REAL MATERIAL ETHEREAL

Proceedings of the Annual Design Research Conference 2019

Edited by Laura Harper

Published in Melbourne Australia, by Monash University, 2020
ISBN: 978-1-921994-52-4

The bibliographic citation for this paper is:

Andrew Burrell. "Malleability and Ethereality in Virtual Reality as a Material of Design." In *Proceedings of the Annual Design Research Conference 2019: Real/Material/Ethereal,* edited by Laura Harper, 56-67. Melbourne: Monash University, 2020

Malleability and Ethereality in Virtual Reality as a Material of Design

Abstract

"Layered Horizons" is a Research through Design and digital humanities project that brings together disparate data sets from linguistics, anthropology, geography and archaeology—within virtual reality (VR)—to create interactive information visualisations which use gesture-based controls to allow a user to interact with information in an embodied manner. A user is literally surrounded by the information as environment and interacts with it in a direct and embodied manner. This paper explores "Layered Horizons" from the perspective of the design processes used to create it and the central role our understanding of the unique affordances of virtual reality as a material of design, in particular its malleability and ethereality, have played in this process. The focus of this paper is therefore the design-led question of "how can data be layered in a VR visualisation to allow previously unseen connections to be investigated?" It will discuss the project's development via a Research through Design framework as enacted by an interdisciplinary team. It will also discuss how we are exploring the affordance of VR in an attempt to move beyond framing data within Cartesian space, in linear time, by taking advantage of the malleability and ethereality of virtual environments.

Part 1: Introduction: *Layered Horizons*

Figure 1. *Layered Horizons* iteration, Science Week 2018,
Image courtesy the authors.

Layered Horizons is an ongoing outcome of "Waves of Words, Mapping and modelling the history of Australia's Asia-Pacific ties[1]", a research project investigating the extent and nature of ancient contact between First Peoples of Australia and the Asia-Pacific region[2]. As such, *Layered Horizons* is continually being iterated upon as both a research outcome and toolset for research. The project aims to use design and digital humanities research as a way to surface novel insights into interrelated data, to communicate these insights using the unique affordance of VR, and for the infrastructure of this VR experience to be transferable to other forms of data. This goal of creating a toolset for research that is useful beyond the scope of "Waves of Words" allows for a wide range of research questions to be investigated using the project outcomes. This could be broken down into three design-led goals:

1. To manipulate data spatially to reveal connections.
2. To visually and experientially communicate this to a variety of audiences.
3. To build a toolset that is transferable to others.

This paper will discuss the project's development via a Research through Design framework[3] as enacted by an interdisciplinary team. It will also discuss how we are exploring the affordance

of VR in an attempt to move beyond framing data within Cartesian space, in linear time, by taking advantage of the malleability and ethereality of virtual environments.

Part 2: People

Layered Horizons is a collaborative, interdisciplinary project that brings together two circles from within a larger team, those working closely on the realisation of this project as an outcome, and the wider circle of those working on the broader research question and feeding data and scholarly input into this output[1]. Andrew Burrell (University of Technology Sydney) is leading the design and development of the virtual reality experience in close collaboration with Rachel Hendery (Western Sydney University) and with the research assistance of Ali Chalmers Braithwaite (UTS).

Our research studio at the University of Technology Sydney, the "Speculative Narratives and Networks Studio[4]" brings together a number of "Research through Design" practitioners to investigate the intersection of narratives, networks and speculative practice. It is in this context that our investigations into virtual environments as material space are carried out.

Part 3: Context / precedents

This project has its roots in an earlier Language visualisation project, Glossopticon[5]. Many of the aims of the Glossopticon project carry over into the *Layered Horizons* project, so it is worth outlining it as a direct predecessor of *Layered Horizons*. Glossopticon began in 2016 with an aim of creating a prototype VR experience which would visualise and sonify the languages of the Pacific region. The initial proof of concept mapped language data to a GPS location with the number of speakers being mapped to the scale of geo-located domes (figure 2-a).

This proof of concept was developed in JavaScript as a sketch in code by Hendery, a sketch which became the basis for the ongoing iteration of the project. Sketching in code is also a fundamental part of the iterative design process used to create *Layered Horizons*. We see code as a material that has the equivalence (albeit with its own unique affordances) to any other design material when it comes to ideating and iterating the design outcome. This is a methodology shared with digital humanities, and this interdisciplinary understanding of code as material has provided this project a grounded strength from the outset[6].

