UNIVERSITETI I EVROPËS JUGLINDORE
УНИВЕРЗИТЕТ НА ЈУГОИСТОЧНА ЕВРОПА
SOUTH EAST EUROPEAN UNIVERSITY

SELECTED CHAPTERS IN

VR/ AR

VIRTUAL TECHNOLOGIES @WESTERN BALKAN UNIVERSITIES

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Endless possibility with Virtual Reality and Augumented Reality

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ACCELERATING WESTERN BALKANS UNIVERSITY MODERNIZATION BY INCORPORATING VIRTUAL TECHNOLOGIES

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Chapter 1

ACCELERATING WESTERN BALKANS UNIVERSITY MODERNISATION BY INTRODUCING VIRTUAL TECHNOLOGIES

QUALITY ASSURANCE POLICY FOR TEACHING AND LEARNING

Main elements to consider regarding VR/ AR teaching and learning

Assistance for quality teaching and learning using VR and AR should take place at three inter-dependent levels:

At the institution-wide level

The universities in its strategy for innovativeness and quality in teaching/ learning should support the VR tech application in teaching and learning. Taking into consideration that today's students are digital natives, VR offers the possibility to better immerse students in their engagement in learning.

This at the same time would advance the VR/AR research in the institution and shrink the gap between the universities and businesses.

At program level

Comprising actions to measure and enhance the design, content, and delivery of the programs within a faculty or a school. VR teaching and learning has a great potential and high effectiveness levels by stimulating spatial memory and allowing users to master various skills in different fields. Each field of study has great opportunities in VR/AR and this should be incorporated in study program so that students are more prepared for the future job market.

At individual level

Including initiatives that help teachers achieve their mission, encouraging them to innovate and to support improvements to student learning and adopt a learner-oriented focus. One of the main advantages of using VR technology in teaching is that students can learn about the world outside of their classroom without leaving it. VR outspreads the range of education to anywhere teachers want to take their students. In this regard teachers should explore VR apps specific for their subject and integrate them into their curriculum.

POLICY LEVER 1. RAISING AWARENESS ABOUT VR/AR IN EDUCATION

Challenge

The future of VR and AR use in education will be determined by better awareness around this technology, as well as improved experience for the user. There is a false impression that VR and AR only have applications for entertainment and video games, and that they cannot be used as a business tool. VR/AR technologies have excellent prospects in explaining complex concepts in fields such as medicine, healthcare, military, aviation, engineering, space etc., offering a unique advantage for virtual learning in higher education.

While there is a trend to include Virtual Technologies in academic culture of universities in developed countries, this is not the case with universities in developing WB countries. There is a need to introduce at Western Balkan universities the concept of virtual technologies as a tool for accelerating university modernization, while contributing on developing knowledge-driven society. This will increase the quality and level of efficiency in teaching and knowledge retention through virtual technologies, thus contributing on skills enhancement and further building of digital society at WB countries.

Key Policy Actions

- Foster the perception that virtual technologies can be used beyond games and entertainment
- Promote VR/AR as an instrument for improving education in learning multifaceted perceptions
- Establish Virtual Technology HUB that will serve as a HUB for other HEIs

POLICY LEVER 2. ENHANCING TEACHING METHODOLOGIES

Challenge

HEIs have continuously been vanguard of novel technologies, pushing progress and establishing the afterward generation of scientists, businesspersons and engineers. Virtual and augmented reality technologies are at the border line of enlargement nowadays.

Improving and expanding the learning practice is at the core of what Virtual Reality can offer to learners and is one of the most effective ways that could transform the learning process.

There is need for academic staff to be equipped with the necessary comprehension, skills and approach to get habit of using Virtual Technologies for teaching. Once having their competencies for this purpose, they will be able to enhance teaching methodologies, which will increase student learning capability and enthusiasm.

Key Policy Actions

- Build capacities for academic staff to incorporate Virtual Technologies in teaching
- Develop teaching methodologies availing of technology and/or ICT tools
- Transform the role of the teacher to be more as a co-learner, coach and development collaborator
- Create learning environments so that they better respond to the challenges of new teaching methodologies using VR/AR

POLICY LEVER 3. ENGAGING STUDENTS

Challenge

The full expression of technologies potential is in line with Einstein' s quote "The only source of knowledge is experience". VR/AR technologies need to be directly practiced, because unlike a lot of other emerging technologies, virtual technologies are extremely visual. It's all about presenting that information in a valuable way that helps applications in different areas to accomplish their objectives. It operates alongside with the user.

A lot of learning areas depend on the students' imagination – students should imagine a place or the internal structure of a body or chemical element. Students' in-class engagement is an issue that requires continuous improvement, through permanent investigation of new techniques and approaches.

With virtual technologies students can visit places far away, all from the learning lab. They can explore the inside of a human organ, the structure of a molecule, the architecture of a computer or network, or practice flying a plane. With these technologies, students can experience and interact with beings and things, which they might never see their lives.

Key Policy Actions

- Increase engagement via interactivity
- Boost learning potential
- Personalized learning experiences
- Practical learning
- Equip students with competencies to use/access tools, software, and platforms
- Increase interaction between teachers and students

- Increase the level of understanding and reduce the grasping time and the effort that students need to learn information by using 3D concepts instead of 2D ones
- Offer a better delivery of basic knowledge even for complex issues, higher learning efficiency and better learning experience by AR/VR techniques
- Transform the role of the student to be a junior collaborator with the teacher and be part of the learning process

POLICY LEVER 4. FOSTER INNOVATIVENESS IN TEACHING AND RESEARCH

Challenge

Innovation is one of the main drivers of quality teaching improvement and research advance. Innovations in teaching and research can be advanced a lot by using virtual technologies, which will bring in narrowing the gap between the academy and industry.

There is a common agreement between students of studying really hard for an exam just the day before and forgot everything studied a week later. It is shown that interactive 3D solutions increase student's attention levels by 92% and increase test scores by 35%.

Mostly in Western Balkan countries teaching methodologies are still traditional so the introduction of AR/VR will be an innovation in their education systems. The need for modernization of study programs is becoming as important as the quality. The usage of a development/training hub is an essential component that allows students to get acquainted with the industrial equipment, which they will meet in the industry/business later.

While innovation is a progressive idea in itself, there is an issues of availability of high-end technology, that can disadvantage some students. The institutions should pay cautious awareness to the evaluation of innovative practices and monitor the effect of innovation on teaching and learning outcomes, while ensuring they become common practice requires appropriate provisions and managerial capacities.

Key Policy Actions

- Experiment with innovative teaching methodologies like actions based learning, gamification, virtual reality and augmented reality
- Define a new classroom ecosystem transforming the teaching process from a Teacher based education to a Student centered education.
- Make learning more flexible and excited
- Train students for the future
- Encourage experimentation and innovation in teaching practices, while recognizing that experiments that fail are also important learning opportunities.
- Foster exploratory approaches and incremental changes, including pilot testing and careful evaluation of innovative teaching methods.
- Involve students in the design, implementation and evaluation of innovative teaching and learning experiments.
- Adjust teachers’ performance evaluation to inspire and acknowledge innovation suitably

POLICY LEVER 5. INTERNATIONALIZATION AND NETWORKING

Challenge

Beside innovative teaching methodologies that will increase learning capability and motivation, an important aspect is the international dimension, exchange of knowledge and interactive networking.

The EU partners will contribute with their expertise in the domain of user experience design and evaluations, considering VR content consumption specifics. Using their experience in this domain they will create the UX design guidelines and pass on the knowledge to partner countries' personnel during teacher training visits. Additionally, they will lead the evaluations of the developed solutions, helping to identify possible issues and find optimizations.

Partner Countries in the project are in Europe Pre-Accession Phase. They should learn to build capacities, standards and criteria used in Higher Education systems of EU countries.

National higher education policy development in Western Balkans is very much influenced by two major European initiatives in higher education – the Bologna Process and the developments around and following the EU's Lisbon Strategy – both related to the project of establishing a "Europe of Knowledge".

The Western Balkan countries are putting attention on the processes of taking European level processes into the national context, the process of Europeanization of systems of higher education (top-down perspective), therefore the cross-regional cooperation is very welcomed for targeted partner country institutions.

Key Policy Actions

- Foster cooperation between academy and industry by organizing open days, joint product developments, thesis supervision etc.
- Develop capacities for future joint research and innovative ideas with the support of Virtual Technologies.

Chapter 2

OBJECT MODELING USING BLENDER/ 3D OBJECT MODELLING

When designing 3D applications, whether those being games, simulations, or other computer graphics implementations, it is crucial to include 3D models in your environments. These 3D models are commonly representations of real-life objects. In this chapter we will discuss three main approaches on how to model 3D objects:

- Using 3D modelling tools
- Using small scale photogrammetry
- Using large scale photogrammetry

To be more accessible for end users, each of the above approaches will be described by using open-source technologies.

Aside from modeling your own objects, one can also look up for repositories that allow downloading 3D objects for free or with monetary compensation. Some of these online repositories can be found bellow:

- Scan the world is an initiative to scan in 3D cultural artifacts and provide them as 3D printable models. Available at: https://www.myminifactory.com/scantheworld/
- TurboSquid is a platform where users can purchase 3D models that can be used for animation, game programming, VR / AR etc. Available at: https://www.turbosquid.com/
- CGTrader is a platform where users can trade 3D models. The platform currently has more than 1.5 million models available and a community of 5.7 million users. Available at: https://www.cgtrader.com/
- Free3D is another platform where users can share their 3D content for free or with payment. Available at: https://free3d.com/

Before we start with 3D modelling, it is important to discuss the different 3D model file formats. We will mention some of the most popular formats below with their strengths and benefits:

- gLTF/GLB is an open-source format created by The Khronos Group. It is a textual format (based on JSON) and allows inclusion of additional files (external) such as textures, shaders etc.

- FBX is one of the most popular formats. Used and maintained by Autodesk it allows inclusion of textures, geometry and animation in one format. The drawback of this format is that it is a closed source and proprietary format.
- OBJ is another well-known format supported by most 3D modeling tools. It also supports geometry, color and texture and it is widely used for 3D printing purposes.
- STL is one of the most used formats for 3D printing. STL only stores geometry information (which is sufficient for most 3D printers).

Other formats also exist, most of which are proprietary and locked to specific technologies. For our purposes, we will mostly use OBJ and FBX.

Object modeling using Blender

Blender (available for free at https://www.blender.org) is a leading open-source 3D modelling tool. This powerful tool is design to allow users to model 3D objects, edit existing objects, create animations, movies, game assets etc.

