

Development of IoT Controlled Agri-Rover for Automatic Seeding

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Abstract

Objective: The field of robotics can be modified with the combination of number of approaches such as, mechanical approach, software technology and electronic control system approach together. In the period of current globalization, scientists are trying to apprise advancements based on robotics which operates and performs tasks very effectively, efficiently and in lesser time. These progressions can be utilized to improve Indian traditional approach of farming. Since in Indian scenario, near about 70% population is reliant on agriculture. So the agricultural field in India should be improved to increase the yield. Agree rover is the best solution to meet the rising demand on quantity and quality of agriculture products and declining labor availability in rural farming areas. The main aim of the designed system is efficient utilization of resources and to reduce a laborious work.

Method: The seed sowing operation is performed by the system using servomotor mechanism controlled by ARDUINO controller and robot motion is controlled by Internet of Things (IoT). The necessities for small scale seeding machines are, the system should be suitable for small field, simple in design and technology and ease of handling.

Findings: The developed Agri-Rover satisfies all those parameters also reduce the human interference. Also increased speed of seed sowing, seed placement precisions made it usable.

Improvement: Agri-Rover made of tough yet less cost material which made it low-cost for the small scale farmers.

Keywords and Phrases: Internet of Things; Blynk; ARDUINO controller; Agri-Rover; Seed sowing system;

1 Introduction

A robot is handled in electro-mechanically to do operations precisely but quicker way. They have substituted human beings in performing perilous tasks which humans desire not to do, or are incompetent to do. Rover is modern autonomous robot which will move according to the will of operator. An Agri-Rover is the rover which can accomplish agricultural tasks. Different types of rovers can be used to do functions like spraying, fruit picking etc in the farm. Guilherme et al have reviewed the developments of vision for mobile robot navigation for the last 20 years. This review has surveyed various aspects of the progress made so far in vision for mobile robot indoor and outdoor navigation¹. Simon Blackmore et al have dealt with how aspects of crop production could be automated in the future. The development process may be incremental but the overall concept requires a paradigm shift in the way we think about mechanization for crop production that is based more on plant needs and novel ways of meeting them rather than modifying existing techniques². Albert et al have presented the design and application of a distributed wireless sensor network prototyping system for tracking mobile search and rescue robots. The robotic system can navigate autonomously into rubbles and to search for living human body heat using its thermal array sensor³. Domagoj et al have developed an advanced localization system for both the autonomous tractors and the human operator. This approach found to be improving the localization accuracy and may be used in harsh environments where the GNSS signal is severely attenuated due to dense foliage⁴.

Shrinivas et al have used a model based on robotic platform which will be useful in performing operations like cultivation on ploughed land. Without using man power cultivation of ploughed land is done automatically. Continues control and monitoring of system motion of vehicle is done by using microcontroller. IR sensors used to detect the objects and will find their way⁵. Hui Liua et al have proposed a system which contains of an infrared radio navigation module, multi-robot board control centers (PCs), a remote server control center (PC), a wireless communication network and an infrared radio navigation module⁶. Gerard Rudolph Mendez et al have developed an automated which monitors agricultural conditions in a pre-programmed manner with three stations: Sensor Node, Router, and Server. Climate conditions in an agricultural environment such as field or greenhouse, the sensor station are prepared with several sensor elements such as Temperature, humidity, light, air pressure, soil moisture and water level⁷. Kulkarni et al have addressed a new system which can be used different in agriculture processes like weed control, cultivation, harvesting, spraying by using autonomous vehicle which increases speed, accuracy and life. A robot developed uses dc motor and IR sensor arrangement for steering and controlling. The robot also controls the weeds in the farm by considering particular rows per column at fixed distance depending on the crop and also detects the obstacles present in the path of vehicle⁸. Peng Jian-sheng has proposed an intelligent WiFi wireless controlled spraying pesticides robot. The microcontroller core for monitoring, a wireless router for the network connection point is employed. The robot gave good results on different terrain, different heights crops for spraying operation. Its low cost, ease of handling and easy maintenance makes it suitable in agricultural production⁹. Many technologists are trying to develop technology based on automation which is robust, effective and faster. Similarly, Shivaprasad et al have designed an agriculture robot in that the direction of the robot is controlled via remote. The robot and the remote system are connected through internet system. 6 DC motors are used for navigation of the robot. The solenoid is used to control seeding and fertilizing operations¹⁰.

