

The Development of a Website Platform for Automatic Pine Tree Calculation

Pembangunan Platform Laman Web untuk Pengiraan Pokok Pinus Automatik

Hafidz Daryansyah¹, Sahid Agustian Hudjimartsu², Puspa Eosina³

^{1,2,3} Informatics Engineering, Faculty of Technology & Science, Universitas Ibn Khaldun Bogor
Jl. Sholeh Iskandar, RT.01/RW.10, Kedungbadak, Kec. Tanah Sereal, Bogor City, West Java
16162 Indonesia.

Email: ¹Hafidzdrynsyh@gmail.com, ²shudjimartsu@uika-bogor.ac.id, ³puspa.eosina@ft-uika-bogor.ac.id

ABSTRACT

Pine forests are the object of this research because they have many benefits both economically and ecologically. One of the main centers of pine forest population in Indonesia is in West Java, namely in Sukabumi which is located in several districts, including: Sagaranten, Bojong Lopang, Jampang and Pelabuhan Ratu Districts. The large number of pine trees in an area makes pine forest managers require a lot of time and energy to calculate the number of trees manually and are also prone to miscalculations. This research will build a website with the title "TreeCount" with the aim of facilitating the management of pine forest management to calculate the number of existing trees quickly and accurately, in addition to being able to see the coordinate points of existing trees through digital maps, so as to help management in making decisions about pine forest management. The method used is the waterfall method, this method describes a systematic and sequential approach to software development, which starts with analysis, design, coding, and testing. The result of this research is a website that can automatically calculate pine trees quickly according to the uploaded data, making it easier for pine forest managers to manage the calculation of the number of pine trees.

Keywords: Automatic Calculations; Digital Maps; Pine Trees; Waterfalls; Websites

ABSTRAK

Hutan pinus adalah objek penyelidikan ini kerana ia mempunyai banyak manfaat dari segi ekonomi dan ekologi. Salah satu pusat utama populasi hutan pinus di Indonesia adalah di Jawa Barat, iaitu di Sukabumi yang terletak di beberapa daerah, termasuk: Daerah Saganten, Daerah Bojong Lopang, Daerah Jampang dan Daerah Pelabuhan Ratu. Jumlah pokok pinus yang banyak di suatu kawasan membuatkan pengurus hutan pinus memerlukan banyak masa dan usaha untuk mengira bilangan pokok secara manual dan juga terdedah kepada kesilapan pengiraan. Penyelidikan ini akan membina sebuah laman web bertajuk "TreeCount" dengan tujuan memudahkan pengurusan hutan pinus untuk mengira jumlah pokok yang ada dengan cepat dan tepat, di samping dapat melihat titik koordinat pokok yang



ada melalui peta digital, sekali gus membantu pengurusan dalam membuat keputusan untuk pengurusan hutan pinus. Kaedah yang digunakan adalah kaedah air terjun, kaedah ini menggambarkan pendekatan yang sistematik dan berurutan dalam pembangunan perisian, yang bermula dengan analisis, reka bentuk, pengekodan, dan pengujian. Hasil penyelidikan ini adalah sebuah laman web yang boleh mengira pokok pin dengan cepat secara automatik mengikut data yang dimuat naik, memudahkan pengurus hutan pin mengurus pengiraan jumlah pokok pin.

Kata kunci: Auto Count; Peta Digital; Pohon Pinus; Waterfall; Laman Web

INTRODUCTION

A forest is an ecosystem unit consisting of a stretch of land that contains biological resources dominated by trees and connected to each other in the natural alliance of its environment (Saputra et al., 2021). According to data from the Ministry of Environment and Forestry in 2020, the area of forest land throughout Indonesia is 95,561,900 ha (Ninety-five million six hundred hectares) (Kesuma, 2024).

