The rapid development of new Virtual Reality (VR) devices such as the Oculus Rift and Google Cardboard together with Augmented Reality (AR) applications such as 3Dplus (by the Finnish company advice) or gaming software such as Unity3D and Unreal Engine 4 raises the question of how we can use these new interfaces and applications to access our increasingly data-rich models. In this paper we will summarise the results of a joint international workshop where students explored the use of these new interfaces on existing models. During the course of the workshop, the students built their own VR environments to test spatial perception and then used different types of housing models with these interfaces to find out what kind of information inside those data rich models is best suited to be accessed using these new interfaces. The question will be if there is any added value - besides the novelty factor - in using these new devices in combination with old models. To give an extra dimension to the virtual nature of the workshop, students collaborated with some of the tutors primarily digitally using the virtual models and other online tools (Skype/Twitter/discussion boards). By having collaboration through the medium of the virtual interactive model as the core communication method, the amount, type and methods of presenting the information is tested and evaluated. This is work in progress and we had to experience several problems that we could not overcome in the available time.

**Keywords:** Urban Modelling, 3D Modelling, Virtual Worlds, City Modelling, Augmented Reality

**INTRODUCTION**

The range of digital models being created today varies a lot in terms of scale and complexity. At one end of the spectrum there are complete city models and complex BIM models whilst at the other end there are smaller individual buildings or components. The use of these different models vary a lot from static renderings to visualise the impact of certain design solutions to sophisticated 3D models for the use in CAVE environments. Originally, we wanted to make use of these models and try to access them using the new low-cost VR devices such as the Oculus rift and Google Cardboard. There are a lot of new devices developed using different technologies and there is currently a renewed interest in this area in the gaming industry. This is a big chance for architects and planners to find out how to make use of these devices for their own needs without having to invest into expensive infrastructure and complex software with a steep learning curve. Our intention was to
use a student workshop with architectural students with limited programming skills to find out if we can achieve get results within these limitations.

WHAT WE DID NOT DO, BUT WILL DO IN THE FUTURE

Originally, we wanted to test these systems using the existing static visibility studies of the surveying department of the city of Vienna as one of our case studies. This visibility studies are a good example of the successful implementation of 3D city models. Quite often the visibility of new projects in a traditional city - especially when they are of historic value and protected by Unesco regulations - are a crucial aspect, but even more so when important historic buildings and sights are affected. A famous example is the protected view from the lower Belvedere castle towards the upper Belvedere castle and the impact of the new developments in combination with the development of the main train station in Vienna. Previously, these implications could only be made visible to the public by outlining the static renderings or an animation of different views. Experts could also use expensive infrastructure like VR CAVES to access the model interactively; our idea was to use these new cheaper devices instead. It turned out that we could not test that in the limited available time within the structure of our courses. So we had to abandon this idea for the moment, but it is still high on our agenda. We still think that there is a huge potential for these devices to be used by architects and planners for themselves and for the whole process including the general public. By making visualisations easily accessible and interactive even for the general public it opens opportunities for a much more open and democratic planning process. We intend to follow this path in the future.

WHAT WE FINALLY DID

As mentioned above we had to shift our focus slightly to adapt to the limited time and a limited number of students. After a lot of discussion we decided to test the use of these devices using a simple but well known setting. So we decided that the students should use their own flats as one of the testing areas. As a starting point all of the students created a digital model of their own flat using SketchUp. The question was how they would experience a well known spatial setting in the "Virtual world". Additionally, we created the model of a Hong Kong flat because we wanted to find out how they would experience an "not so well known" but similar - in terms of space - setting. They would use Unreal Engine 4 to experience these models with the Oculus Rift and Google Cardboard devices and we also wanted to compare it in a CAVE environment. It turned out that even in this setting we had major problems and we were not able to overcome all of them in the available time for this report.

As architects, we are primarily interested in the use of VR in a design environment, so for the workshop we concentrated on looking at the accurate perception of space in a VR environment with the intention of using the students own smartphones in either Google Cardboard and Oculus Rift or one of the other low cost alternatives.

THE WORKSHOP

The workshop was taken by masters and undergraduate students and ran in two distinct phases and locations between students at TU Graz (Austria) and the University of Liverpool (UK). During the first phase in Graz students modelled their own flats using SketchUp and became familiar with Unreal with the help of a tutor from Liverpool University. During the second phase in Liverpool, students developed their models further and then tested them using the VR equipment They compared this with the Hong Kong flat and completed a questionnaire with recorded their experience and accuracy of spatial perception.

THE PROBLEMS

We experienced a significant number of problems (see below) and valuable lessons were learnt from these. Firstly, whilst SketchUp is an excellent and easy to use modeller for architectural use, it can give
significant problems in relation to surface and materials that do not necessarily occur when using other software such as Cinema4D, Rhino, 3D Studio Max or Maya. Whilst these problems did not prevent the import of the geometry, problems occurred with lighting and materials to the extent that the models were not fully useable for VR. The problems arise out of the lack of texture mapping options available during either creation or export from SketchUp. This is not so much a reflection on SketchUp in that as a 'simple to use' modeller, it simply does not have the UV mapping tools that are integral in software designed primarily for 3D creation and rendering. The end result of this was that students were unable to build smartphone versions as originally planned. Subsequent research showed that using 3D data translation software such as NuGraf would alleviate the problems and we are currently investigating the use of this kind of software to overcome our main problems.

