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Tree-Cutting Detecting System Using Residual Neural Networks

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ABSTRACT

Trees are significant in that there are products that originate from them. Wood is the greatest product of trees together with other products like timber and paper. Carbonized wood produces charcoal that is energy used for cooking. Trees, as indicated above, have quite a range of importance and usage to the human beings, hence they are not usable while still intact. Due to this reason, people end up cutting down many trees to meet their needs like timber and charcoal. The problem is finding the culprits who cut down trees for their own selfish needs.

This paper discusses a solution to this challenge. This is the Tree-cutting Detection System designed to alert the forest authorities when there is tree-cutting going on in the forest. There is detecting device placed in the forest to listen to whether there are chainsaw sounds or not. When it detects chainsaw sounds, meaning there is tree-cutting going on, the forest authorities are alerted through an alarm and the location of the device that signal them is given so as to access the scene easily and faster.

The development methodology adopted in the implementation stage was an agile approach. The solution was the designed and developed through several iteration phases of feedback and improvements of functionalities. Finally, testing of the system done severally during development and after the system completed.

Keywords: Algorithms, Tree-cutting, Residual neural networks, neural networks

I. INTRODUCTION

Trees are woody plants that regularly renew their growth and have a single self-supporting trunk containing woody tissues. In most tree species, the trunk produces secondary limbs, called branches. Trees have a significant role with their existence in the environment. Forests are a collection of trees that planted or growing close together, help to stabilize soil and control erosion in mountainous and hilly regions. Trees also protect and conserve water supplies and prevent floods. The existence of trees significantly contributes to the recycle of nutrients, absorption of carbon dioxide and refreshment of oxygen.

Moreover, trees are significant in that, there are products that originate from them. Wood is the greatest product. They also produce other products like timber and paper. Carbonized wood produces

charcoal that is energy used for cooking. Pine and kauri gum produce gums that eventually forms amber. In addition, trees provide food for humans and animals in that they produce fruits and nuts for their nutrition. For primitive people, trees give different items like roofs from palm trees. They use parts of trees as clothing and utensils like calabashes from trees as well. Therefore, trees are important in the environment of human beings and animals [1].

Trees, as indicated above have quite a number of importance's and usage to the human beings and they are not while still intact. Due to this reason, people end up cutting down trees to meet their needs like timber and charcoal.

According to the Laws of Kenya, only trees from private farms are to be cut down and not the trees from public community forests. Since trees are important to our environment, they need protection from any kind of harm like cutting or burning them. The Kenya Forest Service (KFS) is a corporate body established under the Forest Conservation and Management Act no 34 of 2016 gave the Service's mandate as "to provide for the development and sustainable management, including conservation and rational utilization of all forest resources for the socioeconomic development of the country and for connected purposes" [1].

The big challenge is that this authority cannot know or keep track of when the cutting down of trees is occurring; hence they can neither stop the loggers nor punish them. This makes the loggers get away with the crime and are encouraged to cut down more trees, therefore increasing the number of trees cut down.

The harvesting of trees goes on only in private farms, which makes the illicit tree-cutters easily cut down trees from public community forests and later claim that they harvest the trees from private farms [1]. This becomes a challenge for KFS as they try to establish whether the trees cut down are from private farms or public community forests.

KFS are always looking for ways to get hold of illegal loggers but this is a difficult task because getting them in the act and punishing them is mostly not possible. This is because these loggers sneak into forest, cut down trees with different techniques and get away with their act of crime. This encourages others loggers to also cut down trees assuming that they will also not be caught.

The loggers caught with logs cut from public forests during road or highway patrols; claim that the logs are from private firms where one has the liberty to fell trees for many purposes. Therefore, this makes the controlling of illegal logging of trees difficult since loggers tend to get away with the act.

Recent research shows that there are existing systems in this field that assist in curbing this great challenge. They include Acoustic Surveillance of Forests and Acoustic Signal Classification for Deforestation Monitoring.

