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Zoning Map Generator Using Machine Learning and Remote Sensing

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Abstract:

A huge percentage of the population worldwide now lives in crowded cities which have grown organically over the years, leading to a low quality of life. The solution proposed to this problem years ago was Zoning and Urban Planning. But today this process faces a lot of bottlenecks mainly due to human inefficiency, the 3 main steps in Zoning are Surveying, Auditing and Enforcing. We propose to automate the steps of Surveying and Auditing of cities zoning codes. We propose to do it using publicly accessible high resolution remote sensing satellite imagery of a city's structures and analyzing them using a Deep Learning model. Also we intend to build an easy to use web interface to broadcast the results of the model to both, the concerned authorities and the citizens of a particular city.

Keywords **—Zoning Classification, Map Generator, Remote Sensing , Machine Learning.**

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I. INTRODUCTION

In urban planning where local governments like municipality or metropolitan level government, divide the city's land or localities in different divisions called zones. And each zone has some unique regulations for new construction and existing structures which are different from other zones. Zoning occupies a huge percentage of all of the work done by town planning and enforcement authorities. And surveying and auditing is the most prominent of all the work done by these organizations. The method of auditing by municipal inspectors is not possible now because cities are getting bigger day by day. In India the MMRDA which is the authority for Mumbai, Thane, KalyanDombivali, Navi-Mumbai etc, with a combined population of 29 million. It's difficult to survey this large population manually, it's also a waste of time and resources. And we intend to automate the process of surveying and inspecting the zones in any city, in any part of the world using machine learning and remote sensing data.

II. LITERATURE SURVEY

The tables below show the work done by the others authors which are useful and related to our work.

TABLE I
COMPARISON OF DIFFERENT ALGORITHMS FOR ZONING CLASSIFICATION AND RECOMMENDATION

S.No	Title	Year of Publication	Dataset	Algorithm	Accuracy	Improvement
1	Flood risk assessment using multi-sensor remote-sensor data and GIS	2018	Government based dataset.	Machine learning based geospatial approach	The estimated success rate 89.7%.	Its only usefull for ocean region.
2	Mapping urban land use in India and Mexico	2021	European Environment Agency (EEA) dataset	LULC , cloud-based algo.	For Pune F2 Accuracy score- 6 category is 0.4413	Performance is not up-to -the mark.
3	Land-Use Land-Cover Classification	2020	stretch of riparian landscape of the river dominated by patches.	Machine Learning Classifiers for Satellite Observations	RF is better than ANN.	Not enough Algo. Is used to make necessary accuracy.
4	Classification for urban land use	2020	GEOBIA, texture and landscape metrics	Random Forests and bottom-up multiresolution segmentation	92.3% and 0.896 of kappa coefficien	It's only for the forest area.
5	Understand economic well-being in Africa	2020	DHS and Census	DBSCAN Algorithm	Proposed system can provide users	Not Urban Datasets.

6	Zoning additive manufacturing process histories	2019	UC Merced	support vector machine, unsupervised machine learning	Content Based Filtering gives 93% accuracy	Deep learning and neural networks will be used for better accuracy.
7	Zoning eco-environmental vulnerability for environmental management and protection	2018	Real time data	Support vector machine	Proposed system gives an average performance of 91 %.	Datasets not adequate.
8	Land-use classification	2020		CNN	Estimated accuracy is 94%	The combination of bagging and RNC improves both recall and precision.

III. PROPOSED SYSTEM

A. Algorithms

Below table shows Various algorithms which we used for comparison, their accuracy and confusion matrix.

