# Radiation Detection, Measurement, and Visualization Assisted by Virtual and Augmented Reality

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**Abstract-** Localizing a radiation source in an urban environment is a challenge in nuclear nonproliferation and radiation detection. Mobile radiation sensor networks can be sent into an area of interest to collect count rate measurements at many locations in an attempt to find the radiation source. However, there are numerous factors that cause fluctuations in background count rate such as time and location, and these factors make it challenging to analyze the collected data. Displaying these measurements in a virtual model has contextualized them and made it easier to determine if environmental factors are introducing false positives. A virtual model has been shown to display measurements in near real-time, but not in real-time. The ability to quickly localize a source is hampered by this lack of real-time data access as well as by poor quality of virtual models.

This paper introduces, 1) a new data streaming approach to display sensor network detector data viewable in a virtual reality model within a second of measurement, 2) an application designed to quicken statistics-based decision-making on the possibility of a source in an area, and 3) results of a photogrammetry 3D modeling technique that more easily creates higher fidelity models. Data streaming is improved by using AWS DynamoDB for quick data storage and access. An augmented reality application guides users through the process of sampling an area and statistically determining whether a source is present. Drone photogrammetry via Agisoft Photoscan software is used for high fidelity 3D model creation.

# I. INTRODUCTION

In the event that a strong radiation source such as specialized nuclear material needs to be quickly found in an urban environment, a mobile sensor network of many moving radiation detectors can be used to search for the source. Throughout an area of interest, a mobile sensor network collects measurements in real-time to narrow down the location of the source. A data center can process the collected data and help guide sensors to locations that may need additional measurements. In this problem, variations in measured background count rate due to environmental factors such as weather or building material can cause false alarms. Zircher built a to-scale virtual reality (VR) model of a city to display the data collected by the real sensor network in its environmental context, helping users identify false alarms more easily [1].

Zircher's model provides an intuitive way to interpret measurements taken by a mobile sensor network but collected data can only be accessed from its storage bin in the cloud after a 10-minute period [1]. Furthermore, building the 3D virtual models of actual facilities and environments can be resource intensive. In order to develop the virtual model as a real-time tool for a source search, data would need to be available quicker and quality of the 3D models would need to be improved at less cost.

The Kromek D3S detectors, used to collect data for Zircher's virtual reality model [1], can help narrow down the location of a source. Statistical inference of the presence or absence of a source can be made by using the Visual Sample Plan (VSP) software [2]. VSP is a software designed by Pacific Northwest National Laboratory for generating statistic-based sample plans for situations such as response to a radiation terrorist event [2]. A sample plan for this purpose defines where to take radiation detector measurements in an area as well as how many measurements are necessary. Sample locations are generated by VSP once the area has been manually modeled in the software. Modeling takes time, and the coordinates of the resultant sample points where data needed to be taken are difficult to identify quickly in the real world.

We here report new approaches developed to improve time-of-response when using VSP, make detector data quickly available in a virtual city model, and improve virtual model fidelity. VSP is aided through augmented reality (AR) to quickly create a sample plan and reach sample locations. Detector data is made available more quickly by using AWS DynamoDB for storage of immediately accessible data. Virtual model fidelity is improved through drone imaging and photogrammetry. This paper will give a brief overview of the application of these methods.

## II. AUGMENTED REALITY TO GUIDE SAMPLE COLLECTION

The goal is to simplify and automate the process of data collection at desired locations, called *sample locations*. An application was developed in the Unity game engine to run on the Microsoft HoloLens hardware. The HoloLens glasses project holograms onto the environment for the user. The application first collects spatial mapping data and generates a triangular mesh over the environment. The triangular mesh (Fig. 1) represents surfaces where sample locations, where data need to be collected, can be generated. Users first scan the area of interest to define it, and then can generate random sample locations on the surface. Sample locations appear as a virtual cube with a menu and a number floating below it (Fig. 2). The menu offers options to change the color of the cube when data has been collected (green) or skipped (red) in the sampling process. The number indicates which sample location is being viewed.

