Unmellow Yellow

First Responder Assisting Sensor Payload

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Introduction

Data streaming over wireless communication is critical for operating remote sensor payloads. This article focuses on an implementation of a sensor payload designed to locate survivors in void spaces following natural disasters. Finding the optimal method of streaming data wirelessly is critical because any latency will waste possibly life saving time. Since the main goal is to create a remote operated vehicle that first responders could use, ideally from a safe location far from the disaster, our project will need to use wireless transmission. While wired communication offers better quality and speed, it does not allow for increased mobility or remote operation, which are both crucial for this project. This means that our transmissions will likely have worse quality when compared to a wired implementation.

Video Transmissions

Data and Data Loss

Both video feeds and raw numerical data will be streamed from the sensor payload. Two different video feeds will be streamed: one for navigation and one for detecting heat signatures of possible survivors. Since the video feeds will be the most demanding on the communication bandwidth, the focus of this technical report was on how to best transmit video.

Data loss is when data being transmitted does not reach its destination. Wireless transmission can lead to data loss in multiple different ways, namely because of interference. Three options to mitigate this loss are encoding error tolerance, transmission adaptation, and decoding error concealment.

Video Feeds

The hierarchical structure of video feeds should be taken into consideration when deciding how best to stream the feeds. Service-oriented architecture (SOA) is ideal for video transmissions. Xie et al. propose an SOA consisting of two primary layers: a control layer that focuses on encoding and decoding transmissions and a resource layer that encodes error tolerance, decodes error concealment, and adapts transmissions. These services make the resource layer ideal for data loss mitigation in different situations, including unmanned vehicles.

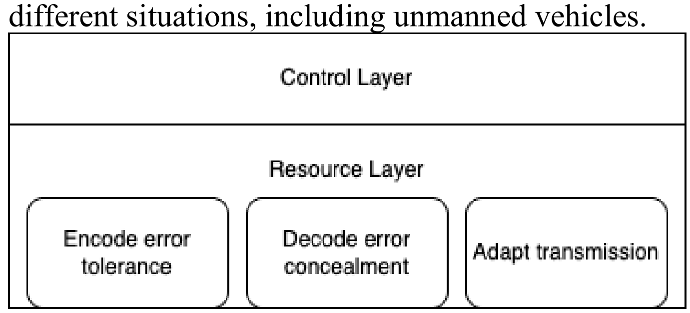

Figure 1. A simplified visual of Xie et al.'s proposed SOA.

The spatial and temporal locality of pixels in video feeds can be exploited. Across consecutive frames, pixels in the same position are typically similar. Likewise, pixels nearby each other in each frame are often similar. These details can be taken advantage of to mitigate data loss.

Streaming Methods

The project will be using a Raspberry Pi 4 as its data collection and transmission device. The main methods researched for streaming video from a Pi are WiFi, Bluetooth, and Bluetooth Low Energy (BLE).

Bluetooth and BLE

Both Bluetooth and BLE have the same theoretical range of around 300 feet ("All the Internet of Things - Episode One: Transports"). However, this would require a very powerful radio. "All the Internet of Things" states that even more than just 30 feet would be difficult. BLE's data transmission rate is worse than that of Bluetooth. For simple projects, BLE could be ideal as it uses less power and has a fast connection time. However, given the nature of our product, it does not make sense to prioritize these over a higher data transmission rate.

Catania and Zammit successfully used Bluetooth for streaming video using two different protocols. They tested several different methods of transmitting video, such as transmitting an encoded video stream from a mobile phone to a Linux station. Their conclusion was that video streaming over Bluetooth was possible but would require extensive encoding and decoding of the video. The size of the data packets being sent was critical to their throughput, with a near linear increase in data throughput as data packet size increased. While Catania and Zammit saw potential in transmitting video over Bluetooth, they limited their testing to a maximum range of 10 meters, which matches with the maximum suggested range from "All the Internet of Things." If we deemed that this distance would be suitable for our project, it would be a viable option for our team to choose because a Bluetooth server could be created from the Raspberry Pi. However, given the dangerous nature of the environments that the sensor payload will be deployed in, it would be better to control it from greater than 10 meters away.

WiFi

WiFi streaming proved to be the best option. Initial research showed that using a router for WiFi would increase the data rate significantly compared to that of BLE. ("All the Internet of Things - Episode One: Transports", Montgomery). Furthermore, WiFi routers examined by Montgomery were being used in houses spanning up to 2,500 square feet. Therefore, it makes the most sense for our project to procure a decent router and have more freedom in terms of data rate and transmission range.

Using a router's WiFi network, we could wirelessly transmit data as long as the payload remains in the range of the router. To do this, we could start a streaming server on the Raspberry Pi, which would allow for multiple video streams (Barreiros). Once this is done, the video stream could be accessed through any web browser. Alternatively, VLC Media Player is capable of receiving camera feeds from a Raspberry Pi over WiFi. This can be accomplished by executing a command on the Pi that uses real time streaming protocol on the network. Another device on the same network could then open VLC and receive the stream (Pounder).

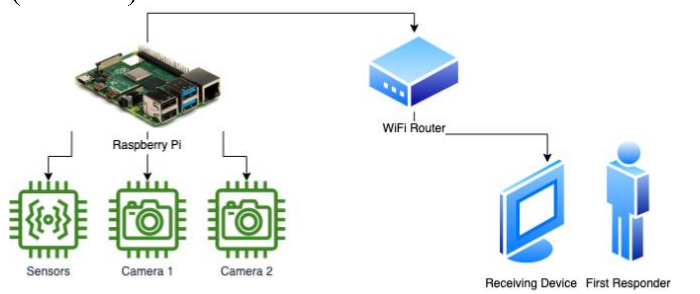

Figure 2. Diagram of the different devices and proposed network connecting them.

While the aforementioned methods of streaming over WiFi would work well for testing the cameras, they do not allow for much customization in terms of the architecture being used to transmit the data. Writing our own code to follow a SOA with custom encoding and decoding to meet our latency and quality needs would be best. To implement this, we could write Python code to capture video from video sources and then optimize the frame rate to decrease the demand on the bandwidth. We could send the captured frames over a custom SOA to encode the hierarchical video stream. Next, we could take advantage of a web server for sending and receiving the video.

Conclusion

In conclusion, the optimal way to stream data wirelessly for a sensor payload designed to locate survivors in void spaces following disaster situations is through WiFi. To mitigate data loss the error tolerance should be encoded, transmissions should be adapted, and error concealment should be decoded over a custom service-oriented architecture.

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