Vehicle Crash Detection Using CNN For Emergency Assistance

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Abstract

Road accidents are a major cause of deaths not only in India but in many other parts of the world as well. Road accidents cause more harm to human lives in densely populated countries like India, China. Sometimes people die because of the severe nature of the accident but most of the time people involved in a road accident lose their lives due to lack of the medical treatment. Our aim through research paper is to research a particular accident detection system that will alert us about the possibility of an accident and if an accident does occur it will alert the nearest police station and hospital so that the people can be saved during these tragic situations. The system will have high resolution camera sensors that can record video and produce a large number of high-quality frames. A dataset will be chosen from Kaggle which will be used for training purposes. It will contain a number of videos in which accidents are occurring then these cameras will be trained using machine learning algorithms so that they can identify a similar situation in which there is a slight probability of an accident occurring and alert the nearest police station and hospitals. The algorithm which we will be using is a part of Artificial Neural Network (ANN), which is used to create models that generate output on various input parameters. The algorithm is known as Convolutional Neural Network (CNN), this algorithm is specifically used for object detection, this is a highly efficient algorithm that has become significantly popular in past years this algorithm identifies input features and gives output accordingly. We will test this system for different type of real time situations and try to find if the system is accurately predicting the possibility of an accident and its ability to alert the nearest community services in case an accident does occur. After carefully studying the results, we will write the conclusion if the particular system is giving accurate result..

Keywords: *Accidents, Convolutional Nural Network, CNN, object detection, alert*

1. Introduction

India is a densely populated country so it has a greater number of vehicles and higher the number of vehicles higher will be the traffic. According to the data provided by Indian Government the number of road accidents that occur in India during a year is more than four lakhs fifty thousand and each year the percentage of death caused by road accidents is increasing. National and state highways of India are just five percent of the total road network of India but most of the accident occur on these highways (fifty two percent of the road accidents). So, the accident detection system that we will be studying will help reduce the number of road accidents and deaths caused by road accidents. Two main technologies that will be used by this accident detection system are Image processing and Object Detection. Image processing is a technique that is used to predict or decide if object in the image belong to a particular class or not. It takes an image with objects as an input

and produce class label which can be mapped several other class labels as output. Object detection on the other hand is a different technique which is used for finding if there is a particular type of object present in the given data or not. It also takes images with objects as input but it produces output that is defined by some properties such as object width, object height or object position. These above two mentioned techniques are related to each other which will help get accurate results. Convolutional Neural Network (CNN) is a very good object detection algorithm that we will be using to detect objects which will be vehicles in this case. By using this algorithm camera sensors will be trained with the help of a training dataset to identify vehicle position in order to decide if a particular vehicle is too close to another vehicle and there is a possibility of accident.

2. Problem Formulation

Crash of vehicles had become a major reason for the death of individuals nowadays. If proper help can be provided on time, we can save the lives of many. So, we have come up with research of crash detection system which detects the crash of vehicle through high-resolution camera's installed on the highways, express-way, and peripherals. We can make a machine learning through supervised learning through machine learning algorithms. We can make a machine learn through various video and images of vehicle crash so that it can differ between accidental vehicles and non-accidental vehicles. Object detection on the other hand is a different technique that is used for finding if there is a particular type of object presents in the given data or not. It also takes images with objects as input but it produces output that is defined by some properties such as object width, object height, or object position. The above two mentioned techniques are related to each other which will help get correct results. Convolutional Neural Network (CNN) is a very good object detection algorithm that we will be used to detect objects which will be vehicles in this case. Taking database from Kaggle we can have such a system of crash detection that can help us out in saving one's life by informing the local emergency services. We have learned about the pre available system in our research and will work on loop holes of them to make it a better one.

3. Tools and Technologies Required

Two main technologies that will be used by this accident detection system are Image processing and Object Detection. Image processing is a technique that is used to predict or decide if object in the image belong to a particular class or not. It takes an image with objects as an input and produce class label which can be mapped several other class labels as output. Object detection on the other hand is a different technique which is used for finding if there is a particular type of object present in the given data or not. It also takes images with objects as input but it produces output that is defined by some properties such as object width, object height or object position. These above two mentioned techniques are related to each other which will help get accurate results. Convolutional Neural Network (CNN) is a really fine object detection algorithm that we will be using to detect objects which will be vehicles in this case. By using this algorithm camera sensors will be trained with the help of a training dataset to identify vehicle position in order to decide if a particular vehicle is too close to another vehicle and there is a possibility of accident. Through this research paper we will find out if this system is capable of preventing a accident and if can alert the nearest community services in need.

