

Augmented Reality for Flood Visualisation

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Abstract

Flooding worldwide has seen increased attention in local and national news over the past decades. The public's need to familiarise and respond quickly to these dangers is very important. Smartphones are a feasible medium through which to educate the public in this way. This paper presents work for a prototype App to engage the public with local flood zones and to visualise potential flood levels. The App is designed to be reusable anywhere in the world, so as not to be restricted to any one particular location. Necessary aspects and considerations of such an app are discussed and future directions presented by way of an example use-case at the River Don's Pocket Park, Nursery Street, Sheffield, UK. This work forms part of the EU funded Citizen Water Observatory project called WeSenseIt.

Keywords

Key vulnerabilities and risks, Flood visualisation, Augmented Reality, Urban Landscapes.

I. INTRODUCTION

CITIZEN observatories establish, collect, process and combine new and existing data sources to produce useful knowledge for a given problem domain. Benefits to both stakeholder and client result from a shared interest in the problem domain and data resulting from mutual interaction. The WeSenseIt Citizen Water Observatory (funded by the European Union Seventh Framework Programme FP7/2007-2013 under grant agreement n 308429; www.wesenseit.eu) facilitates solutions for water-related decision making problems arising due to climate change. Problems in this domain often involve conflicting constraints relating to the environment, economic development, and society (Ciravegna *et al*, 2013). WeSenseIt's rich support of technologies include a variety of sensors, social media analysis, mobile device apps, decision support, and citizen observatory infrastructure. Case studies are conducted in Alto Adriatico Italy, Doncaster UK, and Delft Netherlands (Lanfranchi *et al*, 2014). This paper outlines work carried out within the visualisation work package of the WeSenseIt project.

Flooding in local areas has become increasingly common in recent times (e.g. Yorkshire Water, 2012), and so raising public awareness of potential river levels in local areas is important. The main objective of the proposed work is to involve the public and raise awareness of the reality and danger of local flooding by providing an on-site Augmented Reality (AR) impression (through visualisation) as to the severity of a given flood warning or a user-specified flood level. As a result it is hoped the public will be quicker to respond in times of flooding thus potentially reducing injury and saving lives. Overall, this work furthers the development of practical and life-saving tools to help local populations living in and around flood zones worldwide. The scope of this work goes beyond flood visualisation, with adaptations to other water-related projects possible such as planning and design and renewable energies in and around water catchment areas.

Challenges include demonstrating the ability to utilize AR for flood visualisation on mobile devices, including calibration and maintenance of consistent frame of camera reference within the environment e.g. since no two user's viewpoints are ever the same. Another difficulty is to effectively recognize and/or create 3D models of surrounding buildings in a given flood zone to aid realistic flood visualisation. Models should be built on-site in real-time, or automatically constructed from image feature recognition or from Light Detection and Ranging (LIDAR) aerial data.

II. AUGMENTED REALITY

Augmented Reality (AR) allows to overlay virtual models in perspective view over existing [urban] landscapes using a mobile device and to experience the landscape directly whilst on site (Lange, 2011). The semi-immersive AR app presented in this paper was developed to visualise potential flood levels of known flood zones in real-time. Justification for the use of AR to achieve this goal is evidenced by recent studies of user preference towards immersive experiences (Gill *et al*, 2013). AR provides a direct-to-user hands on experience of the subject matter within the environment of interest. Additionally, mobile devices are omnipresent so that Apps are easily disseminated and obtained by the end-user.

AR's recent revival due to the advent of Smartphones and Wearables has given rise to many Software Development Kits (SDKs) which remain largely undeveloped for in comparison with traditional Smartphone Apps, e.g. Sony's Smart Eyeglass,

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Manuscript received 1 May, 2015.

Google Glass, and Oculus Rift are recent example technologies. There are many unexplored potential applications. The challenge is to determine how to use AR to achieve the objectives of this work in mind. We present a novel solution based partly on a combination of menu, tactile gesture-, and voice-controlled commands. Together, these tools provide for a user-friendly and robust AR app to enable flood simulation in support of the project objectives.

A number of approaches to environment tracking are available such as GPS/Compass/Gyro/Accelerometer, Fiducial Markers, Natural Feature Tracking (NFT), 3D Simultaneous Localisation and Mapping (SLAM), and others (Feng *et al.*, 2008). This work focuses on NFT (2d image tracking) as most AR SDKs now support NFT as standard. We use the free Qualcomm Vuforia SDK. Other systems are available including 13th Lab, metaio, Total Immersion, and Wikitude, for example. Each supports different combinations of platform, tracking, and licensing ranging from free to proprietary.



