I. Immersive and Interactive Virtual Geographic Environments

A. The Earth's geography is wide and diverse, and humans occupy almost every kind of environment – and we seek more, exploring further into the expanse of space and in the depths of our own planet. As technology continues to improve and more efficient techniques of modeling and designing are discovered, more and more data can be visualized in a better way, which provides for us a better way to solve more complex problems. As such, this project is proposed to create a new generation of geographic analysis tools in order to better understand the geology around us and understand its science at a deeper level. Migrating from the usual topological 2-dimensional (approximate) representations, this new generation of visualizations will pursue a fully interactive and very precise 3-dimensional maps, fully textured and traversable for the sake of easier presentation – all in real-time. It would be substantially easier to depict a landscape's elevation and depth, such that problems that were not obvious before now become exposed. Furthermore, this kind of visualization allows users to view the same landscape from several different angles, thus boosting both engineering capability and artistic creativity when it comes to design. This will be especially true when the project incorporates Virtual Reality as a feature, thus further expanding its accessibility. Users would be able to walk around in the virtually created environment, and quite literally get a first-hand view of what they are walking into. This opens the door for a wide variety of applications such as landscaping, construction, and gaming.

B. To successfully complete this project, very efficient data collection algorithms as well as a deep understanding of the graphical pipeline need to be used given the vast amount of data that needs to be rendered. Given the wide array of devices that exist, this project will need to be developed in such a way that all of them (or at least those that the customers will use) will be able to run the program, without sacrificing speed or convenience. The advantage of this project is that the geological data is already previously made and does not have to be generated in real-time, which can be very time-consuming. As such, most of the focus will generally be on efficiently accessing the data.

C. Because of the vast amount of data that must be rendered in real-time, the most obvious design constraint would be graphics processing power and speed. For this project to be effective, real-time detailed renderings are imperative, and so its users must have access to high-end computers or mobile devices that stay up to date with most up-to-date graphical and processing advancements. However, given that not all devices are capable of updating so quickly, doing so will limit the number of devices this project can run on. As such, the design of this project will have to balance speed and accessibility - between using the more exclusive up-to-date features or using the more generally stable slower features.

D. To complete this project, developers must be proficient in object-oriented languages such as C++ and C#, as well as graphics or game engines such as Unreal Engine or Unity. The more skill coming into the project the better, but as long as the developers have a good foundation in these things then acquiring the required skills will not be a problem at all. Furthermore, they will need to have access to high-end desktops or laptops that can easily run such graphics or game engines and be able to render vast amounts of data without a significant decrease in framerate. To expand the project into Virtual Reality, appropriate headsets and gear will need to be used for adequate testing as well. However, this will probably be the last thing developed, as the priorities of this project is being able to render and access geological maps in real-time. Once this is accomplished, delving into more advanced features such as VR will be done. Moreover, during the final stages of the project, developers will need to have access to a wide array of devices in order to test out its accessibility and confirm that the intended customers will be able to use it.

II. Develop Software for a Virtual Video Studio

A. As technology continues to improve with more powerful devices and faster algorithms, many aspects of the technological world are opening more and more doors with regards to how data is visualized. As such, this project aims to further develop and advance one of these ideas by developing a new software aimed at making easier the process of shooting scenes for movies and shows in a completely virtual environment - such as with the new show *The Mandalorian*. Most of its scenes' environments are almost entirely digitally generated, and yet most of this show's watchers would never be able to tell the difference. Unfortunately, in the age of COVID-19, everyone's ability to move about freely to their work has been greatly diminished, thus limited work on such new ideas. But luckily for software developers and computer scientists, such innovation always has its doors open and they can create content for the rest of the world from the comfort of their own homes. This project is no exception, and developers will spend this year using graphics engines and artificial intelligence to create such gorgeous scenes that even an amateur videographer can produce content as if they are on a professional set. Not only that, but developers will have access to the OSU lab with everything they need: high-end computers, camera, microphones, backgrounds, lighting, and more – all for the purpose of developing a virtual studio that can create such digitally generated environments.

