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Tree Sense Imaging - Web Application Using Deep Learning

Abijith T[1], Asif K A[2], Ms. Dharanika S[3]
[1,2] Dept.Artificial Intelligence & Data Science, St Joseph's College of Engineering, Chennai, India
[3]Associate Professor, Dept.Artificial Intelligence & Data Science, St Joseph's College of Engineering, Chennai, India
Email ID: *abijitht2004@gmail.com[1], asifka958@gmail.com[2], skavitha2531@gmail.com[3]*

Abstract
This is the paper concerning TreeSense Imaging. It is a system that can be applied on the web where one can find and count trees automatically. The model adopted in the system was modified with ONNX technology. This is to say that individuals are able to view trees on their web browser. They are not required to have computers and servers in use. The TreeSense Imaging consists of various components.

- *The home page which is the initial one.*
- *A place where you can post the pictures of trees.*
- *A page indicating what the system thinks it discovered.*
- *A history of what the system has accomplished in the past.*
- *There is a section about information on TreeSense Imaging.*

TreeSense Imaging is quite useful to individuals who work with tree and to those who conduct research on trees. It assists them in carrying out the job to the completion. TreeSense Imaging is an application, used by forestry professionals and scientists that map with TreeSense Imaging. This should be more flexible to deploy than the traditional server-based systems because it has better accessibility, faster processing, and it is more flexible. On several datasets of forest images, the accuracy of the testing was recorded to be high exceeding 92 in the detection and counting of trees.

Keywords: *Tree enumeration, computer vision, deep learn- ing, ONNX, web-based AI, forest monitoring, object detection.*

1. Introduction

It is actually significant to monitor the forest and to count the trees, to care about the environment by figuring out the amount of carbon that the forests store and to ensure they are managed in an appropriate manner. The traditional method of using trees to measure this is very demanding in both efforts and time. It is not much accurate either when the forest is large indeed and there are numerous plants and trees that cannot be noticed clearly. Computers have recently improved at examining images and learning by them and although their details are still less advanced than those of humans, they have enabled us to come up with the means of detecting and counting trees using computer technology. This implies that we can have correct data faster to do the analysis and examine truly huge acres of forest. Due to this, it has become easier and more accurate in monitoring forests and counting the populations of trees. Recent progress with respect to artificial intelligence has shown excellent performance in object detection tasks. Such applications have worked in areas such as self-driving vehicles, medical image recognition and farm surveillance. Nevertheless, AI solutions in forestry are still problematic. These are high computational requirements, little or poor internet connection in the remote forest regions, and specialized technical requirements. The issue of systems is that they possess certain limitations. This paper is therefore discussing TreeSense Imaging. It is a web-based system that utilizes intelligence. The automatic capability of TreeSense Imaging can be achieved.

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Count trees. It works out everything, in your web. It uses models modified to ONNX so that they can run in a browser. This implies that you are not required to make use of any servers. This would render TreeSense Imaging highly helpful when you are outside with a location where the internet is not functioning very much or not at all.

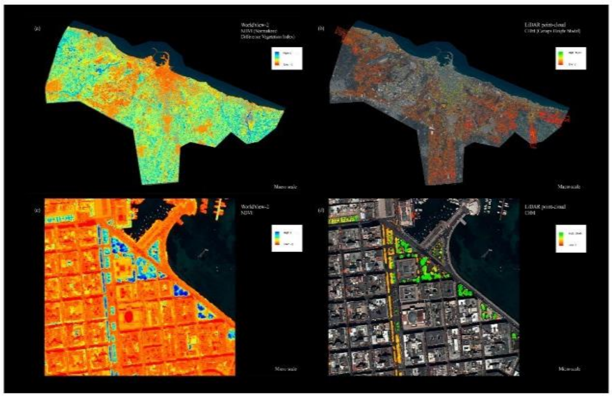

Figure 1 Land Classification

- We desire to create a site that will be able to enumerate trees independently. Computers will not have to assist this site in its work. Counting trees in the website will be self-reliant since it will have its system to count trees. We are discussing a tree counting place that is independent and operates over the internet only. The tree counting site will be, to count the trees and it will not require any external servers to operate well.
- Allowing the use of ONNX-optimized deep learning mod-els to support efficient real-time web browser processing.
- Creation of convenient interface that includes multiple pages, option to upload images, live analysis and visualisation of results and management of past records.
- Experimental analysis of a high-level of ac-curacy and dependable performance on different forest image datasets.

