Hologram Room: New Technology to View Scan Data

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ABSTRACT

The hologram room is an 'Australian made' tool for viewing Mobile Laser Scanning (MLS) files. It brings high-density point cloud data to life in a 3D 'virtual world'. The viewer is provided 'Superman' like powers, as they can fly through the cloud, walk through walls, view features from all angles, hover above points of interest and zoom in to inspect any feature in more detail. The hologram room is a very powerful tool for project visualisation and data inspection. It is developed by a company whose core technology is for managing large sets of point cloud data. The hologram room creates a real life 'virtual world' using the point cloud data. The scan data is projected onto the walls and floor and fully immerses the user into the point cloud. The viewer wears 'tracked' glasses, which enables them to inspect the data in the room in true '3D'. The hologram room provides a very powerful way to inspect equipment and structures – and provides engineering accuracies to enable design work to be carried out. This paper describes the hologram room, its evolution and some things learned from being involved with the evolution of what will one day be part of everyday life.

KEYWORDS: *Hologram room, 3D data, point cloud, laser scanning, holoverse.*

1 INTRODUCTION

The concept of a hologram room is not new and many visions and implementations of the mythical room have been put together over the last few decades. While across the board technology to implement such a room advances every year, the rapid advancement in laser scanners and their capability to capture the real world has been exceptional. In 2001, the HDS2500 terrestrial scanner produced 1,000 points per second and was considered state of the art. In 2012, the HDS7000 produced 1,000,000 points per second. This is an increase of 3 orders of magnitude in 12 years. The introduction of Mobile Laser Scanning (MLS) has meant that even larger quantities of data can be collected – measured in 100s of gigabytes of data per day. The sheer quantity of data being collected makes it challenging to store, view and manipulate these datasets. Large computer servers are required to store the data, and data handling is often slow. Initially, software visualisation tools were limited.

A key algorithm advancement made by a small Australian company early in the 21st century to address this problem has proven to be much more dramatic in terms of change than first anticipated. Amongst many other events, this advancement has led to the development of a new incarnation of a hologram room. In this paper, to distinguish it from other incarnations, it will be referred to as the holoverse.

Over the past 18 months the authors have been fortunate to be able to have one of the first holoverses developed for commercial use. We have been able to work with the company who developed the technology, have provided feedback on the use of the room and have watched as they have developed the room from an R&D concept to its current capabilities. We are very excited about the future of the holoverse and believe it will have a major impact on many aspects of our future. While 20 years ago it would not have been easy to predict some of the advancements of today (i.e. social media and the iPad), once you have been in the holoverse it is not hard to imagine it as a standard household item similar to a modern-day theatre room. While there has been a lot of overhype and disappointment with 3D movies and 3D televisions, we believe the holoverse is different. As the holoverse provides users in different industries with some real value, it is envisaged that its uptake will be rapid once hardware becomes mass produced and appropriate content is available.

This paper introduces some of the background of this technology. It explores, through our experiences with the holoverse, what the technology is capable of today. Finally, we look at where this exciting technology may lead.

2 THE HOLOVERSE

In simple terms, our implementation of the holoverse is just a rectangular room with a relatively high ceiling painted black (Figures 1 & 2). On the ceiling and walls are six fairly standard 3D projectors. Four projectors project onto the walls and two project onto the floor areas. In addition, there are sensors that track the movement of the headset worn by the user in the room. The headset contains a set of active 3D glasses. These glasses alternate blocking one eye and then the other so rapidly that it cannot be detected by the human eye. The 3D projectors transmit two alternating images in synchronisation with the glasses – each one showing the view that would be obtained by the matching eye in the virtual world. This provides a very realistic 3D effect.

