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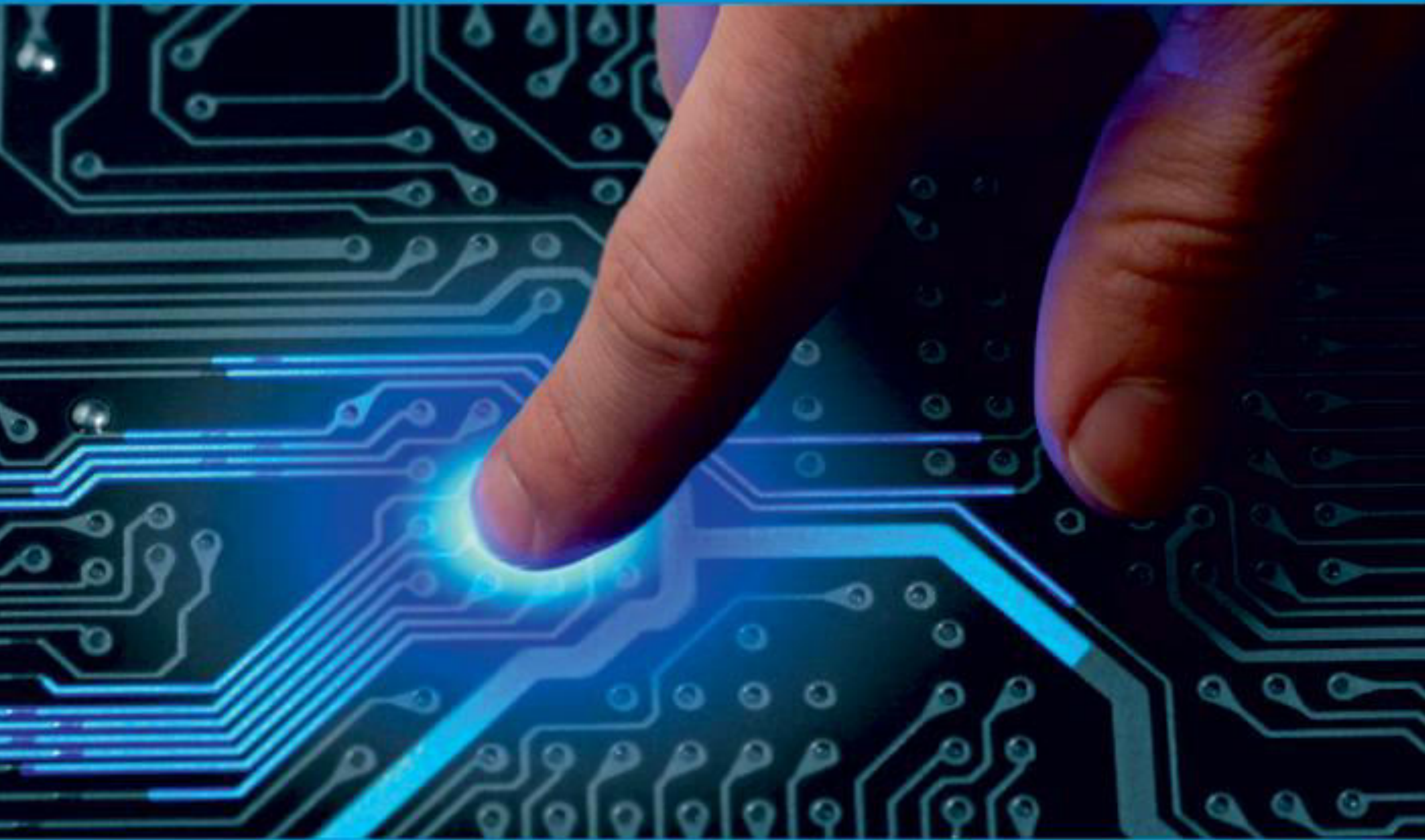

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Labview Controlled Swarm AGROBOT

