Controlling 4 DOF Robotic ARM with 3-Axis Accelerometer and Flex Sensor

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Abstract - *Nowadays there are many robotic systems performed different tasks in many areas, especially in the industry. The usage of the robotic system is at most 5% in all over the world. According to the International Federation of Robotics (IRF), this usage will be much more in the near future compared to now. The robotic system gathers information about surrounds with sensors. Sensors play an important role for robots. Besides, in conventional robotic systems, joints feedback is usually by calculating the angular measuring device such as rotary encoders or potentiometers. These rotary encoders or potentiometers are fixed to the joints to obtained angular data. In advanced systems, an optical measuring device such as an IR sensor or color sensor is used for the position of robots in the working space.*
Versatile solutions are developed in robotic systems. One of the offered solutions in this study is that control robotic system with human hands autonomously. This solution can be used in a critical situation. In this study, two different sensors are used for controlling the robotic arm. These two sensors are an acceleration sensor and a flex sensor. Within the acceleration sensor, the human can control a robotic arm with axes data obtained from an acceleration sensor and within the flex sensor, the gripper can be controlled.

Key Words: Robotic Arm, Acceleration sensor, Flex Sensor, Autonomous Control

1. INTRODUCTION

Nowadays, there are robotic systems that perform different tasks in the different application areas, especially in the factories producing industrial production. The use of robotic systems is becoming more complex, especially in the aviation and automotive industries. The usage rate of robots in industrial production is at most 5% in all over the world [1]. According to the International Federation of Robotics (IFR) data, this rate will be more than 2 million robots in the industry field between 2018 and 2021 [2]. The fact that robots can be operated versatile and the desired tasks can be fulfilled completely is the most important factor in the widespread use of the industry. In robotic systems, whether the robot performs simple or complex tasks, it is possible to control and monitor the movement in robot working space. Many collaborative works on robotic systems are on kinematics and control policy. It is extremely important to know the positions and power of the robot arms to establish and design an effective system. In conventional systems, feedback is usually made by calculating the angular values obtained from rotary encoders or potentiometers fixed to the joints. In advanced systems, an optical measuring device such as an IR sensor or color sensor is used for direct feedback calculation to determine the position of robots in the working space. To select any object whose position is known in the working space, the robotic arm can then be directed so that the position of the object can be displaced [3, 4].

2. SYSTEM ARCHITECTURE

In the study, an open-source model robot arm with 4 degrees of freedom (DoF) [5] was printed with a 3D printer and mounted. The model interface and system architecture of the robot arm are shown in figure 1 below. The robot arm and its components are listed below in the study.

2.1 Power Supply

The power supply converts the power obtained from the battery or AC source into the current and voltage required for the movement of the robot. The used power supply converts 220V AC to 24V voltage and 12.5A current required by the system. Since the movement of the axes in the robot arm used different features and different power requirements stepper motor, all requirements of the system must be met this power supply.

2.2 Motherboard

MKS Gen V1.4 motherboard is used for the movement of the robot arm. The motherboard has an 8-bit AVR RISC-based Atmega2560 microchip, which stands out with its advanced RISC architecture and low power consumption. Atmega2560's self-programmable flash memory for the 256KB system offers very high performance for the microcontroller. The microchip has also 8KB Ram and 4KB internal SRAM. The Microchip also features 8KB Ram and 4KB internal SRAM. The microprocessor with 16MHz operating speed allows storing long character strings with the 4KB EEPROM and hundreds of settings data of an advanced system. It has a total of 100 pins, 86 of the pins are used for I / O data input, while 16 channels accommodate 4 USART and Master / Slave SPI serial interfaces for 10 bit-ADC converters.

MKS Gen 1.4 has a high-performance microprocessor and also integrated Ramps and Ramps compatible firmware. These features stand out a developer-friendly advantageous motherboard with access to Ramps. While it can be controlled with display and LCD board ports on it as well as allows a smart controller with an SD card connector. Besides, there are three AUX ports and servo motor control ports.

There are 5V and 12V voltage output opportunities on the motherboard powered by 12V-24V voltage. There is a recoverable fuse for short-circuit protection on the motherboard. At least 10 stepper/DC motors and 3 servo motors can be controlled with this motherboard. The motherboard is also capable of withstanding up 24V voltage [6, 8].