When the user loads up Blender, it will be introduced with its default layout, as can be seen in the following picture:

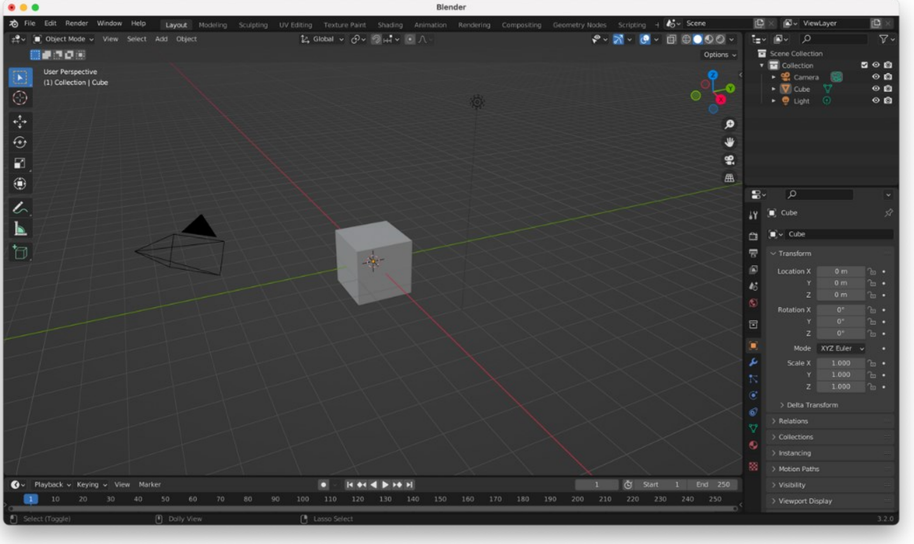


Figure 1 - The default UI of Blender

This default layout can be changed, dependent on how the user aims to use Blender. In our case, we will use this default layout and switch to the Modeling layout when needed. The main window presented to the user is the Viewport. Here we can see the default cube (a basic primitive added to your screen, which we will remove when modeling). This window is basically the work area where we design our scene or model our objects.

In addition to the Viewport, on the upper right corner of Blender, you can find the list of all objects in your scene. Currently, on a default project you will see a Camera, Cube and Light objects.

Bellow this window, there is a tabbed like interface which represents the properties window. This window changes depending on what object you have selected, representing the properties of that particular object.

Finally, there is a timeline window in the bottom of the UI which is used when users work with animations. Animations are not in the scope of this book; therefore we can ignore this UI element.

The default viewport has three objects already present: the default cube, a camera object and a light. These can be seen in the viewport (and interacted with) but also can be seen in the Scene Collection pane (top right corner):

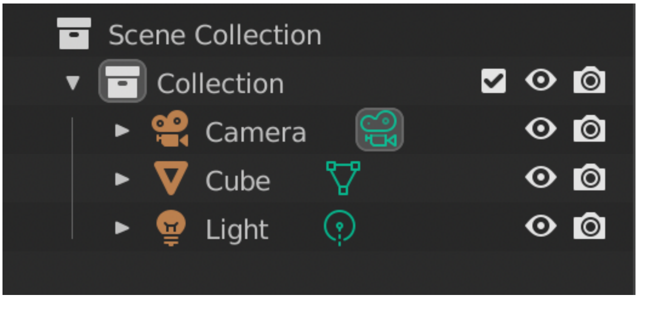


Figure 2 - Scene Collection Pane

Navigation in Blender

Getting used to the Blender interface can be tedious in the beginning. Especially for those that do not have prior experience with 3D modeling tools. Therefore, it is important to cover some of the most important concepts in this regard.

You might notice on the upper right corner of Blender the UI elements as shown in the following figure. We will go step by step through each of these elements.

The magnifier tool allows you to zoom in and out of the objects that appear on your viewport. By clicking on this icon and holding the left button, if you move the mouse up and down, you will zoom in and out of the object that is centered on the viewport.

Many times, you want to see a view of your scene from one of the coordinate axis. E.g., if you want to see the top view, you can just click on the blue Z labeled circle and you will see a top view. For illustration, we have added a cone object in our scene and clicked on all three axis, X, Y and Z.

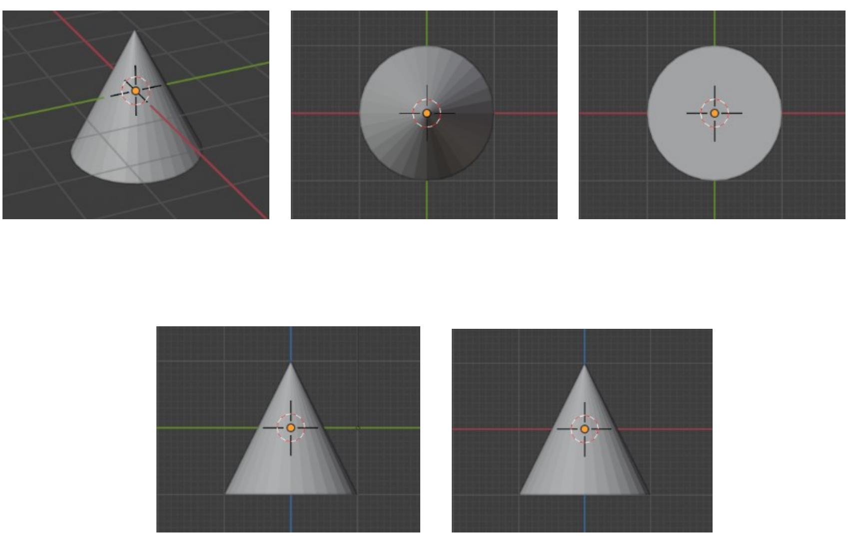


Figure 3 - Different view: a) Default view, b) Top view (z), c) Bottom view (-z), d) Side view (x), e). Front view (y)

Note that in the above picture, the views from X and Y look completely same. That is normal in the case of a cone, where if you see a cone from the side (the X axis) and from the front (Y axis) the view will be the same.

In addition to the navigation options using the coordinate axis, you can use additional navigation tools such as the pane (hand icon), zoom (magnifier icon), camera (camera icon) and projection (grid icon). The hand tool allows panning around the scene. The camera button will show what the scene camera is looking at. This option is helpful whenever one needs to see how the final rendering will look like. Finally, the grid like button will switch from perspective to orthographic projection. In perspective projection the further the objects are, the smaller they look. Orthographic projection will always show the same size of the objects, no matter how far they can be. This projection is often used in architecture, engineering etc., when it is important for the viewer to compare the size of different objects.

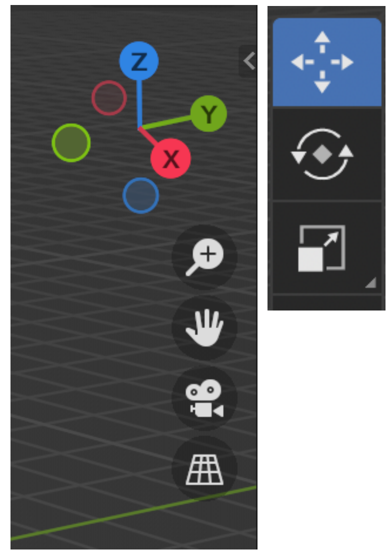


Figure 4 - Navigation tools

Affine transformations

Objects in Blender can be transformed in three ways: translate, rotate and scale. These three transformations are available at the toolbar on the left side of the Blender UI. All three of these operations are applied to a specific axis.

Translate is the first option (keyboard key G) and allows the user to move an object in a given direction. When you select this option, you will need to click on the object you want to move. As you click on the object you will see three coordinate axes appear around that object. These allow you to move the object in a particular direction: towards x axis, towards y axis and towards z axis. The user can just click on one of the axis and move the mouse to move the object towards that direction.

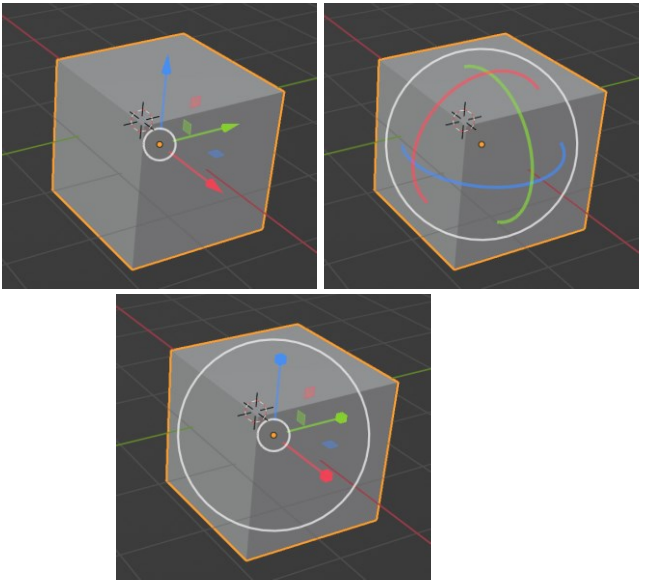


Figure 5 - Different coordinate axes for translation, rotation and scaling

The second option is rotation (also activated with keyboard key R), it allows for the rotation of an object around an axis. When an object is selected to be rotated you can click on one of the circles denoted with red (x-axis), green (y-axis) or blue (z-axis). The picture below denotes rotating an object.

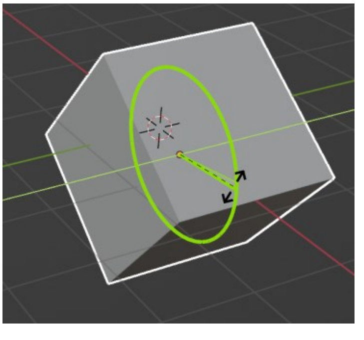


Figure 6 - Rotating an object around an axis

Finally, scaling (keyboard key S) allows for resizing an object in one of the given dimensions. Again, you need to select the axis towards which direction the object is to be scaled.

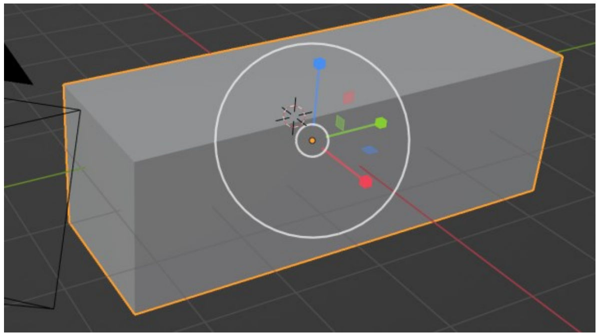
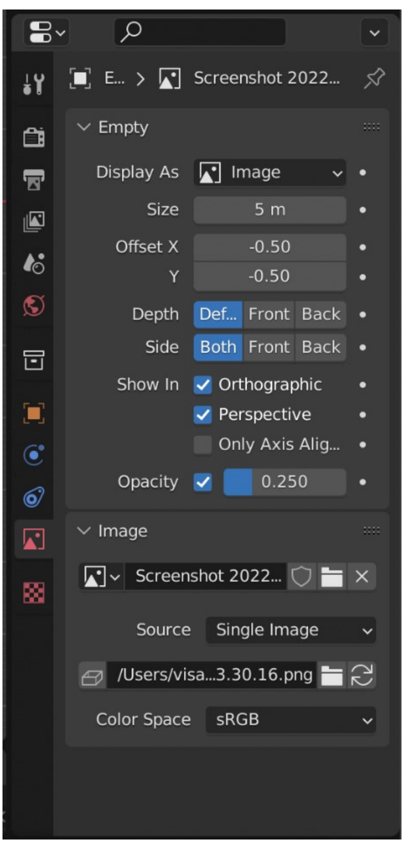


Figure 7 - Scaling an object towards x-axis

Modelling an object

The best approach in modelling is to go by example. As this text follows, we will model a simple logo. The logo of choice is the one of South East European University. This is a very basic logo, which we would like to turn in in 3D.



