as proving something after all.

A second benefit over a regular digital camera the GoPro Fusion holds is its overall design. GoPro advertises its cameras as "action" cameras which means that they are designed to be used in action. As such they are designed with protective measures that digital cameras lack. The GoPro Fusion specifically is covered with a rubbery material which makes it more resistant to bumps and bruises and is water resistant to a certain depth. It also comes with a detachable stand which when detached makes it possible for attaching other objects if you have the appropriate accessories, usually made by GoPro themselves. This means that the camera can be used in the field without having to worry as much over breaking it.

In conclusion, the omnidirectional cameras are usually intuitive/easy to use, hard to break and introduces a new way at capturing documentation. These then are the benefits.

14.3 The disadvantages of using the GoPro Fusion in the field

The GoPro Fusion has a limited battery. It requires daily charge to be able to be used in the field without running out of power. To be able to use it an entire day comfortably, a power bank or other methods of charging while in the field are a recommended precaution. This adds to the amount of gear needed to bring out into the field. By capturing imagery in the GoPro equivalent of the .raw format, the camera requires large amount of battery power to capture and process the imagery. In a normal workday from 8-16, the camera would without any extra charging during the day run out of power. While this is of course depending on how much the camera is in use during the day, it is an important issue to mention.

It is not advisable to use the GoPro Fusion as a regular camera. While you can do so and take the frame you want in post it requires more work than to just use a digital camera in the first place. The two are not interchangeable without putting in a lot more work than it is worth. Bring both as there will be situations where a regular digital camera will function just as well or better than an omnidirectional one.

To get the best result of the GoPro Fusion a steady connection to your phone with which will aid you into getting the best footage is advised. This will however drain your

phone's battery faster than you would expect. Exactly what rate your phone will be empty is dependent on several factors, what battery your phone has, how old it is and its general condition. However steady use of the GoPro Fusion app will drain your battery.

In conclusion, the GoPro Fusion has limited use if required to perform rapidly and lengthily during the course of a day. It will require daily recharge on the minimum, maybe more depending on the excavation in question. The footage it takes is also very specific. It is a niche more than a general instrument and should be regarded as such.

14.4 The real disadvantages of the GoPro Fusion

The GoPro Fusion is easy to use in the field and although it has minor challenges it can capture photographs and video in high resolution without any real issues. However, the cost of using the GoPro Fusion becomes apparent when trying to work with the data after the fieldwork is done.

The first challenge lies in getting to the raw photographs on the camera. In the case of a regular digital camera which usually only carries one storage unit (standard is the microSD card), all you must do is either to connect the camera to a computer and transfer the files or insert the card into your PC in which you can just transfer the files directly.

The GoPro Fusion however is different. Firstly, it requires two microSD's, one for each lens. This makes it harder to access the footage directly from the camera without using the GoPro Fusion Studio app to do so, since they are in two separate folders and require the Studio app or a phone to stitch them together into an omnidirectional footage.

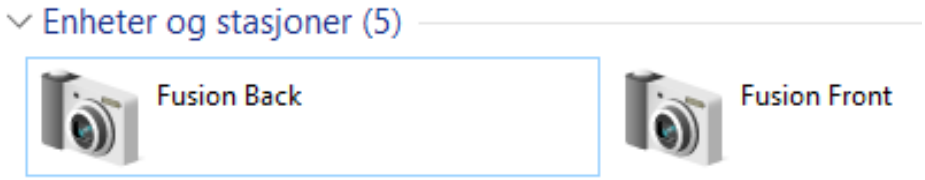

Figure 14 *- The GoPro Fusion gives you access to both mircoSD cards at the same time. Without the GoPro Fusion Studio app, the imagery remains separate.*

Furthermore, since each photograph is made up by two separate photographs stitched into one, it requires twice the storage to keep them. In addition, GoPro software runs using their own filetypes which means that most native systems on Windows won't be able to run them without third party software.

