An Intelligent Remote Control System With Robots For Agriculture Process By Using Fuzzy Controller And Virtual Instrumentation

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Abstract-
This paper explains the microcontroller based fuzzy controller for an agricultural robot which can be used to plough the field, seeding and soil moisture sensing. By using the agricultural robots in field which can be used to reduce manpower and can be operated using remote controls from a distant place. In this paper, an agricultural robot is designed with an internet based remote control by using LAB VIEW and its position and speed control are discussed. Fuzzy controller is designed to change the steering angle and the speed of the robot according to the desired reference position. The control was implemented using Atmega16 Microcontroller and the results are documented.

The Robot control is implemented from a remote place using internet and web publishing tool in LabVIEW. This LabVIEW software enables complex and expensive equipment to be replaced by simpler and less expensive hardware. The agricultural Robot with the designed controller can be controlled from any distant computer. Thus this agricultural Robot control reduces the manpower and becomes advantageous and cost-effective.

In existing they are using RF technology for transmitting and receiving purposes. But RF module operates at 433.92 MHZ and it can transmits the information about a single robot. This is is one of the main disadvantages in existing system so only GPRS technology is proposed to overcome this problem. By using the GPRS transmission of data is very fast, long distance communication, collects and transmits information about multiple number of robots.

Keywords—LABVIEW, GPRS Modem, Sensors (LDR, CO2, IR), ATmega16 Microcontroller.

INTRODUCTION
Many methods exists for plough the field. Earlier days they are using Cattle to plough the field and after that tractor is used for this application. For Seeding more man power is required and also it is a slow process. The
distance between the seeds depends upon the person who is doing that work. Now days we are using special tools for these applications. During irrigation, farmer supply water to the crop, the moisture content of soil may vary depends on the season. It will affect the crop and it results to reduction in overall quality of output crop.

To overcome all these difficulties by using the Agriculture robot, this robot consists of a ploughing tool, seed box and soil moisture sensor. The robot is controlled through LabVIEW software. Remote control real-time processes are getting considerable attention in the academic, industrial communities. Various technologies are developed to perform the remote real-time control using Internet-based technology. LabVIEW is one of the user friendly software packages used in process control applications. LabVIEW uses various protocols such as UDP/IP, Data Socket, etc. that allow remote control using Internet.

**RELATED WORKS**


This paper presents a survey of Web/Internet-enabled technologies to build experimental setups that can fully be operated, controlled and monitored remotely. This paper discusses the major methods of interfacing LabVIEW applications with the Internet/WWW that could be employed for remote operation of experimental setups.

**Disadvantages:**

The user cannot interact with the Virtual Instrument.

A relatively notable slowdown in the execution of application may occur if a large number of users co-currently access the application.

2. **Autonomous Agricultural Robot and Its Row Guidance**

XUE Jinlin1, XU Liming2

A vision-based row guidance method is presented to guide a robot platform which is designed independently to drive through the rowcrops in a field according to the design concept of open architecture. Then, the offset and heading angle of the robot platform are detected in real time to guide the platform on the basis of recognition of a crop row using machine accuracy of row guidance is up to ± 35mm, which means that the robot can move with a sufficiently high accuracy.

**Disadvantages:**

Design is complex.
3. Verification of a Weeding Robot “AIGAMO-ROBOT” for Paddy Fields
Teruaki Mitsui, Takahiro Kobayashi, Toshiki Kagiya, Akio Inaba, and Shinya Ooba.
Increased public interest in food safety and clean agriculture is driving a production system change from dependence on and use of agrochemicals toward their elimination. However, this raises a huge time- and labor-consuming problem with weeds. The weeding robot “AIGAMO-ROBOT” we propose decreases weeds in paddy fields without resorting to herbicides.

