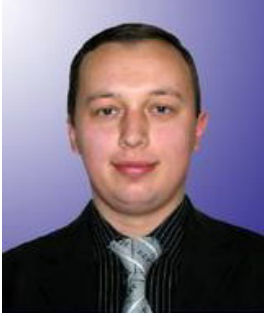
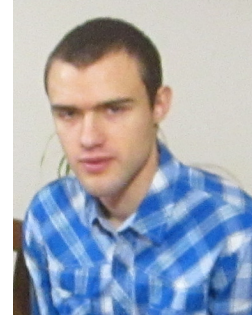


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### **3D MODELLING OF REHABILITATION CORSET WITH USE OF POWERSHAPE DELCAM**

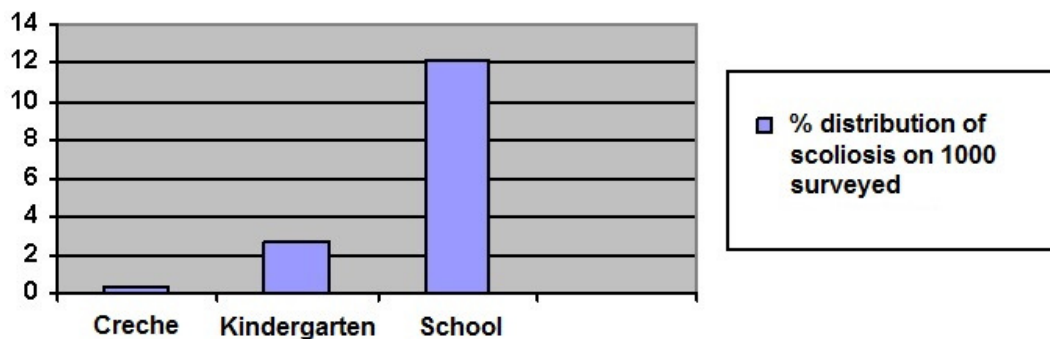
*П.С. Носов, А.Д. Яланський, В.О. Яковенко. 3D моделювання реабілітаційного корсету засобами PowerSHAPE delcam.* Побудовано 3D модель корсету для діагностування відхилень постави людини. Запропоновано систему дослідження, моніторингу і пошуку нових форм реабілітації за рахунок комп'ютерної діагностики стану постави. Запропоновано конструкцію та алгоритм збору та обробки даних під час лікування.

*P.S. Nosov, A.D. Yalansky, V.O. Iakovenko. 3D modelling of rehabilitation corset with use of PowerSHAPE delcam.* 3D model of corset is constructed for diagnosing abnormalities of posture of a man. The system of research, monitoring and searching is proposed for new forms of rehabilitation through computer diagnostics of posture. The construction and algorithm of data collection and processing during treatment is proposed.

**Introduction.** The rapid development of modern medicine and science helped to improve and enhance the quality of treatment in violation of posture - scoliosis. Modern child spends more time in a sitting position, and controlling it during the day is impossible. Therefore imperceptible posture increases, increasing damage (Fig. 1).

Curving posture - a problem in the investigation, of which the human body can get almost irreparable damage. Curvature of the spine is a changing of the configuration of the spine. In the course of time, the deviation of the spine causes very little stress and deflection is not disappearing during the rest. Posture of person can become unstable due to deviation line load. On a subconscious level people will look for a stable posture to maintain equilibrium, and thus will develop curvature of the spine in its other divisions.

For many years, correct of posture was restricted by wearing corsets.



*Fig. 1. Percent distribution of scoliosis in Ukraine*

To increase the effectiveness of treatment we need new methods and formulated basis for future methods, which will reduce time of spine correction.

**Material and research results.** Scoliosis begins in childhood age or early adolescence and develops gradually as the growth of the organism. After growth finished curvature of the spine still remains.

There are several types of spinal curvature. Curvature of the spine is generally measured in degrees: below 30 degrees is considered negligible distortion, above 60 degrees - serious [1]. Treatment is chosen depending on the severity and the patient's age. There are many methods, but just few of them are able to really improve the situation and prevent further development of the disease. One of the surest ways to deal with the disease is corrective corset. This method is most effective for a prevention of progression of the disease. If you wear a corset over 16 hours a day, it will prevent the further development of scoliosis by 90%. However, this method is effective only if the curvature is 20 - 35 degrees, but if it is more than 60 degrees, this method is ineffective. This is because while wearing the corset muscle of man did not evolve and eventually can no longer keep your posture in good condition. People with a severe form of scoliosis are offered surgical treatment, but it is not always justified. Typically it is used for adolescents with curvature over 40 degrees. In some cases it is possible to help children with scoliosis of 45 and even 50 degrees. Indications of adults are not as accurate and have more complications and discomfort throughout life.

