

**EMBEDDED SYSTEMS AND ITS PIVOTAL APPLICATIONS IN ROBOTICS****Chaitali Pawar\*, Shivani Rokade & Shruti Tapare**

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**DOI: 10.5281/zenodo.574462****Keywords:** Robotics, embedded systems, micro controller, interfacing.**Abstract**

We are entering into world of robotics. For something as great as robotics field to be evolved, its assimilation and education is pivotal. When coming towards the robotics platform by learning its key aspects we can develop the robotics to far more extent. This field is linked to many technologies coming up and one of them which is rising up these days is embedded systems. Embedded system is nothing but hardware that is programmed according to one's need for real time computing. Here we present a study of embedded systems involved in robotics. Any Robot is merely a hardware that is made functional by using programming in software which is later interfaced with hardware. In these two contiguously growing technology where one bolsters the other, ideas can be implemented to suffice the increasing demand for it. Robots have always had an advantage over humans of preciseness, speed and work capacity. Henceforth, its study comes in the picture, which is presented here. How a technique is better or can be improvised in embedded systems and inherited in robotics is mentioned here. A review of systems is stated so as to intact the study all in one.

**Introduction**

One of the top technologies which improve the efficiency of human activity is robotic machinery. This type of technology is ideal for tasks which are repetitive and dangerous for humans such as factory assembly lines and chemical waste control. Unlike humans, robotic machinery is immune to fatigue and stress and are invulnerable. Humans have been developing robotic machinery for quite some time, and now, this technology is becoming commonly known by society. The common factor in robotic machines is that they all can be manipulated and programmed to follow certain instruction in order to perform a certain task. Here, an embedded system comes into picture. An embedded system is a branch of electronics. Generally, people think electronics means circuits, IC's, transistors etc; but embedded means 'hidden inside'. A branch of electronic systems where you see components (hardware) outside but those components are controlled by set of instructions (software), which are inherited inside the components, is called embedded systems. In essence, embedded systems nothing but programming in electronics. In this study, the main focus will be learning the use of embedded systems in robotics.

In literatures, researchers suggested a number of embedded systems based on new technologies like GSM, GPRS (General Packet Radio Service), implemented through FPGA( Field Programmable

Internet, USN (Ubiquitous Sensors Network) and Gate Arrays), ASICs (Application Specific Integrated Circuit), DSP (Digital Signal Processing), and MCU (Microcontroller Unit). We communicate or transfer the data with the help of wireless sensor networks such as RF modem, Bluetooth, Wi-Fi and Zigbee.

Computers are playing very important role in our life and there is always a need of high quality software. Software reliability is the most measurable aspect of software quality. Unlike hardware, software does not age; wear out or rust, unreliability is mainly due to bugs or design faults in the software. The exact value of product reliability is never precisely known at any point in its lifetime. The study of software reliability can be catalogued into three parts: modeling, measurement and improvement. There are many models available, but no single model can dire a necessary amount of software characteristics. Software reliability measurement is naive. It cannot be directly measured, so other related factors are measured to estimate software reliability. Software reliability is necessary and hard to achieve. It can be improved by sufficient understanding of software reliability, characteristics of software and good software design. Complete testing of software is not possible; however sufficient testing and proper maintenance will improve software reliability to great extent. [15]



### Brief Overview Of Embedded System

Industrial robotics is a major element in field of automated production. Industrial robots provide large workspace and high speed . *Robot is a combination of electronics, mechanics and programming (non-programmable in some cases), which senses it's surrounding through its sensors; processes the sensor information and does something in response, Here enters the concept of Embedded system in Robotics.*