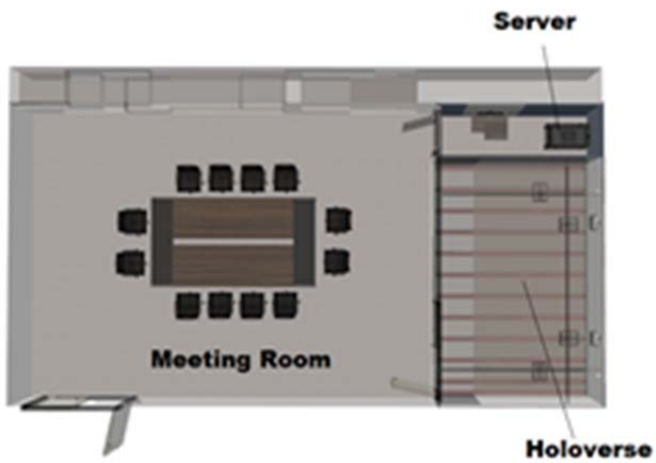

Figure 1: The holoverse is shown on the right hand side. The room has a server room adjacent to the holoverse that contains the PC running the holoverse software and a meeting room with a large screen outside for viewing.

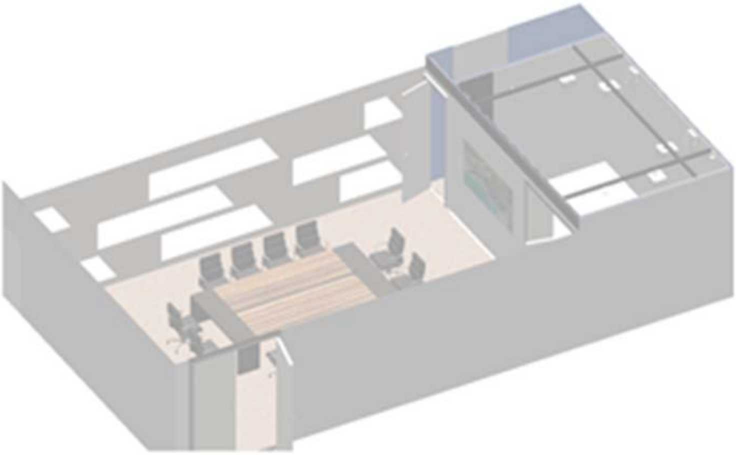

Figure 2: A 3D view of the holoverse facility.

However, being immersed in a room and surrounded by 3D projections synchronised with each other and with your headset is not enough to make a holoverse. Another core component of the holoverse is the ability to track exactly where the user's head and eyes are within the virtual world. As the user's head moves, the viewpoint in the virtual world changes. In order for the scene to remain realistic, the data projected onto the world must be updated in real time (Figure 3). If this is done smoothly and accurately, then the user immediately feels the power of virtual reality. If it is implemented poorly, the user can feel disorientated and maybe nauseous. Therefore, the software engine driving the holoverse is critical.

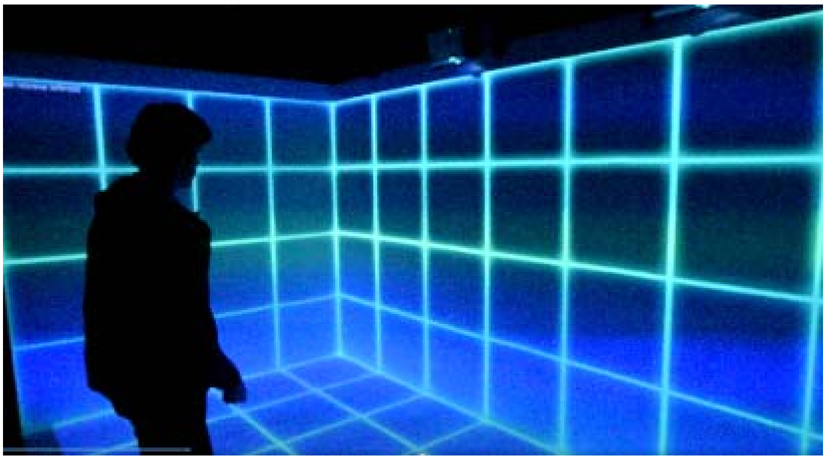

Figure 3: The holoverse with no dataset loaded.

The software that runs the holoverse uses a proprietary point viewing engine. While the end product looks similar to standard video games, the method of projecting the points on the screen evolves from a radically different process. While video game technology has evolved steadily since the 1980s with the advance in software and video display hardware, the new method of displaying point clouds may as well have been developed on a different planet.

