Resurrecting the Archive: 3D printing and interactive technologies in Libraries

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Emerging technologies influence the shape of society, how we interact with the world, how we learn, how our activities create new knowledge and how we can recontextualise old knowledge in new ways. This paper is a collaboration between Victoria University of Wellington School of Design and the National Library of New Zealand and documents a series of projects undertaken by the university that are of interest in advancing the future potential of emerging 3D technologies within libraries. Projects include the use of virtual reality and augmented reality to reinvigorate historical collection materials to provide richer context and connections to other physical and digital items; 3D data management and retrieval through the use of game engine software; 3D printing and associated technologies as a means of materialising knowledge for hands on learning. These projects are explored in reference to the following major library functions: supporting learning, collecting, making collected items findable, and drawing dormant information from heritage items by extending them into three and four dimensional interactive spaces (that is, 3D spaces recreated with the additional inclusion of

temporality that demonstrates spatial change over time). Findings demonstrate that the mere inclusion of emerging technologies within libraries are not sufficient on their own but are necessary in order to share new forms of volumetric information (information concerning objects often rendered two dimensional by traditional archival practices dependent upon paper storage technology), to hold existing collection material up to the increasing demand of informational fidelity, and to make accessible new knowledge held in large datasets otherwise unavailable to general users.

INTRODUCTION

The role of a library is to enable its users to access the wealth of its collected knowledge openly and independently. This is achieved through access to both resources and services. In a time where digital access to information has become the dominant means of access, the institutional differences between libraries, archives and museums are also called into question.

3D Printing and Makerspaces (collaborative work spaces) that concentrate additional new technologies (CNC routing, laser cutting, computational weaving and knitting etc.) for the fabrication of objects are being adopted into the service offering of libraries worldwide. This is often seen as a desperate attempt for physical libraries to maintain relevance through a digital diaspora, as access to material over the internet can be found faster, cross-referenced instantly, and accessed anywhere. With this in mind, The National Library of New Zealand and the School of Design at Victoria University in Wellington embarked upon a collaboration to explore the potential to open up archives in a meaningful and useful way to the public. The focus of our initial research was to move beyond the Makerspace as a default setting, and explore how to better integrate 3D printing technologies into the operations of libraries as a means of making their archives and collections more accessible and engaging, and thereby give the Makerspace a more compelling reason for being. Compelling content and use of contemporary fabrication tools would, we believed, not only open up the library archives, it could also provide direct and tangible access to a whole plethora of historical material so often "lost" in archives through the lack of a medium with which to engage with, and understand, its content.[1]

In his blog "Mission creep: A 3D printer will not save your library" Hugh Rundle gives an astute account of how contemporary maker technology could be considered misplaced in a library environment by drawing on examples from blog posts which fail to link the service of these machines to past or future applications of library collections. However, 3D printers are fundamentally output devices, just like standard paper printers and the applications of this technology rely more broadly on the digital representations which are being made physical. For that reason the complete array of emerging 3D technologies must first be explored.

If 3D printing was truly a useful technology for libraries, there would be serious articles about the potential for information storage,

discovery and dissemination. What the blogs, tweets and presentations of 3D printing enthusiasts are filled with is mostly stories about 3D printers that print in chocolate.[2]

Rundle is right to question the seriousness of 3D printing technologies deployed for their spectacular value rather than as a genuine tool that supplements the mission of the library. To this we would add the need for a genuine appraisal of the usefulness of other tools too. This includes not only the 3D printer itself but equally important, the associated scanning technologies, 3D modelling software, including the trend to more intuitive open source software, online platforms and systems, as well as Augmented Reality (AR), and Virtual Reality (VR).

In her article *Multimedia for the People* (1999) Pat Ensor noted that "Libraries grew up as repositories of printed material because that was how material could be recorded and passed on".[3] At the time of publication she asserted libraries relied on a "limited palette to convey information" as libraries' made audio or video content scarcely available online with part of this problem due to web browsers not offering the same level of support they do today. 3D technology could be considered a form of new media with the platforms that deliver it still in late development.