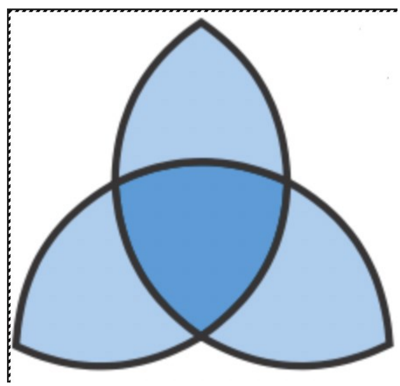


Figure 8 - SEEU Logo

The first thing to do is set this image as a reference in Blender. You can save the above image in your computer or use any other image that you would like to model. After you do that, in Blender we will delete all existing objects (just so we have a clean environment to work on). To do so, select the object and press the X key in your keyboard. You will be asked to confirm the deletion. Next, we want to set Blender to have a front view. To do so, click on the Y button on the top right coordinate system. To keep it simple, we are only going to model one side of the logo (the front side). The next step would be to drag the image from your local computer to the blender interface. It would be helpful to also make the object transparent, which can be done by selecting the object and then select object properties. You will see the opacity property which we will set to 0.25.

The next step would be to add an object to our scene that will be then modeled to the desired shape. You can add a shape by clicking on the menu option Add or just press the key A in your keyboard. Multiple options would appear. In our case we will go in the Mesh option and select Cube (which will add the default cube). We could have added anything and model it to the desired shape. Cube is a little more straightforward to work with. You should see something like in the following image.

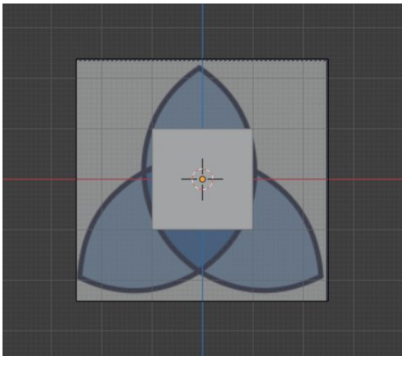


Figure 9 - The reference image and the cube in front of it

Now we could either resize the reference image to have the same size as the cube, or we can resize the cube to have the same size as the reference image. We will choose the second option. If you select the cube, and then press the S button you should be able to scale your cube to the desired size. You can also press the ALT+Z keyboard shortcut to toggle the xray view, which will make the cube transparent.

First, we will want to scale the top side of the object to match the top side of the logo. To do so, press the TAB key in your keyboard (will open edit mode) and select the top part of the cube by drawing a rectangle on top of it. This option will select all the vertices in the top of the cube.

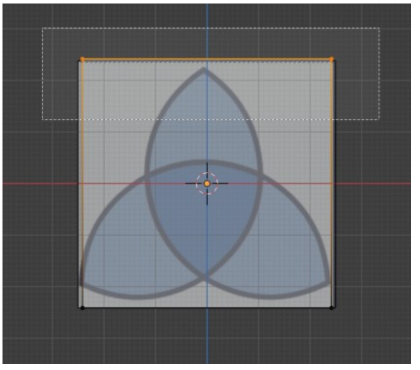


Figure 10 - Selecting the top of the cube

Next press S for scaling and X for scaling in the X axis. Drag the mouse to match as much as possible the shape of the logo. You should have something similar to the image below.

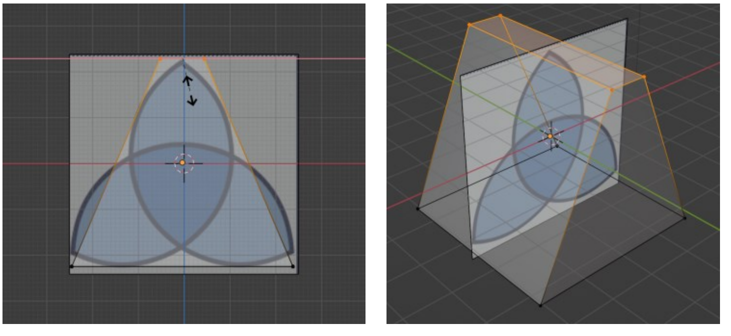


Figure 11 - Under a) is what you should see. Under b) you can see the object from a different angle, just for illustration purposes.

You can continue selecting only the edges as in the previous shape and move all edges to match the edges of the logo. In the end you should see the following triangle shape.

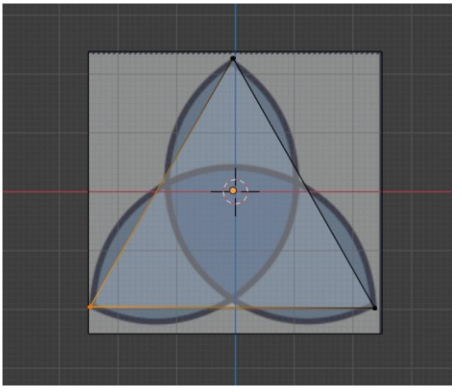


Figure 12 - Matching the edges of the logo

We can see that the logo is symmetrical. So, if we make changes on one side, they should reflect to the other side as well. Blender allows you to do this using the mirror approach. To do that, we will need to first add a new edge to our object. Press CTRL and R on your keyboard and move the mouse on the bottom of your triangle shape. You will see a yellow line that splits the triangle in two parts. Just double click to confirm. It will introduce new edges to your object.

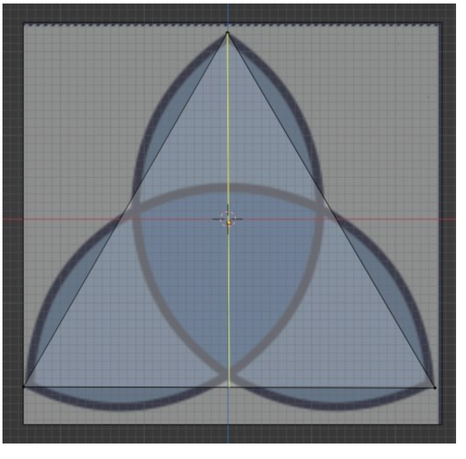
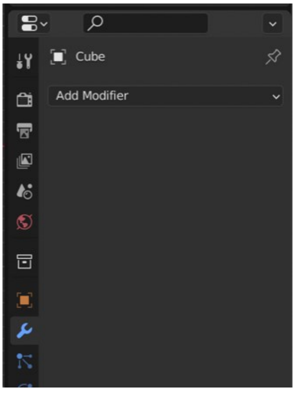


Figure 13 - Cutting the object in half

Next, select one edge (the left or the right edge) and press X on your keyboard and select vertices. This will delete half of your object. After we have done this, we can add a modifier. On the right pane, select the modifier option (the wrench icon) and click on Add modifier. Select the mirror modifier, check clipping and leave the default option (Axis X selected). You can mirror on Y, Z; you can do bisections, flipping etc. Feel free to experiment with all the possible options. We have deleted the left side of the object and after adding a modifier we can now only work on the right side of the object. Whatever we do on the right, it will be reflected on the left side.



Using the CTRL+R option, add as many vertices as you want to your object. This will allow you to morph the shape to a desired outcome. Then, select the edges you want to move (again TAB key and select the edge G key to move). You should see something like the following picture.

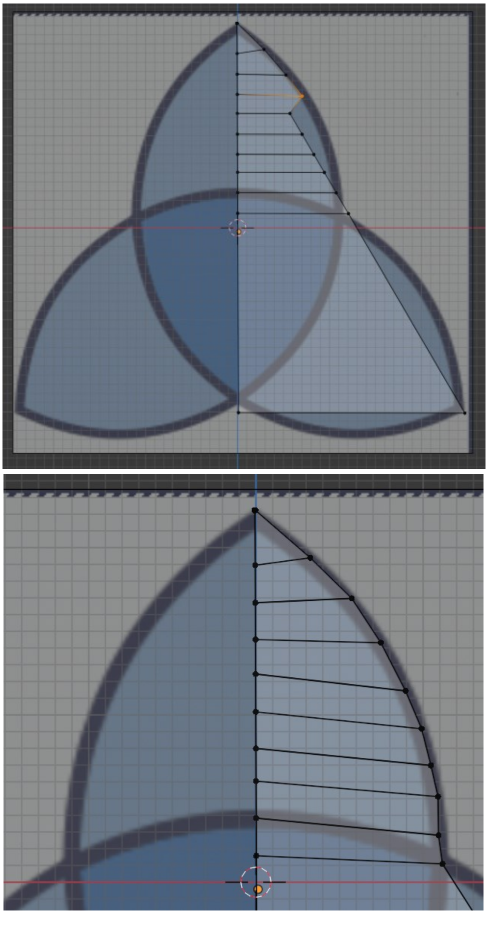


Figure 14 - Matching the outline of the shape.

Try to match the outline of your shape as accurately as possible. When done, do the same thing for the bottom part of the logo as well. Split the object as many times as you want. The more the better resolution you will have (though it will take you more time to model the shape). In our case, this is our final shape:

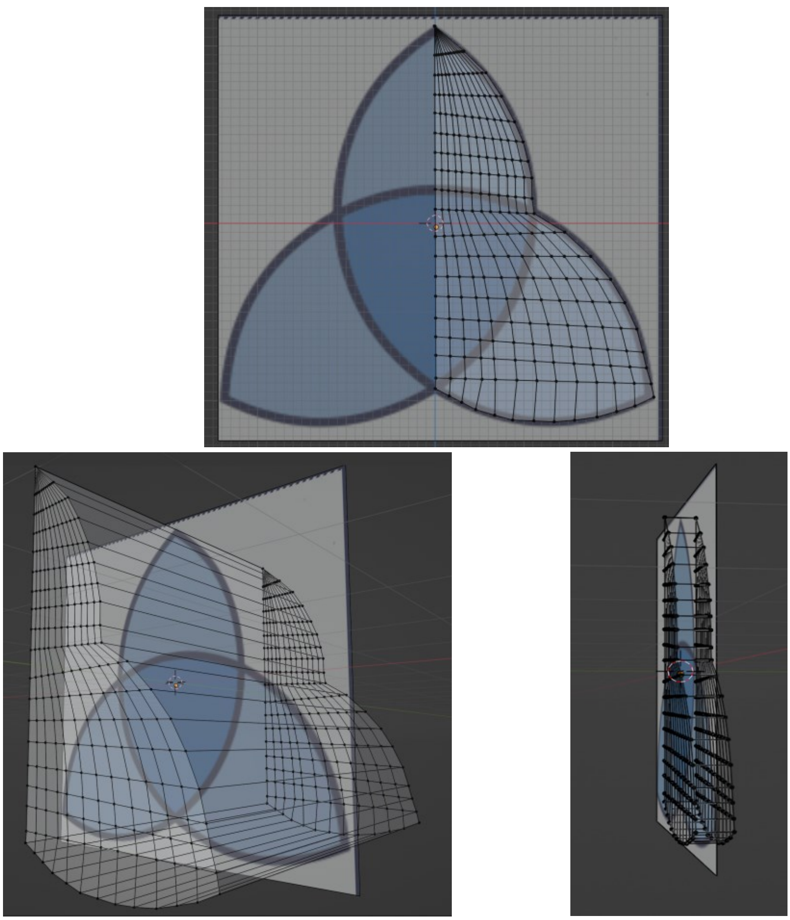


Figure 15 - Final tracing of the logo. Under b) we see the shape from a different angle.