Corsets have undergone several changes over the years: changed shapes and sizes, built from different materials, etc. But the principle of operation remained unchanged. Table 1 shows the advantages and disadvantages of modern corsets:

Modern corsets are comfortable and do not interfere with everyday life, although they partially restrict the movement of the body. To improve the results of prevention and treatment corsets have to expand their opportunities to create a new generation of computerized corsets that will maximize efficiency and versatility, affordability and will allow ability to influence on the individual patient model [2].

Table 1

## Advantages and disadvantages of modern corsets

Advantages	Disadvantages
<p>Modern durable and lightweight materials allow to wear a corset under your clothes. Corsets almost not limits movement of the body.</p> <p>The design of the corset and using in it materials of different rigidity can add accent on certain areas of the back.</p> <p>In a corset are used magnets, which, according to manufacturer, have a benign influence. But researches on this basis almost not conducted.</p> <p>Wide range of models corsets can meet patient ergonomic shape and design.</p>	<p>Works only physically. Modern corsets usually don't have party modifications for improving efficiency.</p> <p>Corsets prescribed by the doctor. Self-medication may be harmful to health.</p> <p>Corsets are created for standard sizes. The market almost doesn't have universal models.</p> <p>Quality of fixing parts of corset may be insufficient, the exploitation time may not be sufficiently large.</p> <p>Corsets can irritate skin and "rub" body.</p> <p>Corsets do not satisfy the requirements of the growing child. Rapid growth of the child may increase time of treatment or even harm.</p> <p>Many corsets light colored. Their coverage quickly contaminated.</p>

Modern corsets are not using all available resources, so based on the corset it is possible to install modifications and additions that will improve the efficiency of the treatment process and alleviate the condition of patient, for example:

- computerized monitoring systems,
- modules of active interaction with the patient's body,
- opportunity to fine adjustments of corset,
- synchronization and data exchange with other devices (smartphone, computer, etc.).

Arises an aim to create a new tool for the correction of spine condition of patient. The new tool that can be the basis for new treatments. Departing from the concept of corsete we should leave all the benefits of corsets, fix flaws, with the ability to add new benefits and opportunities. It is also important to establish a basis for future modifications for different purposes and corrective experiences.

Study of motion of the spine using corsets has some complications, so future construction should repeat form the spine of man. The design must include the ability to install sensor modules and so the design will have empty interior space. Proper fixation is important because with the belts and parts of consolidation structure will be equipped with a suction cup system of low pressure. Changing the size and shape of artificial spine is performed by means of hinged mounting, which al-

low moving separate segment design of 70 degrees in all directions. Distance between segments regulated in docking slots.

The primary function of an artificial spine - definition of coordinates of each segment. With the help of user interface and obtained data it is possible to construct a scheme that will reflect the status of human spine, record changes in the state, provide detailed information to doctor and thereby define the following strategy for continued medical treatment process. It is known that vibration and thermal effects on part of spine have benign effects: blood flow increases, between-vertebral discs are larger and therefore correction and treatment should theoretically be more productive.

The first step in creating design corset is creating a 3D model segment in the program of automated design *Delcam Powershape*. The design must correspond all the above requirements:

1. **Small size.** Reducing the size of the design will increase the number of segments, which in turn will increase the amount of received data and the accuracy of the coordinates. The small size also allows the device to hide under clothing;