Mahesh et al have reviewed the types of innovations done in seed sowing machine available for plantation. Depth of seeding has shown to be an important factor affecting seeding vigor and crop

yield and which can be calculated by using seed metering device. There are variations in types of crops, for a wide range of seed sizes for those high precision pneumatic planters have been developed resulting to uniform seeds distribution along the travel path, in seed spacing¹¹. Andrew et al have approached Automatic Ground Vehicles for mapping and managing the high level of variation found within pastoral paddocks. They have developed affordable, easy to use precision-agriculture technologies that have clear benefits for pastoral farming and which will reduce extra workload of farmers¹². Amol et al have made a comparative study between conventional sowing method and new proposed machine which can perform number of simultaneous operation. Reduced the sowing time, human efforts and labor cost these are some advantages of these system. The machine can perform row to row spacing, seed rate, seed to seed spacing and fertilizers placement varies from crop to crop¹³.

Similarly, in last two decades, the control system development in mobile robots achieved greater highs. Arturo Gil-Pinto et al have explained that the use of a extended Kalman filter (EKF) to fuse the wireless network measurements and the vehicles sensors outputs to estimate the relative distance and angle between robots and conclude that the WiFi network can be also used as a positioning tool in cooperative robotic applications¹⁴. Saliyah Kahar et al have reviewed the use of different wireless technologies for mobile robot controller such as Bluetooth, WiFi or Wireless LAN and 3G. Pros and cons of every technology are discussed. The selection of wireless technologies are depends on the type of application to be developed, apart from that it has to consider the following: range, frequency and data rate¹⁵. Sudarshan et al have designed a rover which has the capability to navigate based on the commands issued to it remotely by an operator. The real time communication was achieved with as minimal a delay. An algorithm is developed which controls the vehicle remotely and safely. The communication between the client and the rover is established based on the connection parameters specified by the operator¹⁶. Shashank has used WiFi as the medium for effective communication using two computers. Those computers are connected to the WiFi which will pass on serial data and also communication is established between one computer located near the robot and a microcontroller present, which controls its trajectory¹⁷. Wireless communication plays an important role while controlling from large distances. Very robust robot in which wireless communication can be achieved using Wi-Fi network or internet is developed. Various buttons are displayed on the web page specifying the various actions which makes controlling of robot easier. Also fast and good quality of image transmission is achieved by using the Android device¹⁸. Yuxiang Sun et al have developed a system for WiFi signal strength-based indoor localization, it compares the classical KNN algorithm and improved KNN algorithm and the probabilistic method is provided about 2m localization accuracy for the test environment¹⁹. Won-Shik Na and Seok-Hoon Kim have proposed an Efficient Data Forwarding Scheme (EDFS) to support an efficient data transmission of the IoT devices because the Wi-Fi technology was not prepared to accommodate those data²⁰. Muthiah et al have presented construction of a robot used for cleaning which is controlled by RF signals and an Induino (microcontroller). Additional feature provided by them such as the wireless camera which makes the robot easy and user friendly for the human to work with²¹. Gonca Ersahina et al have controlled mobile robot remotely with an android interface program. The developed android operating system makes the system more user friendly and it can be operated by more than one user on their own devices²². Mohammed Saquib Khan et al have presented a Wi-Fi controlled robot based on three modules viz. Wi- fi Module, Router, Microcontroller which handles all basic functionalities of a Robot. Interfacing between Microcontroller and Wi- fi module has been done by creating a Webpage²³.

