Detection and Prevention of Termite Infestation Using IoT through Machine Learning

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Keywords: LCD, Alert, Raspberry PI, Decision Making, GSM.

Abstract: This project outlines an innovative system designed for the detection and prevention of termite infestations in furniture and walls, utilizing IoT and machine learning technologies. At the core of the system is a Raspberry Pi microcontroller, which manages and processes data from various environmental sensors. The system includes a DHT11 sensor to monitor temperature and humidity, and a soil moisture sensor to detect moisture levels both of which are critical indicators of termite activity. Additionally, an ADC module is incorporated to ensure accurate data acquisition from analog sensors, enhancing the reliability of the information being processed. The data gathered by the sensors is analyzed using a Random Forest machine learning algorithm, which identifies patterns that may suggest the presence of termites. When abnormal environmental conditions are detected, the system triggers alerts through a GSM module, sending notifications to users, while a buzzer provides a local warning. Real-time data is also displayed on an LCD, offering immediate access to critical information. By combining IoT connectivity with advanced machine learning, this system enables proactive monitoring and prevention of termite infestations, ultimately helping to protect furniture and structures from damage and minimizing the risk of costly repairs.

1 INTRODUCTION

Termite infestations are a significant concern for homeowners and businesses, causing severe damage to furniture, walls, and other wooden structures. Traditional methods of detecting and preventing termite activity often rely on visual inspections, which can be time-consuming and ineffective until significant damage has already occurred. As a result, there is a growing need for more efficient, proactive solutions to monitor and address termite infestations in real time. This project aims to address this need by integrating advanced technologies such as the Internet of Things (IoT) and machine learning to create an intelligent system for the early detection and prevention of termite damage.

The system leverages a Raspberry Pi microcontroller at its core, which communicates with multiple sensors to monitor environmental factors that promote termite activity. By utilizing a combination of temperature, humidity, and moisture sensors, along with data analysis powered by a Random Forest machine learning algorithm, the system can detect patterns indicative of an infestation. This innovative approach ensures early intervention through automated alerts and real-time monitoring, providing a reliable and efficient way to safeguard valuable assets from termite damage. By combining IoT with machine learning, this project offers a cutting-edge solution that enhances the long-term protection of furniture and walls.

In addition to its core functionality of detecting termite infestations, the system also emphasizes ease of use and prompt response to abnormal conditions. The integration of a GSM module allows for immediate notifications to be sent to users, ensuring they are alerted as soon as the system detects environmental changes that suggest potential termite activity. A buzzer further enhances the alert system by providing a local sound warning, which is particularly useful in areas where immediate attention is needed. With real-time information displayed on an LCD screen, users can continuously monitor the conditions and take necessary action without delay. This multi-faceted approach not only enhances the

Madduru, S., Devarakonda, B., Bhumireddy, B., Boya, B. and Dandu, P.
Detection and Prevention of Termite Infestation Using IoT through Machine Learning.
DOI: 10.5220/0013924400004919

In *Proceedings of the 1st International Conference on Research and Development in Information, Communication, and Computing Technologies (ICRDICCT'25 2025) - Volume 5*, pages 161-167
ISBN: 978-989-758-777-1

efficiency of termite detection but also empowers users to act swiftly, preventing extensive damage and reducing maintenance costs over time.

2 RELATED WORKS

The "Termite Detection Scanner: Design and Development" by F. R. Mohammed, S. Prakash, D. Brindha, and T. Kumaran, discusses a method to identify the presence of termites that could potentially cause severe damage to wooden structures and buildings if not addressed promptly. Termites, which thrive in colonies and feed on cellulose-rich materials, can compromise the structural integrity of a building. Detecting them early is crucial, and one effective way to do so is through thermal imaging technology. Thermal sensors are employed to monitor temperature fluctuations within a given area or system, enabling the detection of these pests by observing temperature variations. The resulting data is then presented on a screen as a thermal image, allowing easy visualization of potential termite presence.