Looking to solve some gaming issues and using a completely different way of thinking, the inventor indirectly created a new point cloud viewing engine. This led to the founding of a company to exploit this technology. While many inventors would be happy simply inventing a revolutionary technology and then selling out and retiring, in this case the inventor has been able to bootstrap this success and find numerous areas where the technology can be applied.

The holoverse was one of the first of these (Figure 4). It was developed in response to challenges arising from laser scanning technology:

- What is the point of having a method to display millions of 3D points incredibly quickly if you are limited by the resolution of a standard PC monitor? The holoverse solves this problem.
- What if laser scanning cannot provide the resolution that the point cloud engine can support? The answer to this problem was another product called Solidscan that merges photographs and point clouds to create photo-realistic 3D models. The best place to show these Solidscan images was again in the holoverse.

Figure 4: An example of a user selecting from 3D menu in holoverse.

In this way, the holoverse is part of an ever-growing family of products built around the core 'point cloud viewer' engine development. The holoverse approach to 3D viewing differs significantly from traditional approaches by directly importing the point clouds of scanned objects. Traditional approaches typically transform the 3D point cloud into vector data (i.e. a set of polygons) in order for it to be displayed quickly enough by the computer graphics hardware. This translation from point cloud to vectors is a very time-consuming and expensive process.

The holoverse is unique in that it works directly with point clouds without any modelling required. In fact it is quite a paradox, in that the standard industry requires point clouds to be modelled and transformed into polygons and vectors in order to display them. The holoverse not only displays points directly, but it does the complete opposite and converts any traditional Computer-Aided Drafting (CAD) models from textured polygons into points before displaying them.

3 THE VIRTUAL WORLD

Why would someone want to immerse themselves in a virtual world such as a holoverse? One of the many answers to this question is that we have more power in the virtual world than the real one. For instance, in the real world we can navigate by walking around our model and using our feet and eyes to move closer to objects. We can look at them in detail or move away to view a larger scene. We can turn our head left and right to view objects in what, to us, is a very intuitive interface – it should be because we have been using it since birth.

However, the real world is limiting. In the virtual world we can use exactly the same interface as the real world. We can turn our head left or right to choose what we see. We can also walk around the room to inspect objects more closely (Figure 5). The holoverse allows us to scale our movement, so that one small step in the holoverse can allow us to move 3 steps in the virtual world. However, in the virtual world there are extra things that we can do that we simply cannot do in the real world (without super powers). Some of these things are outlined in this section.

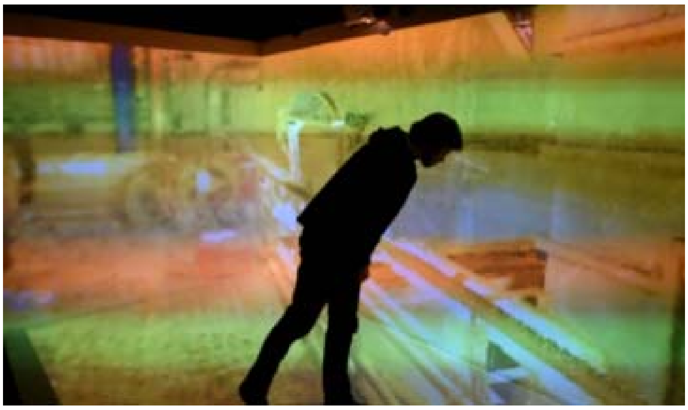

Figure 5: Looking over a rail and down a stair well in the virtual world.

3.1 Fly

By pointing our controller and pushing a button we can take off into the air exactly like Superman. We can watch as the ground below us gets smaller. We can increase our speed and pick a point for our eventual landing. Flying is fun, but it is also a very useful way to get somewhere quickly and to navigate to a spot. Wherever you look is the direction that you fly and you can control speed by movement of the wand. It takes a bit of practice but in a very short time you can perfect a landing. If you want to do a visual inspection of power lines, you can fly along the pixelated power lines as if you were a bird (Figure 6).

Figure 6: Flying in the holoverse.

3.2 Jump into Hyperspace Through Space

If you want to change countries (say, go to Paris) in the real world, you need to drive to the airport and spend time and money before you are standing in front of the Arc de Triomphe. In the holoverse, with one swipe of the wand a menu appears, you load your next model and there you are (Figure 7).