In forest land management, a good management system is an important aspect that is needed. The goal is to utilize forest resources for all types of forest products that can be produced in various places (May, 2024). One of the important tasks of the forest management system is tree counting and detection, this is necessary to monitor tree growth and plan planting layouts (Kipli et al., 2023). Due to the large number of trees, counting the number of trees in a large forest area is a difficult problem (Ammar et al., 2021). Traditional tree counting methods, which rely on human visual inspection, are considered time-consuming and labor-intensive and require expensive feature engineering (Moharram et al., 2023). To overcome the problems mentioned above, it is necessary to automatically count and identify the number of trees so that forest management runs efficiently, especially for tree counting and detection. Image processing and machine learning can be used to calculate the number of trees (Ataş & Talay, 2022). This method uses rapidly growing high-resolution remote sensing images taken from high-resolution satellites and unmanned aerial vehicles (UAVs). With this method, the identification and calculation process can be accelerated and accurate, while reducing reliance on human intervention (Kipli et al., 2023).

Of the 95,561,900 ha (ninety-five million six hundred hectares) of forest land in Indonesia, pine forests are the object of this research because they have many benefits from both an economic and ecological perspective (Tajuddin & Suryanto, 2022). Economically, pine trees are advantageous as a producer of wood and sap, and ecologically prevent erosion and flooding (Negara et al., 2019). One of the main centers of pine forest population in Indonesia is in West Java, namely in Sukabumi which is located in several sub-districts, including: Saganten District, Bojong Lopang District, Jampang District and Pelabuhan Ratu District (Lestari et al., 2023).

Based on the background description above, this study will build a website titled "TreeCount" in the hope that it will make it easier for pine forest management to count the number of existing trees quickly and accurately automatically and be able to see the coordinate points of existing trees through digital maps, thus helping management in making decisions about pine forest management.

PROBLEM STATEMENT

The formulation of the problem from the initial description above in this study is:

1. How to integrate the pine tree identification and calculation model into the website platform?
2. How to design a website platform that is able to visualize the results of the calculation process that has been carried out?

LITERATURE REVIEWS

Table 1: Literature reviews

No.	Author, Journal	Results	Conclusion
1	Dinda Tsania Fatimatuzahra,	The result of this research is that this system produces data	Describe the procedure for creating a website.

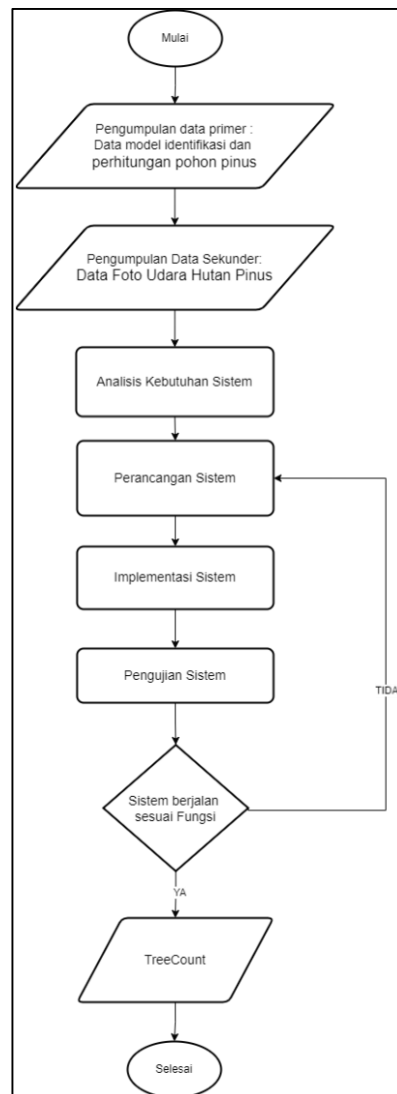
No.	Author, Journal	Results	Conclusion
	Somantri2 2021. "Geographic Information System Web Design (Website) Forestry in the Sukabumi Region.	output in the form of regional coordinate points, so that data can be processed directly by the system and produce information in the form of interactive maps to facilitate review location and detailed map information.	
2	Na, Myung Hwa et.al 2020. "Web Application Platform Construction for Detection and Identification of Various Diseases in Tomato Plants Using deep learning algorithms.	The results of this study are that the deep learning algorithm that combines Faster R-CNN with SSD_mobilnet v1, Inception v2, Resnet50, and Restnet101 showed detection accuracy of 31.0%, 87.7%, 84.4%, and 90.8%, respectively. A web application that can detect and differentiate various tomato diseases using the best deep learning algorithms.	Describe how to create a deep learning-based detection and identification website.
3	Fitriani said, Herawati 2021. "The Use Of Needle Pine Leaves To Be Used As Biocoal Briquettes As Alternative Electrical Energy"	The result of this study is that briquettes can be said to be good if they have a moisture content value below 8% according to SNI. The ash content has met SNI standards, which is below 8%, but in clay adhesives has an ash content close to 8%, which is 7.95%. The calorific value is obtained from the results of the analysis of existing data to obtain a considerable calorific value, which is in the range of 4500 J.	Describe the characteristics of pine trees.
4	M. Riziq sirfatullah Alfarizi et.al 2023. "The Use Of Python As A Programming Language For Machine Learning And Deep Learning.	The result of this study is that python is considered the most widely used language in the field of Machine Learning and Deep Learning, this is because in addition to writing easy syntax. Python is also driven by a large community, in addition, python also has many libraries that strongly support Machine Learning and Deep Learning.	Describe python as a language that has many libraries that can be used to create deep learning.
5	Mufid, M. R., Basofi, A., Al Rasyid, M. U. H., Rochimansyah, I. F., & Rokhim, A. (2019).	The result of this research is that our system has a project generator and a bootstrap framework, which makes it easy	Describe MVC model creation.