Having programs dedicated to work with the digital media captured in the field is the baseline for literally all fields that utilize photography. Archaeology is no exception; however, the omnidirectional camera is different. Photography and imagery can usually be expected to work through the well-known and accepted formats of .jpg, .tiff, .jpeg, .raw and so forth. As such, most of the known photo editing software are easily able to process and store these. By comparison, the imagery taken with the GoPro Fusion camera requires

specifically GoPro companion apps that are designed to be able to interact with them. The raw data that the GoPro camera captures are not native to most software which usually works with photography. This is a problem when working with omnidirectional imagery.

Following on this problem, even when the imagery is properly rendered and ready for inclusion into a database, if the database is not able to read the file it will not recognize it for what it is; archaeological photographic documentation and will refuse to store it. In other words, documentation created by an omnidirectional camera requires either a separate database designed specifically to accommodate the omnidirectional footage, or it requires a database that can accommodate both. To date, there are no official databases within Norwegian archaeology that has allowed for such accommodation, though one can hardly blame them as the usage of omnidirectional cameras within Norwegian archaeology is currently not a widespread practice. As this is the case, databases capable of storing omnidirectional data are not in demand. It is important to note that this is not an argument against the inclusion of new technology in general or the omnidirectional camera specifically. Quite to the contrary it means that there is a lack of omnidirectional technology currently in use in Norwegian archaeology and that this should be rectified. One must begin some place and it might as well start with the GoPro Fusion, although new technology is always being developed and other, more suitable cameras might be available by the time this thesis publishes.

A question which must be asked then, is why is there a lack of omnidirectional cameras within Norwegian archaeology when the technology has been publicly available at least since 2012? The sad reality is that there is no direct need for it to be included. What I mean by this, is that there are no specific issues that could be solved by an omnidirectional camera alone. The advent of technological advances in both society in general, and in archaeology specifically are tied to the need to find the solution to a problem. The usage of LiDAR, geo-radar, DStretch and drones are solutions to issues that have made the application of archaeology easier and opened for new discoveries.

Having said that, I believe that the omnidirectional camera can indeed be useful in archaeology. Inventive solutions to practical problems are both a staple and a constant necessity when working with technology designed to meet a completely different objective which is common within archaeology. However, to realize the potential in anything you would first need to know how it works, which is one of the goals of this thesis. After all, when one understands how something functions one might discover that it could be an unorthodox solution to a problem that has plagued one for a while.

14.5 Are there other uses for the omnidirectional camera within archaeology that does not fall under the category of documentation?

The omnidirectional camera does, as mentioned previously, capture a very specific type of footage, namely omnidirectional footage. It has seen usage outside archaeology, such as entertainment: https://www.youtube.com/watch?v=k9AyO8h2I0k – Hamilton: An American Musical 360° - Wait for it and inside archaeology, such as in the Crossrail project https://www.youtube.com/watch?v=fHSLW2K8ZjM

The short answer then, is that the omnidirectional camera can be used for other purposes than just documentation as we took a brief look at when discussing the current methodology in chapter 12. There might be however, other usages for the omnidirectional camera that has not been tested in this thesis.

What follows has not been tested and is only my subjective opinion. They are possible future applications of the omnidirectional camera in archaeology that includes applications that is not strictly documenting. They are, with exception of the first one, merely concepts in which omnidirectional footage could play a part.

Archaeological usage of omnidirectional camera in the field could potentially create exhibitions where the inclusion of Virtual Reality mixed with real documented footage would show the perceived past in museums to create a more "living" experience for museumgoers. While this is somewhat ironic as the authentic version feels less alive than a virtual reality-based reconstruction it could aid in showing the public the vision archaeologists can create through visual aids.

