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Mobile Incident Command Dashboard (MIS-D)

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Abstract

Incident Command Dashboards (ICDs) plays an essential role in Emergency Support Functions (ESFs). They are typically centralized and display a massive amount of live data. In this study, we explore a decentralized mobile incident command dashboard (MIC-D) with an improved mobile augmented reality (AR) user interface (UI) that can access and display multimodal live IoT data streams in phones, tablets, and inexpensive HUDs on the first responder's helmets. The new platform is designed to work in the field and to share live data streams among team members. It also enables users to view the 3D LiDAR scan data on the location, live thermal video data, and vital sign data on the 3D map. We have built a virtual medical helicopter communication center and tested the launchpad on fire and remote fire extinguishing scenarios. We have also tested the wildfire containment scenario "Cold Trailing" in the outdoor environment.

Introduction

Incident Command Dashboards (ICD) provide a comprehensive real-time view of emergency situations, allowing incident commanders to visualize the space, track public safety officers, recognize the movement of other people and objects, and identify the important locations (e.g., collapsed bridges, victims, and first responders). Augmented Reality (AR) has emerged as a next-generation intelligent interface that integrates cutting-edge sensors, vision, and data communication. AR devices overlay the critical information to the surrounding environment, merging the virtual world with live data and interaction. However, current AR devices are not ready for live incident command and field applications yet: they are heavy, slow to boot, and lack expendability for IoT data streaming.

Many existing ICDs are located in fixed locations with massive wiring cables from sensors and to a wall of monitors. The operators are overwhelmed by the massive isolated 2D data without a holistic view of the 3D reality. For example, many incidents happened in three-dimensional spaces, such as the collapsed Fern Hollow Bridge in Pittsburgh, PA. Emergency medical systems (EMS) often operate in a 3D area, for example, medical helicopters need to navigate through 3D structures, find landing zones, and avoid obstacles like power lines and utility poles. Furthermore, future mobility command dashboards would include multimodalities such as drones and autonomous driving vehicles that depend on 3D LiDAR data to navigate through the city.

In this project, we are developing a portable Incident Command Dashboard (MIC-D) with an improved mobile augmented reality (AR) user interface (UI) that can access and display multimodal live IoT data streams in phones, tablets, HUDs, and first responder's helmets. The new platform is designed to work in the field and share live data streams and positions among team members. It also enables users to view the 3D LiDAR scan data on the location, thermal video data, and vital sign data on the 3D map. The concept design diagram is shown in Figure 1.

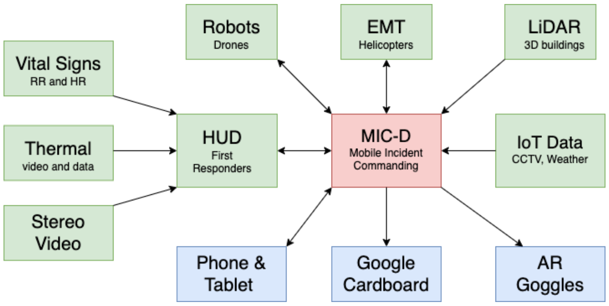

Figure 1. Diagram of the Mobile Incident Command Dashboard (MIC-D)

The Mobile Incident Command Dashboard (MIC-D) is the hub of multiple source data streams. The MIC-D has a set of mobile AR user interfaces (in blue color in Figure 1), including mobile phones, 2D/3D tablets (e.g., Lume Pad, made by Leia, Inc.), Google Cardboard (affordable stereoscopic display with a phone as low as $14 USD), as well as the enhanced AR goggles (e.g., HoloLens tactical goggle with night vision). From MIC-D, users can access and display real-time IoT data streams from CCTV, weather data server, traffic control data, EMT data (STAT MedEvac medical helicopter flight data and patient transport data), and drone flight data and onboard sensor data (RGB video and thermal video). The unique part of our MIC-D lies in the direct connection to the first responders' helmet, which collects and displays real-time vital sign data (e.g., respiratory rate and heart rate), and real-time stereo and thermal video data.