2. Literature Survey

This is how the computer vision of the forestry has evolved over the past decade. Now we are able to use computers and search and number trees by themselves. Initially individuals concentrated on how to see pictures such as identifying the edges of objects in accordance with shapes and examining the form of objects. These ways worked well in the setting but they failed with actual forests as they are too complex and contain numerous activities. Forestry The computer vision is improving. Detection became a great deal more precise with the utilization of machine learning techniques such as support vectors and random forest classifier. In these machine learning processes, objects such as the pattern of texture, color distribution and geometrical features were used to differentiate between the trees and the plants as well as the objects in the background. The machine learning algorithms, which utilize such manually de- signed features, cannot easily adapt to other forest types, light and imaging sources. Machine learning algorithms, such as support, and forest classifiers must have the capacity to evolve.

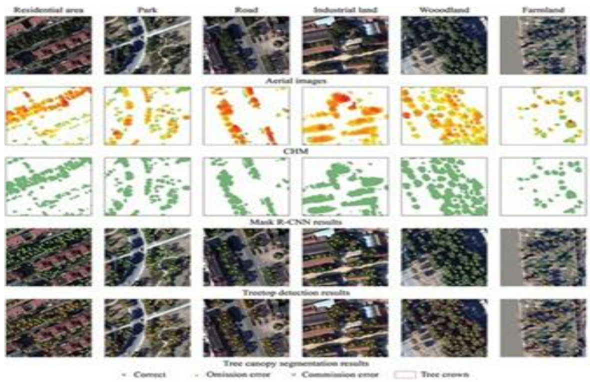

Figure 2 Tree Classification

Deep learning methods have the difference with computer vision in forestry. Particularly, it is the case with neural networks. These networks are exceptionally effective at such activities as locating trees and counting them. Other frameworks that are much more popular in object localisation, such as YOLO and R-CNN, do well on forest images. Another one that is doing a job is the Single Shot MultiBox Detector. Such techniques of computer vision, as neural networks, are quite useful in forestry. These models learn things so well by

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themselves. They are able to locate patterns which are difficult to discern. This implies that they operate well in types of forests when the light is distinct and the pictures would not be that clear. The models can know how to identify things under varying circumstances such as in a forest full of trees or in a forest of plenty of sunshine. These models are excellent in learning through pictures. They are able to work with quite poor pictures. The models are fine, at discovering patterns in images of woods. This helps them to work well.

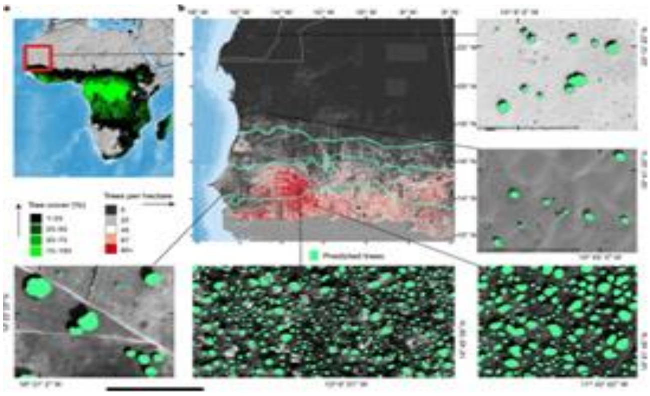

Figure 3 Identifying Trees in Object Detection Finding Trees Object Detection Training Finds Trees: Here, We Need to Identify the Trees Using Object Detection Training in Order to Find Them

Individuals have been researching on making deep learning models to perform better in areas where computing power is scarce. They are experimenting such as down-sizing the models with the help of accurate mathematics and teaching the models what they already know with the aim of consuming less power. In this manner the models can still be able to locate what they seek. They do not require so much power to do it. According to all these new ways of doing things, much of the methods that people are using still bring them back to a big computer somewhere that has no connection that makes it, effective in places that are long distances, out of cities or are without much technology. The deep learning models are yet to find their way in such places. Meanwhile, solutions that are based on AI and include the usage of the web have become popular because they are easy to use and are widely accessible. New software The current JavaScript machine learning frameworks, such as TensorFlow.js and ONNX.js, can now execute deep learning models directly in web browsers. Such transformation will reduce reliance on infrastructures, shorten reaction durations, and improve data confidentiality, which is why AI-based on the browser is especially suited to the forestry and environmental monitoring tasks.