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ABSTRACT: In the field of agricultural autonomous vehicle, a concept has been developed to investigate if multiple small autonomous machines could be more efficient than traditional large tractors and human forces. Robotics is expected to play a major role in the agricultural domain, and often multi-robot systems and collaborative approaches are mentioned as potential solutions to improve efficiency and system robustness. Among the multi-robot approaches, swarm robotics stresses aspects like flexibility, scalability and robustness in solving complex tasks, and is considered very relevant for precision farming and large-scale agricultural applications. Our project aims on the design, development and the fabrication of an AGROBOT which can dig the soil, dispense seeds, level the mud and sprinkle water and pesticide. The whole systems of robot work with the battery. There is a Robot Unit and a Control Unit. Communication is facilitated with the help of LoRa module. The main advantage of this swarm concept is we can control the robot from a certain distance and use it to water the plants by measuring their humidity levels.

I. INTRODUCTION

In the recent trend of smart agriculture making use of robots plays a very important role. Scarcity of skilled laborers and environmental changes have made man to replace with machines. Systems composed of multiple robots are becoming increasingly popular, in the last few years. The advances that have made individual robotics systems more practical have enabled the research on and the development of cooperative robots, where the collective actions of the swarm define the capabilities rather than the individual actions. Moreover, one of the main advantages of having a cooperative system instead of a super-capable individual is in the increased reliability due to redundancy. Swarm robotics also adds benefits with respect to redundancy, scalability, and energy consumption. Here we try to incorporate swarm robotics in to agriculture to produce a Swarm Agrobot. Swarm robotics is the study of how to coordinate large groups of relatively simple robots through the use of local rules. It takes its inspiration from societies of insects that can perform tasks that are beyond the capabilities of the individuals. This describes this kind of robot's coordination as follows: The group of robots is not just a group. It has some special characteristics, which are found in swarms of insects, that is, decentralized control, lack of synchronization, simple and (quasi) identical members. In this project, we will learn to build autonomous swarm robots enabled with wireless communication. The control unit (PC) interfaced with GUI controls the robot while performing its own task and functions based on the signal received. The robots autonomously waters the plants by checking the humidity level of the soil using a soil moisture sensor. Moreover, it can perform functions like ploughing, seed dispensing, pesticide spraying, and soil leveling. This system of robots makes the task of farmers easier by reducing the need of manual labors, helps in achieving precision farming, increase crop production by making use of emerging technologies

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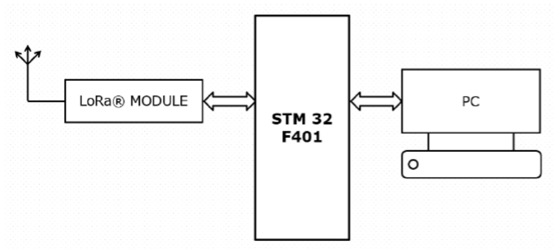
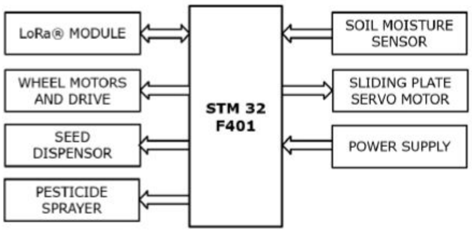
BLOCK DIAGRAM





HARDWARE REQUIRED

- STM32F401
- SX 1278 LoRa transceiver
- DC Motor-60RPM
- Submersible Mini Water Pump
- DC-DC Buck Converter
- L298N 2A Based Motor Driver Module
- MG995 Metal Gear Servo Motor
- Soil moisture Sensor
- Lead Acid 12V 4.5Ah Battery

SOFTWARE REQUIRED

- STM32CubeIDE
- LabVIEW

II. LITERATURE SURVEY

Agricultural problems are characterized by unstructured environments, large spatial distributions and heterogeneities. Indeed, concerning real-world problems, agriculture represents a very challenging and increasingly important domain to be tackled by robotics solutions. Normally available methods for irrigation are sprinkler and drip irrigation. The sprinkler system sprinkles the water into air and breaks water into droplets like a rain. The drip irrigation system directly gives the water to the root by pipelines connected under the plants, this method is effective than sprinkler. These systems are effective but less efficient, it will not stop after the plant got required amount of water and often there is loss of water. Larger machines do not apply solutions to specific area where they are really needed and also adds soil compaction. Most often, one operation is performed by one machine. Indeed they do not offer precision in agriculture. So as to maximise the effectivenes, exploiting biological models of information retrieval and integration is used.

