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An optimized real-time hands gesture recognition based interface for individuals with upper-level spinal cord injuries

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Abstract This paper presents a hand gesture-based interface to facilitate interaction with individuals with upper-level spinal cord injuries, and offers an alternative way to perform "hands-on" laboratory tasks. The presented system consists of four modules: hand detection, tracking, trajectory recognition, and actuated device control. A 3D particle filter framework based on color and depth information is proposed to provide a more efficient solution to the independent face and hands tracking problem. More specifically, an interaction model utilizing spatial and motion information was integrated into the particle filter framework to tackle the "false merge" and "false labeling" problem through hand interaction and occlusion. To obtain an optimal parameter set for the interaction model, a neighborhood search algorithm was employed. An accuracy of 98.81 % was achieved by applying the optimal parameter set to the tracking module of the system. Once the hands were tracked successfully, the acquired gesture trajectories were compared with motion models. The dynamic time warping method was used for signals' time alignment, and they were classified by a CONDENSATION algorithm with a recognition accuracy of 97.5 %. In a validation experiment, the decoded gestures were passed as commands to a mobile service robot and a robotic arm to perform simulated laboratory tasks. Control policies using the gestural control were studied and optimal policies were selected to achieve optimal performance. The computational cost of each system module demonstrated a real-time performance.

Keywords Gesture recognition · 3D particle filter · Neighborhood search · Dynamic time warping (DTW) · CONDENSATION

1 Introduction

Voice, facial expressions, gaze and hand gestures have been widely employed as communication channels for human computer interaction (HCI) and human robot interaction (HRI) [1]. These modalities of interaction have gradually made their way into assistive technologies (AT) domain, such as home medical alert systems (use abnormal behavior recognition) and intelligent wheelchairs (use gesture control). Such applications are designed to help people with disabilities in performing daily living activities [2, 3]. Among the usable communication channels, hand gesture is very effective because of its intuitiveness, and expressiveness to deliver information, even in noisy environments. As opposed to other cumbersome means of interaction, such as joysticks and sip-and-puff systems [4] which require users to physically manipulate controls or sensors, gesture-based interfaces allow users to perform free hand and arm movements to control actuated devices using customized gestures. This feature is especially meaningful for individuals with high level spinal cord injuries who cannot perform hand and arm gestures dexterously. Gesture-based interaction is a promising alternative or complement to the existing control modalities.

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