3. System Architecture and Design

There are sections that combine to form TreeSense Imaging. People can use TreeSense Imaging easily because of this. It also performs effectively and does not fail to do what it is expected to do. There are five web pages in TreeSense Imaging application that interfere with each other. All these web pages, in TreeSense Imaging do something to ensure that everything runs smoothly in TreeSense Imaging. The system employs a client processing method, where the whole of computations are performed directly at the web browser of the user. This design eliminates processing delays and data privacy is preserved as images and analysis data remain on the local computer, thereby avoiding the reliance on third party servers.

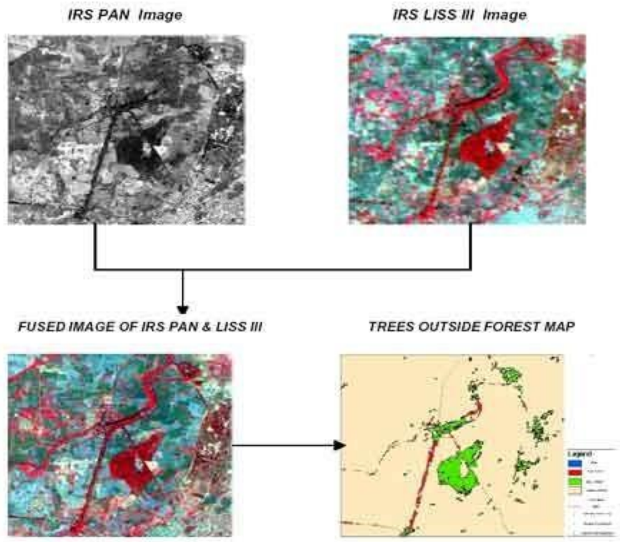

Figure 4 Wet Land and Green Land

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The overall structure consists of a number of key elements, including user interface, AI inference engine, data management module, and result visualization system.

3.1.User Interface Layer

These are five web pages that comprise the user interface. Something is done to the user in every page. The main page is index.html. It is where you start. It tells you about the system. The things you need are easily found and you can access the parts easily. We simplified the interface such that it is user-friendly. It implies that the user interface may be used by people who know a lot, as well as the ones who do not know much, when it comes to computers. People can use the system because of the ease of navigation of its user interface. The user interface is easy and straightforward to navigate hence allowing users to use the system. The input of images is done in the upload.html page. It allows uploading of images in a local storage and live image capture with the aid of a camera. The page has image preview functionality, supports formats checking, and image is automatically resized to enhance processing. It allows processing several images at once and drag and drop uploading pictures to facilitate the workflow as well.

3.2.AI Inference Engine

The AI system has an engine that is based on ONNX.js to execute learning models directly in the web browser. This engine regards a type of neural network known as a convolutional neural network or CNN in short to locate trees. The CNN has been created on the concept that the transfer learning is used with models that are already trained and effective. By so doing the system may locate trees greatly without consuming much computer power. In this way, the AI system ensures that it is good, at locating trees. Model optimization methods such as quantization decrease the memory and processing requirements to enhance efficiency and without much influencing accuracy. Normalization and data augmentation comprise the inference work- flow of images to ensure that it is more resilient. Administering post-processing algorithms, such as bounding box refinement and non-maximum suppression, achieve accurate and high-quality detection outcomes.

