“Fragile museum object, are you ready for your close up?” Robotic arms and cinematic cameras for immersive Moving Macro Films

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Abstract;

This paper explores the relationship between motion graphics and user engagement for museums, collections, and fragile archives through filming with moving cinematic cameras. For museums and collections, one of the key questions is how to increase visitor engagement, both onsite, and online. Additionally, the aim is for these visitors to have a deep immersive experience with items in the collection.

Museums are using filming techniques to give users an experience of their collections online, yet these films record the object in only a basic way. The camera is often static or has only very basic movement, films are formal with only limited immersive qualities. This paper reports on a pilot study made by a small group of researchers into filming objects from fragile museum archives and collections in a more immersive way. Intending to give the film viewer a greater immersive awareness, simulating the experience as if holding and examining the museum object in their hand.

Taking advantage of the recent developments in accessibility to cinematic cameras including motion technologies could reveal new views and experiences of these fragile objects. Filming was made with a variety of methods, including using cameras that are hand held or with robotics support.

Cameras have been attached to a new type of robotic arm, designed for repeatable movements to within 0.1mm accuracy. This has enabled filming with repeatable camera paths in extreme close up with a type of “Moving Macro” only made possible by the use of robotics.

Filming took place at a number of fragile archives including a historical lace archive and mechanical watches and clocks from a major UK collection. The pilot study has raised questions; How do you use robotics and cinematic cameras when documenting an object from a fragile archive? What are the limitations of this filming method? What roles could digital 3D scanning and representation play?

Keywords: Cinematic, Immersvity, DSLR, Camera, Robotic, Museum, User, Experience, Archive, Experiential

Introduction

Museums are continually seeking to engage new and established audiences with the aim of immersing visitors with their collections. However, many objects are difficult or too fragile to display, in the case of some smaller museums and collections access is further restricted by limited public opening. A solution could be filming these objects using immersive experiential video methods combined with interactivity. As online and offline videos these films could offer not only increased access, but also show radically new ways of viewing and experiencing an object, its construction, materials, historical and anthropological backstories.

The author of this paper leads a small group of researchers in an on-going practice based pilot study into how video and motion graphics can be used to reveal authentic new views and experiences of fragile archives. The group seek to create video with immersive qualities for the viewer, influenced by Stephen Bitgood's 1990 research on the importance of authenticity in creating the immersive experience. The pilot projects seek to produce new views of fragile museum objects with the aim of giving the viewer an intimate personal experience with a fragile object. The videos intend to simulate the experience of holding a fragile object for the viewer, examining it and holding up to the light to experience its visual and material qualities. The viewers immersive experience will be further enhanced with pre-recorded audio commentary and subtitles, revealing the objects narrative backstories.

Taking advantage of recent developments, making cinematic cameras, macro lenses and robotics more accessible, the project creates camera movements and views that would not be possible any other way. Here we report on findings from our group's first research project working on a video field study of objects from two UK archives of national and international significance. The videos show these new views of the fragile objects and reveal material qualities that are not always possible inside a museum. The project aims to give the user a similar experience of holding a museum object examining and exploring it in different ways. Compared to viewing an object in its glass museum case, the videos seek to improve and enhance a user's immersive experience.

What are the significant issues for museums?

Nina Simon, Executive Director of the Santa Cruz Museum of Art & History states in her 2011 museum blog raises the questions;

> What are the most important problems in the cultural sector? The two hot problems seem to be; Finding new business models to sustain funding and support operation and making offerings relevant and appealing to shifting audiences

Simon also asks;

> How can we make cultural knowledge, content, context, and experience, as widely, freely, and equitably accessible as possible? How can our institutions and programs improve quality of life for individuals and communities?

It could be said that cinematic filming is now mainstream, being used in many TV programmes and across social media. Its daily exposure often, in new contexts where only standard filming had previously been present, to some extent cinematic is now expected by audiences. The project films intend for museum objects to be shown in a more relevant format for audiences by using cinematic methods.

Museums and collections have significant challenges in displaying and giving public access to their objects. Having large reserve collections museums often only displaying a small percentage of their collection to the public. Our research films could show items from the reserve collections, giving access and also attracting new and established audiences to museums and collections. There is also potential for engaging, social media friendly "Makings of Videos" showing how, in this project, new and old technology, robotics and mechanical watches were used within the production. Potentially attractive to a teenage audience capturing the imagination of this sometimes difficult to attract demographic. The video work could also act as a form of preservation for fragile and decaying items in a collection with the videos giving access without further damage.

