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Automatic Agricultural Robot and Monitoring System using a Programmable Logic Controller and SCADA

Saumitra A. Mhatre[1], Shravan S. Sherigar[2], Varun N. Joshi[3], Dr. Hrushikesh B. Kulkarni[4*]

B. Tech student, School of Mechatronics Engineering, Symbiosis Skills and Professional University, Pune (MS), India[1]

B. Tech student, School of Mechatronics Engineering, Symbiosis Skills and Professional University, Pune (MS), India[2]

B. Tech student, School of Mechatronics Engineering, Symbiosis Skills and Professional University, Pune (MS), India[3]

[*]Assistant Professor, School of Mechatronics Engineering, Symbiosis Skills and Professional University, Pune (MS), India[4]

ABSTRACT:Agriculture plays a crucial role in strengthening the Indian economy, it contributes around 17% to the nation's GDP. But unfortunately, agricultural sector in India is underdeveloped due to minimal assistance from the technological sector. Moreover, automation in any industry results in development in the industry. Due to high dependency on manual labour and orthodox methods, the productivity and efficiency of Indian farming is reduced, this leads to lesser monetary returns on produce The Automatic Agricultural Robot and Monitoring System is designed to provide a technological solution to the agricultural sector to reduce its dependence on the use of manual labour for carrying out various agricultural processes, like loosening of soil, seeding, irrigation, fertilization and pesticide spraying with the help of a PLC and a SCADA system. A Programmable logic controller (PLC) is a digital computer that is ruggedized for industrial use. These types of controllers are known for their durability and longevity. The SCADA system is used with the PLC to supervise and control the processes. The proposed system aims at completing several operations by using dedicated tools and a pre-programmed path.

KEYWORDS: Programmable Logic Controller (PLC), Supervisory Control and Data Acquisition System, Irrigation, Seeding, Pesticide, Fertilizer.

I.INTRODUCTION

Rising concerns about the ever-increasing global population has also given birth to match the food produce, the need of such rapidly increasing population. Moreover, the declining state of the agricultural sector has severed these concerns. According to several surveys and experts the sector needs some assistance from the technological field to make progress and more importantly be ready for increasing demand.There has been research and some scientific progress for 'automation in agriculture' but due to its conventional methods and specific tools and requirements, it has not been of very significant use for the farmers.Every year the crops are introduced to new threats as a result of potential mutations and transformation in the biological components of these pests, and eventually to manage these problems people end up applying the same corrective measures to all of them without even knowing would make a serious mistake. Also, many farmers use chemicals hoping to make better yield and have more production but these chemicals can have an adverse effect on crops as well as soil which makes an uncomfortable situation for crops to grow in, therefore it is important to measure various factors such as moisture, temperature, humidity, pH level and electronic conductivity.

This project aims at providing the said assistance by replicating the conventional methods in a more efficient manner using the automation tools to make all the required processes more convenient and more importantly, more productive. By reducing the human intervention, the processes would not only be carried out more accurately but also reduce the huge labour costs involved in the agricultural sector, in turn providing better monetary benefits to the farmer. The aim of this paper is to design and implement a system to carry out basic farming processes with use of a Programmable Logical Controller. The system would use different tools to undertake different agricultural tasks. The tools would be designed in such a way that they would provide an ease in fitting them to the system. Since a PLC would be used, the system would be highly repeatable and reliable. This would ensure minimum maintenance costs. The system also tries

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to model an affordable monitoring system which can give farmers appropriate readings and information needed for farming. The system would also create an alarm when the values extend the limit and would create an unfavourable condition for crops to grow

Some of the major objectives of the research paper are as follows:

- Ease the difficulties in the agricultural sector by the aid of automation.
- Reduce manual labour needed for agricultural processes
- Deriving a solution compatible with Indian agricultural practices
- Automating the agricultural processes of irrigation, fertilization and loosening of soil using a programmable logical control
- Interpreting information from sensors using a PLC and SCADA

II.PROPOSED DESIGN

After a through survey of literature it was found that, the existing systems for agricultural automation needed a unified solution to include various processes that could function at once. A system was designed that could carry out integral agricultural processes without the hassles of their conventional counterparts.

To ensure a robust and highly repeatable platform, it was decided to base the system on an industrial grade Programmable Logical Controller. A PLC is an advanced controller type that functions on a ladder logic. It is easy to program, the programming platforms are very effective as a long list of functions can be programmed into the controller without physically having to wire the required hardware. For example, timers, counters, comparators, clocks, etcetera. Besides, the fault finding and diagnostic is much easier in comparison to other controllers.

