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REVIEW PAPER ON AUTONOMOUS SOIL ANALYSIS ROVER

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ABSTRACT

This paper presents a review of recent research that has been carried out on the soil testing rover to test the soil for agriculture purposes. To ensure that food production remains at a level that is sufficient for human consumption, computer science plays a crucial role in agriculture. One effective and appropriate way to get over challenges in agriculture is via automation technologies. The conventional method of evaluating soil is fraught with challenges and disadvantages, including the need for a lot of time, a lack of expertise in sample collecting, and discrepancies between laboratory and field results. The Autonomous Soil Analysis Rover is a game-changing solution that streamlines the process of soil inspection and data collection, facilitating more sustainable and efficient agricultural practices and environmental conservation efforts. It embodies the fusion of robotics, sensor technology, and cloud connectivity, making it a powerful asset in our quest for responsible land management and resource optimization.

Keywords: Soil Testing, Food Production, Automation, Robotics, Land Management, Resource Optimization.

I. INTRODUCTION

Agriculture is vital for India's survival, and robotic systems are needed for improved efficiency, accessibility, and accuracy. Robotic systems are increasingly combined with new technologies to automate labour-intensive tasks. The aim is to provide an embedded-based structure for soil checking and water framework, reducing manual field work and providing information in a compact application. When it comes to land management, environmental research, and agriculture, the Autonomous Soil Analysis Rover will be a game-changer in this age of rapidly developing technology. Precision agriculture and environmental monitoring are about to enter a new era marked by this state-of-the-art rover that will revolutionise the way we analyse and comprehend soil. The soil inspection procedure is about to undergo a revolution thanks to this rover's design, which is based on autonomous mobility and cutting-edge sensor technology. The main issue in agricultural rover design is the ability of these robots to operate in unstructured agricultural environments. Moreover, such vehicles must rapidly adapt to the variability of the environment, and for this reason must be equipped with perception sensors.

II. LITERATURE REVIEW

The review was completed by identifying current research in the field of study, extracting the necessary material, and synthesising the data for the final step of review elaboration. the selected papers were published in the time frame of 2015 to 2023. Regarding the selection of the 120 papers about robots in agriculture, the following keywords were used: “Soil testing”, “Agricultural rover”, “Automation”, and “Robotics”.

Jie Wei, et al. [1] demonstrated the ruggedness of the MMRS (Mars Micro-beam Raman Spectrometer) in a 10-day 2013 LITA field campaign at the Atacama Desert. The automated soil sample analysis made by the MMRS unambiguously identified a variety of igneous minerals (quartz, feldspars, and TiO_2 polymorphs), carbonates, sulphates, and carbonaceous materials. The field-MMRS identifications were confirmed by laboratory Raman analysis, which showed that the MMRS has comparable performance as the laboratory instrument when its focusing condition was satisfied. Quantified distributions of major minerals and carbonaceous materials are extracted from the measurements, which can indicate regional geological evolution and potential bioactivities. Through this first-time integrated autonomous drilling sampling-sensing exercise in a natural environment, they learned the challenging issues associated with the drill, the sample presentation to in situ sensors and the sensor calibration. Technical modifications were made in preparation for the next field campaign.

Mohammed Z. Al-Faiz., and Ghufran E. Mahameda., [2] observed that Using data from the GPS and digital compass sensors, the mobile robot correctly determines the route between its starting point and its destination. It has been demonstrated that the mobile robot's five Sharp IR sensors allowed it to recognise and steer clear of challenging obstructions in its route. When a PID controller was used, the mobile robot moved in a straight line at a precise angle towards the goal rather than following a predetermined course and taking longer to get there. Without one, the robot deviates from the chosen path and travels around the target. The disturbances are reduced to 50% and the mobile robot's speed is reduced to 33.3% by regulating the speed of each side of its motors in accordance with the digital compass readings. Despite this, the robot moves smoothly and arrives at the destination in roughly the same amount of time without the need for PID.

