Journal of Advanced Research in Embedded System
Volume 12, Issue 3&4 - 2025, Pg. No. 1-4
Peer Reviewed Journal

Research Article

A Conceptual Design of an IoT-Based System for Real-Time Land Coverage Monitoring in Agricultural Machinery

Maulin V Sondarva[1]

Student, Department of Mechanical Engineering, V V P Engineering College, Kalavad Road, Virda Vajadi, Rajkot, Gujrat, India
DOI: https://doi.org/10.24321/2395.3802.202505

I N F O

E-mail Id:
sondarvamaulin2004@gmail.com
Orcid Id:
https://orcid.org/0009-0007-6693-1501
How to cite this article:
Sondarva M V. A Conceptual Design of an IoT-Based System for Real-Time Land Coverage Monitoring in Agricultural Machinery. *J Adv Res Embed Sys* 2025; 12(3&4): 1-4.

Date of Submission: 2025-08-14
Date of Acceptance: 2025-08-27

A B S T R A C T

Agriculture is an important field for the world and for the people of the world because it is a straightforward matter that we need food to live, so it is only through this field that that food reaches us. So innovation is also necessary in the agriculture field. If we use current technologies like IoT (Internet of Things) and IIoT (Industrial Internet of Things) and concepts of related fields to farm better, then we can bring many improvements to the particular process of farming, and with the help of new technology, we can make that process easier. Currently, there are many farmers in the agriculture field, especially in India, who are deprived of this technology, and due to this, if any problem arises while farming, it takes more time to find a solution. In this project, an attempt has been made to solve one such problem, which is land Coverage Monitoring. There are many farmers in India who still use old machinery for farming, but this level of technology is not available in those machines. This project is trying to create a device that will help farmers to know how much of their land they are operating their machines on. Farmers can install this device in their old machines. Farmers do not have to spend money on modern vehicles for this technology, making it cost-effective for them. Many components have been used to make this device, such as the Global Positioning System (GPS), Microcontroller Communication Module, etc. Other hardware components are also used to make this device, such as an SD card module, TFT display, IMU, TVS diode, and buck converter. The combination of all these hardware components makes the whole device run smoothly. Basically, with the help of these components, the farmer can get information about how much area on the land the machine covers when this device is installed in the machine.

Keywords: Agriculture, Land Coverage Monitoring, Precision Agriculture, Operational Efficiency, Retrofitting, GPS, Farm Management

Introduction

Currently, agriculture has become much easier with the help of technology. In the past, when farming was done, people would carry out all agricultural processes based on estimations. So, when there was a sudden change in climate or some other problem arose, they would not know about it in advance, and farmers had to bear a lot of losses. Agricultural fields also face many problems, such as soil degradation, lack of machinery, lack of knowledge, etc. However, the scenario has changed now because as the world have started using technologies like Industry 4.0 and IoT in their respective fields, the problems that used to arise have now started to decrease, no matter what the field.[1]

Today's world is progressing very rapidly in terms of technology, and Industry 4.0 and IoT are among these advancements. Basically, IoT stands for "Internet of Things", meaning connecting a "thing" to the internet. Here, a "thing" can be any device, such as our home devices, AC, refrigerator, light bulb, etc. With the help of IoT, we can connect all these devices to the internet and control them wirelessly from anywhere in the world. Once these devices are connected with IoT, operating them becomes easy.

As Mentioned above, IoT (Internet of Things) is a network of physical objects. Here, "things" means the physical objects that can be home appliance devices like refrigerators, thermostats, light bulbs, cars, drones, fitness devices, etc. All these things can communicate with each other without any human interaction; this is done by the Internet of Things. The "things" have sensors, software, and technologies that connect them with other devices.

IIoT (Industrial Internet of Things) is a part of IoT. IIoT is significantly used in industries, agriculture, power plants, etc. Here, the "things" are machines and heavy equipment. In industry, high productivity, high efficiency and the best utilisation of machines and manpower are necessary, so IIoT can help in these areas. Also, IIoT helps in agriculture in many operations like resource management, fertilising, crop monitoring, weather change conditions, manual operations like tilling and cultivation, soil degradation, etc..[2] Nowadays, agricultural machines also come with technologies like precision agriculture, smart sprayers, and automated irrigation, etc. Here, precision agriculture means how much area is covered by the machine on the land, like tractors and power tillers; that can be seen on those machines on a particular screen or a separate device. So, it can be helpful to do accurate farming and also reduce the operation time.