Disadvantages:
Not compatibility High cost

4. Design and simulation of fuzzy controller for closed loop control of chopper fed embedded dc drives
N.S. Kumar, V. Sadasivam, K. Prema Dept. of EEE, Mepco Schlenk Eng. Coll., India
An INTEL 8051 microcontroller based fuzzy controller for closed loop control of dc drive fed by dc/dc converter. The controller designed has two loops with an inner current controller and an outer fuzzy speed controller. Computer simulations evaluate (tested) the designed fuzzy controller. The controller is used to change the duty cycle of the converter and thereby, the voltage fed to the armature of the separately excited motor to regulate the speed. The simulated closed loop performance in respect of load variation and set speed change for both fuzzy controller and PID controller has been reported. The simulated results are compared with experimental results by using a buck converter with the fuzzy controller implemented in 8051-based embedded system.

Disadvantages
Performance is not better
Not compatibility

II. PROPOSED SYSTEM
Figure 1 shows an agricultural robot is treated as server system, internet connection and assigned static IP address. The client system can be any PC with internet connection. The system is composed of monitoring terminal, data transmission networks and monitoring center. Monitoring center server is provided with a fixed IP address. The system of data transmission network is formed by GPRS network and the Internet, which is the data transmission channel between the monitoring terminal and monitoring center, monitoring terminal on
which integrates GPRS communication module collects the operating data of Agri Robo through the transmitter of field meter.

![Fig. 1. Block Diagram of the proposed system](image)

The GPRS communication module controlled by microcontroller sends the data to monitoring center via GPRS wireless network. It is an emitter type LDR and CO₂ sensor. The reasons being LCDs are economical; easily programmable; have no limitation of displaying special & even custom characters (unlike in seven segments), animations and so on. A 16x2 LCD means it is an ALTRONIC alphanumeric 16 character, 2 line dot matrix liquid crystal display. It has 96 inbuilt ASCII characters as well as 92 special letters and 8 custom characters, which can be displayed on the screen. It has 16 characters per line and there are 2 such lines. In this LCD each character is displayed in 5x7 pixel matrix.

This LCD has two registers namely Command and Data. This is used to sense the obstacle range up to 5cm, it requires 5V power supply. The LCD Display is used to display the functions like soil moisture level, robot motions and solenoid valve conditions.

At the boundaries of field obstacles are placed. When the IR sensor senses the obstacles the set speed of the motors are changed by the control to change its directions either left or right side alternatively. When no obstacle is sensed the equal value of set speed is given to both the DC motors and the forward movement is achieved. Thus the steering angle and speed control of the robot is achieved.
Figure 2 shows the block diagram of the control system for motors. The system consists of H-bridge converter for driving the separately excited DC Motor in both forward and reverse direction. The performance of DC drive will be based on the choice of controllers. The designed closed loop control has two loops. One is outer speed control loop and another one is inner current control. In outer speed control loop, the speed is fed back and is compared with set speed.

The designed FLC was then implemented microcontroller. After comparison, error signal and the change in error are calculated and are given as input to fuzzy controller. The fuzzy controller will attempt to reduce the error to zero by changing duty cycle of switching signal.

By using the programmed microcontroller the agriculture robo's speed and steering angle is controlled.

A program was developed for the movement of ploughing tool using a DC motor and for controlling the seed flow from the seed box. This program is also implemented in the same microcontroller.

**III. MATHEMATICAL MODEL OF DC MOTOR**

In any electric motor operation is based on simple electromagnetism. A current carrying conductor generates a magnetic field; when this is then placed in an external magnetic field, it will experience a force proportional to the current in the conductor, and to the strength of external magnetic field. DC motor has axle, rotor, stator, commutator, Field magnet(s), and brushes. The stator is stationary part of the motor, this includes the motor casing as well as two or more permanent magnet pole pieces. The rotor consists of windings which is electrically connected to the commutator.