4. Literature Survey

This is a standalone section of the literature survey for Our Project, the focus of which is on the study of previous researches based on the working idea of Accident Detection System which used image processing and object detection. Following are the researches happened based on the Accident Detection System or functioning of Accident Detection System.

- IoT based Vehicle accident detection and rescue information system: In [1] accident detection system was developed using Internet of things. This system discovered the vehicle accident and send the message to nearby hospital and police station using a network. The place was traced with the help of GPS. A vehicle tracking algorithm was used to detect abnormal vehicles and by use of server's notifications were send to all users in that particular network.
- Traffic Accident Detection using Machine learning Techniques: In [2] proposed system was designed to take data from normal roads and identify the situation in which an accident might occur, then an algorithm was used to identify behaviors of vehicles. By using clustering algorithms those behaviors were classified so if a vehicle was showing accidental behavior than it was marked.
- IoT based Accident identification and Alerting System: In [3] proposed system if a vehicle collided the accelerometer and an ultrasonic sensor send a signal to Arduino. The accelerometer sends the signal about increasing speed to Arduino. Then it will send an alert to the number that is predefined and the alert will pop on to the lcd screen of the user. This system was designed for car users. It was made user friendly it was good for the automobile industry.
- Real time autonomous highway accident detection model based on Big Data Processing a Computational Intelligence: In [4] proposed system was a real time accident detection system which was based on computational brainpower techniques. The extracted data was fed to the model which contained a of feed forward neural set of connection prototype to decide the possible occurrence of an accident and send the alert. • Paper [5] proposed mobile application for automatic accident detection and alert system which uses accident detection algorithm. Use of e-Call system for automatically detecting vehicle accidents.
- In [6] an algorithm was proposed which detected a traffic accident from the crash of an airbag of a vehicle. GPS was used to find the location of the crash and Vehicle Ad-hoc networks were used to send messages. This system informed the nearest medical services in case of emergency and also discovered a re-route path for avoiding congestion to reach destination on time.
- Paper [7] proposed an application for accident detection through On-Board Diagnostics (OBD-II) devices and android smartphones. The application makes use of Bluetooth to find an ODB-II device. Then it decides which device is suitable for this particular vehicle, when the connection is established, it starts the monitoring of the system. If the airbag is opened or the speed is increased beyond a certain mark, by using GPS it makes the critical call in the emergency situations.
- Paper [8] discusses the various techniques used in Automatic Road Accident Detection which includes the use of smartphones, GPS and GSM, Vehicular Ad-hoc networks (VANET), and the mobile application.
- Paper [9] makes use of 5G and IoT for Reporting and Accident Detection. It also includes delivery of first aid boxes through an aerial carrier which is automatic. It uses different methods such as Edge computing, Intelligent transportation, IoT and 5G.

- This paper [10] discusses the Automatic Detection of traffic accidents through videos using Deep learning techniques. It uses Temporal Segmentation to divide a video into frames based on various features such as time and space.
- Paper [11] implemented an Accident alert system with vehicle tracking by making use of the GPS and the GSM. The system also used different types of sensors Impact sensor, Piezoelectric sensor Transducer and Arduino.
- Paper [12] focuses at the location of the accident. This paper used a computer system within a vehicle to send a message to accurately locate the vehicle involved in the accident.

5. Proposed Architecture

The objective behind this paper is to prevent a road accident and provide emergency assistance as quickly as possible.

