"Journal of Education for Pure Science- University of Thi-Qar
Vol.14, No.1 (2024)
Website: "jceps.utq.edu.iq" *Email:* "jceps@eps.utq.edu.iq"

DOI: http://doi.org/10.32792/utq.jceps.10.01.01

Fire detection by using CNN Alex net Algorithm

Sadiq Karim, **Dr. Mustafa J. Hayawi**

sadiqkarimcomp@utq.edu.iq mustafahayawi@utq.edu.iq

College of Education for Pure Sciences, Computer science department, Thi-Qar University, IRAQ

Received 8/1/2024, Accepted 7/2/2024, Published 1/3/2024

Abstract:

Fire detection using convolutional neural network(CNN) algorithm and surveillance cameras is a field that aims to use technology to detect and intervene in fire incidents quickly and effectively. Fires are considered one of the most dangerous disasters that can occur in buildings and facilities, so developing early fire detection systems is vital to preserve lives and property. Surveillance cameras are used to collect real-time images and videos and send them to a fire analysis and detection system. . In the event of a fire being detected, an immediate alert will be issued to the competent authorities or building owners to take the necessary measures. Develop a fire detection system using by CNN-based algorithm. This system must be accurate and cost-effective. It has many advantages use of visibility infrastructure compared to other existing systems. There are three types.

First: There is no need to update the stove structure, provided that the place is equipped with surveillance cameras that monitor fire situations and cover the entire place.

Second: camera-based systems provide the actual location, that is, a complete map of the fire location, which is good , helps in detecting the fire.

Third: the methods used can be highly applicable Watching fires in public places.

Our system achieved excellent results with average prediction accuracy of 98.14% and 98% on the Forest dataset and the Local dataset, respectively. AlexNet is well known as a transfer learning model, where knowledge is learned by training a large amount of datasets . AlexNet is a deeper and broader CNN model introduced in 2012. AlexNet is primarily design , Alex Net consists of five convolutional layers and three FC layers. The Alex net structure is shown. The first convolutional layer implemented convolution and max pooling using local response normalization (LRN)Finally, two FC layers are used with dropout followed by a SoftMax layer following the first two convolutional layers Overlapping Max Pooling layers The third, fourth and fifth convolutional layers are directly connected. The fifth convolutional layer is followed by the Overlapping Max Pooling layer, whose output is transmitted to a series of two FC layers. The second fully connected layer feeds into a softmax classifier

After all the convolution and FC layers, ReLU nonlinearity is applied. The ReLU nonlinearity of the first and second convolution layers follows a local regularization step before pooling.

Keywords: deep learning ;convolutional neural network; fire detection; CCTV; Alexnet

1-Introduction

Fire recognition, control and reporting of their presence, convolutional neural network algorithms and defensive camera systems are optimized using the latest technologies. One class of deep learning algorithms called convolutional neural networks (CNN)are used to analyze images and identify certain patterns. These networks rely on the application of transformational sequences. Applying several methods to an image in order to identify patterns and important information. [1]

These networks are trained on a large set of pre-classified images so that they can accurately identify different patterns. When convolutional neural network algorithms are applied to fire detection systems, a large set of images showing fires and other related scenarios are used to train the network. may be able to detect these patterns in new images and determine whether there is a fire or not. Advantages of using surveillance cameras and convolutional neural network techniques in fire detection systems.

Fire detection systems use surveillance cameras to capture images of target areas in real time [2]

2. Related work:

The convolutional network and cameras are fully guaranteed:

A specialized all-detection CNN must be developed in order to use convolutional networks for this plant. A wide range of rejection and other scenarios are used to train these correlations Collect training data: To train CNN models, a large set of countless images and other scenarios must be collected.[3] Improving network performance: Using CNN is responsible for what it takes to improve the learning skills and performance of the network by modifying its parameters. Expectancy can be increased by using strategies such as changing the learning rate after the appearance of side layers.[4] Creating a Microsoft System: Convolutional communication networks should be used to create a polynomial surveillance camera system. Real-world uses: Surveillance cameras and the convolutional neural network algorithm for fire detection have many real-world uses. [4]

3.The suggested program:

In order to prevent obstruction, it is ideal for the surveillance camera used in this system to be mounted at light pole height. The system receives the picture that these cameras take once per minute, together with the coordinates of every single scenario. Individual fire detection photos are divided up by the system and fed into a CNN (Alex Net) that has already been trained on pictures of both fire and non-fire scenes. [5] Each individual fire location is classified as the output of Alex Net. For the purpose of directing firemen to the site of an incident, the system determines the locations of incidents and non-events or generates a map that can be shown on a screen in an appropriate area. **Figure (1)**.Proposed program