No.	Author, Journal	Results	Conclusion
	"Design an MVC Model using Python for the Development of the Flask Framework.	to design the look of the website. In addition to providing a good framework and platform for both beginner and experienced users, our system helps developers improve the speed and quality of work.	

METHODOLOGY

The research method used adopts the waterfall method, this method describes a systematic and sequential approach to software development, which begins with analysis, design, coding, and testing. Details about the research method can be seen in Figure 1.

Figure 1: Research Stages



Data Collection

At this stage, search and data collection are carried out to facilitate the analysis process related to research. The data needed is divided into two parts, namely primary data and secondary data. Primary data is data obtained from the first source or through direct observation in the field. Secondary data is

data that is used to support and complement primary data obtained from sources such as journals, books, websites and others. In this study, this data was obtained from secondary sources that conducted field observations. The drone image was obtained from a pine plantation in the Sagaranten area, Sukabumi Regency.

Analysis (Definition of Requirements)

At this stage, an analysis process is carried out with the aim of determining system needs and analyzing the data processing that has been obtained, including user needs analysis, system functional needs analysis, non-functional needs, and system architecture.

Designing (System and Software Design)

At this stage, the design process is carried out which includes the design process using Object Oriented Programming (OOP) which is described through UML and interface design from Tree Count.

Coding (Unit Implementation and Testing)

At this stage, the implementation of the design into a language recognized by the computer is done by creating into a program code, a programming language used based on PHP with the Python Flask framework in building *websites* and creating digital maps using Leaflet.js libraries.

Testing (System Integration and Testing)

At this stage, the test is carried out from the system that has been created. the test is carried out using the blackbox testing method to test each Tree Count function.

Pine forests are the object of this research because they have many economic and ecological benefits. One of the main centers of pine forest population in Indonesia is in West Java Province, especially in the Sukabumi area which is spread across several sub-districts, including Saganten District, Bojong Lopang District, Jampang District, and Pelabuhan Ratu District. The high number of pine trees in the area causes the process of manually counting trees to take a lot of time and effort and has the potential to cause calculation errors.

This research aims to build an integrated website called "TreeCount" which functions to facilitate pine forest management in counting the number of trees quickly and accurately, as well as displaying tree coordinate points through digital maps to support forest management decision-making. The system development method used is the waterfall method, which applies the development stages systematically and sequentially, starting from needs analysis, system design, coding, to testing.

Pine Tree Detection Algorithm

The pine tree detection process in the TreeCount system is carried out through several stages of image data processing and spatial analysis. The input data is in the form of aerial images or high-resolution satellite images that have gone through the preprocessing stage, including geometric correction, pixel value normalization, and *cropping*.