User Interface and Experience Design

Traditional incident command dashboards typically consist of a wall of monitors in an office and a pile of paper-based forms passing between different responder groups. They are not efficient in terms of command dynamic situations in the field. Mobility and UI/UX have been key issues. Many existing commercial AR/VR products have aimed to replace the wall of monitors and piles of paperwork. However, they have been designed for indoor environments, single users, and offline games, bulky and heavy. For example, Magic Leap ML1 is 740 grams (including the wearable computer) and HoloLens 2 is 584 grams. They have limited expandability to add new data streaming channels or new sensors. Their HUD (head-up display) interfaces are not designed for wearing for long hours (e.g., more than 8 hours) and the headsets prevent incident commanders and first responders from communicating face-to-face or sharing data effectively.

In this project, we aim to improve the mobility of the incident command dashboard. We use a phone and tablet-based platform for field command dashboards. This approach has several advantages: first, it takes existing communication infrastructures such as a 5G network, Bluetooth, Wi-Fi, hotspot, and NFC. Second, it also takes advantage of existing sensors such as cameras, LiDAR, motion sensors, touch screens, and the most important sensor: GPS, magnetic field, and altitude signals. Although mobile devices have their disadvantages – for example, the scalability of the displayed contents on small screens – in return the emergency management team can have better mobility and on-the-fly decision-making capability.

Figure 2. UI/UX design for improving the mobility of the incident command dashboard: 1) Dashboard on iPad and 2D/3D tablet Lume, 2) Dashboard on iPhone and Android phone, 3) Google Cardboard-based stereo display, and 4) the holographic dashboard on first responder's helmet.

In order to improve the User Interfaces (UI) and User Experience (UX), we aim to design the dashboard with ultimate mobility. The users can view and interact with real-time data on mobile phones and tablets. The touch screen is used for navigating multiple sources of data in multiple layers. Users can use their fingers or voice command to zoom in and out on details, drop markers, change the perspectives from 2D to 3D, or rotate the 3D models registered on the map. We trade off intensive interaction for the traditionally larger display space. To reduce overwhelming data streams, we use AI and Machine Learning algorithms such as Decision Tree to prioritize the data and display the critical data based on the user experience. To improve the scalability of the display, users can use Google Cardboard-like AR/VR goggles paired with their phones to view the dashboard in a 3D space. The cost of such an affordable device can be as low as $14 USD. Accessing the motion sensors on the phone, the device can track the user's head movements to see the virtual dashboards and navigate with a voice command interface or a smart watch. Incidentally, we are also building a simple IMU-based smartwatch as a remote controller. See the image at the bottom left in Figure 2.

Besides, users can tile multiple tablets to form a multi-screen display wall on an incident command truck. The users can also use 2D/3D tablets (e.g., Lume Pad from Leia, Inc.). We also built a holographic AR HUD for the first responder's helmet that can communicate with the dashboard MIC-D, which enables data sharing directly between teams and incident commanders. Our AR interface has a thermal camera, IMU, GPS from the phone, and other sensors. It weighs only 41 grams.

Accessing and Displaying Real-Time IoT Data

To access all the data coming from different sensors and IoT devices, our solution MIC-D integrates the Tactical Awareness Kit (TAK) as the backbone of our command dashboard. TAK is a map platform that is compatible with multiple operating systems, e.g., Android, iOS, and Windows, and supports real-time information sharing.

The main advantage of TAK is its unique way to visualize the data coming from IoT devices. It provides a real-time target marking mechanism called Cursor on Target (CoT). CoT can be dropped onto the map either manually from the platform (creating custom targets) or automatically from other devices (updating past targets). An example to illustrate how CoT works is the communication between our AR HUD on the firefighter helmet and the command center. Our embedded AR HUD supports TCP protocol. By following the format and data field requirements of CoT, our HUD can send a message to our command center through TCP to indicate the location and type of the event. As shown in Figure 3, the blue and yellow dots in the cold trailing application show a few data fields associated with CoT, e.g., the level of danger is indicated by the color field of CoT, the ground temperature is indicated with the name field of CoT, the geolocation is indicated with the location field of CoT, and additional information can be indicated with extra detail fields of CoT.

