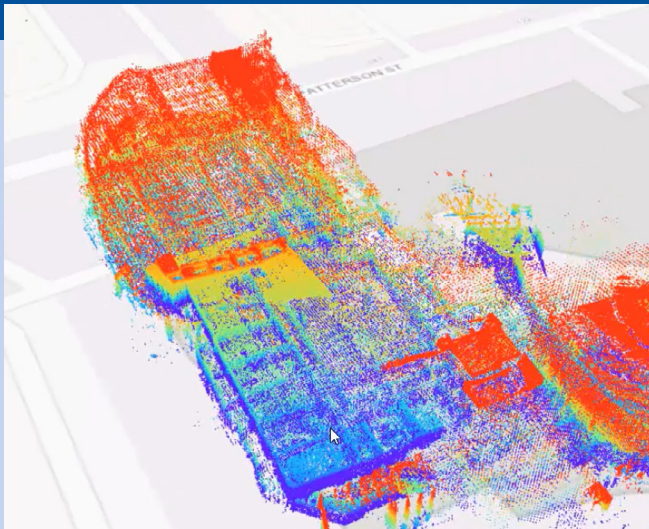# Map901:

Building Rich Interior Hazard Maps for First Responders

City of **MEMPHIS**

U of M THE UNIVERSITY OF **MEMPHIS**

The City of Memphis, in partnership with the University of Memphis, was awarded the Point Cloud City grant from the NIST Public Safety Innovation Accelerator Program for the *Map901: Building Rich Interior Hazard Maps for First Responders* proposal.

After receiving the award, the University of Memphis began surveying 1.86 million square feet of indoor space. The data collected was processed by the City of Memphis for the development of an app that would benefit first responders by aiding in strategizing emergency events.

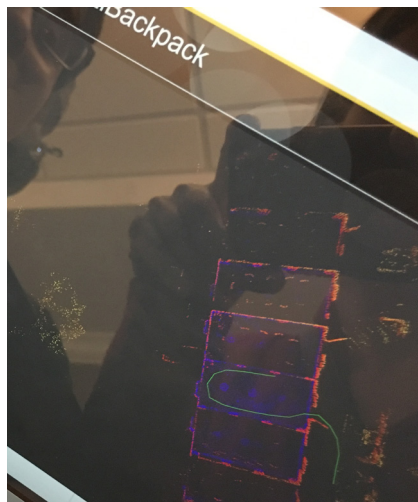| 1.86 Million Square Feet of Indoor Space Surveyed	
Pink Palace	Hickory Hill Community Center
Benjamin L. Hooks Central Library	National Civil Rights Museum
Wilder Tower, UofM	Liberty Bowl Stadium
FedEx Institute of Technology, UofM	

"Accurate, readily available, information-rich indoor maps and models are one of the keys to unlocking indoor localization, tracking, and navigation for first responders – both from an operational standpoint and to enable the R&D community to address specific public safety requirements in this field." -NIST Public Safety Innovation Accelerator Program (PSIAP) – Point Cloud City

Technical Approach

When the surveying began, the team used a camera and LiDAR separately which proved problematic when it came time to sync the cloud points and images. To correct the issue, GVI LiBackpacks with GPS input for timing and synchronization were combined with an Insta360 camera (to provide colors that can easily be referenced to the LiDAR points). Tracking cameras are used in small spaces that are otherwise difficult to scan. SLAM solution software stitches all colored points into one 3D model.

Data is gathered as the team walks through the building with the backpack. GPS locations of external points are used to geo-reference 3D LiDAR point cloud data. Temperature, humidity, and sound information are collected separately by two other sensors. The information from these sensors combined with the image data is used to annotate the algorithm.

Survey using LiDAR backpacks, 360° cameras, tracking cameras, GPS, temperature, humidity and sound sensors.