As you can see from the side angle (figure 15-b), the tracing of the shape looks good, but the logo is to thick. You can move the viewport using your mouse (make sure you have a good view) and then press S in your keyboard for scaling and Y to scale on the Y axis. Move your mouse until you get optimal results.

We can now toggle back the xray view (ALT+Z) and delete the reference image since we do not need it anymore. You should see a result as in the figure 16. This result is good enough for 3D printing purposes (we will need to resize it a little). For other purposes we might need to add a little realism to our object by altering its appearance. This can be done by using material properties and textures.

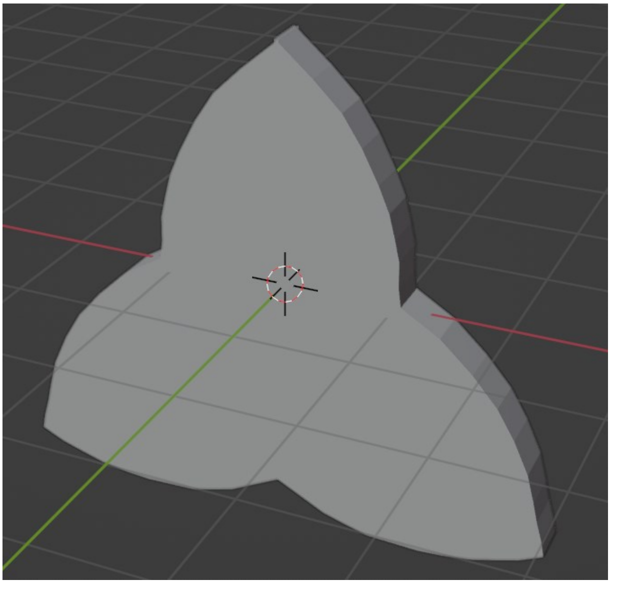


Figure 16 - Final object without texture

To add material, select your shape and click on the material property on the right pane. Then click New and choose a name or leave the default. You will be presented with a lot of options which are not a subject of this topic today. We will just add a basic blue color to our entire shape (though you can select different surfaces to have different colors). Change the base color by selecting any color you want (we selected blue).

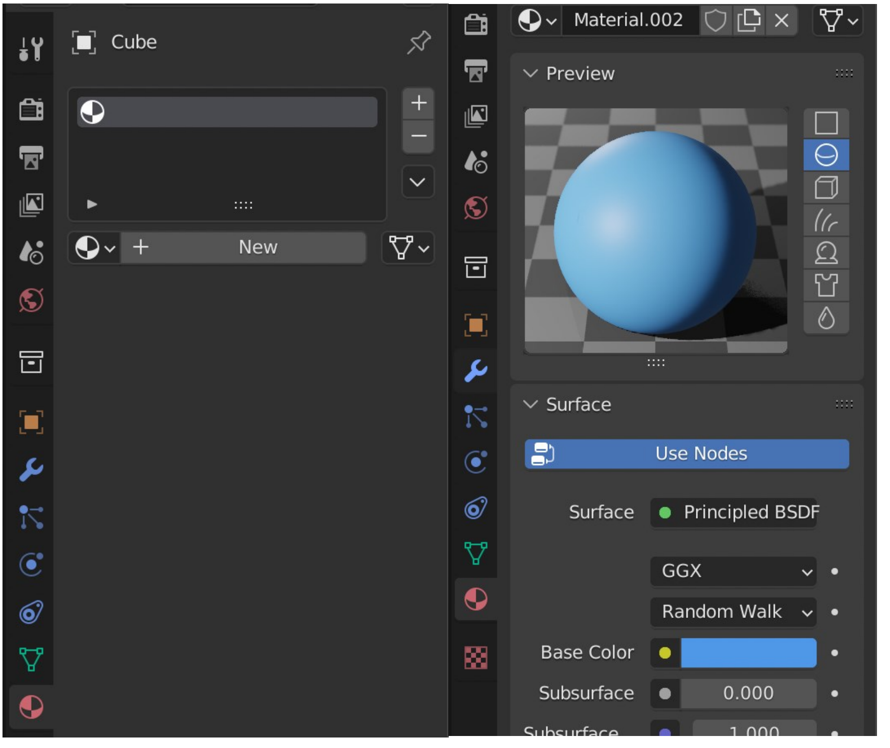


Figure 17 - Adding material to your shape

You will see that while the preview window changes, your shape does not change color. This is because you need to render your object to see the results. To see the end result, press Z on your keyboard and select Rendered object on the circular menu that will appear. You should see something like this:

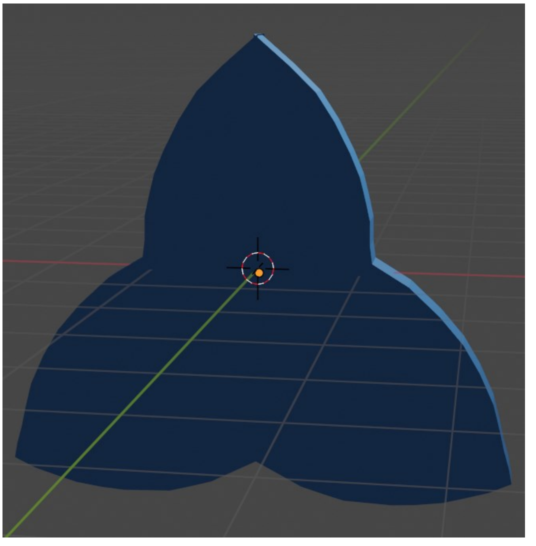


Figure 18 - Rendered figure

To go back, press Z again and select Solid. To this book, this is the highest level of detail we will choose for modelling. Feel free to experiment with additional features. Note that material properties of the shape can be changed in Unity as well after you import this object.

A final consideration is the size of the object. If you want to 3D print the object, it would be wise to resize it a little. If you select your object, press S on the right pane you will see its size, denoted in meters (m). Blender saves its files as a (. blend) file, but you can also export them to a different format such as .obj, .glb, .fbx etc, depending on how you will use that file in the future.

Photogrammetry

A more recent approach in 3D modeling is to extract 3D information from pictures. This process is known as photogrammetry and we will discuss two main approaches on how one can achieve this. The approaches discussed are:

- Aerial photogrammetry – which is often used to model large scale objects such as buildings and terrain
- Close range photogrammetry – which is used to model small scale objects

The most important part of photogrammetry is to obtain images of the subject we want to model. The rule of thumb here is simple: the more images the better. However, one needs to consider also the following image specifications in order to get a better quality model:

- Images should not be blurry
- Use a fixed zoom
- ISO level on the camera should be on the 100 – 200 range
- Shutter speed (the lower the better). This especially applies to Aerial Photogrammetry, in which case you use drones that are moving and are not stable. A low shutter speed will make sure that images are not blurred.
- You can use a DSLR camera (allows for more control over settings) or a mobile phone with an option to take professional photos (most phones have this option in their camera app).

When you take photos of the target object, you need to rotate either the object or the camera around the object. Pictures should be taken in a rotating fashion, from a central, lower and upper position. The following image shows an example of capturing photos from multiple angles using a drone. Also, it is important to have an overlap between pictures. The recommended overlap is more than 75%.

For close range photogrammetry you can use a mobile camera or a DSLR. Take as many pictures as possible from around the object by making sure that the focus is on the object. For a aerial photogrammetry you will need to use a drone that is supported by flight path tools. One such tool is Pix4D Capture (https://www.pix4d.com/product/pix4dcapture) which is a free software that allows you to define the path your drone will fly. It will also allow you to set the angle of pictures, height of the drone, speed etc. A sample screenshot on how you can set the path is shown in the following picture:

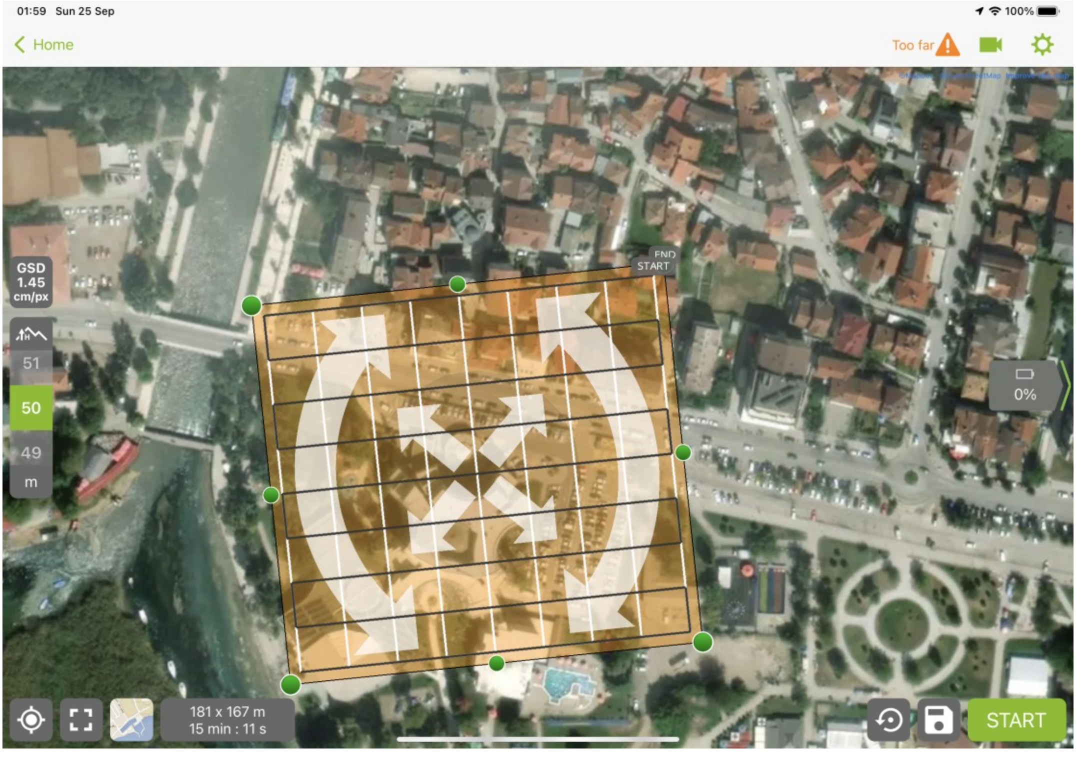


Figure 19 - Setting the flight path of a drone

The drone will fly on a grid and take pictures every few meters. After the pictures have been collected you can upload them to a photogrammetry software. There are plenty options out there, such as OpenDroneMaps (https://opendronemap.org/), RealityCapture (https://www.capturingreality.com/) , Pix4DMapper (https://www.pix4d.com) etc. Images uploaded to these tools will be analyzed and mapped using also the geotagged information from images. The following picture shows how the processing of more than 300 images for an object at SEEU campus.

