Integrated Sensing Techniques for Assistive Chairs: A Survey towards Sit-to-Stand Problems

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ABSTRACT

This paper presents a survey of the contemporary assistive chairs and on-chair sensing approaches of capturing sit-to-stand (STS) movement. Sitting in a chair and standing up from a seated position are activities of daily living (ADLs) performed by humans. However, older people often encounter difficulties with these activities. These difficulties may cause substantial decreasing of the elderly mobility, leading to inactive participation in social activities and increasing the risk of chronic diseases that may cause premature death. Therefore, assisting older people to overcome these difficulties has significance for their independent living. At present, the assistive devices can be allocated in terms of market available ones and experimental prototypes, both of which are discussed here. Afterwards, the authors cast more light on integrated sensing techniques that are currently used with experimental prototypes and create a taxonomy of sensing techniques. Following from this survey, a chair capable of delivering assistance-as-needed is proposed.

Keywords: Assistance-as-Needed, Behavioural Pattern Recognition, Integrated Sensing Techniques, Sedentary Lifestyle, Sit-to-Stand (STS)

INTRODUCTION

Nowadays, the proportion of the world’s ageing population is increasing rapidly. This is mainly due to improvements in medicine and health care. For example, in the U.S, 12.5 percent (35 million) of the population are presently older than 65 years and this number is expected to increase to 20 percent by 2030. [This trend is similar to Australia where there are currently 11.2% of the population of over-65s with a projected increase to over 20% by 2031 (Kothiyal & Tettey, 2001; Kleinpell et al., 2002).

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As people age, physiological changes occur including reduced muscle strength and mass, musculoskeletal weakness in addition to reduced sensory capacity. This will lead to a contracted social space in which the elderly tend to spend more time indoor and in a favourite spot. This spot from studies is often a chair from where they have maximum view of the television, neighbourhood and so on (Forlizzi et al., 2005). However, the aging population often encounter problems during unaided STS transferring process due to adverse physiological conditions like insufficient lower limbs capability and asymmetric body-weight distribution between paretic and ipsilesional limbs (Engardt et al., 1995).

Towards solving these STS problems, a wide range of assistive devices are introduced to the market, standing-up frames, electric and pneumatic lift chairs, etc. When applying the standing-up frame, users need to hold it with their upper limbs to lift-up. Sharing a similar idea with lift-up grab handles in disabled toilet, standing-up frame serve its purpose in aiding the subject to use his/her own motor function and rise from seated position. However, in the cases where their upper limbs are weak or the seats are too low, the users will have to ask their relatives or health care professionals to either give them a gentle pull or adjust the height of the frames. Market available lift chairs deliver all its functions manipulated by a control panel. The chair, acts like an elevator, moves back and forth to itself end points without virtual interaction with the user. It seems to be a ubiquitous solution to the elderly from the first glimpse. However, such chairs can hardly change how much assistance they provide regarding to users with different size and physiological condition.

Admittedly, Electric lift chairs enable users to perform STS motion easily with manual controller. These chairs are controlled manually by the subject seated and can merely provide fixed amount of assistant within the end-points. Comprehensive analysis suggests that most of lift chairs fail to offer sufficient muscle resistance exercises and are unable to provide personalised services for the reason being they simply serve a predefined cycle to the users. This causes their physiological conditions to deteriorate faster especially when they become undue dependent on the chairs for standing up. Moreover, latency may be induced by these electric lift chairs, which will be elaborated later.

As a low-cost alternative to electric lift chairs, pneumatic lift seat assists are promoted. Without the need of batteries and electricity, these seats can be easily attached to a bed or chair. The power of lifting stroke can be defined by selecting the level of weight resistance. But, without professional clinical analysis, the subject will never know the exact amount of lifting he/ she needs. Besides, attaching pneumatic device to existing chair will inevitably increase the seat height, which may have adverse influence on the elderly in ADLs. Additionally, using a gas spring to capture motion and store the energy, this device requires large amount of power every time the subject sits back. It can be particularly hard for the handicapped elderly when the device has not been used for a while in which gas spring may become stiff.

However, it is possible to get this information from a smart chair that uses a suite of sensors for collecting user’s posture information. This survey focuses on present sensing techniques for smart chair posture data acquisition.

Commercial Assistive Devices

Presently, there exist plenty of Electric lift chair manufacturers on the market, among which the market leading brands as suggested by disabled world are Pride lift chairs and Golden technologies (Disabled world, 2010). Disabled world is an organization that provides information and news to the general public and disabled people (Disabled world, 2010). Other Electric lift chair manufacturers include La-Z Boy, Med-Lift and Maxi-Comfort.

Pride lift Chairs manufacture a series of Electric lift chairs that offer various dimensions for people with medium to large body builds. The Pride Cameo C-10 lift chair has
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