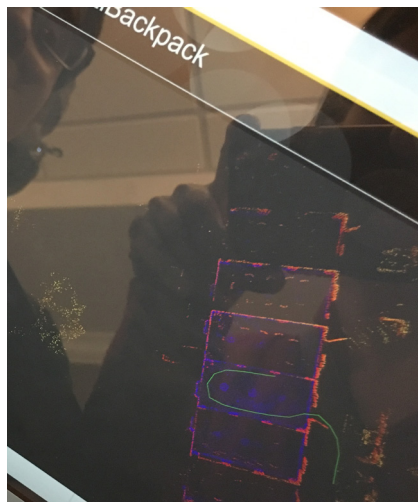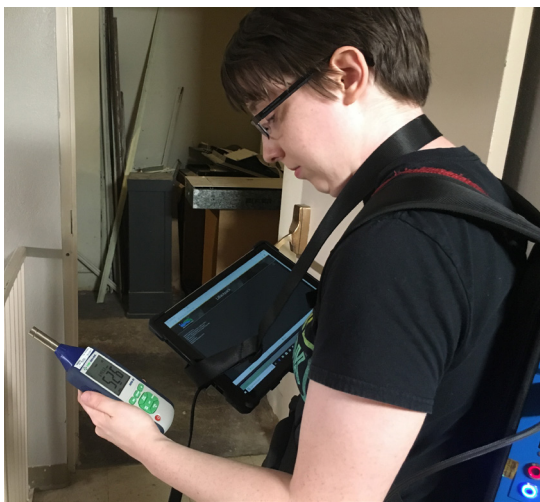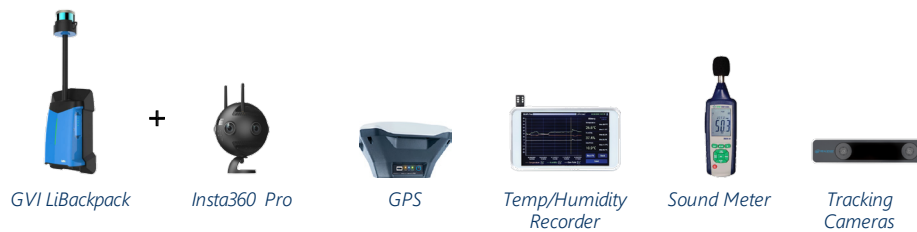| GVI LiBackpack | + | Insta360 Pro | GPS | Temp/Humidity Recorder | Sound Meter | Tracking Cameras |

Point Clouds

Point clouds are a collection of spatial 3D data points defined by a given coordinates system (typically x, y, z coordinates). A point cloud is made up of tiny data points in the three dimensional world to ultimately reflect a physical space. They are collected from a scanner, e.g. LiDAR in a 3D coordinate system, and used to create 3D models such as architecture or virtual reality applications.

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Data Processing Workflow

Annotated 3D point cloud
with RGB information
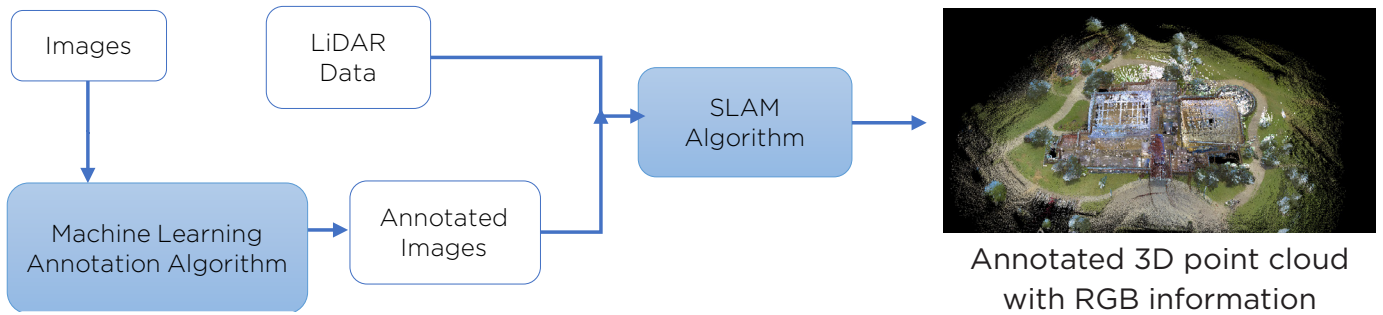
Image Annotation

Mask R-CNN (convolutional neural network) and Google's Inception-ResNet-v2 were trained to detect public safety objects. Mask R-CNN is the gold standard for image classification. R-CNN analyzes snapshots and correctly identifies objects via a bounding box. Inception-ResNet-v2 classifies those objects and refines the bounding box. 43 label classes have been created for a training and testing dataset, e.g. exit sign, fire alarm, person.

