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Utilizing a Smart Integrated Vest for the K9 Companion to Improve Situational Awareness and Reaction Time

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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 live threatening and potential hazardous, with limited awareness of the operational situation, the mission progress and the 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

Introduction

Rescue operations range from small scale emergencies, within one small geographic area andhandled by one discipline of responders, to major disasters, that spread across many differentincident 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 orlife-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, is been developed within the context of the INGENIOUS project [3,4], that aims to assist first responders when operating at 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

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 achievedusing Wi-Fi LAN connectivity. The high-level block diagram of the K9 Vest is presentedin Figure 1. The information is available to the canine handler and the local field coordinator of themission plan and can be forwarded to the Command and Controlcentre upon request. This allowsthe canine handler to focus on the mission, ensuring the unit's safety at the field while providingnear-real time information to the missioncoordinators, increasing the overall situational awareness.In the following paragraphs the hardware and software components of the K9 Vest are presented indetail.

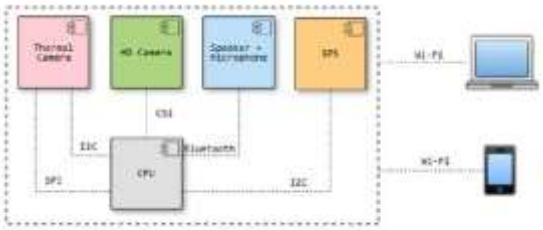

Figure 1. The K9 Vest block diagram.

Hardware Components

Main Computing Module. The vest's main computing module is a Raspberry Pi Zero W, as shownin Figure 2a. It offers on-board wireless connectivity via Wi-Fi and Bluetooth radio interfaces andmultiple wired interfaces to support the various connected components. An additional radiofrequency connector, the U.FL connector, was installed in order to use an external antenna instead ofthe on-board 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 sensormodule which capturesHigh Definition video. It connects to the main board 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, asshown in Figure 2c, with an accompanying breakout board. It requires two interfaces, an I2C forcontrol and an SPI for the video feed. This is a thermal sensor which captures non-contacttemperature data while being small and lightweight. The thermal imaging sensor provides information about heatsources at the field, traditionally not available, and thus further increases thesituational 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, GLONAS and Galileo). It connects to the main board using an I2C interface. It sends information to the board using the NMEA format [5].

Gimbal. The Rider-M 3-Axis Mini Portable Stabilizer, as shown in Figure 2e, stabilizes the imagecaptured for the two video streams. Its compact design ensures that it can be carried easily from thecanine. It has an important role to the overall design, as without it the video would be extremelyunstable due to constant movement and would not offer any usable information.

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

Software Components

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

Video Streaming. GSTREAMER [6] is an open-source multimedia framework. It can work formultiple processor architectures and operating systems and is lightweight enough to operate on

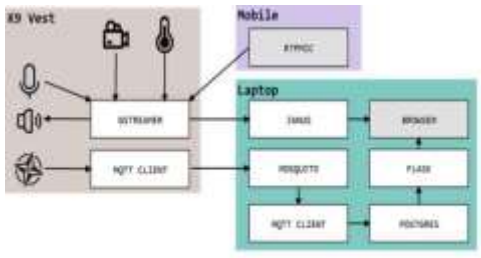

Figure 3. The K9 Vest server architecture.

aresource-constrained environment like the single-core processor of the raspberry pi zero w. It isresponsible for collecting the two video streams from the HD Camera and the Thermal Camera aswell as the audio stream from the Microphone and forwarding them to the media server.Additionally, it receivesthe audio stream and forwards it to the speaker.

GPS integration. A small software component reads the NMEA messages from the GPS over theI2C interface. For each message it constructs a JSON [7] which updates the position of the canine. Themessage is stored and indexed appropriately [8] to a PostgreSQL database.

Audio Streaming. RtpMic1 is an android application which provides live audio streaming. Itcaptures voice from the mobile device microphone and sends an RTP stream through theGSTREAMER 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 aswell as power-constrained devices. It also provides a portable client library for use in applications.

Usage

After detailed discussions with the K9 units, it was decided that the interfaces of the K9 Vestshould be kept minimum focusing on easy deployment, minimal overhead and convenience. To thisend the K9 Vest offers:

Main On /Off switch. It is used to power on and off the K9 Vest, including the gimbal and thecameras. This button is located on the 3D printed box and is carefully designed to prevent accidentalactivation.

Battery level LED light. The handler of the canine is expected to be located in the vicinity but notalways within the line of sight of the canine. To this end, relying on visual sights for cases of hardwaremalfunction or low battery level is not the optimal solution for enhanced user experience. Based uponthis observation, it has been decided to include only one LED light, indicating that the vest is turnedon 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 has been developed.The user interface offers a map where the recorded GPS co-ordinates of the location of the canine arepresented in near-real time and a video streaming of the cameras attached to the main processingunit. The user interface accompanying the K9 vest is developed using Flask [10], a Python webframework.

Conclusions

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

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