A low cost measurement system to extract kinematic parameters from walker devices

Publisher: IEEE

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Abstract:
This paper presents a low cost measurement system that can be used to extract kinematic parameters from walker devices. The proposed measurement system can be easily integrated in any commercial non-smart walker device and includes mainly a set of six force sensing resistors and one 3D accelerometer, with the associated signal conditioning circuits, and the data acquisition and processing unit with wireless communication capabilities. The signals that are acquired from the sensors are used to obtain, in real time, the values of several variables related with strength, acceleration and tilt angles that are associated with the usage of walker devices. The proposed measurement system enables the detection of conditions that are related with a deficient usage of the walker device, such as, bad positioning of the walker legs during gait, amplitude and timing unbalances of the forces applied on the walker legs or on the walker hand grips, excessive values of mechanical oscillations or tilt angles of the walker device. Some calibration and experimental results are included in the paper.

Published in: 2015 IEEE International Instrumentation and Measurement Technology Conference (I2MTC) Proceedings

Date of Conference: 11-14 May 2015

INSPEC Accession Number: 15291506

Date Added to IEEE *Xplore*: 09 July 2015

DOI: 10.1109/I2MTC.2015.7151588

Electronic ISBN: 978-1-4799-6114-6

Publisher: IEEE

Print ISSN: 1091-5281 **Conference Location:** Pisa, Italy

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I. Introduction

One of the main problems of today and future society is related with the quality of life of elderly people and obviously with their mobility. The aging of the population in the top developed countries is progressively increasing. For instance, statistical key numbers in European Union (E U-27), for year 2060, foresees that almost 30 % of the population is aged over 65 and a life expectance of 89 and 84.5 years for women and men, respectively, is forecasted [1]. In this context, mobility of elderly people must be preserved as long as possible and motion aids are a real concern not only in terms of improving quality of life but also in terms of cost savings of health and long-term care systems [2]–[3]. In this context, it is important to refer that a large number of people that use mobility aiding devices, sometimes, don't use them properly. Bad use can generate unbalance and instability conditions and result in falls and harmful injuries [4]–[5]. The importance of this topic is also enlarged because an increasing number elderly people prefer to remain in their homes as long as possible. Thus, assistive technologies that include the usage of mobility aids, such as, canes, crutches, walkers, rollators, among others, demand an increasing attention namely in which concerns the research of reliable measurement systems that provide telemonitoring, telehealth and others technology-enabled services [6]. In this research area, issues related with reliability, self-control and power supply minimization of smart measurement solutions for mobility aiding devices [7]–[8] are of paramount importance. It is essential to promote the development of measurement solutions that can be integrated in non-smart walker devices to improve their capabilities at a low cost. In this context, this paper presents a technical solution that can be applied to walker devices in order to capture motion and force quantities from which several gait and posture parameters can be extracted. As main novelties and improvements that are associated with the proposed solution, behind its low cost and adaptability to existing walker devices, it must be underlined its reliability, its local and remote operating modes, its self-calibration capability and its capability to detect, in real time, potential falls conditions that are directly signalized to the walker user. To validate theoretical expectations, a prototype, based on a conventional walker with four legs ground contact configuration, was implemented and used for testing purposes. It is important to refer that the measurement principles and technical solutions that are presented can be applied to others mobility aiding devices such as canes, crutches and walkers with different ground contact configurations, namely with different type of combinations between legs and wheels.

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