Museum research, immersivity and authenticity

C.G.Screven (1969) describes the museum as;

> Potentially at least, the museum is an exciting alternative to conventional education…… no coercive forces, no grades. The visitor is in an exploratory situation, moving about at his own pace and on his own terms.....The museum should serve as an ideal learning environment for inviting enquiry, questioning and constructive practice in investigatory behaviours

S.Bitgood (1990) defines the 9 factors that may contribute to simulated immersion with the 4th factor being;

> Authenticity or object realism.....When visitors are immersed in an exhibit that simulates a time and place, they are likely to report ……. The exhibit is realistic and natural

Later that year Bitgood et.al (1990) state in their investigations into the museum visitor immersion experience;

> Perceived naturalism or authenticity contributes to the immersion experience

Bitgood clearly explains the importance of naturalism and authenticit. Could we argue that using an optical device such as a high definition cinematic camera, taking its visual input direct from the source, be more immersive than a digital 3D computer graphics model? Whilst it could be argued that a digital 3D file created entirely inside a computer is highly accurate and precise, it's source does not come directly from the object it is portraying. Could it be argued that this form could, if created without sensitively, be counterproductive to immersion, lacking authenticity?

Research team previous films informing project methods

The research team had made some prior experiential immersive film work, in 2012, with a Lace Archive held at a UK University creating the film "Journeys into Lace" (figure 1) The Lace archive consists of highly fragile yarn machine made Lace, and their equally fragile Lace Design books. The Lace has substantial visual qualities with a variety of ways in which it can be filmed, but had restricted access due to fragility. A museum local to the research team was chosen; The British Horological Institute (BHI) had similar issues to the Lace archive, but with very different objects. The BHI has an extensive collection of watches and clocks including those of national and international significance. Yet access to the public was restricted to two days access each year. The films made of both collections used a range of camera filming methods; Hand Held, Monopod and Tripod. As we were in an exploratory phase, we needed to keep agile and responsive, the majority of filming was made hand held.

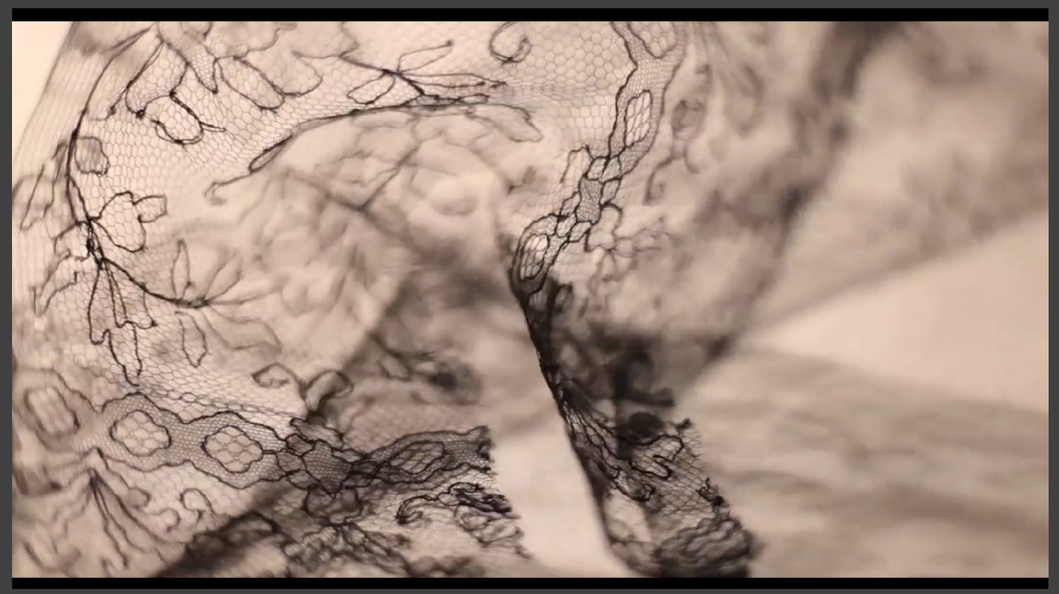
On reflection the "Journeys into Lace" 3-minute-long film, appears to suggest to the viewer that they are in the presence of the real objects. This seems to be apparent from having the camera extremely close up to the object, in one case a series of very old lace sample books. The books are highly worn and decaying with richly coloured spines. The lighting at the side of the books further enhances the textural qualities, suggesting imagined histories for the viewer. The Short Depth of Field (SDOF) from the cinematic lenses adds considerable intimacy. Later on in the film the extreme close ups combined with the sophisticated back lighting combine to shows a piece of white lace, ghost or angel-like in appearance. The delicacy of this white lace, only partially in focus, appears spiritual from the out of focus areas. The in-focus areas inform the view with regard to the lace structure. Towards the end of the film the lighting and SDOF combine helping to describe the touch, feel and drape of the lace fabric.

