Robot Arm Control using Sense HAT

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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 also 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 ebay to use and program.

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 Palletising, 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 forface 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 also in the future. Due to recent advancements inthe 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

A. EV3 LEGO MINDSTORMS ROBOT ARM

Lego Mindstorms EV3 is the third generation robotics kit in Lego's Mindstorms line. This robotic arm has 2 DC motors. One DC motor controls the up and down movement of the arm. The other DC motor controls the rotary motion of the arm. Gears are present to facilitate the grabbing motion of the gripper at the end of the arm. This arm is compatible with Wifi, Bluetooth as well as USB protocols and all these protocols can be used to control the arm. In our application, we have used a Wi-fi dongle to connect the robotic arm to a wi-fi network and hence interface it with the Raspberry-pi board. The EV3 robot arm is controlled by using the Labview software or by assembling the code to facilitate the different movements of the robot arm namely- the up-down movement, the rotary movement and the movement of the grippers.

Figure 1: EV3 Robot Arm

B. RASPBERRY-PI 3 B+

Raspberry Pi is a series of small single board computers (SBCs) developed in the United Kingdom by the Raspberry Pi Foundation in association with Broadcom. Initially it was leaned towards promoting the teaching of basic computer science in schools and in developing countries. The original model sold outside its target market for uses such as robotics which made it more popular than anticipated. Currently it is widely used in various applications such as for weather monitoring, because of its low cost, modularity, and open design.

Raspberry Pi 3 B+ model was released in February 2018 with a 1.4 Ghz 64-bit quad core ARM Cortex-A53 processor, a three-times faster gigabit Ethernet, and 2.4 /5 GHz dual-band 802.11ac Wi-Fi (100 Mbit/s). Other features include Power over Ethernet (PoE), USB boot and network boot.

Figure 2: Raspberry - Pi 3 B+

C. RASPBERRY PI SENSE HAT

The Raspberry Pi Sense HAT is an add-on board for Raspberry Pi hardware. It has an 8X8 RGB LED Matrix, a five-position joystick and includes the following sensors:

- Humidity sensor
- Pressure sensor
- IMU sensor (Accelerometer, Gyroscope, and Magnetometer)

The board allows us to make measurements of temperature, humidity, pressure, and orientation, and to output information using its built-in LED matrix.

Figure 3: Raspberry-Pi Sense HAT

IV. IMPLEMENTATION METHODOLOGY

A. EV3 Robot Arm construction and verification

The EV3 robot arm is controlled by using the Labview software or even Scratch software by assembling the code to facilitate the different movements of the robot arm namely- the up-down movement, the rotary movement and the movement of the grippers.

B. Programming of Raspberry-Pi sense HAT

The sensors on the Sense HAT allow us to know the orientation of the raspberry-pi board and display the values on the terminal in real-time. The code used for running this program is shown in figures 6 and 7.

C. Interfacing EV3 Robot arm with Raspberry-Pi board

This interface is programmed using Simulink. Two Simulink models are developed - Raspberry Pi model: In this model, the data read by the Accelerometer On-board Sense HAT data is used to determine the motor speeds for EV3 robot. A network connection is set up between the Raspberry Pi device and the EV3 robot for data exchange. LEGO MINDSTORMS EV3 model: In this model, the data sent by the Raspberry Pi device is used to drive the two motors of the EV3 robot.