Embedded System is programmed to do a specific function while a general purpose system could be used to run any program of your choice. Further, the Embedded Processor is only one component of the electronic system of which it is the part. It is cooperating with the rest of the components to achieve the overall function. An Embedded system is a device controlled by instructions stored on a chip. These devices are usually controlled by a microprocessor or microcontroller that executes the instructions stored on a Read Only Memory (ROM) chip. Embedded Systems is system that include an application Specific Integrated Circuit or a Microcontroller to perform a specific dedicated application. Basically, Embedded systems are computing systems, but can range from having no user interface (UI) -- for example, on devices in which the embedded system is designed to perform a single task -- to complex graphical user interfaces (GUI), such as in mobile devices. User interfaces can include buttons, LEDs, touch screen sensing and more. Some systems use remote user interfaces as well. Microcontroller plays a vital role in industrial robotics. Criteria for selection of microcontroller in any embedded system is very important which includes the factor like Speed of operation, Packing , Power consumption, Amount of RAM and ROM on chip, Cost Availability of software development tools such as debugger, assembler, compiler

### Literature Review

While development of a microcontroller based robotic arm, [21] micro controller is interfaced with the robots used. MCU, latch 74LS373, 8255 PIO, Magnetic sensing unit, control unit and stepper motor form the basic structure of this robotic arm. Stepper motor, along with all I/O devices is controlled with micro controller's magnetic sensing unit. Researcher's has proposed a model of a robot based on "Human Machine Interfacing Device" utilizing hand gestures to communicate with embedded systems for tracking of enemies. In capturing the human arms behaviors the 3-axis accelerometer is selected as a input device. A non-expert robot programmer can also control a robot using this system quickly. Although, the system is not cost effective and has less range [4]. Further in [22] in the industry based automatic robot system has developed a pick and place robot. Joint and the kinematic forces are calculated. As values are obtained the stepper motor are programmed and values are passed using micro controller. Sensor, motors all are programmed through micro controller. IR sensors are used along with all of the above. The timing pulses from each of the timers are connected to the drivers for speed reduction, since Atmega8 has three timers. In this particular project detailed knowledge of controlling a robot using micro controller is presented. So this is advanced technique compared to the previous one. This helps user to acknowledge the technology currently practiced and flaws that can be improved in future. Also can improve with the can build up task to Control vehicle. By improvement can build up the task to control the remote robot by two way correspondence which prompts robot cooperation. This strategy would require, making it impossible to be utilized as a part of testing working conditions. This kind of control could enhance efficiency, decrease the impacts of dull movements, and enhance security. PIC (Programmable Interface Controllers) microcontrollers are electronic circuits that can be programmed to do a vast range of tasks [3]. They can be programmed to be timers or to do control of a production line and much more. Hardware part of jointed robot arm is implemented using microcontroller PIC 16F628A and each of joint movements are driven by using servo motor. Other hardware components include MAX232, capacitors, diodes, power supply etc. Kinematic modeling method (DH parameters) is calculated to get position and orientation of the end effector with respect to the base. The servo motors were tested using MATLAB GUI software. This system can be enhanced to include inverse kinematic solution to get positioning accuracy [26].

ASTHRA [12] is an automated, dynamic memory mapped robotic vehicle (wheel chair) which enables the disabled to carry on their locomotion with ease and confidence. ASTHRA stands 'Automated Patient Monitoring Unit' which enables to transfer crucial information in case of emergency, as well as normal conditions.

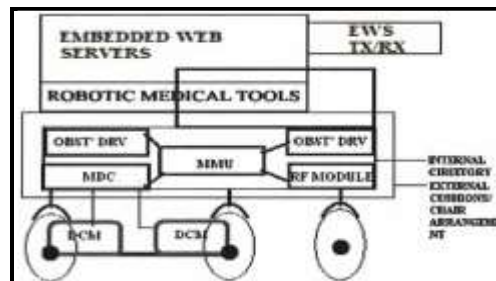


Figure 1: Architecture of ASTHRA[12]