For linear motion, V-SLOT extrusion and belt system were decided for their easy assembling properties. This assembly provides a greater chance to upgrade separate elements with minimal change in the entire assembly. Dimensions- 1400CM- X-AXIS, 90CM – Y AXIS, Elevation from the ground– 50CM.

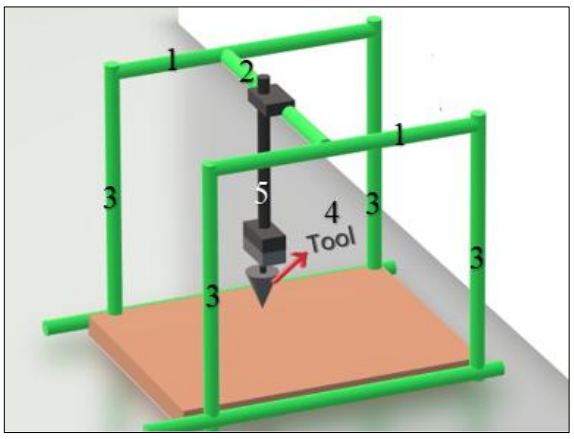

Fig. 1 CAD model of Proposed System

From the figure 2.1, part-1 would be the V-SLOT assembly for linear motion in X- direction. The assembly would run on two separate stepper motors for both sides. Part-2 would be a V-SLOT assembly responsible for motion in Y direction. As motion in Z direction would not be necessary during the process, or the height Z would be constant for a particular process, the member responsible for height could be adjusted to manage the height of the tool from the ground. Part-3 would be beams to support the linear motion assembly. Part-4 is the main tool, this tool would be designed separately for each process that needs to be carried out on the farm. This tool with its complete assembly would be fitted on the Part-5. The system would cover the entire field using the X and Y motion systems. In this way the required process would be carried out on the field without having to manually monitor it unlike the convention method where the farmer has to monitor the process to eliminate errors and guarantee proper implementation.

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III. MAJOR HARDWARE COMPONENTS

Liner motion assembly - V-SLOT extrusion assembly

After analysing various linear motion actuators, it was found that, using V-SLOT linear motion assembly would be suitable for the project. The travel distance, the accuracy required for this model would be easily fulfilled by the V-SLOT. This assembly is flexible and easy to assemble. The gantry plate could be mounted with the necessary assembly to achieve required linear motion.

3 Stepper motors – NEMA 17 – 5.5KG-CM

We chose to use stepper motors due to their higher toque capacity, economically viable costs, longer life and longer life. After analysing the weight and torque requirements of the assembly we concluded to use NEMA 17 motors with holding torque of 5.5kg-cm

1. Step Angle: 1.8°.
2. Current: 1.5 A /Phase.
3. Holding Torque: 5.5 kg-cm.
4. Detent Torque: 2.6 kg-cm
5. Weight – 360 gm.

3 stepper drivers – TB 6600

Specifications

- Input Current: 0~5A
- Input voltage - 9-42v
- Output Current: 0.5-4.0A
- Control Signal: 3.3~24V
- Power (MAX): 160W
- Micro-Step: 1, 2/B, 2/A, 4, 8, 16, 32
- Temperature: -10～45℃
- Humidity: No Condensation
- Dimension: 96*56*33 mm/ 3.78*2.2*1.3 inches
- Weight: 0.2 kg
- Drive IC: TB67S109AFTG

Watering/Irrigation – Sprinklers and pump

It was studied that sprinkler irrigation system would prove to be very efficient. It also was compatible with the designed system as it did not have any pipelines running though the field which would be an obstruction for other processes. To pump the water, a miniature water pump would be used. This would help in transporting the water from the source to the field and also increase the pressure of the water so that the sprinklers can function efficiently.