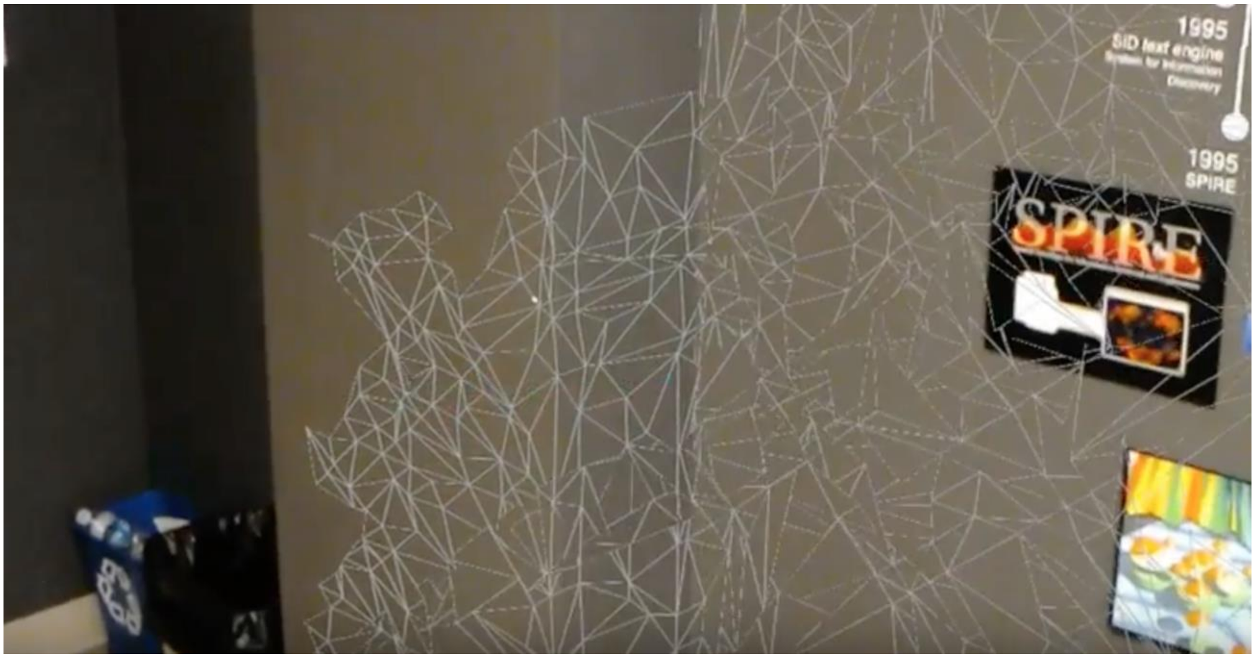

Fig. 1. Spatial mapping mesh partway through the mapping process.