The IIoT technologies that make agriculture accurate and precise come in the form of modern machinery and equipment used in agriculture. However, many farmers are still using their old machinery. So, this research paper is about trying to make a device that can be implemented in old machinery like tractors. The technologies that come in modern machinery and equipment include precision agriculture, as mentioned above, where we can see how much area of land is covered by the machine when it runs on the agricultural field.

So, farmers with their old machines can also perform precision agriculture. This device can be used during the learning of agricultural operations like tilling, soil preparation, harvesting, etc. This device shows the area covered by the machines so learners can track whether they are doing operations accurately or not.

Methodology

For making this device, the components required include GPS, a single board, an IMU, a TFT display, a TVS diode, an SD card, a PCB board, etc. These are all the hardware components used to construct this device.

- **GPS:** The U-Blox NEO M8[4,10] module provides latitude and longitude coordinates over time that are helpful in the calculation of the area covered and the distance travelled by the agricultural machine.[5-12] ESP32 Microcontroller: The ESP32[7,8] is used to handle the data from the GPS and IMU and also to perform calculations.[9,13]
- **IMU:** Here the MPU 9250[14,15] as an IMU (Inertial Measurement Unit) is used to measure acceleration, magnetic field, and angular velocity; it also improves the accuracy of the calculations, especially when this device is placed on old machinery.[16,17]
- **TFT Display:** The thin-film transistor display[18, 19] shows the area and distance covered by the machine to the operator of the machine.[20]
- **Micro SD Card Module:** A Micro SD card module is used for logging GPS data, calculated distance, and other sensor readings.[21-23]

Figure 1 represents the block diagram of the device hardware and its connections. It contains a power supply section in which the power is transmitted to the TFT display, SD card, and ESP32 module. The power comes from the machine battery in which this device is implemented. Here, a TVS diode and DC-DC buck converter are used to protect the hardware of the device from high voltage.

The ESP32 is the centre of all the hardware components. It connects to all the components for different aspects that are mentioned in the above section.

ISSN: 2395-3802
DOI: https://doi.org/10.24321/2395.3802.202505

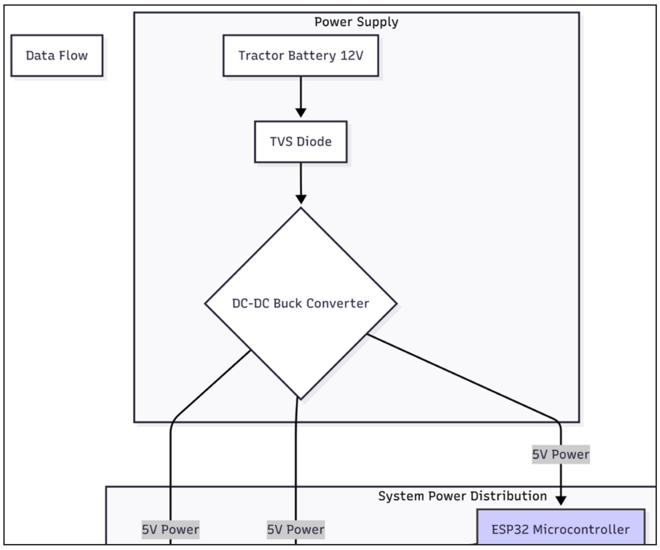

Figure 1.System Architecture and Data Flow Block Diagram

The above flowchart represents the interconnections between all the hardware components of the device.

The circuit diagram and the connection between all the hardware components are shown in figure 2 below. The main hardware component is the ESP32 module. This means it establishes communication between all other components (i.e., TFT Display, GPS Module, Micro SD Card Module and IMU Module).

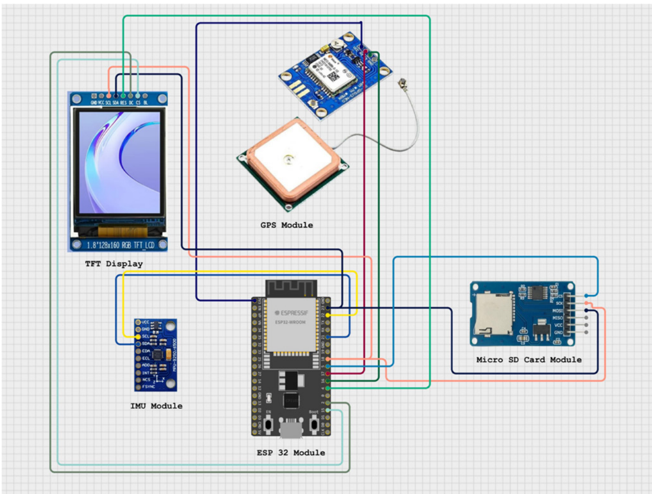

Figure 2.Physical Hardware Implementation and Circuit Diagram

Figure 2 shows the circuit diagram of the device. It contains mainly the ESP32 module, SD card module, IMU module, GPS module, and TFT display. This circuit diagram is created on the software called Circuit Designer.