Glossopticon's legacy of literal mapping of space to a Cartesian plane has posed one of the key design challenges in moving forward into *Layered Horizons* as we literally work against it in attempting to break away from this strict Cartesian mapping of space. This is an ongoing challenge and one that we are working to meet as the project continues.

Figure 2. Glossopticon. (a)Initial proof of concept. (b)fully realised project in VR as exhibited at the Canberra Museum and Gallery, Image courtesy the authors, featuring Dale Middleby, CMAG's Senior Curator.

The final version[7] of Glossopticon(fig. 2-b) allowed the user to fly through the environment, exploring the landscape, while listening to voices speaking local languages in their relative locations and mixing with one another spatially. Users were also able to summon up further information on particular languages using a gaze-based interaction system. This proved problematic due to the resulting sense of disembodiment, a feeling of being a "head in a jar", which was only exacerbated when combined with a lack of physical interaction[8]. In *Layered Horizons* we have instead focused on physical, direct and embodied interactions to manipulate the environment.

Part 4: Research and Design Processes

One of the key conceptual design shifts from Glossopticon to *Layered Horizons*, is the use of data to create all of the visuals on the fly, as opposed to creating a pre-generated environment. In Glossopticon (and other 'standard' virtual environments) the environment is prefabricated and static, created using textured 3D models to represent elements such as the landscape. In *Layered Horizons,* however, the environment is rendered during the experience based on a broad range of data read at "runtime". In this way we can manipulate the environment computationally, manipulating it at the level of the data itself. At the same time, it also allows for the use of the environment *as* interface due to this heightened malleability. This is in keeping with our studio's approach to designing for the material affordances of VR by removing an intervening layer of interface and relying instead on a user's embodied understanding of their body in space to comprehend the membrane of interaction. Rather than relying on now traditional interface elements such as touchable button, clickable icons, draggable slider etc.

the environment itself *is* the interface. Again, the malleability and ethereality of the materiality of the virtual environment makes this possible[9].

