Development of a Prototype for a Motion Controlled Robotic Arm

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Abstract—In this paper, a prototype for a robotic arm that can be controlled with a human interface and can be remotely controlled by a smart device is developed. The developed prototype is fully functional and reacts accurately to the movements of the user. The user wears two gloves that have accelerometers that help the prototype to identify both position and speed vector. The research is being done and methods and designs have been developed. Final conclusions are given and moving on to phase two ie the building phase. Index Terms—robotic arm, human interface, prototype, accelerometers, remotely controlled.

I. INTRODUCTION

Dealing with harmful substances such as chemical or radioactive substances if gone wrong can cause heavy casualties to humans sometimes even resulting in fatal injuries. A motion-controlled robotic arm can be used instead to perform these tasks. This paper shows the development of a robotic arm. The robotic arm is designed so that when a human hand moves, it senses the movement and reacts accordingly. For this purpose, the accelerometer is used in the gloves that the user wear. Then this movement is sensed and used to control the prototype. We are also developing a mobile application that can also be used to control the prototype. MIT app inventor a website developed by the students in MIT is used to create the mobile application mentioned above. A sketch of who the end prototype is Fig.1. A sketch of the end prototype shown in fig 1. While creating this prototype we focus on making the code compact and efficient and reducing the arm's weight as much as possible to reduce the response time of the arm.

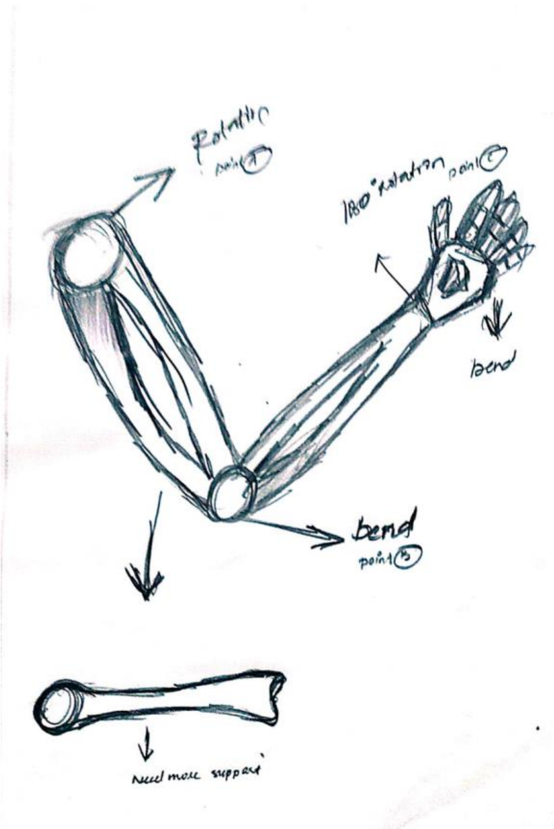

Fig. 1. A sketch of the end prototype

II. OBJECTIVE AND SCOPE

The objective of this project is to design and build a motion controlled robotic arm that can be used to provide a safe working environment for workers in laboratories and industries that handle harmful substances such as chemicals, biohazards, and radioactive materials. Many accidents occur in these type of facility such as burning due to exposure to chemicals, and different health issue caused by getting exposed to harmful substance. Some times these accidents can cause permanent damage or amputation of body parts. The robotic arm should be able to handle and dispense these substances in a controlled Fig. 1. A sketch of the end prototype and safe manner, while also being user-friendly and easy to program and operate. M.A.R.C is a solution for the above problems and more. Building our prototype is to provide a safe distance from these kind of materials thus keeping the workers away from danger and reducing accidents or harm to nearly zero. By avoiding accidents we can create a safe working environment where the employees or workers can work. As a result we can increase the productivity. With the implementation of M.A.R.C we can also explore the possibility of taking a step forward in terms of robotics as it opens a wide area to build upon. Thus building this prototype not only help in the current cause but also maybe the key for future innovations. The scope of this project includes the design, development, and testing of the motion controlled robotic arm. It will involve the selection and integration of appropriate sensors, actuators, and control systems, as well as the development of software for programming and operating the robotic arm. The project will also include testing of the developed robotic arm to ensure that it meets the required performance and safety standards. The motion control system of the robotic arm will enable it to perform tasks withhigher accuracy and repeatability, as well as to respond to real-time changes in the environment. The robotic arm should be able to handle a wide range of materials and have a payload capacity sufficient for the intended tasks. It should also be reliable and easy to maintain, with a user-friendly interface and clear documentation.