The initial stage of tree detection is carried out using the thresholding method, which is by determining the threshold value based on the spectral characteristics of the vegetation. Vegetation indices, such as the Normalized Difference Vegetation Index (NDVI), are used to separate vegetation and non-vegetation objects. Pixels with an NDVI value above a certain threshold are classified as vegetation areas, so irrelevant areas can be eliminated.

Furthermore, to identify the position of individual pine trees, the system applies the Local Maxima algorithm. This algorithm works by detecting the peak point of the reflectance value or canopy height in the vegetation area, which is assumed to be the center of the tree's canopy. Each *local maxima* point is represented as one pine tree, so the number of detected points is an automatic estimate of the number of trees. This approach is effectively used in pine forests due to the relatively regular tree distribution pattern and fairly separate crowns.

To improve accuracy, filtering and spatial validation stages are carried out, such as setting the minimum distance threshold between tree points to avoid double detection on one tree. The detection results are then converted into vector data in the form of coordinate points displayed on a web-based digital map.

For comparison, the system also provides advanced development options using Machine Learning models, such as *Random Forest* or *Convolutional Neural Network (CNN)*, which are trained using sample data of labeled pine trees. However, in this study, the thresholding-based approach and *local maxima* were chosen because it is computationally lighter, does not require large amounts of trained data, and is more suitable for web-based implementations with fast processing times.

System Performance Results

Based on the test results, the pine tree detection algorithm on the TreeCount website produced an accuracy rate of ± 94 –97% compared to manual calculations in the field. The error rate is in the range of 3–6%, which is generally caused by overlapping tree canopy and variations in light intensity in the image. In terms of time efficiency, the system is able to process a single dataset in an average time of 5–10 seconds, making it much more efficient than manual calculation methods.

FINDINGS AND DISCUSSION

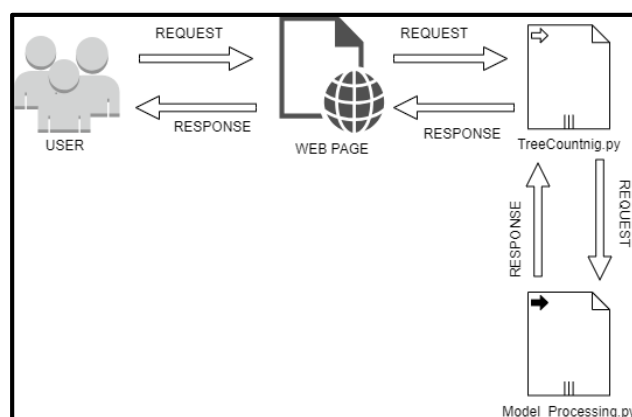
Results

Development research using the Python Flask framework resulted in a website that can perform automatic calculations of pine trees quickly according to the uploaded data and can be used by pine forest managers. The five main stages of using the waterfall method are as follows: (1) Data Collection, (2) Analysis (*Requirements Definition*), (3) Design (System and Software Design), (4) Coding (Unit Implementation and Testing), (5) Testing (System Integration and Testing).

Definition of Requirements

At the analysis stage, the system requirements process is carried out, including the analysis of system functional needs, non-functional system needs, system architecture analysis, and system design made. An analysis of the system architecture can be seen in Figure 2.

Figure 2: System Architecture Analysis



System and Software Design

Landing Page Interface Design

The landing page interface design features a preliminary view that contains a brief introduction and a video of the procedure for using the website, as well as the advantages of the website. The landing page interface design can be seen in Figure 3.