A. Acoustic Surveillance of Forests

This system uses Wireless Sensor Networks (WSN) that acoustically monitor the logging of trees in the forests. The microphone captures sound events and the acquired audio samples forwarded to a server for further processing. Logging sounds captured from any distance using the microphones, together with additive forest sounds and environmental noise. On the server side, the captured audio signal transmits on a wireless network from a monitoring station m. It is pre-processed and parameterized before being analysed by machine learning methods for classification to detect logging sounds. The detection is performed using pre-trained acoustic models for logging and the classification is binary, i.e., detection of logging sounds or not. Once a logging activity detects, an alarm activates to inform forest authorities [2].

B. Chainsaw Sound and Vibration Detector System for Illegal Logging

This application works when the sound and vibrate sensors detect the trees that were cut by receiving the chainsaw sound frequency and detecting vibration values. If the sensor received a sound frequency and vibration value from the sensors. The microcontroller, Arduino Uno processes the sound signal. The GSM module will receive data from the Arduino Uno and send a message via SMS immediately. The mobile device will receive output sent by the GSM module [3].

II. METHODS AND MATERIALS

A. Development Methodology

The development methodology used an agile approach. This is because agile is a more suitable software development approach based on its values, principles, and core practices. The four values it adheres to are communication, simplicity, feedback, and courage.

The skills needed and used were mainly machine learning techniques, Internet of Things (IoT) techniques and sufficient implementation time. While implementing and developing the solution, there was need for iterations in the coding, testing and feedback stages. Finally, the implemented solution worked as expected.

The tools needed were sound sensors, Arduino, GSM module and GPS module. The sound sensor listens and captures the various sounds in the forest. It then sent the output to the microcontroller for classification. The Arduino processes the values and information received from the sensor and sends them to the machine-learning model for processing and classification. The GSM module connects the detecting device and the cloud server. The GPS module sends the location of the detecting device in form of latitudes and longitudes in order to calculate the shortest path and keep track of the coordinates.

The tree-cutting detection solution involved an IoT-based detecting device, machine-learning model and a web-based monitoring platform.

A. Detecting Device

The detecting comprises of the sound sensors, Arduino, GSM module and GPS module. Sound sensor captures the sounds coming from the forest. The detection device sends the latitudes and longitudes by use of the Neo6m GPS Module while the Sim800L helps with the network connection to the GPS data then to the web server.

B. Machine-learning Model

The first step is reading the dataset from disk into memory. The manually divided dataset gives the training, testing and validation data beforehand. The corresponding paths to the training, validation and testing datasets is then stored into variables.

The functions defined are loaded on the folders containing the forest audio files into memory. The forest audio files divided into arrays then chainsaws merged at random positions. The merged audios converted into spectrogram, fed into the model as the input.

Once the training, testing and validation dataset converted to spectrograms, they shuffled using the Random import. The chainsaw sounds placed at random positions within the natural forest audio. Shuffling prevents the model from mastering the dataset because the dataset ordered with consecutive benign images followed by malignant images and this would result in poor training of the model. There was no shuffling for the testing dataset because it helps with drawing inferences from the model. It also assists to predict the audio that converted to spectrogram after training and validation.

The sound is the classified as either 1.0 or 0.0. The 1.0 represents that there is chainsaw sound in the audio and 0.0 represents that there is no chainsaw sound in the audio. The result was used to tell whether there is tree-cutting going on (1.0) or not (0.0). If 1.0, then a notification sent to the forest authorities in the form an alarm alert and the specific location of the device that sent the sound.

C. Web-based Monitoring Platform

The web interface uses Google maps API to show the live locations received from GPS module in the detecting device. The forest authorities use this interface to monitor the locations of all detecting devices that are in the forest. The devices appear as location markers on the map.

In case the model classifies the received sound as chainsaw sounds (1.0), meaning tree cutting is ongoing, the colour of the location markers will change, appearing different from others and also an alarm will be raised to alert the authorities.