The GoPro Fusion is not unique in being detachable from its stand and if future omnidirectional cameras are even lighter one could potentially attach one to a drone together with a light and send it into caves which have been marked as significant risk for humans to enter. What makes this different from just sending in a regular drone (as they do come with cameras) is that the omnidirectional camera would be controlled by a dedicated camera person. By going slow and having a better view of the surroundings one would not be as tied to the principle of always having to watch the drone when one is flying. In this way we could explore without having to risk danger to humans. This is of course dependent on a skilled flier, lighter cameras, and lights. Smaller and stronger drones would also be a prerequisite for this. Or just an integration of omnidirectional technology in drones.

By gathering omnidirectional documentation during an excavation, one could add it when creating maps over the same field. By making a clickable map which would open the omnidirectional footage one could create a stronger context for anyone who comes after to read the map. It would function similar to how Google Maps and Google Street View with how you can maneuver around the field. It would serve to show where the archaeologists have been working, the methods they decided to use and the general layout of the field. <

14.6 Should the omnidirectional camera replace the regular digital camera for documenting purposes?

While I have touched the subject previously, I would like to reiterate that the regular digital camera and the omnidirectional camera are not interchangeable. They do not operate with the same principles of functionality. In short, they are different tools meant for different purposes and while they both take photographs it would require a lot of unnecessary hassle to present a field photo in the same vein as a regular digital camera with an omnidirectional camera.

As previously stated, the omnidirectional camera functions by the way of several lenses capturing a large amount of imagery at once, knitting them together and forming a cohesive whole. This allows for a simulation of being able to move the field of view in the

photograph and "look around". However, you are only moving the limited field of view that humans are capable of. The photograph compasses the entirety of the motive, we are just not able to interpret it as such. The camera then, can do something that humans cannot. Through the application of digital technology, we are able to utilize it, but remove the technology and it just because either a series of normal photographs with a limited field of view or one very long panoramic photo which distorts the interpretation of the photograph in a way that renders it unusable in most aspects. With the GoPro Fusion specifically, you cannot change the perspective to that of a digital camera whilst taking the photograph. Even if the technology is present it requires in many cases specialty software to process and present in the intended way.

Not only that, but any imagery captured by the GoPro Fusion omnidirectional camera will, when inserted into a word document be shown as either like this:

Figure 15 *- A stone construction captured with the GoPro Fusion without stitching it together with another half, resulting in an orblike photo.*

Or like this:

Figure 16 *- Ruins of a stone church on Omey Island, Ireland.*

It loses its rotary function but maintains everything that the camera captured at the time. This means that it might as well just be a normal panoramic photograph which a camera phone can take just as well. The companion software that comes with the GoPro Fusion can showcase the omnidirectional photographs but not convert them into a file that Microsoft Word will recognize as omnidirectional.

Third-party software can convert the omnidirectional imagery into a format that Word will allow, but this might not be the optimal solution as at this point, the introduction of more software may make it harder than strictly necessary to utilize the imagery which again would be contradictory to the point of introducing new technology in the first place. New documenting technology earns it place within the archaeological toolbox by either making the workflow faster, more efficient or by contributing new and unique forms of documentation that adds to the overall knowledge of the field, that be in general or in special cases. Having to jump through hoops that require the user to learn new software just for this purpose to, one could argue, little real gain it seems unnecessary. I would therefore argue that converting the omnidirectional media into a format that allows the user to add it to Word is a meaningless endeavor when one could simply attach the media to the document.

This does, however, leave the issue of how to present such a photo in printed media. Published works which are printed would not benefit from the flexibility and movability of any omnidirectional imagery. To get the same effect one would have to cut one photograph into several smaller, still-shots which negates the entire effort of capturing omnidirectional imagery in the first place. One could, of course, leave a link to an online service in the

article which would be free to access. This is the same way I have chosen to share the imagery I have captured, specifically through YouTube for the videos, and through Facebook for the images. These are not optimal solutions by any stretch of the imagination but are useful in the cases of conveying the documentation to the public.