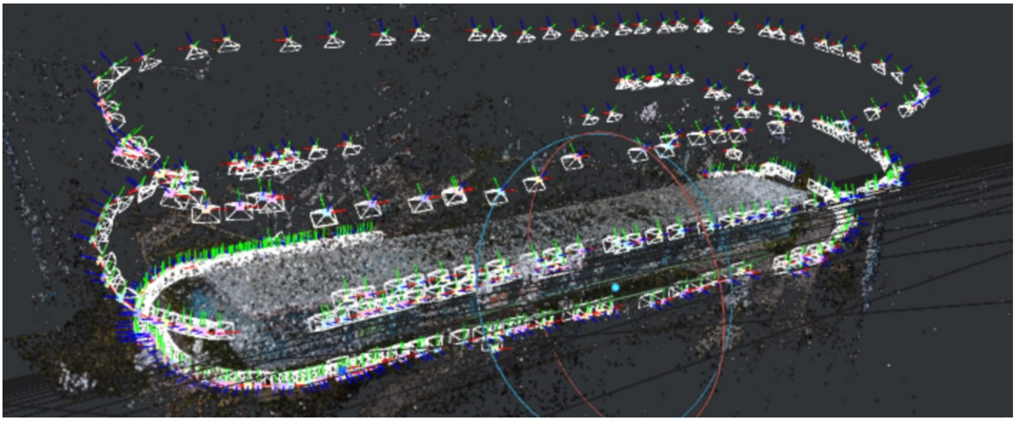


Figure 20 - Collected images for an object at SEEU

Afterwards, a 3D model of the object will be generated. Sample models generated from our approach are following:

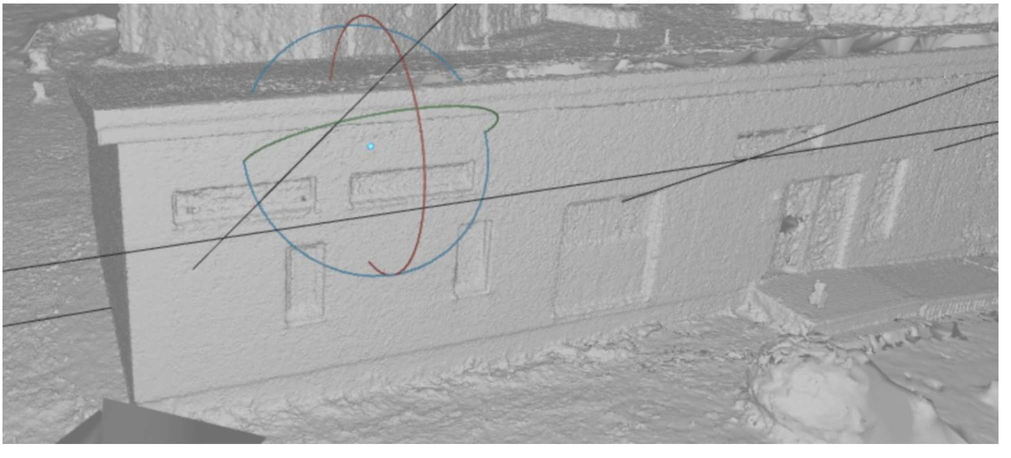


Figure 21 - Solid object without texture

Figure 22 - Textured object

One can notice that the quality of the objects is high. These objects can be exported to a suitable format (.obj, .fbx ...) and imported to Blender for further processing.

Chapter 3
AUGMENTED REALITY IN CONTEXT OF DISASTER MANAGEMENT

Disaster Management

The physical environment constructed for human habitation is continuously exposed to the risk of disasters. Considering that natural and human disasters severely destroy environments and make it hard to access the affected environments, there is an increasing need for decisions to be taken quickly to minimize evolving hazards and to start with the rescue and relief operations. Disaster management is crucial to reduce the probability and impact of the calamity and enable rapid restoration when disasters occur. Studying disaster management can help researchers and professionals gain a better understanding of the response methods needed for various disasters, so that they can improve disaster management measures and provide safer environments. Recently when studying disaster management, the usage of Augmented Reality (AR) and Virtual Reality (VR) has become essential. With the rapid development of technology in the recent years, Augmented Reality and Virtual Reality have been continuously adapted to address various challenges in different domains, including the domain of disaster management and disaster relief operations. This adoption has been possible due to the release of affordable pieces of hardware and software which support the development of customized applications. Scientists, decision-makers, and professionals benefit from Virtual and Augmented Reality, as these technologies provide researchers with virtual emergencies and simulated environmental disastrous scenarios without causing any real-world danger.

Virtual Reality and Augmented Reality

Virtual Reality and Augmented Reality have received a continuous growing amount of interest that has led to the development of different fields of investigation. Although Virtual Reality and Augmented Reality rely on different technologies and provide different solutions, they are both in the same category. They enhance or replace the real environment with a simulated one but at the same time they rely on different components and serve different audiences. AR is defined as a mixed experience in which the main component is reality while the digital components (i.e., holograms) are a secondary component, and VR represents the extreme of this continuum and can be defined as a completely synthetic experience where users are presented with only virtual contents.

Augmented Reality revolutionizing Disaster Management

During the last 20 years, the advances in the internet of things (IoT), intelligent sensors, artificial intelligence technology, wearable tools, and Augmented Reality (AR) have significantly impacted disaster management. With the rapid development of computer technology, research in this field has also constantly evolved.

Augmented Reality presents one of the most advanced technologies that has been adopted to address disaster relief operations. It is a promising technology that is being applied in many contexts as diverse as:

1. Crisis management,
2. Emergency management-related health care,
3. Education,
4. Training,
5. Natural disasters

Augmented Reality devices

The adoption of AR in disaster management primarily has been possible due to the release of affordable pieces of hardware (wearable glass device, head-mounted device, or smartphone applications) and software which support the development of customized applications. Among these pieces, there are the following:

1. Oculus Quest 2,
2. HTC Vive Cosmos Elite,
3. Merge AR/VR Headset
4. Vuzix Blade Upgraded,
5. HTC Vive Pro 2,
6. Magic Leap,
7. Epson Moverio BT-300
8. Snap Spectacles 3
9. Google Glass Enterprise Edition 2,
10. Raptor AR headset,
11. ThirdEye Generation,
12. Kopin Solos,
13. Micrososft HoloLens2, etc.

One of the most widely used Augmented Reality devices is the Microsoft HoloLens 2 (Figure 1).

Figure 23: Microsoft HoloLens 2

According to Microsoft, HoloLens is the first fully self-contained, holographic computer, enabling users to interact with high-definition holograms. This makes HoloLens unique and very much different from the existing augmented and mixed reality technologies. Users can wear the headset, which weights 580-gram and runs Windows 10 to map their environments and display virtual or holographic 2D and 3D objects anchored to that environment.

Although Augmented and Mixed Reality seem to have lots of applications in several various sectors, Microsoft lists disaster and emergency management as one of the main application areas of HoloLens and encourages research and development in this field.

Microsoft HoloLens 2 can be used to simulate various operations needed for rescue and evacuation processes. Moreover, applications can be developed to address specific disaster management processes.

Drone integration with Augmented Reality

During a disaster there are many cases when first responders fall short due to the damage of the disaster itself, because the conditions make it difficult to access the affected areas and provide aid. The two most important things to do during a disaster are:

1. To spot the people in need of urgent help
2. Assess the extent of the damage.

So, to mitigate suffering and further damage, one asset that rescue teams can utilize is drones. Drones can be used to support infrastructures, deliver supplies, establish communication, collect data, provide communication services, etc.

Figure 24: DJI Inspire

Drones are useful in different occasions such as when infrastructure supply lines are cut and disabled, or when roads, bridges, communication cables are compromised. By deploying drone aircrafts over these impossible to reach areas, supplies such as food and water can be delivered to people in danger, without needing to place human-operated aircraft in harm's way. Bigger drones can also be used to transport people, while on the other hand small drones can be deployed

Figure 25: DJI Mavic AIR 2

to provide accurate situational awareness and inspection. Drones that are outfitted with communication systems bring also the advantage of sustaining contact between the command center and firefighters on the ground.

Although drones have received lots of criticism because of their associations with invasion of privacy, integrating drones with Augmented Reality makes it possible to highly improve operational efficiency during crisis management. Drones come in hand in dealing with different disasters and calamities, thus they are being counted as a valuable tool for many reasons. They come with a variety of sizes and prices, which means that they provide greater advantages in costs and in response times when compared to traditional methods. Small drones are affordable, and they deliver the same view available from a helicopter at a fraction of the cost. They are able to fly at low altitudes and offer a detailed and accurate inspection of the situation.

Figure 26: DJI Mini 2

Drones equipped with cameras, together with Augmented Reality and other devices pave an efficient way for disaster management. They make it possible to deliver crucial information in real time, thus they enable first responders to mark the locations where to search for survivors, analyze the overall situation of the disaster and the hazard done, create different types of maps that help rescuers locate critical spots, find ways on how to access and restore resources, etc. On the other hand, drones can also be equipped with a variety of sensors to achieve various functionality, including infrared cameras which can visualize temperature range variability. Finding a human's heat signature is the first step towards rescue and recovery and such drone technology is a great tool to locate people in cases of earthquakes, landslides, hurricanes, fire where many search and rescue missions occur.

Figure 27: DJI Phantom 4 V2.0

These advantages and more, make drones a very important tool which is being used more often in emergency and disaster response situations. They are proving the ability to save lives and prevent damage in dire situations.

Live Streaming from deployed drones

Amongst all the advantages that come out of using drones during disaster management, one of the crucial ones is also the possibility to live stream and inspect the overall situation in the affected areas. Relying on drone-captured live-streamed videos makes it possible for first responders to observe the unfolding situation and facilitate decision making. Live streaming from a deployed drone equipped with a camera can be achieved using various existing streaming protocols, such as RTMP.

The following section provides a step by step guide on how to live stream from a drone.