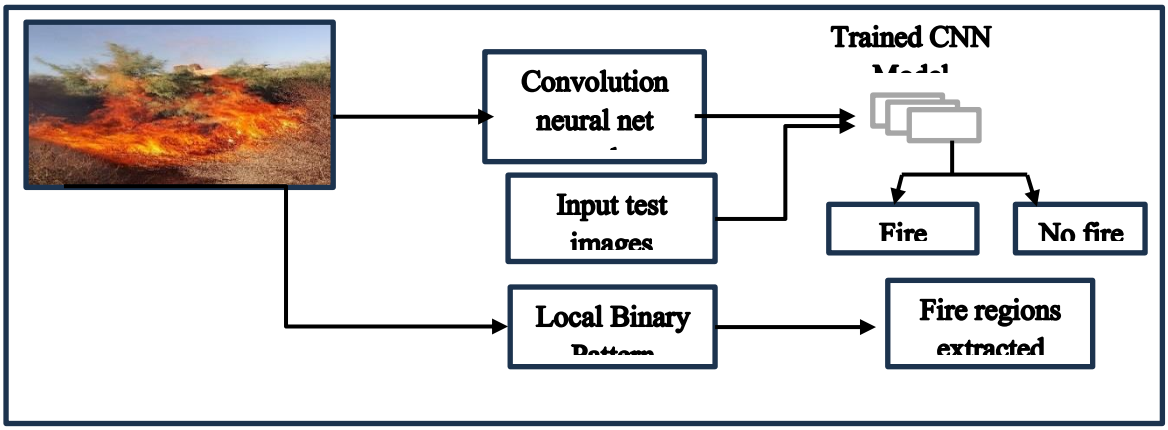


Figure (1).Proposed program

3.1 pre-processing stage

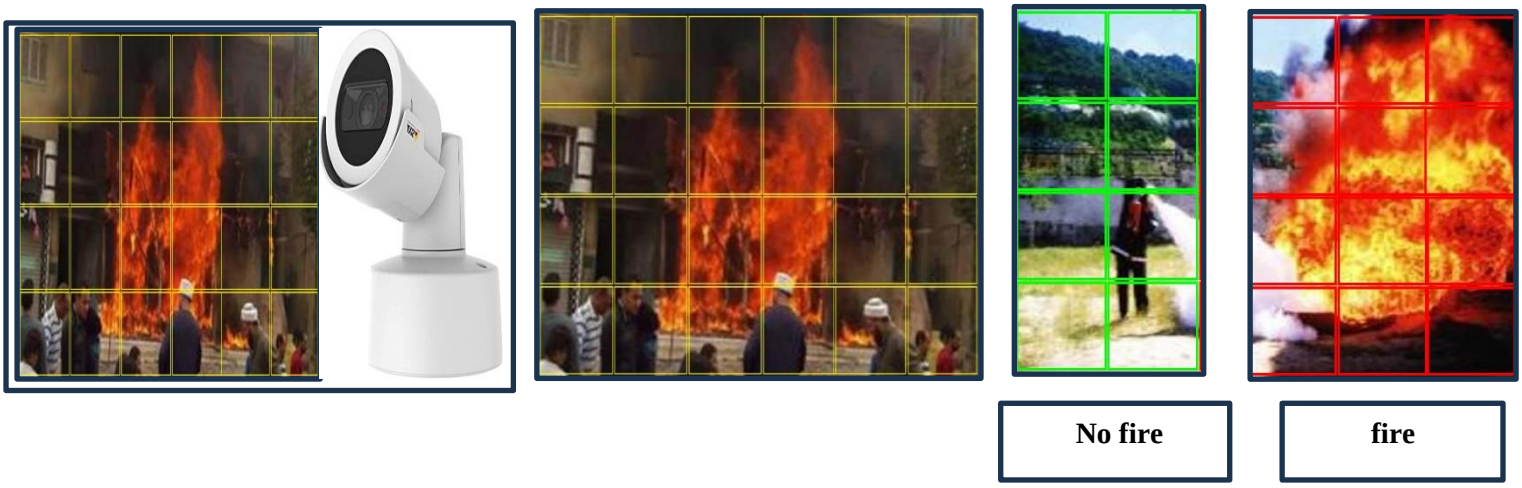
The input image undergoes preprocessing before being used in the suggested system. These actions are:

1- Take a photo of the location usingSurveillance Cameras.