One could also attach a CD or a USB storage device with the published article. The imagery contained within would then be accessible even without internet but imposes other challenges.

The reader of the article would have to acquire the proper programs required to even open the files in the first place, not to mention have a computer strong enough to run them. While most computers today are strong enough to run GoPro VR Player, it is generally viewed to be a nuisance to make the reader download third party software on their computers and might have an adverse effect as to what the writer is trying to convey. As this is the case, I would argue that the omnidirectional camera is unfit for physical publication as there is just no way to view the photographs without access to either a strong computer or the internet. One might enable the reader to view the imagery through VR googles as some sort of physical compromise, but even this requires a meld of digital media and physical equipment. To that end, however, I would like to point out that documentation in the field of archaeology is currently in the process of being digitalized in any case, and that having publications in journals and magazines could leave a link to an online service, preferably hosted on the webpage that hosts the journal or magazine. In this way you enable ease of access to the reader. To re-iterate; omnidirectional imagery is physically impossible to access in physical form and are restricted to a purely digital experience. As this is the case, I would argue against replacing the regular digital camera with an omnidirectional camera for the foreseeable future.

15. Conclusion

*"There are no endings, and never will be endings, to the turning of the Wheel of Time. But it was **an** ending" (Jordan, R & Sanderson, B, 2013, p. 908)*

Throughout this thesis, I have given my account and experience of the GoPro Fusion omnidirectional camera to introduce the usage of omnidirectional cameras to the field of archaeology. To that end, I have posed four central questions, which will, together with their answers be quickly summed up:

- Is the omnidirectional camera capable of producing archaeological documentation?
- What are the benefits and disadvantages of utilizing an omnidirectional camera in the field?
- Are there other uses for the omnidirectional camera within archaeology that does not fall under the category of documentation?
- Should the omnidirectional camera replace the regular digital camera for documenting purposes?

The answer to the first question is yes. Based on the current criteria of what a "good" archaeological photograph is which emphasizes technical skills, orienting features such as scales and north arrows and secondary forms for documentation, slightly modified to account for the omnidirectional media and the definition of archaeological documentation, one can conclude that the omnidirectional camera is indeed capable of producing archaeological documentation.

The second question is that the omnidirectional camera is beneficial in its ease of use, its sturdiness and that it allows for a new approach of documenting artifacts, landscapes and excavations in the field. The disadvantages are that it creates a very niche form of footage that are impractical to work with in post-excavation and that it requires a relatively large amount of power to maintain if used steadily over the course of a day.

The answer to the third question is yes. There are other uses for the omnidirectional camera within archaeology that does not fall under the category of documentation. These includes dissemination and "close sensing".

The answer to the fourth question is no. An omnidirectional camera and a regular digital camera are not interchangeable, and they should not be used as such. While you could in theory create omnidirectional imagery with a regular digital camera, or just take one frame from the omnidirectional imagery it is better to use the specialized tool for the job.

It is important to note that the ways I have tested the omnidirectional camera are not the only ways in which it could be used, and even in this thesis it is merely a small percentage of the potential inherent in the technology at large.

The overall conclusion then, would be that an omnidirectional camera per my experiments, is a very specialized tool in which significant yield of scientific value can be

gained from the right circumstances. These circumstances, however, are not only to be found within the field of documentation, but rather that of remote sensing, although in this case it would be more accurate to refer to it as "close" sensing as it requires proximity to area of interest. Specifically in excavations that involve digging trenches and pits for instance, or surveys, where you need to squeeze a camera in tight spaces where a person or a drone would not fit. It would work as the above-ground equivalent of ground-penetrating-radar where instead of discovering items of interest through the soil, it would be purely visual. the omnidirectional camera would be able to show the irregularities within nooks and crannies. Stonemason's marks, rock art and the like would be a worthy application of the omnidirectional camera. In conclusion, the omnidirectional camera does, in my opinion, have a place within the archaeological toolbox as a supplement if the following caveats are met:

- There are systems in place that can store and translate the omnidirectional footage into a viewable form.
- It is used as its own method of documentation and investigation rather than as a replacement to existing tools, i.e., digital cameras.
- The camera to have enough power to function for an entire day in the field.
- The creation of a method that highlights the strengths of the omnidirectional camera while avoiding its weaknesses.