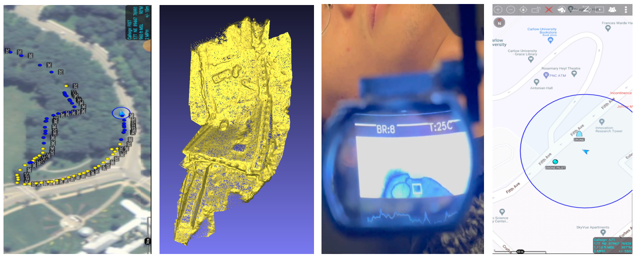

Figure 3. Access and display IoT data with our MIC-D system: 1. "Cold Trailing" (forest ground temperature mapping), 2. LiDAR (reconstructed collapsed Fern Hollow bridge), 3. vital signs (breathing rate), and 4. drone coordinates on a shareable map (cursor-on-target view and cursor view).

To distinguish between the past CoT data and our current location data, a blue arrow on the map indicates our current location and heading, and this is the cursor view from our phone (Figure 3). Combining CoT and the cursor view, anyone connected to the command center can get real-time updates on the emergency situation and the locations of first responders.

In addition to sharing and visualizing the numerical aspects of the emergency situation, our IoT devices can also stream video from the scene. Analyzing the video can provide unique biomedical information to first responders. For example, when the thermal camera is aimed at a survivor, the breath coming from the survivor can change the thermal readings around the nose, so first responders can give a quick diagnosis of the survivor's health condition and report to the incident command dashboard (the third from the left in Figure 3). The emergency medical responders can relay the data to nearby vehicles and hospitals, or they can provide telemedicine over the mobile dashboard.

To illustrate how to transmit the thermal video, consider the communication between our AR HUD and other devices. Using the UDP protocol, we can transmit compressed pixel values of the thermal image recorded in our AR HUD to other devices. We developed our own lossy image compression algorithm that is capable of running with a limited amount of memory on the embedded processor ESP32 and we can also attach temperature values or biomedical measurements to the compressed image. The devices on the other end can use our corresponding decompression algorithm to display the thermal image and temperature values in real time. Since this video streaming happens through UDP, the devices on the other end can be versatile - a laptop, another HUD, or a phone with TAK installed to display CoT and video in parallel.

In summary, our workflow is to collect the field data from IoT devices, then transmit and display the data on our mobile incident command dashboard (MIC-D). For further improvements, we can expand the types of data we can display. Due to the lightweight nature of our AR HUD and numerous sensors that can be interfaced with it, we will potentially develop new wearable sensors to collect and share biomedical vital sign data (e.g., breath and pulse rates) of first responders, so that the incident command center will recognize an emergency situation immediately and send reinforcements to rescue inactive first responders.

Conclusions

Incident Command Dashboards (ICDs) play an essential role in Emergency Support Functions (ESFs). They are typically centralized and display a massive amount of live data. In this study, we explore a decentralized mobile incident command dashboard (MIC-D) with an improved mobile augmented reality (AR) user interface (UI) that can access and display multimodal live IoT data streams in phones, tablets, and inexpensive HUDs on the first responders' helmets. The new platform is designed to work in the field and to share live data streams among team members. It also enables users to view 3D LiDAR scan data on the location, live thermal video data, and human vital sign data on the 3D map. We have built a virtual medical helicopter communication center and tested the launchpad on fire and remote fire extinguishing scenarios. We have also tested the wildfire containment scenario "Cold Trailing" in the outdoor environment.

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Yang Cai is the founder and head of Visual Intelligence Studio and a Senior Research Scientist at Calit2, UC San Diego, CA, USA. He is the author of 6 AI books, including the monograph "Instinctive Computing (Springer-London, 2017)

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