Designing a Robotic Arm with Special Parameters in order to have a Homogeneous Radiation Dose for Several Research Applications

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Abstract: -This project is aimed at designing and developing a "Robotic Arm for medical therapy, biological and other practical Applications" using a special controller. It combines electronic and electrical knowledge. The control panel is used to control all the activities. It is capable of controlling a laser head or any other light source, input devices, such as a digital camera application, are used with a proposed laser depth sensor to follow our target. The design of a robotic arm is suitable to work with three dimensions with ease, which is not too bulky and compatible to use for those applications. However, this arm should be re-programmable according to the applications to be used for regular scanning of radiation with homogeneous dose by a laser head or LED (light emitting diode) that is attached to this arm in order to apply the different treatments without any human error. The number of degrees of freedom corresponds to the number of independent position variables that would have to be specified in order to locate all parts of the mechanism; thus, it refers to the number of different ways in which a robotic arm can move in a particular direction. We depended on the safety and efficacy of the polyethylene terephthalate glycol (PETG) material in order to create the robotic arm parts individually, those parts of the conventional and the dynamic load were measured with a load cell. In this project, we needed to convert Cartesian equations into cylindrical for three-dimension applications. We found that, the arm angle is related to the two elements that are microstep by driving circuit and the used gears ratio. Engine accuracy using stepper motors and driving circuit was certified with high precision (ET, 3N.M). Engine torque was selected by some testes about gravity center and the friction of the robotic arm parts, driver step (0.28±0.01 mm) and the arm angle (0.01125°±0.0001) were related to driving circuit and the used gears ratio. Auto-scan program may be used in order to select, scan and treat the special case of many targets with different sizes and forms at the same time and individually. An example of this is skin cancer treatment using photodynamic therapy by this robotic arm. In conclusion, the results of the parameters and the designed robotic arm in this project were carefully selected in order to have a regular radiation scanning on a processed sample for a selected radiation dose with high resolution. Those results were very useful for different medical treatments and many research applications.

Key-word: Engine torque, regular scanning, stepper motor, PETG

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1. Introduction

Research applications of various types used photonic techniques that depend very sensitively on the microscopic environment in an optical medium in a medical field or in biological sensing applications (1). Information on the interface between laser optics and cell biology was presented by using biophotonics for Medical Applications. Developed application of photonic techniques aid the diagnosis and therapeutics of biological tissues (2) We can understand the principles that are used to set dose limits in order to protect the patients of the biological effects of radiation (3,4), with regular scanning on the treatment sample with high resolution (5).

The technologies were used to develop machines for safety reasons that can substitute for humans. Robots in fact can be used in any situation and for any cause or purpose (6). The robot can easily and completely use seven degrees, but the three degrees can be also used in any point within its workspace, or some work in three dimensions (7). In a preview study, it was apparent how the robotic arm interacted with humans. It should be lightweight and have easy controlling techniques. The author explains 7-DOF design of the robotic arm with a cable driven which is used to pick and place the robotic arm. Robots that are cable-driven are proven to be not feasible (8). The design of MatLab model is used to practically simulate the robotic arm while it is in operation by passing the accurate parameters, further analyze the dynamic behavior of the robotic arm and to get the workspace of the robotic arm (9). Transoral robotic surgery (TORS) performed and created a mouthpiece made of polyethylene terephthalate glycol (PETG) individually shaped for the patient's teeth. The PETG mouthpiece reduced cargo of the tooth compared with the mouthpiece that is made of ethylene–vinyl acetate EVA and the load direction was in parallel with the tooth axis. The PETG mouthpiece as a result enhances tooth safety for TORS (10).

This study presents an overview of previous developments and how the Robotic arms work along with its mathematical aspects. Arm assembly is used to supplement the robot's gestures and allows it to grasp and move objects. Arduino-board and other electronic circuits can be used to drive arm actuators by special programming. It can have a wide range of applications due to the fact that the control system is used to control all the activities. Such as its capability of controlling a laser head or any other light source for photodynamic therapy PDT with suitable wavelength of light, especially when the auto-scan program is used in the controlling process. According to other studies, a PDT was used to treat many skin diseases such as skin cancer, scares and stain birthmarks. It yielded satisfactory results (11, 12, 13, 14, 15). Different laser wavelengths were used for many medical treatments, (16, 17, 18, 19) biological studies (20, 21) and practical applications (22, 23), in order to regular scanning and selected radiational dose with high resolution.

It also has industrial uses. Md. Tasnim Rana designed one type of a mechanical arm and Anupom Roy (24) for similar functions to a human arm and it can be especially used for parcel bomb disposal. This invention marked a new era of industrial advancement. Kamlesh Sasane developed a simple model of a robot worker that deals with and understands its master more effectively. It can help us realize the limitations and capabilities of simulation and find many applications in industry such as a robotic arm used in electronics as assembly of circuit boards (25).

