AUGMENTED REALITY IN EDUCATION AND REMOTE SENSING

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ABSTRACT

Augmented Reality (AR) is a technology that has attracted a lot of attention in recent times, especially, after PokemonGo and quite recently with the gaining popularity of metaverse. AR is not a new technology but its development to maturity has always been dependent on many other technologies like computer vision, mobile processing, optics, etc. We are at that stage in the development cycle of AR where all other technologies not only support but can benefit from its use. This research presents one such innovation in the domain of education - for school children or enthusiasts about geospatial technologies such as remote sensing. In this paper, we have discussed the idea, methodology, and demonstration of one such application which establishes a future trend for use of AR in the education of Geospatial Technology. Different types of remote sensing data, their acquisition method, satellite technology, and applications area are explained using AR for a more interactive experience. Learning about geospatial technology will be helpful as the new frontier of Geo-information is enhancing everyone's day-to-day life and will help in boosting interest in this field.

Index Terms— Augmented Reality, Remote Sensing, Education, 3D Data Visualization, Geospatial Data. Point Cloud

1. INTRODUCTION

The concept of augmented reality or AR became reality in the year 1968 when Sutherland created a three-dimensional display to present the user with a perspective image that changes as per the movement of the head-mounted display worn by the user [1]. The work he presented was described using the kinetic depth effect. Since then, development in the field of augmented reality lacked pace due to various limiting factors in the research may it be software or hardware limitations. But in recent times since the digital revolution and advancements in the development of computer vision algorithms, feature detection & feature matching algorithms and photogrammetric algorithms research in AR has progressed exponentially. Slowly but gradually as the enabling technologies finally caught up to the augmented reality technology, it has rapidly been used in the fields of business, logistics, gaming, manufacturing, retail industry, and many more [2]. However, our interest in this article is to provide a method to utilize AR for visualizing remote sensing data like satellite images, DEM, Thermal Images, etc. along with interactive illustrations to educate students and curious people. This would enable us to improve upon the traditional methods of learning. Also, it would intensify their interest in the subject matter, improving their recollection of the topic and building their intellect for research and development.

1.1 Augmented Reality

Augmented reality is a variation of virtual reality technology in which the user, instead of being completely immersed in an artificial environment, can see the real world with virtual objects superimposed on it in such a way that they appear to exist in it [3]. AR appendages reality instead of completely substituting it. AR improves a user's perspective of and engagement with the actual environment. Virtual objects reveal information that is not visible to the naked eye of the user, which helps in performing better in real-world tasks. AR has been investigated for use in medical visualization, maintenance and repair, annotation, robot route planning, entertainment, navigation, and targeting.

A lot of us have used AR in one form or another which may be through various games such as Pokémon Go or social media platforms (e.g. Snapchat or Instagram). The digital media age is moving towards Overlaying virtual content into the real world and as we can see in this COVID-19 pandemic time that the main medium of interaction is shifting very fast to the virtual medium. Augmented reality is the technology capable of bringing this virtual world closer to the real world such that they merge into each other and enable us to interact with them as we interact with physical objects. Education by employing AR would keep students engaged by bringing the virtual models or animations into their physical environment.

AR is a technology where reference data such as in the "Terminator" movie are introduced in virtual reality when all sorts of digits from sensors and calculation results appeared in Schwarzenegger's brain [4]. AR is a chimeric state of mixed reality, combining virtual elements with real

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objects or surroundings [5] and thus not completely disconnecting from the real world but enhancement of the visual field by adding a virtual component to it. AR depends on an automatic matching between an object in reality and a dataset that overlays on top of the real-world object such that it enhances the user's understanding of it.

AR has been proved successful in improving education from traditional literacy to multimodal literacy. Modes of study can be categorized as visual and auditory forms. Visual mode is composed of visual effects, images and animations whose function is to focus the viewer's attention to important ideas and information whereas auditory mode consists of background music and sound effects used to enhance the immersive experience. These modes along with AR content create a significantly improved multimodal literacy in students [6].