Examples of Objects Detected with Machine Learning		
Utility shutoff	Person	Entrance and exit
Hazmat	Shelf	Fire alarm
Door and window	Roof access	Backpack

Best Practices in LiDAR Surveying

- ▸ Open all doors before surveying
- ▸ Avoid capturing moving objects during the survey
- ▸ Avoid exiting and entering interior spaces through the same threshold when the doorway is narrow
- ▸ Do not repeat a route already traveled
- ▸ Scan one or two floors at a time (<½ hour) and stitch the data together

DELIVERABLES

Data

A data catalog is available for public safety users and researchers and has been shared with the Open Geo-spatial Consortium pilot members. Soon, a request form will be accessible in the City's open data portal, data. memphistn.gov to facilitate indoor maps for smart buildings. Processed data is shared with NIST to accelerate research related to indoor mapping for public safety use cases.
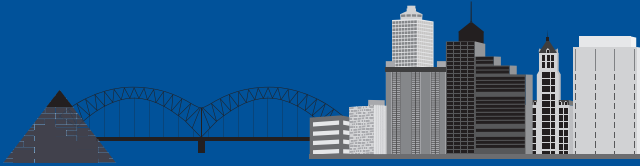
City of **MEMPHIS**
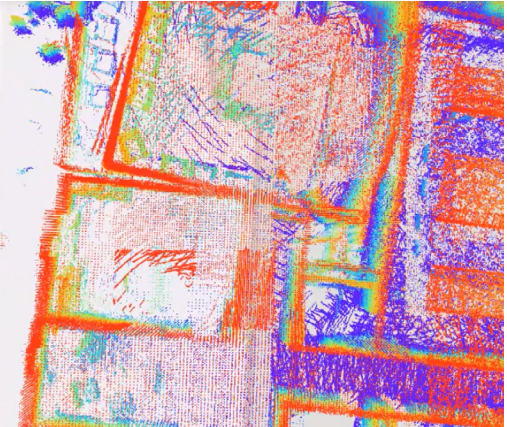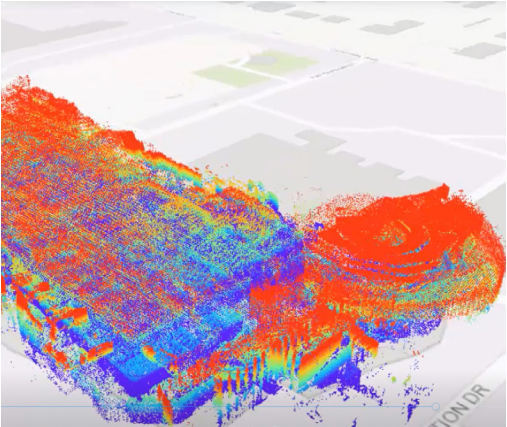
Insight 3D

The Insight 3D app helps first responders coordinate emergency events by allowing users to pan, zoom, and rotate through a building as well as show and hide floors. It is built on the ESRI ArcGIS platform and features a simple, easy-to-use interface that is available from any device via a web link. Future enhancements may include turn-by-turn navigation, an extruded 3D CAD layer for a more realistic view, and targeted objects of interest such as exits.

Virtual Reality

A virtual reality application of *The Year They Walked* exhibit at the National Civil Rights Museum showcases some of the possibilities of indoor mapping for immersive experiences. This type of application could be used for firefighters in training to foster the use of critical thinking to practice their skills, museum visitors to help them navigate displays, and for virtual tours of historic landmarks.

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