2. Locate the specific position's coordinates (planning the fire location)

3. Change the size of each trigger point in the image, noting that CNN supports it, as the key points of each image can be determined through the CNN network.

4- Modify the cropped image's dimensions to conform to the system's algorithm only RGB picture formats. CCTV cameras provide the images for our suggested system. Thus, adding functionality to change the image type is not necessary. The image is RGB, which explains this.(Red, Green and Blue). The Each of these procedures represents the pre-processing phase.[6]



a-The system is outfitted with a camera, which

b- determines the coordinates of

c- crops individual positions images, and determines the individual fire lot

Figure (2): a, b, and c Images Make Pre-Processing Stage Clear

3.2 Stage of convolutional neural network:

After completing the pre-processing of the fire image, CNN Alex Net was used in this study to evaluate the fire situation to determine from the site used, i.e. the one on which it was trained, whether there is a fire.[7]

3.2.1 CNN strata:

They are layers. Everything in this series has a specific function, which are the three types that the layer in the network is tested for:

I- Convolutional layer:

The distinctive features of the raw image are displayed via feature maps, which are produced using it. Convolutional layers, as their name implies, perform entirely different tasks than other neural network layers; instead, they include filters that convert images into feature maps[10]. As an illustration The warped image will be computed as follows if the kernel filter (K) and input image (I) are both of the 2D type. [8] as shown in Figure (3).

$$S(I,j) = \sum_m \sum_n I(m,n)K(I-m, j-n) \quad (1)$$

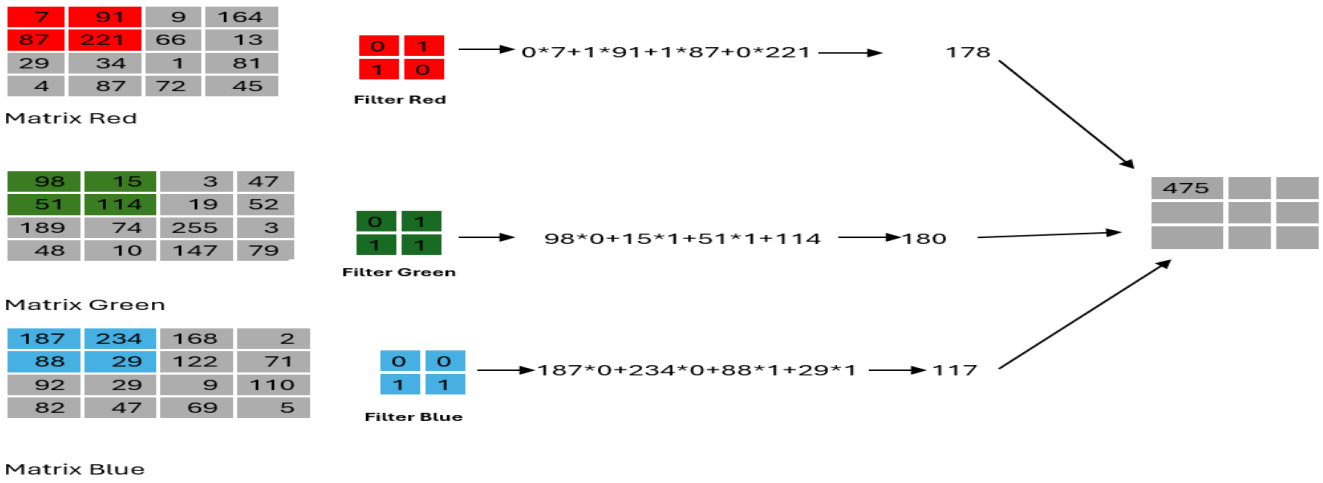
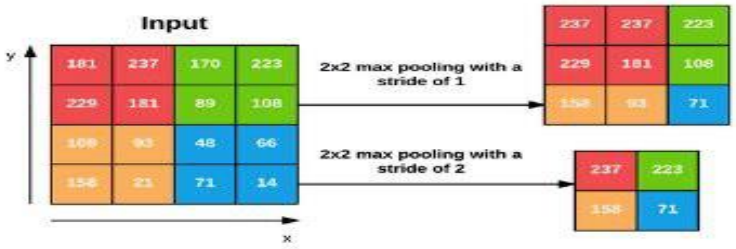