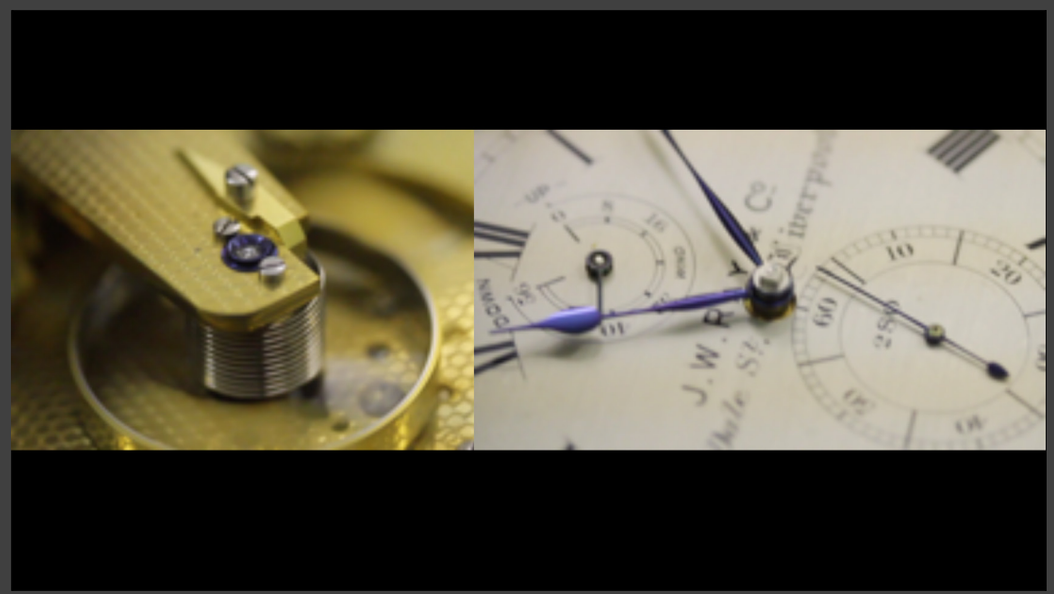
Object Motion and Camera Motion "Journeys into Lace"

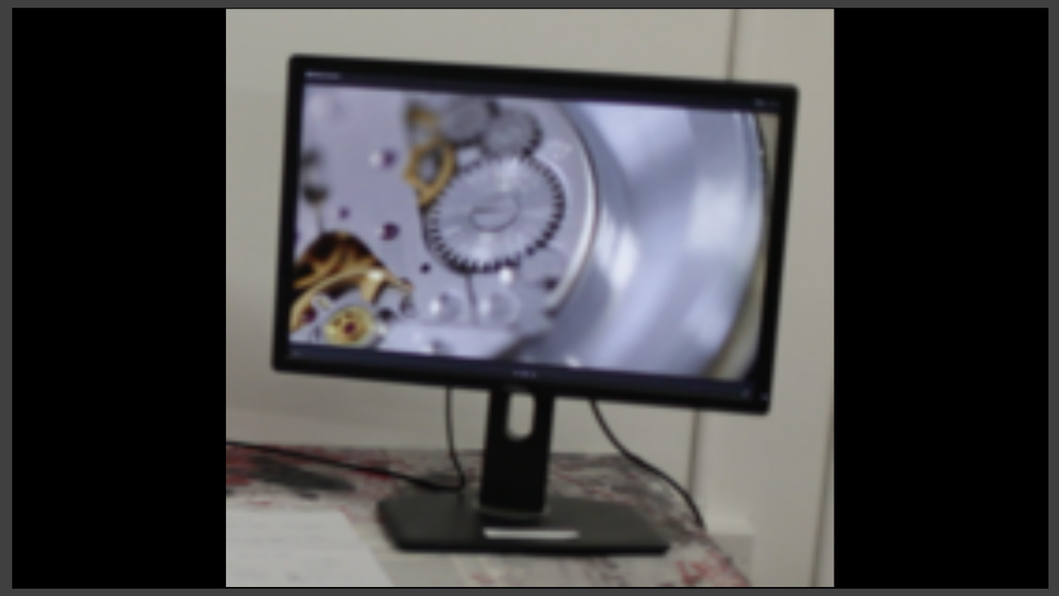
In the parts of the film that feature Lace samples, the manipulation of the fabric is the main motion, so in these cases the camera does not move significantly. Much of the time camera work was hand held, not tripod mounted, to keep agile, to react and respond quickly to the object in front of the camera. With the objects that have limited movement, for example the lace sample books, the camera moves more noticeably. As fabric tends to move in a variety of ways, hence the camera moves less during this film as the fabric itself moves. Objects that are more fixed than fabric, such as clocks, watches and timepieces may require more movement from the camera.

