Mobile Visualisation of Msimbazi Basin Floods

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Tanzania Urban Resilience Project

A dramatic increase in **urban growth** is expected to occur in the coming decades, especially in developing and emerging countries, resulting in large concentrations of people and assets being exposed to a range of **climatic risks**. The **Tanzania Urban Resilience Programme (TURP)** (supported by the Department for International Development, UK, and the World Bank) aims at addressing core challenges which are major contributors to increasing vulnerability of Tanzanian cities, namely: a) **data & information deficit** b) **inadequacy of urban and land use planning systems**, and c) **significant and widening gap of underlying infrastructures**. The TURP framework deploys a multi-sectoral approach encompassing: a) **risk identification** to strengthen the understanding of climate risks, b) **risk reduction** to strengthen cities capacity to plan for and respond and c) **disaster preparedness & emergency management** to prepare vulnerable groups with emergency response plans and design early warning systems.

Fig. 1: Jangwani Bridge: No flood (left) and flooded (right)

Immersive Visualisation

An important instrument for realising the multi-sectoral approach of TURP is the deployment of **emerging and future creative technologies** through **highly immersive visualisations** across commonly used platforms such as mobile phones and tablets. We report on recently undertaken work towards creating a **proof of concept virtual reality** mobile application to communicate the flood risk of the **Msimbazi** river basin in Dar es Salaam (Fig. 1), aiming at addressing not only leaders and decision makers but also citizens of the affected communities.

The philosophy underlying our application cuts across all core pillars of the TURP framework. The purpose is to **communicate** through an engaging and innovative manner the hazards associated with flooding in Dar el Salaam, e.g. by producing interactive computer graphics fly throughs around key locations showing the risk factors contributing to flooding (e.g. inappropriate land use, lack of solid waste management, river sedimentation). The ultimate vision is to create a fully fledged immersive virtual environment to: a) **show the impacts on the flood** (e.g. building canals, raising a bridge, or creating wetlands) and b) **demonstrate different mitigation tools**.

The Application

Our **prototype virtual reality mobile application** (Fig. 2) was developed using the Unreal Engine 4 (https://www.unrealengine.com). We exploit several existing flood and terrain datasets which are converted into **game ready** assets. Our application was built for Android devices and has two operational modes.

Mode 1: Uses the **Gear VR** – a head mounted display also referred to as mobile VR to allow users to visualise the flood event from close angles and in real time;

Mode 2: For **a stand alone android device** to allow users to freely explore the environment using the available on screen controllers while the flood is happening.

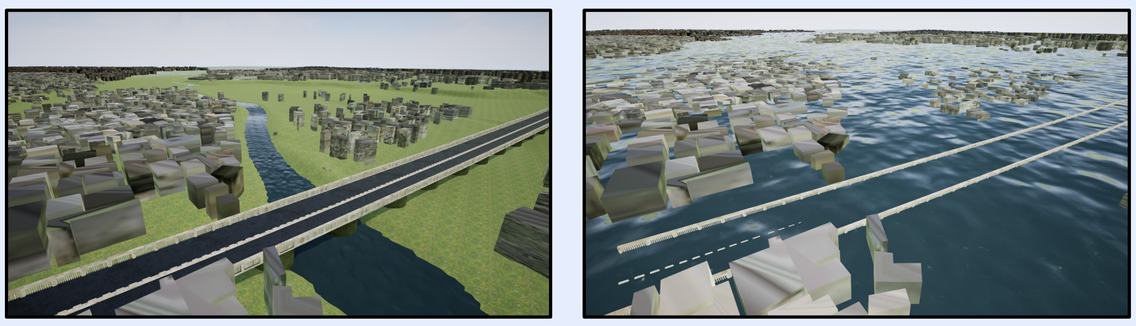


Fig. 2: Our Application: Jangwani Bridge, No flood (left) and flooded (right)

Workflows

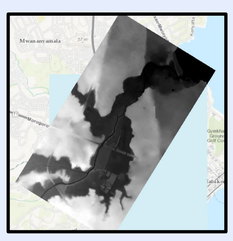
The datasets implemented in our application were collected previously using drones and other means e.g. for topological information and road locations. To create the assets for our mobile VR application several software packages were used including ArcGIS, Adobe Photoshop, Autodesk 3DS Max and Unreal Engine 4.

Fig. 3: QR code linking to Demo Fly-through

Data Pipeline: Terrains

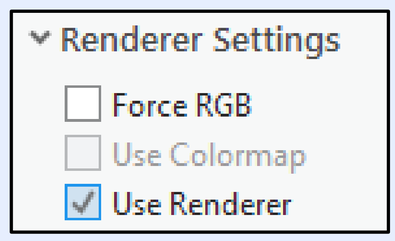
ArcGIS to Image Editing Software

- Export the Terrain as TIFF selecting the Use Renderer Setting, to avoid errors with reading the TIFF in Software other than ArcGIS;
- Open TIFF in an Image editing Software such as Adobe Photoshop, exporting as a PNG format.