If these caveats would be fulfilled the omnidirectional camera could be included in the current practices of archaeological field practice and documentation. Until they are, it is my conclusion that the omnidirectional camera needs more field testing and a time of transitioning before it can become a tool that archaeologists can readily use.

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Appendices

Appendix 1: 04e Fotografering (NTNU University Museum)

Appendix 2: Maps

Map 1 – Selections of locations for data gathering

Map 2 - Total overview of the Norwegian locations for data gathering

Map 3 - Location of Carrowkeel Passage Tombs in Ireland

Appendix 1

04e Fotografering

Generelt

Fotografering i felt er en viktig metode for å kunne dokumentere kulturminnet før, under og etter undersøkelse. Her gis noen kortfattete retningslinjer for ulike typer bilder. Krav til hva som skal fotograferes og hvordan dette skal gjøres er selvfølgelig opp til hvert enkelt prosjekt. Ta imidlertid hensyn til tidsbruk og dokumentasjonsbehov. Det er fort gjort å overdokumentere!

Dokumentasjonsfoto

Arbeidets gang

Ta gjerne bilder av ulike stadier i arbeidet. Innledende flateavdekking, oppstart av manuell graving, prøvetaking osv. Slike foto kan for det ene gi informasjon om feltmetode, men kan også være et nyttig verktøy for å «gjenskape» arbeidsprosessen i etterarbeidet.

Arbeidsfoto er også fine å bruke til formidling, for eksempel i en Norark-artikkel.

Strukturer

Det er flere forskjellige måter å dokumentere strukturer med foto på. Husk bare å ha minst ett bilde med målestokk og nordpil, slik at du aldri er i tvil om strukturens orientering. Prøv også å plasser målestokk og nordpil på en slik måte at det ikke ødelegger motivet, samtidig som målestokken ligger parallelt med kanten på bildet.

En mulig framgangsmåte er å bilder med og uten målestokk og nordpil, slik at du har to sett av samme struktur. Dette gjelder både plan og profil.

Tenk også på lyssetting. Ved sterkt sollys kan det oppstå ugunstige kontraster som kan ødelegge bildene. Få hjelp av en kollega til å holde opp en presenning, eller lignende, for å lage skygge.

Oversikt

Gode oversiktsfoto er viktige å ta før, underveis og etter utgravingen. Slike foto kan brukes til å vise lokalitetens plassering i landskapet, framgangen i arbeidet og dokumentere viktige trekk ved landskapet som mest sannsynlig vil forsvinne når tiltaket er gjennomført.

Oversiktsbilder kan også tas med drone.

Fotogrammetri

Se eget dokument for instruks på hvordan ta bilder til fotogrammetri.

