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MODELLING OF A MECHATRONIC MODULE FOR FOOT RECEPTOR ACTIVATION

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Abstract: *The module is developed like executive mechanism of a biomechatronic system for a rehabilitation of patients – paraplegics and patients during the period of continuous immovability. It must ensure according to the assignment: basing and fixation of the patient's leg; basing of a measuring sensor and a mechanism for acupressure, and also gives the possibility for their connection to various foot points for the programme performance of the procedures. The next stage of the development was optimisation of the module by size and weight and its transformation into independent portable device with insurance for vertical position in the bed of the immovable patients. The models of four variants of constructive design of the module are analysed and discussed. The choice of the most suitable variant is performed for the functional assignment presented in this report. A 3D model of the module is presented. Simulation of the treatment procedure and measuring on the patient's foot via the virtual prototype of the specialized mechatronic module is performed.*

Keywords: ***Mechatronic module, rehabilitation, receptor activation, modelling.***

1. Introduction

The mechatronic module is designed for a applicable in the rehabilitation of patients in the early post-traumatic stage after the occurrence of a spinal cord trauma or poli-trauma, and in the rehabilitation of patients suffering from durable immobilization in a lying position (Platonov et al., 2008). The carried out preliminary scientific and experimental investigations show clearly the effectiveness of this approach not only for the recreation of the functions of the supporting and locomotion human system, but also for the organ function stimulation, projected on the supporting foot surface by the nervous tips.

2. Methods

Developed mechatronic module can ensure treatment procedures on method of acupressure at specific foot acupressure points, receptor activation along specific trajectory or affects foot reflex areas. It operates according to a previously prescribed program. Thus, functioning of the internal organs of patients suffering from durable immobilization (in lying position) is activated.

The module can ensure control measure the bioelectrical resistance by means of a specialized sensor. Such a sensor is needed to design a high-spatial resolution map of acupuncture points of a patient's foot, and the map should be used to analyze the results of the treatment. The sensor measuring both the initial (pre-treatment) foot skin electro-conductivity, as well as the current one operating during the process of medical treatment, is of essential importance for the successful stimulation of patient's foot.

Product *Mechanical Desktop 2005* is applied for the creation of a virtual 3D model of the module.

The program "MSC.visualNastran 4D 2002" for computer simulation is applied on the 3D model.

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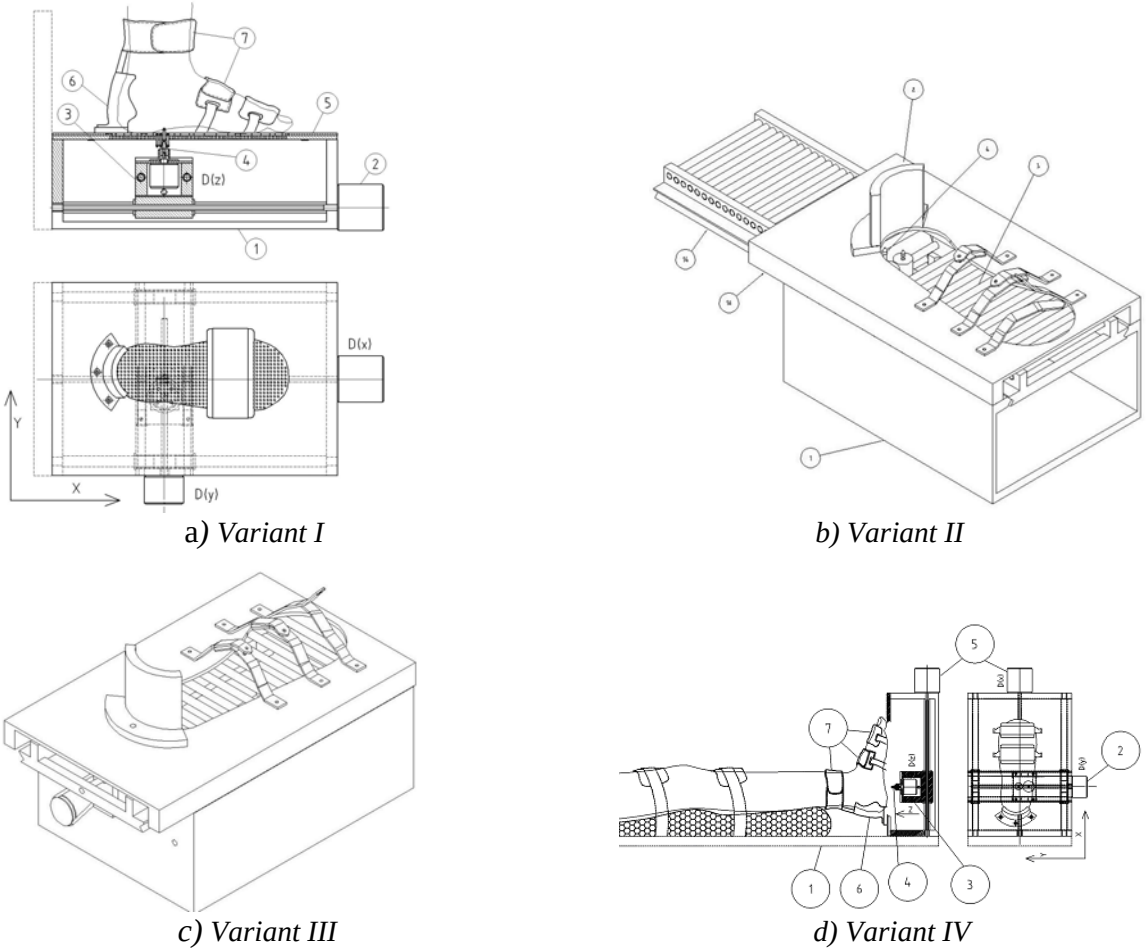
3. Requirements to technical module design

