MAKING DIGITAL ELEVATION MODELS ACCESSIBLE, COMPREHENSIBLE, AND ENGAGING THROUGH REAL-TIME VISUALIZATION

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In this paper, we present our initial experiments with the new high-quality digital elevation model, "Danmarks Højdemodel-2015" (DHM) exposed as an interactive 3D visualization on web and in virtual reality. We argue that such data has great opportunities to spawn new business and new insight for the individual citizen if it is accessible, comprehensible and engaging.

Keywords: WebGL, Visualization, DHM

INTRODUCTION

In recent years, a large amount of spatial has been made available as open data (Regeringen and KL, 2012). The data is of ever-increasing quality and resolution, but the true value comes from usage. The authors are fascinated by the idea of interactive visualization pushing the possibilities within current hardware and software. We believe this can create new business opportunities for companies offering new experiences and new knowledge from data.

In this paper, we give an introduction to some of our experiments with the new height model of Denmark (DHM) (The Danish Geodata Agency, 2015), and the possibilities that arise with fully interactive 3D available in modern web browsers and virtual reality hardware.

Data in itself is tedious to work with – and cannot do anything in itself. The larger the data set, the more difficult it becomes for human beings to make sense of anything at all. On top of that, many software packages suffer extreme performance penalties when data does not fit into memory. The software slowdown can partially be alleviated by constructing sophisticated algorithms that scale better with regard to input/output (I/O)

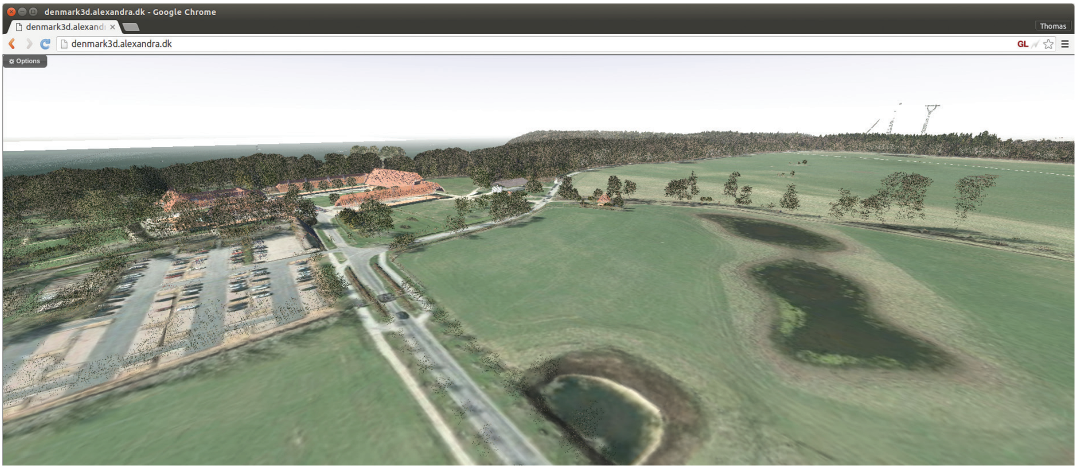

Figure 1. Denmark's Height Model in 3D on a webpage (http://Denmark3D.alexandra.dk)

operations – one variant being the streaming algorithms used in the present work. When the questions that need to be answered through data queries are known, the data can be crunched – i.e., pre-processed in a way so that answers to the given and known types of questions can be given relatively quickly. However, there are many situations in which the question is not clear or known – and where the human observer needs to inspect, observe and experience the data in context. This is especially true in situations with strong visual and emotional aspects, for instance "How does that wind turbine affect my home?"

We argue that those personal perspectives and the exploration of data needed can be achieved if data is available as interactive 3D. We believe that those visualizations should ideally be made easily accessible through simple HTML5 web pages – and that further immersion into full virtual reality allows users to fully grasp scale and impact of (changes in) reality.

IS DHM DATA FOR EVERYONE?

We firmly believe that data such as DHM has a basic level of usage for anyone, ranging from "let's find our house" to "let's find new business opportunities". Even though the data is available, it is not readily accessible, engaging and comprehensible for the broad audience.

Making data accessible

To be fair, DHM is actually easily accessible for someone with a bit of a technical background, but can be almost impossible for a novice within IT. Users need to be registered, data downloaded, new hard disk drives bought, data downloaded again, software found that can read data, software installed, and finally looking at GIS related functionality without knowing what to do.