The simulation and design of the controller was done using equation models of the motor and H-bridge converter. The DC motor has been modeled with the following equations. By Krichoffs law

\[
I_\alpha R_\alpha + L_\alpha \frac{dia}{dt} + e_b = V_a
\]  
\[
(1)
\]

\[
T = K_i J_a
\]  
\[
(2)
\]
\[ J \frac{d^2 \Theta}{dt^2} + B \frac{d\Theta}{dt} = T \]  
\[-(3)\]
\[ e_b = K_b \frac{d\Theta}{dt} \]

where

- \( I_a \) - Armature current
- \( V_a \) - Armature voltage applied
- \( R_a \) - Armature resistance
- \( L_a \) - Armature inductance
- \( e_b \) - Back Emf
- \( J \) - Moment of Inertia of the motor
- \( B \) - Friction coefficient of the motor
- \( K_t \) - Torque constant of the motor
- \( K_b \) - Motor back emf constant
- \( T \) - Torque developed by motor
- \( \Theta \) - Angular displacement of shaft
- \( W \) - Angular velocity of the shaft

IV.FUZZY SYSTEM

Fuzzy Logic (FL) is a multivalued logic that allows intermediate values to be defined between conventional evaluations like true/false, yes/no, high/low, etc. Notions like rather tall or very fast can be formulated mathematically and processed by computers, in order to apply a more human-like way of thinking in the programming of computers.

The steering angle and the driving speed of Robot are controlled by using DC Motors simulation module. The speeds of these motors are changed according to the reference values when the Robot reaches the end points. Control logic is developed to decide the direction of Robot movement based on the starting position and current position values of the Robot.

The actual speed is fed back and is compared with the reference speed. After comparison, the error and the change in error are calculated and are given as input to fuzzy controller. In this work, the error is normalized to per unit value with respect to the reference speed. This helps in using the fuzzy controller for any reference speed. The fuzzy controller will attempt to reduce the error to zero by changing duty cycle of switching signal.

The control algorithm of a process that is based on fuzzy is defined as fuzzy control. The controller which uses control based on fuzzy is called as fuzzy controller. Fuzzy, unlike Boolean or crispy deals with Vagueness, uncertainty, qualitativeness.

It tends to mimic human thinking which is fuzzy in nature. In conventional set theory, based on Boolean a particular object or a variable is a member of a given set then its membership value is 1, or if it is a not a member of a given set then its membership value is 0. But in fuzzy set theory based on fuzzy, a particular object has a
degree of membership in a given set that may be anywhere in the range of 0 to 1.

A. Fuzzy Controller

Fuzzy control is derived from fuzzy set theory introduced by Zadeh in 1965. In fuzzy set theory, the transition between membership and non-membership can be gradual. Therefore, boundaries of fuzzy sets can be vague and ambiguous, making it useful for approximate systems. Fuzzy controller (FLC) is an attractive choice when precise mathematical formulations are not possible. Other advantages of FLC are

1. It can work with less precise inputs.
2. It doesn't need fast processors.
3. It is more robust than other non-linear controllers.

B. Fuzzification

Fuzzy uses linguistic variables instead of numerical variables. The process of converting a numerical variable (real number) into a linguistic variable (fuzzy number) is called fuzzification. In the present work, the error & change in error of speed are fuzzified. Seven linguistic variables using triangular membership function are used as shown in figure 4. The seven linguistic variables used for 'error' and 'change in error' are negative big (NB), negative medium (NM), negative small (NS), zero (Z), positive big (PB), positive medium (PM) and positive small (PS).

Constructing a fuzzy controller steps are

- Create a membership values
- Specify the rule table.
- Determine the procedure for defuzzifying the result.

Membership values

First step is to fuzzify the data or create membership values for the data and put these in to the fuzzy sets. Each set of data is to divide in to ranges. X is used to determine the arbitrary range and Y is used to determine the range of 0 to 1. (theoretically 0 to 100%).