Satish Kumar V, et al. [3] created a clever, self-governing gardening rover using a rocker-bogie suspension setup. Features include the ability to identify different types of plants, measure environmental variables like temperature, humidity, and moisture, and provide the right amount of water and fertiliser to promote plant growth. Utilising the information gathered by the rover, data analysis was carried out, and the outcome was integrated into the Android app and website to offer comprehensive statistics about the garden. In order to identify plants, they used neural networks in conjunction with ORB and FLANN matcher. Real-time and dataset photos were compared to identify the plants. Using JavaScript, Java, and Python, they created a website and app that provides users with information about the current weather, including chances of rain, sunrise and sunset times, actual temperature, wind direction, moon phase, pressure, and humidity. They also included data from rover sensors, such as temperature, humidity, and soil moisture, as well as controls and real-time information about the rover's location and activity.

Francesco Visentin, et al. [4] presented an idea for a mixed-autonomous robotic system for weed detection and removal from crops. The system consists of a fully autonomous robotic system, a gantry robot, and RGB-D cameras. The system uses artificial intelligence and computer vision to accurately detect and eradicate weeds. The robot can be enhanced through control system, autonomous navigation, and identification system enhancement. Other sensors like lidar, sonar, and GPS RTK can be added for autonomous cart movement. The recognition system has seen significant software advancements, with the first division focusing on green vegetables. To address color issues, a neural network could be developed to identify and localize various plants in a single image. This prototype demonstrates the viability of a robotic weeding system that can identify and eradicate individual weeds, removing them from the field. This invention lays the foundation for further research and development to improve the effectiveness, safety, and financial viability of agricultural operations. It highlights the importance of innovation in this field and has the potential to advance sustainable agriculture.

Kojiro Iizuka and Kohei Inaba [5] experimentally verified the relationship between the change in strain, which is the amount of deformation acting on the chassis, and the travelling state while the wheel is travelling. From the experimental results, we confirmed that the strain in the chassis was displaced dynamically and that the strain changed oscillatory while the wheel was travelling. In addition, based on the function of muscle spindles as mechanoreceptors, we discussed two methods of analysing strain change: nuclear chain fibre analysis and nuclear bag fibre analysis. These analyses mean that the raw data of the strain are updated to detect the characteristic strain elements of a chassis while the wheel is travelling through loose soil. Eventually, the slipping state could be estimated by updating the data of a lot of strained raw data, and it was confirmed that the travelling state could be detected.

Goran Kitić, et al. [6] introduces Agrobot Lala, an autonomous robotic system for in-field, real-time nitrate analysis and soil sampling. The suggested approach aids in fertiliser optimisation, which promotes more productive and sustainable output. The system consists of a robotic system for collecting and analysing soil samples in the field, a smartphone application for task monitoring and customization, and a cloud-based application for task management and plotting sample points based on proprietary artificial intelligence (AI) algorithms. A farmer can design tasks for soil collection and analysis using the system, which uses an AI algorithm and a cloud-based platform. The robotic system completes the work and provides the measurement findings instantly. A fertilisation prescription that exceeded 7.5% of KAN fertilizer savings and demonstrated a 1.76% yield enhancement in the initial test is produced as a result of the analysis. Five soil samples were collected and examined in the 1 ha experimental area in order to confirm that the system performed as advertised. A multi-ion probe for identifying other critical nutrients in the soil besides nitrates, along with other sensors for measuring pH and electrical conductivity, can greatly enhance the system that is now being shown.

III. CONCLUSION

By reviewing the mentioned research papers, we have understood that with the help of automation and robotics, we can make an innovative method that revolutionizes soil inspection and data gathering and helps with more effective and sustainable farming methods, as well as environmental preservation. By using a range of sensors like pH sensor, DHT11 sensor, soil moisture sensor, and NPK sensor we can get a comprehensive understanding of soil conditions, temperature, humidity, and nutrient content. With the help of the NEO-6M GPS module, precise location data can be gathered for accurate mapping and tracking of soil conditions across large areas. To navigate the system autonomously we can use IR sensors to traverse challenging terrains while avoiding obstacles. With the help of an ESP32 microcontroller, for data processing and communication, gathered data will be transmitted to the cloud for further analysis and decision-making. The ability to control the rover through a custom Android app using Kodular opens up a world of possibilities for remote operation and real-time data access, empowering farmers and environmental scientists to make informed decisions and optimize land use. From the results of above paper, the rocker-bogie rover gives an energy saving amount of 34% with respect to the linear Suspension rover under the same operating conditions. A future study should improve various areas for a more precise design definition. A completely defined multibody model for the articulated robotic arm should be present in the model.

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