The Vehicle mainly consists of five bottom line components including a Embedded Web Server, DC Motor (Wiper Type) with driver circuit, an Ultrasonic Transmitter and Receiver to detect obstacles, a Radio Frequency Remote and Programmable and Control Memory Unit. The most essential feature of ASTHRA is the Embedded web servers. The use of the embedded web servers is to transfer information regarding the patient's temperature, pulse, ECG and other important necessary features that needs to be transmitted during times of emergency. Another circuit is built around an ATmega328 controller which is a ultrasonic transceiver module HC-SR04, Bluetooth module JY MCU BT, motor driver L293D (IC1), DC motors M1 and M2, and a few common components. PC or Bluetooth phone is used to transmit/receive embedded data such as GPS data wirelessly provided by Bluetooth module. The future implications of the project are very great. Apart from Bluetooth module, other communication techniques of a smart phone can be used. [17] Various electronic components like AT89s52 Microcontroller, IR Sensor, DC Motor, Relays, RS 232 Converter implemented through Visual Studio 2005 and the system is coded using Embedded C [24]. Adding camera to the existing robot for getting access in non-visible area and hence the robot can also be work as a spy robot that can be used for those areas where human cannot enter directly.

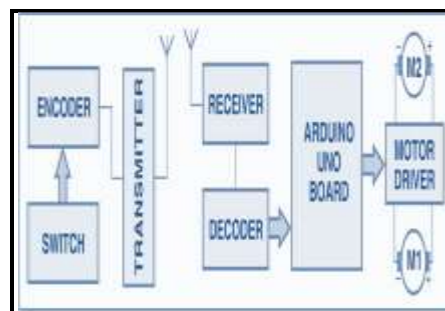


Figure 2: Block diagram of Arduino-based RF controlled robot [8]

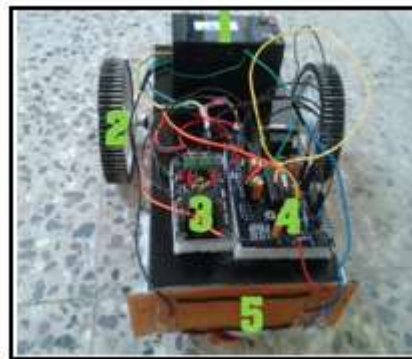
There are hundreds of different techniques of convoluting embedded systems in robotics. [5] Deals with the applications of android and arduino in imperative roles in embedded systems. The robot (manipulator) is controlled by mobile phone and data exchange takes place through RF (radio frequency) module. RF module is the only communication equipment required for this design this module used to transmit the different hand and leg gestures made by user wireless manner which decodes the received 4 bit data according to which gripper and platform moves. The drawbacks are only the internet facility making it to be used as a service robot. Speech can also be used as one of the mode of interaction because of which this system can form part of a so-called Perceptual User Interface (PUI). In another case of Zigbee[2], flex sensors work with great accuracy. Accelerometer converts the deflections into equivalent voltage variation. ADC converts these analog voltage values into equivalent digital values. When there are positive deflections, motor rotates in clockwise direction and in counter-clockwise direction for negative values. Given these conditions, the project can be developed to further higher range and for multipurpose use. Robotic Systems can be developed for human welfare like one of the example mentioned here [11]. By using the embedded computing architecture, the proposed robotic wheelchair controller performs characteristics of compact size, better reliability and lower power consumptions



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while the benefits of powerful computing capacity and familiar coding environment are maintained. On the other hand, this paper also implements the fuzzy logic based autonomous navigation functions such as goal-seeking, wall-following and obstacle avoidance. These fuzzy logic based navigation functions are fused together to solve practical situations of the robotic wheelchairs. Finally, a real robotic wheelchair with three-omni wheel configuration is constructed based on the proposed control architecture, and several practical experiments are also discussed in this paper. This technology can be used also for navigation purpose thus they [25] created a mobile robot that can follow a white line, outdoors, in varying lighting and pavement conditions using the video processing and motion sensing capabilities of an Android smart phone. A custom vision algorithm takes as input the smart phone camera feed and output control data to a motor controller connected to the motors of hobby radio-controlled vehicle. The only drawback of this system is that this mobile robot is nothing but line follower robot controlled using android smart phone. One more design that is studied over here is Robot Control Design Using Android Smartphone [28], in this particular paper; a robot that is controlled by a mobile. Bluetooth function is used along with android application for the working of the robot. Micro controller (Arduino) forms interfacing with android (Bluetooth) and according to the instruction the robot works. Such robots could have been interfaced using other modules which are better than Bluetooth. We need to program that robot in advance way to carry out complex function.

