Gait rehabilitation assessment based on microwave Doppler radars embedded in walkers

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Abstract:
Human gait is a complex motion that implies the movement of different parts of the body such as arms, legs and feet, being the functional human movements' analysis indispensable for bio-mechanical diagnostic and treatment tool for clinics and rehabilitation services. During the rehabilitation process, walkers are frequently prescribed to improve the patient's stability but can also be transformed into instruments for quantitative evaluation of rehabilitation progress by embedding sensors to capture the motion characteristics. In this work, a practical approach concerning the possibilities to use microwave Doppler radars embedded in four wheels walkers for gait capture is presented. The signals acquired from the sensors are processed using time-frequency transform such as STFT. A set of gait characteristics, such as gait velocity and stride rate, are extracted based on wavelet signal processing, STFT spectrogram and moving average filtering. A set of spectrogram features is calculated to discriminate between normal and abnormal gait.

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Contents

The economic developments in the second part of the 20th and 21st centuries made possible dramatic increases in life expectancy that contributed to the population aging phenomena around the world. Considering the aging phenomena the motor disabilities in elderly people are frequently, however advances in medicine and rehabilitation may contribute to maintain the quality of life for this group of people. The relation between aging and disability is not well known but some studies indicate that about 27-39% of adults with disability had the onset prior to age 44, 25 to 32% had disability onset between ages 45 to 64 years, with the remainder of onset occurring in later life [1]. Impairment groups that have seen significant increases in long-term survival include cerebral palsy, spine bifida, muscular dystrophies, spinal cord injuries, polio, and rheumatoid arthritis [2]. The entrances in these groups are frequently related to falls that are major cause of morbidity in elders [3]. The fall risks are related with changes in gait characteristics such as decreasing speed, stride frequency and stride length [4]. To prevent falls but also to help people with motor disabilities the usage of walkers represents a solution [5] [6] [7]. A walker helps the users to stay balanced by giving wide base of support when the right choice of walker is carried out, considering that different types of walkers are available such as no wheels, 2 wheels and four wheels walkers. If stability is a significant concern, the right solution is the standard walker without wheels the walker must pick up to move. The two-wheel walker allows the users to place weight on the walker, the legs with wheels allow the user to easily push the walker forward, and the legs without wheels prevent the walker from rolling while the user is stepping forward. If the user doesn't need to lean on the walker for balance, a four-wheel walker solution, which permits the user to walk faster, is recommended [8]. The walkers are generally used by limited elderly people as primary walking aid, however the walker usage in generalized form during rehabilitation prove to improve confidence and restore or maintain motor ability at the highest possible level. A study published by the Vogt et al. [9] showed that rollator assistance does not interfere with rehabilitation outcome and in some cases may be very useful to decrease the rehabilitation periods. In all the studied cases the used rollators were not characterized by any sensing device, no information about the characteristics of user motion being delivered to the physiotherapist. In these conditions the evaluation of user rehabilitation progress was done based on subjective evaluation and continuous scale physical functional performance [10]. To improve the evaluation process, instrumented walking aids have been developed by different research groups. Thus R. A. Bachschmidt reports [11] the development of a strain gauge-based walker instrumentation system characterized by six degree-of-freedom measurement of resultant subject hand loads. The description of upper extremity kinetics and kinematics during walker-assisted gait can be used to appropriate choice of rehabilitative strategies. Chan et al. [12] presents a smart rollator prototype that includes sensing channels for distance and speed, tri-axial acceleration monitoring, force and seat usage monitoring and also physiological parameters monitoring. In this case, the Bluetooth protocol was used to transmit the data from the sensors to a local data terminal. Referring to gait assessment for walker users, Postolache et al. presents in [5] and [6] a two wheel smart walker and a mobile application that permit to the physiotherapist to access the data from the sensors, including a microwave Doppler radar as a motion sensor. The high demand by physiotherapists for smart walker based solutions for gait rehabilitation monitoring and the recommended improvements obtained during demo sessions as part of EHR Physio workshops organized by the O. Postolache research team, streamlined new developments in this field that conducted to new smart walker

prototypes for unobtrusive continuous gait assessment which offer great advantages regarding walking parameters changes that can be related with the fall risk. At the same time smart walker implementations may be easily integrated in s-Health architectures [13] that focus on m-Health smart cities interractions.

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References

Citations

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