The ways in which information is recorded and disseminated changes with the society in which it was created. We have already witnessed a shift to a digitally dominant mode of information exchange.[4] Articles are published on blogs and websites, we see an increase of self-published material through the cost-effective format of e-book distribution; multimedia content creation has proliferated with services such as YouTube and the affordability of digital cameras and open access to editing software. The change in society we are witnessing is a shift from one that is consumer based to one that is "prosumer" centred - a term coined by Alvin Toffler in 1980 to refer to people who are both producers and consumers[5].

This shift in society is consistent with the findings of previous research conducted by Victoria University of Wellington School of Design investigating the new material culture arising from digital design and fabrication technologies including new modes of production and communities of co-creation. 3D printing as a means of production is additive (material is fused together to form an object), rather than the traditional subtractive means of production found in mass-manufacturing processes which produce volumes of waste material. Digital design software makes the creation of everyday objects a

prosumer activity by reclaiming traditional crafting techniques and presenting them in a digital space where anything can be created without the need to retool based on the object's function or the type of materials being used. This allows for the recovering of mass production's social costs in which, until recently, we have seen people disconnected from the fundamental activity of making that first delivered humanity into civilization. Guild-like culture is on the rise between prosumers.[6]

The sale and digital distribution of media has already shifted. Additive manufacturing ensures that physical products will follow this trend. Khan and Mohr[7] identify seven key areas impacted by the shift from mass production to production by the masses:

1. Mass customization,
2. Resource efficiency,
3. Decentralization of manufacturing,
4. Complexity reduction,
5. Rationalization of inventory and logistics,
6. Product design and prototyping,
7. Legal and security concerns.

The economic benefits provided across these key areas indicate that a production-by-the masses mode of manufacturing is likely to become dominant sooner rather than later. That being the case providing access to this technology as a library service enables users to gain hardware and software knowledge needed in a hands-on environment.

As 3D and 4D (the addition of temporal information to 3D data) formats become ubiquitous and as libraries continue to collect information in new forms, for instance the harvesting and archiving of websites or the inclusion of born digital content, then it stands to reason that 3D files will have a place within libraries in the form of 3D digital surrogates of collection items; AR or VR multimedia publications; animation assets, finding aids, or interpretive materials that take existing library collection material and extract additional information using the new technology. However our fascination is not so much the form that these new digital collections will take, but rather more the opportunity these new technologies offer in revisiting historical analogue collections and archival material; to reinvigorate them and reveal their richness in more engaging ways.

SUPPORTING LEARNING

One of the major functions of libraries is to support learning. But we support it predominantly for those who learn best through reading. In 1983, Howard Gardner formulated the concept of multiple intelligences. Out of seven intelligences that he postulated, libraries appeal to only one: verbal-linguistic. We can't necessarily handle all of them, but by promoting sound and image, we could support musical intelligence and visual-spatial intelligence better than we currently do.[8]

Talking-books exist within libraries to enable disability access: a precedent for how information can be delivered through other sensory channels. As noted by Ensor, not all people learn best through a verbal-linguistic mode of processing information and although multimedia can aid disability it can also expand the opportunities for learning to those who have dispositions suited more to visual, logical, kinesthetic or other modes of learning. 3D technologies democratise knowledge even further by offering tactile properties and interaction across the senses and incorporating the given environment into the knowledge acquisition process.

Quiver is an Augmented Reality colouring book developed by HitLab NZ using MagicBook technology.[9] The user, by means of a smart-device (smartphone or tablet) scans a 2D drawing which triggers an animated AR model from *Quiver's* database. The model can be altered by physically colouring the 2D drawing on paper. The colour from the image is picked up by the camera on the smartphone and mapped onto the AR model. An educational version of the *Quiver* app is also available to aid learning within classrooms.