Swarm Robotics

Swarm robotics (SR) is inspired by nature behavior like most species that can synchronize when working together without any higher entity controlling the swarm. It is clear that animals and insects are very efficient at fulfilling their day-by-day specifics task which inspires the curiosity of many researchers. The main idea of the approach behind this

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domain research is to build relatively many small and low- cost robots that are supposed to accomplish the same task as a single complex robot or a small group of complex robots. Swarm robotics is known for its high scalability due to the decentralized control system, allowing the swarm to maintain high amounts on robots to work simultaneously. The decentralized control system feature a low band with transmission from any source swarm, due to the absence of a central computer updating information in every robot.

The main benefits when using SR reside on:

(1) The robustness feature: explained by the coherency of the whole system when losing some robots; this can gain us money investment in hundreds of small swarm robots, rather than investing the same amount of money or greater in a single complex robot that can leads to the failure of the all over project if a single failure is persisted.

(2) The flexibility feature: enlightened by rather needing a hardware reconfiguration of complex robots to accomplish a task, the same task is achieved by coordinated swarm robots that are not essentially personalized to a given task.

(3) The scalability feature: described by the fact that relying only on local information; a swarm robotic algorithm can be applied unchanged to a group of any (reasonable) size.

This project aims to fabricate a prototype multipurpose agriculture robot which can improve the efficiency and perform the following operations:

• To reduce human effort in the agricultural field with the use of small robot.

• To perform all 4 operations (dig the soil, put the seeds, and close the mud and to spray water/pesticide) at single time, hence increases production and save times.

• To complete large amount of work in less time.

• Farmer can operate this robot through GUI by sitting at one side.

• Miniaturization would allow to apply solutions only when and where they are really needed, avoiding soil compaction typical of large machines.

• Proximal sensing and actuation bring the concept of precision agriculture to the highest realization.

• Redundancy and cooperation within a distributed robotic system can provide resilience and robustness to faults, and can result in super-linear performance.

From Industry 4.0 to Agriculture 4.0

Current Status, Enabling Technologies, and Research Challenges In [1], a review of the current status of industrial agriculture along with lessons learned from industrialized agricultural production patterns, industrialized agricultural production processes, and the industrialized agri-food supply chain is done. Furthermore, five emerging technologies, namely, the Internet of Things, robotics, Artificial Intelligence, big data analytics, and blockchain, toward Agriculture 4.0 are discussed. Also focuses on the key applications of these emerging technologies in the agricultural sector and corresponding research challenges. It is evident that the three previous industrial revolutions gradually modified the form of agricultural activities. 2.2.2 What is A Robot Swarm: A Definition for Swarming Robotics R.Arnold in proposed a definition for a robot swarm, descriptions of a variety of swarm applications, and discussions of challenges that exist in robot swarm development and deployment. The proposed definition includes three clearly defined criteria, a description of relationships between these criteria, a simple one-sentence description that facilities clear communication, and examples of different concepts that are often confused with robot swarms.

What is A Robot Swarm: A Definition for Swarming Robotics

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A Survey on Swarm Micro robotics

In [3], the state of the art for this emerging field, including actuation systems with different power sources, swarm behaviors modeling and simulation, swarm control strategies, and targeted biomedical applications is summarized. Actuation principles of microrobot swarms are categorized in detail, and critical comparisons are made to provide guidance and insight for future swarm micro robotics researchers. Considering the unique features of swarm micro robotics compared to traditional swarm robotics, this article also emphasizes the modeling, simulation, and control of microrobot swarms. Furthermore, recent biomedical applications of microrobot swarms are summarized to illustrate specific application scenarios. Finally, an assessment of the future directions of swarm micro robotics.