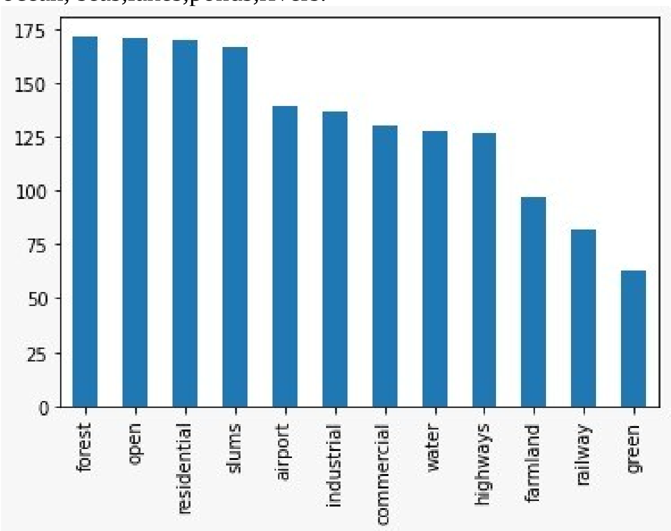
TABLE II
COMPARISON OF DIFFERENT ALGORITHMS BASED ON THE ACCURACY

Name	Time	Value Loss	Accuracy
VGG-16	44 sec	0.1219	97.47%
VGG-19	46 sec	0.1339	96.52%
Resent	59 sec	0.2510	94.30%
MobileNet	45 sec	0.7404	94.94%

B. *Datasets*

We will be creating a dataset with the given classes with at least 150 images per class, it will be suitable for classifying images of indian cities.

1. Residential which include single-family housing, multi-family residential or mobile homes.
2. Commercial/ Institutional property is real estate that is used for business activities.
3. Industrial is a group of structures that are related based on their primary production activities. e.g. Industrial sectors, factories, etc.
4. Slums consist of densely packed housing units of weak build quality.
5. Open spaces means unused grounds or barren land.
6. Green spaces means playground, gardens, park.
7. Farmland is an area of land that is devoted primarily to agricultural processes with the primary objective of producing food and other crops.
8. Forest, those ecosystems that have a tree crown density of 10% or more and are stocked with trees capable of producing timber or other wood products.
9. Railway is a means of transport, on vehicles which run on tracks(rails or railroads).
10. Runways are a paved strip of ground on a landing field for the landing and takeoff of aircraft.
11. Highway is the quickest route for driving between one city and another.
12. Waterbody is any significant accumulation of water. e.g. ocean, seas,lakes,ponds,rivers.



IV. DESCRIPTION

A. Convolutional Neural Networks

A convolutional neural network (CNN) is a form of artificial neural network that is specifically intended to process pixel input and is used in image recognition and processing.CNNs are image processing, artificial intelligence (AI) systems that employ deep learning to do both generative and descriptive tasks, often including machine vision, which includes image and video recognition, as well as recommender systems and natural language processing(NLP).

A CNN employs a technology similar to a multilayer perceptron that is optimised for low processing requirements. An input layer, an output layer, and a hidden layer with several convolutional layers, pooling layers, fully connected layers, and normalising layers make up CNN's layers. The removal of constraints and improvements in image processing efficiency result in a system that is significantly more effective and easier to train for image processing and natural language processing.

B. Remote Sensing

In contrast to on-site observation, remote sensing is the collecting of information about an object or phenomenon without making direct contact with it. The phrase is used to describe the process of gathering knowledge about the Earth and other planets. Remote sensing is used in a variety of fields, including geography, land surveying, and most Earth science disciplines (for example, hydrology, ecology, meteorology, oceanography, glaciology, and geology), as well as military, intelligence, commercial, economic, planning, and humanitarian applications.

The phrase "remote sensing" now refers to the detection and classification of objects on Earth using satellite or aircraft-based sensor technologies. Based on propagating signals, it includes the surface, atmosphere, and seas (e.g. electromagnetic radiation). It can be divided into "active"remote sensing (when a signal is emitted by a satellite or aircraft to the object and its reflection is detected by the sensor) and "passive" remote sensing (when a signal is emitted by a satellite or aircraft to the object and its reflection is detected by the sensor).

C. Web Maps

The technique of using maps given by geographic information systems (GIS) on the Internet, more especially the World Wide Web, is known as Web mapping or online mapping (WWW). A web map, often known as an online map, is both delivered and consumed, making it more than merely web cartography; it is a service that allows users to choose what the map will display.