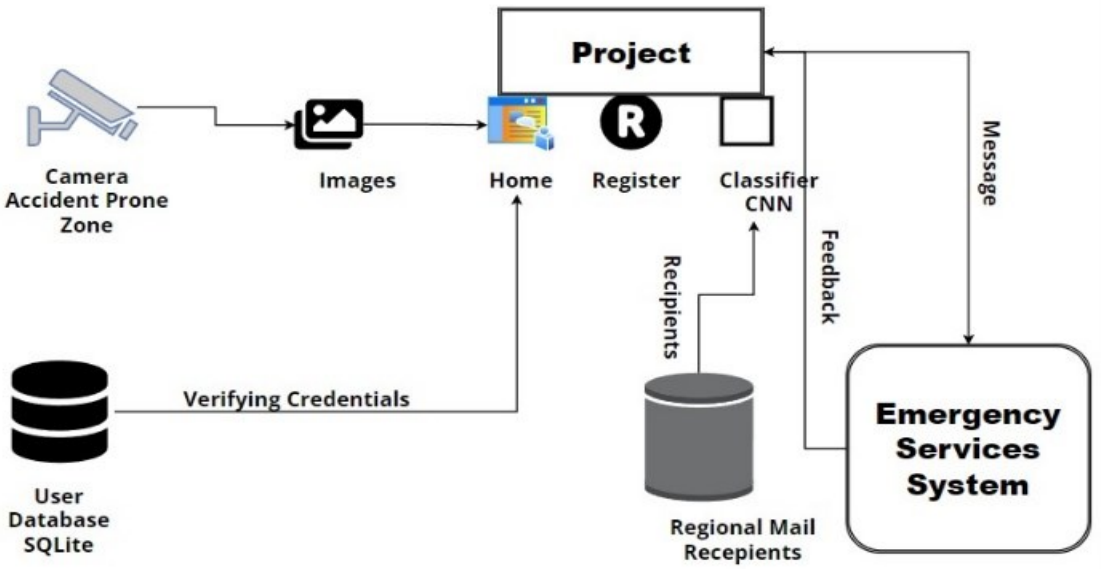

Fig.1 Working of the proposed System

Through the rapid growth of technologies, we see high resolution CCTV cameras on every major highway and road. We aim to make use of these cameras to get the video footage for the accident prevention. The video that will be generated by cameras will be further disintegrated into frames. After that those frames or images will be given to the system for identification of possible accidents. The system will take images as input and look for the features that can help in the accident detection. The system will decide through features like shape, size, distance etc.

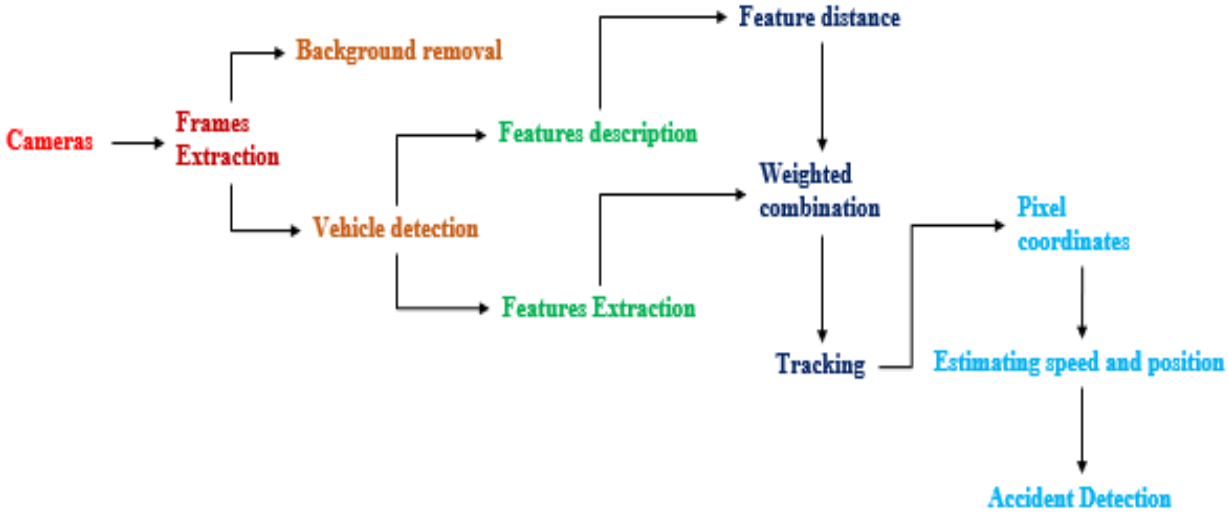

Fig.2 Layout of the proposed system

If there is occurrence of an accident or likeliness of one to happen. After that it will extract their location by making use of the GPS. It will then focus on alerting the nearby community services so people can get help on time and lives can be saved. For implementing the above-mentioned system, we will be using the popular image classification technique Convolutional Neural Network which has higher accuracy and better performance.

