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Regional Detection of Traffic Congestion Using in a Large-Scale Surveillance System via Deep Residual Traffic Net

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Abstract - ***With the growing demand for Smart cities applications, traffic control and its management have huge demand and a highly interested research area. Surveillance images and videos can be monitored effectively to identify traffic congestions. There is existing research available on traffic signal controls through image processing and various machine learning methods. Traffic prediction through surveillance camera videos, images are very interesting as it can update with live data for users. The proposed work detects traffic prediction based on multiclass problems. There are four classes considered for this proposal are heavy traffic, less Traffic, accident prediction and fire accident prediction. As a result, the suggested approach outperforms existing systems that rely mostly on binary categorization. For image training and detection, the suggested work uses a single deep learning technique, Convolutional Neural Network (CNN). With low maintenance, the proposed system can be used for large-scale traffic surveillance systems. The proposed system attained the best accuracy of 80% for 20 epoch training with four detection classes, according to the results of the experiment.***

***Key Words*:** Machine learning, deep learning, Convolutional Neural Networks (CNN), Traffic prediction, multi-class classification.

I. INTRODUCTION

Existing techniques used video detection and other hardware equipment to detect the traffic. Thus, the cost of implementation and maintenance of traditional systems were high. Video transmission and traffic computation cost is high in the traditional systems. Improvements to the deep learning process have appeared in a variety of real-world applications, including traffic monitoring. Deep learning models make image analysis and traffic detection simple. Spatial-temporal data can be used to monitor traffic. With this monitoring system, the area of traffic congestion can be seen automatically.

Traditional surveillance systems are tedious as it requires huge man power and frame by frame monitoring in all surveillance cameras are required. Thus, the objective of our proposed system is to develop an intelligent surveillance system, which can classify traffic congestion into four categories: high traffic, low traffic, fire accident, and accident. The proposed system is considered as multi class classification and this can be achieved by Convolutional Neural Networks (CNN). There are four classes of detection that can be considered, fire detection, accident detection, dense and sparse traffic detection. We regard dense and sparse detection to be our primary goal, with fire and accident as extended research. The main aim is to classify the given input image to dense or sparse based on the trained model from the input dataset.

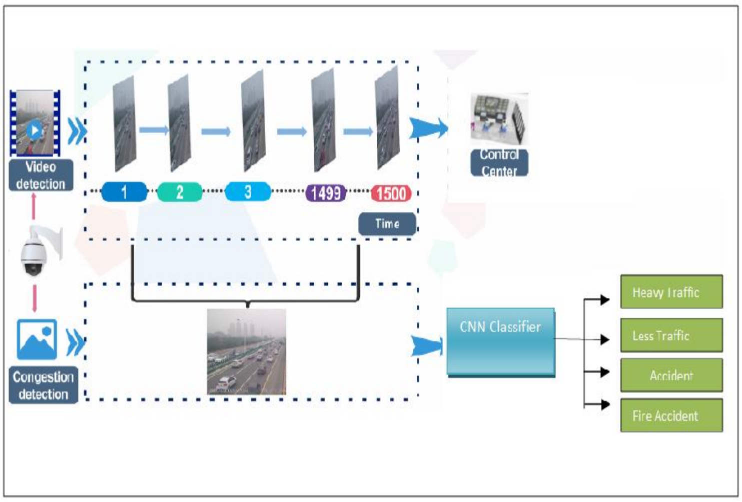

Figure 1: Overall Traffic detection from Surveillance

Surveillance camera images are collected for traffic classification, the image features are extracted and interpreted for the same. Deep learning algorithm, convolutional neural network (CNN) is proposed to get good performance of traffic congestion detection. There were existing works available in traffic detection using machine learning and deep learning approaches. Machine learning Nowadays, traffic surveillance systems collect a lot of videos or images and store them for the live monitoring purposes. Deep learning techniques are used sparingly in traffic surveillance and control systems. As a training dataset, numerous photos with diverse weather conditions are collected. Advantages of deep learning have been exploited in many applications, which use computer vision and image analysis. One of such applications is traffic monitoring, in which large amounts of video or images are processed for effective learning. The traffic surveillance can only monitor, which cannot detect the traffic on particular time.