Fotoliste

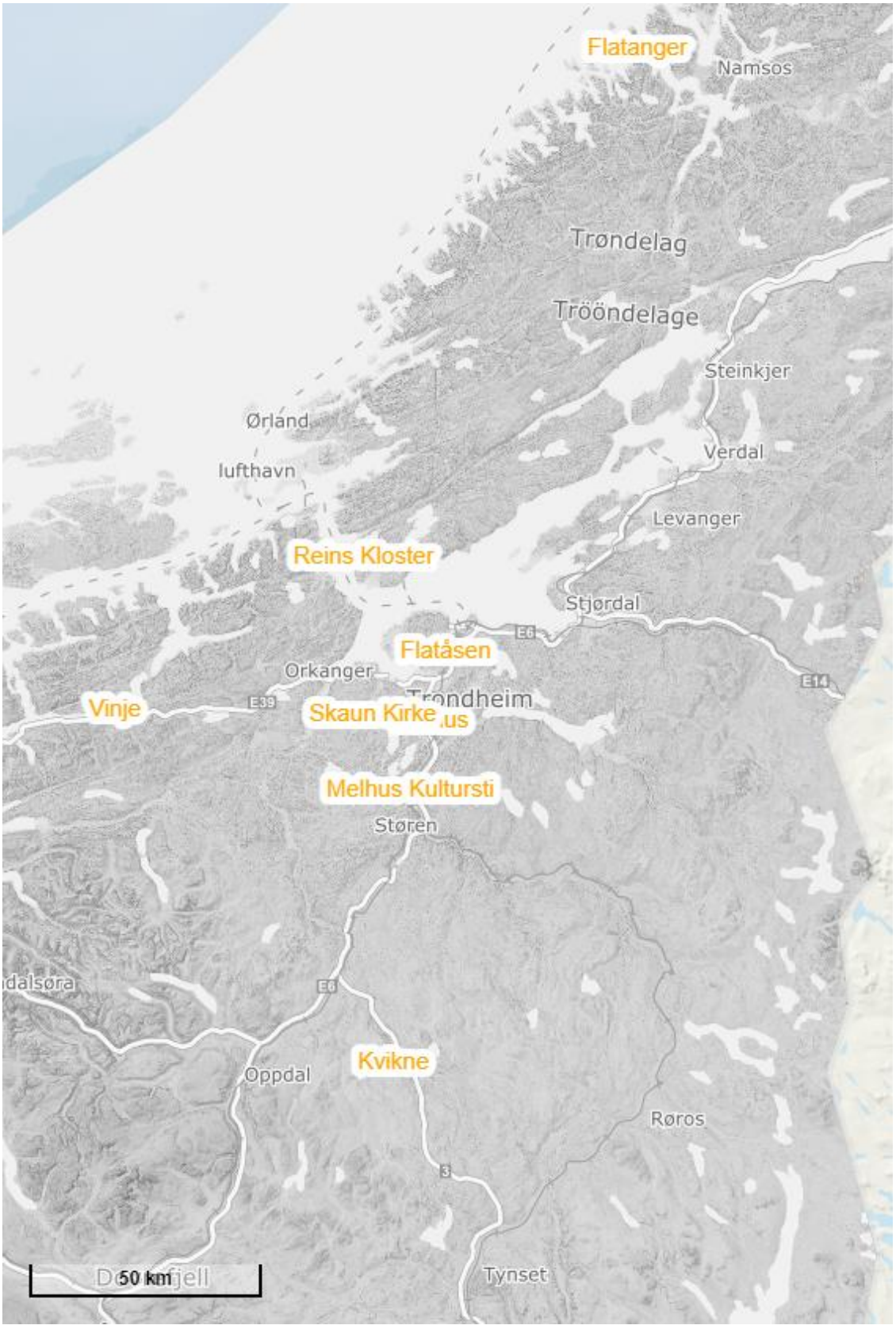
Fotoliste er viktig å føre i felt, spesielt når flere får ansvar for å fotografere. Fotoliste kan føres digitalt på iPad, og enkelt overføres til PC i etterarbeidet.

Finn et system for hvordan ulike typer foto skal navngis, og sørg for å kunne skille mellom ulike kamera. Nullstill gjerne fotonummereringen internt på hvert kamera før feltarbeidet begynner, slik at kameraet begynner på det laveste fotonummeret.