LoRa Technology - An Overview

Popular wireless technology LoRa is compared with other wireless technologies in [4]. Its advantages over the existing wireless technologies are discussed along with its features and network architecture. LoRa is a new found technology that is emerging rapidly. The LoRa technology addresses these needs of a battery-operated embedded device. The LoRa technology is a long-range low power technology.

HARDWARE DESCRIPTION

STM32F401

The STM32F401 is the entry-level microcontroller in STMicroelectronics high-performance STM32F4 series featuring the ARM Cortex-M4 32-bit/DSP core. While running at lower frequency than other STM32F4 devices, it balances performance, power consumption, and integration and claims the lead in its class by offering 105DMIPS at 84MHz, 187µA/MHz active current, 11µA typical STOP current, and a rich set of integrated features. Lower power consumption, tiny 3x3mm dimensions and 105°C ambient-temperature capability makes the STM32F401 well-suited for managing sensors for medical and mobile applications or for fieldbus-powered industrial sensor modules. The STM32F401 allows zero wait-state operation from its 256 Kbyte on-chip Flash, using ST's unique Adaptive Real-Time (ART) accelerator. The device integrates a 12-bit 16-channel 2.4Msample/s ADC, 12 communication ports including USB OTG, I2S, I2C and SPI, a motor-control timer, and multiple general-purpose timers.

SX 1278 LoRa transceiver

Ra-02 is a wireless transmission module based on SEMTECH's SX1278 wireless transceiver. It adopts advanced LoRa spread spectrum technology, with a communication distance of 10,000 meters. It has a strong ability of antijamming and has the function of air wake-up Consumption. The SX1278 RF module is mainly used for long-range spread spectrum communication, and it can resist minimizing current consumption. The SX1278 has a high sensitivity of -148 dBm with a power output of +20 dBm, and a long transmission distance and high reliability.

DC Motor-60RPM

These motors shown in Fig.3.3 are simple DC Motors featuring Metal gears for the shaft for obtaining the optimal performance characteristics. They are known as Center Shaft DC Geared Motors because their shaft extends through the center of their gear box assembly.

Submersible Mini Water Pump

This is a low cost, small size Submersible Pump Motor which can be operated from a 3- 6V power supply. Pump Motor which can be operated from a 3-6V power supply

DC-DC Buck Converter

LM2596 DC-DC Buck Converter Adjustable Step-Down Power Supply Module LM2596 is a step-down voltage regulator, also known as buck convertor, mainly used to step down the voltage or to drive load under 3A.

It carries the remarkable load and line regulation and is available in fixed output

voltages including 3.3V, 5V, 12V.

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L298N 2A Based Motor Driver Module

This motor driver shown in Fig.3.6 for DC Motors and Stepper Motor is widely popular because it uses the famous L298N Dual H Bridge Driver Chip. This motor driver is optimized for maximum performance at a cost everyone can afford. The L298N Dual H Bridge DC/Stepper Motor Driver Controller Module is for driving two robot motors.

MG995 Metal Gear Servo Motor

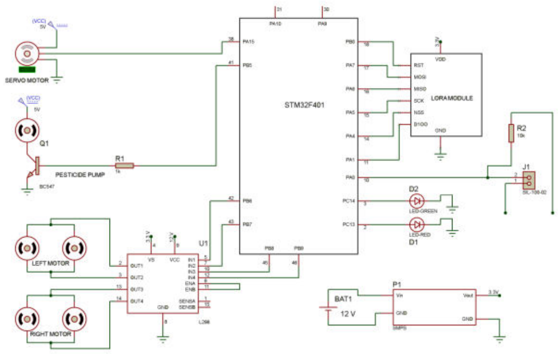
MG995 Metal Gear Servo Motor shown in Fig.3.7 is a high-speed standard servo can rotate approximately 180 degrees .It is a Digital Servo Motor which receives and processes PWM signal faster and better. It equips sophisticated internal circuitry that provides good torque, holding power, and faster updates in response to external forces.