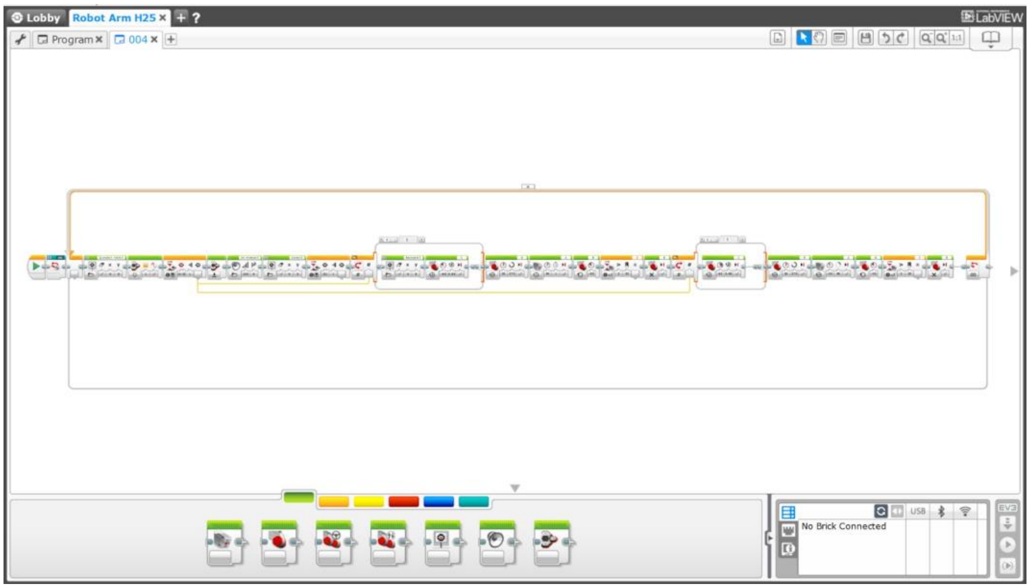

Figure 4: Controlling EV3 robot arm using Labview software

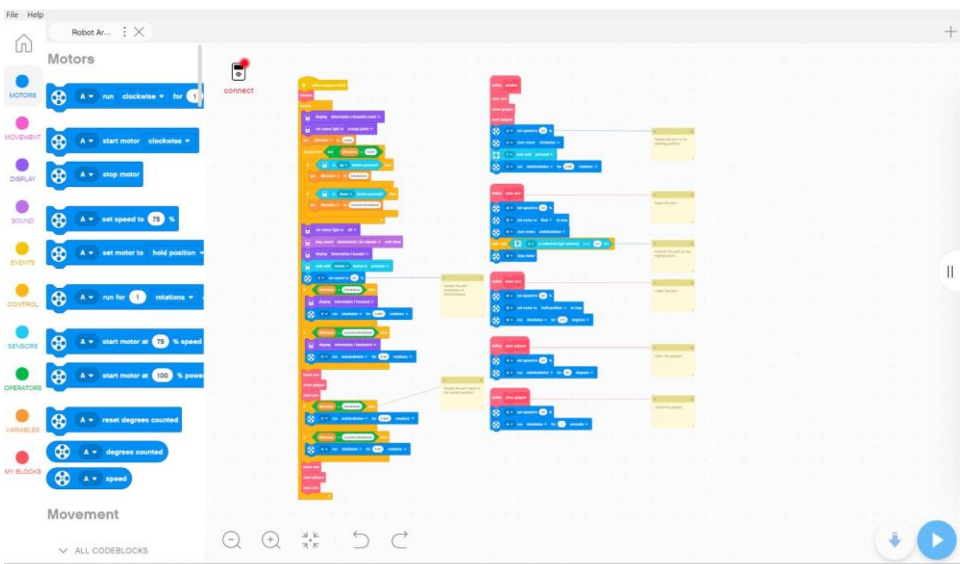

Figure 5: Controlling EV3 arm using Scratch software

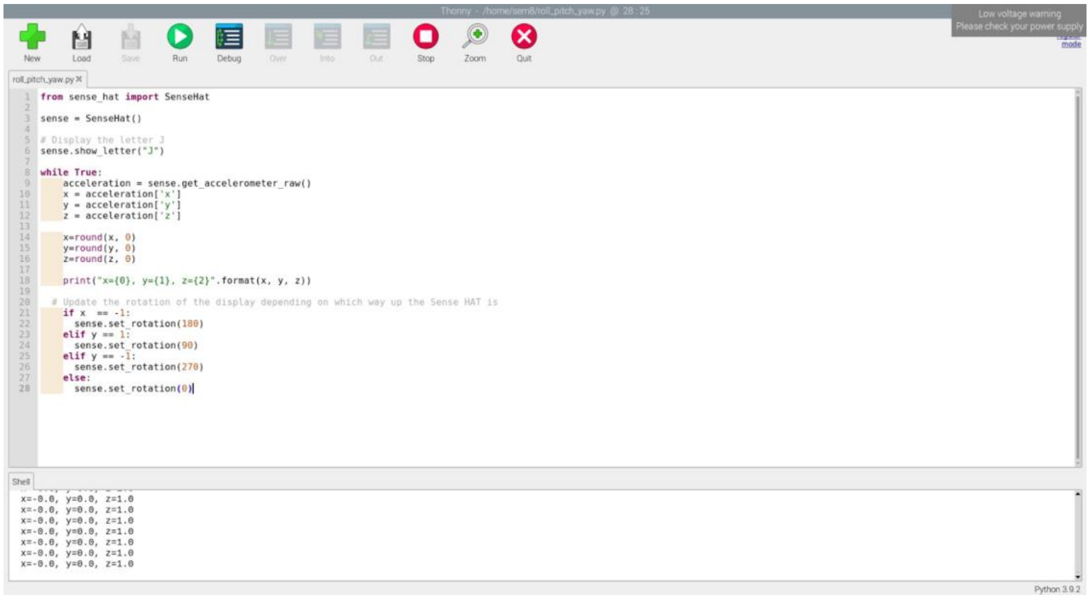

Figure 6: Code to extract x,y and z coordinates of Raspberry-Pi board using sense HAT

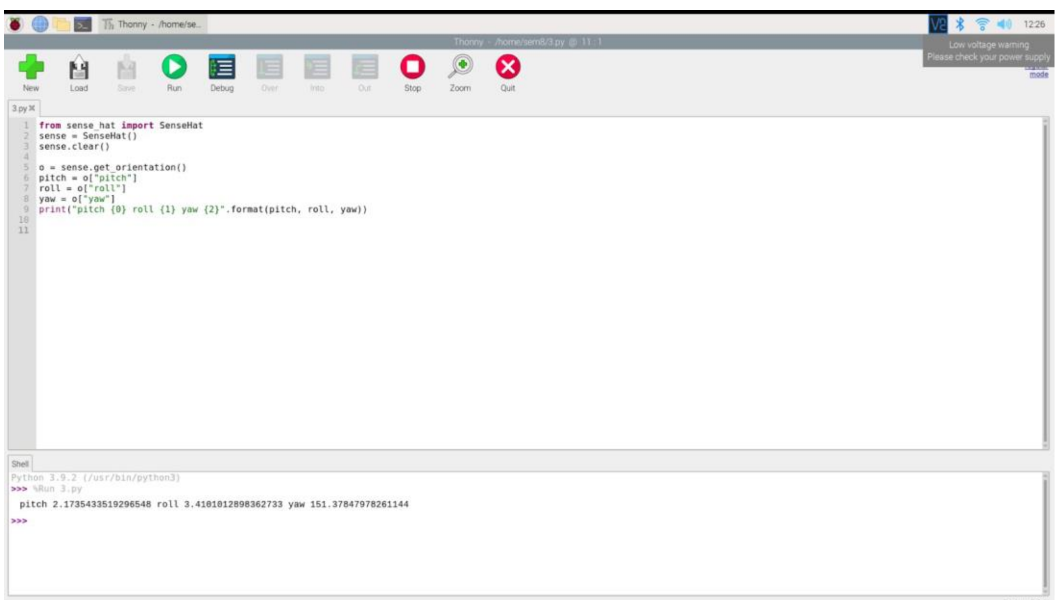

Figure 7: Code to extract roll and pitch values of Raspberry-Pi using sense HAT

V. LITERATURE SURVEY

The paper in [1] describes the design of an end effector which is printed in Laser Powder Bed Fusion (LPBF) and the process of integrating a temperature sensor in the end effector is discussed. The process of justification of the usage of this kind of integration of the sensor to the end effector is also briefly discussed.