The main operational loop proceeds as follows:

1. The ESP32 requests data from the GPS module[4] and the IMU module[14] periodically.
2. The received data strings from the GPS are parsed to extract key parameters. The raw sensor readings from the IMU are collected.[24-26]
3. A unified data record, containing a timestamp, latitude, longitude, altitude, acceleration values, and gyroscopic values, is created.[2,16,17]
4. This record is then written to a file on the Micro SD card.[22]
5. Simultaneously, a subset of this data is formatted and rendered on the TFT display[18, 20, 27] for real-time monitoring.

Power is supplied to all modules through the 3.3V and 5V output pins of the ESP32 development board, which itself can be powered via USB or a dedicated battery, ensuring a common ground reference for stable communication between all components.[25-28]

Conclusion

In this project, a cost-effective device to measure the distance travelled and area covered by agricultural machinery is conceptualised and designed. In this research paper, we have used technology related to IIoT and IoT, like GPS, IMU, and a microcontroller, to get data of latitude and longitude, measure the distance accurately, and do the calculations, respectively. Here, the ESP32 microcontroller is used as a central processing unit to handle data from the GPS and the IMU. The real-time data of the distance and the area covered by the machines can be seen on the TFT display. This device can be used especially in old machinery like tractors to measure the distance and area. Then the farmers can easily analyse their agriculture operations like tilling, soil preparation, etc. There are some limitations to this device; for example, the performance of the device is dependent on the GPS signal quality and the accuracy of the IMU, and the current TFT display has limited interactive capabilities. All these limitations can be improved by analysing the working of the device in the agricultural land, and then the improvements can be made.

Declaration of Interest

The author(s) declare(s) that there is no conflict of interest regarding the publication of this manuscript.

References

1. Rehman S, Talat Bajwa N, Shah MA, Aseeri AO, Anjum A. Hybrid AES-ECC model for the security of data over cloud storage. Electronics. 2021 Oct 31;10(21):2673.
2. Boguspayev N, Akhmedov D, Raskaliyev A, Kim A, Sukhenko A. A comprehensive review of GNSS/ INS integration techniques for land and air vehicle applications. Applied Sciences. 2023 Apr 12;13(8):4819.
3. Minni R, Gupta R. Low cost real time vehicle tracking system. In2013 Fourth International Conference on Computing, Communications and Networking Technologies (ICCCNT) 2013 Jul 4 (pp. 1-5). IEEE.