There could be so many opportunities for the individual citizen to understand or comment on larger decisions of infrastructure within the context of their own home, city and region. Examples could be wind turbine projects, city planning, highway construction, and geo-located statistical data.

Most people are used to simply clicking on a new link that someone sent through an e-mail, or launch that smartphone app that others recommend. That is why we decided that DHM should be made easily accessible through a simple web page, see Figure 1. Visualizing 3D within the browser as part of a web page has been made possible recently through the WebGL standard that enjoys widespread support in all major browsers – even on mobile devices such as Android and iOS. WebGL allows an application programmer to access the hardware accelerated graphics card through an API

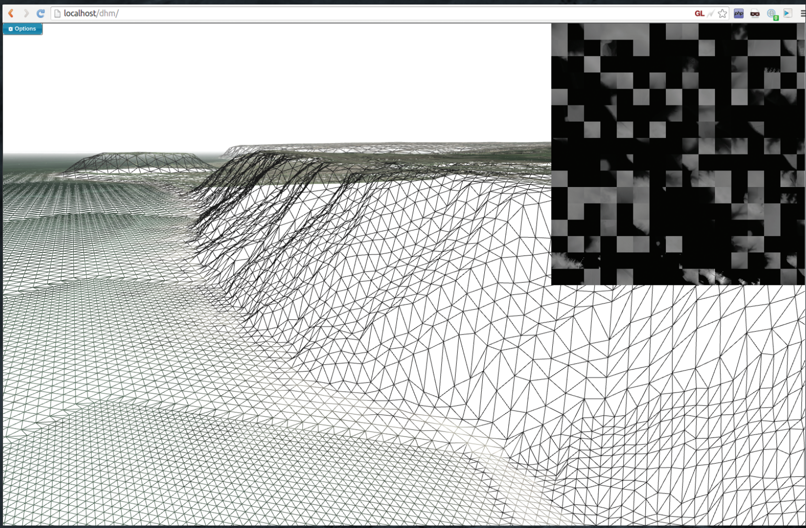

Figure 2. Caching and Level of Detail in rendering. The upper right corner shows the height map tiles that are streamed into the graphics card memory.

in javascript. And, it allows us to deliver an experience close to that of a desktop program, with the added benefit that no application has to be installed or updated, and data can be loaded on-the-fly without requiring huge datasets to be downloaded manually.

Naturally, the large amount of data is still an issue that needs to be addressed, and high performance is still a challenge to reach. The main problem is that the total amount of data is by far too large to fit in both system memory and graphics card memory. For example, a height map of Denmark (approximately 45.000 km2) with a pixel density of 2500*2500 km-2 stored in 4-byte floating-point format requires around one terabyte of memory. However, it is of course not necessary to store the full resolution map of the whole country in order to create highly detailed terrain rendering locally.

Our solution exploits this fact to stream in chunks of the height map in a level of detail depending on what can be seen at the current zoom level. Figure 2 shows a wireframe model of the geometry used for terrain rendering. Notice that the mesh resolution varies with the distance from the observer. The advantage of this technique is that the height map is only needed at full resolution in a small region close to the camera position, while the vast majority of the visible terrain can be rendered with a much lower resolution without affecting the final image quality. When the camera moves through the world, we continuously stream in new high-resolution data on demand. The height map data is arranged in a standard Web Map Tile Service layout which makes it easy to request a chunk of data as a map tile at a certain level of detail. The data tiles that have been streamed in are then stored in graphics card memory in a large unordered pool as shown in the top right corner of Figure 2. The main task of the rendering algorithm is then to keep track of where each tile is located in the pool and to fetch height data from the correct tile, depending on world position and level of detail (Mittring, 2008).

