Flood Action VR: A Virtual Reality Framework for Disaster Awareness and Emergency Response Training

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Figure 1: Screenshots from Flood Action VR. (a) start screen (b) speech-activated information window

ABSTRACT

Natural disasters constitute unexpected and severe threats with devastating effects on communities worldwide. Recent studies emphasize the importance of public awareness and training of first responders in disaster preparedness and response activities. This paper presents a virtual reality framework that creates a realistic 3D gaming environment with real-time and historical weather and disaster conditions. Main goals of the project are to increase public awareness about disasters by using gamification techniques, and train and evaluate emergency responders by simulating real-life scenarios. The system is supported by voice recognition to interact with the virtual world, and analyze user's actions and voice to detect emotional and psychological state.

CCS CONCEPTS

• **Human-centered computing** → **Virtual Reality**; • **Computing methodologies** → **Simulation environments**;

KEYWORDS

virtual reality, disaster awareness, serious gaming, natural language processing, emergency response

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1 INTRODUCTION

Number and devastating impacts of natural disasters have grown significantly world-wide. Total cost of Hurricane Harvey is estimated in the range of $198 billion, surpassing the estimates for Hurricane Katrina's damages [Hicks and Burton 2017]. Recent studies emphasize the importance of public awareness and training of first responders in disaster preparedness and response activities [Burningham et al. 2008; Kapucu 2008]. Novel devices in virtual reality (VR), and advanced techniques in artificial intelligence (AI), and graphical processer units (GPU) makes it possible for state-of-the-art simulations of real-world physics and scenarios in affordable devices. Benefiting from these developments, a virtual world can be created for public and professionals to immerse themselves into an environment to experience a disaster or extreme weather event. Using VR to simulate different scenarios provides a realistic and safe workspace that allows repetition and precise measurements while removing the limitations and challenges of real-world training.

In this paper, we present Flood Action VR, a multi-player and voice-enabled virtual reality gaming framework, with its extensive data resources. Application supports different untethered and tethered virtual reality devices. Design goals of the framework is to serve as an engaging game to increase public awareness on disasters, an educational environment for K-12 and college students, a training platform for emergency responders, and a decision support tool for decision makers and scientists.

2 FLOOD ACTION VR

Flood Action VR is a virtual reality framework that utilizes real-time and historical weather, disaster, and geographic data to construct a 3D gaming environment for awareness and training about disaster preparedness and response. Architecture of the game (Figure 2) includes weather and geographic data layer, VR game framework, interaction channels, and targeted devices. Data in the framework is

retrieved from various sources including the United States Geological Survey (USGS), National Oceanic and Atmospheric Administration (NOAA), The Weather Channel (TWC), and ArcGIS City Engine. The framework allows users to interact with the environment using natural language (NL) by supporting speech recognition.

2.1 Data Resources

Flood Action VR is empowered by various real-time and static data resources that are incorporated in different stages of the application. Elevation and terrain pattern is critical in the simulation of floods to calculate inundation level and water flow direction for specific locations. Digital elevation model (DEM) data is used to recreate the surface of the terrain. Texture for the reconstructed terrain is retrieved from satellite images and mapped to the 3D models. ArcGIS provides geolocation, elevation, and shape files for buildings, trees, roads, bridges, and traffic lights that are used for 3D construction. Weather and disaster data is integrated in the application to realistically create the environmental circumstances for disaster scenarios. Retrieved real-time and historical weather data consist of precipitation duration and intensity, humidity, wind speed and direction, temperature, and visibility along with the observation location and time. Historical flood events are defined by flood extent, return period, depth, watershed characteristics, and water level data.

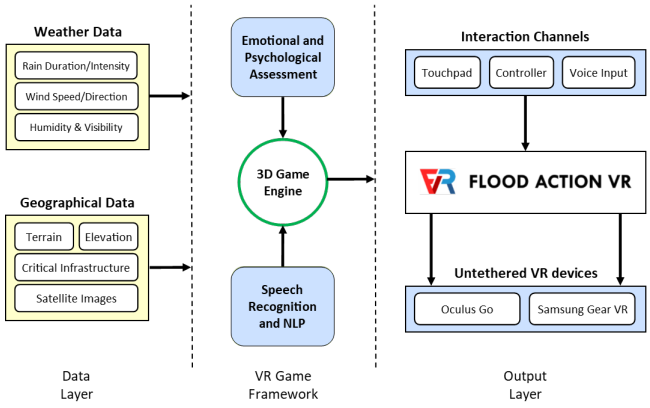

Figure 2: Architecture of the Flood Action VR framework

2.2 Gameplay

Game consists of various tasks to be accomplished during extreme weather and disaster events. Users can explore the environment by flying like a rescue drone. Interaction is made via voice with NL commands or using the inputs of the client device via touchpad or controller. Voice input is used to analyze voice trends of users along with their reactions to incidents to detect emotional and psychological state. Game features both single and multiplayer options to allow team activities which can result in higher satisfaction and game popularity [Salen and Zimmerman 2004]. Multiplayer option allows users to simultaneously play the game to achieve tasks while coordinating through real-time group voice chat. Although free-roaming is allowed to explore the virtual world, some tasks require to be completed in a predefined period of time.

2.3 Implementation

The application is implemented in C# using a cross-platform and virtual reality enabled game engine (Unity3D). Unity3D is utilized due to its rich 3D resources, support for advanced physics, and mobile deployment and publishing capabilities. 3D components for terrain and critical infrastructures are modeled and constructed in ESRI City Engine, and exported in FBX file format which then is imported in Unity3D for use in scene generation. The Flood Action VR supports Android operating system for use with Samsung Gear VR virtual reality headset. Other virtual reality headsets can be supported as well by merely updating the interaction methods adhering to the user interface of the targeted device.

3 DISCUSSION

The initial prototype of Flood Action VR was announced and presented at the 2017 Samsung Developer Conference (SDC) as part of The Weather Channel SDC Innovation Challenge. More than 200 individuals tested the prototype version of the application that features the outdoor mode with real-time weather data and generated flood scenario. Participants consist of a diverse set of people from various technical backgrounds, including students (K-12, undergraduate and graduate levels) professionals, developers, designers, entrepreneurs, and faculty from all around the world. Even though participants were not trained prior to testing the game, and didn't have a chance to play for long periods of time, they were able to successfully navigate in the game and complete tasks with little instruction due to the application's intuitive gameplay.

4 CONCLUSIONS

This paper presents Flood Action VR, a virtual reality framework to increase public awareness for extreme events and provide an immersive and interactive environment for training and education on disaster preparedness and response. Framework utilizes extensive real-time and historical weather and geographical datasets and employs gamification techniques to ensure an engaging and realistic experience. The framework provides extensive opportunities for accessibility, scalability, and adaptation to different use cases due to its global data support, utilization of dynamic geospatial datasets, immersive virtual reality models, capability to capture behavioral and psychological evaluation of the players, and potential to become a support tool for emergency responders and decision makers.

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