IOP Conference Series: Materials Science and Engineering

PAPER • OPEN ACCESS

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To cite this article: E A Khmyachina *et al* 2020 *IOP Conf. Ser.: Mater. Sci. Eng.* **747** 012085

IOP Conf. Series: Materials Science and Engineering **747** (2020) 012085 doi:10.1088/1757-899X/747/1/012085

Automation of the manipulation robot construction trajectory for soft tissues tensoalgometry

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Abstract. The problem statement and solutions for using the vision system to automate the machine learning process of a manipulation robot for constructing trajectories for tensoalgometric diagnostics of human soft tissues are considered. The research structure of the robotic system is equipped with a vision system and a power sensor. Robots to accelerate the procedures of geometric power characteristics of soft biological human tissues. The results of the work in the form of programs and algorithms are presented.

1. Disclosure of the concept of a tensoalgometry robot manipulator.

When carrying out such complex manipulations as tensoalgometry of soft tissues, it is necessary to create a model of the trajectory of the robot manipulator, equipped with a system of force sensors that estimates the force of the reaction of soft tissues to immersion of the probe. The trajectory of movement is uncertain and depends on the structural features of the human body. To speed up the research, a system is needed which is able to perceive the parameters of the medium being studied and memorize them in the memory of robot control system, and reproduce the movements during repeated research without the participation of a programmer.

The system consists of two components: the control system of the robotic arm and a personal computer, which are connected to a shared local area network via Ethernet.

2. The principle of operation robot algorithm.

The interaction process is as follows: there is a shared network folder that is accessible to the main components of the system. A C# language program has been written that works with a camera connected to the PC, capable of taking high-resolution photographs, thereby forming a technical vision system for PCs running the Windows operating system.

The camera is placed above the working area of the robotic arm and is directed by the viewfinder vertically downward towards the patient. At the operator's command, the camera takes the first picture of the patient's body, ready for the study. The operator places colored stickers on the patient's body with marking, all the material that contrasts well with skin color. After placing the stickers, the operator gives the command to the program for the second shot.

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The program algorithm was compiled using the OpenCV computer vision library (EmguCV), which solves the problem of determining the coordinates of color markers (stickers) in the photo by subtracting the color of each pixel of the first image from the corresponding pixel color of the second image.

The result of this operation is a black and white image, where black means the color of both pixels with a given deviation threshold and white means those pixels where this threshold was exceeded those places where the mark was pasted.

Further, the algorithm using the OpenCV library tools eliminates noise and other unwanted elements in the image resulting from the movement of the patient through filtering. Also, using the built-in tools of the OpenCV library where all white areas are removed, which is less than the programmed mark area. Applying the operation to determine the contours of the resulting figures, the program generates a table file in a folder common with the robot control system, where the coordinates of the centers of the circumferences of the markers are stored and recalculated in the coordinate space of the manipulator.

The control program for the robot manipulator is written in such a way to be able to select the desired file in the network folder, to be able to go from point to point from the table, performing diagnostic methods of immersing the probe along with the vertical axis until the threshold for soft tissues reaction force is reached, or a command will not be received from the operator or from the patient, signaling the end of the movement and the transition to the next mark.

At the time of immersion of the probe, the control system records the readings of the sensor system in a table opposite the coordinates of each point, where data on each millimeter passed is recorded for subsequent visualization and assessment of the patient's condition.

Thus, soft tissues are examined and their condition is evaluated without directly programming the trajectory of the manipulation robot, which significantly reduces the requirements for operator qualification, speeds up the research and eliminates the probability of errors in positioning the robot.

For the task of implementing positional-force control of the KR5 robot during massage, a program was developed that implements force training of the robot. The purpose of this program is that it is necessary to adapt the work of the robot during manipulation on any surface with a different laying.

For the hardware implementation of this method, it is necessary to have additional measuring systems, for example, a computer vision system (CVS). Dynamic tracking of the patient's position with the help of CVS will allow with a certain frequency to make a "video capture" of the area where the patient is located.