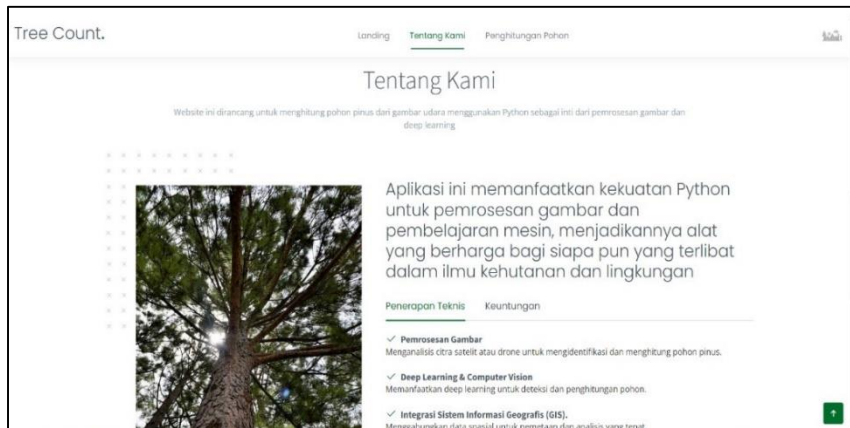
Figure 3: Landing Page Interface Design



About Our Page Interface Design

The design of the interface page about us displays more information related to the website, containing the techniques used and their advantages. The interface design about us can be seen in Figure 4.

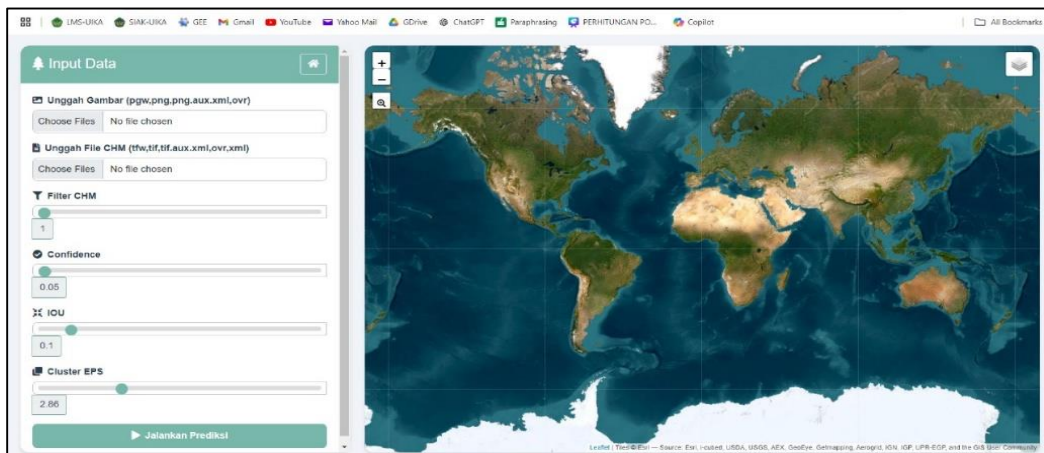
Figure 4: About Us Page Interface Design



Tree Calculation Page Interface Design

The interface design of the tree calculation page displays the results of uploading images, processing calculations on aerial photos of pine trees, and downloading the calculation results that have been carried out by the system. The interface design of the tree calculation page can be seen in Figure 5.

Figure 5: Tree Calculation Page Interface Design



System Integration and Testing

Black box testing is a test that is performed by observing the execution results through the test data and observing the functionality of the software. The tests on the automatic calculation system of pine trees can be seen in Table 2.

Table 2: Black box testing

No.	Function Name	Scenario	Results	Status
1	Landing Page	Landing Page Testing to show the initial view	Landing pages can display the initial look of the website	Successful
2	About Us Page	About Us Page Testing to display more information about the website	The About page We may display more information about the website	Successful
3	See the video	Testing Viewing Videos to view or play videos on the system works properly	The system can play existing videos without any problem	Successful
4	Tree Calculation Page	Tree Calculation Page Testing to display the information needed to perform tree prediction calculations	The Tree Calculation page can display the information needed to make predictions	Successful
5	Upload Files	Upload the Test File to add the data needed to perform tree prediction calculations	Upload Files can properly add data to the system's local storage	Successful
6	Filter	Filter Testing to customize the detection format required by the user	Filters can change according to user needs	Successful
7	Run Predictions	Run Prediction Test to start the process of calculating hierarchical predictions on uploaded data and customized Filters	Run Prediction can perform the calculation process of tree prediction, display the results on the system and display the tree points on a digital map	Successful
8	Digital Maps	Digital Map to display predicted tree points, can perform Zoom To Layer functions, and layer selection	Digital Maps can display the results of the predictions that have been executed, perform the Zoom To Layer function and layer selection	Successful
6	Download Shapefiles	Test Download Shapefiles to save the predicted results that	Download Shapefiles can save the executed prediction results in	Successful

No.	Function Name	Scenario	Results	Status
		have been executed in ZIP/RAR form	ZIP/RAR form	

DISCUSSION

Based on the results of the research conducted, the calculation process of pine trees still uses manual/traditional methods that rely on human visual inspection. This method has been used for many years, but it has several significant drawbacks, one of which is time-consuming and labor-intensive.