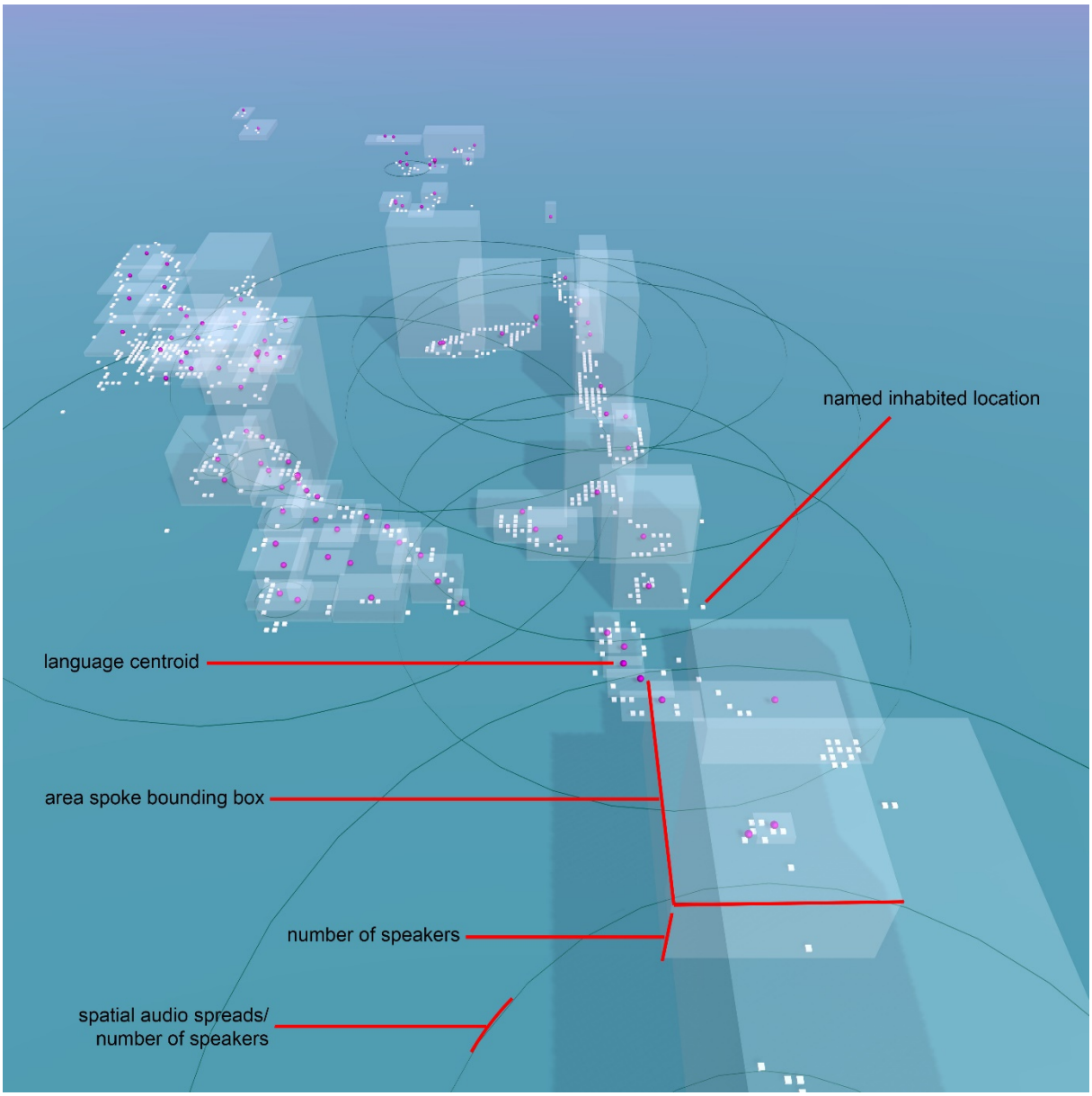

Figure 3. A variety of datapoints mapped in Layered Horizon,
Image courtesy the authors.

As an example, data points that make up the "map" of the pacific region are created from a dataset of "inhabited locations" provided by the National Geospatial-Intelligence Agency[10]. This particular data set also provides an interesting insight into the affordances of data as a material in that the coordinates for these locations are made available rounded to six decimal places, creating a distinctive grid like layout within the visualization due to "rounding error". The pattern strengthens the visual design as a direct result of the material qualities of the data. By designing with data rather than 3D modelling a landscape we can manipulate the resulting

environment through a direct change in data. This is a deliberate design tactic and its payoffs play out in the case study to follow.

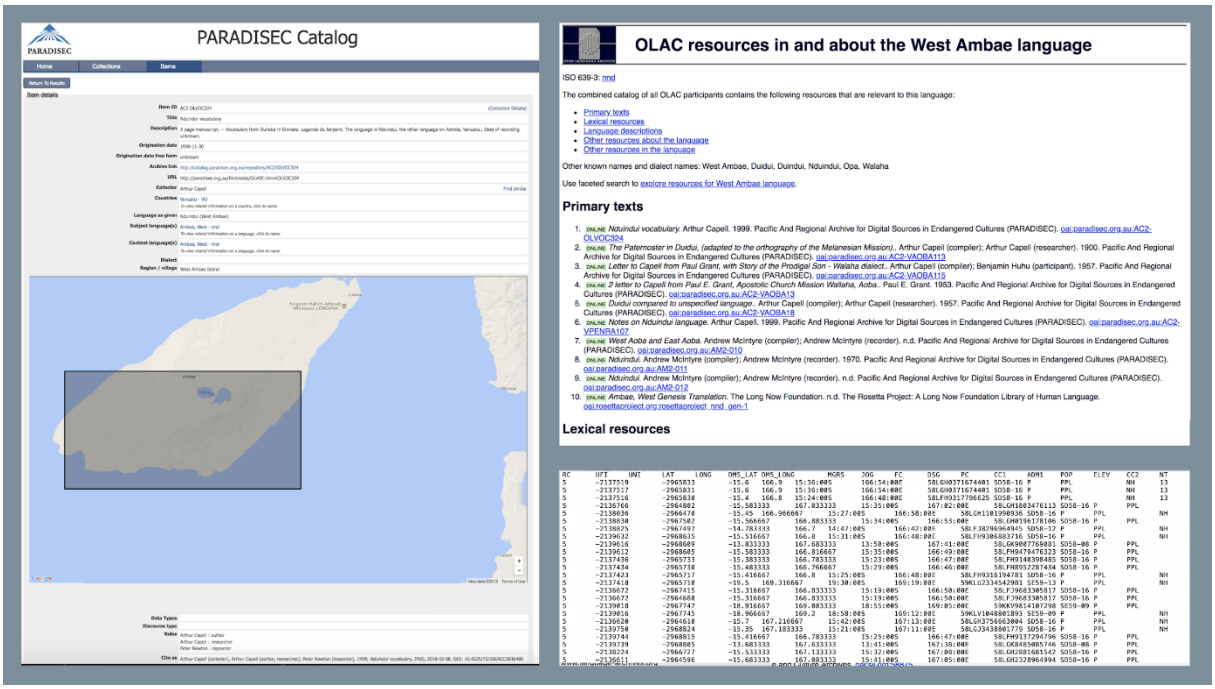

Figure 3. Examples of information/data as raw material, PARADISEC, OLAC and the National Geospatial-Intelligence Agency.