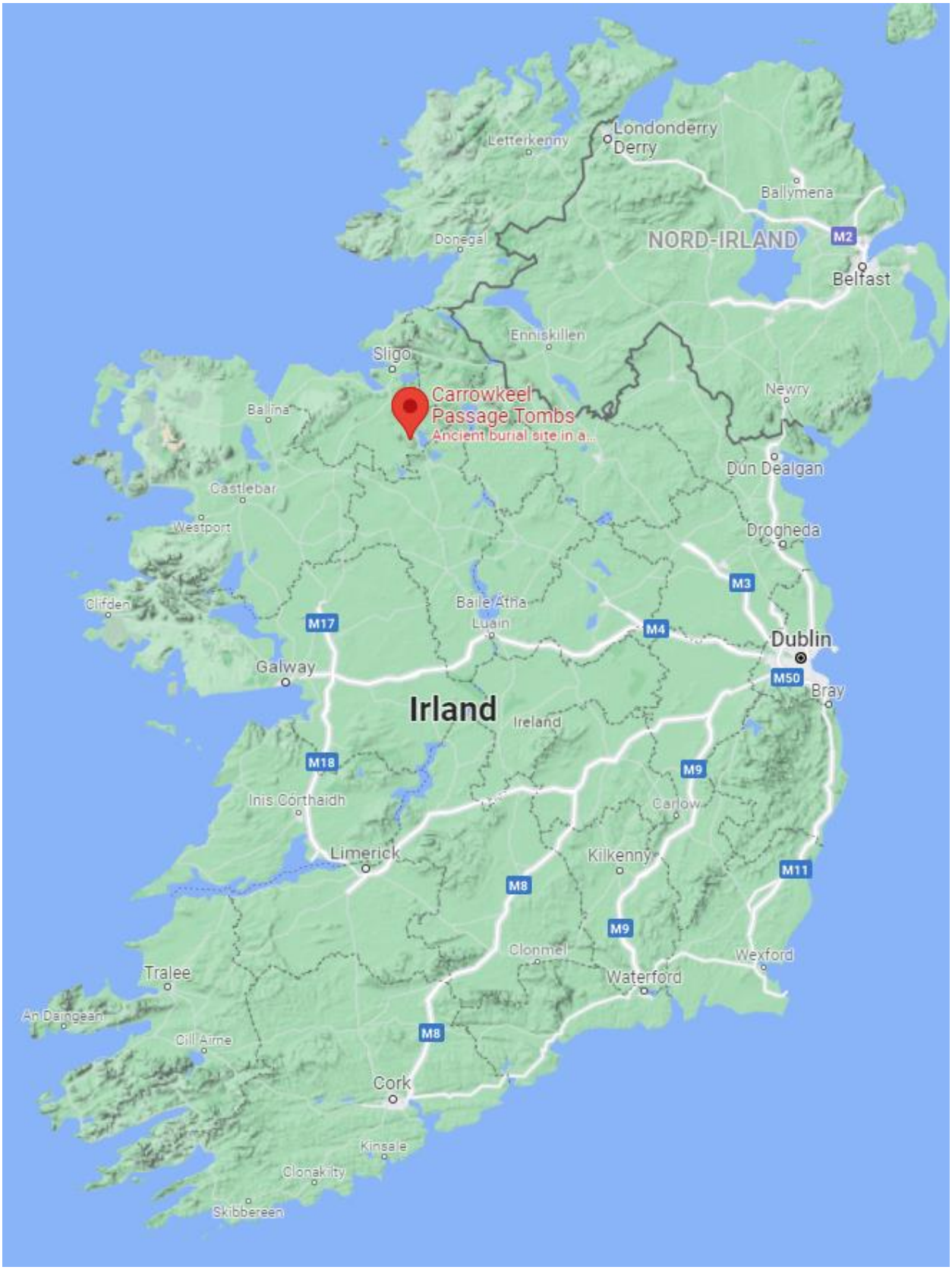
Appendix 2

Maps

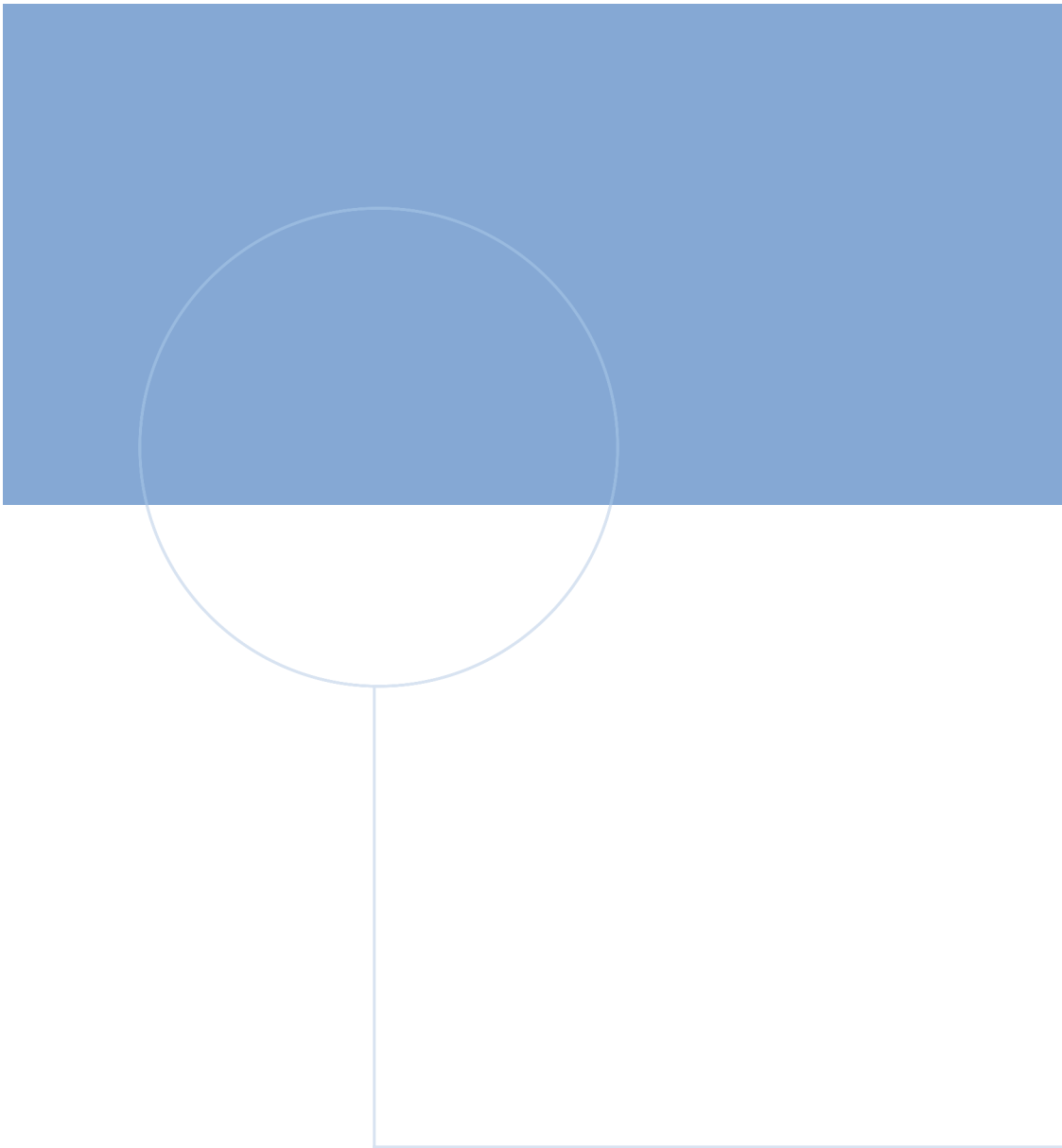
Map 1 *– Selections of locations for data gathering*



Map 2 *- Total overview of the Norwegian locations for data gathering. Some overlap in labels.*



Map 3 *- Location of Carrowkeel Passage Tombs in Ireland*



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