The study titled *"Classroom Furniture Vulnerability to Drywood Termite Infestation"* by A. J. Mark Rojo, investigates the extent of drywood termite infestations in classroom furniture at the University of the Philippines Los Baños, College of Forestry and Natural Resources, located in Laguna, Philippines. Conducted in February 2016, the research utilized nonparametric statistical tests to assess whether the type of furniture, material composition, and protective coatings could influence susceptibility to termite damage. Out of all the furniture examined, only 15% showed signs of drywood termite infestation, including visible damage and fecal pellets. The Kruskal-Wallis test revealed a statistically significant variation in damage ratings across different furniture types and materials at a 95% confidence level. Furthermore, the Mann-Whitney U test indicated that unpainted furniture was significantly more prone to termite infestation. The study also identified specific features such as cracks, natural checks, misaligned or overlapping wood, and exposed end grain as key factors that contribute to the vulnerability of furniture, as they provide entry points for termite swarmers (alates).

3 PROPOSED METHOD

The proposed method for termite detection and prevention integrates Internet of Things (IoT) and machine learning technologies to create an advanced monitoring system. Central to this system is a Raspberry Pi microcontroller that serves as the processing unit, gathering data from various sensors. These sensors include a DHT11 sensor for measuring temperature and humidity, and a soil moisture sensor to track moisture levels, both of which are key indicators of termite activity. To ensure the accuracy and reliability of the data, an Analog-to-Digital Converter (ADC) module is used for precise data acquisition from analog sensors. This setup allows the system to continuously monitor environmental factors that could signal potential termite infestations.

Once the data is collected, it is analyzed using a Random Forest machine learning algorithm, which is capable of detecting patterns that indicate the presence of termites. If the system identifies abnormal environmental conditions, it triggers alerts through a GSM module to notify users, while a local buzzer provides an immediate warning. Additionally, real-time data is displayed on an LCD screen, giving users direct access to critical information. By combining real-time sensor data with machine learning capabilities, the system not only detects but also helps prevent termite infestations, offering a proactive solution to protect furniture and structures from significant damage.

The system leverages a combination of real-time environmental monitoring and advanced data analysis to provide an efficient solution for termite prevention. By continuously tracking temperature, humidity, and moisture levels in the surrounding environment, the system can detect fluctuations that may indicate favorable conditions for termite activity. The integration of machine learning further enhances the system's ability to recognize patterns in the data and make accurate predictions about potential infestations. The use of IoT technology ensures seamless communication between sensors, the Raspberry Pi microcontroller, and the GSM module, allowing for immediate notifications and alerts. With this proactive approach, the system not only alerts users to possible termite threats but also enables timely intervention, reducing the risk of extensive damage and the need for costly repairs.

3.1 Block Diagram

The figure 1 shows Block Diagram.

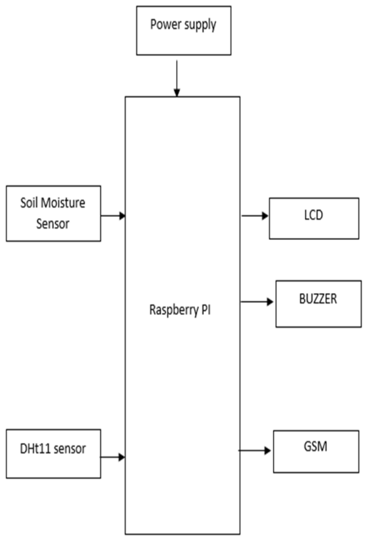

Figure 1: Block Diagram.

4 METHODOLOGY

Hardware Required for this project

4.1 Raspberry Pi

Figure 2: Raspberry Pi.

In this project, the Raspberry Pi (figure 2) plays a pivotal role as the central microcontroller that manages and processes data from various environmental sensors. Chosen for its versatility and computing power, the Raspberry Pi acts as the system's brain, collecting real-time data from sensors like the DHT11 and soil moisture sensors. With its GPIO (General Purpose Input/Output) pins, the Raspberry Pi interfaces directly with the sensors, converting analog readings into digital data that can be processed and analyzed. The compact size and processing capabilities of the Raspberry Pi make it an ideal choice for IoT applications, enabling the integration of multiple sensors and peripherals into a single cohesive system.