Normal surveillance of traffic is handled manually, which requires high manpower to handle and lacks in efficiency. It is a highly complex system to monitor manually and identify traffic. Moreover, human error may occur, as it is not possible to watch all cameras under surveillance. Thus, the effective monitoring of large-scale surveillance systems with an automated monitoring for traffic congestion is needed for the

intelligent transport system (ITS), which in turn is required for building smart cities in the nation.
K-nearest neighbor (KNN) and Support vector machine (SVM) were used for image classification. As the traffic images are highly complex to classify, a better performance algorithm is required. The proposed system is an intelligent based traffic detection system, From the input image frames acquired from surveillance footage, which can classify as dense or less traffic. The deep learning algorithm CNN, which was used here, solved the problems of traditional machine learning methods. As a regional traffic congestion detection, this can be implemented as a large-scale surveillance system, which can be effectively used for smart cities. The proposed system is considered a multi- class problem, in which we identify high or low traffic, accidents or fire.
The following chapters discuss the existing work researched on traffic detection in chapter II, implementation of CNN algorithm for traffic prediction in III. In chapter IV, experimental results were discussed. In chapter V, work conclusion and future extensions were discussed.

II. RELATED WORK

Many researchers have studied traffic detection based on machine learning and deep learning models. Some of them are discussed below.
Traffic classification based on Convolutional Neural networks was studied in [1], in this work, the author classified input images as LOS (Level of service) as four different types of LOS. This Level 1 to level 4 is traffic from low to high representation. The system analyzed the vehicle number or density on the road for classifying it as LOS 1 to 4. The author compared the proposed work with multi-layer perceptron and Deep learning with encoders and also with different numbers of CNN layers. The system showed good performance with CNN algorithm with three layers.
Portable traffic prediction through Wi-Fi channel state information was studied in [2]. The work has taken OFDM orthogonal frequency division multiplexing to receive WIFI carriers' information. When the vehicles passed, it received information, this is classified as five vehicle types like bike, car, truck etc. The input CSI information is reduced using PCA analysis and trained using CNN algorithm for classification. The results showed a good classification accuracy using CSI information gathered from WIFI.
In [3] traffic monitoring is used to classify vehicles, the study covered three types of vehicle classification in road based, over road based and side road based. Vibration based and magnetic sensor-based detection were analyzed. Similarly, on road-based detection such as surveillance detection through camera by various machine learning methods including SVM and GMM models were studied. The methods of detection on the side of the road, such as light detection and range, radar, and WIFI, were investigated. The survey concluded with analysis that a large set of labeled datasets is required, which can be achieved by closed loop self-learning.

Traffic light control based on Q-learning was proposed, to reduce time delay and to set the signal wait time properly, Q - learning was used in [4]. The criteria of optimal latency and automated learning was met using neural network-based learning. The proposed method provides reduced delay on intersections.
Traffic prediction based on Recurrent neural networks was studied in [5], in a specific Gated Recurrent unit, which achieved high accuracy on prediction. Data traffic matrix considered for seven months, artificial neural network is used to train the model and evaluation automatic model is used for evaluation of the model. Resource allocation handle in this model is efficient.
Traffic prediction in intra-data center networks using autoregressive models is arrived at by author [6]. A hybrid model NARNN is a nonlinear autoregressive neural network. The author implemented Recurrent neural networks and also in feed forward neural networks. By comparing both models, FNN has shown a better performance than RNN model, due to the reason that forecast error is propagated and considered to reduce on the learning phase in FNN. The input pattern is given from chaotic maps, the model tested with 600 epochs. This approach, on the other hand, can only forecast and predict significant traffic.
Traffic analysis and prediction through machine learning techniques was proposed by the author in [7]. The study employed the US traffic data 2015 dataset, which includes parameters such as route type (rural or urban), station id, state, direction, latitude, and longitude. Regression methods such as SVM regression, Random Forest regression and decision tree regression were used for implementation. The machine learning model was built using the optimized features, and the testing revealed that the computed MSE error for the Random Forest model is lower.
Traffic speed prediction by Long short-term memory - neural network was proposed in [8], the dataset collected from Manchester, UK. There are two types of models discussed: parametric and non-parametric. The ARIMA method is employed in the parametric model, where the traffic state is assumed to be stationary. Under a non-parametric approach, the algorithm used is ANN and no assumption is made for learning data. The LSTM-NN model is experimented on with different parameters to learn and predict and achieve less error.
There were many studies carried on this area, traffic prediction is one challenging area for researchers. Handling large amounts of dataset and learning them effectively through algorithms is challenging. The existing works have studied effectively in this area and attained good results. None of them, however, has divided road traffic congestion into different classifications or predicted accidents. The proposed system achieves this by applying CNN algorithm.