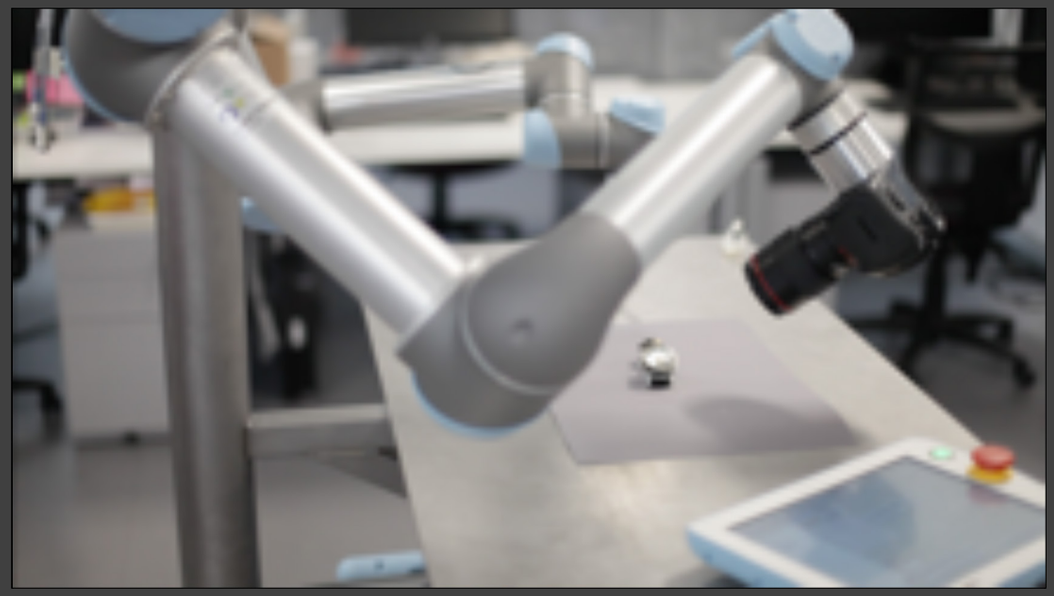
Immersive filming of the BHI collection

A series of films were made from a short list of watches and clocks in the extensive BHI collection. Initial films were made on site with the museums natural lighting, using hand held and tripod mounted cameras. "The Mudge









Images clockwise from top left:

Figure 1: "Journeys into Lace" https: vimeo.com/61249310 , Figure 2: "The Mudge Copy Chronometer" www.vimeo.com/jonathanhamilton/mudgeclock , Figure 3: Robotic arm macro footage; Sekonda modern pocket watch, Figure 4: Universal Robotics arm and Macro Camera filming
Source: All images by Author of paper, 2016.

Copy Chronometer" (figure 2) film shows a beautifully crafted marine chronometer clock, with highly polished and machined brass parts. The main spring is moving at an almost furious pace producing a noticeably frantic sound. The clocks movement and the sound enhance each other, behaving almost like a musical instrument. The spring moving, coiling and uncoiling in constant rhythm is like a beating heart.

www.vimeo.com/jonathanhamilton/mudgeclock

When listening to the sound of this mechanism with headphones on it is extremely immersive, almost like being "inside" the clock. The face of the clock has beautiful purple anodised hands, the minute hand being reminiscent of the leg of an insect, set against an ivory clock face. The graphic design of the lettering and numbers on this face is particularly sophisticated in its use of thin lines and ivory watch face. When pausing the film, it is possible to see that the numbers are hand painted with evidence of brush strokes, this only appears to be visible through the video compared to seeing the object in person.