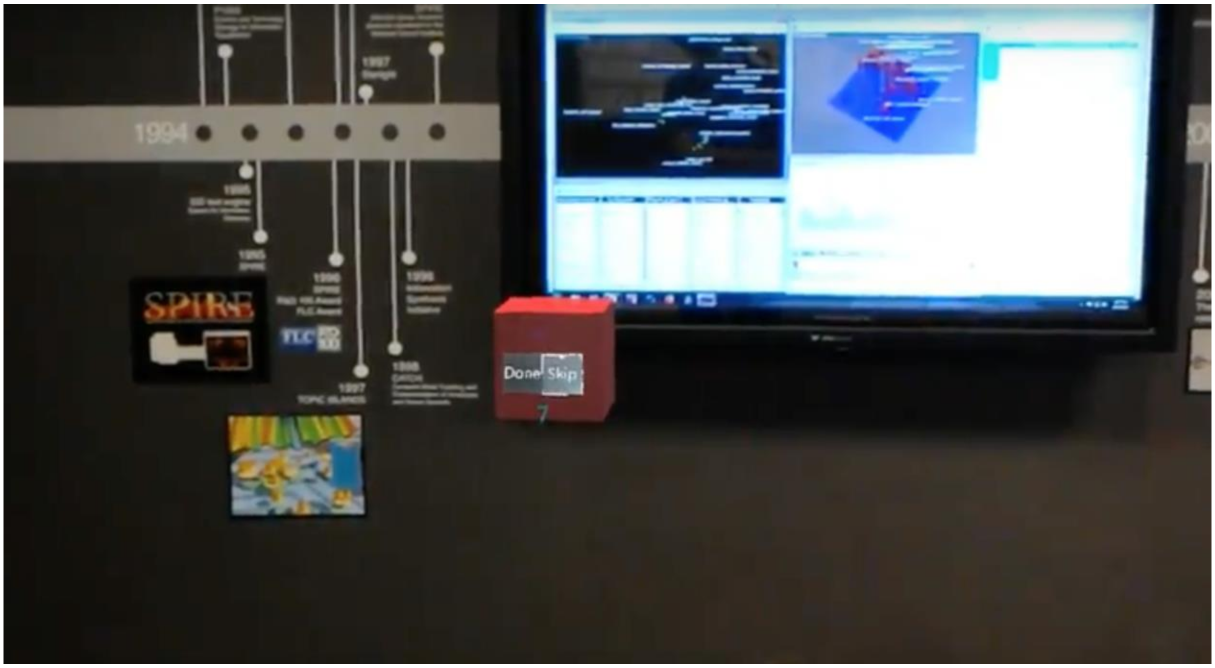


Fig. 2. A skipped sample, number 7, on the edge of a tv monitor.

## III. REAL-TIME DATA ACCESS IN UNITY GAME ENGINE

A new data streaming method was identified and implemented to gain immediate access to new field detector measurements inside a Unity virtual environment. An AWS DynamoDB table updates each second with new data. The table also allows access to the data as soon as one second after the update. A sample of the data in the table is shown in Fig. 3. Using the DynamoDB C# package, each second a script accesses the newest measurements made by a detector and can update the display in the virtual environment.

| detectornumber | time | counts | latitude | longitude |
|---|---|---|---|---|
| D3S SGM104446 | 1524774977 | 27 | 40.1119484 | -88.2285094 |
| D3S SGM104446 | 1524774978 | 33 | 40.1119484 | -88.2285094 |
| D3S SGM104446 | 1524774979 | 25 | 40.1119484 | -88.2285094 |
| D3S SGM104446 | 1524774981 | 31 | 40.1119484 | -88.2285094 |
| D3S SGM104446 | 1524774983 | 30 | 40.1119484 | -88.2285094 |
| D3S SGM104446 | 1524774984 | 32 | 40.1119552 | -88.2285182 |

Fig. 3. Detector data stored as a DynamoDB table on AWS.

## IV. PHOTOGRAMMETRY TO IMPROVE MODEL FIDELITY

The Agisoft Photoscan software builds 3D models from many images of an object or area. A DJI 3 SE drone was sent in a circular path around the roof of the University of Illinois' Talbot Laboratory by using the Pix4DCapture mobile application. 84 pictures taken in the air around the building were processed in Agisoft Photoscan. A high fidelity model was generated using the high quality reconstruction options (Fig. 4). Developing a similar model with classical approaches would have taken much more effort.

Fig. 4. Photogrammetry generated model of Talbot Laboratory

## FUTURE WORK

The new data streaming approach solves the latency on data availability, and modeling with photogrammetry allows generation of high fidelity models with less effort. The augmented reality application, however, must be integrated with the visual sample plan software. VSP should eventually run directly on the HoloLens and take the spatial mapping data collected by the HoloLens as input. That way, statistical models for sampling can be applied from the HoloLens.

ACKNOWLEDGEMENTS

This work was supported in part by the Consortium for Nonproliferation Enabling Capabilities under Department of Energy National Nuclear Security Administration award number DE-NA0002576. Thank you to Nick Cramer at PNNL for his work on the AR app, the VSP team at PNNL for designing the initial software.

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