ENABLING GESTURE-BASED CONTROLS FOR FIRST RESPONDERS AND K9 UNITS

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ABSTRACT

Search & Rescue (SAR) operations often require the full attention and movement-dedication of First Responders (FR) in specific high-priority tasks, other than controlling a device or generating a message. In this work, novel technologies of wearables for FRs and K9 units in SAR operations are presented. The first goal is to provide alternative and complementary, low-overhead means of messaging in highly-demanding environments. The second goal is to use such platforms as control apparatus that significantly lowers the workload for FRs when controlling complex equipment like robots. These technologies are currently under development and already prototyped as part of the SAR Kit of the FASTER project, which is to begin field testing activities this year.

Keywords: Search and Rescue (SAR), gesture recognition, motion-based control, Unmanned Aerial Vehicle (UAV), emergency responder, earthquake, drone.

1. INTRODUCTION

A First Responder (FR) team operating as a Search & Rescue (SAR) unit inside a disaster area must be able to prioritize safety, mobility, and situational awareness over-focusing on user interfaces in applications and screens [1-3]. Users like to be able to operate several devices in a hands-free manner and, specifically for FRs, handling K9 units is typically based on "translating" the dog reaction according to its training by the FR. Regarding Unmanned Ground/Aerial Vehicles (UxV), suppliers provide users with cumbersome remote controllers that require both hands to be operated smoothly. Additionally, controlling such vehicles requires some kind of experience and is not straightforward. In contrast, FRs would like to be able to navigate the UxVs accurately by employing simple and ergonomic gestures. Based on these requirements, the FASTER[1] project proposes solutions that are capable of collecting data from gestures performed by the FRs, detect canines' activity and barking by applying Machine Learning algorithms and, subsequently, forwarding these data for further processing, direct device control (UxV) or immediate alerts. The following sections provide an insight into such solutions, currently being developed in the project.

2. WEARABLE DEVICES AND GESTURE RECOGNITION

2.1. Wearable devices for humans

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[1] This work is supported by the project FASTER, which has received funding from the European Union's Horizon 2020 (H2020) programme under grant agreement No:833507.

In FASTER, humans use wearables in order to communicate with gestures in the field of action [4]. The use of gestures to generate messages is considered for two reasons in FASTER: (a) use when in immediate danger without engaging his/ her mobile phone; and (b) when environmental noise is high and oral commands are not likely to be delivered successfully. For the former, the training of an Artificial Intelligence (AI) smart wearable framework named MORSE (MOvement Recognition for firSt rEsponders) is implemented. This framework tracks the FR arm movements, looking for certain predefined ones, in order to map them to pre-defined messages or alerts, therefore creating personal awareness messages and notifications. The generated alerts are typically broadcasted in the area near the FR, but they can also be forwarded inside the FASTER architecture to be used for situational awareness update.

To achieve the needed performance characteristics, after concluding with the selection of the tracking gestures, the algorithm is trained with datasets generated by different people that each, repeatedly, performs the selected set of gestures (see Figure 1). For MORSE, the smartwatch that is selected for use in FASTER is the Fossil Gen 5 smartwatch. At the same time, for reporting specific events using gestures, a mission management smartwatch application leveraging on the Wear OS built-in gesture recognition that counts only two selected gestures is being developed. This approach preserves low battery consumption and, hence, achieves higher device autonomy, which is of paramount importance in emergency scenarios. In addition, the design and development of a gesture recognition model are able to run in smartwatch devices exploiting the device's inertial sensors, increasing the number of available gestures for the mission management application. As a result, both solutions will be accompanied by specially designed applications that run on smartwatches and smartphones, supporting WearOS. Especially for MORSE, two applications will be developed: one for training the algorithm and one for use by the First Responders during the pilots and the evaluations tests.

Apart from wearables, FASTER also provides a Smart Textile Framework (STF) solution, which is a mobile application that collects data from a smart textile prototype. To this end, STF monitors the biometrics and environmental data from many sensors embedded on the FRs' undergarment and outside of their uniform in a transparent and modular way. Through the STF, alerts are generated and sent to the FR smartphone, e.g when a biometric measurement is outside the "safe" range. These alerts are also delivered to other components in the FASTER architecture (e.g., Scene Analysis from IoT Sensor Data module, or the Portable Command Center) to decide whether further actions are required.