In this project, a robotic arm was designed in order to control the physical parameters of the radiational therapeutic dose and may uses for some industrial applications too, such as etching alloy using laser for fixed dental prostheses.

This robotic arm with an auto-scan program can be very useful to treat a health problem that has many ulcers or tumor cells to evaluate the useful radiation dose.

2. Experimental Details

The design and simulation of a robotic arm for a research robot using a computer system and attached digital camera is used to help in medical therapy and biological and other practical applications. Using image processing algorithms is more successful in the diagnosis and evaluation of the treatment stag (26).

We tried several endurance tests and torque before all parts are standardized by a 3D design software (Meshmixer & sketch Up), link1 _link2= 30cm.

Printing machine software was adjusted for printing material by CURA program (Print temperature, base temperature, print speed, cooling fan speed, print density, etc.)

A prototype of robotic arm was printed to test all our application parameters and handpies of robot movement with high resolution by the three dimensions on our target according the different research applications. 3 DOF is the number of degrees of freedom and independent position variables that would have to be specified in order to locate all parts of the mechanism. The prototype was compared to a main type to make several experimental tests in order to have the best project as a robotic arm that has handpiece which can catch different types of the light sources.

3. Control Types

The system with drivers is used to control the motion of the motor (three stepper motors – Servo motor) and is connected to each motor. We send signals using Arduino to decide the position we want the robot to locate by using the "microstepper library" and forward kinematic equations.

A stepper motor by a regular movement and with high resolution (3%-5%) is used for regular scanning on our target. The base supports the whole assembly of the robot. The material is used for the base is called PETG (Link assembly is connected to the base by means of the screws).

The motor rotates the base at approximately 360 degrees. Brass standoff is fixated between the supporters of the robot assembly, a motor fixed in the base is connected to the link.

The specifications of the motor are selected for the base with special properties.

The Arduino Mega 2560 is a microcontroller board based on microcontroller executes powerful instructions in a single clock cycle (AT mega 2560) (27, 28). It has 54 digital input/output pins). We found that the robot uses open hardware to easily develop many projects related to automatic control and should be re-programmable according to the application to be used for chosen biological or medical applications. This allows it to strike a fine balance between power consumption and processing speed.

An attached digital camera, placed on top of the handpies of a robotic arm, was used in the morphology study of the target. This study was aimed at following and evaluating the stages of the treatment process with high resolution.

4. Results and Discussion

The robotic arm is controlled using a proposed laser depth sensor to select the parameters of the treatment sample for regular scanning with limited dose (skin diseases, laboratory experiments, parasites irradiation, metal alloy etching …etc.). In this study, the laser dimension sensor which captures the user input and inverse kinematics algorithm was used to define the motion of the robotic arm in order to perfect treatment work without any experimental error. We analyze various methods and techniques for the design and development of the robotic arm compatible to use for those different applications. In this study, we found that the arm angle is related to two parameters: microstep by driving circuit and the used gears ratio. The results showed that the driver step (0.28±0.01 mm) and the arm angle (0.01125º±0.0001) were related to driving circuit and the used gears ratio in this design. The auto-scan program can be a very innovative idea to treat skin cancer and acne.

The movement of an arm head between a point and another is related to the resolution of angles, trigonometric and radial equations. The main parts are shown in figure (1).

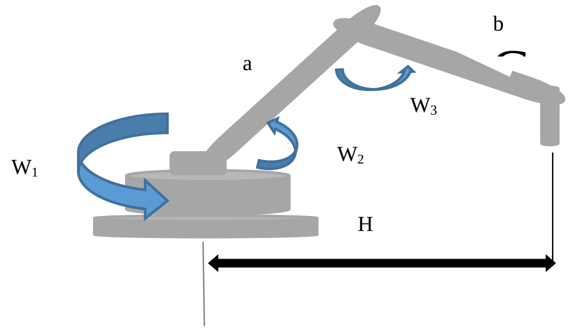

Fig .1. The angles between the main parts of a robotic arm

The equations used to select motor angles in order to follow the interest point (our target):

$$H= sqr\ t[x^2+(Y+Y_1)^2] \quad (1)$$
$$W_1= arc\ tan\ [(Y+Y_1)/X] \quad (2)$$

Y_1: constant distance between the arm center and photo area.
X, Y: coordinates the interest point as shown in figure (2).

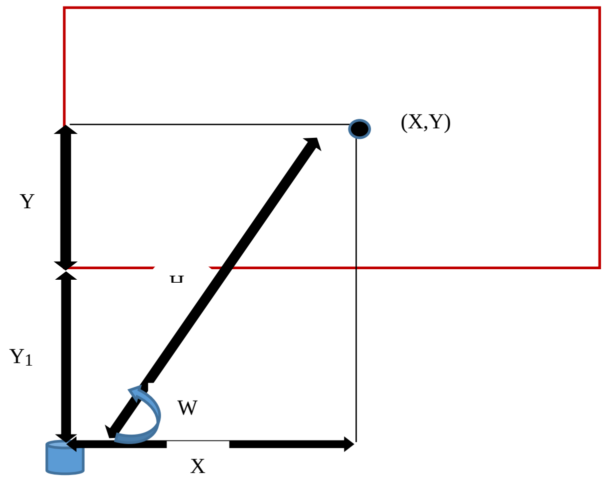

Fig .2. Coordinats of the interest point

In order to develop this design, we converted Cartesian equations into cylindrical for applications of three dimensions. Figure (3).

