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DEVELOPMENT OF A KINEMATIC MODEL OF AN INTELLIGENT MEDICAL ROBOT FOR ULTRASOUND DIAGNOSTIC STUDIES.

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The main reason for using robotic ultrasound is to improve the accuracy and robustness of ultrasound examinations. By removing the human factor from the examination process, robotic systems can perform ultrasounds at a level of accuracy that is difficult to achieve manually. This leads to more accurate diagnosis and treatment plans for patients. This article presents the kinematic modeling of an ultrasound medical robot.

The kinematic model describes the motion of the robot without taking into account forces. Functionally, kinematics can be divided into forward and inverse kinematics. With each change in joint angle, the position and attitude of the end effector of the manipulator can be obtained using forward kinematics. This process represents the transition from joint space to Cartesian space. Inverse kinematics solves the change in the joint angles of the manipulator based on the position and attitude of the end effector. Since the kinematic equation of the manipulator is a set of nonlinear equations, it is necessary to consider that there is a unique solution and multiple solutions and methods for solving these equations. Inverse kinematics is more difficult to model and solve than directional kinematics. For a robot, this includes forward and inverse kinematics.

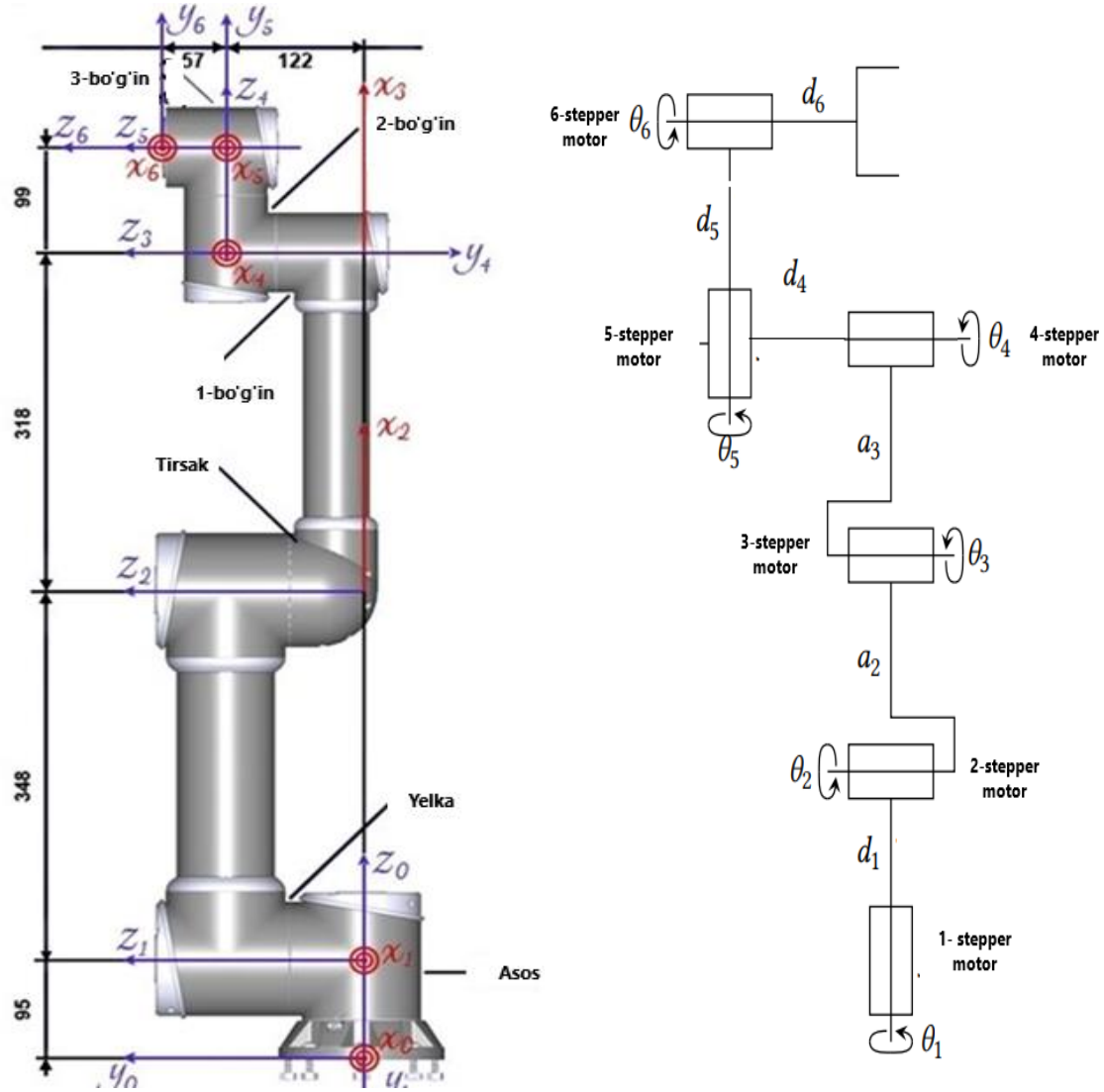

Figure 1. Robot and its parameters

The end effector positions in all three dimensions in robot coordinate are obtained as follows.

$$T_i = \begin{bmatrix} \cos\theta_i & -\sin\theta_i \cos\alpha_i & \sin\theta_i \sin\alpha_i & a_i \cos\theta_i \\ \sin\theta_i & \cos\theta_i \cos\alpha_i & -\cos\theta_i \sin\alpha_i & a_i \sin\theta_i \\ 0 & \sin\alpha_i & \cos\alpha_i & d_i \\ 0 & 0 & 0 & 1 \end{bmatrix}$$