After that, reference points are identified that are attached to the parts of the body (for example, the seventh cervical vertebra, contour of the back, contour of the spine). Based on the received image, the lengths and distances between these points in millimeters are calculated. According to the topographic-anatomical landmark of the average person's laid in the computer's memory, the information picture is adjusted from the CVS to the landmark grid, - (figure 1).

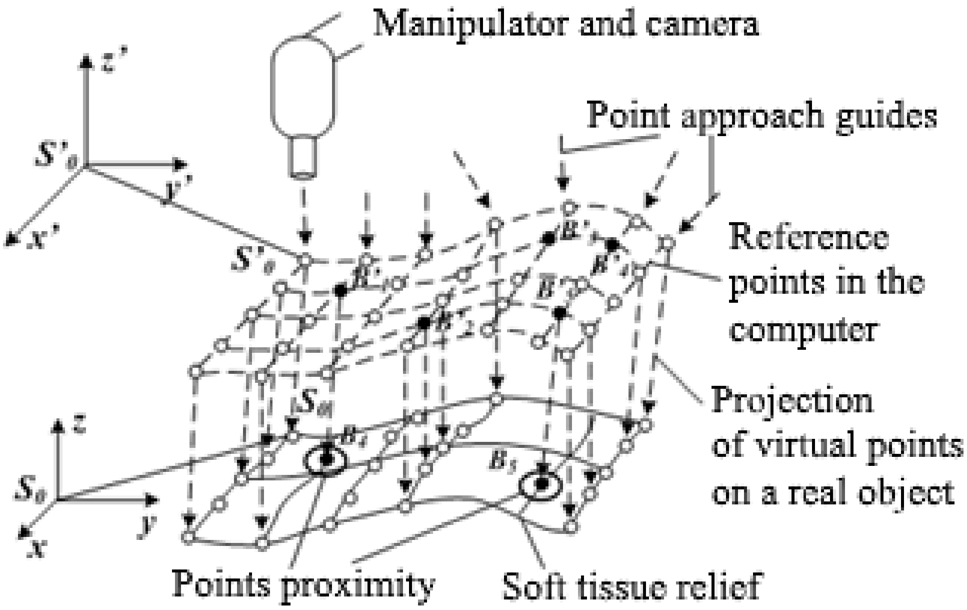

Figure 1. The scheme of transferring the virtual grid to the projected area.

Here:

(x', y', z') - the coordinate system of the landmarks of the training points; (x, y, z) – coordinate system of a bio object.

(S'0, S0) - reference points (bones, tendons, articular protrusions). Recalculation of points from a virtual grid to a real object (B'n → Bn) is associated with the calculation of individual anatomical spatial data (which is different for each patient), focusing on the reference points S'0, S0 coordinates of which are determined using CVS.

After calculating the parameters x, y on a real surface, the parameter z is determined by the calculation method, but requires experimental refinement, because the laid of a particular patient is determined only by contact.

Knowing x, y, the probe of the robot is positioned above the projection of the point Bn and, dipping into it, upon contact, remembers the corresponding point z, running in parallel with the algorithm for polling the force sensor.

Next, the cycle of operations associated with the search for subsequent z, lowering and removal of diagnostic information at the found point in terms of elasticity is repeated.

After the next removal of the point parameters, the information is transferred to the computer's memory. At the same time, it is necessary to diagnose the required number of points in order to form impact management. The scheme of such an algorithm is shown in figure 2.

