ROBOT ARM CONTROL USING SENSE HAT

Abstract

End effectors are crucial for any robotic application. There is a need for the development of an all-in-one type of system in order to control a robot arm or an end effector and incorporate any additional intelligence to the end effector as necessary specific to the applications themselves. A Sense HAT provides this capability to the raspberry-pi apart from being easy to use and program.

Keywords: EV3 Mindstorms, Lab View, Raspberry Pi, CAN Protocol, IMU Sensor.

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I. INTRODUCTION

Humanoid robots are professional service robots that are built to mimic human actions and interactions and to provide value to different applications by automating tasks in a way that leads to cost-savings and productivity. An end effector is a peripheral device that acts as a bridge between the robot and the surrounding environment, allowing the robot to interact with its task. Many robots are used for specific tasks nowadays, replacing manpower, as they provide efficiency and accuracy parameters. They can be seen in use by many Industries which require professional expertise, such as Assembly, Packaging and Palletizing, surface finishing, quality, and inspection, and so on. Temperature sensing end effector for a humanoid robot can be used for touch response, pick and place, and so on.

Coronavirus was a transmittable virus; it was spreading rapidly throughout the world. It spreads through human interaction, and hence, the use of humanoid robots was seen to be a boon in many places such as Hospitals, clinics and ICUs, where the robots themselves used to deliver the food items and other essentials to the people who were down with the virus. This proved to be a very fascinating feat for human kind, as this automation took place at a large scale in many countries like China, Japan, Korea and so on. Like these, there are many other uses of humanoid robots, such as Research and space exploration. Rover bot which is capturing data, pictures and other information on Mars, personal assistance. Many of the Humanoid robots are already deployed in Airports and other public places, manufacturing and supply chain, transit, and transportation delivery bots, and many are used for research purposes such as Bots for face and speech recognition, and can walk at a reasonable pace. This report includes elaborate insights on Humanoid robots and their end effectors, which are used for these purposes.

II. AREA OF APPLICATION

With the boom in Embedded Systems and Artificial Intelligence and robotics during this 21st century, there is an enormous demand for these domains right now, and in the future. Due to recent advancements in the above-mentioned domains, there are various predictions, by 2026, there will be crewless aerial vehicles for commercial and military sectors. Humanoids are set to replace manpower in various industries, such as Agriculture. Humanoids will help in Farming, Milking and so on. There are predictions about humanoids deployed in Cab services, freight shipment, also in the military and defense sectors. Humanoids are set to be deployed to work in harsh areas and places, where it is increasingly difficult for humans to operate in such conditions.

III. COMPONENTS

1. **EV3 LEGO Mind storms robot arm:** Lego Mindstorms EV3 is the third-generation robot set in Lego's Mindstorms product line. This robot arm has 2 DC motors. The DC motor controls the up and down movement of the arm. The other DC motor controls the rotation of the arm. Gears are present to facilitate the clamping movement of the gripper at the end of the arm. This arm is compatible with Wi-Fi, Bluetooth as well as USB protocols and all these protocols can be used to control the arm. In our application, we used a Wi-Fi dongle to connect the robotic arm to a Wi-Fi network and thus interface it with the Raspberry-pi board. The EV3 robotic arm is controlled by LabVIEW software or

by assembling code to facilitate various movements of the robot arm, namely up and down movements, rotational movements, and clamping movements

