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ROAD DETECTION AND EXTRACTION USING HIGH RESOLUTION SATELLITE IMAGE

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Abstract: Object detection has increasing attention within the field of remote sensing image analysis. Advance background, vertical views and variation in target kind and size in remote sensing images create object detection difficult task. Also, road is the important object for detecting and extracting using high resolution satellite image. As road plays important in geographic information system. In urban space road is essential infrastructure connecting different areas and also play important role in human civilization. Detection and extraction of road from aerial and satellite imaginary has gained and increasing attention. Road network has key role in development of transportation, road navigation, unnamed vehicle, geodata update, land use, land cover analysis and urban planning. Due to natural disaster like flood, earthquake it is necessary to check the quality of the road. It required large amount of time to check quality of road manually and it generate error. So, developing new method to road network from high resolution remote sensing images would be beneficial to geographical information system (GIS) and intelligent transportation system (ITS). With Development of Remote sensing technology, high resolution satellite image improve and obtain easily from which road can locate road accurately. Road recognition from remote sensing imaginary has two part: first is road detection and second is road extraction. This study aim to understand the deep learning and machine learning based method with the help of high resolution satellite image for detection and extraction of road.

Index Terms **– Remote sensing, machine learning, image processing.**

I. INTRODUCTION

A geographic information has an important in our day to day life and widely used in many field. Keeping GIS data updated is the challenging factor, and traditional method such as surveying and mapping are difficult to use. With the development of remote sensing, satellite data can be used to locate and identify ground object within GIS. High resolution satellite image can observed the small changes of the earth's surface on a small space scale. Road is the most important man-made object and has a significance in landscape and transportation. Identification of road in remote sensing is important research. It has various application such as navigation, unnamed vehicle, and urban planning. Research differs in the resolution of input images, the primitives employed for road identification, experiment configurations, way of processing, general assumptions, and so on. But the measure problem is the complex image of satellite image which contain the road, building, houses, tree etc. as the each object has its own feature and spectral and geometrical properties. The road on the high-resolution image shows a narrow and continuous region with grey scale and geometric features slowly changing. The ideal road characteristics are as follows: geometric, functional, and photometric topological, contextual. [1] [2]

Geometric feature: Geometric function has a wide aspect ratio, continuity in width, little continuity in width is comparatively uniform. The length to width ratio of a road in an image can be understood to be greater than any constant.

Photometric feature: Photometric Function emphasize the difference between road and non-road edges. The two visible edges lines of the path have a perfect gradient of ground.

Topological feature: network of road is not interrupted. Generally, a road has intersections.

Contextual feature: road associated image function refers to the contextual attribute. It is possible to use urban road or rural expressway to determine by car because road tress along the road is relatively single, road surface is not covered.

Functional feature: In real world there is specific function for road. The cycle lane, truck lane, pose as functional units. it must have some constraint conditions in order to realize those function.

Road is essential infrastructure in urban space that connect different areas and has the role in management of human civilization, traffic management, and emergency management. Rapid changes in road network and for instant road mapping, it is required to detect and extract road network.

II. Related Work

A different techniques for road extraction and detection have been Proposed in different studies. The relevant structure of the study is as follows:

G.kumar, D.murgan,et.al (2018) have used Otsu method and genetic algorithm to detect road from satellite image. The empirical evaluation of two algorithm suggested that genetic algorithm is capable for extracting majority of road network and get better result. The presence of bushes and tree decreases the accuracy of result. The algorithms would cluster trees that are very close to each other, causing an error in the final detection of roads.[3]

P.Yadhav and S.Agrawal (2018) has extracted roads using Outs segmentation method. Along with they used connected component analysis and morphological operation. Result obtain has the extraction and detection of road. However, areas connected to road network could not been removed by this methodology.[4]

Pankaj Pratap Singh and R.D.Garg (2013) has extracted and detected the road by using adaptive global threshold with high resolution satellite image. Minimize detection of aforementioned pixels by applying certain morphological operations. The approach is based on intensity values of the pixel, which induces the detection of certain unwanted objects. Using road tracking algorithm it removed non-segment area. Correctness and completeness values of quality assessment parameters are calculated as 96.52 and 95.32 respectively, which show degree of road network extraction. However, in some cases misclassification take place such as barren land and parking areas and classified as road5]

Beril sirmac,ek and cem unsalan (2010) has extracted and detect the road by using canny edge forming the spatial voting matrix and tracking. Method of road network extraction is tested on six images having different characteristics from iksons. In these test images the total length of the road network is 12608 pixels. Method was able to detect Without applying the tracking step 78.85[6]