1. To fly the drone, we will be using the DJI Fly application.

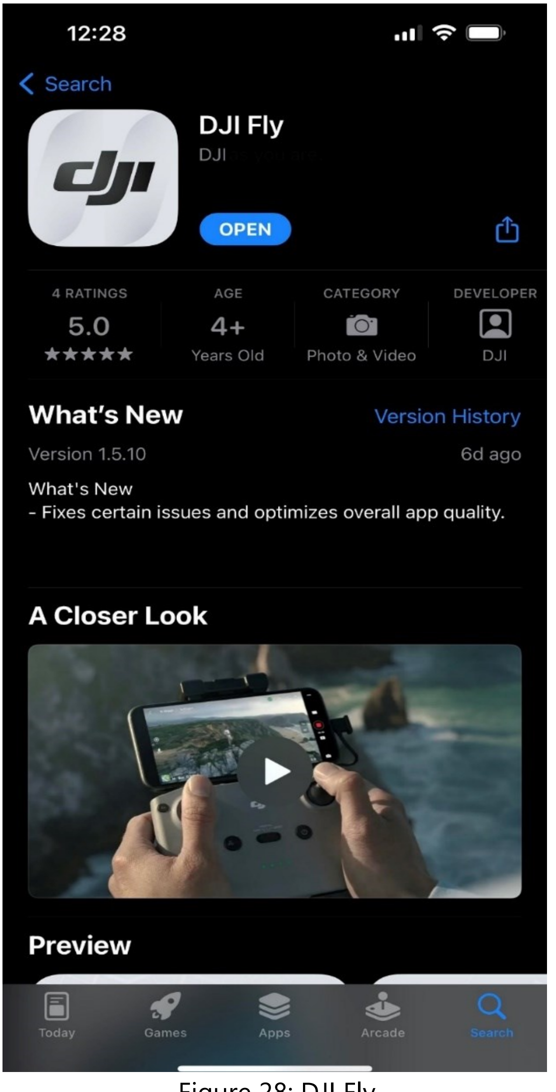


Figure 28: DJI Fly

After connecting the aircraft with the DJI Fly application, we open the Settings in the application itself and under Transmission we select Live Streaming Platforms.

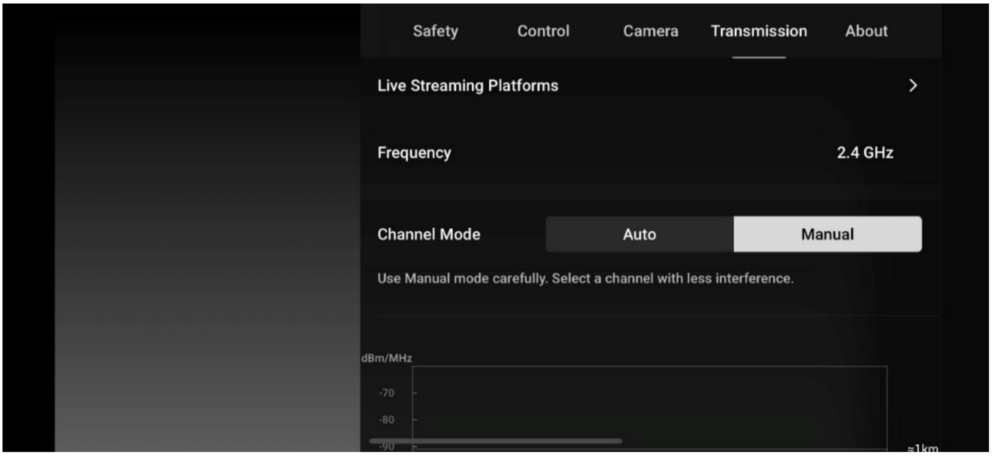


Figure 29: Transmission Settings in DJI Fly Application

Under the Live Streaming Platforms, we have the option RTMP, and we choose it. RTMP makes it possible to map services like YouTube to what the deployed drone is recording in real time.

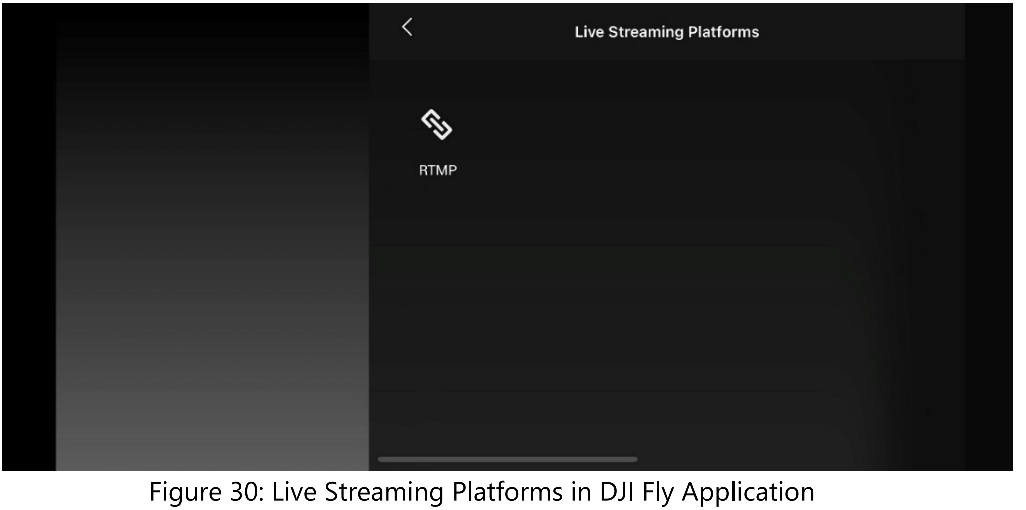


Figure 30: Live Streaming Platforms in DJI Fly Application

When choosing RTMP, we are then prompted the following window, where we need to specify the RTMP address. The RTMP address, is the address that makes it possible for the mapping to happen in real time. Moreover, the streaming resolution will be 1080p and the bit rate will be 2Mbps.

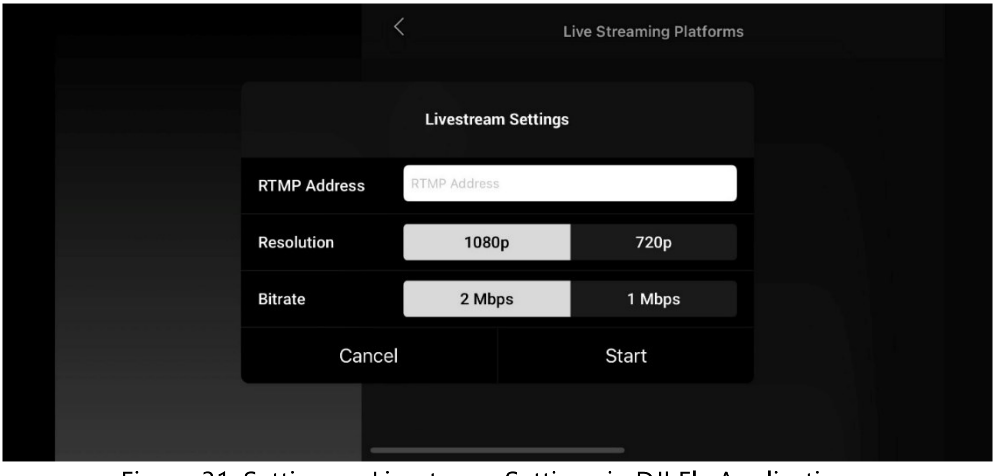


Figure 31: Setting up Livestream Settings in DJI Fly Application

We will be using YouTube to do live streaming so we will get the RTMP Address and the secret key from our YouTube channel.

First, we login to YouTube and we click on Go Live.

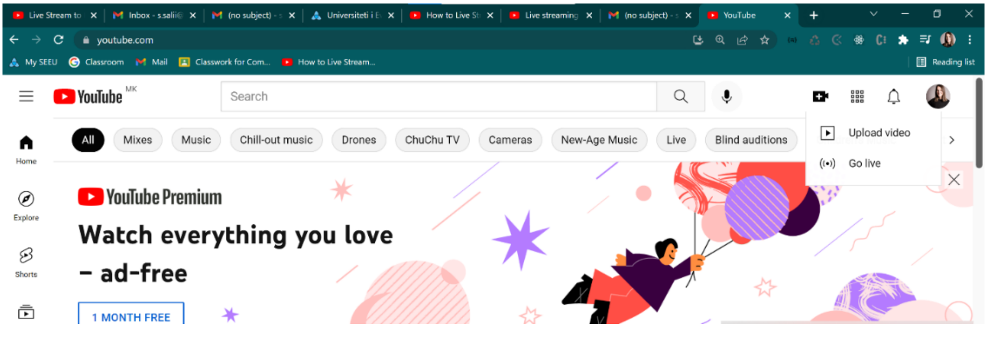


Figure 32: Go Live in YouTube

Next, we go under Stream Settings. We copy the Stream URL and Stream Key. After copying the Stream URL and Stream key, we structure them in the RTMP address and we will be connected.

Figure 33: Setting up live streaming in DJI GO 4

The following figure (Figure 12) shows an image of live streaming using RTMP in a personal YouTube channel.

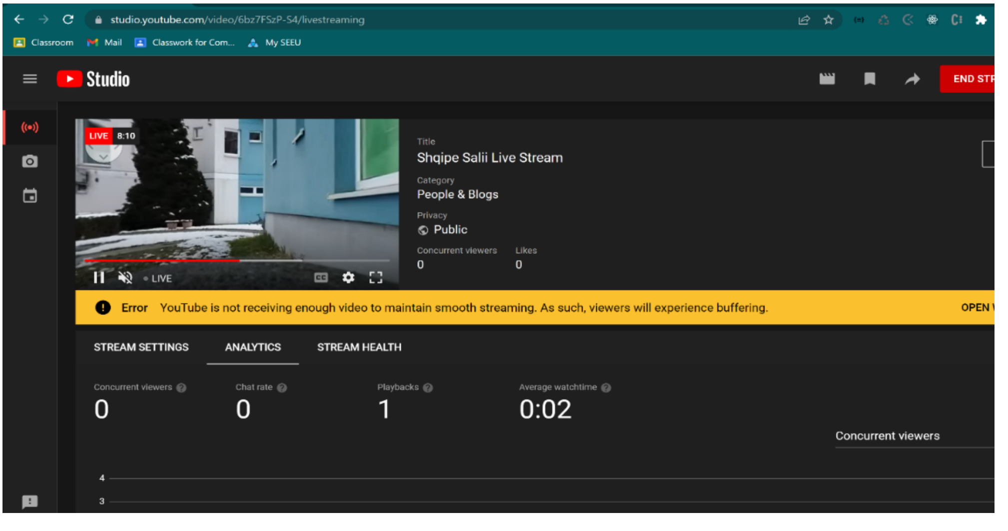


Figure 34: Live streaming from deployed drone to YouTube

Augmented Reality System using Maps SDK

An Augmented Reality System (ARS) is a system that integrates an image of reality with a virtual image that extends the visible scenery of reality. In context of crisis management its use lies on representing invisible and unreachable disaster relevant information and overlay it with the image of reality. The design of an ARS is a challenge because the system integrates different components like mapping, 3D visualization and photogrammetry, real-time streaming, etc.