From the above literature survey it can be seen that, existing seeding techniques are either complex or time consuming. Also wastage of seeds, lack of man power and several other aspects affects the yield production. Automation in agricultural field is required to overcome those shortcomings. In this research, existing complex seeding mechanisms were replaced by the simple flap and servomotor mechanism which improves accuracy and precision of seeding. Similarly in robot control system, most of the literatures use accelerometers, flex sensors, RF modules and Wi-Fi technology to control the robot which are having certain disadvantages. These can only control robots up to a certain radius, but controlling the robot from remote location can be achieved by using Internet of Things²⁴. There are some real world problems such as lack of control options in field such as agricultural applications. These problems can be minimized by using IoT as the medium of communication. Further, the conceptual design of agri-rover and seeding mechanism are discussed in section 2, Control system design is explained in section 3, Hardware selection and implementation of Agri-Rover is briefly mentioned in section 4, software implementation and experimental prototype are explained in section 5 and 6, summary of the developed IoT controlled Agri-Rover with future scope is discussed in section 7.

2 Conceptual Design Of Agri-Rover

Figure 1 shows the proposed system of Agri-Rover which has servomotor fixed at the bottom of the frame. A cardboard flap has been mounted on the shaft of the servomotor. The hole is made at the end for the free fall of seed. The entire assembly is mounted on the body of the rover.

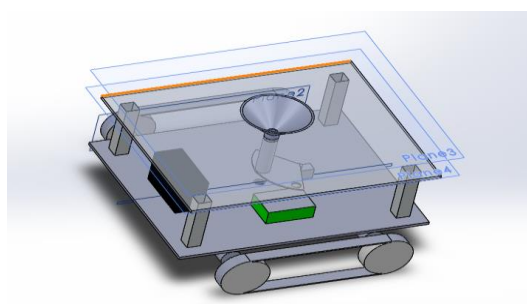


Figure 1: CAD Model of Proposed System

The developed system uses a simple and less complex mechanism for the seed sowing. As shown in Figure 2, mechanism contains a tapered feeder, a servomotor driven by the ARDUINO controller and one flap having opening. Arduino program is developed in such way that it Arduino UNO is used to control angular speed of the motor and ultimately the opening and closing of the container. The time delay for opening and closing of the feeder can be adjusted by varying the Arduino programming. Using different time delay seed falling distance can be varied in the actual environment.

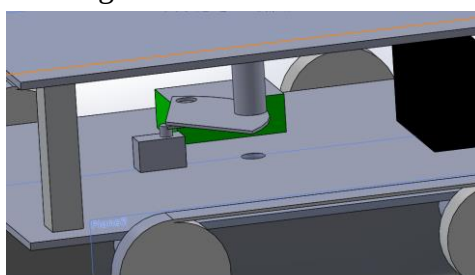


Figure 2: CAD Model of Seeding Mechanism

Container mounted on the upper part of the rover contains seeds to be sowed. The tapered container is provided with an opening which is extended up to the lower step of the rover. Container acts as a feeder which continuously provides the seeds. This feeder holds half kilogram of seeds at a time. This capacity of holding seeds can be varied as per the requirement. Considering variation in diameter of seeds ranging from 2.5 mm to 9mm, the feeder has given 13 mm hole at the end. The same diameter hole is drilled at the base of an agri-rover to ensure free fall of seed. To control the seed flow, the container opening is provided with the flap which is coupled with the servomotor shaft. This opening and closing is controlled by Arduino program as discussed earlier.

