

DESIGN AND CONSTRUCTION OF SOIL MOISTURE DETECTION TOOL USING ANDROID BASED DECISION TREE ALGORITHM

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Abstract: Soil moisture is an important factor in determining the watering needs of plants for optimal growth. Therefore, accurate monitoring of soil moisture is necessary. This research aims to design and build a soil moisture detection tool based on the Decision Tree algorithm with the support of the YL-69 sensor for humidity measurement and the DHT11 sensor for temperature measurement to increase data accuracy. This system uses NodeMCU ESP8266 as a microcontroller and is integrated with an Android application as a user interface. Sensor interpretation data is analyzed using the Decision Tree algorithm to determine soil conditions (dry, damp or wet). The test results show an accuracy level of 95% from 300 data samples. Thus, this system is able to detect soil moisture effectively and can help increase the efficiency of crop management on a household and commercial agricultural scale.

Keywords: agriculture, android, decision tree algorithm, sensors, soil moisture detection

Abstrak: Kelembaban tanah merupakan faktor penting dalam menentukan kebutuhan penyiraman tanaman agar pertumbuhannya optimal. Oleh karena itu, pemantauan kelembaban tanah secara akurat sangat diperlukan. Penelitian ini bertujuan untuk merancang dan membangun alat deteksi kelembaban tanah berbasis algoritma Decision Tree dengan dukungan sensor YL-69 untuk pengukuran kelembaban dan sensor DHT11 untuk pengukuran suhu guna meningkatkan akurasi data. Sistem ini menggunakan NodeMCU ESP8266 sebagai mikrokontroler dan diintegrasikan dengan aplikasi Android sebagai antarmuka pengguna. Data hasil pembacaan sensor dianalisis menggunakan algoritma Decision Tree untuk menentukan kondisi tanah (kering, lembab, atau basah). Hasil pengujian menunjukkan tingkat akurasi sebesar 95% dari 300 sampel data. Dengan demikian, sistem ini mampu mendeteksi kelembaban tanah secara efektif dan dapat membantu meningkatkan efisiensi pengelolaan penyiraman tanaman pada skala rumah tangga maupun pertanian komersial.

Kata kunci: algoritma decision tree, android, deteksi kelembaban tanah, sensor, pertanian.



INTRODUCTION

The Darul Ihsan Modern Islamic Boarding School is an Islamic educational institution located in Selemak Village, Hamparan Perak District, Deli Serdang Regency, North Sumatra Province. Apart from focusing on educational and religious activities, this Islamic boarding school also has a garden as a means of greening and beautifying the environment. The park plays an important role in maintaining the balance of the ecosystem and creating a comfortable learning atmosphere for students. However, in garden maintenance, soil moisture is the main factor that must be considered because it greatly influences plant growth and health.

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With advances in Internet of Things (IoT) technology and mobile devices, soil moisture monitoring activities can now be carried out automatically and integrated. A soil moisture sensor-based monitoring system connected to an Android device allows users to know soil conditions in real-

time, efficiently and accurately. Furthermore, to increase the accuracy of data analysis, artificial intelligence algorithms such as Decision Trees can be used, which function to classify soil conditions (dry, damp, wet) based on data from sensor readings.

Several previous studies have developed soil moisture monitoring systems using various approaches. Previous research compared several machine learning algorithms, including Decision Tree, in improving volumetric water content (VWC) predictions using low-cost soil moisture sensors [1]. Another study developed an IoT-based system with pH and humidity sensors integrated into an Android application to help farmers in water and fertilizer management [2]. In addition, there is the development of low-cost handheld soil moisture sensors that are suitable for small farmers [3], as well as a moisture estimation method using machine learning-based soil images from cell phone cameras [4].

Other research proposes a sensor-based agricultural land monitoring system and Neural Network and Decision Tree algorithms to monitor soil and weather conditions [5]. Apart from that, the Decision Tree algorithm has also been applied to automate plant watering systems based on the results of soil moisture detection [6], and decision tree algorithms such as Random Forest have proven effective in predicting the output of capacitance soil moisture sensors [7]. These studies show that the Decision Tree method and its derivatives are quite effective in making decisions based on environmental sensor data.

However, there are several research gaps (gap analysis) that need to be filled. First, most research focuses on large-scale agricultural areas, while the

application of similar systems in Islamic boarding school gardens with local soil and climate characteristics has not been widely carried out. Second, not many studies have integrated Decision Trees with Android applications as the main user interface for direct monitoring. Third, some monitoring systems are still limited to data collection without providing real-time automatic classification of soil conditions that can help users determine optimal watering times. Fourth, the problem of calibration and long-term stability of sensors is also often ignored, even though these factors affect the accuracy of sensor data in the field [8].