III. METHODOLOGY

The proposed work, traffic congestion detection from surveillance image dataset using deep learning algorithm is implemented with following methodologies 1. Dataset collection 2. Image pre-processing, 3. Training using Convolutional Neural Networks and 4. Recognition of output.

DATASET COLLECTION

There are four different classes of input traffic scene images collected from the web. The class value output of scenes is given along with a dataset image collection. We have collected four classes namely sparse_traffic, dense_traffic, fire, accident, every class type contains images of 900 for train and validation purposes. The folder name itself represents the class value for classification output.

The sample dataset visualization is shown as below

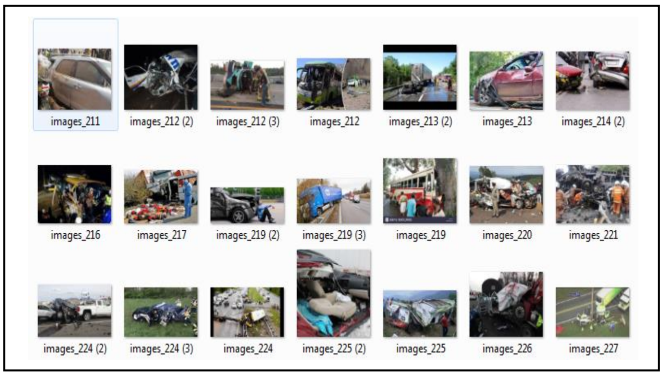

Figure 2: Accident images dataset

The following image shows the heavy traffic dataset

Figure 3: Heavy Traffic images dataset

The below figure shows the dataset with fire accident images

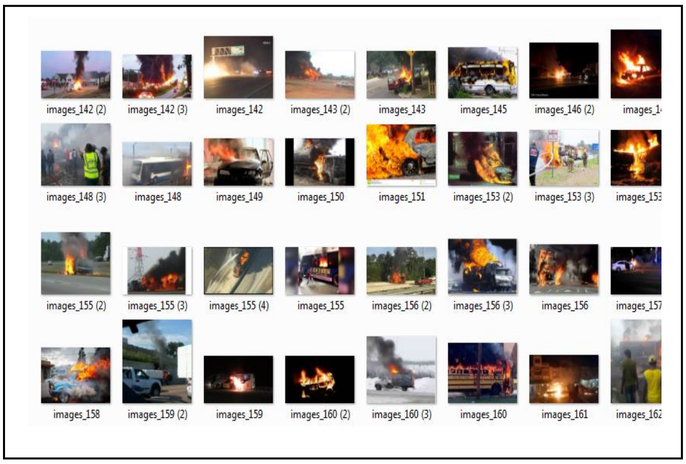

Figure 4: Fire Accident images dataset

The following figure shows the dataset with less traffic

Figure 5: Less traffic images dataset

Conv2D layer is used with two hidden layers and in each hidden layer 256 dense neurons were used and these are multiplied with random weights. Convolutional Neural Networks (CNN) model with Relu Optimization was used in the model. In hidden layer one, the number of convolutional kernels used is 32 and in hidden layer two, the number of convolutional kernels used is 64. The layer used a learning rate of 0.004. The below table shows the parameters used for CNN algorithm as input

Layer Operation	No. of feature images	Feature map size	Validation images
Conv2D	900	150 x 150	300

Table 1: Layer Summary

The methodology followed on implementation of Traffic congestion includes dataset collection, splitting into train and test, CNN is applied as per above design the model is trained. To the trained model, image or video is given as input for traffic congestion classification. The following image shows the overall architecture of proposed work.