Figure 7: Swiping to bring up a menu of bookmarks to change model.

3.3 Jump into Hyperspace Through Time

As well as changing to different models, in the virtual world you can be looking at a scanned model of a particular area and change to the exact same view of an older model scanned at an earlier time period. Once accurate models have been collected and archived it will be great to watch and measure buildings and other objects change over time. This adds a valuable historical perspective to data scanning. Imagine being able to walk around the Coliseum as it was when in its peak in Rome. If only the Romans had laser scanners.

3.4 Move Through Walls

In the real world, there are strict protocols and rules of physics, e.g. to get from upstairs to downstairs you must use the stairs or the lift. In the holoverse, you can also do it this way, but if you want to take a short cut and see what is below the floor, above the ceiling or on the other side of a wall, all you need to do is put your head through the wall and see if the model is complete. This is the beauty of the holoverse in that the wall is only a visual limit. In fact for certain 'user' experiences the holoverse developers are looking at ways to enforce the real world rules and stopping users passing through surfaces.

3.5 Change Scale

In the real world, our scale changes only slowly as we grow from child to adult. In the virtual world, you can be standing next to a tree and then with the selection of a menu item shrink down to the size of a mouse and look at the smaller part of the model from this viewpoint (Figure 8). Naturally, the model we are viewing requires sufficient density to provide views at the smaller scale. This can be a very powerful feature for viewing something in more detail.

Figure 8: Viewing the point cloud as a 3D map to pick a point to zoom into.

3.6 Measurements

In the virtual world, you can use the equivalent of a laser pointer to point at an object. By holding down a button and dragging the pointer away, a line can be seen in the air with the distance superimposed (Figure 9). It is this easy to take measurements in the virtual world without the need for a tape measure.

Figure 9: Taking a measurement in the holoverse.

4 GEOSPATIAL APPLICATIONS TODAY

4.1 Point Cloud Quality

If you are in the business of collecting point cloud data, there is no better tool for appreciating the quality of the data you are collecting than by immersing yourself in the dataset. Most point clouds look good from a distance. Terrestrial scans in particular look great when viewed from the viewpoint of the scan station. From this location, there is good point density of any objects near the scanner. The point density for distant objects (which are less important) is lower. From another viewpoint, however, it is clear that the point density is uneven and inconsistent.

When traversing through your data in the holoverse, these varying point densities are clearly seen and any laminations, poles not aligning or holes in the data become apparent very quickly. The holoverse is an excellent tool to visually inspect the accuracy, density and general quality of any point cloud data. Currently, many end-users prefer that vector data is extracted from point clouds so that it can be loaded into traditional CAD packages for design. The holoverse can be used to validate the quality of the extraction of these strings against the raw point cloud (Figure 10).

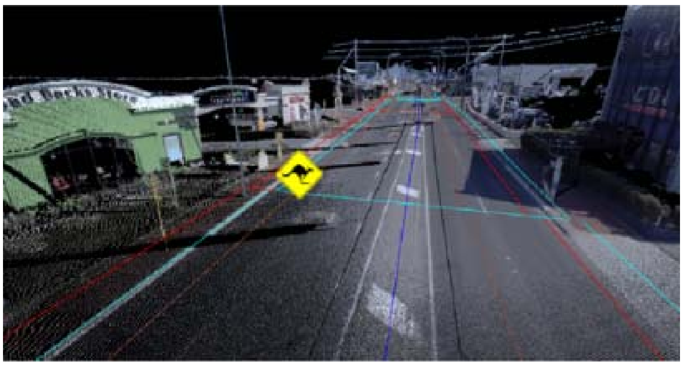

Figure 10: Example of line work being superimposed on the point cloud for validation.

4.2 Planning

An ideal application for the holoverse is visualisation and planning. The first real application for the holoverse was in a proposed development on the coast in Perth, Western Australia. The developers were interested in building a multi-story building along the coast and were naturally concerned with the opinions of the neighbouring residents. They were looking for a way to alleviate some of the unnecessary fears of the residents. They also wanted to provide an accurate view of the final structure to the councils, to enable them to make an informed decision that will be as fair as possible for all the stakeholders and the future of the area.