Data is at the very core of this project, so it makes sense to have it driving the design. As table 1 suggests there are many types of data included, ranging from strict numerical data, to what might be better classified as information. However, data does not blindly define the design outcome in any sort of automatic way, but is instead seen as a raw material that shapes and informs the design decisions in the same way the affordance of any other material would. Figure 3 provides an insight into some of the ways data incorporated into the project is traditionally presented.

geographical data	e.g. place names, places, maps
general linguistic audio	e.g. voice recordings from PARADISEC
general linguistic stats	e.g. PARADISEC[11] and OLAC[12]
specific linguistic data	e.g. tabu words
simulated / algorithmic data	e.g. canoe journeys
relative data with known relationships	e.g. words for bananas / banana types

Table 1. Types of data/information currently incorporated into the *Layered Horizons* visualisation

Another important process to understand in the way of working being developed for this project is the tripartite relationship between *technology*, *concept* and *content* coming together to form a holistic research process. This is important to keep in mind when considering the use of VR technologies as a primary material for the project's outcome.

Part 5: VR as material

Virtual reality as a material of design is complex, not only because it is an emerging technology, for which a shared language is still being developed, but also because it relies on a 'stack' of preceding material technologies and disciplines. These include interaction design, the language of cinema, spatial and architectural design and game design, each having their own unique affordances that overlap with and influence the new affordances of VR.

In order to tackle this, it was necessary to re-pose our design-focused research question to ask, "how might we represent data using the affordances of VR to highlight previously unseen connections across, disparate data sets, disciplines, spaces and times?" Interestingly, this question also demonstrates the appropriateness of VR as the core technology for the *Layered Horizons* project in the first place. As we are dealing with data that sits across not only disciplines but also a very wide field of both time and space, we find that an understanding of the malleability and ethereality of virtual environments provide a unique platform to visualise such material in a coherent manner.

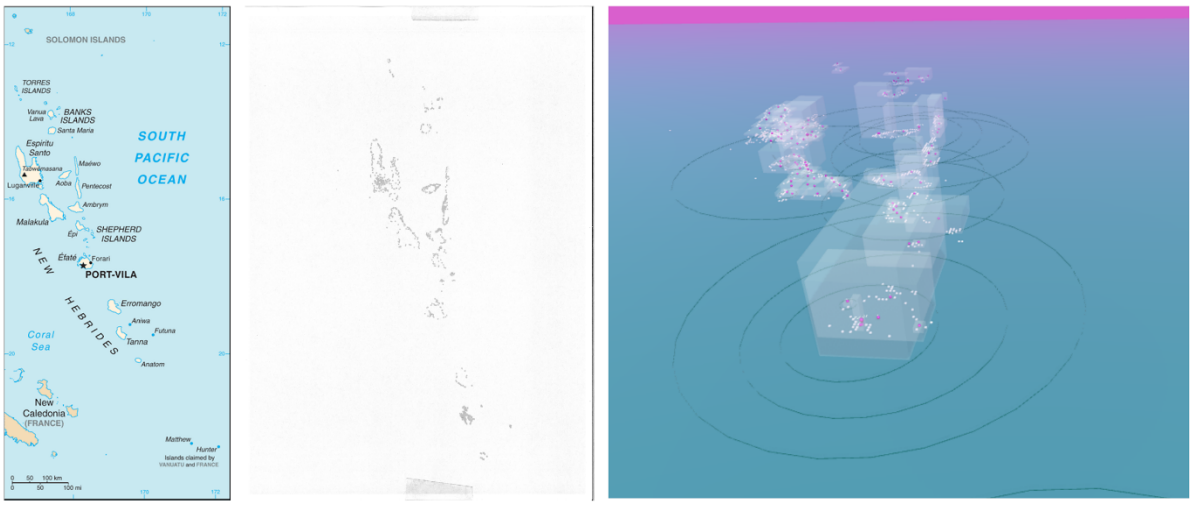

Figure 4. Vanuatu as traditional map, raw data points and in Layered Horizon, a Wikimedia Commons, b and c Image courtesy the authors.