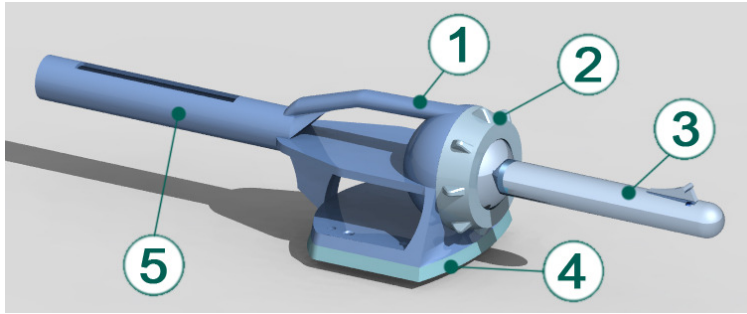
2. **Strength and large internal amount.** Each segment is the carrier for coordinate measuring module and other possible modules, therefore as more internal amount of the segment, the larger and more complex modules can be installed inside. By reducing the amount occupied by the same segment, you can increase the amount of modules, although this will reduce the strength of the whole structure. Segment must withstand attaching to it other segments and modules, and possible load during operation, so for optimum strength it is necessary to find a balance between acceptable reduction of employed segment capacity and the ability of the material from which made the segment design;

3. **Modification.** Possibility of modifying the design is an important criterion, which makes the device a universal basis for third-party modifications. The installation and replacement of internal modules extends the functionality and capabilities of design. For easy replacement of those modules design provides easy accessibility to the internal part of the body, almost all upper body segment is open. Strength and protection of internal modules is performed by external elements of the segment, which together form the small skeleton. In amount of the modifications is included easy exclusion and connecting of separate segments;

4. **Fixing for a body.** Not less important requirement. Fixing for the body of carrier can be like using straps or corset, and by fixing with help of low pressure. This refers to the creation of low pressure in special cavities, which contact with the body, in which the segment will not lose contact with the body until desired pressure is supported. Also possible fixing by sticky material.

According to all criteria and requirements, design segment acquired optimal shape (Fig. 2):

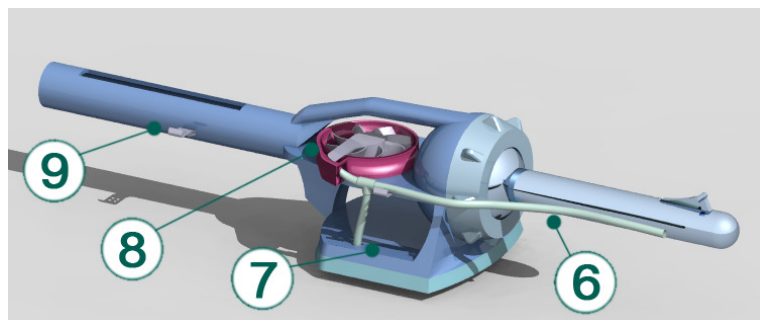
The basis for the future is solid cast metal construction (1), in which installed all sensors and modules. The design consists of bonded segments, being able to move in all three planes of space with help of articulated fasteners (3).



*Fig. 2. General view of the construction segment*

Distance between segments manually adjustable by hinge slots (5) if necessary. Division of one segment from another is possible by taking off the hinge cover (2), so you can change the number of segments and the length of the whole construction, or quickly replace the segment.

To create an area of low pressure under each segment the first segment of the ordinal number is equipped with an air output (8) (Fig. 3). Hole in the segment (7) and the system of output of air connected by tubes, also segments connected by tubes, recreating a coherent system. This design is quite simple: the system can operate on specific segments, increasing the lifetime of the system in offline. The basis of the same function will perform other fasteners or corset, and fixation will improve the accuracy and reliability of received data.



