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Review Article

Review on plantar data analysis for disease diagnosis

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ABSTRACT

Force distribution on foot surface allows to understand the human mechanical behavior, providing detailed information for the evaluation of foot alterations. In diagnosis for diseases related to plantar pathologies, there are many devices for plantar pressure measurement, and corresponding algorithms for data analyzing, providing medical tools for assisting in treatment, early detection, and the development of preventive strategies. In medicine, use of computational intelligence is increasing, making the diagnostic processes faster and more accurate. Clinical Decision Support Systems (CDSS) can handle large amounts of data to improve decision-making, helping to prevent the deterioration of people's health. Numerous approaches have been applied over the past few decades to solve medical problems such as hepatitis, diabetes, liver disease, pathological gait, and plantar diseases, among others. This paper presents the developments reported in the literature for detecting diseases through plantar pressure data and the corresponding algorithms for its analysis and diagnosis, using different electronic measurements systems. Finally, we present a discussion about the future work required to improve in the field of plantar pressure diagnosis algorithms using different approaches suggested by the authors as potential candidates. In this sense, hybrid systems which include fuzzy concepts are the Q2 most promising methodology.

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1. Introduction

Nowadays, computational intelligence is present everywhere, providing us with a better quality of life. The development of intelligent systems to support the diagnosis of diseases is and has been one of the priorities of researchers. With the evolution of computing and the availability of huge amounts of data, remarkable developments have made possible to detect, monitor, and treat diseases in medicine. This offers a benefit to extend the health coverage to more people and to obtain a faster and more accurate diagnostic process.

Plantar pressure measurements provides detailed information for the evaluation of diseases or abnormalities, involving the function of the ankle, knee, hip, the back and other pathologies that are reflected on the footprint [1]. It also allows understand the mechanical behavior of the human foot in both static and dynamic load conditions.

To measure the distribution of plantar pressure, there are devices in the market such as imaging technologies with sophisticated image processing software, pressure platforms, and instrumented footwear systems as shown in Fig. 1. Optical pedo-barographs, consists of an acrylic sheet covered by a thin film, with an internal light oriented to the internal transparent acrylic plate as in Fig. 1a. Light intensity proportional to pressure is captured with a camera which is positioned to focus at 45° from the film [2].

Pressure platforms are restricted to be used in laboratories. They are made of a flat and a rigid array of pressure sensing elements, embedded in the ground platform as in Fig. 1b. These platforms can be used for dynamic and static studies, but the patient displacement space is restricted [3]. Instrumented footwear systems, are made of a flexible and portable array of sensing elements embedded into the shoe, for detecting the plantar pressure distribution as in Fig. 1c. These systems allow many different studies such as gait analysis, footwear design, and athlete monitoring. Many authors reported that the instrumented footwear systems are the most flexible, efficient and mobile [3–7].

These systems allow to estimate many parameters from plantar pressure analysis, such as mean pressure, peak pressure, center pressure and displacement speed of the center of pressure as potential variables to correlate with abnormalities [11]. Also, many foot pathologies can be diagnosed, such as the type of foot (hallux valgus, clubfoot, and pes planus) [12], diabetic foot [13], pathological plantar hyperkeratosis [14], among others.

Actually, the medical diagnosis depends strongly in the medical's experience, which cannot be inherited incoming generation, repeating the training processes with new doctors. For this reason, it is needed to develop diagnosis systems that help to store and manage the information acquired with the experience, to provide a tool for improving the diagnostic processes [15]. Traditionally, hospitals continuously collect huge amounts of information by monitoring physiological parameters of patients. This becomes a great opportunity and a challenge, because the manual analysis of large amounts of medical data is a hard task [16,17]. Clinical Decision Support Systems (CDSS) are currently useful for analyzing medical data, and much work has been done in medical diagnosis problems [18–26], but in the case of diagnosis of diseases related to plantar pathologies, only a few works has been reported.

This work presents a review of reported developments about the analysis and diagnosis of plantar related diseases by using different measurements systems, including the algorithms with potential use to improve the automatic diagnosis process. This paper is organized as follows: Section 2 presents a review of works about plantar pressure analysis for detecting pathologies. Section 3 shows the algorithms to automate the diagnosis of plantar pathologies. In section 4, the potential algorithms for detecting, monitoring, and diagnosing pathologies are discussed. Finally, the conclusions about the results reported with the used algorithms and the new opportunities to improve in this field are presented, evidencing that the hybrid systems that include fuzzy concepts are the most recommended.

2. Plantar pressure analysis

There are many systems developed with different technologies, for measuring the footprint pressure distribution [7,3,27,6]. The development of algorithms to analyze load distributions between healthy and unhealthy people, allows to obtain useful information for medicals and researchers [4]. To obtain more efficient and precise plantar pressure measurements and to facilitate its analysis, the foot is divided in different areas which support all body weight and balance adjusting.

For example in [28–30], the authors sectioned the foot into four areas; in the case of [31–35], is divided from eight to fifteen areas. In many cases, those areas satisfy the requirements of a particular study, but when not all the regions are considered,

Fig. 1 – Plantar pressure measurement systems. (a) Optical pedo-barographs [8]. (b) Pressure platform [9]. (c) Instrumented footwear [10].

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