We believe that this technology would be a valuable tool for artists who wish to create 3D content but lack the necessary computer aided design skills. When combined with an automatic model generation technique, there are a number of possible fields which could benefit from this technology for example in architectural design, and rapid prototyping of 3D designs.[10]

The app goes further and takes this virtual content and explores the possibilities of 3D printed outputs.[11] Dylan Hughes-Ward's design thesis, *Making Connections: 3D printing, libraries and augmenting their reality* builds on top of *Quiver* and the work done by HitLab NZ and the MagicBook technology by integrating Augmented Reality with existing library holdings. In a scenario aimed toward primary school users, Hughes-Ward takes a children's book from the National Library collection and seeds it with an AR model; *Big Sloppy Dinosaur Socks* written by Jan Farr and illustrated by Pamela Allen. Image recognition brings the book to life with an interactive animation anchored to the book that can be viewed in 3D by moving the smart-device around the book. The interaction allows for expansion upon the narrative. The potential app would provide a paper print out which can be coloured in and augmented again, similar to *Quiver,* to change the colour texture of the animation character or alterations can be made in-app with a range of sliders. At any point the animation can be paused and the model 3D printed in its given pose. The model itself can then be used as a smart object engagement point outside the library to link to related books and resources, or simply provide expanded engagement for the blind and kinaesthetically inclined learners.

Figure 1-5: Dylan Hughes-Ward's thesis, *Making Connections* demonstrates how the combination of AR and 3D printing invites co-creation and participatory design with the coloured in drawing from Jan Farr. All images courtesy of the authors.

In a secondary school scenario a book seeded with AR overlays provides questions that test students' knowledge and unlocks printable smart objects. The overlays may contain a gloss for terminology, extended descriptive information or external links to other information sources.

A further exploration looks at the possibility of a dedicated library space for searching AR content in which seeded collection items or 3D printed smart-objects can be interacted with and overlays of digital content can be projected onto a desk surface.

AR seeded content offers new opportunities in the marketplace of instructional design and is an example of new multimedia worth collecting by libraries. Under Cognitive Load Theory learners process information through two channels; a verbal/auditory channel, and a visual/pictorial channel with a limit to how much information each channel can process at once[12] *Making Connections* as a method to support learning greatly reduces cognitive load as the interactivity provides the multimedia benefits of offloading textual information from the visual to auditory channel, it allows pre-training of important concepts through added descriptions or glossing of unfamiliar terms through AR overlays, and allows learners to move at their own pace in response to user action unlike traditional video/animation.

Figures 6-8: Demonstrating how 3D printing can invite and encourage different ways of extending narratives.

AR applications such as this are an example of the move from a digital society toward one that is cyber-physical. A key notion of cyber-physical systems is that knowledge exists not only in a mental space, but in cyber space, physical space, and socio spaces. Cyber-physical systems take advantage of intelligent environments by merging digital resources with physical resources. Artificial spaces contain both physical and social characteristics and the use of these spaces in facilitating information exchange is key to the development of new epistemologies made possible through human-machine, and machine-to-machine interactions, and with communication between smart objects across the Internet of Things.[13] *Making Connections* takes the work of HitLab NZ in a new direction by providing interactions with existing information sources. It then layers this with expanded information. The knowledge gained by the user, however; will change with the context of artificial spaces; at home, at school, at a library or in a museum.

COLLECTING AND FINDABILITY

Ryan Achten's thesis *Virtual Recollection: Artefact Engagement in Three-Dimensional Environments* identifies an opportunity within cultural institutions to extend the practice of digital archiving to represent artefacts in three dimensions. Standard practice for digitisation is to scan or photograph items as two-dimensional digital representations. This is adequate for capturing textual information but has become common for physical artefacts within library and museum collections. In these instances only a facet of an object can be represented and the utility of their form is lost altogether.

Achten has prototyped a software interface called *Vertice* using the game engine Unity 3D. The software allows users to upload either born digital objects or surrogates of 3D objects produced through precision scanning and photogrammetry to be staged for ingest into a digital archive. The user inputs metadata through a descriptive form to contextualise the object. *Vertice* adheres to Dublin Core metadata standards and the current prototype uses a schema based on the International Committee for Museum Documentation's (CIDOC) Conceptual Reference Model (CRM).

