Design and Implementation of Plc Based Robot Control of Electric Vehicle

Surao Anuj

project engineer at atronix acquisition corp, georgia, usa. design and implementation of plc based robot control of electric vehicle

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Abstract: In engineering automation and process control applications the robotic motion control methods and Programmable Logic Controllers (PLCs) are important. These autonomous devices are used in many industries like military, space, health and agriculture. Now-a-days driverless vehicle technology is developed. It is expected that the transportation sector will be included in this field in upcoming days. The major issue in this is detection of front object. Recently, many methods are developing for driving the vehicles, but not giving an accurate result. Therefore, this system detects front object and takes diversion. Therefore, by using this design and implementation of PLC based robot control of electric vehicle shows better results interms of security, accuracy and precision.

Keywords: Programmable Logic Controllers (PLCs), Robotic, Electric Vehicle, Driving

I. Introduction

Industry 4.0. (I4.0) has transformed almost every industrial sector, and the promotion of new digital and cyber-physical technologies has modified manufacturing plants [**1**]. They are now expected to produce parts at minimum cost and be able to quickly adapt their structure according to changes in production capacity and functionality. Production is shifting toward the customization of products, and to cope with constant market changes, automation equipment and intelligent machines must easily reconfigure their tasks and effectively collaborate with each other to achieve the highest productivity and quality[2]. One of the main challenges of I4.0 is the complexity of adapting to engineering changes while supporting different hardware and software platforms while maintaining adequate levels of robustness, safety, and reliability of devices during process execution [3].

Robots have been increasingly used in industry over the last 30 years, especially in the automotive and electrical/electronic fields. In particular, starting from the early 1970s, scientific and technical improvements have contributed to their diffusion, and now, Industrial Robots (IRs) play a key role in modern smart factories, performing a wide range of tasks such as material handling, picking and placing, product packing, inspection, palletization, precise assembly, machining, and additive manufacturing operations[4]. However, despite the extremely high versatility offered by their mechanical structure, the closed architecture of IR controllers is still a limiting factor for the abovementioned challenges. In other words, IRs can be defined as “flexible machines rigidly programmed and controlled”[5].

In the past, IRs were programmed to perform repetitive tasks in a static environment. Once tasks were defined, few code changes were made over time. New manufacturing systems, on the other hand, need to dynamically adapt their processes to meet the latest production demands, especially for mass customization, zero-defect, and quality optimization. This has given rise to greater complexity in production systems and, consequently, in the IRs' control and programming[6].

Most of the IRs used today are completely dependent on their manufacturers' software platforms, and robot programming is based on specific proprietary robot languages offered by each robot vendor [7]. These features make it difficult to maintain, update, or add new functionalities based on the current production needs. Moreover, the lack of interoperability complicates the development of interacting multi-robot control for IRs from different manufacturers. Additionally, the integration and communication between IRs and other devices (e.g., external sensors and actuators) are restricted. The heterogeneity of platforms hampers integration, especially in dynamic environments [8]. As a result, it is difficult for production system components to communicate and exchange data dynamically, which is a barrier to collaborative work. Another limitation imposed by the current architecture of IRs is the difficulty of carrying out more complex control applications since access to the low levels of the control system is restricted [9].

In factory automation and elsewhere it was once common to use fixed layouts built around conveyors or other transportation systems in which each robot performed a specific task [10]. These assembly lines had distinct workstations, each performing a dedicated function. Robots have been used at the workstation level to perform operations such as assembly, drilling, surface finishing, welding, palletizing, and so on. In the assembly line, parts are routed sequentially to the workstations by the transport system. Such systems are very expensive to install, require a cadre of engineering experts to design and program, and are extremely difficult to modify or reprogram as needs change.

The vast majority of commercial industrial robots use electric servo-motor drives with speed reducing transmissions. Both AC and DC motors are popular. Some servo-hydraulic articulated arm robots are available now for painting applications. It is rare to find robots with servo-pneumatic drive axes. All types of mechanical transmissions are used, but the tendency is toward low- and zero-backlash type drives. Some robots use direct drive methods to eliminate the amplification of inertia and mechanical backlash associated with other drives. Joint angle position sensors, required for realtime servo-level control, are generally considered an important part of the drive train. Less often, velocity feedback sensors are provided.