III. LITERATURE SURVEY

A. The research and design of a Smart mobile robotic arm based on gesture controlled [1]

In this paper, a smart mobile robotic arm based on gesture control is constructed, consisting of a remote-control smart automobile outfitted with a robotic arm. The Leap Motion module serves as the gesture recognition sensor, and it uses the Processing API function on the PC to identify the location information of both hands in 3D space and transform it into different control data. It communicates through Bluetooth and the automobile system. The controller for the automobile system is the STM32 NUCLEO-F411RE development board, which analyses and processes the gesture data received over Bluetooth. The technology used here is gesture control. Here the proposed system is highly accurate and reacts correctly to the gestures that are performed. This is one of the main advantages of this system. But the gesture control system has a limited number is gestures which mean only a limited number of required actions can only be performed.

B. Motion Recognition-Based Robot Arm Control System Using Head-Mounted Display [2]

This paper describes a revolutionary remote monitoring system that makes use of a head-mounted display (HMD). The usage of an HMD provides the user with a high level of immersion and a sense of reality. Furthermore, the coordinates collected from the HMD sensors make it easier to modify the camera position while directing the robot arm on which the camera is placed. The suggested system accomplishes two functions. To begin rendering pictures in the HMD, the camera records input images, and the PC attached to the robot arm delivers the image in real-time to the PC connected to the HMD, after which the image is produced in the HMD.The proposed system is for controlling a head-mounted display that is on a gesture-controlled robotic car and arm. As mentioned the technology used here is gesture control the user has a set of gestures that are previously coded. The system is highly accurate and ready to react to users movements.

C. Development of a Motion Controlled Robotic Arm [3]

This paper develops an affordable, lightweight, and easily controllable robotic arm with a human interface. The created robotic arm is entirely functional and precisely responds to the user’s motions. On his or her arm, the human user wears two accelerometers. The robotic arm receives location and speed vector information from these accelerometers. In addition, the user wears a glove that controls the flex sensor, which provides readings to the claw. The robotic arm is mounted on a completely movable platform that allows it to roam from room to room. Before the robot system is produced and tested, the research methods and design are presented. The proposed system is a motion-controlled robotic arm. The main disadvantage for this system is that a claw is used here so that the set of actions are limited.

D. Real Time Robotic Arm Control Using Hand Gestures [4]

In this paper, we suggest an entirely electrical method of achieving Human Computer Interface (without mechanical sensors). The objective is to replace previous approaches of manipulating robotic arms using joysticks and buttons with more intuitive techniques, such as directing robotic arms with hand motion or gesture. It also proposes a fast and simple algorithm for the hand gesture recognition problem. As for many the issue that the following system face is that there is a limited number of gesture and actions that the system can perform.

E. Human-like coordination motion learning for a redundant dual-arm robot [5]

This research presents a unique redundant dual-arm robot motion learning system based on human-arm coordination features. It can actualize the human-like coordinated motion of a dual-arm robot in both Cartesian and joint space. The proposed solution was tested on a genuine redundant dualarm robot platform. Experiments involving two tasks, carrying and pouring, were conducted, and the results show that the robot can successfully reproduce the demonstrated human-arm motion tasks, and the dual-arm robot has the characteristics of coordinated human-like motion, making robotic dual-arm manipulations more smooth and natural.This paper develops a redundant dual-arm robot motion learning method based on human-arm coordination characteristics. It makes robotic dual arm manipulations more smooth and natural. It’s limited to a particular set of actions and it also needs constant monitoring and updations.

F. Characteristics-based visual servo for 6DOF robot arm control [6]

In this system the robotic arm is controlled by visual servos. Visual servoing, also known as vision-based robot control and abbreviated VS, is a technique that uses feedback information extracted from a vision sensor (visual feedback) to control the motion of a robot. The main advantage for this system is that it is simpler and effectiveness for indicating the precision of pose error both simulation and actual environments. The accuracy for this system is limited.