SPECS- Flow Rate: 4.5 Litres Per Min

VOLTAGE – 12V DC

TYPE - DIAGPHRAGM

Loosening of soil - Mini-Rotavator

In actual farming activities a Rotovator tool is used to loosen the soil and remove the unnecessary weeds from the farm. The rotavator is mounted on three-point linkage system of tractor and the power to the tilling unit is provided through tractor PTO (power take-off). The blades of the rotavator, rotate and land an impact on the soil, bringing the underlying soil layer above, and breaks the clods. Similarly, a miniature version of this tool would be fabricated to replicate the function of a rotovator. This tool would be attached to the Part -5 (refer fig. 5.1)

Adjustable nozzles for fertilization and pesticides

The spraying of pesticides requires a mist spray so as to ensure that the pesticide liquid has appropriately sprayed on every part of the plant. The nozzle takes the pesticide from the pump and mists it over a certain area. when clubbed with a few more nozzles it can mist a considerable area with pesticide. For fertilization, the nozzle needs to be adjusted and loosened as per requirement. When loosened it can reduce the water pressure and give a stream of water as opposed to a mist of water. The liquid fertilizer has to be mixed with the water and then pumped to the nozzle through a water pump.

Sowing / seeding – automatic seeding tool

For seeding we would need to fabricate a dedicated tool that can be mounted on the platform of the assembly. After research and brainstorming the tool was designed and fabricated. It consists of a wheel with compartments to load the seeds. This wheel was mounted on the motor, so it would rotate in the seed accumulator, the compartments would be filled with seeds, when the wheel rotates it would deposit these seeds in the funnel situated on the other side of the accumulator, and indeed dropping seeds onto the field.

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Controller – Siemens 1214c DC/DC/DC series PLC
Among the wide variety of PLCs available in the market, siemens s7-1214c DC/DC/DC controller was chosen. The controller's ability to seamlessly work on small to medium automation projects was suitable for the required tasks. The integrated I/O system of the controller provides an easy platform for engineers to work on. Some of the technical specifications of the controller include:
rated value- 24vdc
number of High-speed outputs- 4- 100khz
total number of outputs -10
total number of inputs – 16; of which Analog -2
communication-ethernet
protocol -TCP/IP

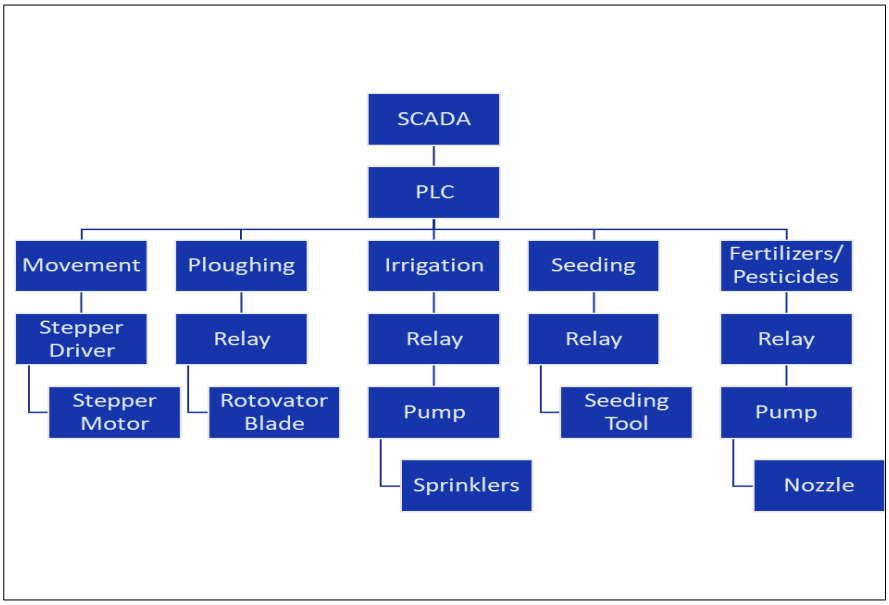
Sensors for Monitoring
To monitor the physical values of the soil, we need to electrically measure the value and feed the value into the PLC. This is done by the help of various sensors for measuring different types of physical quantities such as soil moisture, humidity, temperature. More sensors can be added into the system as needed for more detailed monitoring of the field. Some of the sensors that can be used for the monitoring system.

- Humidity sensor - HIH-4030 Breakout
- Soil Moisture sensor – SKU: DSM058
- Temperature sensor – soil temperature sensor SHT10
- PH level of soil - Veinasa-Ph
- EC of soil - SPR500-03

a) SCADA
SCADA screens are developed and programmed on Siemens WINCC RT ADVANCED. WINCC is an excellent tool developed by SIEMENS, which can be used to monitor the processes being carried out when connected to the hardware.

IV. SYSTEM FLOWCHART

Fig. 2 System Flowchart



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V.CONCLUSION

The system was able to perform the agricultural processes traditionally performed using conventional methods using manual labour. The system was able to monitor the values of physical quantities by interpreting values through the sensors. The use of the dedicated tools successfully carried out operations of loosening of soil, fertilization, pesticide, seeding, irrigation. The system was able to cover the entire work space with the help of the instituted linear motion system.