This brings about the possibilities for an embodied understanding of this layering. Embodied and spatial cognition in real time enable a complex layering and manipulation of these elements in a way that remains understandable to a viewer that otherwise would not be in a

two-dimensional visualisation. Users can use their hands as tools for navigation (e.g. point in the direction you want to move, gesture with a thumbs up to rise up) and as tools for interaction (e.g. point and touch a location to reveal further information about it, such as its name, or cup a language location marker in your hand to isolate a voice speaking that language and reveal how many people currently speak that language). A user can move amongst the data, creating a sense of immersion that in turn produces an understanding of themselves within the environment. Whilst immersed in this way, they can directly manipulate the environment through interaction—and this is key to their embodied understanding of the data presented.

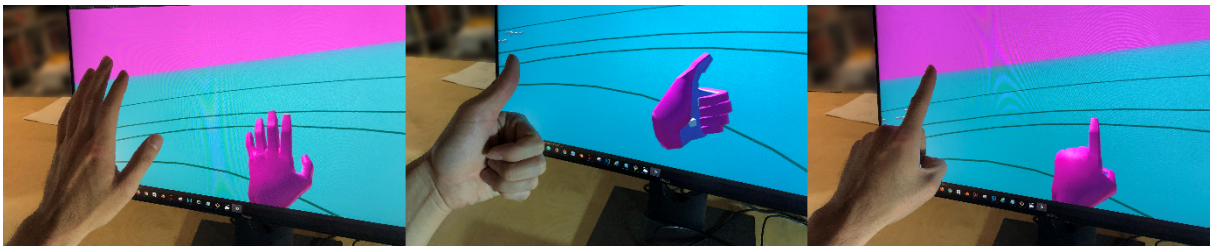

Figure 5. Testing gestural interface, highlighting the one to one mapping of physical and virtual hands, Image courtesy the authors.

From the point of view of embodied cognition, our design practice takes advantage of the user's ability to offload cognitive processes into an environment. As Margaret Wilson suggests, "[w]e make the environment hold or even manipulate information for us, and we harvest that information only on a need-to-know basis[13]".

Users of the experience are then able to use the virtual environment, and their body's relationship with it, to off-load the cognitive work of making sense of the large amount of information presented and use this to bring in their own understanding of the various aspects of data in order to synthesise new meanings of the whole. While other affordances of the technology are at play within the visualisation, this notion of offloading cognitive work is central to the success of the project and forms an important and continued point of reference for the design process.

Part 6: Case Study

One of the central concerns of our research moving forward is how non-western/non-Cartesian understandings of space and time can be better understood and represented by taking advantage of the malleability and ethereality of virtual space.

One way we have started to look at space differently is by looking at the idea of *canoe time*. Using data from Laurent Dousset and Anne Di Piazza's simulated canoe journeys between

key locations in the Pacific, we can start to manipulate the representation of physical space against the time/space-based data of these simulations[14].