An Augmented Reality System will be designed and implemented and the terrains where the disaster is active will rendered and visualize in the form of 3D maps. These critical sports will be then further visualized and marked in the map with objects, and real-time inspection of these areas will be done by deploying drones and creating live broadcasts.

Development environment

As a working environment for building Mixed Reality applications, Unity (2020.3.17f1) with Unity Hub will be used. Moreover, Mixed Reality Toolkit (MRTK), as a toolkit that provides various components and features, used to accelerate cross-platform MR app development in Unity will be utilized as well. And finally, to be able to target the HoloLens 2 device, Mixed Reality OpenXR plugin will be installed and the XR configuration will be setup.

On the other hand, to develop and render the 3D terrains in the maps, Maps SDK (Maps SDK, Microsoft Garage project, n.d.) will be used. It is a Bing Maps API that makes it possible to incorporate 3D world data into Unity based Mixed Reality experiences and at the same time handles streaming and rendering of 3D terrain data with world-wide coverage.

Once installed, the reference to the Maps SDK package is represented in the manifest.json file.

```
{
  "scopedRegistries": [
    {
      "name": "Maps SDK for Unity",
      "url": "https://unity.virtualearth.net/npm/registry/",
      "scopes": [
        "com.microsoft.maps"
      ]
    },
    {
      "name": "Microsoft Mixed Reality",
      "url":       "https://pkgs.dev.azure.com/aipmr/MixedReality-Unity-
Packages/_packaging/Unity-packages/npm/registry/",
      "scopes": [
        "com.microsoft.mixedreality",
        "com.microsoft.spatialaudio"
      ]
    },
       {
               "name": "iBicha",
               "url": "https://registry.npmjs.com",
               "scopes": [ "com.ibicha" ]
       }
  ],
  "dependencies": {
    "com.microsoft.maps.unity": "0.11.0",
    "com.microsoft.mixedreality.toolkit.examples": "2.6.2",
    "com.microsoft.mixedreality.toolkit.foundation": "2.6.2",
    "com.microsoft.mixedreality.toolkit.tools": "2.6.2",
       "com.ibicha.youtube-player": "1.6.0",
    "com.unity.2d.sprite": "1.0.0",
    "com.unity.2d.tilemap": "1.0.0",
    "com.unity.ide.rider": "2.0.7",
    "com.unity.ide.visualstudio": "2.0.9",
    "com.unity.ide.vscode": "1.2.3",
    "com.unity.multiplayer-hlapi": "1.0.8",
    "com.unity.test-framework": "1.1.27",
    "com.unity.textmeshpro": "3.0.6",
    "com.unity.timeline": "1.4.8",
    "com.unity.ugui": "1.0.0",
    "com.unity.xr.arcore": "4.1.7",
    "com.unity.xr.arfoundation": "4.1.7",
    "com.unity.xr.arkit": "4.1.7",
    "com.unity.xr.legacyinputhelpers": "2.1.8",
    "com.unity.xr.management": "4.0.7",
    "com.unity.modules.ai": "1.0.0",
    "com.unity.modules.androidjni": "1.0.0",
    "com.unity.modules.animation": "1.0.0",
```

```
    "com.unity.modules.assetbundle": "1.0.0",
    "com.unity.modules.audio": "1.0.0",
    "com.unity.modules.cloth": "1.0.0",
    "com.unity.modules.director": "1.0.0",
    "com.unity.modules.imageconversion": "1.0.0",
    "com.unity.modules.imgui": "1.0.0",
    "com.unity.modules.jsonserialize": "1.0.0",
    "com.unity.modules.particlesystem": "1.0.0",
    "com.unity.modules.physics": "1.0.0",
    "com.unity.modules.physics2d": "1.0.0",
    "com.unity.modules.screencapture": "1.0.0",
    "com.unity.modules.terrain": "1.0.0",
    "com.unity.modules.terrainphysics": "1.0.0",
    "com.unity.modules.tilemap": "1.0.0",
    "com.unity.modules.ui": "1.0.0",
    "com.unity.modules.uielements": "1.0.0",
    "com.unity.modules.umbra": "1.0.0",
    "com.unity.modules.unityanalytics": "1.0.0",
    "com.unity.modules.unitywebrequest": "1.0.0",
    "com.unity.modules.unitywebrequestassetbundle": "1.0.0",
    "com.unity.modules.unitywebrequestaudio": "1.0.0",
    "com.unity.modules.unitywebrequesttexture": "1.0.0",
    "com.unity.modules.unitywebrequestwww": "1.0.0",
    "com.unity.modules.vehicles": "1.0.0",
    "com.unity.modules.video": "1.0.0",
    "com.unity.modules.vr": "1.0.0",
    "com.unity.modules.wind": "1.0.0",
    "com.unity.modules.xr": "1.0.0"
  }
}
```

A Bing Maps Developer key will be used to enable the mapping functionalities of the SDK.

Implementation

People involved in disaster management operations expect data represented in a clear and understandable form. The new approaches for visual representation of virtual environments give life to such new ways of coping with disaster management. They enable users to obtain a clearer perception of the disasters and its characteristics, including providing specific and brief details about it.

In this section step by step the implementation phases of the Augmented Reality tool are presented. This tool consists of an Augmented Reality based 3D Map, which is a 3D map that marks the areas (points of interest) which are in danger, shows the geo-location information, including longitude and latitude and provides a real-time accurate inspection of these locations from drones deployed in these areas.

The first phase of the implementation consists of rendering the terrain where the disaster is happening and focus the center of the disaster. The following figure (Figure 13) shows the rendered terrain in Unity and a description panel which gives a general overview about the map.

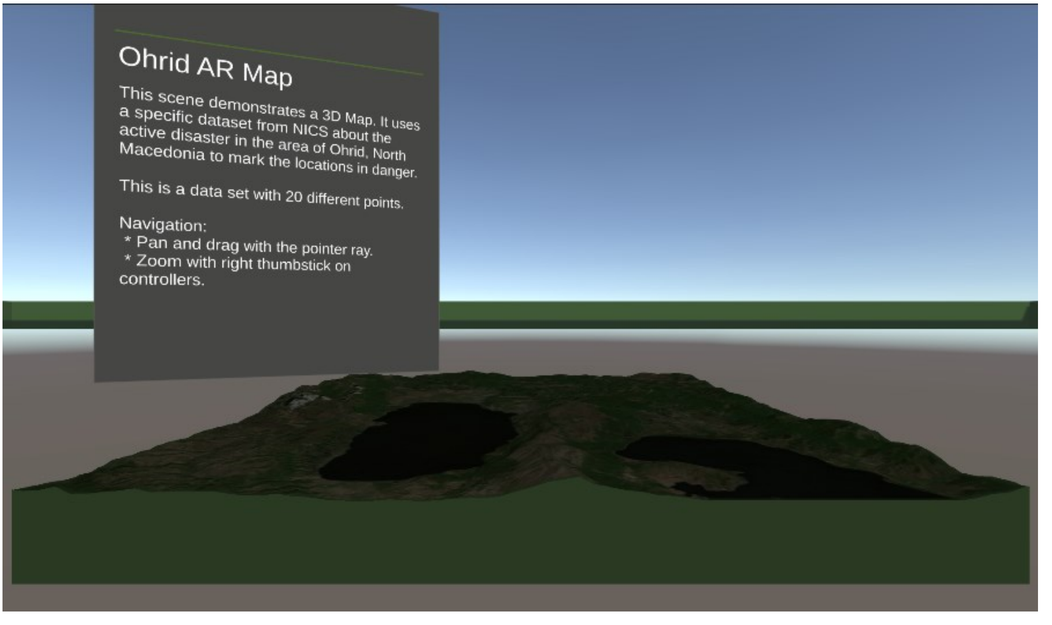


Figure 35: Implementation phase 1: Rendering the terrain

The upcoming phase consists of marking the locations in danger and enabling live broadcasting for each of the locations.

Using Bing Maps and the geodetic information for latitude and longitude, the locations can be easily spotted and marked. The locations are marked with 3D cube geometry objects, where above each one of the cubes we display the name of the location. Initially, the POIs are clustered based on their distance and the map view can change via translation or zoom. Clustered POIs are marked with a circle, which also displays the count of clustered pins. The maps are grouped, until the level of detail of the map view is high enough to display individual pins.

The reason behind clustering is that when dealing with large datasets, the number of component instances to be rendered for zoomed out views is reduced. The following figure, (Figure 14) presents an image of the rendered map in Unity, together with clustered and unclustered POIs.

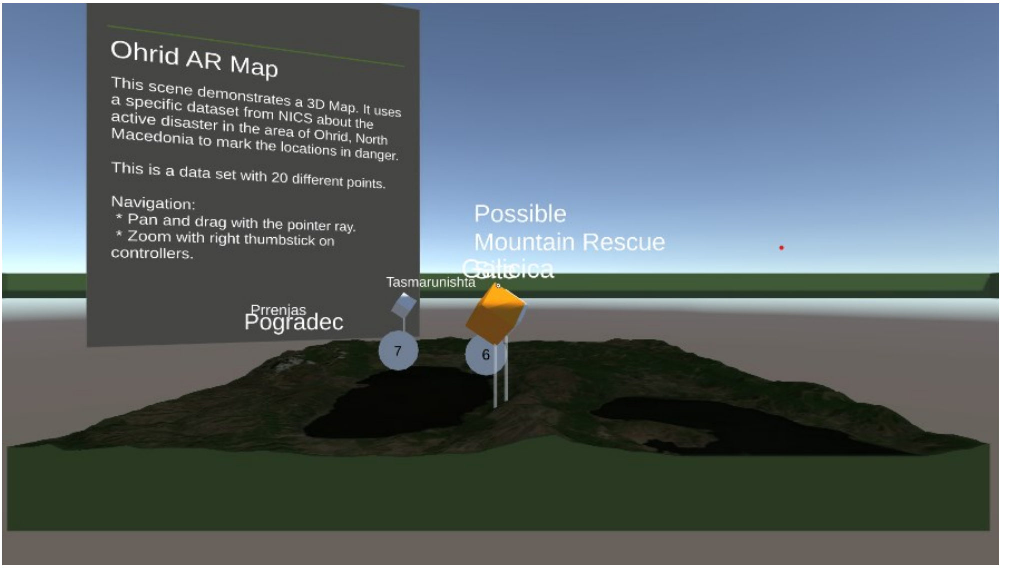


Figure 36: Implementation Phase 2 - Presenting Clustered POIs

The last phase includes enabling interaction with the components that mark the POIs and enable the live streaming functionality. By clicking on each of the POIs, the basic information about that location, such as the: name, longitude, and latitude is provided. Moreover, a video player will be added, to which live streaming directly from the drone will be enabled. During the disasters, the drones will be deployed in the areas where the disaster is active and there is still danger.

The following figure (Figure 15) presents an image of the rendered map in Unity when there is active interaction with one of the marked locations. The live broadcast is not yet created, thus there is not valid URL to stream from.