$\theta\_i : \ angle\ of\ rotation.$
$d\_i, a\_i : \ shoulder\ length$

To obtain the end effector position and direction, the transformation matrices are multiplied:

$$T_{end} = T_1 \cdot T_2 \cdot T_3 \cdot T_4 \cdot T_5 \cdot T_6$$

$$x_{rr} = d_4 s_1 + a_2 c_1 c_2 + d_6 c_5 s_1 + a_3 c_1 c_2 c_3 - a_3 c_1 s_2 s_3 + d_5 c_1 c_2 c_3 s_4$$
$$+d_5 c_1 c_2 s_3 c_4 + d_5 c_1 s_2 c_3 c_4 - d_5 c_1 s_2 s_3 s_4 - d_6 c_1 c_2 c_3 c_4 s_5 + d_6 c_1 c_2 s_3 s_4 s_5$$
$$+d_6 c_1 s_2 c_3 s_4 s_5 + d_6 c_1 s_2 s_3 c_4 s_5$$
$$y_{rr} = a_2 s_1 c_2 - d_6 c_1 c_5 - d_4 c_1 + a_3 s_1 c_2 c_3 - a_3 s_1 s_2 s_3 + d_5 s_1 c_2 c_3 s_4$$
$$+d_5 s_1 c_2 s_3 c_4 + d_5 s_1 s_2 c_3 c_4 - d_5 s_1 s_2 s_3 s_4 - d_6 s_1 c_2 c_3 c_4 s_5 + d_6 s_1 c_2 s_3 s_4 s_5$$
$$+d_6 s_1 s_2 c_3 s_4 s_5 + d_6 s_1 s_2 s_3 c_4 s_5$$
$$z_{rr} = d_1 + a_2 s_2 + a_3 c_2 s_3 + a_3 s_2 c_3 - d_5 c_2 c_3 c_4 - d_5 c_2 s_3 s_4 + d_5 c_2 s_3 s_4$$
$$+d_5 s_2 c_3 s_4 + d_5 s_2 s_3 c_4 - d_6 c_2 c_3 s_4 s_5 - d_6 c_2 s_3 c_4 s_5 - d_6 s_2 c_3 c_4 s_5$$
$$+d_6 s_2 s_3 s_4 s_5$$

Conclusion. The conducted research was conducted on optimizing the ultrasound examination path, controlling the robot from the spot or remotely. However, it was not possible to find a resource on conducting ultrasound examination using a robot based on artificial intelligence among open source studies, therefore, research in this direction may allow creating a new type of robotic ultrasound system. These technologies will not only expand the capabilities of medicine, but also create the opportunity to provide patients with improved medical care. The development of medical robots will also provide the development of artificial intelligence and machine learning technologies, which will open up new opportunities for future medical technologies.

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