Arduino's principal advantage is that it furnishes access to micro-controller technology with the lowest possible cognitive load and start time. Initially some researchers have tried to use it with sensor. The Arduino Based Photovore Robot with the light dependent sensor a controlled robot has been designed.[7]With no source of energy other than solar energy they have successfully designed a robot which can be upgraded with the colour sensor and energy storing element to work in dark which makes it an autonomous system. Further, Animatronics [9] is defined as a device to emulate a human or an animal. Wireless embedded teaching system where the main control board (Arduino) receives voltage signals from the teaching robot via its analog pins and transforms them into position commands for the motion of each joint and fingers. This voltage sensed servo motors wirelessly.



**Figure 3: Arduino based RF Photovore robot [7]**

Using Xbee radio frequency module stimulated with the XCTO software, the project is designed to develop a robotic vehicle using Arduino for remote operation for monitoring purpose.[8]ATmega328 microcontroller with transmitter and receiver pair (HT12E and HT12D) is used for building various projects in wireless communication in robotic systems used to pick and drop objects, capture real time picture in night vision, transmit and receive the RF signals which are used in military, automation of homes. This system can further be improved by adding another Arduino board with added features to perform multiple functions together at the same time such as accelerometer. In industry like mining we come across so many hazardous [6] chemicals. There is a wireless controlled robotic arm aimed to be used for handling hazardous chemicals the gesture information which will be the basis of robotic arm behavior will be collected through a glove controller equipped with the flex sensors and combinational accelerometer and gyroscope. The data is transferred via zigbee protocol interface attach to the user and arm controller.



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Science has no end so does technology. We know that robot or a system is basically controlled by operator, remotely or with the help of buttons and joysticks. Researchers found it as, controlling the complete Robotic Arm by the operators hand gesture. The Hand gestured [1] robot, name indicates the robot with some intuitive technique to eradicate the stereotype which is controlled by operators and gestures. They also have designed a device which transmits signals to the robot through an auto device fixed on the gloves which will be put on hands to serve the robot as input. APC-220 module (RF module) is used for interfacing to transmit the receive gesture. But due to the input which is a gesture will provide the noise from the background clutter. Altogether, its not an autonomous system and the complexity of the circuit is much higher when it comes to implementing it. This is an attempt to achieve something prodigious. Arduino is low cost, versatility, user friendly and is supported by a large community of users. The robot built has been accomplished using low-cost commercial components. The components are mounted are motors, sensors and controllers that complete the design of the robot. The layout that forms the user interface of the application is written in an XML.[30]Another very important type of robot we came across is a bipedal robot[29]with two legged walking robot which imitates human pace as well as tread. It has been used substantially in places where wheels cannot go easily for example stairs, terrains, etc. World is contracting with the growth of mobile phone technology. The designed robot is operated by android phone using [10]APIs (Application Programming Interfaces) provided for the Android operating system and can be remotely controlled over the internet. The camera on the Android phone is used to send video feedback to the remote user simultaneously over the internet with the MATLAB tool GUI. By using APIs operating system they have overcome the range issue. We can program the robot such that it can detect objects and reach them on its own to become completely autonomous. Things such as Internet access, wireless networking, data logging, and device control are facilitated by the open source nature of Arduino.

### Conclusion

For the research, it's necessary to have a clear vision for its goal. Microcontrollers play an important role in formulation of any embedded system. Based on the microcontrollers, various software implementations can be done. Microcontrollers can be implemented with various communication modules. After the study of this projects/papers we come to know that as robotics can be designed as one wants. Among Zigbee, RF, Bluetooth, devices should be chosen that give maximum range. Microcontroller forms the heart of embedded systems, using this and other technical things whole new technology can be developed. Also from the above study we can conclude that Arduino is an appendage or Development of a Micro-controller on a Board with other fringes for help, hence, it is a Development Board. From the investigation it has been clear that Arduino's ready to use structure makes it easy to use it. In this paper we have provided a desegregated approach for coherent embedded systems design.

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