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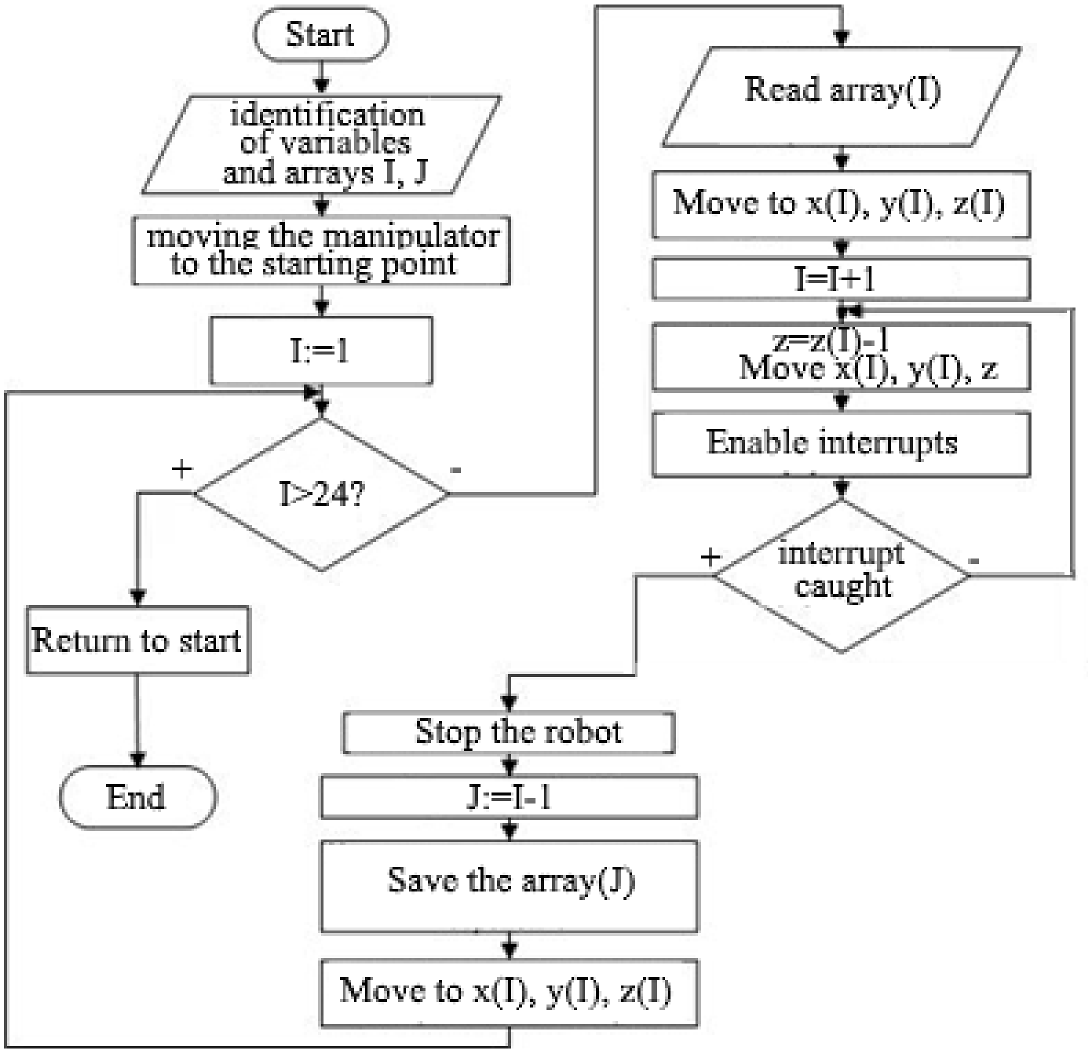

Figure 2. Block algorithm of the KR5 robot strength training implementation program for performing mechanical stimulation procedures.

In the cycle there is a survey and control with a certain frequency of the following data:

- current position of the patient;
- recalculation of the coordinates of virtual points in real to the surface when the tool is shifted along the z axis.

When shifting the current position, it is necessary to switch to the mode, which involves the removal of the instrument from the surface of the point to a safe distance, in the next measure, the continuation of incomplete reception is carried out.

3. Tensoalgometry of soft tissues.

The implementation of the method of automated construction of trajectories for a manipulation robot performing a diagnostic strain gauging procedure can be provided only on robots or with position-force control and the second option using a vision system. The CVS functions include initial scanning of contrast marks applied to the profile of the human back surface, software image processing and noise filtering, the formation of a file with target coordinates for constructing trajectories along which the robot tool will move.

The article describes and provides algorithms for machine learning, the identification of geometric parameters of the profile of the surface of a person's back. It also describes the environment for software processing of signals read by a CVS video camera. According to the developed algorithms, programs were written that are currently being investigated.

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