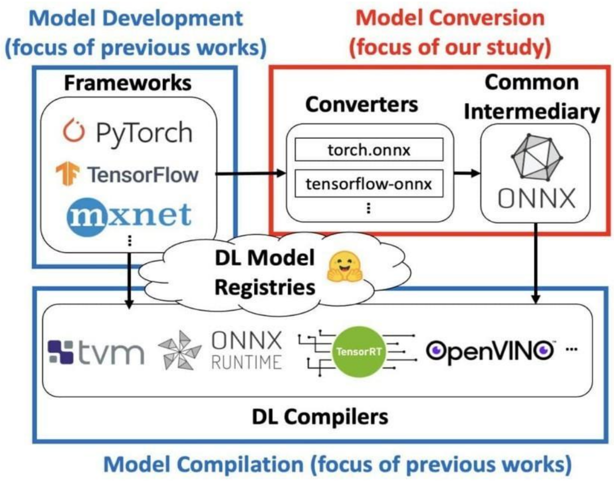

Figure 5 Data Flow Diagram

4. ONNX Model Implementation

It is very difficult to deploy models that utilize ONNX in a web browser. Also presents us with some fresh opportunities to do things. One of the problems TreeSense Imaging experiences in order to come up with a solution to is to create models that can be used with a lot of ease with tips that are really helpful and the smart way of handling the computers power. The ONNX models are used at TreeSense Imaging. They ensure that such ONNX models are functioning well. A version of the YOLO framework makes up the tree detection model. This version is well suited in the web browsers since it is fast. The model of the tree detection takes advantage of a model known as Mo-bileNetV2 to examine the features of things. The reason why this MobileNetV2 is an option is that it is effective with locating the trees and it does not consume excessive computer power. There is a technique involved in the part of the tree detector model which detects the trees. This method is referred to as -scale feature fusion. It assists the tree detection model to locate the trees of different sizes on forest pictures. This technique is good in detecting trees due to the fact that it is a tree detection model. The network structure comprises of 24 convolutional layers as well as the batch normalization and ReLU activation functions. It takes depthwise separable convolutions to reduce the computational and model size that further makes the model appropriate to browser-based and resource-constrained settings. Quantized form After quantization, the end model consists of approximately 3.2 million parameters and occupying approximately 12.8 MB.

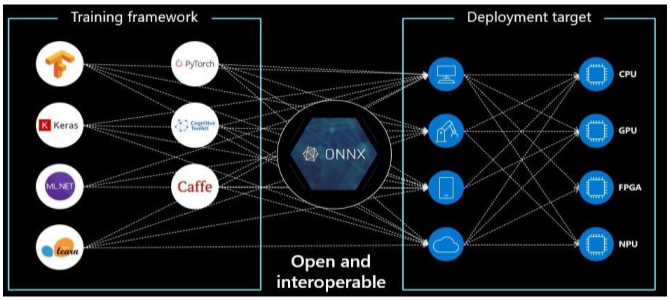

Figure 6 Neural Network

4.1.Browser Optimization

Executing learning models in a web-based format is quite difficult and it requires certain special modifications to ensure that it performs well on other platforms and other devices. It is ONNX.js runtime, and it is doing what can be described as WebAssembly to accomplish the math parts fast. It is similar to a computer language to facilitate heavy mathematic work. The system is also excellent in the area of managing memory and this means that it utilizes the computers memory in a manner and discards items that it does not require anymore. This aids in avoiding the issues with the memory as you are using it over a period, in deep learning models. Progressive loading has been employed in the system to ensure the user interface remains responsive. This is an attribute that enables the model to be loaded in the background without interfering with the user interactions. With further addition, caching is used such that the model is only downloaded once in a session. This arrangement will lower the network usage and enhance performance when repeated predictions are required.

4.2.Model Architecture

There are many preceding steps, which occur in the inference pipeline. After it makes a detection. These measures render the identification more precise and convenient to the user. When the system receives an image it automatically made the picture smaller such that it is 416, by 416 pixels. The system also ensures that the images appear identical so as to have equal data. The users can also add certain steps to the images such as data augmentation techniques in order to make the model operate in various scenarios. The significance of the inference pipeline and model is explained by the fact that it assists in the detection accuracy and the user experience of the inference pipeline. The system then applies post-processing procedures, such as confidence thresholding and non-maximum suppression, after inference. Such measures assist in the elimination of unnecessary or low confidence detections. The positions of the identified bounding boxes are reversed to positioned in the original imaging size. Every single de- tection is accompanied by a confidence score that assists the users to change the sensitivity of the system to suit personal requirements.

5. Web based Interface Design

The web-based interface emphasises on usability, access and visual intelligibility. It is also well kept and scientifically as well as commercially appropriate. Every HTML page serves a certain purpose in the whole user process. The navigation is user friendly and design features are consistent and unite the pages together.