6. Convolutional Neural Network

The main technique that we will be using for research of this system are Convolutional Neural Network: It is different from other neural networks because of its higher performance with images, audio signals and speech etc. It consists of three layers:

1. Convolutional layer
2. Pooling layer
3. Fully connected (FC) layer

With each layer its complexity increases to identify more features of the image. Earlier level concentrates on the normal features of the image such as its color and edges. As the data processes through the layers of the Convolutional Neural Network it starts to identify large aspects of the image such as shape of object until it finally recognizes the intended object.

6.1. Convolutional layer

It is the main layer and building block of the Convolutional Neural Network. In this layer most of the computation process takes place. It needs some components which are input data, a feature map and a filter. For example, if we consider a colored image which is made up of matrix pixels in 3D. This indicates that input will have three dimensions depth, width and height which concurs to RGB in a image. It also contains a feature detector which is also known as kernel it moves to different areas of the image to check if the feature is there or not. This process is known as convolution. Feature detector is a 2D array with weights which represents areas of image. Filter can vary in size but typically it is a 3x3 matrix this also calculates the size of receptive field. Then filter is applied to different parts of the image to calculate the dot product between the filter and the input pixels, then it is fed to output array. This process is

repeated until the whole image is covered, the final output form the strings of dot products is known as a activation map, feature map or a convolved feature. There are some parameters that affect the size of output that is set before the training of the neural network. These parameters are

I. Number of filters: - More filters mean more depth of the output.
II. Stride: - Number of pixels kernel moves on the input matrix. Higher stride means small output.
III. Zero-padding: - It is used when filters does not fit input image. It is of three types
    a. Valid padding: In this recent convolution is dropped if dimensions do not fit.
    b. Same padding: Ensures that output layer has similar size as input layer.
    c. Full padding: It grows the size of output through addition of zeroes to the end of the input.

After every convolution process Convolution Neural Network implements Rectified Linear Unit (ReLU) transformation to feature map to make the model non-linear.

6.2. Pooling Layer

It is also known as down sampling because it conducts reduction of dimension to reduce the number of input parameters. It is similar to convolutional layer pooling filter moves over entire input but difference is pooling layer does not contain any weights instead it applies an aggregation function to the values. It is of two types:

I. Max Pooling: In this filter select the maximum value from the input and send it to the output array.
II. II. Average Pooling: In this filter calculates the average value from the input and send it to the output array.

6.3. Fully-Connected Layer

As we discussed earlier pixel value of image are not connected to output array directly in above layers but as you can guess from the name in this layer every node in the output layer is connected to the node in the recent layer. This layer performs classification based on the features collected by earlier layers and filters. Both Convolutional layer and Pooling layer uses Rectified Linear Unit (ReLU) function while fully connected layer uses a SoftMax activation function to classify the input into appropriate category, producing a probability between 0 and 1.

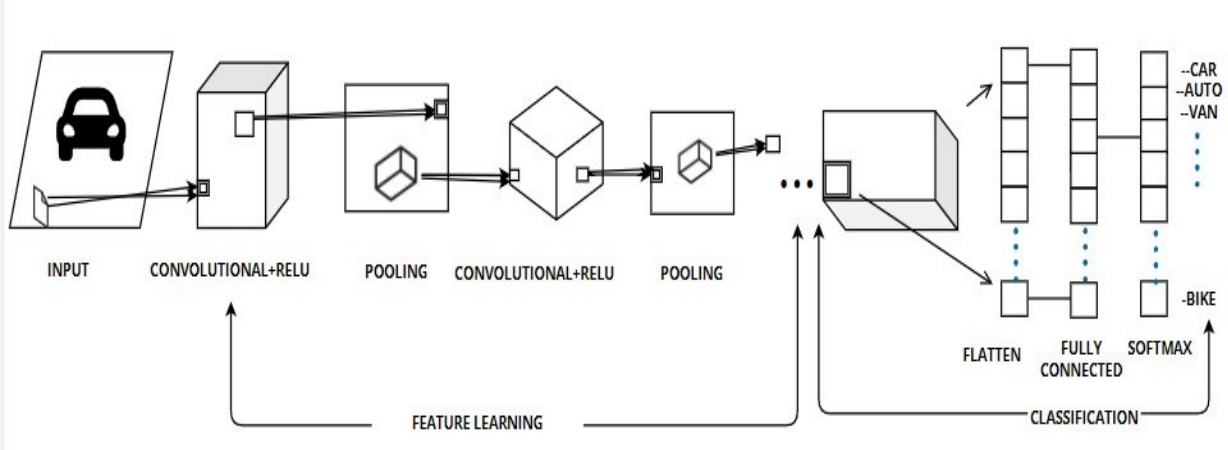

Fig.3 Convolutional Neural Network (CNN)