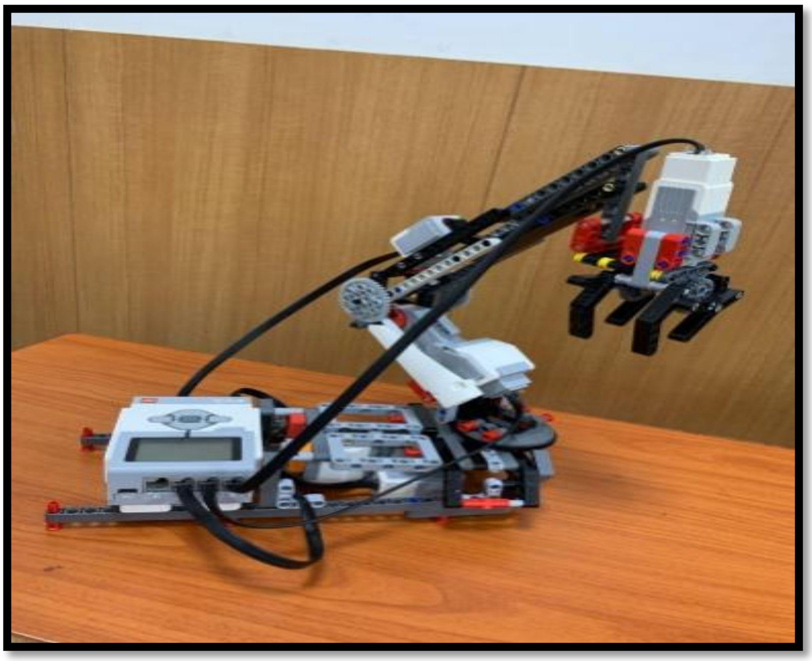

Figure 1: EV3 Robot Arm

2. **RASPBERRY-PI 3 B+:** The UK's Raspberry Pi Foundation and Broadcom collaborated to create the Raspberry Pi line of compact single board computers (SBCs). It was initially intended to support computer science instruction in classrooms and poor nations. The first model was sold outside of the intended market for uses like robotics, which led to its greater popularity than anticipated. It is now widely utilized in many applications, including weather monitoring, because of its inexpensive cost, versatility, and open architecture. used. With a 1.4 GHz 64-bit quad-core ARM Cortex-A53 processor, 3x faster Gigabit Ethernet, and 2.4/5 GHz dual-band 802.11ac Wi-Fi (100 Mbps), the Raspberry Pi 3 B+ variant was introduced in February 2018. Power over Ethernet (PoE), USB boot, and network boot are additional features.

Figure 2: Raspberry - Pi 3 B+

3. Raspberry PI Sense HAT

An addition board for Raspberry Pi hardware is called the Raspberry Pi Sense HAT. It has a five-position joystick, an 8x8 RGB LED grid, and the following sensors:

1. Humidity sensor
2. Pressure sensor
3. IMU sensor (Accelerometer, Gyroscope and Magnetometer)

Using the integrated LED matrix, this board enables you to measure and display data regarding temperature, humidity, pressure, and direction.

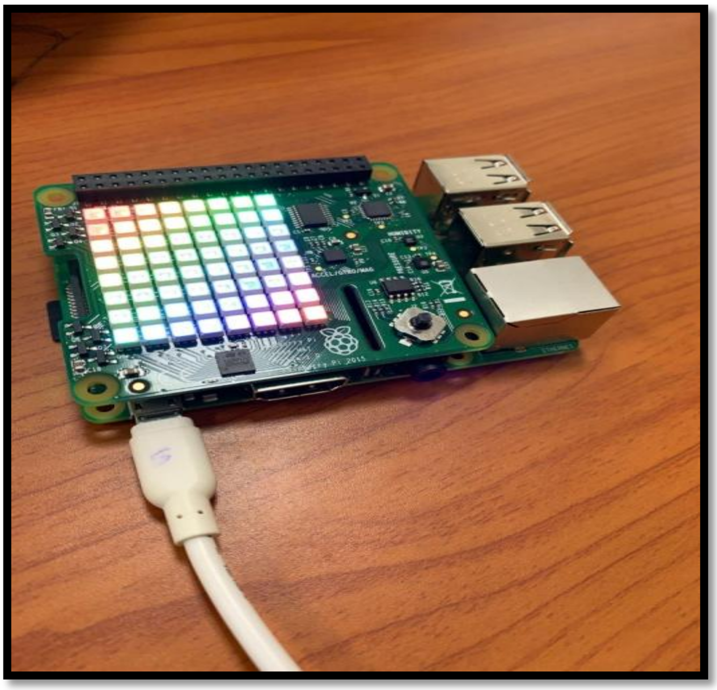

Figure 3: Raspberry-Pi Sense HAT

IV. IMPLEMENTATION METHODOLOGY

1. **EV3 Robot arm construction and verification:** The EV3 robotic arm is controlled by LabVIEW software or even Scratch software by assembling code to facilitate different movements of the robot arm, namely up and down movement, turning rotation and motion of the clamp.