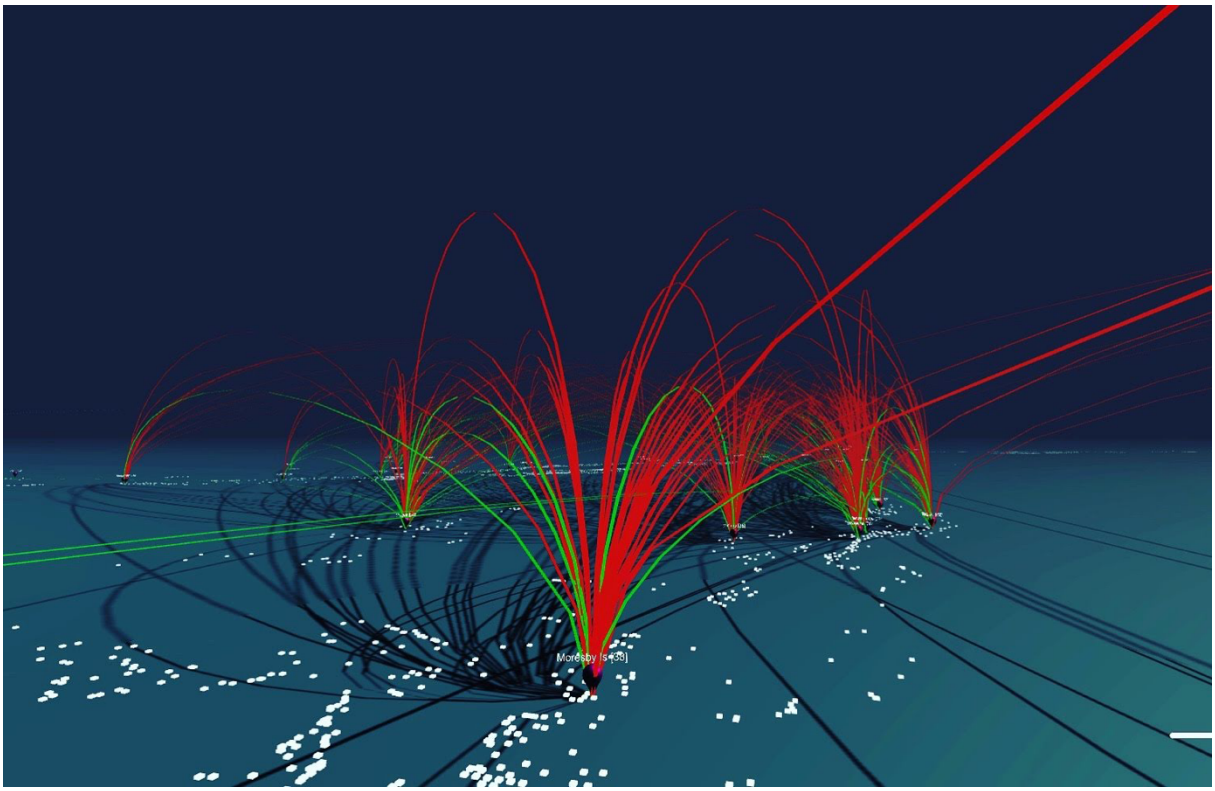

Figure 6. Pacific canoes journeys represented in Layered Horizon,
Image courtesy the authors.

In figure 6, we can see simulated canoe journeys mapped as arcs (to remove the temptation to read them as direct journeys) and colour coded as journeys taking a longer or shorter time than the average journey time between any two given locations. Because of the functioning of spatial cognition in VR, the complex spatial relationships become much more immediately apparent than they can from a traditional screen-based visualisation, which unfortunately is not at all obvious from the 2D images presented here.

Our research journey is iterative, driven by practice-based design investigations, and as can be seen from figure 7 the visualisation of these arcs are being developed using the iterative sketching in code process mentioned previously.