G. Robotic Arm controlled using IoT application [7]

Robots are increasingly being used in industries. Control via remote is a difficult problem that has received little attention from researchers. This paper proposes to design a robot that can be controlled via Wi-Fi using the BlynkIoT App and widgets such as Joysticks and Sliders, allowing robot operation and control to be done from anywhere. The robot's Internet of Things-controlled arm will assist doctors and nurses in remotely monitoring and caring for patients while they risk their lives during C-19. The Internet of Things (IoT) includes sensors, software, and other technologies that allow it to connect to and exchange data with other devices and systems via the Internet. Many industries have worked remotely using Wi-Fi and the Internet as a result of IoT technology. Almost every industry has implemented Industry 4.0. As a result, this IoT-controlled Robotic Arm can also make hospitals smarter and faster in order to save people's lives. The main goal of this work is to allow for easy monitoring of patients via various sensors and actuators, to reduce person-to-person contact between doctors and patients, nurses to patients, and patients to patients, and to allow technicians to easily control the arm of the robot via IoT remote access and control.

H. Lightweight force-sensing tomato picking robotic arm with a "globallocal" visual servo [8]

A lightweight force-sensing tomato picking robotic arm with a ”global-local” visual servo is proposed in this paper to address issues such as large volume, large mass, high inertia, high cost, complex control, and inadequate safety protection during automated tomato picking operations. A six degree-of-freedom (DOF) manipulator force-sensing system is established based on the relationship between arm resistance and joint motor current to develop a mechanism to ensure that human workers and plants do not accidentally collide with manipulators during picking operations. During picking operations, the system can determine the magnitude and position of the impact force and immediately stops moving if the values exceed a certain threshold. To improve the repeat positioning accuracy of the arm's end, a ”global-local” visual servo is used. A prototype is built for testing, and the results show that the average error of the lightweight manipulator's force sensing system in estimating the magnitude and position of the impact force is 7.6 percentage, and the average repeated positioning error of the global-local visual servo is 1.3 mm. The error is reduced by 57.4 percentage when compared to a traditional interpolation trajectory planning algorithm, meeting the accuracy requirements of automated tomato picking operations. The robotic arm can pick 93 percentage of the fruits with good safety protection during the picking process, meeting the requirements for efficiently and automatically picking fruits and vegetables.

I. Design of an affordable IoT open-source robot arm for online teaching of 8 robotics courses during the pandemic contingency [9]

This article describes the design and construction of a low cost, open-source robot arm for online robotics education. The proposed robotic prototype's main goal is to deal with the current situation of pandemic contingency, in which students and instructors cannot physically attend laboratory facilities. The main components of the robotic system are an electromechanical robot arm structure, a control system, a Wi-Fi communications module, and a human-machine interface. The Internet of Things (IoT) robot arm can be used to demonstrate important robotics topics like direct and inverse kinematics, which are demonstrated by programming simple and complex motions using the Denavit-Hartenberg (DH) methodology. The robotic system's capabilities are enhanced by IoT technology, which is demonstrated with an HMI interface deployed in a smartphone via wireless Wi-Fi communication via an ESP32 microcontroller. The arm's purpose is to be a low-cost and replicable robot that aids understanding of robotics design through project-based learning, from theoretical aspects to actual coding and prototype construction.

J. Development of a metering mechanism with serial robotic arm for handling paper pot seedlings in a vegetable transplanter [10]

The development of an automated metering mechanism for vegetable transplanters is described in this paper. It was made up of a three-degree-of-freedom serial robotic arm and an automatic feeding conveyor. The robotic arm was designed to pick and place tomato seedlings grown in biodegradable paper pots. A matrix-type feeding conveyor was created to transport the pot seedlings to a predetermined position where the robotic arm could pick them up one by one. The intermittent movement of the conveyor was performed using an LDR (Light Dependent Resistor) - LED (Light Emitting Diode) sensing unit. The developed system was tested in both the laboratory and in the field. The robotic arm could pick and drop 20 seedlings per minute, with an effective cycle time of 2.5 to 3.1 seconds per seedling handled. The developed system's conveyor and robotic arm consumed 18 W and 16 W of power, respectively. The developed robotic armbased metering mechanism was simple, light in weight, and effectively handled the pot seedlings without damage, assisting in the mechanization of vegetable seedling transplanting.