The high-resolution CCTV camera receive images at a certain frame rate for processing. In early stages images are uploaded manually. The system is integrated with Convolution Neural Network and a alert system. Images are received and classification is performed only the images showing any kind of accident are categorized and an alert is sent to the nearby hospitals and police stations for providing emergency and medical assistance. As mentioned earlier CNN has multiple layers that works on activation layer (ReLU) and a loss function that removes noise from the images. The ideal activation function is identified by experimenting with the system. Accuracy of the system directly depends upon the quantity of data. The model also categories the images based on nature of accident. It is trained through large data to identify if that particular accident is severe or minor. Once the image is processed and is categorized into severe or minor category then an alert is sent to the nearby hospitals and police stations. The alert send to the hospital s also contains the coordinates of the accident area in order to save time in that critical moment. In this way the model identifies the images and recognizes an accident to provide emergency assistance. Feedback is taken after every iteration to constantly improve the model.

7. Dataset Description

The dataset that will we used to train and test the system must contain different instances of accidents happening on the roads and highways. Images should not be same and every image should have unique features that will system give the desired easily. Also, the location of the camera that will send those videos for frame-by-frame identification must be known for quick response to help the people involved in the accident. Based on those requirements we decided to take a dataset that will have two types of accidents. First, we will use mild accidents like headlight breakdown, little deformities in the body of the vehicle, breakage of windshields, side mirrors to train the model so it does not alert the services for unnecessary reasons. Then we will use the severe accidents in which instant help is needed for saving the lives of the people. Severe accidents will involve significant body damage to the car.

7.1. Reading the dataset

Pictures are categorized according to the nature of the accident such as images containing mild accidents and images containing severe accidents. Using the labels and features from our dataset the provided images will be detected through a statistical relation between the features of the dataset.

Sample Images

Mild Accidents

Severe Accidents

We have used a RAR dataset file named as accidents.rar. This RAR file will extract a directory accidents with the help of patoolib library. Accident contains two subfolders, first folder is named as mild which contains images of mild accidents that we will be using for training and testing for initial implementation of the system. The second folder is named as severe which contains images of severe accidents to help identify the more harmful accidents that require immediate. Images belonging to these subfolders will be read with the help of the cv2 library of python.orientation.

7.2. Training dataset

Load the directories which contains images of the accidents. Then we will reshape images so it fits into our model. We will reshape images to a particular size and we will using gray scale. Then we will serialize those images into a fixed format. Then with the help of os.listdir and cv2.imread method we will create image array then we will resize the array for normalization of the data for training of the proposed system. Then we return the training data which produces following result:

```
100%|██████████| 118/118 [00:00<00:00, 3268.66it/s]
100%|██████████| 1225/1225 [00:00<00:00, 5597.77it/s]1343
```

After that image inside the directories are shuffled or chosen at random. Then the features of each image in the training data are extracted. The extracted features are then stored in an array. Then the array is further resized for normalization of the data and is printed. Above process produces the following results:

```
[[[ 47]
  [ 47]
  [ 55]
  ...
  [199]
  [194]
  [194]]

 [[ 56]
  [ 56]
  [ 64]
  ...
  [204]
  [200]
  [200]]

 ...

 [[186]
  [186]
  [187]
  ...
  [138]
  [125]
  [125]]

 [[191]
  [191]
  [191]
  ...
  [134]
  [117]
  [117]]

 [[191]
  [191]
  [191]
  ...
  [134]
  [117]
  [117]]]
```