*Fig. 3. General view of the construction segment*

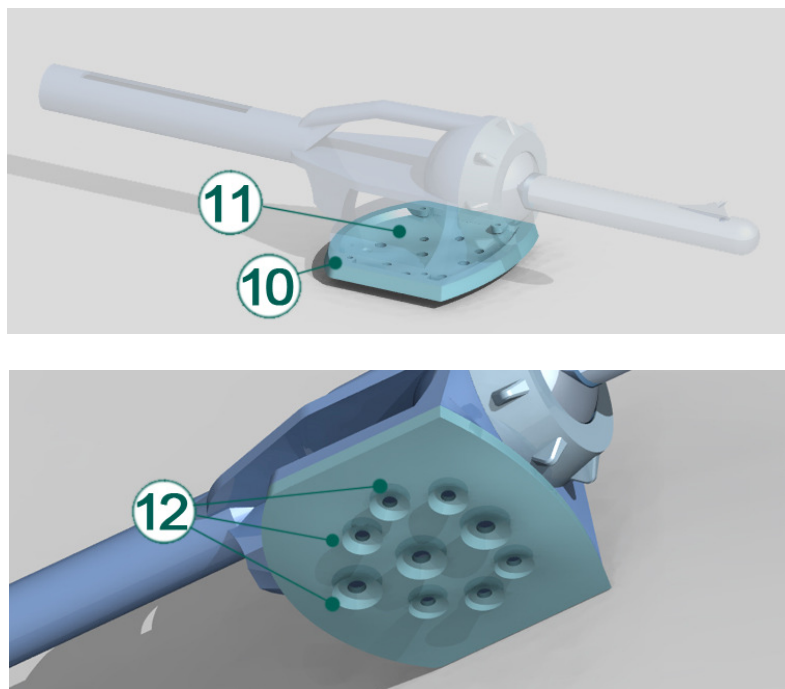
The segment equipped by fixed bottom (4), which serves as a fixation and prevents segment glide over the body of carrier. Material of detail - elastic polymer - resin. The bottom has empty interior space (11), and from out of it on the bottom situated holes with suckers (10). Detail attached to the main body through mounting in holes of the main body and the bottom. At a time when the bottom bolted to the main body (1), air can circulate through the top hole (7) and through holes-suckers (12). Creating of a region of low pressure in interior space of the bottom,

suckers are pressed by difference in pressure to the human body, thereby fixing the segment in a given area of the body (Fig. 4).

The design provides separation of segments to make the design smaller, or to focus on a certain area of the spine. Re-fixation design needs, if necessary, putting labels or signs on pretrial attachment places. Accuracy of further research will increase.

To determine the coordinates of the segments was decided to use 3-axis accelerometers (Fig. 4) [3]. These devices are actively used in smartphones and tablets, they have wide range and a lot of classes of accuracy are available with small geometric amount. Each segment contains one 3-axis accelerometer, which transmits data position in space through a common data bus to the microcontroller. Accelerometer mounted in the interior space on the first or second level. Using a special algorithm and known serial number of segments we can construct a scheme provision of whole design in real time.

Received data is used to detect changes in spine as in the active use time and in the timely review of a doctor. In addition to changes of the spine, data can show the level of stress per day or during work. Focusing on received data, the system is able to attract attention of carrier on his position of the spine using a small vibrating device in one of the segments. Valid and invalid positions are set by doctor, after violation of which carrier will be notified and will change position of posture. This will help to build a 3D model of evaluation of trajectory movements of patient [4].



*Fig. 4. Fixing segment to body*  
Автоматизація і комп'ютерні технології  
Automation and computer technologies

Each accelerometer design while working will provide output data in the form of acceleration force (in our case gravity)  $G$  on each axle. Using the algorithm and received data it is possible to define segment position in space with an accuracy up to 1 degree (depending on the accuracy of the accelerometer) (Fig. 5). While man walking occurs tremors that will interfere device to get correct data, so accelerometer should be of relevant class and have optimal sensitivity (such as in automotive motion sensor), otherwise the device will be used as a diagnostic when person is not moving.

Trough data bus each accelerometer sends output data, which is coming in portable storage or a computer, laptop or smartphone. For distinguishing and correct work of algorithm each segment is given a number. Output data, received from a particular segment, will be labeled with serial number.

Time of received data will be assigned by computer. The signal with the label is as follows:

$[N][x:0.000; y:0.000; z:0.000;]$ , where  $N$  – serial number of segment;  $x, y, z$  – acceleration value for each of the axes.