5.1.Landing Page (index.html)

The homepage of TreeSense Imaging presents the visitor with the capabilities of the site. It informs them of the things it possesses and makes it easily accessible to navigate. This page has a great look as shown in any type of device such as desktops, tablets and phones. It is simple to navigate as it contains things that one can click on it and what to do is indicated. This will allow customers to discover the capability of TreeSense Imaging. Another vital information I found on the page is the system requirements, browser compatibility information, and quick-start instructions. This gives one who is using the tool a first-time user an idea of what the tool

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can do and what it cannot do. It has performance indicators and real-time updates of system status in which the users can have a clear idea of how much processing they can do and the approximate time taken to respond.

Table 1 Model Architecture Components

Component	Layers	Parameters	Output Size
Backbone	18	2.1M	19 × 19 × 576
Neck	4	0.8M	19 × 19 × 256
Head	2	0.3M	19 × 19 × 30
Total	24	3.2M	-

5.2.Upload Interface (upload.html)

In ways, the upload interface can be used to add images. The user is able to choose files in his computer. Use drag-and-drop. They are even able to make photographs using their camera. The upload interface design is essentially an issue of providing visual feedback to the users. It depicts them of the progress indicators. It also tests whether the image is the format or not and informs the user whether it is not. The upload interface goes to an extent of showing the users a preview as to the image. This is all aimed at ensuring that the process of uploading the image is improved to the benefit of the image upload. It is the post of the image, you know. The main points are batch processing, which enables people to import and work with a number of images simultaneously. The interface as well processes image resizing, automatic changing format and quality control so that it can perform well at the stage of processing. Effective error-handling systems provide proper granting of notifications in case of unsupported file format or corrupted images.

5.3.Prediction Interface (predict.html)

The prediction interface is quite nice in making guesses of things that are outside and present the results in a form that is easy to comprehend. Once you post a photograph it will indicate the trees that it identified and place a box around them all. and also it tells you how confident it is that it had discovered a tree and how many trees it believes there are in the picture. The page offers the option of changing the pickiness of the interface, regarding what it considers a tree. You can see the result in accordance with its certainty. The tool, the prediction interface, is a prediction interface that, also, helps you save the results in formats. It is all possible with the help of the prediction interface. It is possible to zoom, and pan in the visualization system, thus one can have a close look at detection details. The colors of bounding boxes change according to the confidence ratings, and the user is able to change the color scheme to meet his or her preference and accessibility. Summary statistics provide a visualization such as the count of the number of trees, mean estimation of the confidence metrics, and the geographic distribution of the detections in the image.

5.4.History Management (history.html)

The analysis is logged through the history management system. It will allow individuals to view outcomes and compare with one another. These results are also exportable to users under necessity. The interface is user friendly as one can easily locate what they want in the system. They can. Organize search results by such factors as the date of what the picture appears like and what the system detected.
One can retrieve previous, to modify some elements and make reports that make comparison between the old and new outcomes of the history management system. This is quite useful whereby users require to observe the way things have evolved over time using the history management system. It has the option of data export in different formats such as CSV, JSON, and PDF. All the historical data are stored locally on the device to ensure it is available across browser sessions as well as to guarantee privacy of the user. This implies that there exists no external servers required.

5.5.Information Pages (about.html, contact.html)

Information section gives in depth documentations, technicalities and contact material to the users. The about.html document has a clear explanation of the system methodology and accuracy metrics and the

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provisions of effective usage. The page called contact.html allows users to give their comments, claim problems, and explore the possibilities of cooperation.

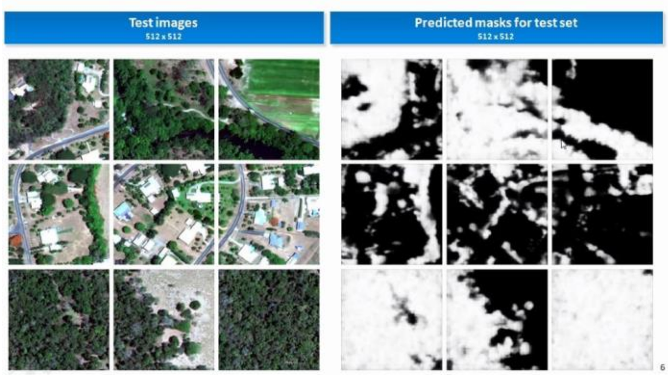

Figure 7 Predicted Marks

6. Experimental Finding and Assessments.

Detecting accuracy, processing efficiency and general user experience in a multi-scenario and multi-type devices combinations were evaluated using TreeSense Imaging by evaluating based on a variety of forest images.