The next watch inscribed "Mr Constantin Vacheron, Genève" had a different sound to the Mudge, still frantic but a gentler sound. It was also possible to see the mechanisms coloured jewels moving up and down and in and out. The Regulator Timepiece Clock from 1818 is different again, very precise in both its audio and movement, the camera reveals the enamel texture to the clock face. In extreme close up of the minute hands it is clear to see the hands move with gradual but high precision; the fractions of a minute are visible in extreme macro.

In the presence of the actual clock these features were not apparent, yet when reviewing the films, it appears more noticeable. In some cases, the films of the clocks appear to be creating a stronger experience than being in the presence of the actual object itself. The watches appear to have personalities it may be possible to tell the clock or watch by its sound alone – it could potentially be a game for school kids to listen and identify?

Limitations to hand held filmmaking

There is so much to observe within all the moving parts of the watches and clocks held at the BHI, the macro camera in its hand held mode struggles to show features accurately and precisely. To move the camera around the complex layers of moving mechanisms of the Mudge Clock is almost impossible to repeat with any great degree of accuracy. There was a need to find a way of filming with a macro camera that could give us control over its movement with a greater degree of accuracy and repeatability.

Looking for alternatives to hand held cameras

The film making industry uses custom robotic systems "Motion Control Rigs" that enable most types of camera movement. These were too cumbersome and expensive to hire at this stage of the project. Whilst these systems are still a potential method to use in the future, at this early stage of the project we were looking for a more agile, flexible and responsive system. Universal Robots (UR) make robotic arms capable of repeatable movements with 0.1mm accuracy and are simple to program. We had access to UR robotic arms held at one of the research teams' university. It was straight forward to attach a cinematic Digital Single Lens Reflex (DLSR) camera. The aim was to move the camera, with a lens capable of great magnification, around a fragile object to reveal views that could not be achieved any other way.

The research team chose the methodology of Bricolage and Agile thinking (C. Levi-Strauss. 1962) to keep the creative and technical process flexible, and to keep open to new ways of working. Aware of the dangers of working with technically complex systems and the tendency to become trapped within a complex technical process, resulting in narrow thinking. UR promote their robots as having a user friendly graphical programming language, using waypoints. Easy to learn, requiring minimal training, ideal for our agile methods. Yet we were keen not to let the waypoints method dominate the camera movement. Instead for a more agile method was sought to lead the programming of the robotic arm.

Drawings were made on photocopies of clock and watch photographs, to determine potential camera movement pathways. Using instinctive, agile methods to inform the programming of the robotic arm movement. Reflective practice "on and in action" methods, (D. Schön. 1983) were used, these drawings were evaluated on and in action under a number of headings to identify the potential of each pathway drawing.

On the very first day of filming the robotic arm footage was unstable due to a weak attachment with resultant vibration in the footage. But we could see that the footage was very engaging, informative, with high levels of cinematography, even though the footage suffered from vibrations. As the camera moved around the watch, with its lens aperture wide open, for extreme SDOF, caused the camera lens to continually seek focus. Less sophisticated cameras would have created very jerky footage, un-cinematic and counterproductive to immersivity. Our chosen DSLR with its 64 point focussing system appeared to intelligently look for active parts of the image on which to focus. This was very similar to how a cameraman would choose instinctively what to focus on. One of the technicians noticed that the footage at the start of a sequence was often out of focus. Other members of the team suggested that this was a positive and artistic quality that should be embraced. Appearing to simulate qualities of human vision when picking up a new object for the first time. Could this be similar to the human eye, with the mind trying to question and understand what the objects qualities, material construction and meaning could be?

Solving robotic problems

Vibration

The UR robotic arms possess very powerful motors in each of their joints, causing serious vibration in the cinematic camera footage. This disturbance was further exaggerated by the extreme close ups from the macro lenses we were using. Vibration effected footage was stabilised using Adobe After Effects (AE) which reduced the problem, but did not eliminate the issue. The AE stabilisation process also caused some cropping of the image. Composition within the camera frame had been carefully made, the team were reluctant to set this framing to chance by this digital cropping, so the main technical focus was to reduce vibrations from its source.

Robotic filmmaking

Prior to filming with one of the clocks from the BHI our aim was to establish a proof of concept filming method using a modern mechanical pocket watch mechanism as our test subject (figure 3). Once this vibration had been eliminated, to then approach the BHI for the opportunity to film one of their historic timepieces using the robotic macro camera combination. The SDOF filming with the robotic arm worked highly effectively in suggesting the view an individual may have if they were holding the object themselves.