2.3 Robot Arm

The robot arm was obtained from an open-source software library with a 3D printer. The robot arm has 4 axes and fingers. Stepper motors have been used to provide the 2-dimensional horizontal and vertical movement of the robot arm. The manipulator task in the robot arm is achieved with a stepper motor and TB6560 driver. The used TB6560 motor driver is provided with high performance in the robotic arm system that can withstand up to 35V / 3A, it sends the current required by motors of different properties used in different joints of the system.

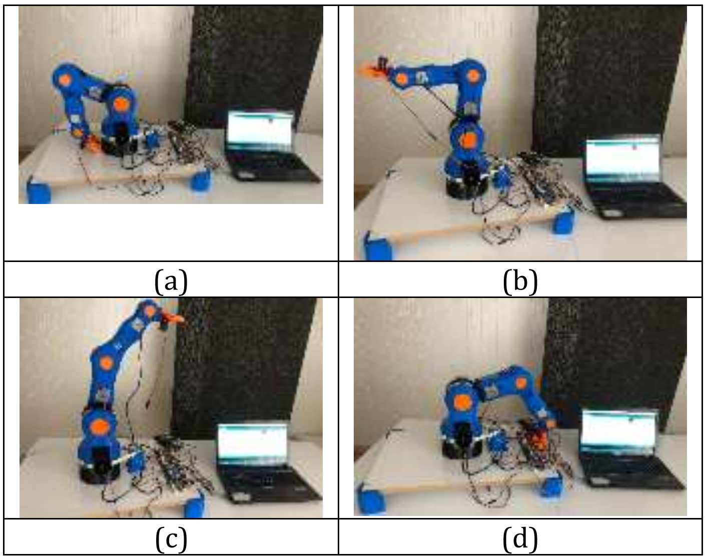

Fig-1: 4 DoF Robotic Arm Working Space

The motherboard used in the project is Arduino AVR based MKS Gen 1.4. With this motherboard, only single operations can be performed and therefore the movement of the axes is carried out sequentially. The base of the BCN3D Moveo has approximately 270 degrees rotational angle in the horizontal plane, the 1st joint has a maximum 220 degrees rotational angle in the vertical plane, the 2nd joint has a maximum 250 degrees rotational angle in the vertical plane, the 3rd joint has a maximum 210 degrees rotational angle in the vertical plane, and the gripper can clutch a maximum 8cm width object. Within the scope of the project, the base of the BCN3D Moveo robot has 270 degrees and the 1st joint has 220 degrees, even if the robot arm base is programmed 180 degrees the robot can reach any object in the 360 degrees in working space. It is shown in figure 1.a-d.

2.4 Motor driver

The TB6560 motor driver is a driver made of Toshiba TB6560AHQ chip and used especially for operating two-phase bipolar stepper motors. It is effective in controlling even large stepper motors such as Nema 23 with its continuous maximum 3A current. The chip on the drive incorporates various safety functions such as overcurrent, low voltage shutdown, and overheat protection. The driver does not have reverse-voltage protection. The voltage can withstand between 10-35V voltage and 3.5A current however the optimum voltage for the driver is 24V and the working current is 3A. The sensitivity of the driver is 1, 1/2, 1/8, 1/16 micro step degree, the user can also interfere with the step control of the motor. The current on the driver is controllable with 100%, 75%, 50%, and 25% rates, this also helps prevent overheating of the used motors [7, 11, 12].

2.5 Stepper motor

Stepper motors respond to a very important need among known motors. There are many common uses of stepper motors used especially in measurement and control applications, robot applications, CNC applications, etc. [9].

2.6 Sensor

Within the scope of the study, 2 different sensors were used for the movement of the robot arm system. One of the sensors used is the acceleration sensor and the other is the flex sensor. Each joint of the robot arm is moved by the axis values obtained with the acceleration sensor. Each joints movement is obtained by these values and microprocessor moves step by step each joint. The gripper is controlled by the flex sensor which is located at the head of the 4th joint.

2.6.1 ADXL345 sensor

ADXL345 acceleration sensor used to provide the movement of the joints of the robot arm. The acceleration sensor gives positive and negative axis values of X, Y and Z axes. The single acceleration sensor gives just only 3 axis values and it is not enough for the movement of 4 manipulators. Because of that, two acceleration sensors used for 4 manipulators. Two-axis of each acceleration sensor was used to determine the movement of 4 DoF joints. Each acceleration sensor was located on two gloves, and 4 manipulators were controlled with 2 axis values obtained from these sensors.