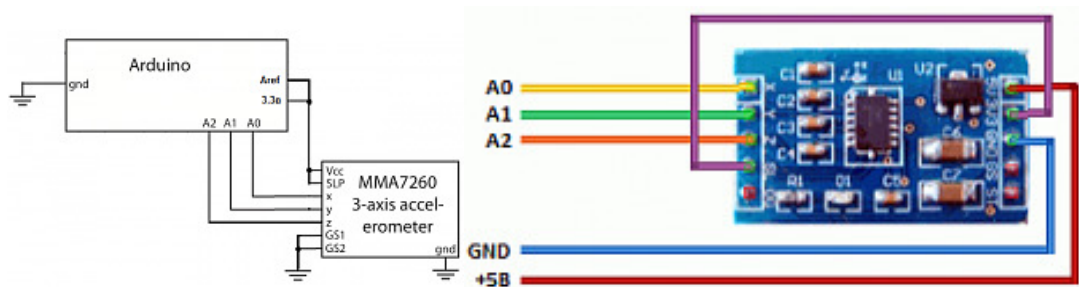


Fig. 4. 3-axis accelerometer MMA7260

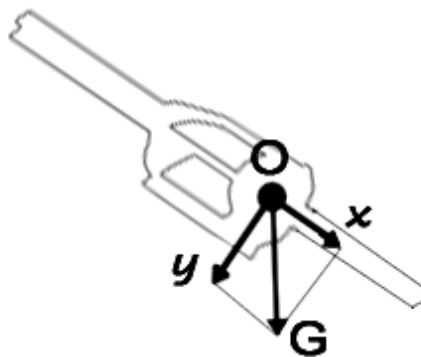
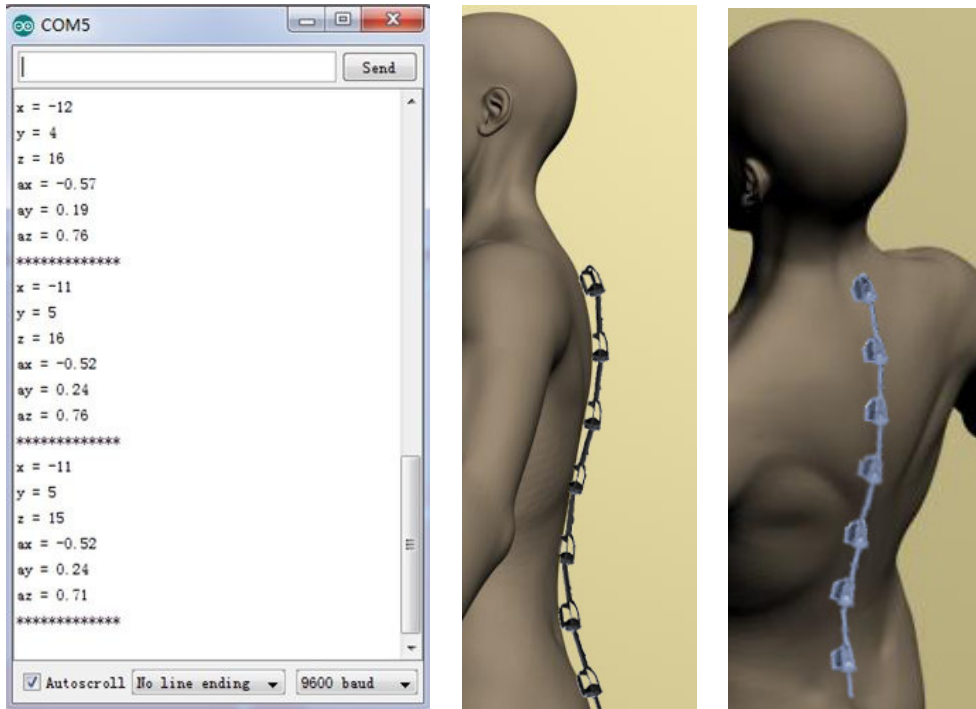


Fig. 5. Principles of accelerometer work in segment





*Fig. 6. View of input data and 3D model of corset*

Algorithm is implemented in program interface. With help of serial numbers it is possible to get a schematic view of position of each segment. If it is known position of first segment, then it is known radial location of next segment, and so in order.

Algorithm is to find the angle of plane using accelerometer's output data. The resulting corner will display position of each segment, which then will be reflected in the program by creating a picture-diagram.

Particular position of segment in space, the connection between them and the correct position is determined by a mathematical model: segments are separated from each other by distance.

If we draw the line between segments, then position changing in space is equal to the angle rotation of the segment line.

Coordinates of next segment are oriented on preceding segment (Fig. 6). Getting data occurs in real time.

While using the device in offline mode received data arrives to microcontroller and memory block, which is located in first segment.

Power supply 5V~1000 mA·h provides the device throughout the day.

If necessary, changing of frequency of the device work is available.

Memory capacity from 2 MB will be sufficient for the tireless work of the system.



**Conclusions.** This model offers a new approach to the diagnosis and treatment of human posture. Versatility and ease of use makes it accessible, and ability to modify and improve methods allow you to create new and innovative courses of treatments.

Subsequent researches will be focused on construction of processing algorithms and data identification of electronic elements of design, recognition of posture abnormalities and creating decision support system for efficient diagnosis and treatment of patients.

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