CIDOC CRM is an ontology designed to enable integration of cultural heritage data across library, museum and archives. A CRM

uses semantic mapping to link items as complex intellectual objects, or entities, as opposed to simple strings of text. The NZ Electronic Text Centre (NZETC) at Victoria University of Wellington uses CIDOC CRM to link digital resources between collections and across institutions. As the digital resources held with NZETC are text heavy, linking is achieved by a framework of topic maps interlinked by event-based references.[14]

As the CRM forms entities from information and interlinks these entities in reference to events in which they were involved, *Vertice* creates an opportunity to cut out redundancies. The 3D object itself can be semantically mapped to topic maps such as those in the NZETC, or to other forms of media with semantic associations. The schema creates links via relationships such as "made by," "refers to," "is a type of," "created in," as seen in Achten's CRM diagram (Figure 11).

Figures 9-10: The *Vertice* graphical user interface "import" and "artefact information" for collection items from the Auckland Museum

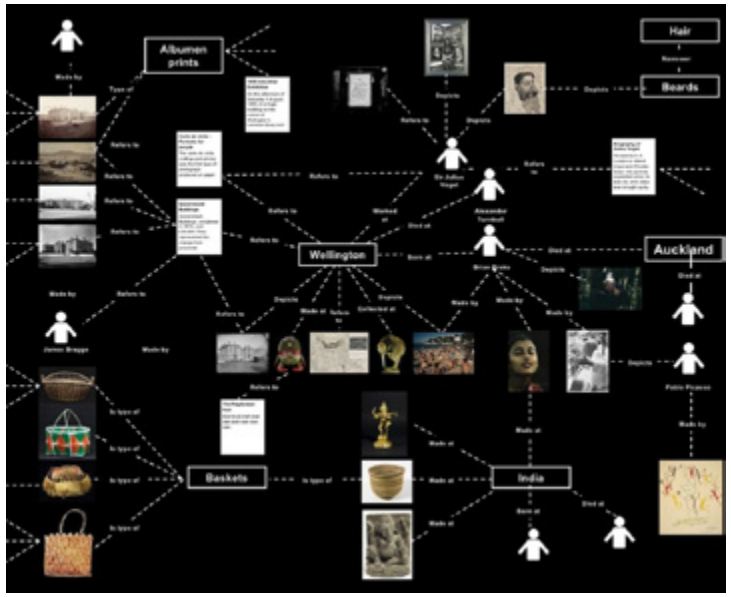


Figure 11: *Vertice* research: example of a semantically linked CRM ontology

Figure 12: An example of both parametric and photogrammetric models in *Vertice* showing relational information, contextual overlays, and diegetic interactions

Semantic linking such as this is useful for *Vertice* as it explores further means of engaging with 3D content via narrative virtual space (Figure 12) which allows objects to relate with similar objects in their natural environments and to retell history through new forms of representation that can be generated through linking.

In a cyber-physical context these semantic links can go beyond linking solely with other digital resources to forming links with what Zhuge refers to as other "semantic nodes" ; a term which can refer to anything from text, images, human beings, concepts, events, machines, or networks with the role of these nodes reflecting back attributes of given spaces.[15] This means cultural institutions can help resource each other through open digital access but the institutions as socio spaces will reflect back different forms of knowledge given their function within society. When utilized within a library environment *Vertice* becomes both a powerful finding aid and interpretive medium with the opportunity to output 3D printed smart objects. In a museum environment *Vertice* may serve a stronger curatorial function by aiding curators in more easily making links across associated objects in its database and allowing these objects to be quickly and easily test printed for mock up display.