Making data comprehensible

Visualizing data is sometimes thought of as a direct mapping of spatial data to 3D projections – without any intermediate “manipulation”. Nothing could be further from the truth. Artistic and technical choices are at the heart of visualization

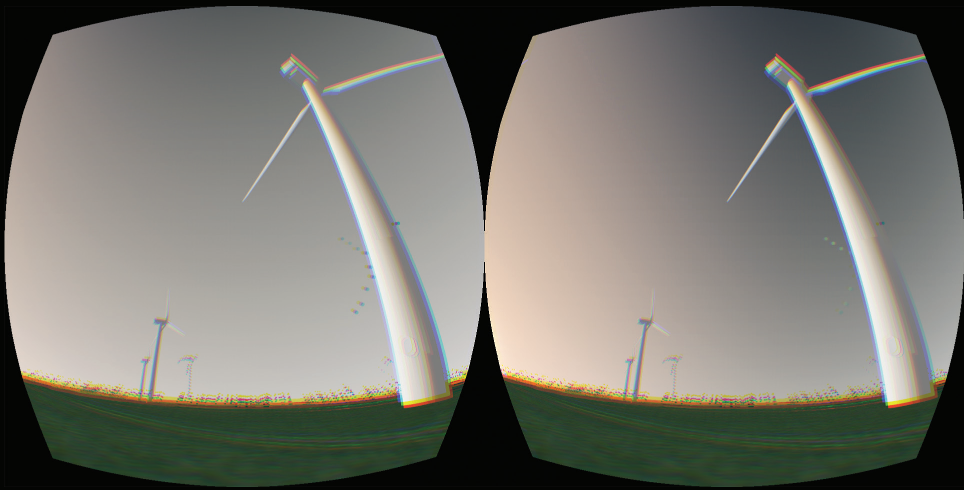

Figure 3. The image shows stereoscopic rendering for each eye. When viewed through the lenses of a VR helmet, sizes, distances and colors will appear as if they were real.

and always include a level of interpretation and presentation. One such set of choices concerns the more or less realistic shading of surfaces arising from reflections, materials and light. We argue that this is one important aspect of giving the user the illusion of seeing something real – which then becomes comprehensible to him or her.

Ideally, we would like the users to be fully immersed in the virtual environment to comprehend the environment and really be able to feel the visual impact and size of large changes in buildings, nature and infrastructure. An important upcoming trend, driven by the computer game industry, is virtual reality (VR) where users see a virtual environment through head mounted glasses. The first VR equipment was built by Ivan Sutherland in the 60's, but was never really successful due to severe limitations in display technology. Since the successful Kickstarter of Oculus VR in 2012 and the later acquisition by Facebook in 2014, the field has been re-booted with new promises of total immersion in photorealistic virtual environments. As computer graphics geeks we finally believe the hype; the new generation of VR has the necessary low latency, lightweight headset, and wide field of view in a high resolution to realize a believable digital world. Consequently, we also ported our DHM visualization to the Oculus VR.

Making data engaging

To engage users, they need to see, explore and experience things that matter to them. One such thing is the construction of wind turbines near one's home. We did a prototype utilizing the DHM dataset to visualize the impact of a wind turbine construction for the individual citizen, see Figure 3.

This is one case where VR has a great potential impact beyond images, videos, and interactive applications. No screen can give the impression of being there, but VR can. VR allows the user to judge true size and distance – and can present the users with scenarios that can otherwise only be imagined. Thus, we believe that digital modelling of proposed constructions combined with the DHM data and VR can be a useful platform for public evaluation of environmental impact assessments. A key challenge in the widespread use of VR is that users are required to purchase head-mounted displays. These are expected to be adopted widely by gamers but probably not by the average consumer. There are, however, several low cost products available today, e.g. Google Cardboard and Samsung Gear VR, that transform a regular smartphone into a VR system. Thus, the target audience with access to VR equipment can be expanded significantly with such products.

CONCLUSION & FUTURE WORK

Our current VR visualization of the DHM dataset is a stand-alone application, not integrated with the web-based WebGL visualization. A key issue is the current lack of support for VR in browsers. A new standard, WebVR, is available in nightly/experimental builds of Firefox and Chrome and suggests that we might have an easily accessible VR platform in the very near future.

Our recommendations for working further with the DHM data are to adopt web-based visualizations as a means to make it easily accessible for people to explore this impressive dataset – and further, to empower both private citizens and businesses with the ability to utilize the dataset as a canvas for many other applications. We also recommend embracing truly interactive applications with real-time feedback made possible through techniques such as the those we have described here, and not accept the performance of sluggish desktop applications that try to import gigabytes of data for presentation. Finally, we suggest that Virtual Reality may hold unexplored opportunities to present "larger-than-life" scenarios in training, simulation and construction – and that visual effects from computer games can be embraced as very effective means of visual communication.

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