The controller's human interfaces are critical to the expeditious setup and programming of robot systems. Most robot controllers have two types of human interface available: computer style CRT/keyboard terminals for writing and editing program code off-line, and teach pendants, which are portable manual input terminals used to command motion in a telerobotic fashion via touch keys or joy sticks. Teach pendants are usually the most efficient means available for positioning the robot, and a memory in the controller makes it possible to play back the taught positions to execute motion trajectories. With practice, human operators can quickly teach a series of points which are chained together in playback mode. Most robot applications currently depend on the integration of human expertise during the programming phase for the successful planning and coordination of robot motion. These interface mechanisms are effective in unobstructed workspaces where no changes occur between programming and execution. They do not allow human interface during execution or adaptation to changing environments.

Ii. Literature Survey

S. Tomas, K. Michal and K. Alena, et.al [11] design of a fuzzy control system for robotic arm and its implementation to PLC. Fuzzy logic is used to calculate the proper speed of robot tool center point depending on the tilt of the joystick handle in manual operating mode. In fully automatic mode the fuzzy logic is used in form of a fuzzy PI controller to achieve the desired velocity with the load compensation. Fuzzy system was designed in the Siemes Fuzzy Control ++ and was implemented to Simatic S7-\300 PLC.

A. Shaik, G. Bright and N. Tlale,, et.al [12] create a 6 degree of freedom (DOF) robotic manipulator that had a workspace to footprint ratio comparable to that of a serial robot but with a lower inertia, higher speed and improved energy efficiency. This paper briefly describes some parts of the design and then discusses the method used to obtain results for a simulated energy comparison against a serial robot.

S. Li, J. Liu and Q. Jiang, et.al [13] Leaf-spring manipulator is a kind of equipment used to handling and leaf the spring. In order to make the leaf-spring manipulator realize the fast movement, accurate positioning, greatly improve the production efficiency and reduce the labor intensity of the workers, the system adopts PLC centralized control mode and modularization program design, develops control system and control procedures, equipped with high-performance servomotor system and adopts high accuracy, good linear and induction sensitive sensors.

A. J. Ishak *et al.*, [14] presents the IDAP Robot, which is designed and fabricated by taking the first Malaysia robot games festival or Robofest 2002. Development of the IDAP Robot based on the contest regulation to place out the beach balls into the cylinder tubes. This paper focuses on strategies motion of the IDAP robot. The strategies that involve are; it can carry out eighteen beach balls in one time and it is able to place all the cylinder tubes in one track within 3 minutes. The hardware part involves the design and development of the platform module, storage module, arm manipulator module, power supply module, permanent magnet DC motor, sensing system, control panel, circuit protection and programmable logic controller (PLC). The platform module is divided into three parts namely, Y-axis design, Z-axis design and /spl theta/-axis design.

A. I. Bhuyan and T. C. Mallick, et.al [15] proposed a gesture recognition based 6DOF robotic arm controller using gyro-meter with accelerometer to improve the stability and to detect the rotational gesture of human arm. The arm also has the capability to grab object. To find out the angular position of an object, it is easiest way to fuse 3axis accelerometer and 3axis gyro-meter sensor. A low cost MEMs chip (integrated 3-axis accelerometer and 3-axis gyro-meter) used to detect human arm gesture as well as its angular position. Here gyro gives gesture orientation data to determine dynamic gesture behavior. An artificial algorithm used to evaluate all gesture data which helps to train the robotic arm.

S. Maeda, N. Tsujiuchi, T. Koizumi, I. Nakai and M. Sugiura, et.al [16] developed a pneumatic robot arm driven by pneumatic actuators as a versatile end effector of a material handling system. Also, we constructed a PI controller through simulations. However, in industrial fields, robots for a material handling system must be able to work while holding objects. We did not consider this in previous research, so this research aims to construct the PI controller for when the hand holds an object. In this research, we experimented in three situations: one is the hand holding nothing, another is holding a tennis ball, and the last is holding a baseball.

T. Choi, H. Do, K. T. Park, D. Kim and J. Kyung, et.al [17] industrial dual-arm robot is being developed to meet these social issues fundamentally. The dual-arm robot can work instead of human workers. Here, the new dual-arm robot for manufacturing mobile phone and TV are introduced. It has advantages such as the solo controller for both arms, the human sized body and arms. The software platform for the industrial dual-arm robot is also being developed which has strength in its convenience compared to conventional the robot software platforms. The software platform for the industrial dual-arm robot has the real-time control capability, the precise motion command and the convenience of usage. Here the development of the dual-arm is introduced.