B. To successfully complete this project, very efficient data collection algorithms as well as a deep understanding of the graphical pipeline need to be used given the vast amount of data that needs to be rendered. Given that detailed virtual environments need to render an unimaginable amount of data (which requires a lot of power), this project will need to be developed in such a way that it would be able to run smoothly on a wide variety of devices (or at least those that the customers will use), and sacrifice the least amount of speed or convenience. The advantage of this project is that an artificial intelligence system will be taking care of the graphical heavy lifting in generating the virtual environment, and so the focus of the developers will be managing and visualizing the data the it creates. Furthermore, developers will need access to high end cameras and other recording equipment in order to train the artificial intelligence to recognize how to add real objects into a virtual environment.

C. Because of the vast amount of data that must be rendered in real-time, the most obvious design constraint would be graphics processing power and speed. It is imperative that the renderings are as realistic as possible for this project to be effective, and so its users must have access to high-end computers that stay up to date with most up-to-date graphical and processing advancements. However, given that not all devices are capable of updating so quickly, doing so will limit the number of devices this project can run on. As such, the design of this project will have to balance speed and accessibility - between using the more exclusive up-to-date features or using the more generally stable slower features. Given that other expensive equipment is required to fully take advantage of the software, it is likely that better features will be prioritized over accessibility.

D. To complete this project, developers must have some prior experience in software development in some way, as well as the ability to work well both independently and in a team environment. The more experience coming into the project the better, but as long as developers have a good foundation in these things learning the required material will not be a problem at all. Preferred qualifications include experience in videography, 3D graphics, and using graphics or game engines (such as Unreal Engine). Furthermore, the developers will need to have access to high-end desktops or laptops that can easily run such graphics or game engines and be able to render vast amounts of data without a significant decrease in rendering time. To fully take advantage of designing this project, they will also need access to common equipment used by videographers (such as cameras and backgrounds) so that they can best tailor the software to their needs.

III. Generation of high density point clouds from moving stereo cameras

A. The Earth's geography is wide and diverse, and humans occupy almost every kind of environment – and we seek more, exploring further into the expanse of space and in the depths of our own planet. As technology continues to improve and more efficient techniques of modeling and designing are discovered, more and more data can be visualized in a better way, which provides for us a better way to solve more complex problems. However, with most things in the realm of engineering, there are usually sacrifices engineers have to make depending on their target. With data handling in computer science, the battle is usually between speed and completeness. With drafting an architectural design, the battle can be between readability and a complete visualization of all the features. And with the realm of forestry, this is no exception: the measurements used for collecting forest inventory can either be accurate but slow (and expensive) or vice versa, depending on what kind of equipment one has access to. However, given that better algorithms are being created that improve the conversion from a 2-dimensional image to a 3-dimensional object, it has become a more realistic possibility to use less expensive cameras to generate better quality models. As such, this project aims to combines the best of both worlds: creating a software that is accurate and runs in real-time, producing photogrammetric point clouds. Furthermore, students will be responsible for building the two cameras that will be taking the pictures, thus applying skills in both computer science and mechanical engineering.

B. To successfully complete this project, very efficient data collection algorithms as well as a deep understanding of the photogrammetry pipeline need to be used given the vast amount of camera data that needs to be organized and converted. Photogrammetry algorithms are generally very slow, but they generally do not require a lot of power. As such, it would be simple to create an effective software that converts a set of images into a 3-dimensional object. However, given that the goal of this project is to combine both high speed and density, devices with high capacities for power must be used – thus limiting the amount of devices that will be able to successfully run the program.

C. Due to the vast amount of data that must be managed in a short time, the most obvious constraint to this project would be processing power and speed. It is imperative that adequately detailed point-clouds are generated in a short time for this project to be effective, and so its users must have access to high-end computers have the high amounts of RAM and powerful CPU's installed.

D. While there are no explicit qualifications for this project, it is clear that the more skill a student has coming into this project, the better – not to mention any basic skills that come with building electrical machines and software development. To complete this project, students will probably want to be proficient in object-oriented languages such as C and C++, as well as having a good handle on data structures and photogrammetry algorithms. Furthermore, they will need to have access to high-end desktops or laptops that can process vast amounts of information without over-exerting the machine's internal hardware. As for the camera creation, students will need to have access to an adequate 3D printer that can print strong models, as well as a good understanding for how cameras work in order to be able to create one from scratch. Lastly, they will need access to a forest or some adequate location in order to test out their equipment and tailor the software to their users' needs.