GESTURAL COMMUNICATION WITH ACCELEROMETER-BASED INPUT DEVICES AND MULTI_MODAL DISPLAYS

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ABSTRACT

Many operational settings such as combat, firefighting, or certain law enforcement and/or emergency management situations place significant demands on operator's sensory capabilities. Noisy (e.g., weapons fire, vehicle engines, stormy weather, etc.) and murky (e.g., smoke, sandstorms, nighttime) environments, for example, impose great demands on hearing and vision, and can compromise the ability to exchange critical information through conventional communication pathways. To circumvent these environmental difficulties it is now possible to provide a redundant source of information through the modality of touch, by using tactile signaling. According to an Army field manual (FM 21-60) on visual signals, efficient combat operations depend on clear, accurate and secure communication among personnel. When vocal means of communication are inadequate, which is often on the noisy battlefield, visual signals can be an effective alternative for transmitting orders, information, or requests for aid or support. However, by definition, these signals require line-of-sight between the transmitter and receiver. As previously stated there are numerous situations where a direct visual connection is unavailable. Nighttime operations, inclement weather, man-made and natural terrain obstructions, or concealment often impede visual communication attempts. To overcome some of these issues, "daisy-chaining" or relaying a message is frequently used to send a message through a group. However, this method can delay the transmission from the original sender to the intended recipients. Moreover, visual communication demands a focus on the visual modality possibly distracting a receiving soldier's visual attention from alternate, perhaps more urgent, tasks. This work introduces a communication system that uses common military hand and arm gestures but does not require a visual connection between the transmitter and receivers. Moreover, the purpose built system instantaneously delivers the message to all recipients and can do so through a variety of message output devices. Specifically, it is a computer-mediated gesture recognition system that employs a wireless, accelerometer-based input device for collecting and classifying one- and two-hand and arm gestures. The system delivers message output through an audible channel and through a tactile display. The tactile display maps and then emulates the hand-signal's spatial qualities through a sequence of vibrations delivered via an elastic belt worn around the soldier's waist. These tactile sequences can be made to intuitively mimic the corresponding hand signal, and research has shown that tactile communication can succeed in conveying information to a recipient even under high physiological stress. The system benefits from reusing hand-signal training provided to military personnel. A transmitting user need not learn a new set of commands in order to employ this platform. Instead, the required hand signals are encoded into the gesture

recognition system's machine-learning algorithm, providing user-independent and/or user-specific signal examples. A message recipient does require a short training period, when using the tactile display, in order to learn which tactile sequences correspond to which hand signals. However, research has shown that this training period is very small if the tactile signals are intuitively mapped from their visual-spatial equivalent.
This paper will introduce this novel communication system, and provides detail on initial experiments and applications. Additionally, the software application used in training the machine learning algorithm and used for teaching a recipient on mapping hand-signals to tactile sequences will be discussed. Finally, avenues for moving this technology from the lab into the field will be discussed, specifically, embedding accelerometers into a soldier's gloves and porting the gesture recognition and transmission systems to pocket-size computing devices.

KEYWORDS: multi-modal displays, gesture recognition, accelerometer, tactile displays, visual signaling, auditory signaling, arm-and-hand signals

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