Secondly, the approach to modelling for interactive VR environments is very different than that required for static rendering or fixed animation. Whilst students were made aware of this, it requires a radically different approach and mind-set to actively reduce the polygon count to enable smaller and more easily interactive models to be created. It is only natural that students insert readymade models from the Warehouse to give scale and 'realism.' The problem is that these models are of variable quality, often converted from other software and, whilst they work for their original purpose, are largely not suitable for a VR environment. The integration of this into a VR based design phase requires a different approach to modelling and one with needs more research.

Students also used Unity3D to create a version of their model for viewing on the Oculus Rift. This was easier for some of the more technically orientated and experienced students, but used the same basic SketchUp models as were used in Unreal.

THE HONG KONG FLAT
As already mentioned we wanted the students to test a flat with which they were completely unfamiliar as well. The floor plan of the flat that we used is in Hong Kong, located in the Beaumont Tower 2 in Tseung Kwan O (New Territories). The flat itself is a typical Hong Kong flat within an exemplary urban housing project in Hong Kong and for this purpose is a suitable subject for this research. One of our researchers had a first hand experience of the flat and even interviewed the owners of the flat before he build the model. The interior of the 3D model is modeled as being indicative for the type of the flat type rather than an accurate representation.

THE TESTING
Students were asked to spend about five minutes viewing each flat, walking freely around (with no required path) and visiting each room in turn. After they had firstly viewed their own flat, and then the LOHAS model (see figure 1), students were asked to complete a questionnaire which asked them to estimate key dimensions of rooms in the flat (floor area/height etc), They were also asked whether it was larger or smaller than their own flat. The survey finished with some general questions about their experience and what more, in their opinion would be needed to get a better impression of the spatial qualities (e.g. more details, more realistic visual information etc)

Several interesting observations were made during the actual testing. After an initial short acclimatisation period, the students became immersed in the environments despite the apparent lack of realism caused in some models by little or no materials and inaccurate lighting. In fact some commented that the almost conceptual, 'white card' rendering style used for everything aided sense of presence.

Students also had the opportunity to view a chosen model on a high-end power wall environment (figure 2) at the University's Virtual Engineering Centre where an almost 1:1 stereoscopic projected image allowed them to walk relatively freely at a real scale. Whilst the sheer size and resolution of this were impressive, the single direction view did not give the range of opportunities afforded by the 360degree
SURVEY RESULTS AND DISCUSSION
From the survey, a number of conclusions can be derived. All the results are rather limited in significance because of the limited number of students. Still in some aspects, there is a significant consensus.

Amongst the most notable of these were that there was clear consensus that ...
- Viewing in a VR system helped to understand the design better (94%)
- Spatial perception was much clearer and closer to reality than a 3D CAD model (94%)
- They could easily orientate themselves easily in the flats (90%)

The question about 'atmosphere' elicited a mixed response which can be almost certainly attributed to the rather surreal nature of the 'white card' renderings of most of the flats and the simplistic materials of the Hong Kong model.

When asked to estimate the size of the unknown LOHAS flat in comparison to their own flat, there was a fairly close correlation in the estimated areas (e.g. the size of the living room varied from 15 - 20 sq m, actual size - 18 sq m) Not unsurprisingly, the participants thought that the furniture etc. was of great help in estimating the sizes.

When it came to what would be of assistance in improving the spatial perception, more detail, colour and materials where noted. Interestingly, only one respondent noted that a more natural navigation (e.g. walking) would help the experience.

One of the interesting observations noticeable when watching the students interacting with their models was the naturalness with which they looked around which was in a marked contrast to the slightly awkward keyboard based navigation. Without conscious effort, they looked on top of and underneath shelves and peeked around corners into rooms. It was only when they were specifically asked about this that they were aware of it. This indicates a very high degree of immersion (or presence) in the environment. Developments such as the Leap Motion which enables a more natural interaction and the ease with which graphical interfaces can be created in Unity3D/Unreal suggest a more natural navigation system will further enhance the degree of presence and user experiences.