Jiuxiang Hu, Anshuman Razdan, et.al (2007) has proposed the method for extraction of road network and intersection detection from aerial image by tracking footprint. This paper has, to identify the intersection of road and to extract the inscribed lines of road network used an adaptive unsupervised approach .Road tree pruning approach efficiently trims the paths that leaking into the road surroundings, significantly enhance the performance of our road tracker, and increases correctness and quality of the results obtain. [7]

He Youquan and Qiu Hanxing,Wang Jian et.al(2011) has proposed method for crack image detection of road based on the mathematical morphology. This paper has a mathematical morphological operation to detect crack on the road from the image. This method mainly serves to repair and prune crack road image for pre-segmentation. It effectively suppress noise, but extracts the edge of image clearly and accurately, and solves image edges damage by noise removal. It not only effectively suppresses the noise, but it clearly and accurately extracts the edges of cracks. [8]

X. Yu and E. Salari proposed method for Pavement Pothole Detection and Severity Measurement Using Laser Imaging. This paper has an image processing module for extracting regions of laser colour from an image. Following the extraction of laser line for deformation different image processing technique used for detecting pothole using a laser pattern.[9]

III. Methodology

Roads are often represented as continuous and elongated homogeneous region with almost constant width in aerial and satellite images. Geometric road parts shapes also play a key role in road identification. The proposed methodology for road detection and extraction is shown in figure 3.1.

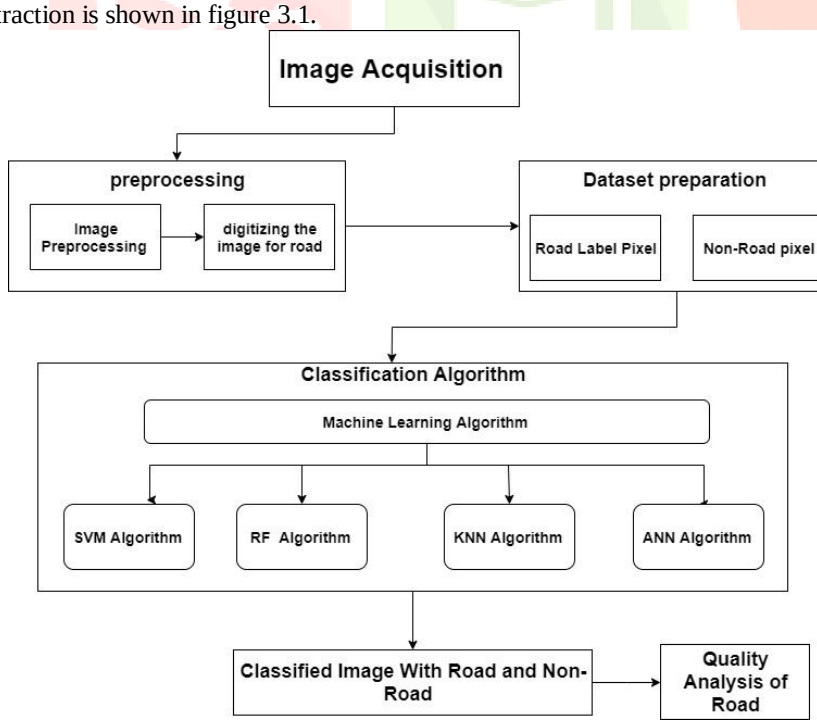


FIGURE 3.1: Block Diagram for Proposed Methodology.

3.1 Study area

3.0.1. Image Acquisition

The proposed approach result were checked on the TIFF (Tag image file format) image of World View3 with high Resolution of 1.24m capture in New Delhi India. The selected scene contains variety of city features, such as highways, water bodies, tree, cars, parking.

3.0.2. Image Preprocessing

Pre-processing image used for noise removal, image correction and image enhancement. Enhancement of image is an important technique better vision of human it separated the image in dark areas and bright areas the pre-processed image set as the input to the proposed approach.

FIGURE 3.2 : Satellite Image

3.0.3. Image Digitization

After image Pre-processing, digitization collect the ground truth data form geo-registered high resolution satellite image. Select road pixel and non-road pixel for further preparation of dataset as shown in fig 3.3

FIGURE3.2: Label Image

3.0.4 Prepared dataset

After digitized the road pixel and non-road pixel from the high resolution satellite image, the road pixel labelled as 1 and non-road pixel labelled as 0. Prepared dataset is further used for proposed methodology.

3.0.5. Classification Algorithm

In this section, labelled data is given to different machine learning algorithm that come under the ensemble learning approach which gives the better classification result in less time as compared to image processing approach. Support vector machine[12], random forest [13][14], Knn[15], artificial neural network [16]This are some algorithm which gives the encouraging result in less time.

Support Vector Machines (SVM)

Support vector machines are supervised learning models To analyse the data classification and regression analysis associated with algorithm. Hyperplane surface separate the two classes to maximise the margin between them.