Over the last years, mobile robot platforms are having a key role in education worldwide. Among others, LEGO Robots and MATLAB/Simulink are being used mainly in universities to improve the teaching experience. Most LEGO systems used in the literature are based on NXT, as the EV3 version is relatively recent. In contrast to the previous versions, the EV3 allows the development of real-time applications for teaching a wide variety of subjects as well as conducting research experiments. The goal of the research presented in [2] was to develop and validate a novel real-time educational platform based on the MATLAB/Simulink package and the LEGO EV3 brick for academic use in the fields of robotics and computer science. Classical algorithms like rapidly-exploring random trees or artificial potential fields, developed by robotics researchers, are tested. The restrictions and advantages of the proposed platform are discussed in order to enlighten future educational applications.

Soft and smart robotic end effectors in [3] with integrated sensing, actuation, and gripping capabilities are important for autonomous and intelligent grasping and manipulation of difficult-to-handle and delicate materials. Grasping and actuation are challenging to achieve if using only one opto-mechanical tactile sensor. It is highly desirable to equip these useful sensors with multimodal actuation and gripping functionalities.

Robotic manipulators in [4] are one solution for helping with ADL; however, intuitive, accurate interfaces for higher degrees of freedom (DOF) robotic arms are still lacking. An intuitive control system based on artificial neural network (ANN) classification of real-time surface electromyography (sEMG) signals from the user's forearm to detect nine hand gestures and control the movement of the 6 DOF robotic arm is proposed. The classifier chosen was a neural network model, with a classification accuracy of 85%, due to accuracy and usability in a Simulink model.

The work in [5] develops a new educational platform based on the Matlab-Simulink package for the teaching of robotics using the Lego EV3 platform. The majority of Lego platforms used in the literature are NXT platforms, as the EV3 platform is relatively new (January 2013). Moreover, in contrast to previous Lego robot versions, this platform allows to develop a real-time framework to teach Robotics subjects. The framework is based in Matlab, the most widely used programming environment with LEGO Mindstorms, and employs the package provided by MathWorks. The proposed framework is tested here for a new motion planning algorithm, where the user can interact with the environment and the robot in real-time via a web camera. To the authors' knowledge, this is the first time a real-time application, capable to interact with the student, is developed to teach Robotics with EV3platforms.

In the paper in [6], the authors present the multivariable controller design of a Lego Mindstorms NXT robotic arm for educational purposes. System identification was performed to estimate the parameters of a coupled plant. A Proportional-Integral-Derivative (PID) controller was designed for the system after it was decoupled. Thesesteps conform one of the basic techniques to design the controller for a multivariable system. Therefore, it is a valuable model to learn multivariable controller design for undergraduate students. This provides a hands-on approach experience in controller design where some aspects of advanced controller theory are blended with implementation details.

The work in [7] discusses the design study of end effectors and the grippers that are attached to these end effectors, based on the applications such as pick and place, painting spray gun, welding electrode holder and so on.

The paper in [8] extends and proposes design, modeling and control issues of a simple robot arm design. Mathematical, Simulink models and MATLAB program are developed to return maximum numerical visual and graphical data to select, design, control and analyze arm system. Testing the proposed models and program for different input values, when different control strategies are applied, show the accuracy and applicability of derived models. The proposed are intended for education and research purposes.

The work in [9] addresses the design and construction issues of a laboratory robotic arm for educational purposes. First of all, the robotic arm performance analysis has been accomplished using Matlab / Simulink. The obtained knowledge has been utilized to develop the suitable algorithms for analyzing the robotic arm kinematics. Once the model is successfully determined, a real-time xPC target system is used in order to connect the real laboratory robotic arm with the corresponding Matlab / Simulink block diagram.

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

In keeping up with our proposed solution and the model developed, there are a few ways to improve and fine tune our design in order to enable the robot arm to carry out much more extensive and complicated tasks to make life easier for human beings. One of the solutions or improvements that we came up with is the use of a CAN (Controller Area Network) Bus. This CAN bus uses the CAN protocol to send and receive data in real time between two raspberry-pi boards in real-time.

A controller area network (CAN) is ideally suited to the many high-level industrial protocols which embrace CAN and ISO-11898:2003 as their physical layer. Its cost, performance, and upgradeability facilitate tremendous flexibility in system design.

Integration with the CAN protocol would enable the control of the robot arm using hand movements, that is, the movement of the arm would follow the movement of the user’s hands. This would facilitate remote operations such as bomb diffusing, weapon launching, etc.

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