Paper is structured in a very crisp manner as Section 2 provides the description of data used and Section 3 shows the methodology acquired for visualization. Section 4 provides the discussion of the result generated. And section 5 concludes the overall research components with cited references.

2. DATA

Remote sensing data are generally acquired from satellites or UAVs fitted with special sensors that record data in various spectrums of electromagnetic radiation. This data is transferred to a storage device which can then be used for digital image processing tasks. For this demonstration, remote sensing data that has been used is from a UAV and the sensor used for data capture is MicaSense. Other types of data include graphical illustrations, 3D objects, and point cloud data acquired using Faro S350+ Terrestrial Laser Scanner. In addition to these visual components, auditory information is also fed into the application which is collected from various sources and converted into an audio file. The visual data used can be classified into 2D, 2.5D and 3D.

2.1 2D data

Satellite images, Ortho-maps, and Land-use/Land-cover maps, all come under 2d information generated out of remote sensing and photogrammetric processing. The information they have is structured in a form of a 2d array with the value of the intensity of radiation recorded to each pixel in different bands of the electromagnetic spectrum. 2D remote sensing data used in the demonstration is shown in figure 1.

2. 2 2.5D data

Digital Elevation Model both Surface and Terrain model (DSM, DTM) can be classified as 2.5D Models. They have information related to the third dimension in a discreet manner, gridded data in images known as pixels are filled here as in elevation values.

Figure 1. 2D Remote sensing data (RGB, NIR FCC, Rededge FCC, Thermal)

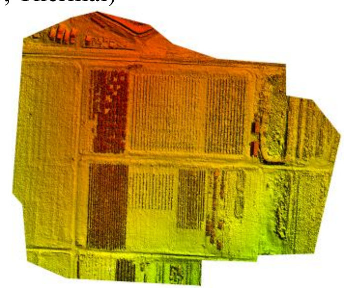

Figure 2. 2.5D data generated from Remote Sensing – Digital Elevation Model(DEM)

Figure 3. 3D point cloud data of Department of Civil Engineering, IIT Roorkee recorded using TLS

2.3 3D data

Point Clouds and Mesh models have information about all three dimensions to form a 3D representation of an object or feature. These datasets can be structured or non-structured depending upon the source (Photogrammetry or LiDAR). Figure 3 shows the point cloud data that is used in the demonstration application. The data is recorded using the Terrestrial Laser Scanner(TLS) at the entrance of the Department of Civil Engineering, IIT Roorkee.

3. METHOD

For the purpose of demonstration, an AR application for learning Remote Sensing is developed. In this regard, firstly sample data is collected. For remote sensing data, sample data provided by DroneMapper named 'MicaSense Altum Red, Green, Blue, NIR, Rededge, Thermal'. Point Cloud data is recorded using TLS and then processed and

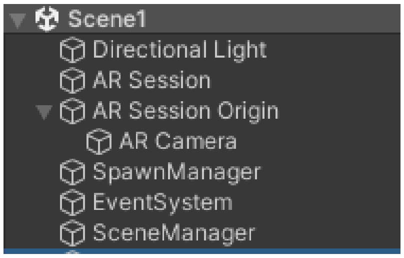

Figure 4. Hierarchy of elements in the AR scene with components like ARSession, ARSessionOrigin, ARCamera etc.

resampled using CloudCompare. Graphical Infographics and audio files are generated using various tools. Once all the data is collected and ready, ARCore – AR software development kit (SDK) is used with the UnityEditor which is an application development software. Unity provides the environment and packages for developing android or iOS applications. The methodology is discussed as follows: firstly, an AR development environment is set up using the package manager in UnityEditor. AR Foundation libraries with their subsystems are required for the development, so it is installed with the additional package from ARCore (for android) or ARKit (for iOS). After the environment is set up properly, the platform is chosen from android or iOS. In our case, we have used the android platform and ARCore SDK. The next step is to import the data collected previously from various sources and bring them to this project inside UnityEditor. The scene is organized which contains the elements like ARSession, ARCamera, ARSessionOrigin, etc. arranged in the hierarchy as shown in figure 4 with a custom C# script to handle ray cast, UI, and other interactive elements. Once the desired result is achieved and bugs are removed the whole project can be exported as an android package which can be installed on android ARCore supported devices.