Those features was exclude that have different spectral values in classification from those of highways. The entire image was divided into two categories road and non-road.

Road group include those feature which has same reflectance value of road while training only pixel representative of road were selected because in the classification process false road features would be classified if it has same spectral value of road. All other feature which had different spectral values from road would be grouped into the non-road features.

The training data were used to train svm and model result was used to classify the entire image into characteristics. The software package by change and Lin for implementation of svm (2001). Gaussian RBF was used as kernel function.

Random Forest Algorithm

Random forest is a method of ensemble-learning (Breiman 2001). It produces several classification trees, which are aggregated to calculate a scoring (Breiman et al., 1984). Salamon and Hansen (1990) stated that a sufficient and adequate condition for an ensemble of the trees listed to be more accurate than any of its individual members is that the ensemble member do better than random and divers.

The supervised study of random forests applied to many number of feature combination derived from the segment extracted by segmentation.

Random forest increasing the diversity between classification trees by replacing data resampling and alter the predictive variable sets at random over the various induction processes of the tree. The number of tree(k) and number of predictive variables used for dividing nodes(m)is user–define parameter required for the random forest growth.

K-nearest neighbor (KNN)

KNN is among the simplest and most commonly used method for classification. in these researches, the KNN is normally used as a pixel-wise classifier which rely heavily on the optimal distance metric and feature space.

The knn algorithm assumes that pixel belongs to same class if they are close to each other in feature space.it goes to decision rule before it bypass density function estimation. Several decision rules have been developed, which include the majority of vote in feature space among the training sample from nearest neighbors.

Artificial neural network

Neural network are inspired by neural biological neural network.it contain two main stages which are Learning and recall. Learning –for fulfil the specific task there is process which modify weight between neurons Recalling- generalization ability of the trained network.

Artificial neural network are superior because of its capacity to integrate both spectral and contextual information. Ann algorithm used to verify the impacts of different input parameters on network's ability to find out optimum input vector for the problem. A variety of network structures with different iteration times are used to determine the best network structure and termination condition in training stage.

The most common learning algorithm is Back-propagation. To minimize the error iterative gradient algorithm is designed. The desired output is compared with the output signal and error signal is propagated back to neurons.

BPN applies generalized delta rule which has two phases: forward pass and backward pass. In forward pass the input is propagated to forward through network to get output value. Backward pass of the error signal to each unit in the network and calculate weight changes. When the value of error function is small this algorithm stop. In test phase no learning take place which means weight are not updated. Each test vector is fed into input layer.

The neural network are capable to handle multisource data , it does not required explicit modelling of different data sources. There is no need to treat them independently as statistical procedures (Benediktsson et al., 1990).

IV. Results and Discussion

Quality assessment

Quality assessment focuses on two main point[18]: (1) How complete is the extracted road, and (2) How correct the extracted road. The completeness corresponds to the user's demands ("what is missing in the output I want"), whereas the correctness is related to the probability of an extracted linear piece to be indeed a road. Before applying these correctness and completeness measures, the extracted candidate road segments have been categorized into three classes as explained below

True Positive (TP) : are the road pixel(object) which are extracted as road (object)which are actually road pixel.

False Positive (FP) : are the road pixel (object) which are not road pixel but falsely extracted as road pixel(object).

False Negative (FN) : are the road (objects) that are the true road; however, they are not extracted and left as a non-road area.

Quality measures, which are specified as below, were applied after categorisation.

Completeness: This determines percentage of road in the reference map which have been correctly extracted using proposed methodology. It has been calculated as.[20]

$$= \frac{Extracted\ road\ that\ are\ true\ road}{total\ number\ of\ road\ in\ sence}$$

$$\approx \quad \frac{TP}{TP+FN}$$

Correctness: determines the threat of being a road of every extracted candidate road segment and it has been calculated as.[20]

$$= \frac{Extracted\ road\ that\ are\ true\ road}{total\ number\ of\ road\ in\ sence}$$

$$\approx \quad \frac{TP}{TP+FN}$$

Quality tells us how good the approach. It has been the measure of both completeness as well correctness. It can be calculated as.

$$= \frac{Extracted\ road\ that\ are\ true\ road}{number\ of\ road\ extracted\ in\ output}$$

$$\approx \frac{TP}{TP+FP+FN}$$

Data Set Split

The dataset consists of total road and non-road pixel present in an image. Further that dataset split into (60 (%)) training set and (40(%)) test set standard ratio use for training machine learning algorithm. Here we validate (40(%)) building pixels to check how well algorithms get trained on a given training sample. Below is the table which shows the result after applying the machine learning algorithm.