2. **Programming of raspberry-Pi sense HAT:** We can determine the Raspberry-Pi board's position and view the values on the terminal in real time thanks to the sensors on the Sense HAT. The code used for running this program is shown in figures 6 and 7.

3. **Interfacing EV3 robot arm with raspberry-pi board:** Simulink was used to program this interface. Two Simulink models were created, one for the Raspberry Pi. The motor speed of the EV3 robot is calculated using information obtained from the onboard Sense HAT accelerometer sensor in this model. The EV3 robot and Raspberry Pi device interact

over a network to share information. Model for LEGO MINDSTORMS EV3: In this setup, the Raspberry Pi device's data is used to drive the two motors of the EV3 Robot.

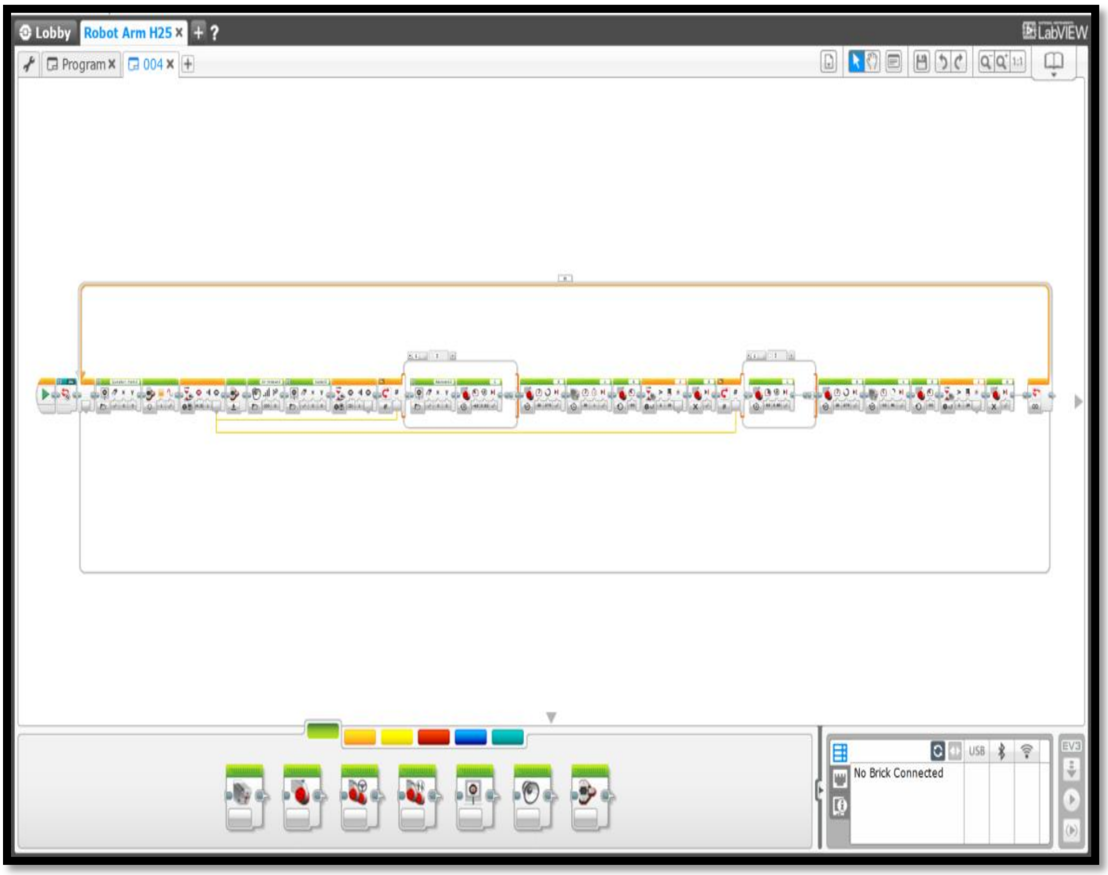

Figure 4: Controlling EV3 Robot Arm Using Lab VIEW Software

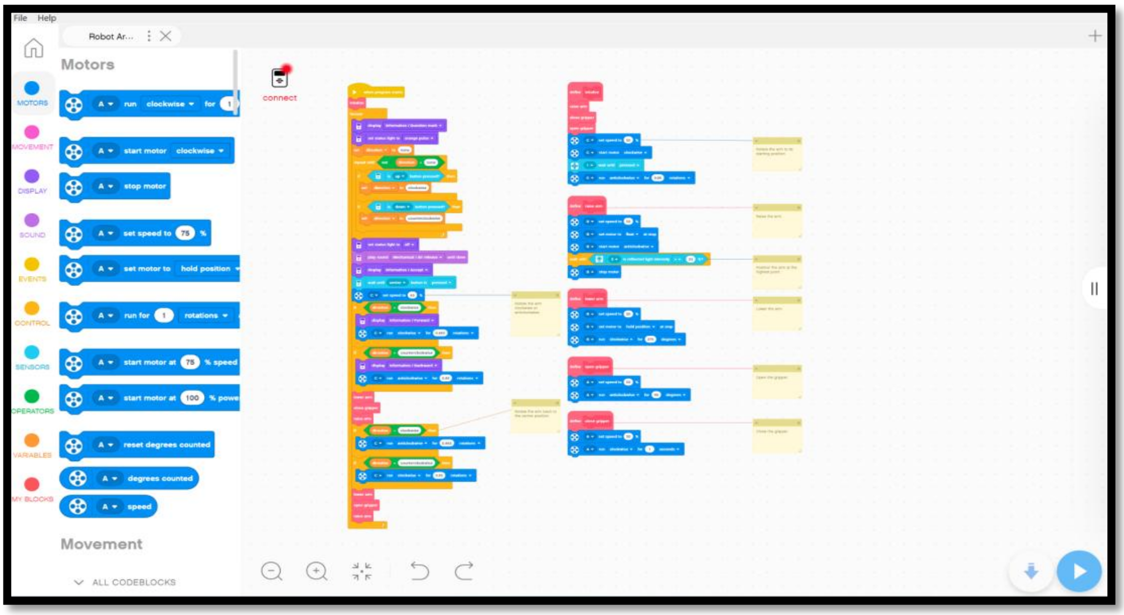

Figure 5: Controlling EV3 Arm Using Scratch Software

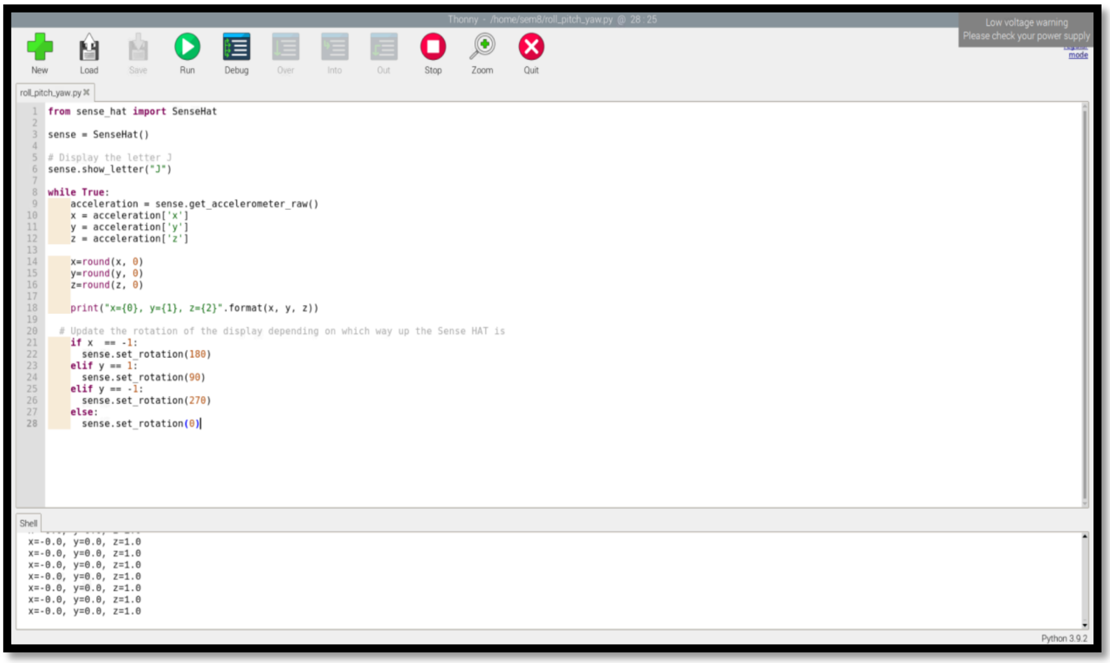

Figure 6: Code to Extract x, y and z Coordinates of Raspberry-Pi board using Sense HAT