Recent research shows that utilizing IoT-based sensor data and machine learning algorithms can increase the accuracy of soil moisture predictions and support irrigation efficiency and smart agriculture [9]. On the other hand, tree-based algorithm approaches such as Decision Tree and Boosted Tree Ensemble have proven effective in predicting soil moisture based on Ground Penetrating Radar (GPR) data with a high level of accuracy [10].

Based on the research background and gaps, this research aims to design and build a sensor-based soil moisture detection tool that is integrated with a microcontroller and an Android device, implement the Decision Tree algorithm to classify soil moisture conditions into dry, damp and wet categories, produce a soil moisture monitoring system that is able to provide real-time information to users efficiently and accurately, test system performance in terms of algorithm accuracy, response time efficiency, and sensor stability in the garden environment of the Darul Modern Islamic Boarding School. Ihsan.

It is hoped that this research can

be an innovative solution in automating soil moisture monitoring in educational environments such as Islamic boarding schools, as well as being the first step towards implementing smart environments based on IoT and Decision Trees.

METHOD

This research uses observation methods, interviews and literature studies to obtain information about plantations, soil types and other information and data that will be used. The research was carried out in the garden of the Darul Ihsan Modern Islamic Boarding School. In this research, materials were used, namely NodeMCU esp8266, Soil Moisture Sensor, RTCDS3231 Module, 16x2 LCD and I2C Module

Data is obtained from a soil moisture sensor (YL-69) connected to a NodeMCU esp8266. Data includes: Soil moisture (%RH), Data received from the sensor will be directly sent to a database where this research uses Google Firebase as a database, then data from the database will be sent to Android via an internet connection, then the data will be classified into 3 categories, namely Dry, Moist, Wet.

The Decision Tree algorithm calculation involves splitting data at each node based on entropy or Gini index, to determine the best attributes for dividing the dataset. Entropy functions to measure data uncertainty while⁽¹⁾ Information gain functions to measure the reduction in uncertainty after separation, where both have different formulas, namely as follows.

$$Entropy(S) = \sum_{i=1}^n p_i \log_2 (p_i)$$

$$IG(S,A) = Entropy(S) - \sum_{v \in values(A)} \frac{|S_v|}{|S|} Entropy(S_v) \quad (2)$$

After modeling 1500 soil samples consisting of 500 dry soil samples, 500 moist soil samples, and 500 wet soil samples, it was produced and compared with temperature, so the information gain was obtained as in the table below :

Table 1 Information Gain (IG)

Attribute	Information Gain (IG)
Humidity	1,483
Temperature	0,108

So it can be concluded that the "Soil Moisture (%)" attribute remains the main factor in classification, with an IG of 1.483, while the "Temperature (°C)" attribute has an IG of 0.108, which means that temperature does not really influence the separation of soil moisture classes. In the De-cision Tree algorithm, the attribute "Soil Moisture (%)" will remain selected as the main node. After selecting the attributes, a decision tree structure is obtained as follows:



Figure 1. Decision Tree

Explanation:

If Soil Moisture $\leq 20\%$, then the soil is classified as Dry, If Soil Moisture is 21-40%, then the soil is classified as Moist, And If Soil Moisture $> 40\%$, check temperature:

If the temperature is $\geq 39^\circ\text{C}$, then the soil is moist, And If the temperature is $< 39^\circ$, then the soil is wet.

The system built consists of two main components, namely hardware and software. Following are the details of each component:

The flowchart starts from the oval node with start which indicates the start of the prediction process, after which the data will automatically enter from the sensor and then the data will be checked if the humidity is ≤ 20 then the data will be classified as DRY, if the humidity is 21-40 then the data will be classified as MOIST and the data > 40 will be checked by the temperature sensor if the temperature is ≥ 39 then the data will be classified as MOIST and if not then it will be classified as WET, the data will be immediately classified based on the criteria that have been created, which can be seen in the image below:



Figure 2. Flowchart

The following is a picture of the design of the tool that will be made in this writing:

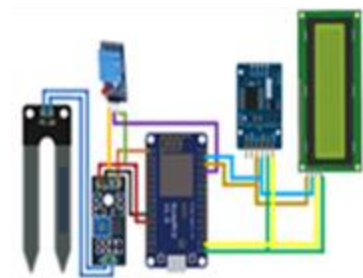


Figure 3. Tool Set

Aplikasi Android applications are developed using Android Studio with the Java programming language. This application functions to receive soil moisture data sent by the microcontroller, visualize the data, and provide information about soil moisture status to the user. The main feature contained in the Android application is that on the first page a button will be displayed to check soil moisture, after pressing the check humidity button on page one it will automatically switch to the second page where on this page we can immediately see the soil moisture status. Following is the software design:

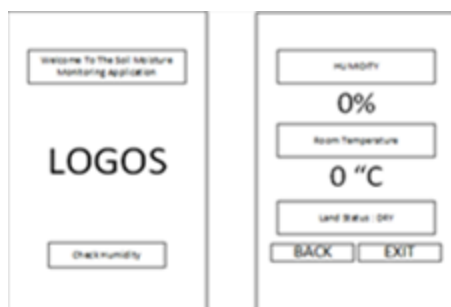


Figure 4. Software Design

RESULTS AND DISCUSSION

The results of research and testing carried out by the author. Can be seen in the figure 5.



Figure 5. Software Start Page

The entire main page of the Soil

Moisture Monitoring application is designed with an attractive appearance. At the top there is a greeting in the form of the text "Welcome to the Soil Moisture Monitoring Application" written in bold font. In the middle there is a visual illustration in the form of a soil moisture sensor with two electrode rods stuck in yellow soil media, symbolically depicting the main function of this application. At the bottom there is a green button that says "CHECK HUMIDITY" which is the main button to access the soil moisture checking feature. This display is structured in a simple but informative way, while being easy for users to understand, and directs them directly to the main functions of the application intuitively.

This display is a page of soil moisture monitoring results from the Soil Moisture Monitoring application, which presents the main information clearly and directly. The visual design remains consistent with the main page. In the center of the screen two important pieces of information from the sensor readings are displayed, namely the soil moisture value of 0.0% and the room temperature of 22.6%, each written in large, bold and easy to read letters.

This data comes from two sensors: a soil moisture sensor and a temperature sensor, which are used to accurately determine the condition of the planting media. Below that there is a panel with a white background containing the information "Soil Status: DRY", which is the result of the system's interpretation based on the humidity value which is in the dry category. This status is very useful for users because it provides direct conclusions from the data displayed. At the bottom there are two green buttons, namely "BACK" to return to the previous page and "EXIT" to close

the application. This display is designed to be intuitive and easy to use by all groups, including farmers or general users, so they can quickly make decisions regarding watering or plant care.

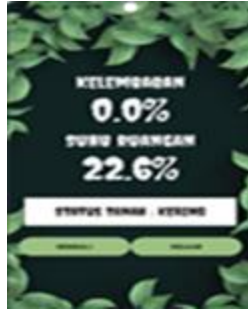


Figure 6. Software Home Page

The following is a display of the hardware that has been assembled from the various components needed to make this project such as soil moisture sensor, temperature sensor (DHT11), NodeMCU Esp8266, battery box and in this project the author also added time information which is displayed on a 16x2 LCD which is attached to the tool where the time information is obtained from the DS3231 RTC module, then all the components are connected using cables. jumper, can be seen as in the figure 7.



Figure 7. Hardware Network Display

Then, after all the components have been assembled into the black box as their place, the box will then be closed to further enhance the appearance of the hardware.

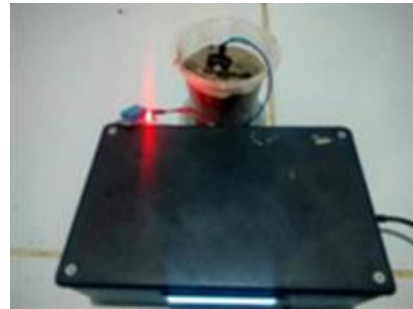


Figure 8. Hardware Display

CONCLUSION

Based on the results of the analysis, design and testing that have been carried out, several things can be concluded as follows, The Decision Tree-based soil moisture detection system was successfully built and integrated with the Android application. This system is able to detect and display soil moisture conditions (dry, damp and wet) in real-time through data obtained from the YL-69 humidity sensor and the DHT11 temperature sensor, The Decision Tree algorithm has proven to be effective in classifying soil moisture based on sensor data, with good accuracy results of 95%. The Information Gain value shows that the soil moisture attribute has the most dominant influence in determining classification compared to the temperature attribute. This shows that this method is appropriate to use for decision making in monitoring systems based on environmental sensor data, The system designed provides added value in the form of ease of monitoring soil conditions without the need for manual observation, as well as increasing the efficiency of time and energy in plant care.