Web GIS places a greater emphasis on geodata processing parts of design, such as data gathering, and server software architecture, such as data storage and algorithms, than on end-user reports. The terms web GIS and web mapping are still used interchangeably. End users who are web mapping gain analytical capabilities, and web GIS uses web maps. Web mapping of consumer goods and services is referred to as location-based services. A web browser or another user agent capable of client-server interactions is commonly used for web mapping. Its evolution is being driven by questions of quality, usefulness, social advantages, and legal limits.

D. Keras

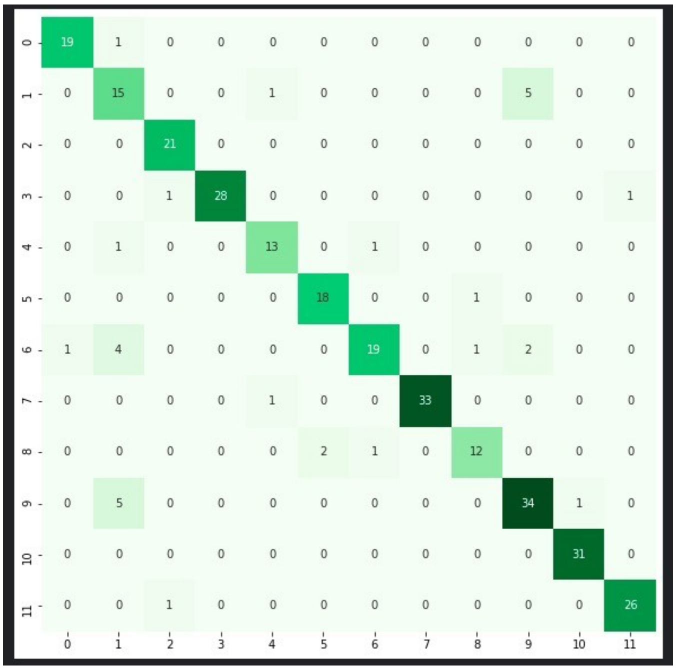
Keras is an open-source software library for artificial neural networks that includes a Python interface. Keras serves as a user interface for TensorFlow. Keras supported a variety of backends up until version 2.3, including TensorFlow, Microsoft Cognitive Toolkit, Theano, and PlaidML. Only TensorFlow is supported as of version 2.4. It is user-friendly, modular, and expandable, with the goal of allowing quick experimentation with deep neural networks. It was created as part of the ONEIROS (Open-ended Neuro-Electronic Intelligent Robot Operating System) research project, and François Chollet, a Google engineer, is the principal author and maintainer.

Keras includes many implementations of standard neural-network building blocks like layers, objectives, activation functions, optimizers, and a slew of other tools to make working with picture and text data easier while also reducing the amount of coding required to write deep neural network code. The code is maintained on GitHub, and community support forums include a Slack channel and a GitHub problems page.

V. IMPLEMENTATION AND RESULTS

As, we have used VGG-16 for our project, the following method is used for calculating the accuracy using the confusion matrix for our project. We have observed accuracy of 84% for this model.

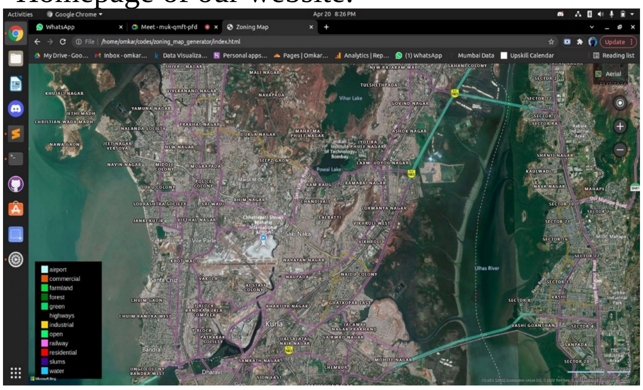
Accuracy of the model:



X-axis shows the predicated value, Y-axis shows real value.

