CONTROL DEVICE OF HUMAN BEING SPATIAL POSITION BASED ON MICROMECHANICAL INERTIAL MODULE

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ПРИБОР КОНТРОЛЯ ПРОСТРАНСТВЕННОГО ПОЛОЖЕНИЯ ЧЕЛОВЕКА НА БАЗЕ МИКРОМЕХАНИЧЕСКОГО ИНЕРЦИАЛЬНОГО МОДУЛЯ

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The article discusses the control device of spatial position the human based on MEMS sensors, it is a kind of miniature navigation system. The device contain several micromechanical inertial modules, calculation unit, radio channel for receiving and transmitting data, and software for displaying and visualizing human motion. Micromechanical inertial module includes a three-component, gyroscope, accelerometer and magnetometer.The purpose of the work is developing a device that allows patients to improve the general physical condition and the ability of independent movement.

В статье рассматривается прибор контроля пространственного положения человека на базе МЭМС датчиков, своего рода миниатюрная навигационная система. Прибор содержит микромеханические инерциальные модули, вычислительный блок, радиоканал приема и передачи данных, а также программное обеспечение отображения и визуализации движений человека. Микромеханический инерциальный модуль включает в себя 3-х компонентный гироскоп, акселерометр и магнитометр. Цель работы разработать прибор, который позволит пациентам улучшить общее физическое состояние и способность к самостоятельному передвижению.

The task of preserving balance, movement’s orientation or coordination in vertical rack, walking and other actions take a significant place in today's world of technological progress. Driving vehicles, works with different mechanisms, production management of processes impose strict requirements for motor coordination reactions. On the one hand, various pathology types of subclinical level or no diagnosable pathology can manifest themselves in the most tragic way. On the other hand, many diseases of the musculoskeletal system have their own symptoms, which are expressed in a change of balancing the patient's body reaction in the basic stand, sitting or walking. However, clinically the presence of certain symptoms becomes the obvious only when the full pathology was detected. There are special methods that allow detecting changes in health much earlier, and it becomes possible to diagnose at a stage of disease or its consequences, even when the patient has not any complaints.

Nowadays a new medical specialty - posturology has been developed in some countries. As a science, posturology studies the processes of conservation, management and regulation of body balance with different body positions.

The terms stabilometry and posturography are often used as synonyms in Russia. They mean the analysis of changes human posture only on a certain type of equipment - stabilometric platform. Nevertheless, Posturography includes stabilometry only as one of the techniques.

The techniques are different by the type of using equipment. The equipment measure various physical parameters associated with the movement of the center of pressure, the movements of the limbs and body segments, force push (jump) and others.

Stabilometry is used in medicine [3], sport [4], psychology [5] and other areas for quantifying motor coordination capabilities. The method is included in the Russian standards of health care as one of the methods of diagnosis in some diseases: congenital malformations of the nervous system, trauma of a backbone and spinal cord injury, Parkinson's disease, polyneuropathy [6] and others.

The posture analysis method is based on processing signals from the accelerometer. This method has the name "accelerometer", "spatial stabilometry", "3D-stabilometry" and others.

Accelerometer method is more sensitive for different vibrations registration than the stabilometric or pododinamometric platforms use. It allows to obtain more information and to investigate a wide range of oscillation frequencies. Accelerometer method has some limitations. It, unlike the devices pododinamometric, does not allow receiving the position coordinates of the center of gravity or its projection on the bearing area. But it has another physical essence. For the clinician it is important that the stability of the human body balance in any of its positions is now possible explore a technically simple method. This is important not only in the clinical setting but also in the household conditions. It is now possible to measure the amount of movement that performs the one or another person during the day or more. Here there is also direct access to the clinical problem - it is an objective assessment of the number of physical activity for the patient during physical therapy sessions, household activities, etc.

The other side of such technology is the possibility of objective registration of tremor of any body segment in the entire frequency range. Such studies have become available relatively recently, for example, the registration of limb function after suffering a cerebral stroke. This technology allows fast and inexpensive evaluating of the movement disorders in the treatment process or action drug therapy [8].

The control devices of spatial position based on the foregoing of human based on MEMS sensors consist of the blocks (Figure 1). The figure below shows the block of the micromechanical inertial modules, enshrined on a human, a calculation unit (system of collecting and processing data received from the IM), radio channel to receiving and transmitting data, and software to display and visualize human motion.