Figure (3): Multi-element array count in convolutional language.[8]

The second layer is the pooling layer, also known as the subsampling layer. Dimensional reduction happens right after the torsion process is finished. As a result, the parameter set is reduced, which lowers the amount of overprocessing and training time [9]. It contributes to keeping both the input and output maps in their current states. This process's formulation is described.[10]

$$X_j^i = \text{down}(X_j^{i-1}) \quad (2)$$



] t to the categorization la ısing a fully connected layer using features that were taken from Latin antecedent (convolutional layer). The neural and fully connected layer is used as the classifier. [11]

3.2.2 Alex Net

It also known as transfer learning model where knowledge is learned from large-scaler, training Quantity of data. Alex Net consists of five convolutional layers, three maximum pooling layers, and three fully connected (FC) layers.

- **Programmatic steps to implement Alexnet Architecher:**

To implement the AlexNet fire detection algorithm, the following programming steps must be followed:
1- Preparing data: A data set must be prepared that contains images of fires and other non-fire images.
2- Model creation: This includes building an artificial neural network based on the AlexNet architecture.
3-Training the model: The model must be trained using pre-processed training data.
4- Model testing: After training, the model's performance should be tested using a separate test data set.
5-Optimization and tuning: Network parameters and algorithms used can be adjusted to obtain the best possible performance. These are the basic programming steps to implement the AlexNet fire detection

algorithm. It is noted that these steps form part of a broader process to develop a complete automatic fire detection and classification system

- Alex net is a classic convolutional neural network architecture it consists of convolutions , max pooling and dense layers as the basic building blocks. Figure (5) shows an illustration of the Alex Net architecture.

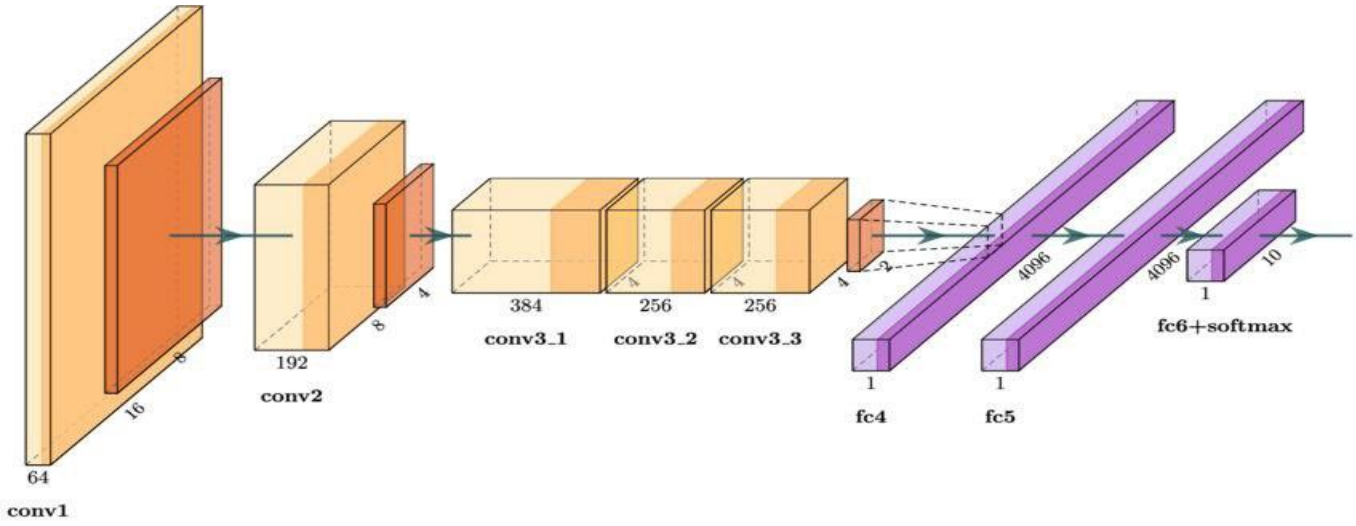


Figure (5). Diagram of Alex Net layers [12]

3.2.3Training of Alex Net

The Alex Net network training procedure involves selecting convolutional layer kernels and FC layer weights that minimize discrepancies between the output predictions and ground truth labels available in the training dataset (fire detection system). Table 3.1 shows how the model performs under different combinations of kernel and weight. The performance of the model is determined .First, the pre-trained Alex Net images and segmented images are loaded into the image data store in order to fine-tune the Alex Net using the fire detection system dataset. The data store does not load images into memory, it immediately adds the labels “Presence of fire” and “No fire” to each image. The image size is read if 227 x 227 and is submitted directly to the Alex Net without any size modifications. We then separated the image sets into test sets and training sets.[13]

