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Proceeding Paper

Increasing the Situation Awareness and Response Time of K9 Units Using a Smart Integrated Vest for the Canine Companion †

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Abstract: First responders are tasked to intervene in small-scale emergencies and major natural or human-made disasters under unknown environments. They are required to operate around the clock, in situations that are life-threatening and potentially hazardous, with limited awareness of the operational situation, mission progress, and time sensitivity. They more often than not risk their own personal safety and well-being in order to keep civilians safe. During the most demanding and extended incidents, first responders operate under complex response operation plans that involve the collaboration of multiple disciplines and teams including K9 units. Within the context of the INGENIOUS project, a K9 vest for the canine of the unit is developed, aiming to improve their response time, enhance their situational awareness, support the collaboration between agencies, and most importantly, increase their safety during missions.

Keywords: K9 units; first responders; emergency response; smart integrated sensors

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1. Introduction

Rescue operations range from small-scale emergencies, within one small geographic area and handled by one discipline of responders, to major disasters that spread across many different incident areas and involve complex response operations and cross-agency collaboration. In all cases, the first responders are asked to take many risks and operate under unknown, possible hazardous or life-threatening, situations where time is of the essence [1].

To this end, many technologies have been developed aiming to support the first responders during the field operations, increase their situational awareness, and their timely notification in case of changes to the operational plan [2]. A system to provide all these needs has been developed within the context of the INGENIOUS project [3,4], which aims to assist first responders when operating in the field, increasing their efficiency and their situational awareness and decreasing their response time. To achieve that, the development of a next-generation integrated toolkit (NGIT) for collaborative response is undertaken to increase the protection level of the first responders and augment their operational capacity when responding to incidents. Part of this toolkit is also a smart integrated K9 vest that provides situational awareness to the canine handler regarding the canine's well-being, location, and operation status.

2. System Design

The K9 vest offers two video streams (HD and thermal) as well as bidirectional audio. Additionally, it monitors the canine's location with a high-precision GNSS receiver. Communications are achieved using Wi-Fi LAN connectivity. The high-level block diagram of the K9 vest is presented in Figure 1. The information is available to the canine handler and the local field coordinator of the mission plan and can be forwarded to the command and control centre upon request. This allows the canine handler to focus on the mission, ensuring the unit's safety in the field while providing near-real-time information to the mission coordinators, increasing the overall situational awareness. In the following paragraphs, the hardware and software components of the K9 vest are presented in detail.

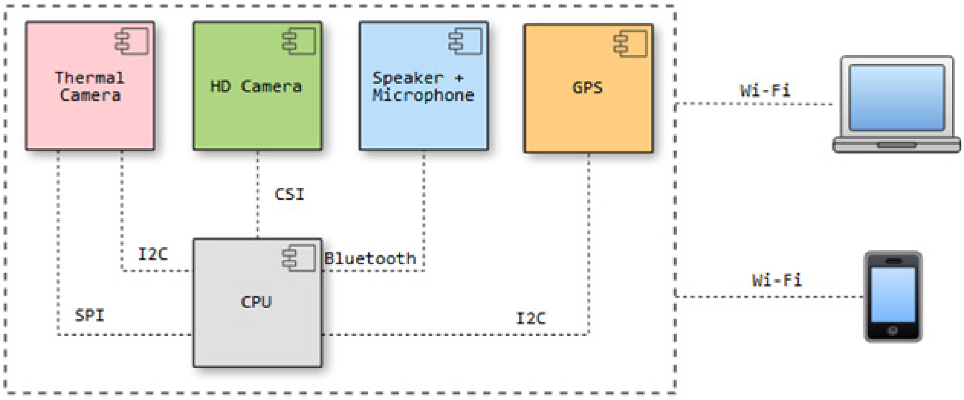

Figure 1. The K9 vest block diagram.