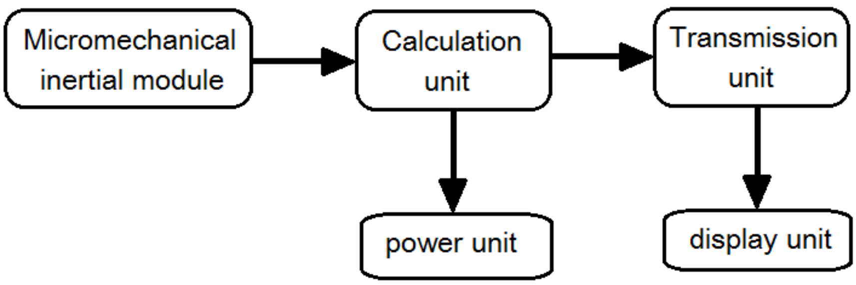

Fig. 1. Block diagram of the device human spatial position

The control devices of spatial position of human based on MEMS sensors can become a good alternative to traditional stabilometry.

Micromechanical inertial module (MIM) is a digital measuring device, built on the basis of micromechanical inertial sensors that measure linear acceleration, the parameters of the magnetic field and the rotation angles (see Figure 2).

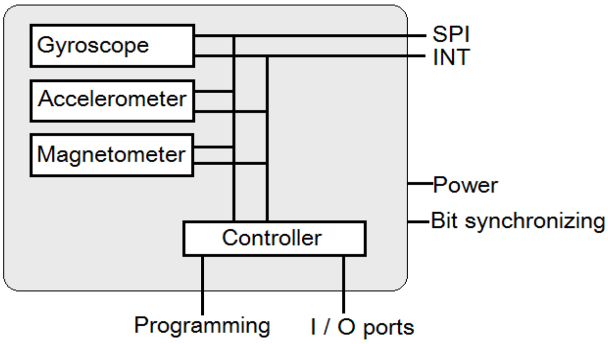

Fig. 2. Architecture MIM

The aim is to construct a miniature navigation system for determining the spatial position a person using micromechanical systems, as well as for rehabilitation, functional diagnostics posture stability.

To perform calculation and visualization it is needed to construct a mathematical model of the human body. This model must take into account the different characteristics of the human body structure, but then there are some difficulties with the manufacturing. It is advisable that the model includes only elements which will be attaching by sensing elements.

The taken human body model is shown in Figure 3. It consists of 13 components.

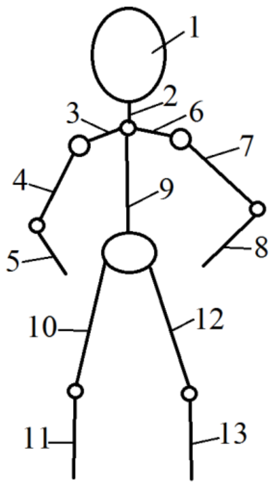

Fig. 3. Human body model

Users of the system must be kept informed about the movements in a convenient way that includes visibility of the output information, the ability to visually assess the specific measurement. Thus, the calculating unit performs the following tasks:

1. Obtaining orientation angles at the output parts of the body:
   - relative to the reference coordinate system;
   - relative connected systems of coordinates of adjacent segments;
2. Visualization of human movements in three-dimensional space.

The input data is a set of quaternions, the appropriate number of body segments. They contain information about the orientation of the body parts in a given time, as well as the length L of movable parts of the human body.

Block diagram of the developed algorithm is shown in Figure 4.

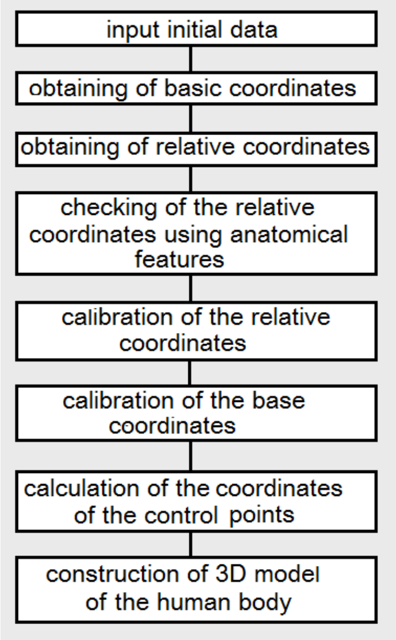

Fig. 4. The algorithm of information processing

Checking the operation of the entire algorithm will be carried out by computer simulation in software product in MATLAB / Simulink.

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