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C. Defuzzification

The reverse of fuzzification is called defuzzification. The Fuzzy controller (FLC) produces required output in a linguistic variable (fuzzy number). According to real world requirements, the linguistic variables have to be transformed to crisp output.

The error is calculated by subtracting the reference speed from the actual rotor speed as follows: 
\[ e_1[n] = s[n] - a[n] \]

Where \( e[n] \) is the error, \( s[n] \) is the reference speed, and \( a[n] \) is the actual motor speed. The change in error is calculated by above Equation where \( e[n] \) is the previous error value.

\[ e_2[n] = e_1[n] - e_1[n-1] \]

In the fuzzy logic control system, two normalization parameters for input and output are defined. In normalization Process, the input values are scaled between (-1, +1) and in the de-normalization process, the output values of fuzzy controller are converted to a value depending on the terminal control element.

Fuzzy logic differs from traditional Boolean logic in that fuzzy logic allows for partial membership in a set. It can use fuzzy logic to control processes represented by subjective, linguistic descriptions. A fuzzy system is a system of variables that are associated using fuzzy logic. A fuzzy controller uses defined rules to control a fuzzy system based on the current values of input variables.

D. Rule Table and Inference engine

The rules are in the following format: If error is \( A_i \) and change in error is \( B_i \) then output is \( C_i \). Here, if "part" of a rule is called the rule-antecedent and is a description of a process state in terms of all combination of atomic fuzzy propositions.
the "then" part of the rule is called the rule consequent and is a description of the control output in terms of all combinations of fuzzy propositions. This rule table corresponds to Fuzzy PI controller [9]. The rule table for the designed fuzzy controller is given in table 2. From the rule table, the rules are manipulated as follows. If error is NB, and change in error is NB then output is NB

TABLE 1

**FUZZY RULES**

<table>
<thead>
<tr>
<th>CE/E</th>
<th>NB</th>
<th>N</th>
<th>M</th>
<th>N</th>
<th>S</th>
<th>Z</th>
<th>PS</th>
<th>P</th>
<th>M</th>
<th>P</th>
</tr>
</thead>
<tbody>
<tr>
<td>NB</td>
<td>NB</td>
<td>N</td>
<td>M</td>
<td>N</td>
<td>S</td>
<td>Z</td>
<td>PS</td>
<td>P</td>
<td>M</td>
<td>P</td>
</tr>
<tr>
<td>NB</td>
<td>NB</td>
<td>N</td>
<td>B</td>
<td>N</td>
<td>B</td>
<td>M</td>
<td>S</td>
<td>N</td>
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<td>N</td>
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<tr>
<td>N</td>
<td>N</td>
<td>B</td>
<td>N</td>
<td>B</td>
<td>NB</td>
<td>NM</td>
<td>N</td>
<td>S</td>
<td>Z</td>
<td>PS</td>
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<tr>
<td>N</td>
<td>N</td>
<td>B</td>
<td>N</td>
<td>B</td>
<td>NM</td>
<td>NS</td>
<td>Z</td>
<td>P</td>
<td>S</td>
<td>PM</td>
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<td>N</td>
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<td>B</td>
<td>N</td>
<td>B</td>
<td>NS</td>
<td>Z</td>
<td>PS</td>
<td>P</td>
<td>M</td>
<td>PB</td>
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<tr>
<td>Z</td>
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<td>PS</td>
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<td>PM</td>
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<td>P</td>
<td>PB</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
The Web Publishing Tool is used to create an HTML document and embed static or animated images of the front panel or to embed a front panel in an HTML document so a client computer can view and control the front panel remotely. By using the Snapshot option in the Web Publishing Tool to return a static image of the front panel of a VI currently in memory on the server computer. The Monitor option in the Web Publishing Tool to return an animated image of the front panel of a VI currently in memory on the server computer. Embedded option in the Web Publishing Tool to embed a front panel in an HTML document so a client computer can view and control the front panel remotely. The front panel of the VI to be published might be large. It takes the Web Server longer to create a large image, which can slow the execution of the VI. Also, a large image takes a significant amount of time to transmit to the browser, especially over a slow modem connection. Therefore the front panels of VIs used to publish are reduced to a reasonable size.