SketchUp has become the de facto choice for student when designing digitally in 3D. Its reduced toolset and ease of navigation means that it is easily mastered. The same cannot be said for the current VR design process which is, at best, a 3 or 4 stage process (Sketchup > Unity3D/Unreal > edit > export/view) which is not conducive to a good, interactive design environment. There have been attempts over the years to develop a designed based VR, but the time is now ripe, and technology mature enough, for a genuinely VR based immersive design environment.
CONCLUSIONS

With the advent of more usable and readily available gaming software, the creation of VR models has moved from the realm of the dedicated VR professional designer/artist/programmer to being accessible to anyone with a powerful enough computer. Whereas Unity3D is long established software aimed at the professional market (with a price to match), the release of Unreal Engine 4 as free professional level game development software which handles VR on a range of devices was a welcome development. With increasing numbers of smartphones, the development of more accessible interfaces is a very promising development. As it turned out, there are still a lot of problems to be solved to make the vision of an easy accessible and low cost VR tool that can be used in the design process a reality. But because of the rapid developments in the field caused by the interest of the gaming industry there is a great chance that it will not take long to establish an easy to use workflow for the use of these devices...it is our challenge to be part of these developments. At the moment we are still working with the students and we plan to have an extended group of students to work on the project in the future.

On a city scale we can see that city departments claim that the implementation and the use of 3D data is crucial in a modern city and becomes more and more important for the daily work. Previous work (Knight and Brown, 2003) shows that a natural navigation method significantly enhances the sense of immersion that participants experience and new interface devices such as Google Cardboard and the Oculus Rift (together with their associated applications) have a great potential to give a whole range of new possibilities for accessing the data at very low cost and comparatively little additional effort - at least that can be expected in the near future.

Less 'Augmented Reality', more 'Augmented Information'.

APPENDIX 1: THE QUESTIONNAIRE

1. Perception of planners

The questionnaire consists of two parts which are targeting on gaining different insights. In the first part, we will evaluate student’s findings after immersion virtually into their own apartment. In the second part we look into the spatial perception of the Lohas project. For all statements below please answer with 1-5 (Legend: 1 strongly agree, 2 agree, 3 neutral, 4 disagree, 5 strongly disagree)

Please open the app of your self-provided floor plan with your VR device - Smartphone and VR HMD mount (virtual reality head-mounted display mount) - and put it on. Walk around freely and observe your apartment carefully. Please walk into every room and look around.

You have created a 3D model of it and you are living in the real apartment. Would you agree to the following statements:

• Spatial perception is much clearer and closer to reality in the VR model - compared to the 3D CAD model.
• Observing the design via VR-device helps to understand the design better.
• The VR observation of space is no help at all.
• I can easily orient myself as in the real apartment
• I get a good notion of the real apartment and about its atmosphere

2. LOHAS apartment

Please open the file/app of the LOHAS floor plan with your VR device - Smartphone and VR HMD mount (virtual reality head-mounted display mount) - and put it on. Walk around freely and try to observe and to internalise the whole apartment for maximum 5 minutes. Please walk into every room and look around. You should use the whole 5 minutes to get comparable results.

After the virtual walk through please answer following questions in chronological order:

A. Testing of perception (to get an idea how close
For these questions you should know the size of one apartment/house you used to live in/spent a great deal of time in (don't answer if you do not have a precise idea of the living space size.)

- What is the size of your reference apartment?
- How much bigger/smaller is your reference apartment? (allowed are factors such as "1.5 times bigger" or percentage e.g. 150%)

**Further estimations**
Please try always to estimate as good as possible the room size/requested dimension. If you do not remember e.g. the requested room or get confused with them please do not answer the question.

- What is the room height? (Remark: the whole apartment has the same room height)
- What is the size of the living room?
- What is the size of the bathroom?
- What is the size of the kitchen?
- What is the size of the bedroom? (consider, that the cabinet belongs to the apartment and has a depth of 58 cm)
- What is the total size of the living area in square metre/square feet.

**Immersion and Benefits**

- Through the use of VR, it was easy to grasp the layout of the apartment.
- After the walk through, I have a good impression of the apartment.
- I have a good spatial perception.
- I think the virtual walk through the apartment makes it easier for me to understand/grasp the floor plan.

Scenario: You are looking for an apartment to live in, and the building is not yet built. Normally that would mean you rely on renderings (visualisations) and floor plans for interpreting potential space.

- In this Scenario the VR model can facilitate better understanding of the potential built space and can also add value in decision making.
- The VR model can help me to understand the internal order, daily routine and circulation.

**C. Improvements**
What helped you to scale the dimensions in perceiving the spaces?
For the examples below, please comment them with 1-5 (Legend: 1 strongly agree, 2 agree, 3 neutral, 4 disagree, 5 strongly disagree)

- Proportions of room heights and width
- Furniture
- Doors
- I would need more details (e.g. furniture and fixtures) to grasp the size of the apartment.
- I would need to see colours and materials of the interior to grasp the size of the apartment.
- I would need a more realistic visual information to grasp the size of the apartment.
- I would need to physically walk through the virtual reality to get a better understanding of the apartment size.
- I would need a higher display resolution to achieve a greater sense of immersion. (Please name the device)
- I would need a device with less lag. (Please name the device)

**REFERENCES**
Knight, MW and Brown, AGP 2003 'nAVRgate X, A Naturalistic Navigation Metaphor for Large Scale Virtual Environments', *Proceedings of the 8th International Conference on Computer Aided Architectural Design Research in Asia*, Faculty of Architecture, Rangsit University, Bangkok, Thailand, pp. 625-630