Demo Abstract: Inviz: Low-power Personalized Gesture Recognition Using Wearable Textile Capacitive Sensor Arrays

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Abstract—This demonstration presents Inviz, a low-cost gesture recognition system that uses flexible textile-based capacitive sensors. Gestures are recognized using proximity-based movement detection using flexible capacitive sensor arrays that can be built into the environment or placed on the body or be integrated into clothing. Inviz provides an innovative interface to home automation systems to simplify environmental control for individuals with limited-mobility resulting from paralysis, paresis, and degenerative diseases. Proximity-based sensing obviates the need for physical contact which can result in skin abrasion which is particularly deleterious to people with limited-to-no sensitivity in their extremities. A custom-designed wireless module maintains a small form factor facilitating placement based on an individual's needs. Our system leverages a hierarchical sensing technique which facilitates learning gestures based on the individual and placement of the sensors. Classification uses just-in-time embedded computational resources to provide accurate responses while maintaining a low average power consumption, in turn reducing the impact of batteries on the form factor. To illustrate the use of Inviz in a smart home environment, we demonstrate an end-to-end home automation system that controls small appliances. We will interface our system with a home automation gateway to demonstrate a subset of potential applications. This interactive demonstration highlights the intuitiveness and extensibility of the Inviz prototype.

I. INTRODUCTION

Approximately 1.5 million individuals in the United States are hospitalized each year because of strokes, brain injuries and spinal cord injuries [1], [2], [3]. Often these injuries cause severe impairments such as paralysis, paresis, weakness and limited range of motion. Extensive periods of expensive rehabilitation are necessary for individuals with such severe impairments because physical recovery can be a slow process [4], [5]. Assistive technologies can help reduce the time spent in rehabilitation by supplementing the direct care allowing the patients to become independent sooner.

Environment control is one of the keys to becoming independent while rehabilitation. Gesture recognition systems are capable of allowing patients with mobility impairments greater control over their environment. Several techniques such as the use of inertial sensors, vision systems, and other forms of tracking can be used to capture body gestures [6], [7], [8], [9], [10]. Gesture recognition systems for individuals with mobility impairments, however, present a set of fundamental challenges that typical gesture recognition systems often fail to address. First, sensors for gesture recognition are intrusive, bulky, or expensive [11]. Eye tracking systems necessitate the use of mounted cameras while evoked-potential or touch-based systems use electrodes that can cause skin irritation and abrasion, conditions that can have a deleterious effect if unnoticed due to diminished sensation in the extremities. Second, existing systems are often not suitable for mobility impairments as they assume certain motions which a person may not be able to complete. There is a need, therefore, of systems that require minimal set-up and maintenance, and cause minimal fatigue and intrusiveness.

The above challenges are addressed by Inviz [12] which uses wearable sensors built from textile-based capacitive-sensor arrays (CSA). These CSAs work on the principle of change in capacitance when there is movement in the proximity of the fabric capacitor plates. These plates can be sewn into clothing fabrics. Figure 1 illustrates a prototype Inviz system built using the capacitive plates and conductive threads sewn into the denim fabric. We have designed a low-power
shorts between adjacent threads which are difficult to diagnose, to fraying on the ends of the thread and can cause microscopic threads and non-conductive threads. Unfortunately, this leads to fraying on the ends of the thread and can cause microscopic shorts between adjacent threads which are difficult to diagnose, especially when vampire connectors were used to connect the thread to the data collection board. The second challenge was soldering onto the conductive threads which we mitigated using vampire FCC connectors.

**Technical Requirements**: The system requires the components of the prototype described above. Given the hardware requirements and a minimal setup of the PC hardware, the Inviz prototype will recognize the gestures for which it has currently been trained. An offline training of the machine learning algorithm is required for a different customization or integration of the capacitive patches. Further research is being conducted to automatically adapt and retrain the system given a change in the prototype environment.

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**REFERENCES**