F. Caccavale, V. Lippiello, B. Siciliano and L. Villani , et.al [18] environment for open real-time control of an industrial robotic cell is presented in this paper. The experimental setup is composed of two industrial robot manipulators equipped with force/torque sensors and pneumatic grippers, a vision system and a belt conveyor. The new control environment allows advanced control schemes to be developed and tested for the single robots and for the dual-arm robotic cell, including force control and visual servoing tasks. An advanced user interface and a simulation environment have been developed, which permit fast, safe and reliable prototyping of planning and control algorithms.

S. Maeda, N. Tsujiuchi, T. Koizumi, M. Sugiura and H. Kojima, et.al [19] pneumatic robot arm driven by pneumatic actuators was developed as a versatile end effector for material handling systems. The arm consists of a pneumatic hand and pneumatic wrist. The hand can grasp various objects without force sensors or feedback control. Therefore, this study aims to control the wrist motions to expand the hand motion's space. The hand is shaped like that of a human being, and it can grasp objects that have different shapes and mechanical characteristics. However, the wrist has redundant degrees of freedom. This is useful when the robot moves to avoid obstacles.

H. Jiang, J. P. Wachs and B. S. Duerstock, et.al [20] a gesture recognition interface system developed specifically for individuals with upper-level spinal cord injuries (SCIs) was combined with object tracking and face recognition systems to be an efficient, hands-free WMRM controller. In this test system, two Kinect cameras were used synergistically to perform a variety of simple object retrieval tasks. One camera was used to interpret the hand gestures to send as commands to control the WMRM and locate the operator's face for object positioning. The gesture recognition interface incorporated hand detection, tracking and recognition algorithms to obtain a high recognition accuracy of 97.5% for an eight-gesture lexicon.

S. Shirwalkar, A. Singh, K. Sharma and N. Singh, t.al [21] proposes Maximum Velocity Drift Control approach for gesture based telemanipulation of an industrial robotic arm. The approach is quite intuitive for the operator and requires minimal amount of training. Since only the visual feedback is available in gesture based control, it becomes inadequate as in case of occluded views. Hence, to perform the safe telemanipulation, we have combined force-control with gesture based control for avoiding any collisions with the environment. The target tasks were Pick and Place and Liquid Handling operations which demonstrate position control and orientation control respectively.

P. Neto, J. N. Pires and A. P. Moreira, et.al [22] proposed an accelerometer-based system to control an industrial robot using two low-cost and small 3-axis wireless accelerometers. These accelerometers are attached to the human arms, capturing its behavior (gestures and postures). An Artificial Neural Network (ANN) trained with a back-propagation algorithm was used to recognize arm gestures and postures, which then will be used as input in the control of the robot. The aim is that the robot starts the movement almost at the same time as the user starts to perform a gesture or posture (low response time). The results show that the system allows the control of an industrial robot in an intuitive way.

Iii. Framework Of An Design And Implementation Of Plc Based Robot Control Of Electric Vehicle

In this section, framework of an design and implementation of PLC based robot control of electric vehicle is observed in Figure.1.

Energy management is the set of actions and processes aimed at optimizing energy consumption in order to rationalize. It also reduces costs without affecting consumers. It also involves the planning of energy production and consumption. An energy management system is a system of computer-aided tools used by operators of electric utility grids to monitor, control, and optimize the performance of the generation or transmission system.

A battery is defined as an electrochemical device (consisting of one or more electrochemical cells) and it can be charged with an electric current and discharged whenever required. These devices are usually made up of many electrochemical cells that are connected to external inputs and outputs. It is an unlawful application of force directly or indirectly upon another person or their personal belongings, causing bodily injury or offensive contact.

DC-to-DC converters are devices will store electrical energy temporarily for the purpose of converting Direct Current (DC) from one voltage level to another. For automotive applications, they are an important intermediary between systems of different voltage levels throughout the vehicle.