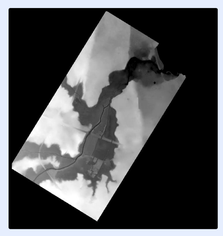


TIFF in ArcGIS

TIFF error outside ArcGIS



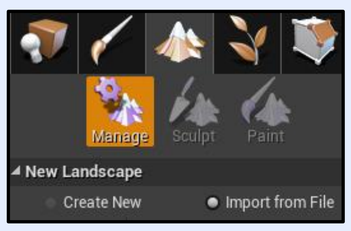
Export settings in ArcGIS



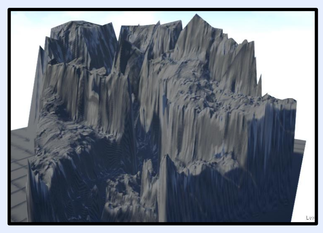
Correct TIFF export outside ArcGIS

Image Editing Software to Unreal Engine 4

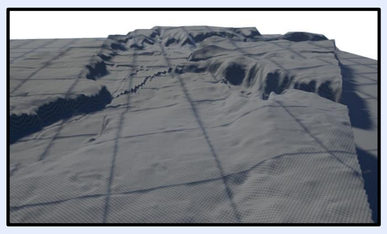
- Create a new landscape by importing the terrain PNG format into Unreal Engine 4;
- Control the Z axis scale, to avoid assigning to the landscape an incorrect height (see images below).



Importing Terrain



Z axis Scale: 100

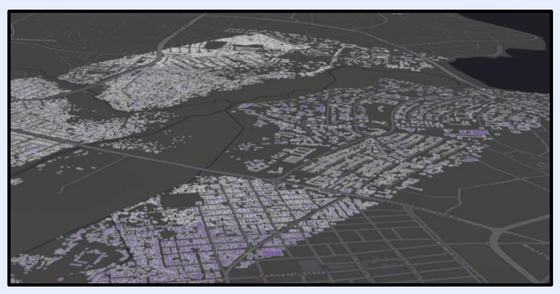


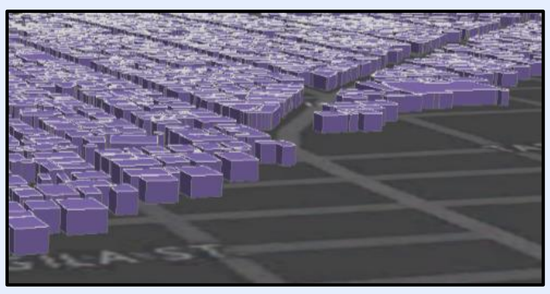
Z axis Scale: 10

Data Pipeline: Shape Files

ArcGIS to Autodesk 3ds Max

- 3D shapefile in ArcGIS are exported into Autodesk CAD format; this will export all of the shapes belonging to that layer, as one object;
- The Autodesk CAD format needs to be opened in Autodesk 3ds Max, in order to be exported as an FBX.





Autodesk 3ds Max to Unreal Engine 4

- It is important to select small areas of the mesh in 3ds Max and then export as FBX as it will incorrectly render the mesh in VR for large meshes;
- Import FBX files into Unreal Engine 4.

Challenges

A prominent issue in this process was the apparent incompatibilities among the different software packages, e.g. in terms of file formats, creating the need for **standardisation** of the underlying **data pipelines**. A further issue identified in our development regarding the data pipelines was the need for **optimisation**, e.g. in terms of file sizes, to avoid performance bottlenecks and more importantly unwanted performance penalties, e.g. **display latency** disrupting the real-time user experience when running the application on standard mobile platforms. Although streamlining has been conducted manually for this prototype, in future we are planning to integrate (semi-) automatic techniques to allow **scalable processing** of data pipelines.

Conclusions and Future Work

We reported on a proof of concept mobile VR application to communicate the effects of flood; **fly-through videos** generated from this application can be seen through the links to the QR code on the left (Fig. 3). The plan is to built upon this innovative tool to develop a **fully fledged environment** to demonstrate flood impact and mitigation efforts to a **wide range of viewers**: government agencies, affected communities, bilateral organisations and other stakeholders in the Msimbazi Valley.

The next steps in our developments are to add a controller to allow end-users to **manually alter** flood parameters (e.g. depth) and define key points of interest along which to generate **customised navigations** of the virtual environment, e.g. including zooming in/out and/or other interaction operations. We are also planning to work on **standardising** and **optimising** the underlying **data pipelines** towards offering an easy transition from the original flood/terrain datasets into the Unreal Engine 4.

Our ultimate vision is to develop a **lightweight** and **modular toolkit** for TURP that can be easily deployed by the relevant users (e.g. via web services) who are typically non-experts in VR giving them interactive and engaging visualisation experiences to communicate the impact of floods and the efficacy of mitigation solutions.