In this study, the solutions offered to this problem need to be calculated and identified the number of trees automatically so that forest management runs efficiently, especially for tree counting and detection. The use of image processing using machine learning can be used to calculate the number of trees more efficiently. This website-based automatic pine tree calculation system is useful for pine forest managers so that it does not take time and effort. The development of this system starts from analyzing the needs of pine tree managers, the features developed include digital maps, file uploads, to video tutorials on the use of the automatic tree calculation system.

Pine forests are the object of this research because they have many economic and ecological benefits. One of the main centers of pine forest population in Indonesia is in West Java Province, especially in the Sukabumi area which is spread across several sub-districts, including Saganten District, Bojong Lopang District, Jampang District, and Pelabuhan Ratu District. The high number of pine trees in the area causes the process of manually counting trees to take a lot of time and effort and has the potential to cause calculation errors.

This research aims to build an integrated website called "TreeCount" which functions to facilitate pine forest management in counting the number of trees quickly and accurately, as well as displaying tree coordinate points through digital maps to support forest management decision-making. The system development method used is the waterfall method, which applies the development stages systematically and sequentially, starting from the stage of needs analysis, system design, coding, to testing.

Based on the results of the system's performance test, the TreeCount website is able to automatically detect and count pine trees with an accuracy rate of $\pm 94-97\%$ when compared to manual calculations in the field. The resulting error rate is in the range of 3–6%, which is generally caused by overlapping tree headers and the quality of the input data. In terms of time efficiency, the system is able to process data and display the calculation results in an average time of 5–10 seconds per dataset, much faster than manual methods which can take hours to days for large areas.

The results of this study show that the TreeCount website can be used as a solution to support pine forest management because it can increase time efficiency, reduce the potential for miscalculations, and provide spatial information in the form of tree coordinates digitally to support more effective and data-based forest management.

CONCLUSION

Based on the results of the design and testing on the TreeCount website that has been created, the conclusion is obtained, namely:

1. This website was created to make it easier for pine forest managers to quickly find out the number of trees in the managed area and to facilitate future decision-making. The use of digital maps to provide aerial visualization of tree locations and also managed areas.
2. The calculation of pine trees can be done automatically according to the uploaded data, the processing time depends on the filter used at the time of calculation.

ACKNOWLEDGEMENT

In compiling this report, the author would like to express his deepest gratitude to all parties involved who made it possible for this report to be completed on time, including: The two parents who always provided extraordinary moral and material support to the author, made it possible to complete the final report of this project. Dr. Ir. Muhammad Nanang Prayudyanto, M.Sc. as the Dean of the Faculty of Engineering & Science, Ibnu Khaldun University Bogor, Fitrah Satrya Fajar Kusumah S.Komp., M.Kom as the Head of the Computer Engineering Study Program, Faculty of Engineering & Science, Ibnu Khaldun University Bogor, Dr. Erwin Hermawan S.Si., M.Sc. as the head of the Geospatial Information Technology specialization laboratory, Dr. Puspa Eosina S.Si., M.Kom. as the main supervisor who always helps, provides direction, and guidance to the author, Sahid Agustian Hudjimartu S.T., M.Kom. as a co-supervisor who has provided a lot of guidance and input in each process of completing this final project, All Lecturers and Staff within the Faculty of Engineering & Science, Ibnu Khaldun University Bogor, especially the Lecturers and Staff of the Computer Engineering Study Program, and friends of LAB GIT who have given encouragement and motivation to the author to complete this final project, the author prays that Allah SWT will give His Grace and Grace to all parties who have assisted the writer in completing this final project report. The author is also aware that this final project still has many flaws, therefore any constructive suggestions and feedback will be well received.

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