A precursor to both Hughes-Ward's *Making Connections* and Achten's *Virtual Recollection* was their 2014-2015 Summer Scholarship project: *Digital Archives of the Future* with fellow scholar Ruth Barnard. This took place over a ten week period and covered four scenarios that interpret library collections. *My National Library* is one scenario that promotes a sense of public ownership and sharing of individual content and proposes to interlink with the National Library's existing website as a space to collect sets of digital items such as photos, text,




Figures 13-16: Augmented Reality exhibition piece showing waterfront reclamation at Queens Wharf and the growth of Wellington in this area

paintings, audio recordings and 3D model content. Research can be tracked and digital resources can be managed via smart-devices and image recognition with interactions being stored on the user's My National Library webpage. Extending upon *My National Library* with progress made by the *Making Connections* project, and the semantic link network provided by *Vertice* there is a powerful opportunity to search across collections and institutions, saving and tracking research, overlaying descriptive or further link information onto physical space, original items, and both 2D and 3D printed replicas alike. In doing so it addresses the issue of Makerspaces in libraries as a default setting, by transforming them into Makerspaces with a sense of purpose that is inseparable from a library's traditional historical collections.

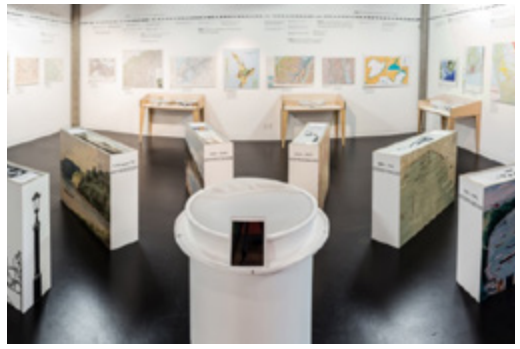
FORMATION FROM INFORMATION

Although Google Earth is available to anyone with an internet connection there are many places on earth where detailed satellite data is unavailable. In the example of Afghanistan much of this data is classified and shaded relief maps are generated not from satellite data but from paper topographical maps.[16] Topographic maps make

up a valuable resource offered by libraries and due to traditional cartographic methods any understanding of elevation information is only available through the ability to read contour lines. 3D printing provides an immediate means to output digital elevation models (DEM) extracted from paper maps which reveals, very reliably, otherwise invisible information. This also exemplifies what can be done with digitised heritage items to meet growing demands for new types of data not otherwise present in traditional forms and how curatorial services within libraries can offer richer interpretation of their collections.

Over the summer of 2015-2016, Victoria University of Wellington's Summer Scholars undertook a ten week project titled *Visualising Wellington* to investigate how AR, VR, and 3D printing technology can be used to interpret collection material in new and engaging ways. Three examples were produced as exhibition items for display within the National Library. All exhibition pieces relate to Queens Wharf on the Wellington waterfront.

The first example looks at the reclamation of the Wellington waterfront. A physical representation was created through CNC milling 3D topographical information and vacuum-forming acrylic to form Wellington's terrain. Laser cutting on acrylic was used to form puzzle-pieces approximated from library collection content that represent the Wellington waterfront over periods 1857-1867, 1889-1903 and 1967-1970. Images from these periods were also used alongside an algorithm to generate the buildings occupying Wellington's terrain which are made visible through AR and recognises which puzzle pieces are present.



Figures 17-18: Queens Wharf AR interactive installed in *Unfolding the Map* exhibition at the National Library of New Zealand

As puzzle pieces are added to the terrain to expand the waterfront; new buildings spring up as AR overlays to match the profile of the city during the given period. For pre-existing land the AR updates with the time period to represent the expansion into the city in addition to the expansion across reclaimed land.

The second example introduces Virtual Reality applications in the form of public viewing binoculars that recreate a first person view of a historic Queen's Wharf through interpretation of static library images. The binoculars house an Oculus Rift VR headset that orbits around a point on a stationary stand. If installed in a location on present day Queen's Wharf the physical binoculars would allow for an interesting merge of physical and digital spaces bringing together different socio spaces from the physical present and digital past.

