Forest Fire Detection using CNN

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***Abstract*—Forest fires are a global issue, affecting both natural habitats and human populations. We have proposed a Convolutional Neural Network (CNN) model for forest fire detection, using image analysis techniques to automatically identify forest-fire images. By training the CNN on image datasets, we teach it to recognize visual features of images that indicate forest-fire. Through iterative refinement and optimization, our model achieves high accuracy in detecting fires across various environmental conditions.**

***Index Terms*—CNN, fire detection, neural networks**

I. Introduction

Forest fires pose a significant threat to ecosystems, human lives, and infrastructure, hence it is necessary to detect them timely with appropriate action. Conventional methods for detecting forest fires often rely on manual surveillance, satellite imagery, or sensor networks, which may have limitations in scalability, accuracy, and real-time responsiveness. Convolutional Neural Networks (CNNs) have emerged as powerful tools for analyzing images, capable of learning patterns and features from visual data. Their ability to extract hierarchical representations makes them well-suited for tasks like object detection, classification, and segmentation. Using CNNs for forest fire detection holds the potential to improve accuracy, reduce false alarms, and facilitate swift response to fire incidents. This report presents the application of CNNs for forest fire detection, covering various aspects such as data preprocessing, model architectures, training techniques, and performance evaluation metrics.

II. Objectives

The objective of our project is to study and implement CNN in detecting forest fires. The main goal is to differentiate between images of forests with fire and no fire.

III. Data Description

In our project, we have used a dataset called the "Forest Fire Dataset", which is available on Kaggle. This dataset helps to identify forest fires. Each image in the dataset has three color channels and is of 250 × 250 pixels. This dataset presents a binary classification, It determines whether there is a fire present or not in forests. It contains a total of 1900 images, split into 1520 training images and remaining 380 testing images, both split evenly as each class (fire and no-fire). For our study, we divided the training dataset into an 80:20 ratio for training and validation purposes.

IV. Proposed Model

The model used for the Forest Fire detection is CNN (convolutional Neural Network), the model has several convolutional Layers, max Pooling, dense layer (fully connected layer) , flatten etc.

Below is the description of the layers used by model:

1) Input Layer: The model takes input images of (128 x 128) each image of size (128 x 128 x 3). It takes coloured images (RGB).
2) Convolutional Layer 1: This convolutional layer has 32 filters/kernel each of size (3 x 3) with activation function ReLU(Rectified Linear Unit).
3) Max Pooling Layer 1: This layer uses window of 2 x 2 and stride of 2 pixel. This helps in lowering the computational complexity and enhancing the features.
4) Convolutional Layer 2: This layer has 64 filters with size (3 x 3) with activation function ReLU.
5) Max Pooling Layer 2: This layer uses window of 2 x 2 and stride of 2 pixel(default). x
6) Flatten Layer: The output from maxpooling layer 2 is flattend to 1D vector. This is important for connecting the convolutional layers with fully connected one.
7) Dense Layer: This layer uses 128 units and ReLU activation is used here.
8) Dropout Layer: This layer Randomly sets input units to 0 with a frequency of 0.5 at each step, to avoid model learning the training data too accurately
9) Output Dense Layer: The final layer is a dense layer with a single unit, it uses sigmoid activation function. The output is single neuron, it is ideal for binary classification.

This model architecture, with its layered approach, aims to achieve high accuracy in detecting forest fires from image data. The use of max pooling reduces dimensions and and enchances features, while the sequence of convolutional layers with ReLU activation allows efficient learning of complex patterns.The dense layers help the model learn important patterns, making it good at identifying two groups apart.

```
model.summary()

Found 1216 images belonging to 2 classes.
Found 304 images belonging to 2 classes.
data shape =  (16, 128, 128, 3) (16,)
Model: "sequential_1"
_________________________________________________________________
 Layer (type)                Output Shape              Param #
=================================================================
 conv2d_2 (Conv2D)           (None, 126, 126, 32)      896

 max_pooling2d_2 (MaxPoolin  (None, 63, 63, 32)        0
 g2D)

 conv2d_3 (Conv2D)           (None, 61, 61, 64)        18496

 max_pooling2d_3 (MaxPoolin  (None, 30, 30, 64)        0
 g2D)

 flatten_1 (Flatten)         (None, 57600)             0

 dense_2 (Dense)             (None, 128)               7372928

 dropout_1 (Dropout)         (None, 128)               0

 dense_3 (Dense)             (None, 1)                 129

=================================================================
Total params: 7392449 (28.20 MB)
Trainable params: 7392449 (28.20 MB)
Non-trainable params: 0 (0.00 Byte)
_________________________________________________________________
```