ISSN: 2395-3802
DOI: https://doi.org/10.24321/2395.3802.202505

4. u-blox. NEO-M8 Series summary; NEO-M8Q-0. Digi-Key India [Internet]. [cited 2025 July 12]. Available from: Digi-Key India website.
5. Hofmann-Wellenhof B, Lichtenegger H, Collins J. Understanding GPS: principles and applications. 2nd ed. New York: Springer; 2006.
6. U.S. National Coordination Office for Space-Based Positioning, Navigation, and Timing. Systems: GPS Overview. GPS.gov [Internet]. 2021 Feb 22 [cited 2025 July 2]. Available from: https://www.gps.gov/systems/gps/
7. Espressif Systems. ESP32 Series Datasheet, version 5.0 [Internet]. [place unknown]: Espressif Systems; [cited 2025 Sep 2]. Available from: https://www.espressif.com/sites/default/files/documentation/esp32_datasheet_en.pdf
8. Espressif Systems. ESP32-WROOM-32E & ESP32-WROOM-32UE datasheet, version 1.9 [Internet]. [place unknown]: Espressif Systems; [cited 2025 Sep 2]. Available from: https://www.espressif.com/sites/default/files/documentation/esp32-wroom-32e_esp32-wroom-32ue_datasheet_en.pdf
9. Kolban N. Kolban-ESP32. [Internet]. 2017 May 2 [cited 2025 July 7]. Available from: Archive.org item "kolban-ESP32
10. u-blox AG. NEO-6: u-blox 6 GPS Modules – Data Sheet (Document No. GPS.G6-HW-09005-E). [Internet]. [place unknown]: u-blox AG; 2009 [cited 2025 Sep 2]. Available from: https://content.u-blox.com/sites/default/files/products/documents/NEO-6_DataSheet_%28GPS.G6-HW-09005%29.pdf
11. Sinnott RW. Virtues of the Haversine. Sky and telescope. 1984 Dec;68(2):158.
12. Di Grande S, Berlotti M, Cavalieri S, Gueli R. Harnessing Multivariate AI to Enhance Hydropower Generation Forecasting. In2024 AEIT International Annual Conference (AEIT) 2024 Sep 25 (pp. 1-6). IEEE.
13. Arduino. Arduino Language Reference [Internet]. Last revised 18 Feb 2024 [cited 2025 July 30]. Available from: https://docs.arduino.cc/language-reference/
14. TDK InvenSense. MPU-9250 Register Map and Descriptions [Internet]. San Jose, CA: TDK InvenSense; 2016 [cited 2025 Jul 30]. Available from: https://invensense.tdk.com/wpcontent/uploads/2015/02/MPU-9250-Register-Map.pdf
15. InvenSense Inc. MPU-6000 and MPU-6050 Register Map and Descriptions. Rev 4.2, Document No. RM-MPU-6000A-00 [Internet]. Release date 2013 Aug 19 [cited 2025 Jul 2]. Available from: https://invensense.tdk.com/wp-content/uploads/2015/02/MPU-6000-Register-Map1.pdf
16. Welch G, Bishop G. An Introduction to the Kalman Filter. UNC-Chapel Hill, Department of Computer Science; Technical Report TR 95-041, 24 July 2006 [Internet]. [cited 2025 Sep 2]. Available from: https://www.cs.unc.edu/~welch/media/pdf/kalman_intro.pdf
17. Madgwick SO, Harrison AJ, Vaidyanathan R. Estimation of IMU and MARG orientation using a gradient descent algorithm. In2011 IEEE international conference on rehabilitation robotics 2011 Jun 29 (pp. 1-7). Ieee.
18. Display Future Ltd. Introduction [Internet]. [place unknown]: Display Future Ltd; [cited 2025 Sep 2]. Available from: https://www.displayfuture.com/Display/Introduction.asp
19. Sitronix Technology Co., Ltd. ST7735S Single-Chip TFT Controller/Driver Datasheet [Internet]. Version 1.1; 2011 Nov [cited 2025 Sep 2]. Available from: AllDatasheet.com page for ST7735S, https://www.alldatasheet.com/datasheet-pdf/pdf/1775164/SITRONIX/ST7735S.html
20. Adafruit. Adafruit-GFX-Library [Internet]. GitHub repository; [cited 2025 Sep 2]. Available from: https://github.com/adafruit/Adafruit-GFX-Library
21. SD Specifications. Part 1, Physical Layer Specification (JESD84-B51) [Internet]. Internet Archive collection "SD-specs"; added 18 Feb 2024 [cited 2025 Sep 2]. Available from: Internet Archive entry for JESD84-B51, https://archive.org/details/SD-specs/JESD84-B51/
22. National Instruments. Implementing SPI Communication Protocol in LabVIEW FPGA [Internet]. NI forums; [cited 2025 Sep 2]. Available from: NI Forums thread "Implementing SPI Communication Protocol in LabVIEW FPGA, https://forums.ni.com/t5/Example-Code/Implementing-SPI-Communication-Protocol-in-LabVIEW-FPGA/ta-p/3511851
23. National Marine Electronics Association (NMEA). NMEA 0183 Interface Standard [Internet]. National Marine Electronics Association; [cited 2025 Sep 2]. Available from: NMEA website page "NMEA 0183 Interface Standard".
24. NMEA N. 0183 Version 4.00: Standard for Interfacing Marine Electronic Devices.
25. Tyler L, Caulfield A, Nunes ID. Efficient Control Flow Attestation by Speculating on Control Flow Path Representations. arXiv preprint arXiv:2507.12345. 2025 Jul 16.
26. Semiconductors NX. I2C-bus specification and user manual UM10204. Avalable: http://www. nxp. com/documents/user_manual/UM10204. pdf. 2014.
27. Institute of Electrical and Electronics Engineers. IEEE Power Transmission and Distribution Standards Collection: VuSpec™ [Internet]. [place unknown]: IEEE; [cited 2025 Sep 2]. Available from: IEEE Power Transmission and Distribution Standards Collection: VuSpec (PDF) , https://standards.ieee.org/wp-content/uploads/import/documents/tocs/pwrtrandist.pdf

ISSN: 2395-3802
DOI: https://doi.org/10.24321/2395.3802.202505