3 Control system design

Figure 3 shows the control system of Agri-Rover, Android Smartphone is connected to the Blynk server. Server developed a specific key for the particular project which was created according to the GUI required. Entering this unique key into the ESP8266-Arduino connection program device got connected with the server. Here, Blynk server is used for IoT. ESP8266-12 Wi-Fi modules are connected to the same server by using unique key provided by the Blynk server. ESP8266 module is connected to any Wi-Fi hotspot with same SSID and password as provided in the interfacing program. Control signals are transferred from GUI of application to the ISP of Blynk server. Wi-Fi module receives the control signals from the Wi-Fi router provided with internet connectivity. This module is further connected with DC motors via Arduino UNO controller. The four push buttons were added for forward, backward, right, left motion of Agri-Rover. Specific pins are configured for each motion using application feature. This will send high / Low signals to the Wi-Fi module. When pin configured to the particular push buttons becomes high it gets converted into the specific commands by Arduino and is passed to the DC motor to achieve the desired motion.

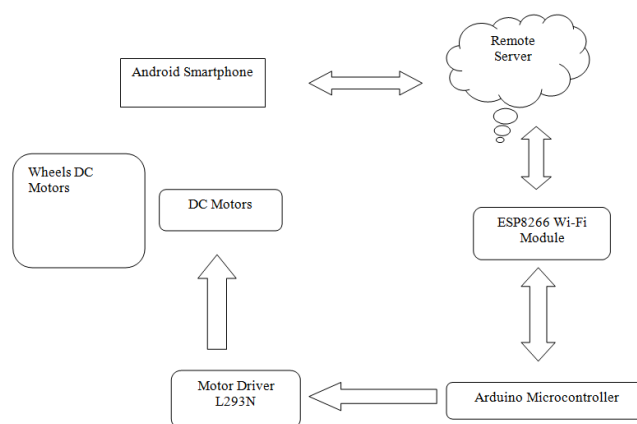


Figure 3: Block Diagram of Control System

4 Hardware selection and implementation

The hardware components of Agri-Rover and its implementations are briefly explained in this section.

A. ESP8266 Wi-Fi Module

ESP8266-12 is very low cost Wi-Fi chip equipped with TCP/ IP stack and also has an inbuilt microcontroller. The module is programmed in such way that it drives the agri-rover without any wired connections. Agri-rover can be connected with Wi-Fi in mere minutes. ESP8266 Thing Development Board – an ESP8266 development board, with an integrated FTDI USB-to-Serial chip is used with twelve GPIO ports as shown in Figure 4. It is basically available with pin breakout. Third party board of ESP8266 comes with a voltage regulator IC which converts 5V to 3.3V, hence can be powered by a 5V supply directly.



Figure 4: ESP8266 Wi-Fi Module

B. Arduino Uno Microcontroller

From the literature survey, Arduino UNO ATMEGA 328 is chosen as MCU. Figure 5 shows MCU which is used. This is microcontroller board which uses the ATMEGA328P. It has 14 digital pins for input output connections, 6 of them can be used for Pulse Width Modulation outputs, other 6 for analog inputs, a 16 MHz quartz crystal, a USB connection, a power jack, an ICSP header and a reset button. Power is supplied by connecting it to a computer with a USB cable or with adapter which converts AC to DC or battery to get started. This Uno board is different than all other previous programming boards. No FTDI USB-to-serial driver chip available. Instead, it uses the Atmega16U2 (Atmega8U2 up to version R2) programmed as a USB-to-serial converter. The ATmega328 has 32 KB with 2 KB of SRAM and 1 KB of EEPROM.



Figure 5: Arduino Uno

The module is programmed in such way that it transfers signals to the Arduino board. Arduino board will act as input source to the motor driver circuit (L293N) which drives motor and motion is achieved. Rover is equipped by four DC motors, belt drive of wheels are driven by these motors. Belt type wheel provides force and traction required in agricultural land and in muddy land.

End user (farmer) can control and navigate the rover from a large distance. User is provided with the GUI which allows him to operate and to steer the rover as per his will. Figure 6 provides detailed working and actual signal flow.