V. SYSTEM IMPLEMENTATION

The entire control was implemented practically using atmega16 microcontroller and DC Motor Controller Trainer. Fuzzy Controller with the H-bridge converter was tested on the DC Motor. The AT89CS1 microcontroller is made up of Atmega16's high density non-volatile memory technology and incompatible with the industry standard MCS-S1 instruction set and pin out. Atmega16 is a high performance CMOS 8bit microcontroller with 4k bytes of flash memory (PEROM). It requires less power. It is combination of a versatile 8-bit CPU with flash on a Monolithic chip. It is a powerful microcontroller; it provides a more flexible and cost effective solution to many embedded control applications.

VI. RESULTS AND CONCLUSION

Using LabVIEW, the designed fuzzy controller was tested. The simulation results were compared and verified by Real time implementation. The simulated graph of speed of the motor for a set speed 23S rpm is given in figure S. The speed regulation using fuzzy controller was implemented and verified in this.
Fig. 5. Response of motor set speed 235rpm

Fig. 6. Graph for PWM waveform generated by the micro-controller for duty cycle of 0.4

Fig. 7. Graph for PWM waveform generated by the micro-controller for duty cycle of 0.8
Fuzzy controller was implemented in Atmega16 microcontroller by using LabVIEW Embedded Toolkit. The figures 6 and 7 show the PWM waveform generated by the microcontroller unit for two different duty cycles. The dynamic response of the dc motor speed variation with fuzzy controller was tested and found to be giving satisfactory results.

The LabVIEW Embedded toolkit has the advantage of reduced cost, increased performance and reduced time to implement the design. The conventional control needs design objectives such as steady state and transient characteristics of the closed loop system to be specified. But fuzzy control overcomes the problems with uncertainties in the plant parameters and structures encountered in the classical model based design.

VII. SIMULATION

The simulation of control for Ploughing and seeding, steering angle and driving speed control of an autonomous agricultural Robot is done based on equation modeling technique in LabVIEW. The ploughing and seeding VI consists of stepper motor simulation. When ploughing task is selected phase 2 and phase 4 will energize then stepper motor will rotate 90 degrees. Seeding task is selected phase 2 and phase 4 will energize and also solenoid valve will open.

Agriculture robot VI consists of dc motor, fuzzy control and H Bridge. Two DC motor is used for direction control. If robot is moving in forward direction motor will rotate in maximum speed, for moving right side one DC motor will rotate in maximum speed and other will become zero. The simulation was figures 8, 9 and 10. The parameters of the dc motor used are given in table 2. The complete simulation is run for a step change in motor reference speed and the actual change in speed is recorded.

The DC Motor parameters are given in Table 2

<table>
<thead>
<tr>
<th>DC Motor Parameters</th>
<th>Values</th>
</tr>
</thead>
<tbody>
<tr>
<td>DC Supply Voltage</td>
<td>110V</td>
</tr>
<tr>
<td>Armature Resistance Ra</td>
<td>1 ohm</td>
</tr>
<tr>
<td>Armature Inductance La</td>
<td>46 Mh</td>
</tr>
<tr>
<td>Inertia Constant J</td>
<td>0.093 Kgm²</td>
</tr>
</tbody>
</table>
Damping Constant $B = 0.008$ Nm/ rad/sec

Torque Constant $K_t = 0.55$ Nm/A

Back-Emf Constant $0.55$ V/(rad/sec)

Speed $1500$ rpm

Fig. 8. Interfacing of Agri Robo with LABVIEW

Fig. 10. Block Diagram of the Agricultural Robot
Fig 9. Schematic Representation of Agri Robot

Fig. 11. Front Panel of the Agricultural Robot
REFERENCES


