a remote diagnosis,
accelerometers a human gait analysis,
GPRS

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A SYSTEM FOR REMOTE DIAGNOSIS OF HUMAN GAIT DYNAMIC PARAMETERS

SHORT NOTE

In this paper an architecture of a system for remote diagnosis of human gait dynamic parameters is presented. The system consists of some sensor groups located on lower limbs. The main system task is collecting and transmitting information describing human gait parameters such as: coefficients of energy, momentary and average power of muscles groups, movement pathologies.

1. INTRODUCTION

Walk is a natural form of human locomotion on land. It allows a body to move to desired location. A gait, in its normal form, is a symmetric and cyclic process, i.e. certain phases of limb movement are repeated. During walk, value of a vertical part of reflection force achieved by legs is less than doubled body weight. Owing to that, there is no flight phase in walk. Walk is one of the most complex movement activities that are performed subconsciously [1]. It is estimated that it takes 7 years to master this movement activity to the full.

Since the ancient times man has been fascinated with the surrounding world. However, at the prehistorical times, one was limited to taking observations, due to the lack of adequate measurement tools. He presented the results of these observations in the form of drawings. It is a similar situation in case of human movement. The first scientific analysis of human gait is presented in Aristotle treatise "On the Gait of Animals". However, the first comprehensive observations of human movement were done by Leonardo da Vinci. The principles of body movement were precisely described and illustrated in his works.

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2. CURRENTLY USED TOOLS FOR A HUMAN GAIT ANALYSIS

Development of engineering and sciences such as physics allowed to create many new tools that can be used for human walk parameters data acquisition. Currently used measurement tools can be divided into the following classes [2, 3, 4]:

- mechanical, electrical, electromechanical, electronic,
- photographic, photomechanical, photoelectric, magnetic, acoustic.

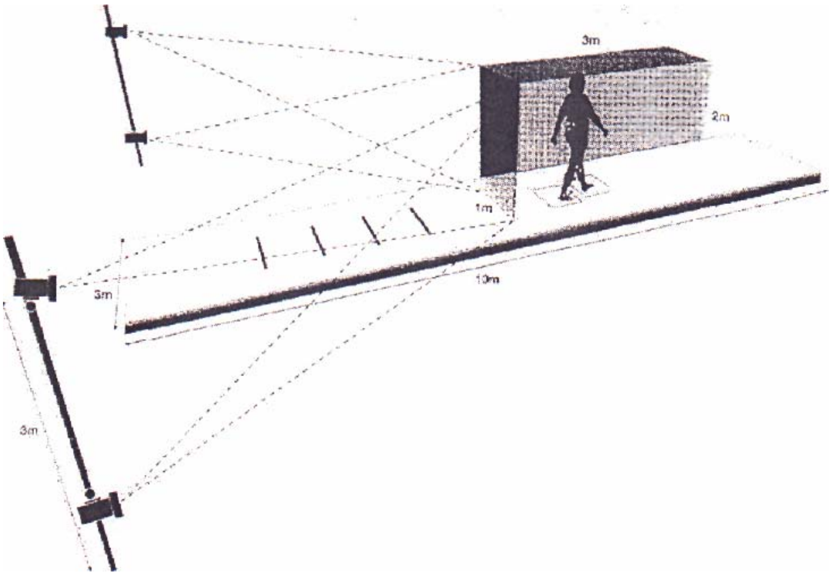

Fig.1 Gait data recording using a complex optoelectronic system with two dynamometer platforms.

Efficiency of these devices varies. A measurement tool choice is based on movement activity under research and research laboratory funds [6,7]. The most important of the measured values are:

- relative angles between main leg segments,
- surface reactive force,
- waveforms of electromyographic signals,
- duration of each movement phase,
- pace velocity,
- acceleration of selected body points,
- oxygen usage.

Currently, a laboratory gait examination is usually done with the aid of the system that consists of four motion cameras and at least one dynamometer platform (fig. 1). The cameras enable to record co-ordinate location of markers, which are mounted on the examined bio–object. As a general rule, these markers are located on characteristic points of a lower limb. Sometimes they are also located on other body parts, e.g. on the area of a lumber part of a vertebral column. It depends on the used human movement model [6].

For the purpose of human locomotive parameter measurement, a system based on accelerometric sensors can be used. Each measurement point consists of a few sensors located on the main movement axes. In case of a lower limb, it could be the following axes: flexion –

extension, abduction – adduction, internal rotation – external rotation. The accelerometers can be mounted on two neighbouring limb segments (fig. 2).