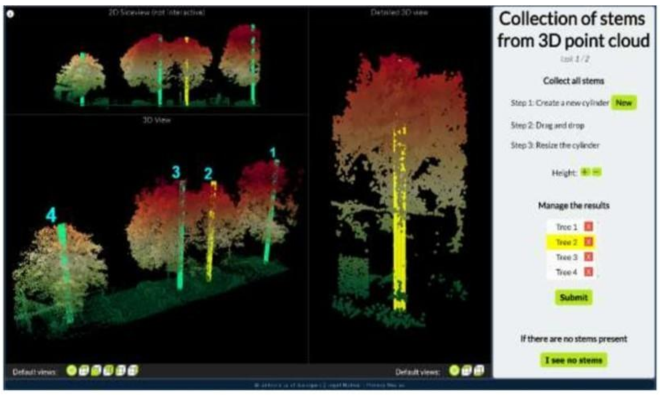

Figure 8 Heat Waves

6.1.Dataset Description

Those responsible (i.e., makers of TreeSense Imaging) used TreeSense Imaging on three sets of pictures:

- Forest-1K with a thousand images of forests taken in the air with the location of trees marked manually.
- Ground-Level Trees which contains seven hundred and fifty images of topography taken on the ground among various forests.
- Mixed-Scale Forest that consists of half a thousand pictures captured at various heights and with various degrees of detail.

These collections of images depict various kinds of forests, the type of trees the density of the foliage and frequent ways people insert pictures in the forest such that the TreeSense Imaging can be tested in numerous different conditions, the TreeSense Imaging and observe the effectiveness of the TreeSense Imaging as well. Forestry experts then annotated the ground truth to make sure that the reference data in terms of performance assessment was accurate. The differences in seasons, lighting and geographical locations are also presented in the datasets and gives the model a comprehensive test on its strength and generalization capabilities.

6.2.Accuracy Assessment

The TreeSense Imaging performance was evaluated based on how to determine the ability of something to find objects. This comprises such items like precision, recall, F1-score and mean Average Precision. When we examined all the test data TreeSense Imaging did not slack. It was 94.2 percent and it found the right things 89.8 percent of the time. TreeSense Imaging had the F1-score of 91.9 percent. These findings indicate that TreeSense Imaging is effective. It is good as the server-based solutions are good.. As well, Treesense Imaging is capable of running in a browser and therefore, it is more flexible and also easy to use. By examining the data in more detail, it was found that the model was more consistent between different types of forests and states in the imaging. The best accuracy was offered by aerial images due to increased separation of the trees and little occlusive. Ground-level images were even more difficult with partial visibility and the distortion of the perspective with even less, but still reliable, accuracy levels. Detecting errors analysis provided the main leading sources of challenges. These were a large amount of tree cover, very small trees or tree covers, that are too distant to be detected, and some instances of large shrubs or thick vegetation

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being mistaken for trees. In spite of these edge cases, the system was performing on similar performance to the consistency demonstrated by human annotators. This implies that the model has almost hit maximum functionality given the inherent uncertainties in some of the images of forests.

6.3.Performance Analysis

Computers and web browsers were used to test the system to determine its success in the real world. It took approximately 2.3 seconds to obtain results with good desktop computers. On mobiles it could take approximately 8.7 seconds. This implies that the system works well with things that we do on a daily basis. The system is compatible with hardware installed systems and web browsers. It is an effective system, of what we use daily. They did not experience any memory impairment even in extended sessions. The highest consumption was approximately 350 MB in loading and model inference. The system is very resourceful as the one cleaning up is also automated after processing. This guarantees their compatibility with other devices.

7. Experimental Finding and Assessments

We got 45 people to test TreeSense Imaging to test their opinion. These are people of forestry specializing, researchers and students whose knowledge level varied. They performed certain tasks through the use of TreeSense Imaging and then provided our thoughts by answering questions and also interviewed us through questions and dialogs. The respondents rated the system at 4.3 out of 5.0. The ease of use of the system is something that pleased people. They also enjoyed the fact that it is fast and can be taken even without being connected to the internet. The system is easily comprehensible. Individuals need not have to use the services of special programs or a server to view the images. The system is just easy to use. That is what people found likable in it. Constructive feedback has also identified some room of improvement which included enhanced visualization, export range support and expanded analysis findings. These lessons are very useful towards future updates as well as feature enhancements.