KNN Algorithm

The result of the k-nearest neighbour algorithm and test image and extracted road are as follows:

Algorithm	road Pixel	TP	FN	FP	Accuracy
ann	66209	54782	11427	13683	85.68%
KNN	66209	51753	14456	8336	84.34%

- Random forest

The result of the Random Forest algorithm and test image and extracted road are as follows:

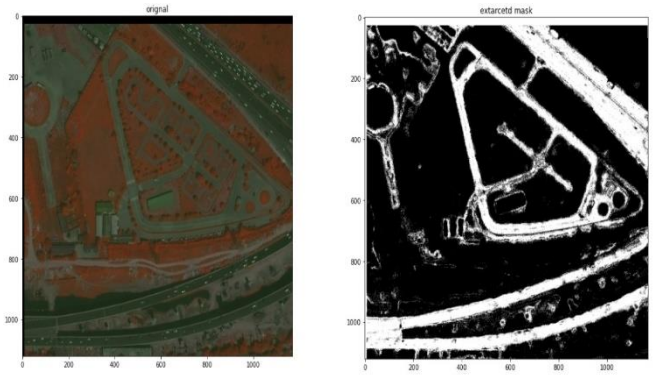
Algorithm	road Pixel	TP	FN	FP	accuracy
RF	66209	51753	52526	10752	83.22

- Artificial neural network

The result of the Artificial neural network algorithm and test image and extracted road are as follows:

Result

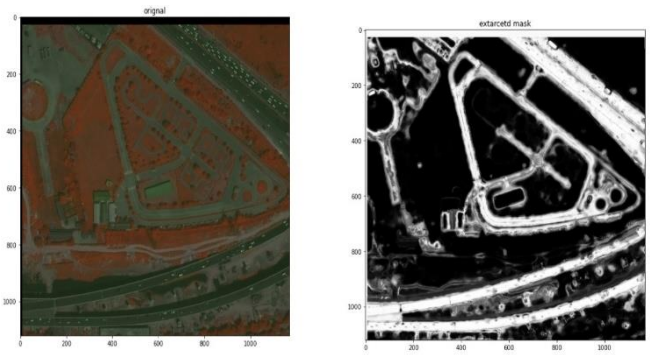
The result of the k-nearest neighbor algorithm test image and extracted road are as follows:



A) Test image. (B) Road detection.

FIGURE: KNN Algorithm Result.

The result of the Random forest algorithm test image and extracted road are as follows:

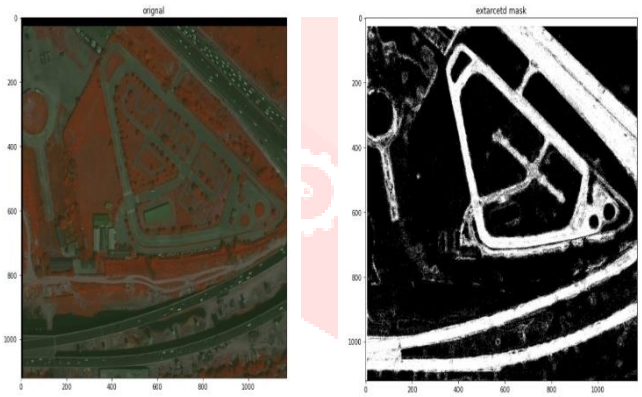


A) Test image. (B) Road detection.

FIGURE: RF Algorithm Result

The result of the ANN algorithm test image and extracted road are as follows:

Algorithm	road Pixel	TP	FN	FP	accuracy
KNN	66209	51753	14456	8336	84.34
RF	66209	51753	52526	10752	83.22
ANN	66209	54782	11427	13683	85.68



(A) test (B) road

FIGURE: ANN Algorithm Result.

Compression result of algorithm

By considering the above results ANN performs better than other algorithms so we conceive to use the ANN algorithm for classification.[?]Back propagation technique makes the classification of satellite image feasible. Back-propagation algorithm reduces the measure drawback to a reasonable level of training time. It also progressing so that real learning time or near real time could be possible.to include spatial and temporal information or for more channels accommodation is easily modified in back propagation.

V. Conclusion and Future Scope

Road detection and extraction from multispectral satellite images has been considered an essential area of research in remote sensing and computer vision. Road detection and extraction is more effective in rural areas than urban areas where man-made objects are less and possible to detect road more easily, and minimized the human labour in some extent. In this study, we proposed an efficient road extraction method that can successfully extract road from multispectral satellite images having different size and shape with minimal human intervention. The effect of the input road performance parameters for neural network high resolution satellite tested on multispectral image. The back propagation algorithm was introduce with different size of hidden layers equipped with different iteration to avoid overtraining issues.

Proposed methodology can be further used to extract other natural and man-made object from multispectral satellite images.

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