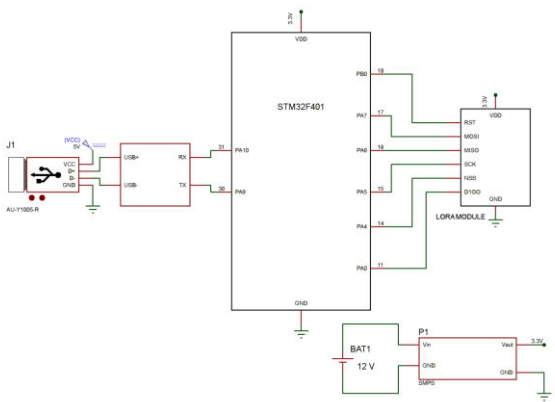
Soil moisture Sensor

The Sensor uses a dielectric permittivity measuring device. Dielectric permittivity in the soil is water dependent. The sensor tests the water level across the whole duration of the instrument. It is made of two probes used for volumetric water quality measurements. The two probes cause the current to flow. through the ground and then the resistance value is determined. The module also includes a potentiometer which sets the threshold value and compares the threshold value. If there is more water the resistance will be less, if there is less water the resistivity will be higher.

Lead Acid 12V 4.5Ah Battery
A 12V 4.5Ah Rechargeable Sealed Lead Acid Battery is used.

CIRCUIT DIAGRAM





III. WORKING

Our proposed system is implemented by two Robot units and a Control unit.Both Robot and Control unit have STM32F401 microcontroller. The control unitconsists of a PC installed with a GUI - LabVIEW through which user can control the robot units. The commands are processed by the microcontroller of the control unit side and are given to the LoRa module for transmission. The LoRa module of the robot unit receives the signals and forward these

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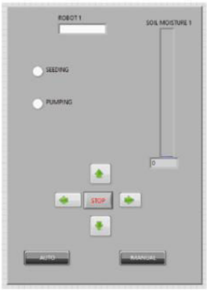
to microcontroller. As per the commands given by the operator, the microcontroller send these commands to different peripherals attached to it. (eg:To move the robot, to dispense seeds, to sense the moisture and pump water, etc). The robot unit is also able to sense the moisture content of the soil and pump water only when the moisture level goes below a certain value. The GPS module determines the location of robot units which can be displayed in the GUI.

IV. RESULTS

The swarm robot system is built to be useful in real-life applications and hence is required to give consistent and good quality results. We conducted certain experimental tests on the prototype. The results are summarized as follows.

Sending instructions to Control Unit:

Here the instructions are given to the Control Unit from PC (LabVIEW). The Control Unit sends different wireless messages meant for the 2 robots placed at a distance in the field.



Instructions received by Robot Unit:

Here the instructions given to the Robots are sent by LoRa transmitter in Control Unit and is recieved by LoRa reciever in Robots. The robots reacted after getting their "activation messages" and proceeded

'ROBOT'S MOTION' : Robot's motion by R1-Robot 1 and R2-Robot 2 is controlled by control unit towards forward,backward, right, left manually.

'CHECK MOISTURE-AUTO WATER' : It goes near a plant and soil sensor is put into soil and soil moisture is measured and it gives water. If the moisture content is enough, then watering is stopped.

'PLOUGHING AND LEVELLING' : Ploughing and levelling are accomplished

along with the motion of robots.

'SEED DISPENSER ' : Seed is dropped to soil.

'PESTICIDE SPRAYER' : Pesticide is sprayed.

'CHECK MOISTURE-MANUAL' : It goes near a plant, soil sensor is put into

soil and soil moisture is measured. It gives water only when 'WATERING' command is given.

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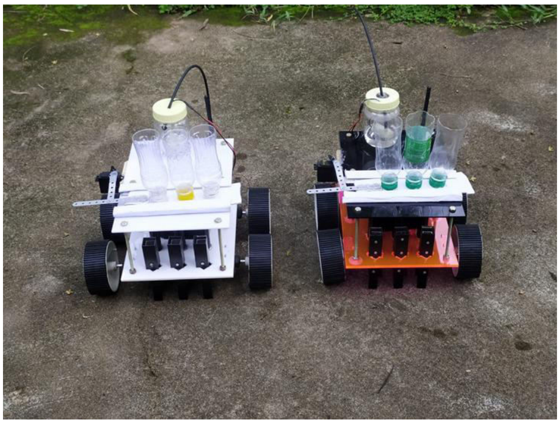

Operations performed

Robot's Motion

Robots reacted after getting their "activation messages" and proceeded according

to it. Robot's motion by R1-Robot 1 and R2-Robot 2 is controlled by control unit towards forward, backward, right, left manually. The operations like ploughing, levelling are accomplished along with the motion of robots.