To facilitate this, the suburb was scanned from the air at a low density and also from the ground along the main streets to provide a very accurate point cloud of the area. The advantage of the low density aerial scan data was that it provided a good model of the views in the distance of the sand dunes, marina and distant houses. The high density mobile scan data provided the houses and balconies of the local residents. This enabled operators to view the impact of the proposed structure from the balconies of every resident in the area.

The proposed development was brought into the point cloud as a 3D model. The view could then be inspected with the model included and the model removed to fully evaluate the effect on each resident in the most realistic way possible (Figure 11). In this situation, the holoverse provided and ideal tool for both the council and the residents to view and analyse the visual impact of the proposed structure. These decisions are never easy, but using the holoverse provided everyone the best information available for the decision making process.

Figure 11: Super-imposing a building into a point cloud model.

4.3 Small Scale Planning

While large scale projects are obvious candidates for scanning and viewing in the holoverse, there are many small scale projects where the same benefit is obtained. A very common case is the development of a single resident property and concerns of the neighbour of shadowing, loss of views and the deterioration of the quality of life for the initial resident. Using scanned data in the holoverse, both the residents and council decision makers can not only see maps and plans of wall heights and roof lines but they can get the feel of walking in the final development. It is not hard to imagine that in the future every council responsible for such decisions will have a holoverse and the capability to collect data for such decisions. The aim is to ensure that at the very least decisions are made on real rather than perceived concerns (Figure 12).

Figure 12: Inspecting a bus stop.

5 THE USER EXPERIENCE

During the first 18 months of its use, the holoverse has changed significantly and we have had to learn and adapt our approach. Over this time, we have encountered some technical issues (e.g. poor tracking of the headset and projector replacement) but the system is slowly evolving into a more robust ‘consumer-level’ product.

From the first use of the holoverse, the most notable thing has been the ‘realness’ of the experience. When looking over the side of a 6-story building, one user accidently pushed the laser button knocking him off the edge of the building. Momentarily forgetting he could fly, the user gave out a small squeal. It is surprising that even though there are enough clues that the situation is not real (i.e. you can see the side walls) the brain is happy to accept what it is seeing as reality. During the last year, we have had a few hundred people visit the room. Approximately 95% come away excited from the experience. There is a small percentage that for some reason does not feel well or did not see 3D properly. It is easy to tell from the body language when someone really believes what they are seeing.

Many features of the holoverse have evolved over time. One of the challenges is moving the viewer around within the model – controlling both velocity and acceleration. Similar to the evolution of standard controls used to drive a car, a standard way of navigating a holoverse will evolve to allow anyone to easily navigate the virtual world. The first incarnation for speed control used a button and a fixed velocity that was set in a menu. However, it was soon discovered that some control over acceleration was required to fly and land like Superman. A recent mode added called ‘rocket mode’ enables high-speed flight where the ground tilts as the user banks to turn a corner. While at first it is confronting, with some use it seems powerfully natural. The system incorporates both bookmarks (to quickly remember and jump to different scenes) and also the ability to record and playback a route.

One current limitation is that the holoverse only supports one person at a time. This is a natural limitation due to the images shown on the walls being customised for the perspective of the one user’s location. However, development is underway to be able to connect multiple rooms so that two people in different rooms can be connected and traverse the same virtual world – similar to multi-player gaming. Connecting more than one person will be essential for gaming and training applications. A similar feature being considered is the ability to display the user experience on a screen outside the room. This allows external groups to share the user's experience (both visual and audio), making using the room a much more collaborative experience.

6 OTHER TECHNOLOGIES

The holoverse is not the only virtual reality product being developed by the wider community. There are many others. 3D glasses and helmets have been evolving for over 20 years and always seem to be on the cusp of a breakthrough. A myriad of devices have been on the market, and games developed for people interested in 3D gaming are always improving. There have been major acquisitions of companies with technology for headsets, indicating that the market considers the big breakthrough of this technology into the mainstream market is imminent.

It should be noted that the makers of headset systems are battling a different problem to that of the holoverse. With a headset, there is a small computer screen directly in front of each eye. The aim is to update these screens in such a way that the brain believes it is seeing the same view as if the user was really moving around in the virtual world. Similar to the holoverse, the device must also take into account the head and possibly eye movements of the user. However, with the headset, the screen must be updated immediately when the wearer moves their head at a suitable rate so as to convince the brain that the scene is real. Any lags in the update of the screen (even if only a few milliseconds) will only convince the wearer that they do not feel well.