The designed module must meet the following requirements:

1. Sustainable basing the patient's leg, which is in a reclining or sitting position.
2. An accessibility to be ensured to maximum number of points on the foot with the aim to measure the bioelectrical resistance by means of a specialized sensor.
3. Accessibility to maximum number of points on the foot for automatic acupressure performance according to a programme assignment, individually for each patient.
4. Discomfort must not be created to the patient, and also not to influence the precision of the carried out measurements.
5. Basing to be possible at different patient's feet sizes.
6. Safety of the patients to be ensured of the device activity at arising programme or mechanical reasons.

4. Technical module design - variants

Four variants of the module for founding of patient leg, measuring and acupressure are developed and modelled and they are presented in Fig. 1.



a) *Variant I* b) *Variant II*

c) *Variant III* d) *Variant IV*

Fig. 1: Module- shoe for founding of patient leg, measuring and acupressure – variants.

Variant I was developed mostly and on a patent level and was registered as a Bulgarian patent BG 109266 A which was developed as a stationary variant of a biomechatronic system for rehabilitation of paraplegics. The next stage of the development was optimisation of module by size and weight and its transformation into independent portable device with insurance for vertical position in the bed of the immovable patients. The study describing the realization of Variant I is close to the cited in literature Japanese patent, registered in Europe as EP 0 372 114 A1. The objective of the work presented in this paper is a modelling of Variant IV, being the most suitable one for a portable device for application in a patient's bed when the patient being stationary.

4.1. View of the device

The developed module includes the following component, (Fig. 2): 1- base, 2 - translation linear drive along axis Y, 3 - combined module-carriage, 4 - executive mechanism for acupressure, 5 - translation linear drive along axis X, 6 - heel support, 7 - foot fixations.

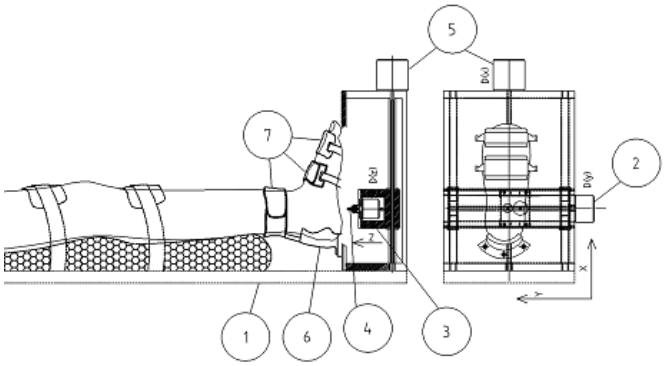


Fig. 2: General view of the device.