3. METHODS OF HUMAN GAIT MATHEMATICAL MODELLING

Complexity of a human locomotion system requires using mathematical and physical models for theoretical and experimental research. Assuming that bones are rigid elements and joints are kinematic pairs that allow rotary movement only, full human body model would have 240–250 degrees of freedom, while limbs only model – about 120. Simplification is achieved by reduction of degrees of freedom; however, such a reduction cannot lead to loss of similarity between the model and the original.

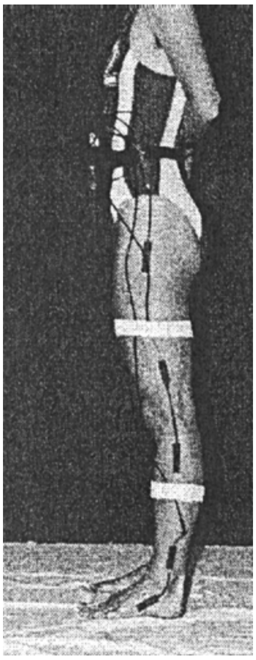

Fig. 2 Measurement of a lower limb acceleration with aid of accelerometric sensors

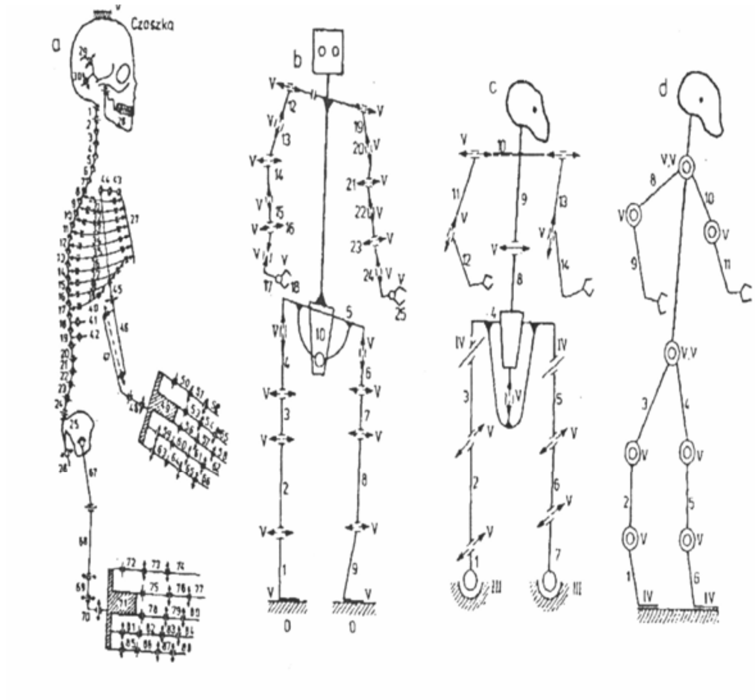

Fig. 3 Selected models that are used in human movement research; a) a full model, b) a robot model, c) a space model, d) a flat model

In research on human bipedal locomotion, flat and space models are used, which consist of 3-17 segments and which have 5-50 degrees of freedom (fig. 3)

4. THE WORK SCOPE AND OBJECTIVES

1. Determining dynamical parameters of human walk that are necessary for a proper diagnosis.
2. Developing a granulation method of information from accelerometers.
3. Developing a degranulation method of information that goes through GPRS net.

4. Creating an user interface for analysis of received information.
5. Verification of correctness and optimality of used diagnosis method.

5. THE MEASUREMENT SYSTEM ARCHITECTURE

The block diagram of a system for biomedical data transmission in presented in fig. 4. It consists of data acquisition module that co-operates with a selected sensor group, module for information stream granulation and adaptation to GPRS transmission protocol which is used in cellular telephony systems. A mobile part of the system co-operates with a stationary device, connected with a PC computer that enables to assemble granulated information into a stream.

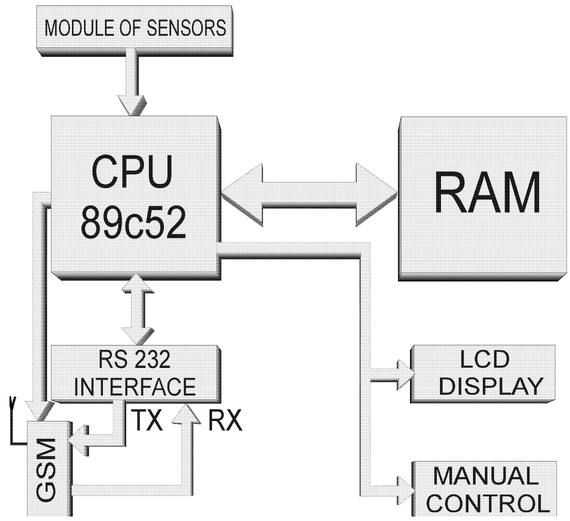

Fig. 4 A block diagram of a system

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