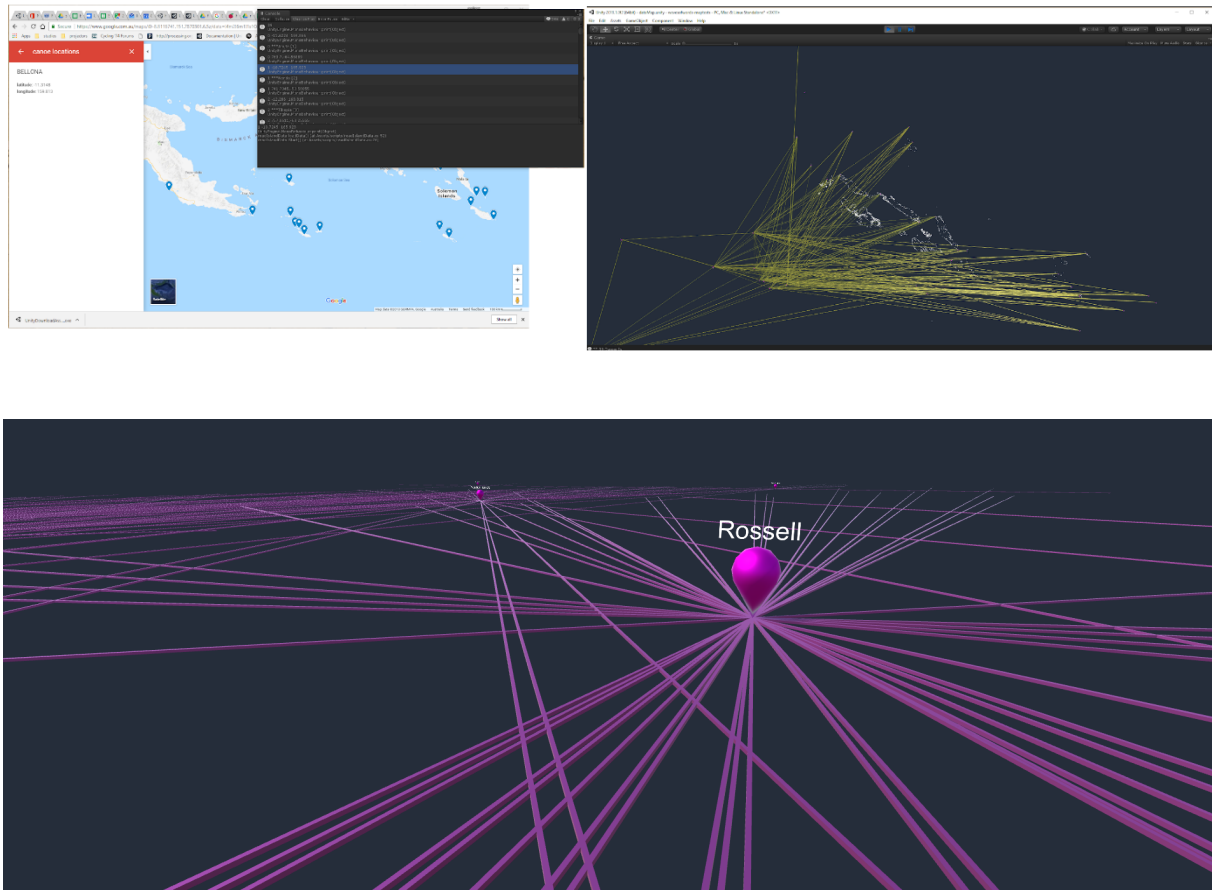

Figure 7. Iterative processes of representing canoe journeys in Layered Horizon, Image courtesy the authors.

The series of images in figure 8 represents one such iteration for combining a language data set of “Tabu” words (compiled by linguist Patrick McConvell), with the simulated canoe journey data. This is then combined with the ability for the user to shift and warp the virtual environment itself based on the space/time relationship of the canoe journeys. Rather than a traditional mapping of the physical environment, the location of Pacific islands in the environment is based on the time it might take to move between islands in *canoe time*, rather than the physical distance between two places.

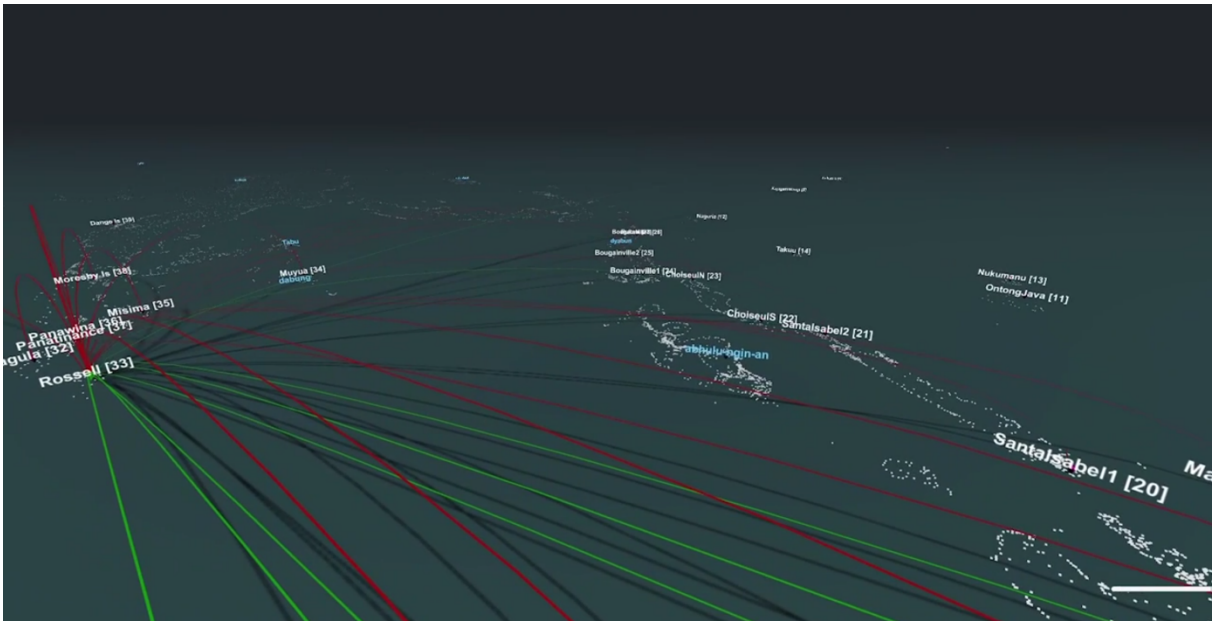

Figure 8. Locations, Tabu words and canoe journeys represented in *Layered Horizons*,
Image courtesy the authors.