Fig. 1: Pocket Park and Flood Defense by the River Don at Nursery Street, Sheffield City Centre.

III. DISCUSSION OF THE APP

Details of the prototype App are now given with discussion by way of an example use-case at the pocket park and flood defense in Sheffield, UK (see Fig. 1)

Initially the user must take up position along the riverside. To maintain good AR stability experiments show the perceived vista should contain limited motion parallax, i.e. when orienting the mobile device (position, pitch, yaw, roll) a vista in which objects remain (reasonably) stationary relative to one another works best. The system does work with higher parallax vistas, but with increased visual defects and intermittent discontinuity of visualisation. This artefact is most likely a result of NFT tracking, resolution of which might depend on alternative tracking method(s).

A target image is taken live on-site to calibrate the App to the environment. The underlying NFT system tracks the target image to maintain a geometric frame of reference (see Fig. 2). No matter how the user orients the mobile device the system keeps track of the target image so long as the target is at least partially in camera view. The target image centre is designated origin of the frame of reference into which geometric models may be placed.



Fig. 2: Target image tracking, with the user panning the mobile device from left to right.



Fig. 3: Mock up of riverside navigation at River Don, Nursery Street, Sheffield.

At this stage the user may navigate the riverside in vicinity of the target image as depicted in Fig. 3. Currently only one target image is supported, but multiple targets can be processed with relative ease to provide the user with a larger area of ground cover, e.g. to support AR coverage along a whole riverside. Persistent tracking usually requires the target image to be in camera view at all times, but “extended tracking” can be used to maintain tracking by inferring where the target image should be when out of camera view.

Flooding an environment using AR requires geometric knowledge of surrounding buildings, i.e. occlusion geometry. Occlusion geometry is necessary to occlude a virtual flood plane where buildings would in reality obstruct water flow. There are a number of options available to achieve this including automatic building recognition (using techniques of computer vision), automatic building model construction (using aerial LIDAR data, see Fig. 4), loading and positioning pre-built models, and real-time on-site construction of building geometry by the user. The current prototype uses the latter approach. The former two approaches are more complicated, in particular the first, but the second approach may be an option for future development since LIDAR data (see Fig. 4) is freely available for academic use. In particular, LIDAR data of UK rivers is available at 25cm resolution, with most of the UK covered at resolutions between 50cm and 2m.

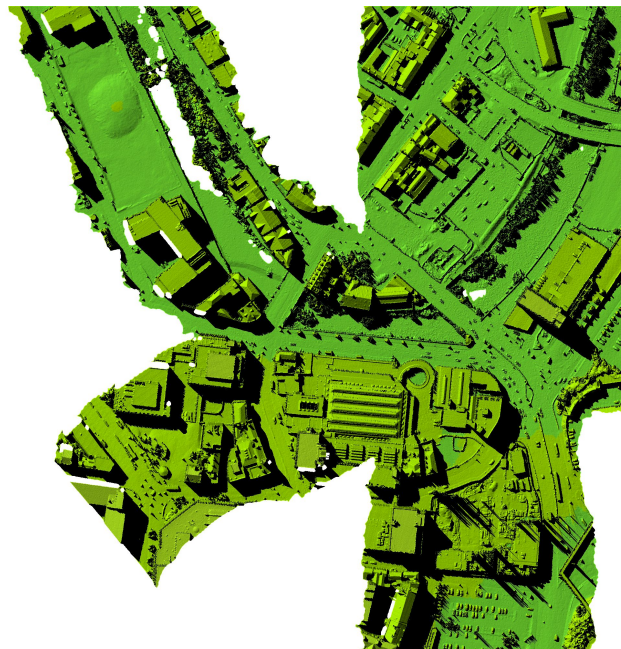


Fig. 4: LIDAR data for River Don, Nursery Street, Sheffield, freely available for non-commercial use from Geomatics Environment Agency at resolutions of between 25cm-2m.



Fig. 5: Real-time construction of occlusion geometry (actual app footage).

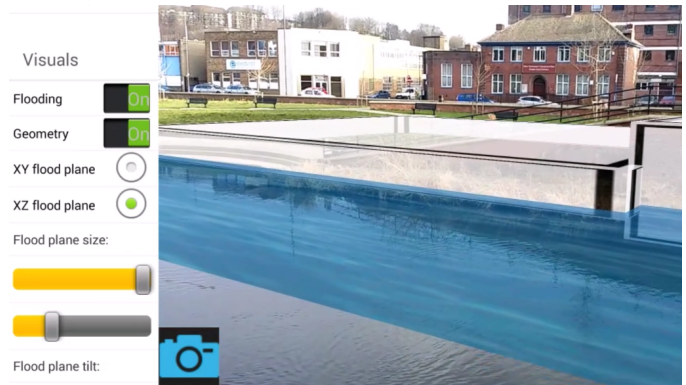


Fig. 6: Flooding the environment with occlusion geometry enabled (actual app footage).