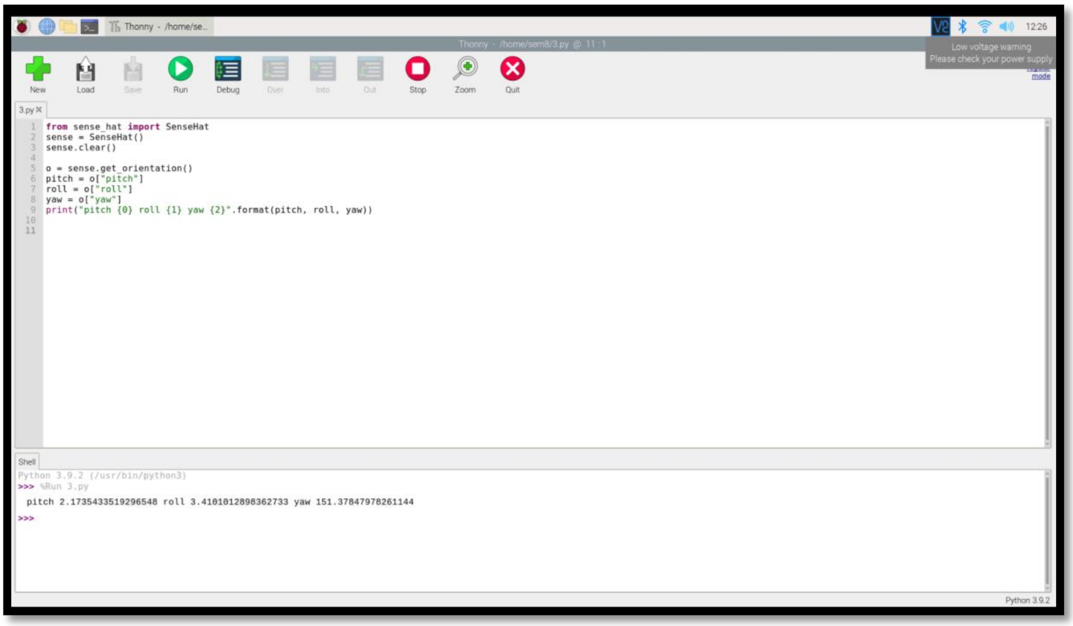

Figure 7: Code to Extract Roll and Pitch Values of Raspberry-Pi using sense HAT

V. LITERATURE SURVEY

The design of an end effector that is printed using Laser Powder Bed Fusion (LPBF) is described in the paper in [1], and the procedure for integrating a temperature sensor in the end effector is covered. It is also briefly described how the use of this type of sensor integration with the end effector is justified.

Mobile robotics platforms have been increasingly significant in education over the past few years. Universities primarily employ MATLAB/Simulink and LEGO Robots among other tools to enhance the learning process. The majority of LEGO systems mentioned in the literature are based on NXT because the EV3 version is still very new. Unlike earlier versions, EV3 enables you to create real-time applications for carrying out research experiments and teaching a range of disciplines. A novel real-time teaching platform based on the MATLAB/Simulink package and LEGO EV3 blocks is being developed and validated for academic use in the domains of robotics and computer science, as stated in [2]. Traditional algorithms are put to the test, along with robotics researchers' artificial potential fields and quickly exploratory random trees. To clarify potential educational applications, we talk about the platform's advantages and limitations.

For autonomous, intelligent gripping and manipulation of challenging and delicate materials, [3]'s soft and intelligent robotic end effectors with integrated sensing, actuation, and gripping capabilities are essential. Opto-mechanical tactile sensors are insufficient for grasping and actuation. It is highly desirable to equip these valuable sensors with multimodal actuation and gripping capabilities.