Moreover, the Raspberry Pi facilitates seamless connectivity for communication and alerting functions within the system. Through its onboard Wi-Fi or Ethernet capabilities, it can send notifications via the GSM module to inform users of potential termite activity. The microcontroller also displays real-time data on an LCD screen, providing immediate access to critical environmental information. By using the Raspberry Pi, the project can harness the power of machine learning algorithms to analyze the sensor data, improving accuracy in detecting and predicting termite infestations. This makes the Raspberry Pi a key component in achieving the project's goal of proactive termite detection and prevention.

4.2 MOISTURE SENSOR

The soil moisture sensor (figure 3) in this project plays a critical role in detecting environmental conditions that may contribute to termite activity. Termites are highly sensitive to moisture levels, and they often thrive in areas with high humidity or excess moisture, such as walls or furniture exposed to damp conditions. By monitoring the moisture content in the surrounding environment, the sensor provides valuable data that helps identify areas at risk of termite infestations. The sensor works by measuring the electrical resistance or capacitance in the soil, with higher resistance indicating drier conditions and lower resistance signaling increased moisture. This allows the system to detect subtle changes in moisture levels, which can be an early indicator of termite presence or activity.

In the context of the termite detection system, the soil moisture sensor enhances the overall accuracy of the monitoring process by providing real-time data that correlates with other environmental factors, such as temperature and humidity. By integrating this sensor with the machine learning algorithm, the system can better understand patterns and trends in the environment, leading to more accurate predictions of potential termite infestations. The sensor's ability to detect even small fluctuations in moisture levels ensures that the system can react quickly to changes in the environment, alerting users to possible termite threats before they cause significant damage. This proactive monitoring approach helps protect both furniture and structures, reducing the need for expensive repairs.

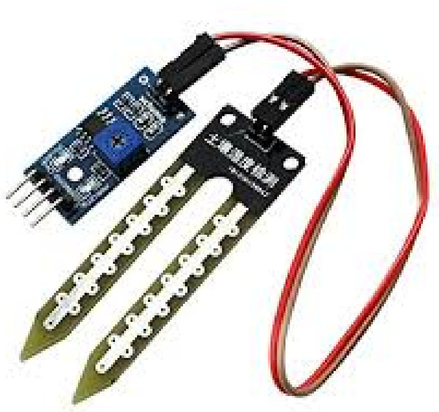

Figure 3: Moisture Sensor.

4.3 GSM

In this project, the GSM module plays a crucial role in enabling remote communication and alert functionality. The GSM module is integrated with the Raspberry Pi microcontroller, allowing the system to send notifications directly to the user's mobile phone when abnormal conditions are detected. This feature is particularly important for users who may not be in close proximity to the monitored area, as it ensures they are promptly informed of any potential termite infestations. Once the sensors detect environmental anomalies such as unusual temperature, humidity, or moisture levels, the GSM module is triggered to send a text message alert to the user, providing them with real-time information about the status of the system.

Figure 4: GSM.

The GSM (figure 4) module enhances the overall functionality of the system by offering a reliable communication channel, independent of local network infrastructure. This means that even if the user is outside of the immediate vicinity or in an area without internet access, they will still receive critical alerts via SMS. The ability to send alerts through SMS ensures that users can take immediate action to address the problem, whether by inspecting the area further or contacting pest control services. In combination with the other components of the system, the GSM module ensures that termite detection and prevention efforts are timely and effective, ultimately helping to safeguard valuable furniture and structures from damage.

4.4 LCD

In this project, an LCD screen is incorporated to provide real-time feedback and display vital information related to the environmental conditions monitored by the sensors. The LCD offers a clear and intuitive interface, allowing users to quickly access data on temperature, humidity, and soil moisture levels, which are key indicators of termite activity. By continuously updating the display, the LCD ensures that the user has up-to-date insights into the conditions within the monitored space, making it easier to track potential termite risks. This real-time display also serves as an immediate visual reference for the system's status, offering a user-friendly method to monitor the system's performance and detect abnormalities.

Figure 5: LCD.