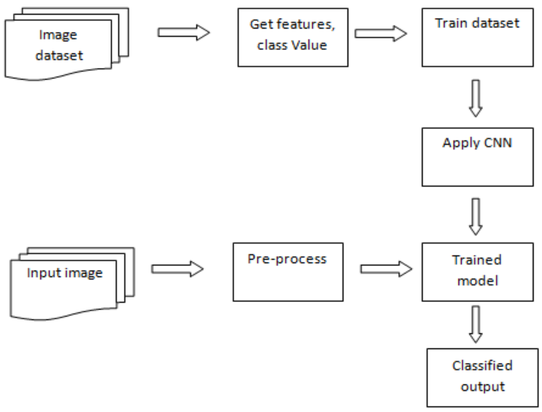

Figure 6: Overall architecture of Traffic congestion prediction

In convolutional layers, each input neuron in the hidden layer is connected to each output neuron. Thus, the network created is a fully connected hidden layer. Convolutional layers used here extract the features from input images and pass them to the input neuron. The CNN layer used for implementation is depicted as follows.

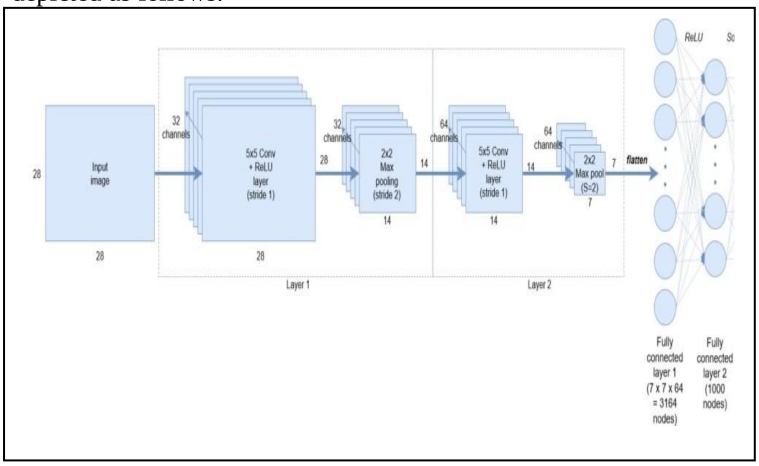

Figure 7: Overall Architecture of CNN

The CNN algorithm operates like this: As input layer, a 150 by 150-pixel image is provided. In the hidden layer, we choose a kernel size 5x5 moving window, Activation function used here is 'Relu'. In the convolution and max pooling layer, input batch size is 28x28 and 32 is the number of output channels produced.

The trained CNN model has generated model.h5 and weight.h5 files. These files can be used for real time detection of traffic from images and videos. The input image is pre-processed to convert into NumPy values and given to predict function. The output classified is Heavy traffic, less traffic, Fire Accident, Accident as four classes. Though the multi-class classification is done, the results are highly accurate.

The proposed traffic congestion prediction is implemented in Python 3.6.4 with deep learning libraries Keras and TensorFlow and other necessary libraries such as OpenCV and matplotlib were used. Dataset used 900 images in each class with 4 classes. Training dataset 80% considered and 20% considered as test dataset. CNN is applied and builds a training model. The application is designed in TKinter, where users can give input of images to classify and get results. Similarly, users can give input of a video file, which in-turn split into image frames and classified and results were given to the user. For video, we considered 25 frames per second and these frames are processed for detection of traffic congestion. The output on each frame is identified and the output video is compiled as given as output to the user. The application front end designed in TKinter for implementation is shown in the following screen.

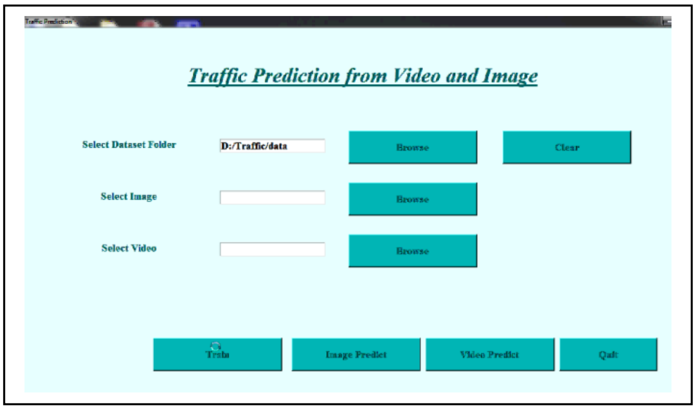

Figure 8: Application for Traffic Congestion detection

The following images show the output of classified images as an accident by the trained CNN algorithm.