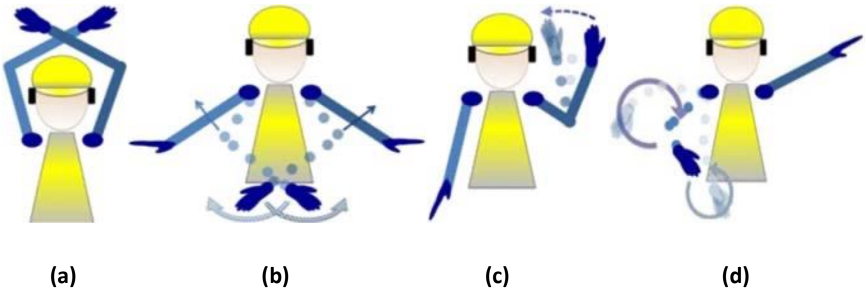

Figure 1. Gestures for recognition by the MORSE component: (a) "Recommend stop", (b) "Emergency contained", (c) "Recommend evacuation", (d) "Fire indication". The "distress" gesture is custom (not displayed here).

2.2. Wearable Devices for Animals

FASTER also develops wearable devices tailored to animals, specifically K9 units trained for SAR operations in disaster areas. A neck-mounted, wearable device for animals is designed and developed where a specially designed AI algorithm to detect barking of the K9 unit and recognize its activity whenever a dog performs a movement that can be translated to a specific action, e.g. detecting a victim in debris. This algorithm runs in the computing unit in the dog's collar and results to the playback of predefined audio messages, by a speaker also embedded in the dog's collar. This apparatus is used for informing a detected victim that help is on the way and provide support until the FR team arrives. To extend the collar's coverage, a Base Station is also being considered as an intermediate hop node between the collar and access to FASTER's main infrastructure. The wearable device for animals is also able to broadcast the location of the K9 unit, information that is displayed by a specially designed application that helps the FR to track the dog's movement by displaying its location on a map.

2.3. UAV gesture control

FRs employ UAVs to assist them in several tasks while operating, including risk detection and victim localization. Typical UAV remote controllers tend to be heavy and cumbersome, require both hands to operate and have a significant learning curve. This is often contrary to the needs of FRs who may need to carry other important equipment and need to keep their hands free during a mission for other tasks. Considering the above, FASTER will introduce vision-based gesture control allowing FRs to fly UAVs in an intuitive and effective manner, without compromising their freedom of movement, safety, and ability to carry out their mission.

Figure 2. Controlling a UAV with finger-based gestures in a simulated environment.

FASTER has already identified a set of initial requirements [5], which have been used to drive the process of selecting the appropriate modes of control as well as the individual gestures to be used. In particular, two different modes of control were identified, which allow UAV control with simple gestures using a single hand: finger-based control defines a minimal set of gestures that correspond to controlling, one at a time, throttle, yaw and pitch forward; while palm-based control directs the UAV to follow the attitude and lateral movement of the user's palm, allowing for all UAV control combinations. The initial implementation of FASTER's gesture recognition module for both control modes is based on LeapMotion, an infrared hand tracking peripheral. The two control modes were implemented in a UAV flight simulation environment, gamified with the inclusion of in-game collectible objects which define a path users can try to navigate using gestures. The resulting application, shown in Figure 2, provided the means to evaluate gesture controls a user study, with the participation of both FRs and members of the general populace. Palm-based control proved more effective, more intuitive, and easier to learn among a pool of testers; finger-based control can be useful for slow, precise maneuvers in tight spaces. Following positive feedback from the user study as reported in [5], gesture control has been connected to a DJI Mavic 2 Enterprise Dual (M2ED) UAV for evaluation in a real scenario (Figure 3). Regarding the technical setup, the LeapMotion controller is connected to a laptop running a Unity app, which recognizes users' hand position and orientation via the LeapMotion SDK and translates them into UAV commands. The UAV is controlled by a mobile device connected to the remote controller and running DJI's mobile SDK. Early test flights with both novice and experienced FR UAV pilots indicate that gestures provide easier and more intuitive control compared to the hand-held controller while allowing the same range of control and maneuvering.

Figure 3. Pitching forward (left) and backward (right) with the DJI Mavic 2 using palm-based gestures.

3. CONCLUSIONS

Modern wearable devices with significant computing power in small sizes enable the implementation of novel technologies for low-overhead messaging, alerting and control for work-overloaded FR teams operating inside a disaster area. For wearables for humans, a set of pre-selected gestures are used to train an AI-based component called MORSE. This approach is supplemented by the STF, a textile- integrated system of sensors that provide biometric and environmental measurements. In addition, similar wearable solutions are being developed for the K9 units for recognizing canine activity by designing and developing a neck-mounted collar equipped with sensors (e.g., accelerometer, gyroscope, camera) and an SBC (i.e, a Raspberry pi) to collect and process data related with the identification of a possible victim during action [1]. In terms of control, gesture-based UAV commands can be more intuitive and reduce the clutter of equipment carried by FR pilots on the field. More of these next- generation human-computer interaction prototypes are expected to be developed in the near future.

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