The use of the LCD (figure 5) enhances the system's functionality by presenting the data in a structured and readable format. Instead of relying solely on alerts or notifications, users can visually assess the environmental conditions at a glance, making it easier to interpret sensor data. Whether the system is running normally or triggering warnings, the LCD provides an accessible overview of all relevant parameters. This contributes to the overall effectiveness of the system, ensuring that users have the necessary information to make informed decisions regarding termite prevention and maintenance, ultimately helping protect their furniture and structures from potential damage.

4.5 Buzzer

In this project, the buzzer plays a critical role in providing immediate, local alerts when the system detects potential termite activity. The buzzer is connected to the Raspberry Pi microcontroller and is triggered whenever abnormal environmental conditions, such as a rise in temperature or moisture levels, are detected by the sensors. This serves as an audible warning, notifying users in the vicinity of potential termite presence, enabling quick action to address the issue before it escalates into significant damage. The buzzer's sound ensures that the alert is heard even in noisy environments, making it a reliable tool for raising awareness about the problem.

Figure 6: Buzzer.

The buzzer also complements the GSM module, which sends remote notifications to users. While the GSM module communicates the alert over long distances, the buzzer provides an immediate response to any changes in the local environment. This dual-alert system increases the effectiveness of the monitoring system by ensuring that users are alerted both locally and remotely. The use of a buzzer adds a layer of responsiveness and efficiency to the system, contributing to the overall goal of proactive termite infestation prevention. The figure 6 shows buzzer.

4.6 Power supply

The power supply board in this project is designed to efficiently convert and regulate input power to meet the requirements of various system components. It accepts an input voltage range from 12V to 18V and utilizes two separate regulators: a 12V regulator and a 5V regulator. The 12V regulator provides a stable 12V output to power components that require this voltage, such as the Raspberry Pi and certain sensors. Meanwhile, the 5V regulator ensures that components requiring 5V, such as the GSM module and certain other sensors, receive the appropriate power supply. By splitting the output into two regulated voltages, the power supply board ensures that all components receive the correct voltage, preventing damage and ensuring the system operates reliably.

The board is equipped with essential components such as capacitors and diodes, which work together to provide smooth and efficient power conversion. A bridge rectifier, made up of diodes, is included to convert the alternating current (AC) input into direct current (DC), ensuring that the power supply provides the necessary DC output for the system's components. Capacitors are placed across the output lines to filter out any voltage spikes or fluctuations, providing stable and clean power. This well-designed power supply board is crucial for the proper functioning of the system, ensuring all components are powered reliably while protecting them from voltage irregularities.

Advantages and Applications

Advantages

- Proactive
- Efficient
- Reliable
- Cost-effective
- Smart
- Scalable
- Real-time
- Sustainable
- User-friendly

Applications

- Pest control
- Home automation
- Building maintenance
- Environmental monitoring
- Smart homes
- Agriculture

- Structural health
- IoT security
- Property protection
- Forestry management

5 RESULTS

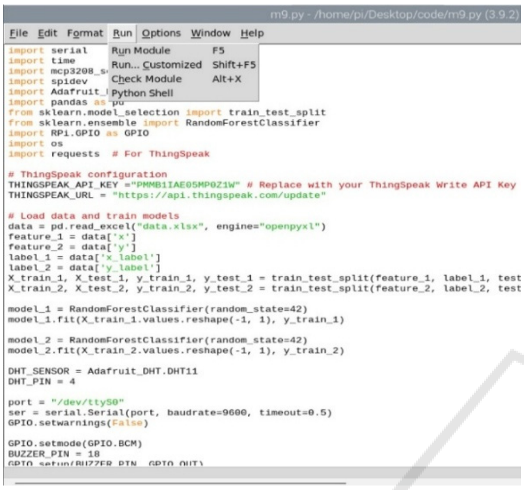

Figure 7: Implementation Code.