K. Wireless Mobile Robotic Arm [11]

This paper describes the creation of a wireless mobile robot arm. A mobile robot capable of pick and place operations and controlled by a wireless PS2 controller. It can travel forward, reverse, turn right and left for a set distance determined by the controller. This robot's development is based on the Arduino Mega platform, which will be interfaced with the wireless controller to the mobile robotic arm. The robot's performance has been evaluated using metrics such as speed, distance, and weight capacity. Finally, this robot prototype is supposed to solve problems such as placing or picking objects that are far away from the user, as well as picking and placing hazardous objects in the quickest and easiest method possible.

L. Internet Controlled Robotic Arm [12]

This paper describes the creation of an internet-controlled robotic arm. A computer can control the movement of the robot arm over the internet. This robot can be used to demonstrate how a robot can be utilised to perform daily human tasks inside a home. The robot is controlled by an Arduino Uno, which is linked to the internet via the Arduino Ethernet Shield. This research included two types of analysis: servo motor analysis and accuracy testing. This robot prototype demonstrated that the procedure was successful. This easy to-use robot is expected to bridge the gap between robots and domestic duties.

M. Microcomputer-based robot arm control [13]

This paper outlines the tools and techniques used to convert a toy robot arm into one that can communicate with a computer (IBM PC or compatible). This mechanical arm has six degrees of freedom, but in this experiment, only two of them are regulated. The arm's motion is communicated by plastic gears connected to stepper motors. These motors are linked to a computer, and the movement of the robot arm is controlled by inputting the angle and direction of motion into the computer keyboard.

IV. PROPOSED SYSTEM

The proposed system is a Motion Controlled Robotic Arm prototype. This is a completely working prototype with motion control that allows the user to control it and come in contact with harmful substances without harming the user. The proposed system performs all the actions that the user performs. This can also be controlled using a mobile application that is built using MIT App Inventor. The proposed system uses Arduino Mega as the main board. This is coded and is used for sensing the movement and performing functions accordingly. The user is equipped with a pair of gloves that are used for detecting motions. The gloves are equipped with Accelerometer Gyro sensors that is used to detect speed vector and position thus sensing the movement of the user's hand. For the prototype part, different types of servo motors are used in order to control all the actions and movements

V. TECHNOLOGY USED

• Arduino IDE

The Arduino Integrated Development Environment - or Arduino Software (IDE) - contains a text editor for writing code, a message area, a text console, a toolbar with buttons for common functions and a series of menus. It connects to the Arduino hardware to upload programs and communicate with them. This software is used here for connecting and uploading programs to the Arduino Mega

• MIT App Inventor

The Massachusetts Institute of Technology maintains MIT App Inventor, a web application integrated development environment initially offered by Google (MIT). It enables newbies to computer programming to construct application software (apps) for two operating systems (OS): Android and iOS, which is currently in final beta testing as of July 8, 2019. It is free and open-source software distributed under two licenses: a Creative Commons Attribution ShareAlike 3.0 Unported license for the source code and an Apache License 2.0. This application is used here to build a mobile-based application that controls the robotic arm.

VI. ACKNOWLEDGMENT

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VII. CONCLUSION

Based on the research and development conducted as part of this project, it can be concluded that the developed robotic arm is an effective tool for providing a safe working environment in laboratories and industries that handle harmful substances. The robotic arm has been designed with a number of features that contribute to its safety and effectiveness. These include a high degree of accuracy and repeatability, a payload capacity sufficient for handling a wide range of materials, and a user-friendly interface that allows for easy programming and operation. M.A.R.C can be controlled both with our motion and the mobile application Overall, the developed robotic arm has the potential to significantly improve the safety and efficiency of work environments that handle hazardous materials, and could have a wide range of applications in industries such as chemical manufacturing, pharmaceuticals, and biotechnology.

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