8. Discussion

TreeSense Imaging has a lot of competence in its field. This demonstrates that we may apply artificial intelligence on the internet in special jobs with trees. WithTreeSense Imaging can be used to correctly locate and count trees without relying on computers. The TreeSense Imaging system will address the issues that individuals face when attempting to preserve forests and ensure that they are of good health. One of the alternatives would be TreeSense Imaging since there are numerous advantages of it as compared to the conventional server-based solutions. The conventional systems typically need an internet connection which can be an issue. There are also certain privacy concerns with them since they need to transmit image information via the internet.. Being frank, their establishment is sometimes extremely tricky. TreeSense Imaging is not like that. It employs the browser-based strategy, which implies that it lacks such issues. The TreeSense Imaging provides you with competitive accuracy and performance even at the time. One such solution is TreeSense Imaging since it simplifies the process and resolves some of the major challenges with conventional systems. The TreeSense Imaging system consists of components that can be readily modified according to the requirements of the people who are exploiting it. Individuals using TreeSense Imaging are able to decide to add items to it such as special analysis tools or other methods of viewing the data without disrupting the primary items that TreeSense Imaging provides. This implies that TreeSense Imaging can be applied differently such as to conduct research in the school environment or maintain forests in a business environment. TreeSense Imaging is quite elastic. It is in that reason why it would be appropriate to most research and management forest jobs as well as TreeSense Imaging, which is used to administer forests. The existing constraints are reliance on the processing capabilities of the devices of the users, compatibility of the browsers and page size restrictions of the models due to the bandwidth used by downloading. The future work will be focused on the overcoming of these issues with the help of more

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optimization of the models and searching appropriate strategies of deployment.

9. Future Work

We looked at the results. What people told us. Now we know what we need to do. Our models we would like to make better. We are able to do it with the help of such mechanisms like attention and transformer-based methods. This will assist us to locate something in the right way. This is especially necessary in cases where things cannot be easily viewed such as in cases where there are many trees at one place or at least partially concealed. In such cases we have to ensure that our models are able to identify trees. One of the things that we are trying to detect is trees. More possible analysis tools like tree species classification, health analysis, and monitoring of growth, would make the system more applicable to forest management. Such advancements would be based on the available platform but have specialized characteristics to use in diverse applications.

Table 2 Dataset Characteristics

Dataset	Images	Trees	Avg. Density	Resolution
Forest-1K	1,000	47,532	47.5/image	1024 × 1024
Ground-Level	750	12,847	17.1/image	800 × 600
Mixed-Scale	500	23,165	46.3/image	Variable

The use of TreeSense Imaging as a progressive web applicant (PWA) would enhance the offline presence. It would also allow updating automatically as well as it would work better with mobile devices making the system more field-friendly. Last but not least, the introduction of collaborative capabilities to share data, perform comparative analysis, and continuously improve its models is also an excellent opportunity in the future. These features would foster further usage and keep on improving with the contribution of users.

Conclusion

TreeSense Imaging is an application, which assists individuals to use A.I. to observe forests and the surrounding. This system demonstrates that you can really apply artificial models of intelli-ance in your web-browsers. TreeSense Imaging does so without losing its fair portion of looking after what it is seeking. It is easy to use. The high-level is with regard to creating artificial intelligence for forestry and environmental surveillance without making it difficult. The analysis demonstrates that the AI solutions based on browsers are as efficient as the old-fashioned server-based systems. There are benefits of browser-based AI solution such as easy accessibility and privacy of data. They are quite malleable in regards to installing them as well. These data inform us that AI solutions based on the browser can be utilized in additional fields, primarily, those in which one wants to be capable of operating even when offline and has easy access to starting. In such cases, browser-based AI technologies comes in handy. The open structure and modular design of the system provided the good basis upon which future improvements and body will be made to adapt the system to changing requirements in forest monitoring and environmental assessment. Altogether, TreeSense Imaging demonstrates that AI tools in browsers can help to make high-tech tools of analysis more available to different communities of users.

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