Color code for the different Zones:

Homepage of our website:



After Implementation:

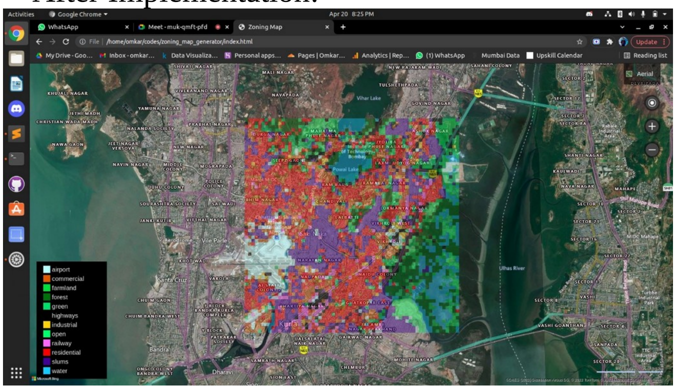
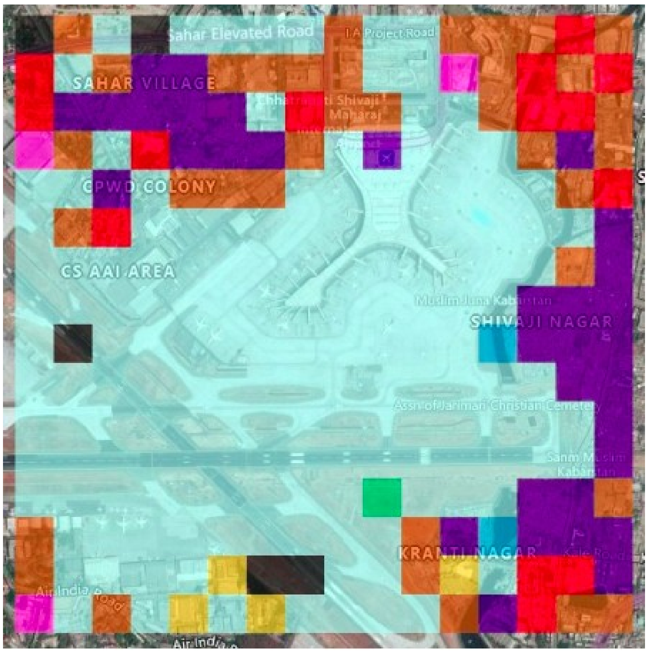
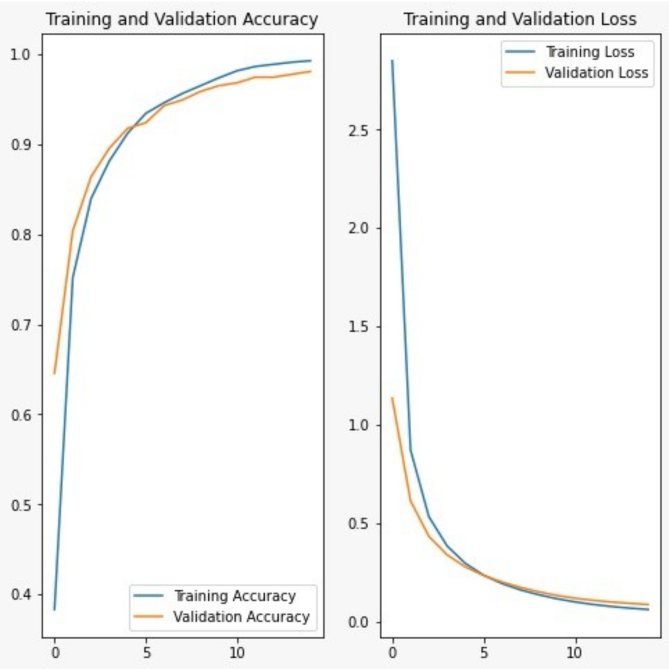


FIG. REAL IMAGE

FIG. ZONING CLASSIFICATION



ACCURACY GRAPH



VI. CONCLUSIONS

The web map generated by our model clearly shows the success and accuracy that our module has achieved.

Similar tiled map for a larger area can create a solution to major Zoning and Urban Planning Issues.

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