2.1. Hardware Components

Main Computing Module. The vest's main computing module is a Raspberry Pi Zero W, as shown in Figure 2a. It offers onboard wireless connectivity via Wi-Fi and Bluetooth radio interfaces and multiple wired interfaces to support the various connected components. An additional radio frequency connector, the U.FL connector, was installed in order to use an external antenna instead of the onboard one to increase radio performance.

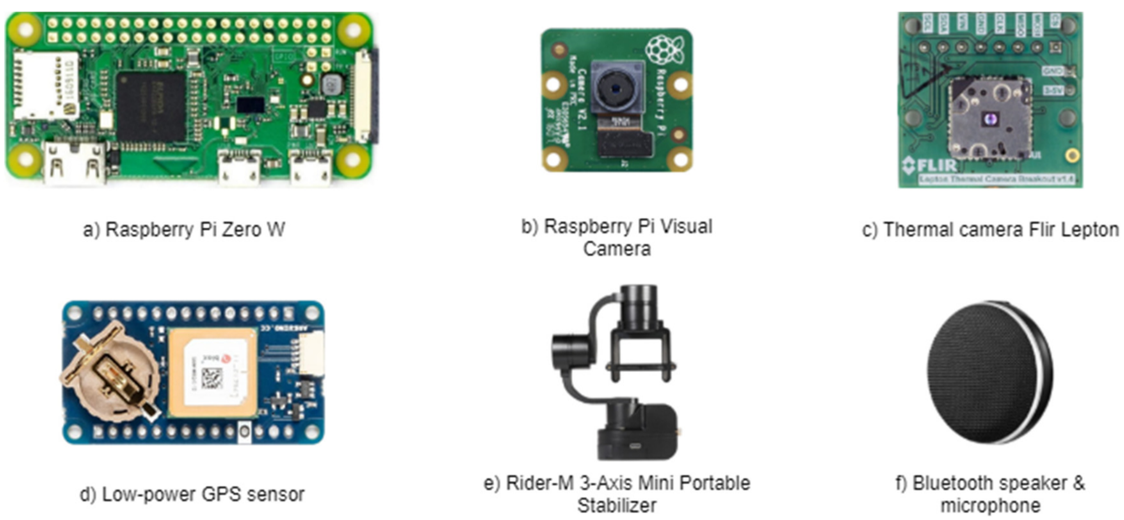

Figure 2. The K9 vest components.

Visual Camera. The Raspberry Pi Camera, as shown in Figure 2b, is a lightweight image sensor module which captures high-definition video. It connects to the mainboard via the CSI connector. The video is captured, encoded, and forwarded to the back-end server.

Thermal Camera. The K9 unit contains a thermal camera which is a Flir Lepton 2.5 module, as shown in Figure 2c, with an accompanying breakout board. It requires two interfaces, an I2C for control and an SPI for the video feed. This is a thermal sensor which captures non-contact temperature data while being small and lightweight. The thermal imaging sensor provides information about heat sources in the field, traditionally not available, and thus further increases situational awareness.

GPS Sensor. The vest determines location via a low-power GPS sensor, as shown in Figure 2d. It can calculate position based on multiple satellite systems (GPS, GLONASS, and Galileo). It connects to the mainboard using an I2C interface. It sends information to the board using the NMEA format [5].

Gimbal. The Rider-M 3-Axis Mini Portable Stabiliser, as shown in Figure 2e, stabilises the image captured for the two video streams. Its compact design ensures that it can be carried easily from the canine. It has an important role in the overall design since without it, the video would be extremely unstable due to constant movement and would not offer any useful information.

Microphone and Speaker. The audio input/output device is a wireless Bluetooth speaker, as shown in Figure 2f, with optional wired connectivity. It allows a bidirectional audio feed between the remote location and the canine handler. It is used by the handler to issue comments to the canine and/or communicate with located victims.