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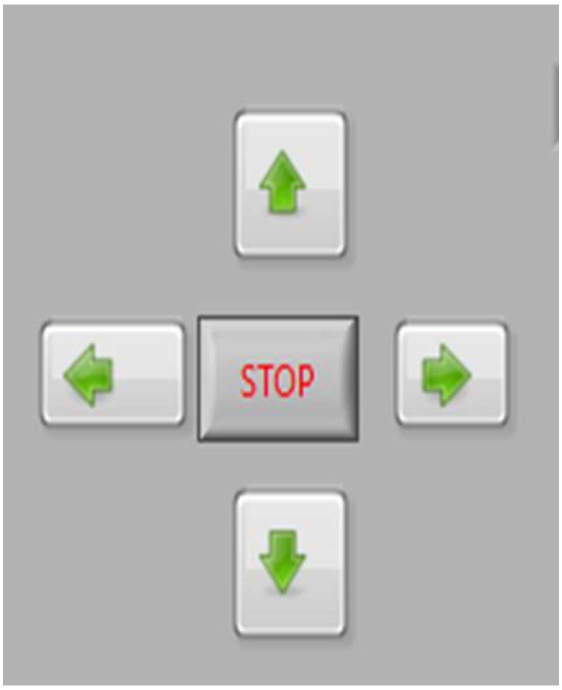
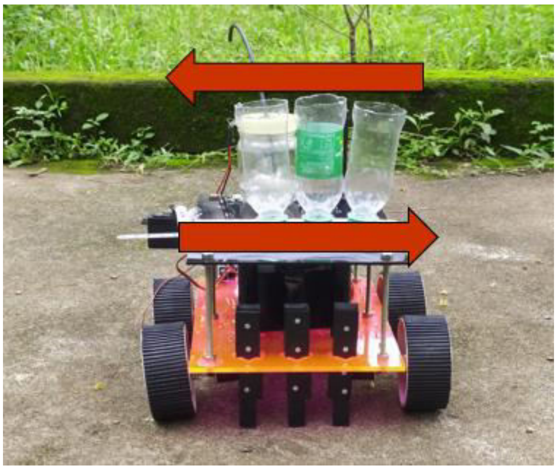


Seed dispensing

Seed dispensing shown in Figure carried out by servomotor and sliding plate arrangement. Seed is dropped to the soil by this to and fro mechanism.



Soil moisture sensing andWater pump spraying

Soil moisture is sensed by soil moisture sensors immersed in the soil. Pumping of water takes place in accordance with the moisture level as shown by Figure. When the moisture falls below a a threshold value then pumping of water is initiated. If moisture level is above the threshold value pumping is stopped.

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Pesticide spraying

This is accomplished in the same mechanism as that of water spraying.

V. CONCLUSION

With the SAGA experiment, our goal is not only to demonstrate the technical feasibility of a swarm robotics approach to precision farming, but also to evaluate its potential economic impact. Indeed, one of the tenets of the swarm robotics approach is the usage of a large number of small and relatively simple robots, as opposed to large and expensive machines. Verifying the economic value of the swarm robotics approach in a practical application scenario is important for future developments of the field. We intend to use the knowledge gained and the results of the experiments to evaluate the economic advantages and drawbacks of a swarm robotics approach to precision farming. There is definite scope to enhance our existing design. Future developments should hence take into account not only decentralized sensing, but also parallel and collaborative approaches to weed control. In this way, it will be possible to put forward the relevance of swarm robotics also for other application domains. The prototype can be modified to be used in several other applications like searching for the lost things, underground mining rescue operations and all-terrain exploration

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