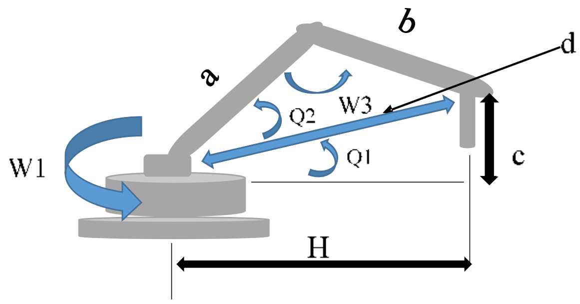

Fig .3. Parameters of a robot arm movement to the interest point

$$d = sqrt\ [c^2+H^2] \quad (3)$$
$$Q_1 = arc\ tan[c/h] \quad (4)$$
$$W_3 = arc\ cos\ [(a^2+b-d)/(2ab)] \quad (5)$$
$$Q_2 = arc\ sin\ [sin\ (w_3)\ (a/b)] \quad (6)$$
$$W_2 = Q_1+Q_2 \quad (7)$$

The engine accuracy was achieved using certified stepper motors and driving circuit with high precision (ET, 3N.M). After conducting some tests about gravity center and the friction of the robotic arm parts, the engine torque was selected. Here, the torque decreased as the resolution increased (Table 1).

Table .1. The relation between motor torque and the increase of resolution

Microsteps/ full step	Holding Torque/ Microstep
1	100.00%
2	70.71%
4	38.27%
8	19.51%
16	9.80%
32	4.91%
64	2.45%
128	1.61%
256	0.61%

In this study, we increased the motor resolution up to 0.9 mm by increasing the number of pulses using a suitable driving circuit.

Motor resolution 0.056º was selected by using this technology when we have motor step resolution = 32, that means 1.8º/32=0.056º which suitable for all treatment processes and practical applications with special design as shown in figures (5).

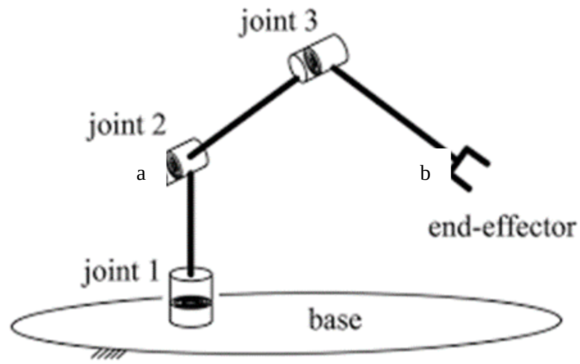

Fig.4.simulated form of our system

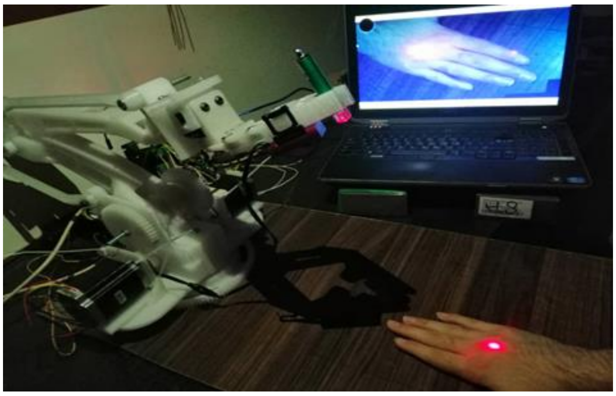

Fig .5. final form of our robotic arm system

Input devices such as a digital camera application by using a proposed laser depth sensor (29, 30) is used to follow and select dimensions of our target to adjust and focus the laser or light spot.

Following the samples and the morphology study with accuracy and precision using an attached digital camera to evaluate the steps and advantages of the treatment process with regular irradiation scanning and useful dose without any human error was confirmed and supposed by our designed robotic arm system.

The control system was used to control all the suitable activities to work with three dimensions of freedom. And its capable of controlling a laser head or any other wavelength of a light source to be used for radiational regular scanning with a homogeneous and selected dose to treat different cases such as skin cancer, cutaneous leishmaniosis and skin scares.

5. Conclusion

Our study is an example of the simultaneous motion control, which is a unique solution for many medical treatments, research and industry application problems like those which occur following applications from the accuracy of motion and the time the operation takes. Sample morphology studies with a high precision to evaluate the advantageous steps of the treatment process using a useful dose without any human practical error confirmed and supposed by our designed robotic arm system.

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