The accelerometer gives positive and negative data on X, Y, and Z axes that provide data transmission using I2C serial communication protocol or SPI digital interface. It is a high-resolution 13bit sensor that can be up to ± 2g, ± 4g, ± 8g or ± 16g. Digital output data is formatted by completing 16 bits, and data is obtained via SPI or I2C digital interface. The low range gives more resolution for slow movements, on the other hand, the high range gives a good resolution for high-speed monitoring. It can be fed with an input voltage 3-5V since the sensor has an internal voltage regulator.

Measurement of slope changes less than 1.0 degrees is ensured by the high resolution of the sensor (4mg / LSB).

There are several special detection functions on the sensor (Figure 2). Detection of activity and inactivity, the presence or lack of motion, and whether any acceleration in any axis is exceeded by a user-adjusted level can be determined. Step detection helps single and double level detection. Freefall detection gives information on whether the device falls or not. These functions are achieved by mapping one of the two cutting output pins. Low power modes, threshold detection and active acceleration measurement due to extremely low power loss allow intelligent motion-based power management [10].

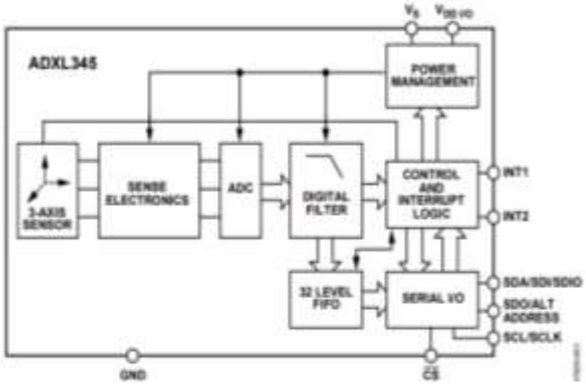

Fig 2: Functional Block Diagram [8]

2.6.2 Flex sensor

The flex sensor is a variable resistor that helps achieve resistance change as it bends. When it is not bending, it has ~25KΩ resistance value, while this value increases to ~100KΩ during bending. Its structure is very similar to force-sensitive resistors (FSR). Angle displacement is obtained by bending, one of the most important areas of use is robot technology.

2.7 Block Diagram

The movement of the robot arm depends on the two acceleration sensors and the gripper movement of the robot arm depends on the flex sensor. The flow diagram of the robot arm is shown below (Figure 3).

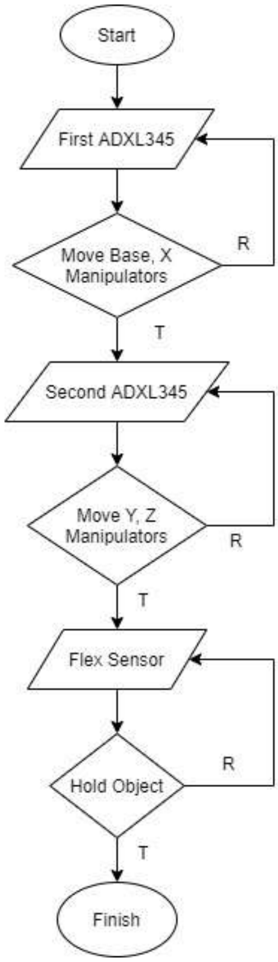

Fig-3: Block Diagram of Robotic Arm

3. APPLICATION

With the applied prototype study, the joint movement of the robot arm was provided depending on the axis values coming from the acceleration sensor on the gloves. Thus, the robot arm, which is controlled by humans, can be developed as a prototype that can be used in hazardous areas that people cannot enter. It can especially be used in the industry, it is necessary to work in fast decision-making processes without waiting for autonomous programming function, in first aid rescue works, etc. There may be vibrations on the robot arm, depending on the hand sensitivity of the human who use the robot arm. In the next phase of this study, a system will be developed to be able to tolerate the hand vibration of the user.

In the prototype study, the movements of the robot joints are controlled with an Arduino compatible ATmega2560 processor and the use of MKS Gen 1.4, which performs a step-by-step operation, makes it imperative that the motion of each joint is performed sequentially. With the use of multi-processing motherboards, multiple joints can be moved simultaneously and more effective results can be achieved.

4. CONCLUSIONS

A robot arm was successfully designed which can rotate 360 degrees around its axis and executed all the necessary tasks sequentially. It can grasp any object in the working space with autonomous control. The system has an autonomous controllable feature. Using powerful ATmega2560 microprocessor stands out with many features for the control of the system, a robot arm prototype quickly detects axis movements due to acceleration changes obtained and gives early reflexes.

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