The final example provides a glimpse at an alternative Queens Wharf through the modelling of the proposed Lambton Tower precinct; a tower that was never physically built. A document held by the library covering floor plan and elevations, artist's impressions and images of hand-crafted models was scanned and imported into computer modelling software. This allowed the floor plans to be extruded and output for 3D printing in three segments of white ABS plastic at a scale of 1:500 to the original tower design. While this may have been time consuming to model it also revealed the ways in which an algorithm could be created to speed the modelling processes up and make interpretation of similar planning documents more accessible to library staff and its users.

Figures 19-20: Scale model of Lambton Tower interpreted from National Library collection material and 3D printed in white ABS

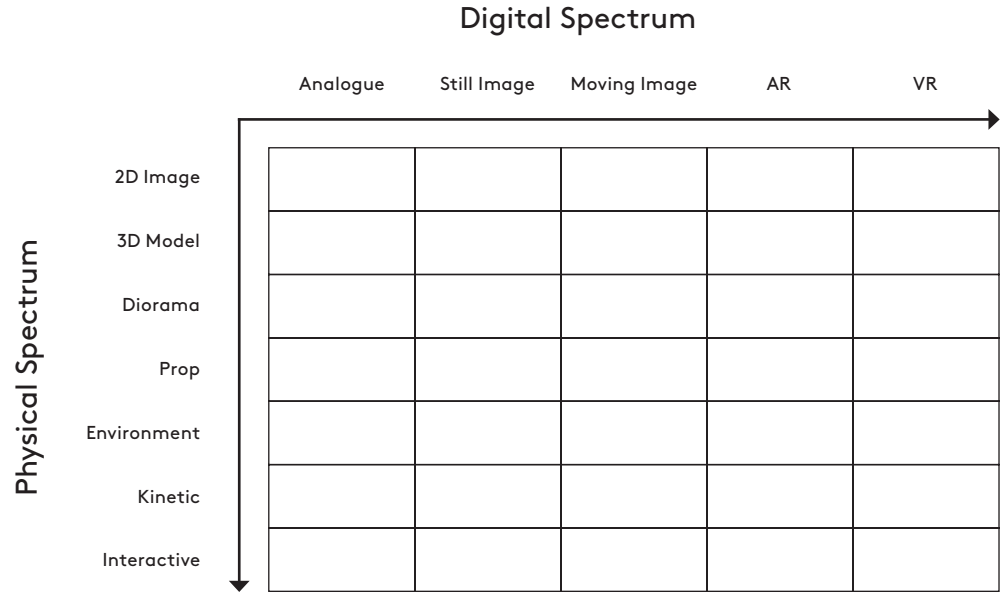


Figure 21: Research matrix

Through the formation of these exhibits the research team developed a research matrix that quantitatively plotted precedents of contemporary exhibition methods along a physical axis and a digital axis with each axis stretching a scale of less to more complex in terms of its carrying capacity for human interpretable information with more innovative research precedents occupying greater areas of the matrix.

Interpretive material such as the work done by the *Visualising Wellington* can be archived and made findable using systems such as *Vertice*. My National Library as another example would provide another means of saving and interacting with the research and the further developments made in the *Making Connections* project extend upon those developed in the Summer Scholarship project of 2014-2015 titled *Digital Archives of the Future* of which My National Library was one of four examples. The other three provide further examples of ways libraries can reconfigure their holdings. The following outputs were also presented as an exhibition at the National Library of New Zealand:

The first example interpreted material connected with *A Contemporary Conversation;* a National Library exhibition commemorating the centenary of the First World War, its impact, and connections with ongoing conflict in the world today. Three items were given treatment:

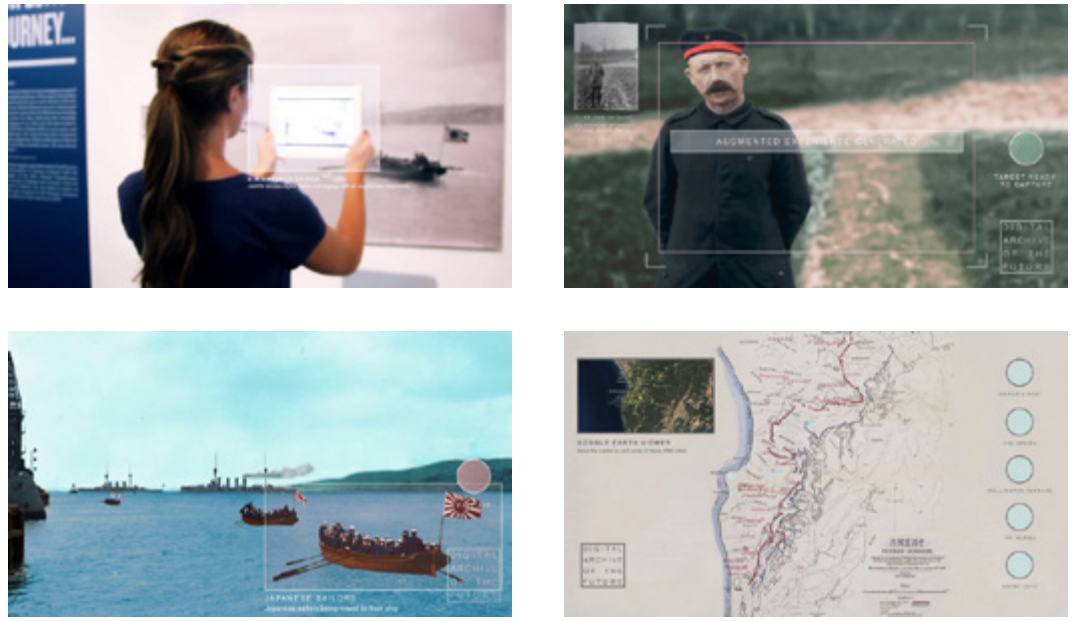
1. A photograph “Warship escorts for the New Zealand Expeditionary Force” was colourised and further enhanced with descriptive overlays about the ships in the image and a QR code that enabled downloading of a 3D printable model of the ship.

2. An ANZAC trench diagram was represented as 3D printed terrain where the viewer can move a 3D printed figure across locations and view on a screen the relevant location transformed via Google Maps with an overlay of the Gallipoli map. Options to 3D print the soldier figurine, or a section of the terrain, are also presented.

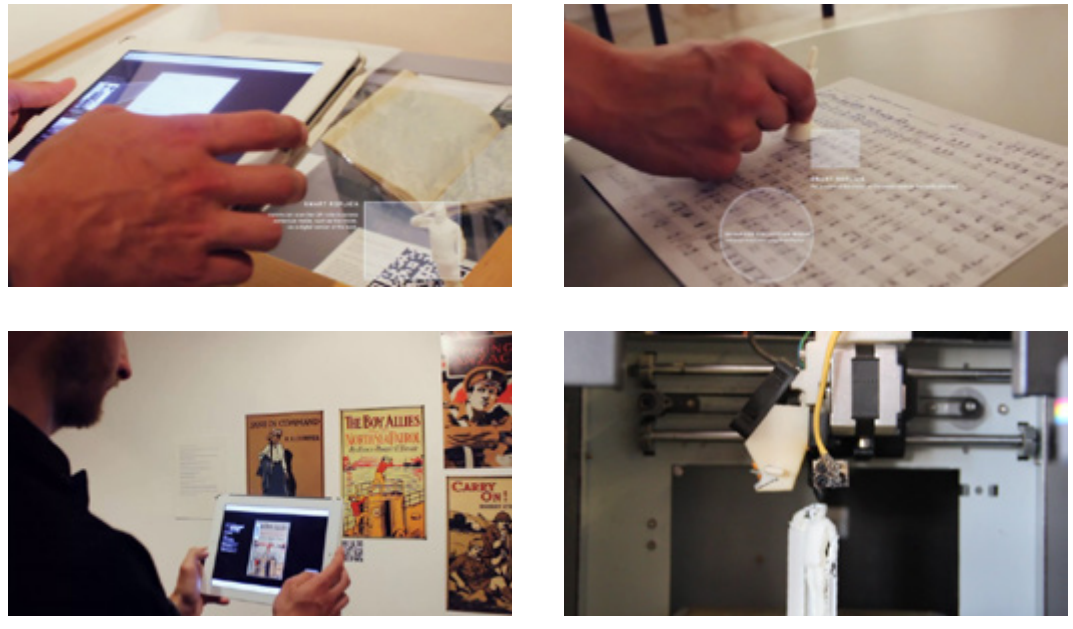
3. A photograph of Alsatian prisoner of war, Jules Gominet is brought to life through animation in which he tells his story to connect further than the photograph alone and link back to the library collections, notably the work of the photographer Henry Armitage Sanders, and the location of Colincamps in France.