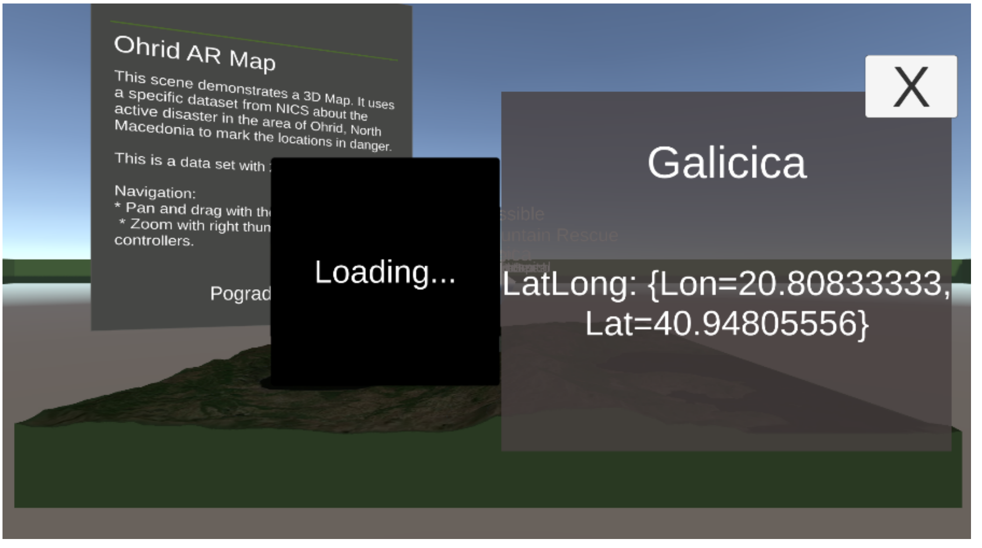


Figure 37: Implementation Phase 3 – Adding interaction and live streaming

At this stage, for implementation purposes, the drone DJI Phantom V2.0 using GJI GO 4 application will be deployed at the campus of Southeast European University to implement and test live streaming capabilities.

In order to create live broadcast in Unity, we will be using custom RTMP Address.

Figure 38: Live streaming from DJI GO 4

Once the RTMP address is mapped to the video player in the Unity application, real-time images of the drone in the video player can be seen.

The following figure (Figure 17) shows an image from Unity with live broadcasting

Figure 39: Livestreaming in Unity

Deployment to Microsoft HoloLens 2

To test the developed ARS, the Microsoft HoloLens 2 will be used. Initially, the system needs to be deployed to the device.

The following steps are required to deploy to HoloLens 2 over USB.

1. Open the build in Visual Studio.

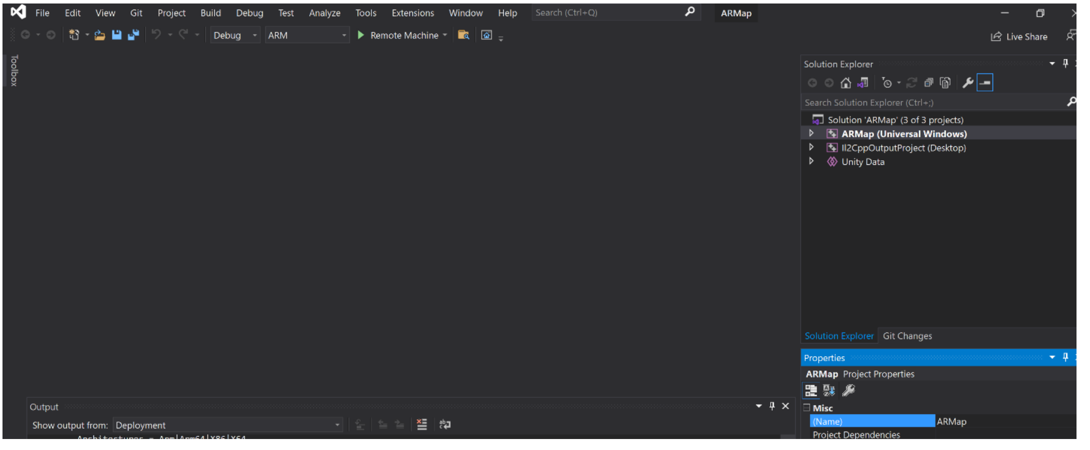


Figure 40: Visual Studio Build

2. Go to Project > Properties > Debugging and set the IPv4 address that you have in HoloLens

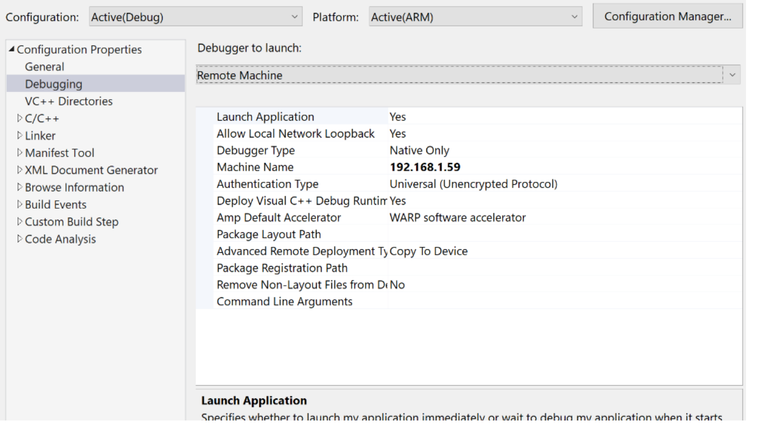


Figure 41: IP Address Configuration

3. Next Select your apps compilation options

    a. Choose either Release or Master

4. Select your build configuration based on your device

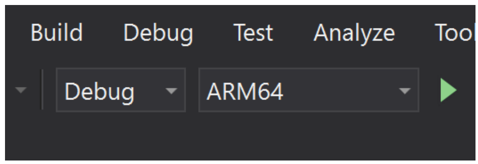


Figure 42: Build configuration selection

5. Select Remote Machine in the deployment target drop-down menu

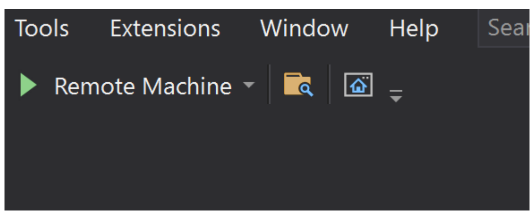


Figure 43: Remote Machine

6. Build, deploy, and debug your app based on your needs

    a. Select Build > Deploy to build and deploy without debugging

Once these steps are covered, the system is successfully deployed.

The following figures show the deployed increments of the Augmented Reality System. The following figure (Figure 22) shows the rendered terrain together with the points of interests, identified with cubes and the names of the locations on top. The map is interactable, can be moved, resized, etc.

Next, the deployment of the second increment with the interactivity added is tested, clicking on the cube is enabled and the address information for the critical point is also displayed in the panel. Furthermore, this increment consists also of

Figure 44: Rendered terrain with POIs

adding the video player where the drone-captured videos will play, mapping of the RTMP address and some last adjustments in the map description panel.

For testing purposes, the DJI Phantom V2.0 will be deployed at Southeast European University, to get real time drone-captured videos

Figure 45: Displaying address information for the POIs

And once the connection is live, drone-based video streaming images are received.

Figure 46: Flying DJI Phantom V2.0

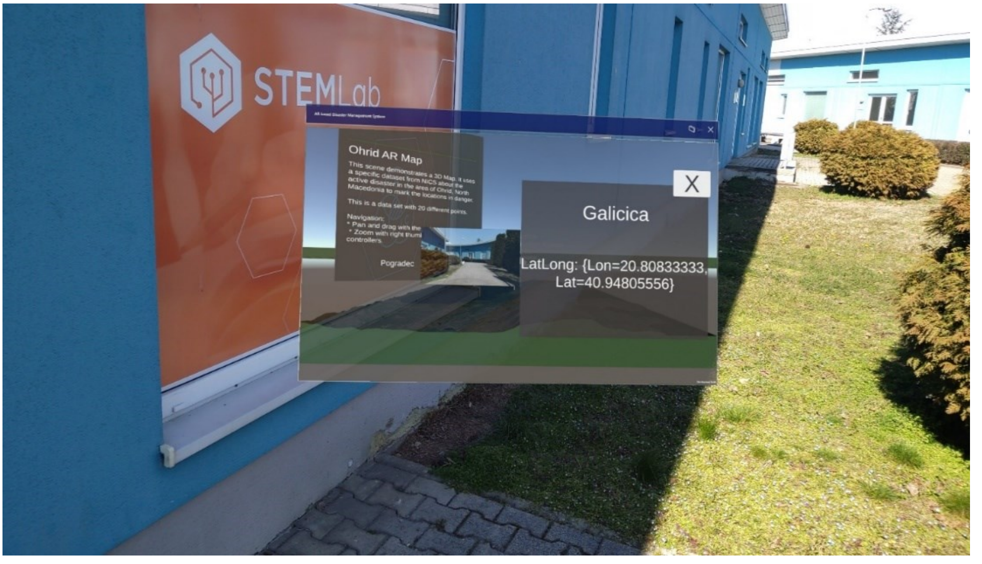


Figure 47: Live streaming to the implemented ARS in HoloLens

Advantages of using Augmented Reality in Disaster Management

The advancements on Augmented Reality technology and tools, bring lots of advantages, including enabling its usage and implementation in context of disaster management.

Augmented Reality can be used to highly improve mission planning processes:

1. Applying Augmented Reality during hazard recognition and prevention by creating virtual disasters, firmly assists in the design of disaster management plans before the disasters themselves occur.
2. Augmented Reality allows various virtual emergencies to be simulated for first responders to train until they master the necessary responding techniques. The responding techniques include the development of

various skills to mitigate the hazard of a disaster and reduce the loss when a disaster occurs.

Moreover, considering that decision making in emergencies requires non-traditional approaches and tools, Augmented Reality can play a crucial role in decision making. It makes it possible for disaster management teams and emergency responders to get vital and real-time insights about:

- The state of the unfolding situation and its progress,
- The rescue teams in the terrain and their operations' statuses,
- The situation in the highly risked areas, etc.

Being provided such information, proactive reaction is possible and the risk for wrong decisions is highly minimized.

Nevertheless, the benefits of integrating drone mapping and inspection capabilities with Augmented Reality are also plenty.

When adding Augmented Reality to a drone, operational efficiency in context of disaster relief operations is further improved. It enables various additional functionality to help first responders during disaster planning, recovery, and preparedness, such as:

- Assessing the extent of the damage when flying a drone in inaccessible areas with blocked or destroyed roads.
- Facilitating the locations where first responders should search for survivors or
- Sending information about closed roads and bridges to command centers.
- Structural inspection of civil structures.
- Visual data modelling for risk management professionals.
- Simulation of calamities and safety training for mastering life-saving techniques