This represents an example of the layering that the project's title suggests, and this is again something that is immediately much more understandable from within the VR experience. Representing these relationships within the data over space and time in virtual space is central to these iterative investigations and we believe the nature of virtual environments is currently the best-suited space for these investigations to take place within.

Part 7: Looking Forward

We are at a point in the project where our understanding of ways of designing for the unique affordances of virtual environments is placing us in a prime position to bring together many of experiments and proof of concepts we have created to this day. All of the outcomes as tools are being made available as open source projects[15] and we believe that this research through design will provide fertile ground for moving our own projects forward, as well as for designer and digital humanists working in the emerging material space of virtual reality and with data as material.

Endnotes

[1] Waves of Words is funded by the Australian Research Council (DP180100893) and we are grateful for the input of the other project team members: Patrick McConvell, Laurent Dousset, Antoinette Schapper, Michael Falk, Billy McConvell, Matthew Spriggs, Tim Denham and Ali Chalmers Braithwaite.
[2] I would also like to acknowledge the collaborative co-creation of Shannon Foster (D'harawal Saltwater Knowledge Keeper) and Danièle Hromek (Budawang/Yuin, Designer and Researcher) as Indigenous knowledge holders, on an iteration of the Layered Horizons project dealing directly with Dharug and Dharawal laguages, which although not discussed directly here has, by the nature of iterative design practice, informed the project as a whole.
[3] This framework has been heavily influenced by Zoë Sadokierski's work in this area, see for example Zoe Sadokierski, 'Critical Journal / Contextual Portfolio: A Framework for Documenting and Disseminating RtD as Scholarly Research', paper presented at *Research Through Design, Delft, The Netherlands, 19-22 March 2019.* https://figshare.com/articles/Critical_Journal_Contextual_Portfolio_A_framework_for_documenting_and_disseminating_RtD_as_scholarly_research/7855829.
[4] See https://specstudio.com.au/
[5] Andrew Burrell, Rachel Hendery, Nick Thieberger, 'Glossopticon: Visualising Archival Data', 23rd *International Conference in Information Visualization – Part II*, (2019), 100-103.
[6] This notion of sketching in code is perhaps best expressed by the Processing creative coding environment, a software toolkit for artists and designers using code as material, where the coding environment is referred to as a sketchbook and the programs written in it are called sketches. See: https://processing.org/
[7] First exhibited at the Canberra Museum and Gallery in the show "Memory of the World in Canberra", curated by Dale Middleby. This was part of the UNESCO Memory of the World Programme for safeguarding documentary heritage.
[8] See also https://glossopticon.com
[9] This concept is very much inspired by Brenda Laurel's approach to the design and realisation of virtual environments in both her early work and more recent look at contemporary VR design incorporating her invaluable hindsight. See: Brenda Laurel, Strickland, R., Tow, R., 1994. 'Placeholder: landscape and narrative in virtual environments.' *ACM SIGGRAPH Computer Graphics* 28, (1992), 118–126. And Brenda Laurel, 'AR and VR: Cultivating the Garden.' *Presence: Teleoperators and Virtual Environments* 25, no. 3, (December 2016), 253–66.
[10] Toponymic information is based on the Geographic Names Database, containing official standard names approved by the United States Board on Geographic Names and maintained by the National Geospatial-Intelligence Agency. More information is available at the Maps and Geodata link at www.nga.mil. The National Geospatial-Intelligence Agency name, initials, and seal are protected by 10 United States Code Section 425. http://geonames.nga.mil/gns/html/namefiles.html
[11] PARADISEC, the Pacific And Regional Archive for Digital Sources in Endangered Cultures, see: http://www.paradisec.org.au
[12] OLAC, the Open Language Archives Community, see: http://www.language-archives.org/
[13] Margaret Wilson, 'Six Views of Embodied Cognition.', *Psychonomic Bulletin & Review* 9, no. 4 (December 2002), 625–36.
[14] For an in depth write up the processes involved in creating these simulations, see: Di Piazza, A., Di Piazza, P., Pearthree, E., 'Sailing virtual canoes across Oceania: revisiting island accessibility.', *Journal of Archaeological Science* 34, (2007), 1219–1225.
[15] https://github.com/waves-of-words