Figure 9: CNN Predicted Results as Accident

The following images show the output of classified images as Heavy Traffic predicted by the trained CNN algorithm.

Figure 10: CNN Predicted Results as Heavy Traffic

IV. RESULTS AND DISCUSSIONS

Python 3.6 is used in the implementation with Keras and Tensorflow libraries for deep learning implementation. We have created a new Tensorflow environment and named it 'tf'. Convolutional Neural Network algorithm is used for training. The experiment makes use of the input parameters specified in the "Detailed design" section, as well as a total of 900 photographs for each class. Once the training is done, this model is tested against input of 200 images in each class. The experimental result shows that this model achieves around 80% of accuracy. We have used an epoch 20, the accuracy increased with the number of epochs.

The following table shows the accuracy arrived at in our experimental study. The table clearly shows that when the number of epochs is increased from 5 to 20, the accuracy improves.

Epoch	Accuracy
5	68.50
10	72.50
15	75.40
20	79.50

Table 2: Experimental Analysis

The below figure, Figure 6, shows the accuracy arrived from the CNN model for the training and validation dataset with 20 epochs.

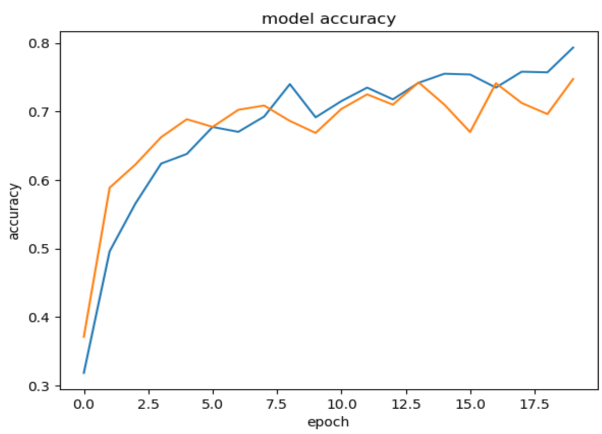

Figure 11: CNN model Accuracy for Training and Validation

The following figure shows the model loss (Mean Square error MSE) arrived at by the CNN algorithm for training and validation dataset with 20 epochs. It is observed from the figure, that the loss value is reduced when the number of epochs is increased.

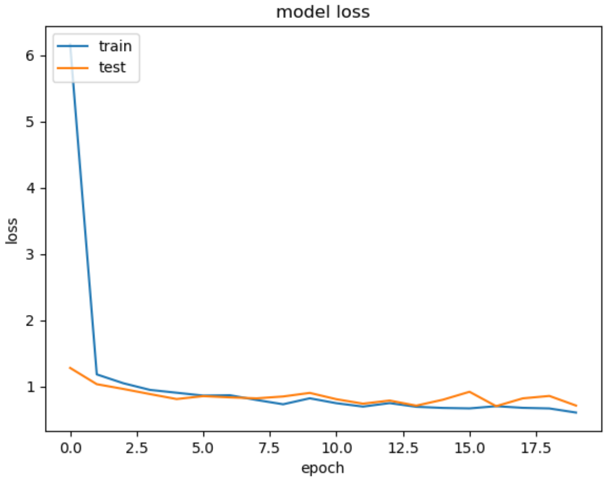

Figure 12: CNN model loss for training and validation sets

V. CONCLUSIONS

The automated traffic surveillance monitoring system is regarded as a significant issue, and it has been solved using a deep learning CNN model. The dataset collected on four different classes are trained with CNN and heavy traffic or less traffic is identified by the trained model. Deep learning has the advantages of learning features effectively, thus it can be applied in transport congestion detections.

In future enhancement, we intend to work on detecting traffic conditions on the traffic videos in real time. This can be done by video splitting technique and find the traffic condition on every frame. Real time traffic detection on video is quite important research for developing countries like India.

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