Table (3.1): An explanation of Alex Net's network parameters

teachers' name	Parameter Value
Learningrate	0.00001
MaxEpochs	5
Minibatch Size	64

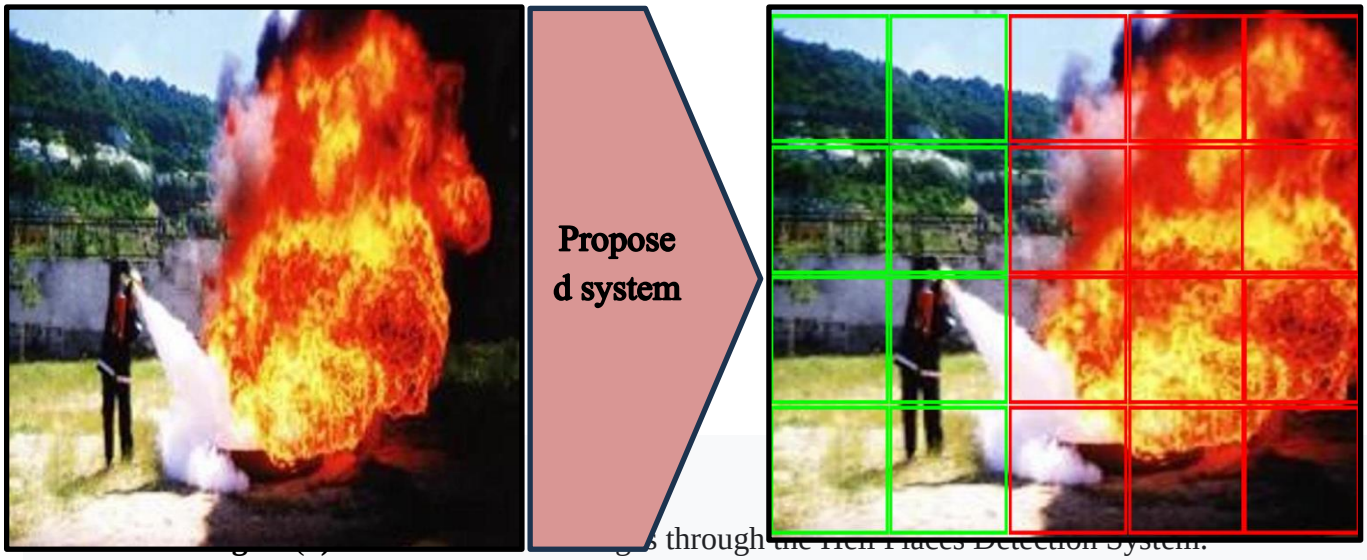
Initial Learn Rate	1e-5

3.2.4 Testing AlexNet

The transaction begins immediately after the training ends. 190 technician tested from FOREST data and 125 local data were used and then divided into 70% for training and 30% for testing the Alex Net models which were effectively trained.

3.3 Stage category

The convolutional neural network's classification stage, which comes at the end, is where the fire surveillance camera's image is classified. Following the acquisition of the image, the image is resized to match the algorithm and the individual fire area is cropping based on the input coordinates, An image with dimensions of 227 x 227 is fed into the CNN by the Alex Net algorithm, while the two other algorithms (Dense Net 201 and ResNet50) require an input size of 224 x 224. which will compare the images input from the camera with the images of the test samples to ascertain whether or not a particular image contains a fire.[13]