7.3. Testing the dataset

Now for the testing part we will split the dataset in training and testing datasets. This is the part where we apply the Convolution Neural Network algorithm. By using the idea behind convolution layer and the pooling layer we start the initial implementation of the proposed system. For applying the logic of the convolutional layer, we will be using Conv2D method. Also, Maxpooling2D method is used for the making use of the pooling layer. Padding is made to be the same. Then the model is compiled for checking the accuracy of the training dataset. We get the following result after successfully compiling the above discussed methods:

```
15s 570ms/step - loss: 25.0347 - accuracy: 0.8535 - val_loss: 0.3456 - val_accuracy: 0.9164

10s 418ms/step - loss: 0.3027 - accuracy: 0.9095 - val_loss: 0.2910 - val_accuracy: 0.9164

9s 384ms/step - loss: 0.2453 - accuracy: 0.9108 - val_loss: 0.2816 - val_accuracy: 0.9133

9s 371ms/step - loss: 0.2218 - accuracy: 0.9214 - val_loss: 0.2962 - val_accuracy: 0.9071

9s 371ms/step - loss: 0.1722 - accuracy: 0.9374 - val_loss: 0.3374 - val_accuracy: 0.9009
```

Then we move to the testing dataset for measuring the testing accuracy of the model. We will convert testing dataset to an array of images. Then we will resize that array for the normalization of data. Then we will evaluate the model by giving it testing image array as input. After successfully compiling the above-mentioned operation following result is obtained:

```
9/9 [==============================] - 1s 54ms/step - loss: 0.2696 - accuracy: 0.9405
[0.26962143182754517, 0.9405204653739929]
```

8. Results

For calculating the result, we will prepare the above discussed model by loading all datasets. The datasets are further converted to image arrays. These image arrays are further resized for normalization of the data. Now with the help of tf.keras.models method we will load the 64x3-CNN model for prediction. We will be taking an unused image named as acc.jpg for the identification. After printing the prediction, the following result was obtained:

```
model=tf.keras.models.load_model('64x3-CNN.model')
prediction=model.predict([prepare('acc.jpg')])
print(prediction)
print(CATEGORIES[int(prediction[0][0])])
```

```
[[1.]]
Severe
```

We had used a severely damaged for the prediction. As it can be seen from the output that the model has successfully identified the nature of the accident. So, we can say that the proposed model is working efficiently and predicting accurate results.

9. Conclusion

After successfully testing the proposed system through unseen data it can be said that the proposed model is working to produce intended results. The discussed system worked efficiently for detecting the accidents when subjected to unseen data. After successful detection an alert was sent to the nearby hospitals and police stations. The alert carried location of the accident which helped community services reach the location shortly. So emergency assistance could be provided to the people involved in the accidents. Technology is evolving at a rapid pace and we see new technologies are discovered every day. With the help of new technologies, we can work the betterment of the proposed model. We will continue our work towards improving the efficiency of the system. We will focus on making the proposed model more accurate. The proposed model beside its intended use was also helpful in identifying the data related to the various accidents that takes place on highways and road of our country. The proposed model was ideal for observing the information related to the categories or nature of the accident. Convolutional Neural Network is an ideal technique for identifying the images and their features. It works efficiently and provides correct results. Overall, the output of this proposed system will help people to get timely medical and other emergency services so more harm can be avoided.

10. Future Scope

The discussed model deals with the accident detection by making use of the Convolutional Neural Network Algorithm. It also suggests a method for sending alerts and location of accident to the nearby hospitals and other community services for emergency assistance. Accident Detection can be endlessly optimized for better accuracy. In near future it can be used on real highway and roads by making use of the CCTV cameras that are present on different highways. The highway authorities can take the idea and with the help of professionals it can be integrated as a monitoring system. It will have many advantages like the authorities can prepare in advance if there is a accident. After receiving the location of the accident, they can send different community services like ambulances or fire fighters and police. Also, through the increasing technology this can somehow be integrated in the vehicle. Once the vehicle undergoes an accident or involved in some kind of collision, with the help of sensors it can be identified. On successful identification the system can send the location of area where the accident has happened. Through that location nearby emergency services like hospitals and fire vehicle can arrive on time to save the people that are involved in the accident. Convolutional Neural Network could get even better with the ever-evolving technology. Then it will perform more efficiently and the models and system that will be generated based on this technique will be more effective. These models then can be considered for real life implementation. It will contribute to the society immensely by reducing time taken in providing the help and saving lives.

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