The geometry of the holoverse is more forgiving in that the virtual world is being drawn on a wall several metres from the operator. If the wearer moves their head, the new view will need to adjust but the tolerances for error are considerably less. For both technologies, the mass market will not adopt them unless the average person can find the experience comfortable and believable. Headsets have many advantages in portability and cost over a holoverse and they will one day reach their objective. However, it should be noted that headset development may take longer as it is simply a more difficult problem that is being tackled and obscure issues with names like 'vergence-accommodation conflict' may take some time to resolve.

The other technology for virtual worlds is the standard 3D computer screen, again with some form of head tracking equipment. In some ways this is very similar to a holoverse and there are some very good products in both the geospatial and gaming worlds built around this technology already.

At present, the main difference between the holoverse technologies and these products is whether the software is using standard video card technology and showing textured polygon models or raw point cloud points. There is an extremely large and profitable industry built around the current technology. Grand Theft Auto is a good example of a video game built around a complete virtual world (Figure 13). There is already lots of activity in turning these types of virtual worlds into 3D games based on existing technologies that are well suited to the task. Naturally, both technologies will evolve, and time and market forces will eventually determine which technology will become the winner.

Figure 13: Screen shot from Grand Theft Auto video game.

7 THE FUTURE

Similar to the Global Positioning System (GPS) in the 1990s, surveyors were the first to use this new technology as they had one of the first applications that could justify the cost. While in the early days few outside of surveying and the geosciences knew or cared about this exciting satellite-based technology, few would have appreciated that 20 years later Global Navigation Satellite System (GNSS) technology would be built into every person's mobile phone along with a camera. Even fewer would have predicted the number of applications developed that required location devices or that there would be a trend called 'big data' where masses of information would be uploaded automatically from these devices for processing.

Today, the geospatial industry is the early mass user of point clouds and we are privileged to be the first to see and use this new holoverse technology. However, it is not too hard to see that over time geospatial users will become a smaller part of the pie chart. The gaming industry will clearly be a big user of this type of technology and it may even bring back the return of the gaming arcade that was lost to the home computer market of X boxes and play stations more than a decade ago. The new arcades would be full of holoverses and possibly rule for a time until the home holoverse eventually becomes the standard for modern living.

Why would you want a holoverse in your home? Shopping is one option. Imagine if rather than a webpage on your computer screen you could visit stores in the virtual world. You could walk around the show room and look at a car or boat in full 3D just as if you were there. Shopping, whether for clothes, appliances or even food, can all be better in 3D. Imagine floating down a virtual supermarket isle selecting items with your wand to fill up your virtual shopping basket. Home shopping is there now but the holoverse would provide a more natural interface.

Selling real estate is clearly a big market and well suited for virtual computer tours. Would it not be a better experience to go to a 'state-of-the-art' holoverse and without travelling view properties from all around your suburb, state, country or the world, and experience them as if you are actually there?

Just as nearly all industries have benefited from computers, industries such as medicine, architecture, real estate and construction will also benefit from the advent of the virtual world and holoverses. Each industry will naturally evolve their own custom applications to meet their needs.

One of the first industries that will benefit almost immediately will be in training and health and safety, particularly in mining and on oil and gas platform situations. There are many places that are difficult to experience and train for without being there. Imagine the power of being able to simulate these environments in minute detail so the user is fully aware of the environment, dangers and safety features before ever arriving on site. However, in reality, it is unlikely that we will know the full extent of how this technology will be used in the future. All we can say for sure is that it will be in 3D.

8 CONCLUDING REMARKS

The version of the holoverse discussed in this paper was implemented in March 2014 and has been evolving slowly with improvements in software and hardware ever since. Using the holoverse has been a great tool in evaluating the quality of point cloud data and also in communicating development and planning decisions today. While we are continuing to improve our point cloud collection and processing methods, the holoverse is currently a valuable tool in this process. The full list of applications for the holoverse in the future and the direction this technology will take are both unknown and limitless.

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