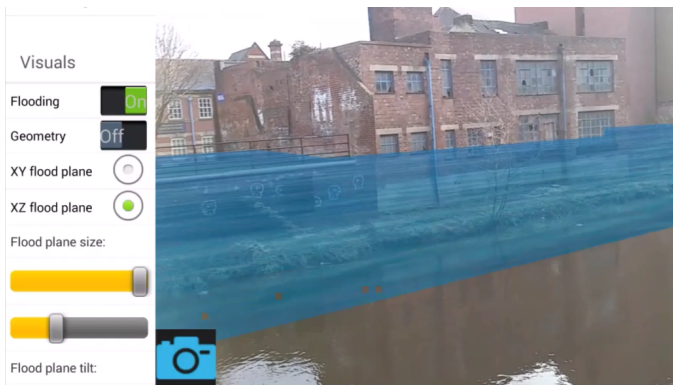


Fig. 7: Right-panned view of the flooded environment with occlusion geometry disabled (actual app footage).

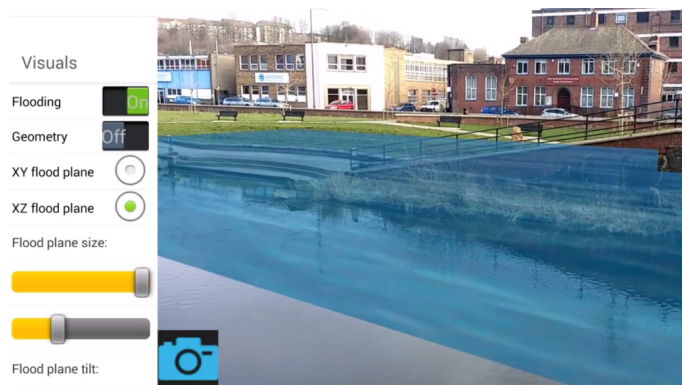


Fig. 8: Left-panned view of the flooded environment with occlusion geometry disabled (actual app footage).

Constructing geometry on-site in real-time poses the problem of effective Human Computer Interaction (HCI). The current solution works well, with a navigable left-side scrollable menu which can be hidden/revealed as required. Experiments with voice command recognition were also carried out using the Pocketsphinx SDK, but the menu based system was adopted for primary HCI as it is consistently reliable. Objects can be easily populated, positioned, scaled, and translated on screen whilst orienting the mobile device within the environment. Fig. 5 shows primitive geometric models representing the brick walls and pocket park. Currently only primitive geometric objects are supported, but this could be improved upon, particularly with the inclusion of automatic geometric model construction from existing LIDAR data.

Flooding the environment is then possible, as depicted in Fig. 6 with occlusion geometry enabled, and in Figs. 7 and 8 with occlusion geometry disabled. At this point the user is free to navigate the vicinity and experience different flood levels. This is currently achieved by manually raising and lowering the flood level parameter. Future development might see control of the flood visualisation linked directly to the WeSenseIt water sensors, or to a flood model based on these sensors.

IV. CONCLUSION & FUTURE WORK

Viability of the use of AR for the proposed objectives has been demonstrated, with development of an App to track the environment, populate it with occlusion geometry, and introduce an interactive flood plane. Occlusion geometry editing allows a user to construct building models in real-time and virtual flooding allows a user to gain a sense of risk within the environment. Preliminary results support proof of concept as a prototype application.

A key problem of AR for such applications is that of correctly matching real-world coordinates in physical space with corresponding coordinates in AR space displayed through the mobile device's display. At the very least, knowledge of three such corresponding pairs of points is required to correctly position objects on screen as they should appear in the real world. Moreover, knowledge of the physical distances between these points is necessary to represent AR distances on the mobile display. Work is currently underway in this direction.

Additional improvements, as mentioned earlier, could be made to the way occlusion geometry is created. Automatic building recognition would be one option, but perhaps a simpler initial approach would be to use readily available LIDAR data. This, however, also has its drawbacks since LIDAR data may become outdated due to new local developments over time.

Assuming these problems can be addressed, the flood visualisation could be linked to sensors or a flood model based on these sensors. Ports to wearable technologies such as Sony's Smart Eyeglass may also provide a more immersive natural experience.

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