Fig. 1. CNN Model

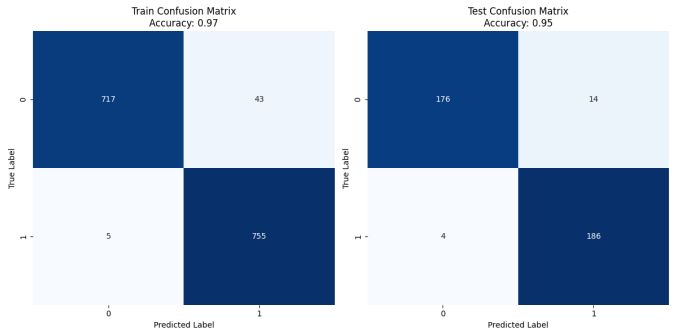

Fig. 2. Confusion matrix

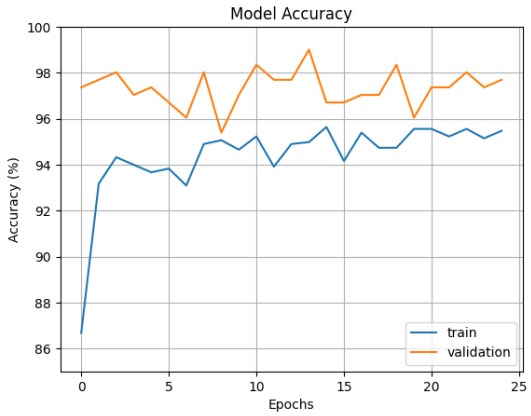

Fig. 3. Validation Accuracy v:s Epochs 25

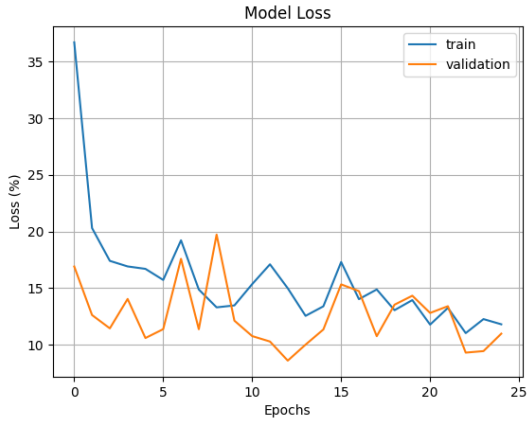

Fig. 4. Validation Loss v:s Epochs 25

V. Training and Test

In our experimental setup, the training dataset comprises 80% of the 1520 image samples, each with an image shape of 250 × 250 pixels , with three color channels (RGB). Similarly, the validation dataset consists of 20% samples of the training dataset and testing dataset consists of 380 images. In our experiments, we utilized a batch size of 16 and trained the models for a total of 25 epochs. The classification task involved predicting among two classes, resulting in a total of two output classes, Fire and No fire.

VI. Result

The training results shows decrease in validation loss, indicating the improved ability of model to accurately classify forest fire images. The training accuracy steadily increases, reaching 95.48% by the final epoch, while the validation accuracy remains consistently high, highest at 98.03%.

The training phase gave a confusion matrix with 717 true positives(TP) for fire, 755 true negatives(TN) for non-fire, 43 false negatives(FN), and 5 false positives(FP). In the testing phase, the confusion matrix showed 176 true positives(TP) for fire, 186 true negatives(TN) for non-fire, 14 false negatives(FN), and 4 false positives(FP). These results indicate that the model effectively distinguishes between fire and non-fire instances, achieving high accuracy in both training and testing datasets.

These results suggest that the Convolutional Neural Network (CNN) effectively learns to distinguish between fire and non-fire images, achieving high accuracy in both training and validation datasets.

VII. Conclusion

In conclusion this models uses layer architecture with aim to classify image with fire from images with no fire. the accuracy of the model is 97% , indicating that the model accurately classify the images of forest fire from image of no fire.

References

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[2] keras Documentation - https://www.tensorflow.org/guide/keras