2.2. Software Components

The architecture of the K9 vest, as shown in Figure 3, includes the following software components:

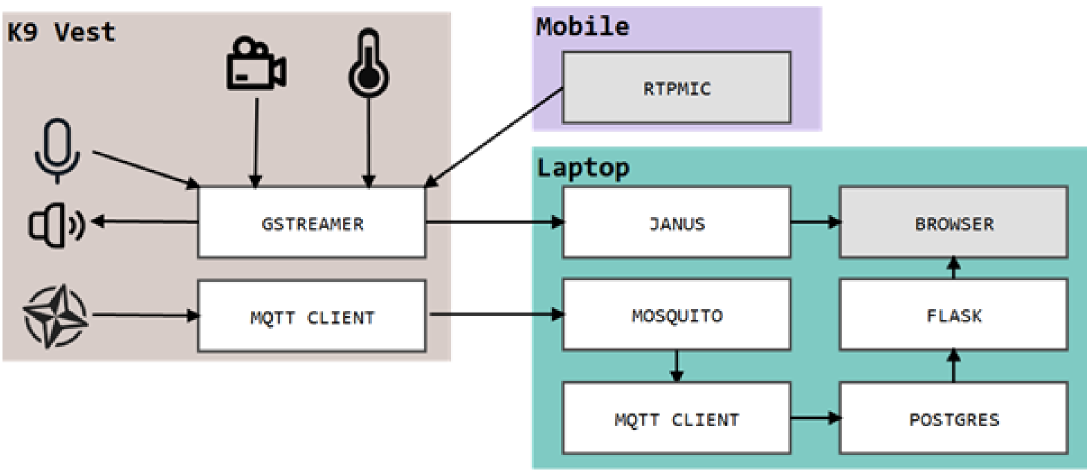

Figure 3. The K9 vest inner architecture.

Video Streaming. GStreamer [6] is an open-source multimedia framework. It can work for multiple processor architectures and operating systems and is lightweight enough to operate in a resource-constrained environment such as the single-core processor of the Raspberry Pi Zero W. It is responsible for collecting the two video streams from the HD camera and the thermal camera as well as the audio stream from the microphone and forwarding them to the media server. Additionally, it receives the audio stream and forwards it to the speaker.

GPS Integration. A small software component reads the NMEA messages from the GPS over the I2C interface. For each message, it constructs a JSON [7] which updates the position of the canine. The message is stored and indexed appropriately [8] to a PostgreSQL database.

Audio Streaming. RtpMic1 is an Android application which provides live audio streaming. It captures voice from the mobile device microphone and sends an RTP stream through the GStreamer to the speaker.

Message exchange. The message exchanges of the K9 vest are handled by Eclipse Mosquitto [9], an open-source MQTT message broker. It is lightweight and suitable for single-board applications and power-constrained devices. It also provides a portable client library for use in applications.

2.3. Usage

After detailed discussions with K9 units, it was decided that the interfaces of the K9 vest should be kept minimum, focusing on easy deployment, minimal overhead, and convenience. To this end, the K9 vest offers the following features:

Main On/Off switch. It is used to power on and off the K9 vest, including the gimbal and the cameras. This button is located on the 3D-printed box and is carefully designed to prevent accidental activation.

Battery-level LED light. The handler of the canine is expected to be located in the vicinity but not always within the line of sight of the canine. To this end, relying on visual sights for cases of a hardware malfunction or low battery level is not the optimal solution for an enhanced user experience. Based upon this observation, it was decided to include only one LED light, indicating that the vest is turned on and operating, which turns orange and blinking when the battery level is below 20%.

User interface. Aiming to facilitate the usage of the K9 vest, a user interface was developed. The user interface offers a map where the recorded GPS coordinates of the location of the canine are presented in near real time and a video streaming of the cameras attached to the main processing unit. The user interface accompanying the K9 vest is developed using Flask [10], a Python web framework.

3. Conclusions

In this paper, a complete system for the increase of the situation awareness and response time of the K9 units is presented. The system includes a smart integrated vest for the canine companion, a user interface and a mobile application for the canine handler, and a complete back-end system for the storage and retrieval of information. The K9 vest is being tested by two K9 units within the context of the INGENIOUS project. The results of these tests will be evaluated, and any needed modifications will be incorporated into the design to further improve the usability of the system.

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