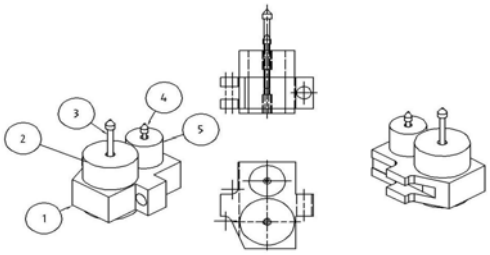


Fig. 3: Combined module-carriage.

The foot is based at support 6; leg is fixed above the ankle joint and in the front part of the foot is prepared fixations 7, which place is regulated longitudinally according to the foot size. The surface of the foot remains uncovered for a direct contact to each point for measurement of the skin electrical resistance and acupressure. Combined module - carriage (Fig. 3) comprises carriage 1, to it is immovably attached module for acupressure 2 and a measuring module 5.

In the modules joints are included respectively two linear drives, by means of which a translation along axis Z is realised. The respective useful contact pressure of an electrode for measurement 4 is achieved by means of drive control and the external force (acupressure) is regulated by means of the executive mechanism 3.

4.2. 3D model of the module for founding of patient leg, measuring and acupressure

Module functions simulation is performed on the derived 3D model of the module for basing of the leg, measuring and acupressure.

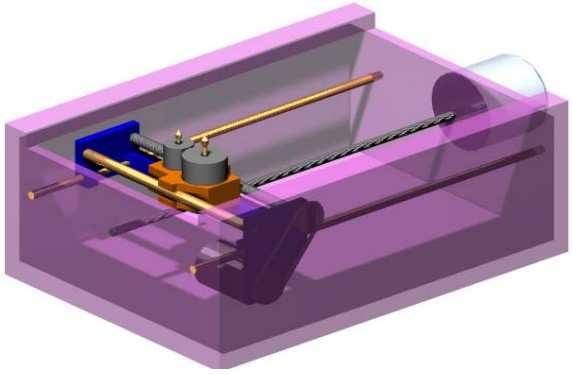


Fig. 4: A mechanism for a plane motion and positioning for measurement and acupuncture.

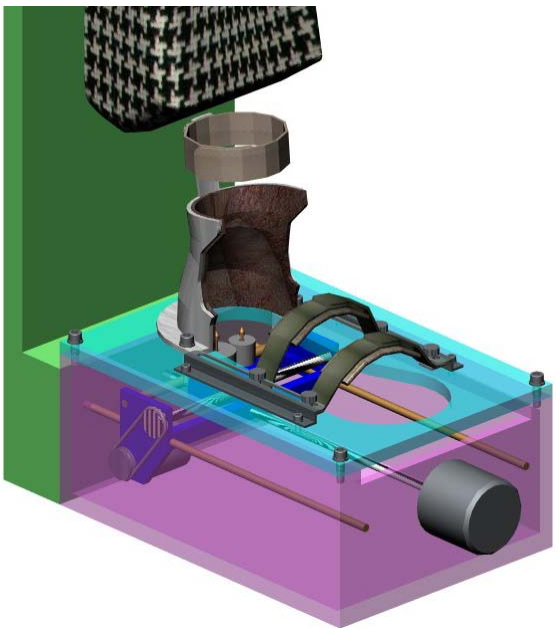


Fig. 5: 3D model of the mechatronic module

5. Conclusions

The conclusions derived after modelling and simulation help the successful realization of the prototype of the portable module for procedures with supporting and healing effect of patients in the early stage after the occurrence of a spinal cord trauma or politrauma.

The following scientific and application results are expected:

- Measuring of the bioelectrical resistance to be performed in the foot points for each individual patient by means of a specialized sensor "***Skin Touch***". An individual chart of the acupuncture foot points of the patient is build up.
- Planning and performing of treatments (acupresura) in definite points, along a defined trajectory or an area on the foot.
- Performing of a periodical estimation and control of the treatment results by means of measuring of the bioelectrical resistance in definite foot points. The healing programme undergoes a consecutive variation if necessary.

The mechatronic module can be applied in the clinic practice after performing technical, laboratory and clinical experiments.

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