For using the application, start the AR session. Video from the camera is recorded and processed for detecting distinct features from each frame of the video feed. As the features are recorded, a feature matching algorithm starts to identify the already recorded features in the subsequent frames. In each frame from the video, the features are used to detect horizontal and vertical planes in the physical world. As soon as a plane is detected it is rendered with a custom shader on top of the video to show the user that the program is ready to place the virtual object in the physical world. Touch input is provided using the mobile's display which sends a ray cast that hits the detected plane and gives 3D location information and direction. This point is termed as an anchor point and is then continuously tracked for changes in viewing angle and position. This change is viewing angle and position is used to calculate the changes required to do adjustments to the virtual object so that a believable AR system is maintained (figure 5).

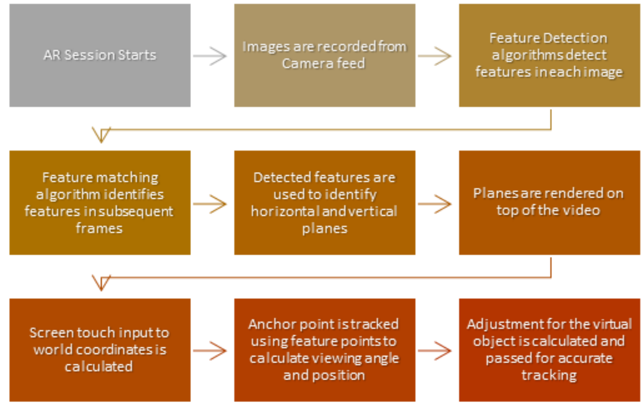

Figure 5. AR object detection and tracking methodology

4. RESULTS AND DISCUSSION

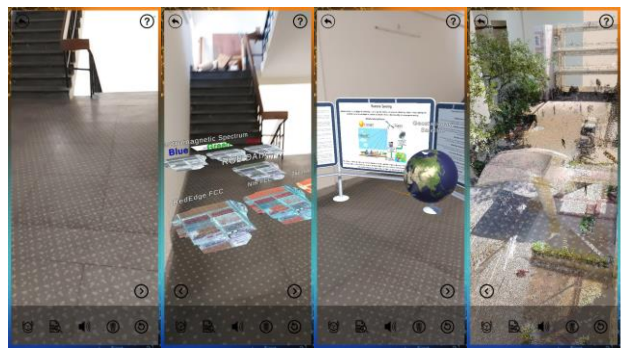

Figure 6. Screenshots of the demonstration application showing plane detection, object placement and point cloud visualization.

Figure 6 shows the demo of augmented reality-based visualization of remote sensing data for education. Various types of data are used like remote sensing satellite images, false-color composite, thermal band information, DEM, 3D animated objects, and point cloud. It can be seen that gound is detected and objects are placed on it. Using AR for the education of remote sensing helps in learning and is an intuitive approach to traditional methods.

5. CONCLUSION

Augmented reality can make learning more efficient and immersive for students at any level of their education. This will help students in comprehending concepts in an interactive environment, which will simplify concepts and make learning easy. In this study, we have developed an app using Unity and ARCore SDK for showcasing Remote sensing Data in a more efficient manner for educational purposes. We have used multi-spectral band images, FCC, DEM, animations, audio and point cloud in form of multi-scene multimodal approach for learning using AR and provided a platform to interact with the datasets. Semantic information related to the datasets are also attached in the viewer to enhance the characteristic information of each dataset.

The app developed showcases that augmented reality can be used effectively to enrich the user's understanding of remote sensing in an engaging manner and those who are not so well versed in this subject can be easily taught about it with the use of augmented reality. This method of reality-based education is the future direction of the transformed education system. This type of method can be employed for various types of 2D, 2.5D and 3D data generated from remote sensing. The methodology employed was easy to use, fast pace and can be done by anyone with little knowledge of coding.

Dataset: MicaSense Altum Red, Green, Blue, NIR, Rededge, Thermal by DroneMapper. https://dronemapper.com/sample_data/

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