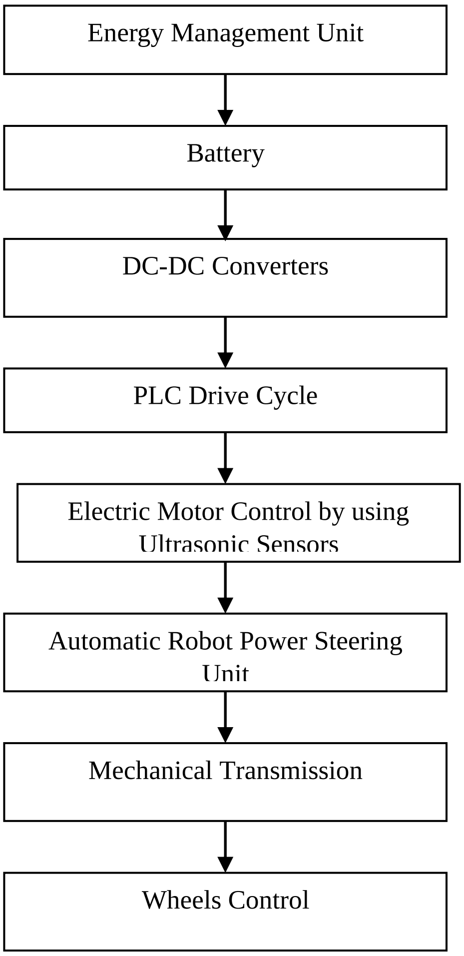

Fig.1: Framework of an Design and Implementation Of PLC Based Robot Control Of Electric Vehicle

A Programmable Logic Controller, or PLC, is a trusted computer used for industrial automation. These controllers can automate a specific process, machine function, or even an entire production line. Most ultrasonic sensors are based on the principle of measuring the propagation time of sound between send and receive (proximity sensor). The barrier principle determines the distance from the sensor to the reflector (retro-reflective sensor) or to an object (through-beam sensor) in the measuring range. These ultrasonic sensors are used primarily as proximity sensors. They can be found in automobile self-parking technology and anti-collision safety systems and also used in robotic obstacle detection systems, as well as manufacturing technology.

The steering control unit calculates optimal steering and also supports the steering torque but also considers many additional vehicle parameters. The steering control unit is also the interface to other control units of the vehicle.

Mechanical power transmission refers to the transfer of mechanical energy (physical motion) from one component to another in machines. These machines need some form of mechanical power transmission. Some of examples like electric shavers, water pumps, turbines and automobiles.

A sim racing wheel is a control device for use in racing games, racing simulators, and driving simulators. These are usually packaged with a large paddle styled as a steering wheel, along with a set of pedals for the accelerator, brake, and clutch, as well as transmission controls.

Iv. Result Analysis

In this section, result analysis of design and implementation of PLC based robot control of electric vehicle is observed.

Table.1: Performance Analysis

Parameters	**Micro Controller Robot**	**PLC Robot**
Accuracy	84.2	90.9
Security	91.4	95.1
Precision	86.7	92.6

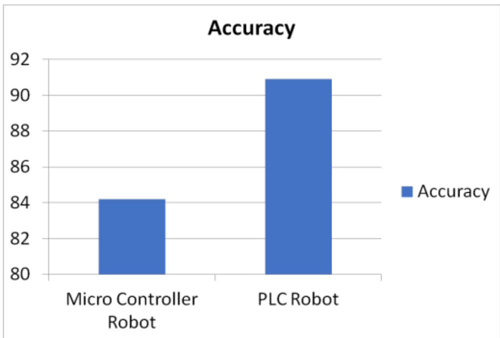

Fig.2: Accuracy Comparison Graph

In Fig.2, accuracy comparison graph is observed between Micro Controller Robot and PLC Robot. The PLC Robot shows high accuracy for design and implementation of PLC based robot control of electric vehicle.

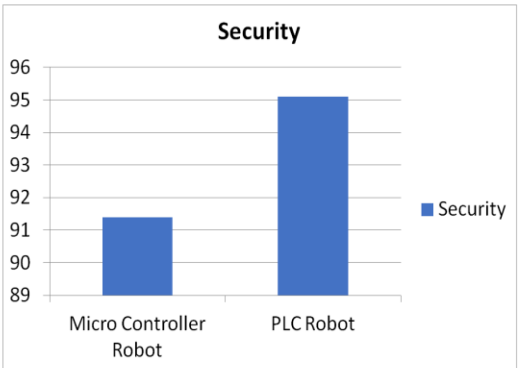

Fig.3: Security Comparison Graph

Security comparison graph is observed between Micro Controller Robot and PLC Robot in Fig.3. The PLC Robot shows high security for design and implementation of PLC based robot control of electric vehicle.