The time taken by the system to complete the agricultural processes is substantially less than the time taken to complete the same processes by conventional means. Moreover, the proposed system is more environmentally sustainable as it eliminates the harmful substances emitted by the tractors and conventional agricultural machinery. The system reduces the emphasis on manual labour and manual intervention by automation of the agricultural operations which in turn increases the efficiency of these processes.

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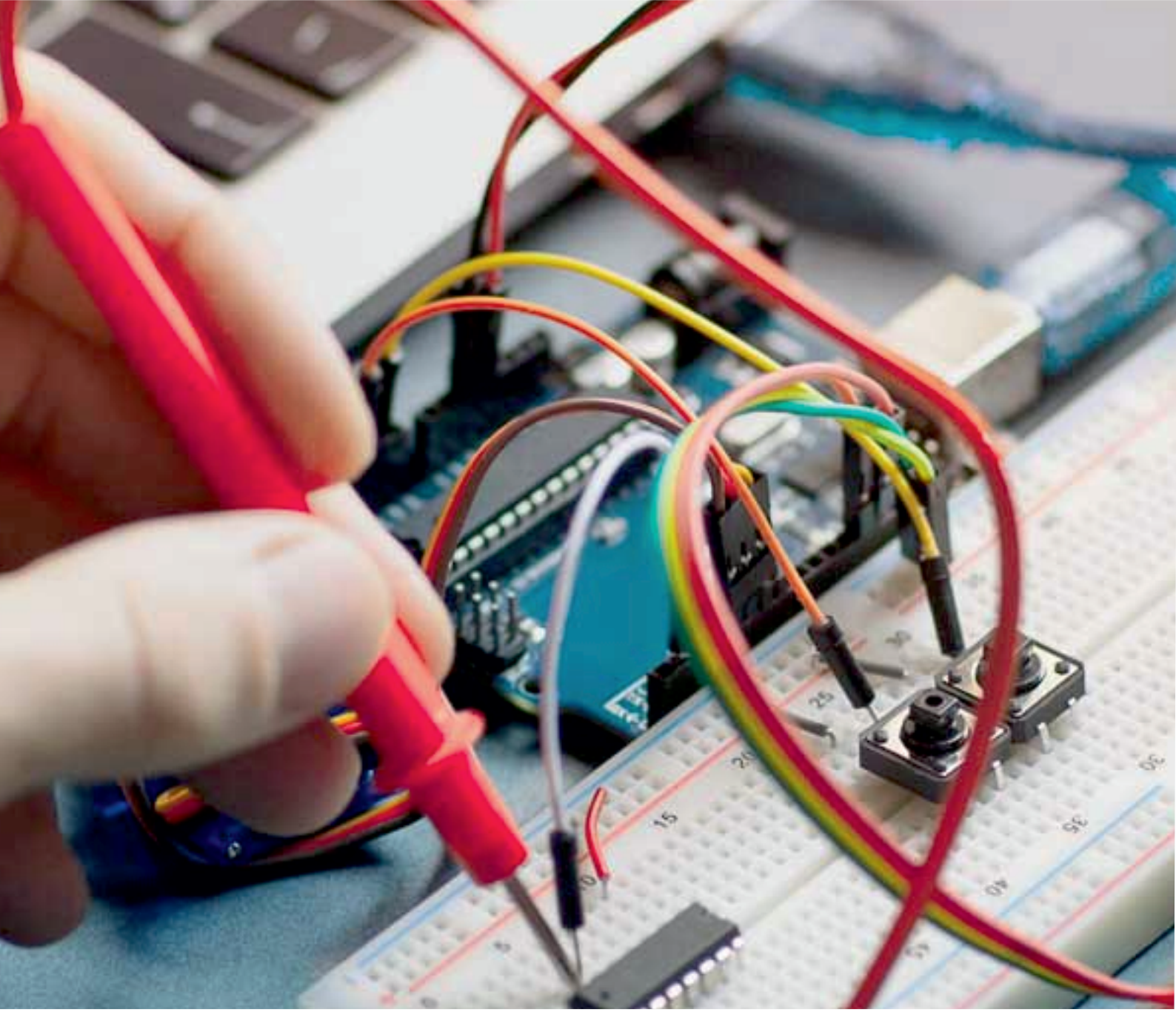

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