III. RESULTS AND DISCUSSION

A. The Implementation Environment

The hardware specifications included an Intel or AMD equivalent i7 or better processor, 7th generation or newer (Virtualization must be supported) and a 1920×1080 or greater screen resolution. Additionally, a 256GB or larger Solid-State Drive (SSD), 16GB of RAM recommended, a dedicated Graphical Processing Unit with at least 2GB of RAM, Arduino Uno R3, Sound Sensor, Neo-6M-1-001 GPS Module and a Sim800L GSM Module. Furthermore, the web and database server requirements used to host the project were A CPU with a clock speed of 2×2.50 GHZ, 16 GB of RAM and 200 GB of disk space for cache.

The software specifications used in the implementation included MySQL (fast, easy-to-use RDBMS being used for many small and big businesses (Anon n.d.). These stores the GPS data received from the GPS module) and Google Maps API (used to convert GPS coordinates sent by the GPS module into addresses that are pinned on the map for easier identification).

B. Detailed System Implementation

This section explains the modules of the system, showing how the solution was developed. The Forest Authorities module is where the authorities keep track of the detecting devices' locations and receive alerts in case tree cutting is underway.

Fig 1: Web Based Platform

The web interface uses Google maps API to show the live locations received from GPS module in the detecting device. The forest authorities use this interface to monitor the locations of all detecting devices that are in the forest. The devices appear as location markers on the map. In case chainsaw sounds detected, meaning tree cutting is ongoing; the colour of the location markers will change, appearing different from others and an alarm raised to alert the authorities.

The detecting device module detects the sounds and classifies whether it is chainsaw sounds or not and sends the location of the device to the forest-authorities module. Some of the components involved include GPS and SIM800L Connection to Arduino and the Sound Sensor Connection to the Arduino.

The GPS and SIM800L Connection to Arduino establishes the connection as a GPS tracker that sends GPS data to the web server which in turn displays them on the map in form of location markers showing the location of the Detecting device. The latitudes and longitudes of the Detection device position sent by the Neo6m GPS Module while the Sim800L used for Network Connection.

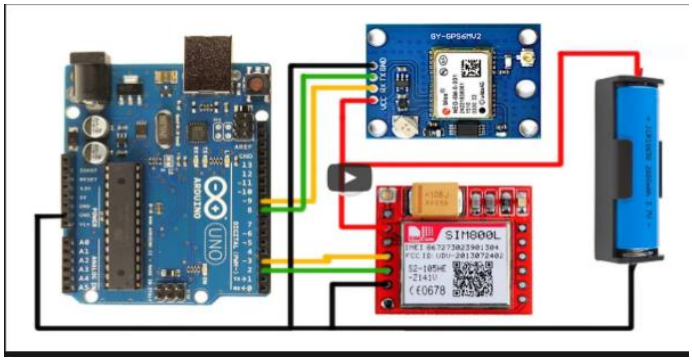

Fig 2: GSM and GPS module Connection to Arduino

The Sound Sensor Connection to the Arduino captures/listens to the sounds coming from the forest. The sound captured is sent as an audio and fed into the machine-learning model in the cloud. The model processes and classifies the audio as either chainsaw or not. If it is chainsaw, a signal sent to the web application in form of danger, alerting the forest authorities in form of an alarm and location of the device sending signals.

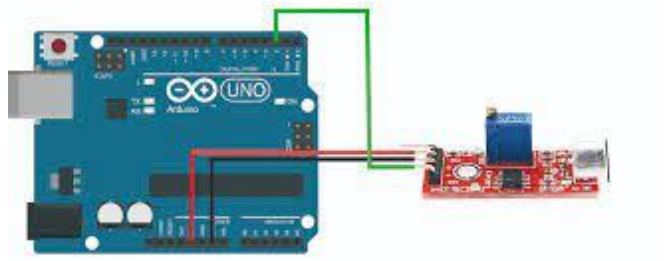

Fig 3: Arduino to Sound sensor Connection

The detection device module captures the sounds in the forests and sends it to the machine-learning model in the cloud for processing and classification.