Integration with the Android application also provides easy access and visualization of data directly for users in

the field, Even though the system is functioning well, there are still several technical challenges such as the need for regular sensor calibration to maintain reading accuracy and increasing connection stability between the microcontroller and the Android application, and This research has the potential for further development, such as adding automatic watering pump control features, applying other algorithms (for example Random Forest or Support Vector Machine) to increase prediction accuracy, as well as integration with Internet of Things (IoT) systems so that data can be accessed online from various locations.

Overall, this research makes a real contribution to the development of an intelligent and efficient soil moisture monitoring system by utilizing the Decision Tree algorithm as the main classification method, and shows that the application of Android-based technology can be a practical solution for modern land and park management.

ACKNOWLEDGMENTS

The author would like to thank the supervisor for his guidance and direction throughout the research process. Thanks are also expressed to all parties who have assisted in collecting data and preparing this research.

BIBLIOGRAPHY

- [1] I. Setiawan, M. D. T. Musa, D. A. Afriza, and S. N. Hafidah, "Comparing Machine Learning Algorithms to Enhance Volumetric Water Content Prediction in Low-Cost Soil Moisture Sensor," *J. Appl. Informatics Comput.*, vol. 9, no. 1, pp. 140–145, 2025, doi: 10.30871/jaic.v9i1.8905.
- [2] B. Sutomo, T. A. Saputri, and I. W. Satria, "Utilizing IoT Technology for Soil Moisture Management through Integration of pH and Moisture Sensors in an Android Application for Rice Farming," *Int. J. Softw. Eng. Comput. Sci.*, vol. 5, no. 1, pp. 248–258, 2025, doi: 10.35870/ijsecs.v5i1.3538.
- [3] S. Mane *et al.*, "Development of low-cost handheld soil moisture sensor for farmers and citizen scientists," *Front. Environ. Sci.*, vol. 13, no. May, pp. 1–23, 2025, doi: 10.3389/fenvs.2025.1590662.
- [4] M. R. H. Hossain and M. A. Kabir, "Machine Learning Techniques for Estimating Soil Moisture from Smartphone Captured Images," *Agric.*, vol. 13, no. 3, 2023, doi: 10.3390/agriculture13030574.
- [5] T. Song, Y. Si, J. Gao, W. Wang, C. Nie, and J. J. Klemeš, "Prediction and monitoring model for farmland environmental system using soil sensor and neural network algorithm," *Open Phys.*, vol. 21, no. 1, 2023, doi: 10.1515/phys-2022-0224.
- [6] M. Muchlasin, Muhammad Hasbi, and Sri Siswanti, "Decision Tree Method for Automation of Plant Sprinklers and Monitoring Based On Soil Moisture," *J. Nas. Pendidik. Tek. Inform.*, vol. 12, no. 1, pp. 25–32, 2023, doi: 10.23887/janapati.v12i1.59075.
- [7] E. N. Mardiyati, T. Dewi, and Y. Oktarina, "Analisa Prediksi Tegangan Input Sensor Capacitive Soil Moisture dengan Random Forest untuk Mendukung

- Pertanian Pintar,” *J. Appl. Smart Electr. Netw. Syst.*, vol. 4, no. 2, pp. 47–53, 2024, doi: 10.52158/jasens.v4i2.787.
- [8] S. N. Faridah, M. T. Sapsal, T. A. A. Jamaluddin, A. D. Achmad, and M. A. Surya, “Stability of soil moisture sensors for agricultural crop cultivation,” *Res. Agric. Eng.*, vol. 71, no. 2, pp. 88–94, 2025, doi: 10.17221/33/2024-RAE.
- [9] I. Ivanova, “Soil moisture forecasting from sensors-based soil moisture, weather and irrigation observations: A systematic review,” *Smart Agric. Technol.*, vol. 10, no. November 2024, p. 100692, 2025, doi: 10.1016/j.atech.2024.100692.
- [10] J. Panyavaraporn, P. Horkaew, R. Arjwech, and S. Eua-apiwatch, “Machine Learning Approaches for Soil Moisture Prediction Using Ground Penetrating Radar: A Comparative Study of Tree-Based Algorithms,” *Earth (Switzerland)*, vol. 6, no. 3, pp. 1–25, 2025, doi: 10.3390/earth6030098.