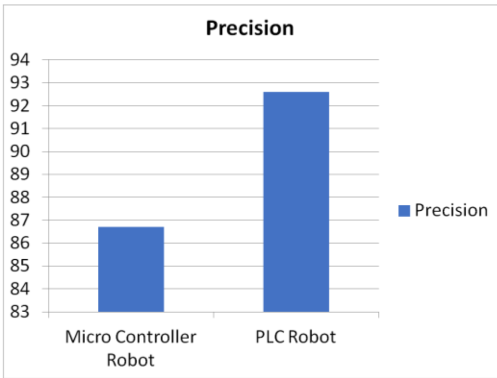

Fig.4: Precision Comparison Graph

In Fig.4, precision comparison graph is observed between Micro Controller Robot and PLC Robot. The PLC Robot shows high precision for design and implementation of PLC based robot control of electric vehicle.

V. Conclusion

Hence, design and implementation of PLC based robot control of electric vehicle is concluded in this section. Hybrid electric vehicles combine the conventional features and electric cars to enhance environmental performance without sacrificing convenience. They get their driving power from both an internal combustion engine and a battery powered electric motor that results in greater fuel efficiency and cleaner emissions than most conventional methods for vehicles. Therefore, by using this system the vehicle will detect the front object. Hence, this system achieves better results interms of accuracy, security and efficiency.

Vi. References

[1] C. -G. Haba, R. Cociu and L. Cociu, "Mixed mode verification of PLC based control systems," *2011 7TH INTERNATIONAL SYMPOSIUM ON ADVANCED TOPICS IN ELECTRICAL ENGINEERING (ATEE)*, Bucharest, Romania, 2011, pp. 1-4.

[2] R. U. Islam, J. Iqbal, S. Manzoor, A. Khalid and S. Khan, "An autonomous image-guided robotic system simulating industrial applications," *2012 7th International Conference on System of Systems Engineering (SoSE)*, Genova, Italy, 2012, pp. 344-349, doi: 10.1109/ SYSoSE.2012.6384195.

[3] C. -h. Park, K. -t. Park and D. -g. Gweon, "Development of Industrial Dual Arm Robot for Precision Assembly of Mechanical Parts for Automobiles," *2006 SICE-ICASE International Joint Conference*, Busan, Korea (South), 2006, pp. 3059-3062, doi: 10.1109/SICE.2006. 314712.

[4] R. Sekhar, R. K. Musalay, Y. Krishnamurthy and B. Shreenivas, "Inertial sensor based wireless control of a robotic arm," *2012 IEEE International Conference on Emerging Signal Processing Applications*, Las Vegas, NV, USA, 2012, pp. 87-90, doi: 10.1109/ ESPA.2012.6152452.

[5] P. Laguillaumie, M. A. Laribi and P. Vulliez, "How to draw like a robot: Practical-case teaching in mechatronics," *2013 7th IEEE International Conference on e-Learning in Industrial Electronics (ICELIE)*, Vienna, Austria, 2013, pp. 33-37, doi: 10.1109/ICELIE.2013.6701267.

[6] Z. Lu, A. Chauhan, F. Silva and L. S. Lopes, "A brief survey of commercial robotic arms for research on manipulation," *2012 IEEE Symposium on Robotics and Applications (ISRA)*, Kuala Lumpur, Malaysia, 2012, pp. 986-991, doi: 10.1109/ISRA.2012.6219361.

[7] V. Pereira, V. A. Fernandes and J. Sequeira, "Low cost object sorting robotic arm using Raspberry Pi," *2014 IEEE Global Humanitarian Technology Conference - South Asia Satellite (GHTC-SAS)*, Trivandrum, India, 2014, pp. 1-6, doi: 10.1109/GHTC-SAS.2014.6967550.

[8] D. Kokvin, G. Sziebig and Wei Deng Solvang, "Design of a robotic arm for automatic cleaning of cargo containers," *2013 IEEE 4th International Conference on Cognitive Infocommunications (CogInfoCom)*, Budapest, Hungary, 2013, pp. 631-636, doi: 10.1109/CogInfoCom.2013.6719179.

[9] J. Rozman, R. Luža and F. V. Zbořil, "ROS-based remote controlled robotic arm workcell," *2014 14th International Conference on Intelligent Systems Design and Applications*, Okinawa, Japan, 2014, pp. 101-106, doi: 10.1109/ISDA. 2014. 7066281.

[10] X. Han, L. Zhang and C. Zhou, "Robotic arm force sensing interaction control," *2012 7th IEEE Conference on Industrial Electronics and Applications (ICIEA)*, Singapore, 2012, pp. 481-485, doi: 10.1109/ICIEA.2012.6360776.

