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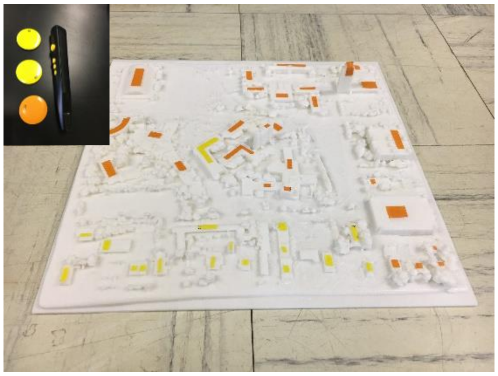
3D Printed Maps for People with Visual Impairments: Final Report

Geography and cartography can be viewed as a visual field, making use of sight to build a cognitive map of our environment and begin to understand complex spatial patterns. As a result, there is a lack of proper systems that allow for those with visual impairments to learn about the world around them through an intuitive and immersive experience. To do so, such a system would need to make use of both tactile and audio feedback methods; both of which are senses those with visual impairments rely upon to navigate. Our research sought to create such a system, and through implementations of various mapping systems, we feel that we have been able to do just that.

The foundation for our systems were 3D printed maps. 3D models of campus were created using photogrammetric techniques and web-services that extracted information from open-source maps such as OpenStreetMaps. These models could then be 3D printed using the 3D printer housed in our lab to create ~260mm^2 map tiles. These tiles could then be joined adjacent to each other to form a complete map of the NIU campus. The map tiles produced using photogrammetric techniques depict the environment exactly as we see it, even including trees. The other form of map tile contained generalized features, however this included roads, sidewalks, and other paths that were raised from the surface. This allows the user to trace a path from one building to another. Now that the map tiles had been carefully crafted, we were then ready to begin implementing different methods all with the same goal in mind.

The first implementation method made use of the PenFriend system. It consists of a pen-shaped device that has a small camera where the ink end of the pen would normally reside. This system made use of stickers that contained a repeating dot sequence, which allowed the user to record personal messages to their device based on the selected sticker. We cut these stickers to match the shapes of each building for our project area, then recorded information including the building name, its function, and nearby buildings (see image at left). This method was simple, easy to use, and the actual device had been developed with the needs of the visually impaired in mind. However, serious limitations were realized, the biggest being that information is stored locally on each device. This meant that if we wanted to create a fully functioning system that everybody could make use of, we would have to record information onto each device individually. Also, we wanted a system that would not rely on raw human input, such as audio recordings, to supply information to the end user. This need for richer information extracting abilities led us to the next method of implementation.



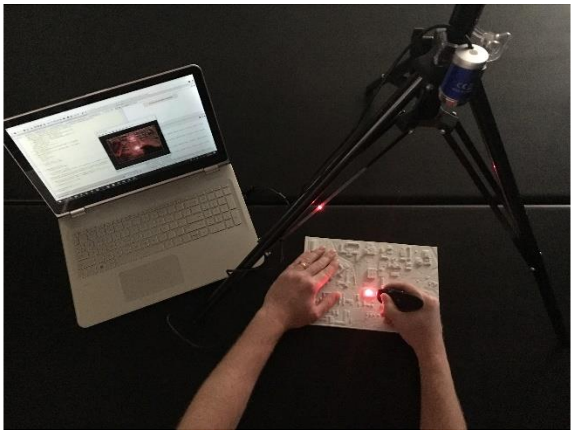
The second method we sought to implement expanded on the concept of placing labels on each building, serving as a unique identifier that can be linked to custom-tailored information. QR codes have been around for over a decade, and are becoming an increasingly familiar sight. They can be found, for example, on brochures or product literature for companies, serving as a link from the physical world to the digital world. In a general sense, QR codes consist of a unique pattern of pixels (see bottom-right image) that are scanned using a smartphone camera. The camera can interpret this pattern, which then links the user to various forms of media, including text, images, and websites. The ability to link to websites was appealing to us for various reason. For one, websites are accessible by anybody in the world with a working internet connection. By creating a system that makes use of the internet, the product will allow everybody

to use it. Also, websites can contain a wide array of embedded information, including pictures, text, videos, and even audio.

I created a website that could be of use to everybody. The key component of the website is its ability to read aloud to the user information about the scanned building. Furthermore, this is done without needing to click any button on the screen; it triggers automatically upon loading the page. The website also featured a transcript of the audio recording, an image of the building, and an embedded map from OpenStreetMap.

While this method proved to be extremely more versatile than the PenFriend system, it too came with its own drawbacks. Once the codes were scanned, the web page took over and worked great. However, the issue comes with scanning the code. For one, to make use of the system the user must have a smartphone or other smart-device with the ability to read QR codes. While many individuals today have such technology, there are still those that do not, and this can restrict access to our device. Also, and perhaps more troubling, is the tactile disconnect that occurs when the user finds a building they would like information for, but then must break that connection to get their smartphone, open the camera, and have to find the building all over again. The tactile experience is the foundation of our research, and if the connection between the map surface and the users finger is broken, then the information chain is also broken. As a result, we wanted to explore a final implementation method that made use of both the simple nature and intuitiveness of the PenFriend system, but also the information extracting ability of the QR code system as well.

The resulting method was the most complex to develop, however we believe it to be the best method to help those with visual impairments build a cognitive map of the world around them. At the same time, it is a low-cost solution that only requires a computer (to run the code),



an inexpensive webcam, and a laser pointing device. The user explores the 3D map surface to first build a general concept of what that specific area may look like. Once they are ready, and have found a building they would like information on, they point the laser at said building (image at right). Our system sees this laser point in a simple x-y coordinate system, and then converts this to geographic coordinates. These geographic coordinates (latitude and longitude) can then be used to extract information from OpenStreetMap (OSM). OpenStreetMap can be viewed as a Wikipedia version of services such as Google Maps. Individuals can create and edit features in OSM, and even go so far as to specify detailed information about features that can of great use to those with visual impairments. The include but are not limited to surface type, if the crosswalks have an audio countdown, and if the street corners have grooved/bumped surfaces. When a user of our camera-based system points the laser at a specific building, it will first say the name of the building. If the user would like to know more about the building, they can point the laser at the building again and it can read off all associated information, including that which is of great use to the visually impaired.

We believe that this final product best meets our goals created when the research project was first envisioned. It creates and immersive, intuitive, and also inexpensive means in which the visually impaired can begin to better understand their environment around them, and potentially even understand complex spatial patterns that were once thought only to be possible by use of conventional cartographic techniques. I believe that we explored the above described methods in the most effective and efficient way possible, and we were indeed able to create a system that we had envisioned at the beginning of the semester. We were able to build upon and combine existing technology in a way that has not yet been explored. This research has not met its ceiling, and we already have future goals that focus on removing the laser-pointer altogether, and just rely on the simple pointing at buildings on the map surface. I believe that this research has created a new, solid foundation that we, and hopefully others, can build upon and expand upon the current capabilities of the system.

The research that funding through the Student Engagement Fund has allowed me to conduct along with Dr. Thomas Pingel has truly been one of the best experiences I have had during my time at Northern Illinois University. It has had a profound impact on me both academically and personally. I have come out of this research project more confident in not only my crtical thinking and problem solving skills, but time management as well. I know that going forward the oppurtunity that the SEF allowed me to have has more than prepared me for any challenges I may face once I complete my degree at NIU. It was an incredible experience that only those who too have been fortunate enough to have their research project funded through the SEF will be able to truly understand the lasting impact it will have on their lives.