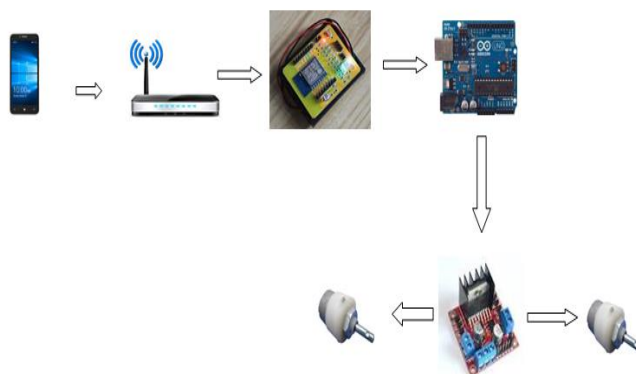


Figure 6: Actual Signal Flow

5 Software Implementation

The Android application was made by using Ionic framework. Widgets such as slider, toggle buttons and push buttons were added by using ionic source codes provided by ionic framework. ESP8266 and mobile application pin ports are connected to each other via server. Push buttons provided on the interface allows the operator to navigate the rover in forward, backward, left, right motion required. Application is configured in such way that desired movement of Agri-Rover is achieved from a large distance. Application provides ease of use, continues control, less complications with wide operating range. Figure 7 shows the screenshots of the designed application. The movement of Flap-Servomotor mechanism is also controlled by the similar way by adding additional push button in GUI.



Figure 7: Mobile Application for Navigation

6 Experimental Prototype

Figure 8 shows the prototype of Agri-Rover after the fabrication and assembly. It can be seen in the figure assembly of seeding mechanism, belt drive wheels. The agri-rover is equipped 100 rpm DC motor. Rubber belt drive is used to drive in the agricultural field. Four DC motors were powered by 12V DC supply. The whole mechanism is carried on the four wheels having diameter of 70 mm.

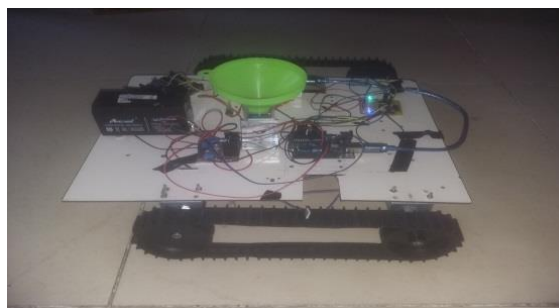


Figure 8: Prototype of Agri-Rover

7 Summary and future scope

An IoT controlled Agri-Rover for automatic seeding was developed, based on the development of IoT control system and conceptual design of Agri-Rover, the following points are concluded,

- Instead of earlier semi automatic complex seeding mechanisms like lever, plunger, cams, an automatic seeding Agri-Rover with a simple mechanism using flap was developed.
- IoT enabled Agri-Rover with newly developed Flap-servomotor mechanism provides extensive advantage over the existing mechanisms.
- ESP 8266 version 12 Wi-Fi module which is newly developed hardware was used to achieve the wide range of wireless control without delay in the control.
- Use of DC motor for the movement and navigation gives precise control. Use of IoT gives increased range from which farmer can operate and the desired applications like pesticing, weeding, seeding can be done.
- Use of Arduino program for servomotor control provides exact and precise control over seeding.
- Arduino program also offers transformation in time delay required. By changing the delay, distance between the two consecutive seed drop can reformed.
- Further development can be possible using IoT in agricultural sector. Use of electronic control with IoT in agricultural field going to push the limits of engineering streams beyond the conventional methods.
- In order to increase the controlling capabilities in agricultural environment an advanced microcontroller like raspberry pi etc. can be used further.
- Future enhancement can be done by giving live video streaming at the farmer end. Continues video streaming will allow the farmer to control the Agri-Rover beyond the line of sight.
- Agri-Rover can be equipped with different sensors and mechanisms to perform other agricultural applications like weeding, pesticing etc.

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