The second example interprets content from another related exhibition *A Child's War* using 3D models as signposts for exhibits that can be interacted with using AR via an iPad or smartphone. The AR application in this exhibit extends to interacting with the books or diaries on display. Keywords can be touched to provide related information beside an image of a corresponding model. A book of music encourages interaction by playing back the sounds that are presented on the paper.

The final example looks at the collection of Paul Jenden; a writer, director, choreographer, set and costume designer and looks to encourage physical interaction. 3D interactive models have been produced from Paul Jenden’s *Punch and Judy* sketches and gesture interaction has been incorporated to allow the user to select either the Punch or Judy puppet and manipulate the model through the user’s movements. A countdown begins at the beginning of the interaction and once it ends a snapshot is taken giving the viewer the option to 3D print these puppets in their final pose.



Figures 22-25: *World War One: A Contemporary Conversation*



Figures 26-29: *A Child’s War*

Figures 30-32: Paul Jenden exhibition material

CONCLUSION

As smart-devices, smart objects, and other semantic nodes proliferate we see that digital resources are already so accessible that the way we best utilise our physical resources and the spaces they occupy now requires readdressing. With emerging 3D technologies offering full 360 degree perspectives of both narratives and histories in a more immersive and engaging manner - we are freed from the limitations of text and two dimensional image capture. In the instance of text based resources conceptual reference models now allow pictorial, auditory, and object information to be returned and explored through their relationships with each other overcoming the limitations of text only searching. Augmented reality allows this information to be overlaid onto physical space, 3D printing allows information to be output into physical space, and Virtual Reality allows physical space to be simulated. The potential of these advancements to enhance education, entertainment and supply chains will impact the way information is recorded and in the case of libraries how and what is collected. As these shifts occur existing collections may benefit from reinterpretation so that the information they hold can be presented in ways that make them compatible with new means of transmitting and receiving knowledge. Whether 3D Printing, Augmented Reality, Virtual Reality, or any future technologies are useful or not for libraries depends not on the mere inclusion of technologies themselves but the active imagination of wider society capturing, re-interpreting, and co-creating new knowledge with the technology made openly available to enable this.

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Big Sloppy Dinosaur Socks

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National Library Liaison

Peter Rowlands

ENDNOTES

1 In this instance we use the term "lost" in a figurative rather than a literal sense that archival material that remains buried is, to all intents and purposes, "lost" to the public. It should be noted that such a contention could split archivists depending on the assumption that archival material exists for contemporary display or for future preservation but an advantage of these technologies is that data, once extracted can be manipulated an reinterpreted while the original archive can remain a place of preservation. Indeed, access to and reconfiguration of previously unattended archival material can serve the longer term purpose of preserving archives that are suddenly understood publicly for the value they contain.

2 Rundle, Hugh. "Mission creep: A 3D printer will not save your library." *It's Not About the Books blog* (2013)

3 Ensor, Pat. "Multimedia to the People: plenty of room for multimedia enticements alongside traditional library offerings." *Library Journal New York* No.124, p.15.

4 Recognising this shift and its potential to open up access, libraries and archives have, over the last three decades embarked upon a digitisation process that is ongoing to this day. The quality, file formats and best practice for digitising and making available archival material is a vibrant and ongoing discussion (for contemporary theoretical and practical historical examples of archival digitisation see Garde-Hansen 2011 and Denvir 1998).

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