[11] S. Tomas, K. Michal and K. Alena, "Fuzzy control of robotic arm implemented in PLC," *2013 IEEE 9th International Conference on Computational Cybernetics (ICCC)*, Tihany, Hungary, 2013, pp. 45-49, doi: 10.1109/ICCCyb.2013.6617628.

[12] A. Shaik, G. Bright and N. Tlale, "A 6 DOF robot design and simulated energy usage comparison," *2013 6th Robotics and Mechatronics Conference (RobMech)*, Durban, South Africa, 2013, pp. 34-39, doi: 10.1109/RoboMech.2013.6685488.

[13] S. Li, J. Liu and Q. Jiang, "The design and implementation of leaf-spring robot control system," *Proceedings of 2011 International Conference on Electronic & Mechanical Engineering and Information Technology*, Harbin, China, 2011, pp. 121-124, doi: 10.1109/EMEIT.2011.6022877.

[14] A. J. Ishak *et al.*, "Design of entertainment mobile robot: IDAP," *Proceedings. Student Conference on Research and Development, 2003. SCORED 2003.*, Putrajaya, Malaysia, 2003, pp. 298-303, doi: 10.1109/SCORED.2003.1459710.

[15] A. I. Bhuyan and T. C. Mallick, "Gyro-accelerometer based control of a robotic Arm using AVR microcontroller," *2014 9th International Forum on Strategic Technology (IFOST)*, Cox's Bazar, Bangladesh, 2014, pp. 409-413, doi: 10.1109/IFOST.2014.6991151.

[16] S. Maeda, N. Tsujiuchi, T. Koizumi, I. Nakai and M. Sugiura, "Gripping strategy of pneumatic robot arm for industrial fields wrist control in consideration of compensation of gravity," *IECON 2012 - 38th Annual Conference on IEEE Industrial Electronics Society*, Montreal, QC, Canada, 2012, pp. 2713-2718, doi: 10.1109/IECON.2012.6389148.

[17] T. Choi, H. Do, K. T. Park, D. Kim and J. Kyung, "Small sized industrial dual-arm robot with convenient program interface," *IEEE ISR 2013*, Seoul, Korea (South), 2013, pp. 1-5, doi: 10.1109/ISR.2013.6695691.

[18] F. Caccavale, V. Lippiello, B. Siciliano and L. Villani, "RePLiCS: an environment for open real-time control of a dual-arm industrial robotic cell based on RTAI-Linux," *2005 IEEE/RSJ International Conference on Intelligent Robots and Systems*, Edmonton, AB, Canada, 2005, pp. 2493-2498, doi: 10.1109/IROS.2005.1545520.

[19] S. Maeda, N. Tsujiuchi, T. Koizumi, M. Sugiura and H. Kojima, "Development and control of pneumatic robot arm for industrial fields," *IECON 2011 - 37th Annual Conference of the IEEE Industrial Electronics Society*, Melbourne, VIC, Australia, 2011, pp. 86-91, doi: 10.1109/IECON.2011.6119293.

[20] H. Jiang, J. P. Wachs and B. S. Duerstock, "Integrated vision-based robotic arm interface for operators with upper limb mobility impairments," *2013 IEEE 13th International Conference on Rehabilitation Robotics (ICORR)*, Seattle, WA, USA, 2013, pp. 1-6, doi: 10.1109/ICORR.2013.6650447.

[21] S. Shirwalkar, A. Singh, K. Sharma and N. Singh, "Telemanipulation of an industrial robotic arm using gesture recognition with Kinect," *2013 International Conference on Control, Automation, Robotics and Embedded Systems (CARE)*, Jabalpur, India, 2013, pp. 1-6, doi: 10.1109/CARE.2013.6733747.

[22] P. Neto, J. N. Pires and A. P. Moreira, "Accelerometer-based control of an industrial robotic arm," *RO-MAN 2009 - The 18th IEEE International Symposium on Robot and Human Interactive Communication*, Toyama, Japan, 2009, pp. 1192-1197, doi: 10.1109/ROMAN.2009. 5326285.

Anuj Surao, Project Engineer at Atronix Acquisition Corp, Georgia, USA. Proficient in AutoCAD Electrical, PLC programming, Linux Bash scripting, Python programming and ABB & FANUC robotic equipment. Holds a Master's degree in Electrical Engineering from the State University of New York at New Paltz, New York, USA.