The first step was reading the dataset from disk into memory. The manually divided dataset helps in training, testing and validation of data beforehand. The corresponding paths to the training, validation and testing datasets was then stored into variables then functions were defined to load the folders containing the forest audio files into memory.

The forest audio files divided into arrays then chainsaw audios merged at random positions. The merged audios converted into spectrogram then fed into the model as the input. Once the training, testing and validation dataset converted to spectrograms, they shuffled using the Random import. Shuffling prevents the model from mastering the dataset because the dataset ordered with consecutive benign images followed by malignant images and this would result in poor training of the model. No shuffling done on the testing dataset because inference by the model predicts on audio that converted to spectrogram after training and validation. The result was used to tell whether the audio played was a chainsaw or not, then send signal to the Arduino to send GPS location to the web server.

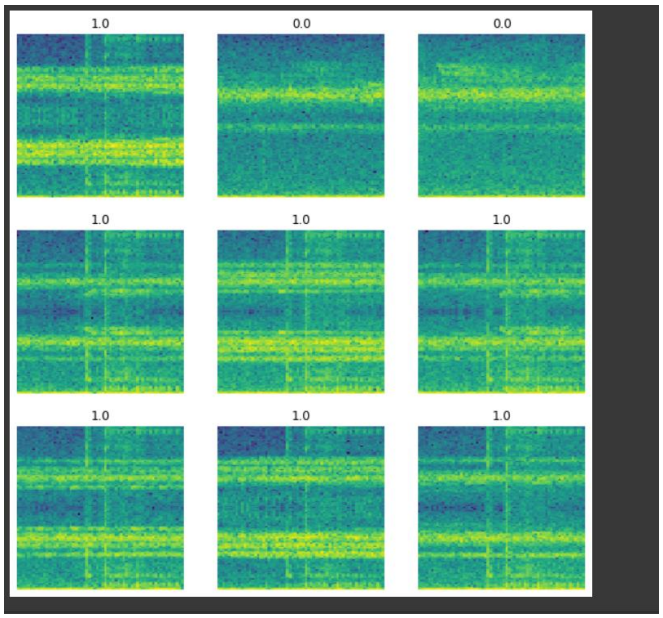

Fig 4: Results of the Machine-learning model

White boxing testing is testing of software solution's internal structure, design and coding. This type of

testing focuses mostly on verifying inputs and outputs through application, designing design and usability [4]. During the training of the model, the white box testing follows. The weights and performance metrics used to improve the performance of the model. Data preprocessing ensures that the data expected by the model is in the size, shape and type.

Black Box Testing is a software testing method in which the functionalities of software applications tested without having knowledge of internal code structure, implementation details and internal paths. Black Box Testing focuses on input and output of software applications. It is based on software requirements and specifications [5]. (Hamilton, 2020b). During the prediction stage, the saved model predicts on an out of sample dataset. The testing dataset goes to the model and predictions made without any modification to the model. This type of testing carried out when testing the web application that has the model.

The different test cases used in the testing process are on table…

TABLE 1: SYSTEMS TESTS

Test Case	Description	Result	Test Verdict
Playing forest audio without chainsaw sound	Natural Forest audio played to the sound sensor to classify if there is a chainsaw sound.	The LED turns off indicating to chainsaw sound	Pass
Playing forest audio with chainsaw sound	Natural Forest audio played to the sound sensor to classify if there is a chainsaw sound.	The LED turns on to indicate that is chainsaw sound	Pass

IV. CONCLUSION

Due the increasing number of trees being cut-down in the forests, this paper highlights the use of technology in order to reduce the number of trees that get to be cut down in the Kenyan public forests. It does that by capturing the sounds in the forest, processes the sounds and detects whether it is a chainsaw sound or not. If confirmed that is a chainsaw sound then, it means tree cutting is going on hence the forest authorities receive the necessary alerts.

Tree-cutting detection solution was developed using an agile approach. The skills and technologies required for the project were first assessed examined. The system was the designed and developed through several iteration phases of feedback and improvements of functionalities. Finally, the solution was tested severally during development and after the system was completed.

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