The metal watch mechanisms caught the light showing machined textures helping to reveal the manufacturing processes that made the watch, but also offering new views of the object. The camera and robotic arm pathways were complex at times passing around and over the object sometimes several times. The DSLR cameras' 64 point autofocus system produced sophisticated foreground to background focus changes in a similar way to how a camera operator would possibly do in the same situation. But the footage was distinctly different and original. Could robotic filming be creating a new genre or approach to the moving camera in contrast to human controlled camera movement? (figure 4)

Comparative analysis of films made with robotic and tripod camera supports

After completing some of the robotic test films the research team was concerned that the footage may not be visually distinctive. Deciding to make a comparative analysis study, the pocket watch was filmed with the camera attached to a fluid head tripod. On viewing this tripod footage, the watch mechanisms were extremely clearly represented, but the film appeared very formal and stiff, lacking in movement. To counteract this the mechanical watch needed to itself move, rotate, to create additional movement within the camera frame. When the tripod footage was compared to the footage from the robotic arm camera combination the team were relieved to see that the robotic arm footage appeared more immersive through its more varied pathway around the object. When comparing the tripod footage/ watch rotation footage this looked far more artificial being noticeably controlled by an outside source.

www.vimeo.com/jonathanhamilton/sekondatripod

Restrictions of the robotic arm camera combinations

Whilst the robotic arm gave us a unique way of moving the camera with a macro lens, and the ability to film at high magnification, there were some disadvantages compared to hand held filming methods. The first most notable difference is that when the robotic arm is moving it is not possible to interact with the camera, to change any settings or functions, in particular the focus of the lens could not be changed. Ability to react to the object during filming is restricted. This was not a major problem because hand held videography in "Journeys into Lace" (2012) and "Never Quiet Never Still" (2011) kept the camera focus fixed and instead moved the camera, resulting in a more immersive experience for the film viewer. These current disadvantages of the robotic arm are far outweighed by its abilities to film in extreme close up with repeatable precision. In future projects we aim to use bigger more professional cameras that allow focus and other controls to be manipulated remotely during filming. We would expect this to produce better quality footage with higher levels of cinematography. However, at present we are keen to keep the equipment simple, straight forward, and agile.

Future BHI projects with the robotic arm

Now we have established this proof of concept we are ready to film one of the valuable historical clocks with the robotic arm/ macro camera combination. The Mudge Copy Chronometer, Marine Clock was difficult to film with both hand held and tripod methods, the robotic arm could film this clock in a unique way, communicating more about this complex clock.

Robotic Conclusions

Agility, Drawing, Waypoints and Macro filming

Robotics have some significant benefits for this creative project, but may not be suitable for every fragile archive/collection object, so it should be used with care. The current robotic system still lacks agility; it does not seem possible to easily make a manual camera/robot movement that accesses instinctive camera pathways. Waypoints and Graphical Interfaces are a significant step forward in ease of use, but still far from ideal for Art and Design users. If camera pathways were created in the same way as in digital applications, like After Effects, allowing users to adjusting a path visually, using Bezier curves would help with agility. As Macro filming with its high magnification requires precision and accuracy. There does not appear to be any other method that can be as effective and as accurate as a robotic arm for filming a tiny watch mechanism. Whilst the camera moves freely around, can start to replicate the experience of holding the fragile object.

Next steps

The BHI hand held films appear to reveal more about the watches and clocks than when being in the presence of the actual object. This may be due to the lenses and magnification, or it could be due to framing, making the eye focus and concentrate. This had been a surprise, as these were rough tests films, we were not expecting to make any revealing discoveries at this early stage. We have made some significant progress filming using the robotic arm and camera. From the very first shoot using the unstable plastic camera mount, the footage showed that this method was showing that it could reveal new viewpoints that could not be achieved any other way. We have made good progress with the robotic arm for "Moving Macro" filming, with the modern mechanical pocket watch as its subject. What could the robotic arm and camera reveal when filming one of the BHI's sophisticated highly designed and engineered historical watches? This will be the focus of our next tests.

The robotic filming with optical cameras is achieving good results and could play an important role in creating an immersive experience for the online and off line museum visitor. 3D scanning is one area we would like to try. New approaches to 3D scanning objects are being developed by researchers in the UK and worldwide. In particular, the work being done at Liverpool John Moores University, UK has recently demonstrated their ability to scan metal objects, which otherwise has not been possible. VR, 360° filming and Augmented Reality could also be highly effective for communicating in and immersive way. Scanning and filming directly from the source objects appears to be a focus for authentic immersive experiences.

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