A solution to aid ADL is the robot manipulator in [4]. For robotic arms with more degrees of freedom (DOF), a clear and precise interface is still missing. It is suggested to develop an intuitive control system that classifies real-time surface electromyography (sEMG) signals from the user's forearm using an artificial neural network (ANN), nine hand gestures, and a 6-DOF robotic arm. Due to its accuracy and usability in Simulink models, a neural network model with 85% classification accuracy was chosen as the classifier.

In work [5], we provide a brand-new learning environment based on the Matlab-Simulink software to instruct robotics using the Lego EV3 platform. Most of the LEGO platforms utilized in the literature are NXT platforms because the EV3 platform is still fairly new (it was released in January 2013). Additionally, this platform permits the creation of real-time frameworks for teaching robotics subjects, unlike earlier iterations of LEGO Robots. This framework employs MathWorks packages and is based on Matlab, the most popular programming environment for LEGO Mindstorms. Here, the suggested framework is put to the test using a brand-new motion planning technique that enables the user to utilize his webcam to interact with the surroundings and the robot in real-time. This is the first real-time application that has been created that can interact with students and teach robotics using the EV3 platform, to the author's knowledge.

For instructional reasons, the authors of the paper [6] propose a multivariable controller design for the Lego Mindstorms NXT robotic arm. To estimate the coupled system's parameters, system identification was done. For the separation system, a proportional-integral-derivative (PID) controller was created. These actions relate to one of the fundamental methods for creating multivariable controllers. Therefore, it is a useful model for teaching multivariable controller design to students. It offers a practical controller design experience by fusing a number of areas of advanced controller theory with implementation specifics.

According to applications like pick-and-place, painting spray guns, welding electrode holders, and other similar ones, the design research of end effectors and the grippers that are attached to these end effectors is covered in the work in [7].

For a straightforward robotic arm design, the article in [8] expands on and suggests design, modelling, and control issues. For the selection, design, control, and analysis of arm systems, the mathematics, Simulink model, and MATLAB software are created to return as much visible and graphical numerical data as possible. Testing the suggested model and programme against various input values demonstrates the resultant model's correctness and applicability when using various control tactics. The proposed is being made for learning and research reasons.

The issue of designing and building an experimental robotic arm for instructional purposes is addressed in a study in [9]. First, we examined the robot arm's performance using Matlab/Simulink. The acquired knowledge was put to use in the creation of appropriate algorithms for studying the kinematics of the robotic arm. A real-time capable xPC target system is utilized to link the actual laboratory robotic arm to the matching Matlab/Simulink block diagram after a successful model determination.

The paper in [10] describes the need and use of the CAN protocol bus, utilizing the various CAN protocols made available, such as, FTT-CAN which make use of TDMA and CSMA techniques, and TTCAN protocols, while suggesting for a new protocol called RTCAN, which is a real-time bus protocol with low latency, low jitters and other advantages.

The study in [11] describes the planning of the motion path of the humanoid robot with walking capabilities, which requires a lot of motion planning and trajectory planning, due to the under actuation of the friction limited contacts to the ground. It also describes methods to solve this issue in a simulation environment.

The decentralized architecture used for CAN protocol in [12] for applications such as robots, end effectors, and so on, while discussing the various advantages of the CAN bus protocol for robotics.

VI. FUTURE SCOPE

Based on the proposed solution and the developed model, there are several ways to improve and improve the design so that the robotic arm can perform much larger and more complex tasks. To make people's lives easier. One of the proposed solutions or improvements is to use the CAN bus (Controller Local Area Network). This CAN bus uses the CAN protocol to send and receive real-time data between two raspberry-pi boards in real time.

Controller Area Network (CAN) is the physical layer and is ideal for many advanced industrial protocols, including CAN and ISO-11898:2003. Cost, performance, and scalability provide great flexibility in system design. Integration with the CAN protocol allows the robot's hands to be controlled by hand movements. In other words, the movement of the hand follows the movement of the user's hand. This facilitates remote operations such as dropping bombs, firing weapons, etc.

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