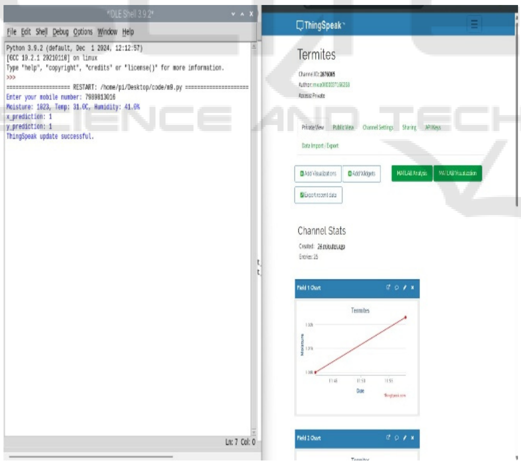

Figure 8: User Details.

The figure 7 shows Implementation Code and figure 8 shows Figure 8: User Details.

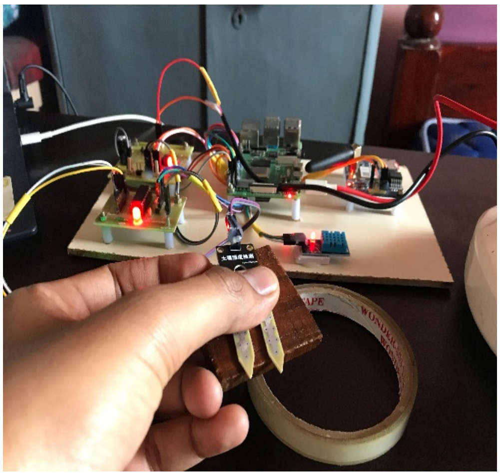

Figure 9: Testing Wooden pieces.

Figure 10: Sending Alerts to User.

The figure 9 shows Testing Wooden pieces and figure 10 shows Sending Alerts to User.

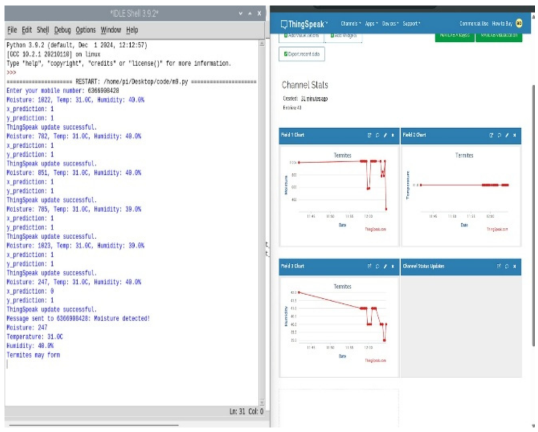

Figure 11: Graphical Updates on Thing Speak.

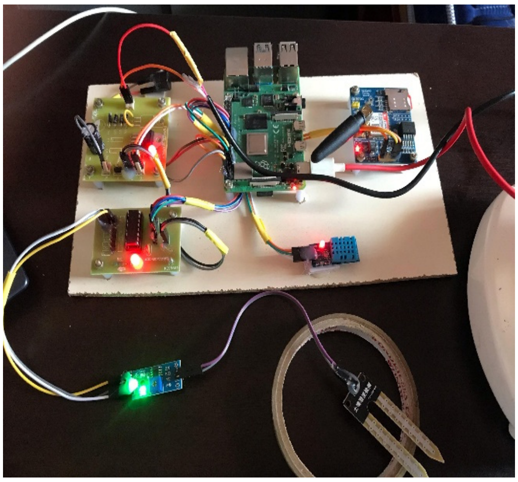

Figure 12: Circuit Diagram -Total KIT.

The figure 11 shows Graphical Updates on Thing Speak and figure 12 shows Circuit Diagram -Total KIT.

6 CONCLUSIONS

In conclusion, the proposed termite detection and prevention system successfully integrates IoT and machine learning technologies to provide an efficient and proactive solution for monitoring and managing termite infestations. By utilizing sensors to measure critical environmental factors such as temperature, humidity, and moisture, the system can detect fluctuations that indicate the presence of termites. The combination of real-time data analysis through machine learning and seamless communication via IoT ensures that the system can accurately identify potential threats, triggering alerts through both GSM notifications and local buzzers. This integrated approach not only helps prevent significant structural damage but also empowers users to take timely action, ultimately reducing the risk of costly repairs and enhancing the protection of valuable furniture and buildings.

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