Input images **The resulting fire detection map**

4. Datasets: In this study, the Forest data set was used and the local data set.

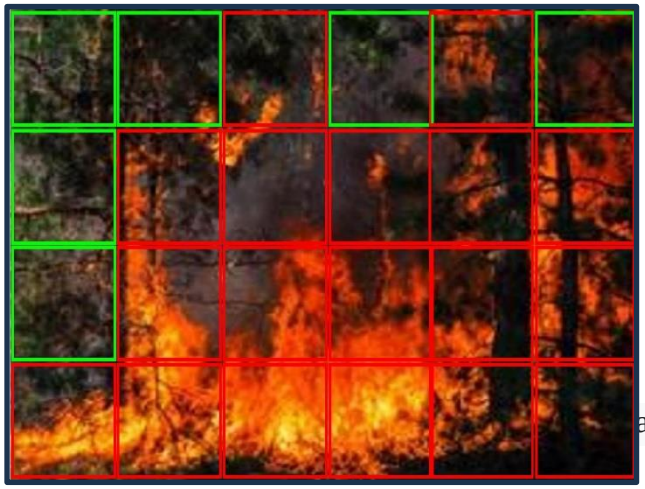
4.1 The Forest Dataset

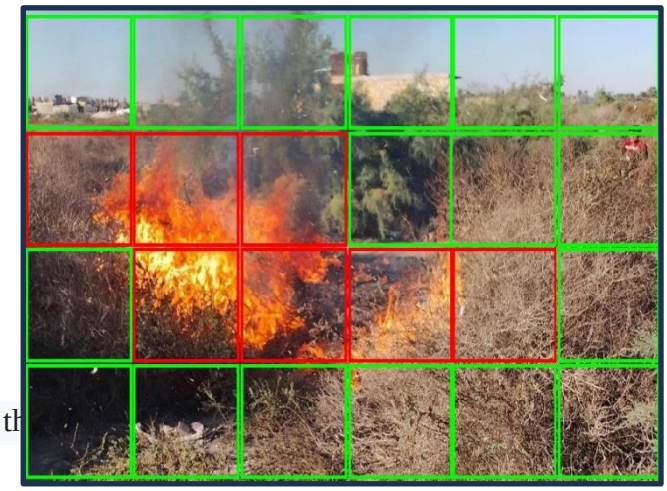
The Wildfire Dataset is a dataset containing 14,240 fire images detailed about wildfires in many locations around the world. This collection was compiled by a research team in the field of computer science and artificial intelligence to facilitate the study and analysis of forest fires and their locations and the development of predictive models. The wildfire dataset includes a wide range of information, including

the date and time, the geographic location of each fire, the area of land affected by the fire, the cause of the fire if it can be determined, fire suppression methods used, types of vegetation burning, and local weather conditions during the fire outbreak. Data was collected from various sources Such as government agencies, fire monitoring companies, and historical records. The data has been carefully cleaned and analyzed to ensure the accuracy and reliability of the information provided. The wildfire dataset is used in many research and applied fields, including environmental science, computer science, climate change, and fire management. Analysis of this set of data is an important tool for understanding forest fires, their location, and their impact on the environment and society. When the percentages were shown in relation to the local and global database.[15]

4.2 Local Dataset

Sample images were obtained by researchers for this study. The dataset It consists of 125 images of long hours. It is (125*24=3000) which means that the total number of fire locations is 3000 images. They are inspected and hand- marked. The number of places with fire is 1891, and the number of places without fire is 1191. All of these photos were taken in places near and far from the house in Dhi Qar Governorate/Iraq. Images were acquired over the historical time period, changing the location of the fire from 2:15 PM to 5:00 PM for one day. Using a 64-megapixel camera from the top of the two-story building to see the main plankton that can talk between the neighbors or behind them.





ating th

5. Evaluation criteria:

According to the proposed system, the number of people to choose: First,

The second, third recall, precision measure ,F,[14] was used. The symbols in the equations mean that TP (true positive) is the number of manual images of the target as fire and actual fire, TN (true negative) is the number of mental images of the non-Japanese as non-motorcycle, and FP (false came) is the number of conceptual images of its target as It's a motorcycle. fire. Not actually a fire. FN (false negative) is a number of tactical images that appear to be non-motorcycle images and are actually fire.

TP: It is the correct form in which there is no error, i.e. correct statements.

TN: These are true and false statements, meaning the picture contains an error.

FP: These are false statements that are true, meaning there is an error in the picture.

FN: These are false statements, meaning the picture contains an error.

$$Accuracy = \frac{TP+TN}{P+N} \quad (1) \qquad Precision = \frac{TP}{(TP+FP)} (2)$$

$$Recall = \frac{TP}{(TP+FN)} (3) \qquad F\text{-}score = \frac{2\times Precision \times Recall}{Precision+Recall} \quad (4)$$

6. Implementation details:

After completion of training, testing procedures begin. While CNN classifier is used for testing The new unclassified images are the classifier generated during the training process, the fire image. The fire image is then listed as neither fire nor fire. 70% of the samples during the training phase (70 images) were randomly selected to train Alex Net. The remaining 30% of images (30 images) were randomly selected from all samples to test the performance of the proposed CNN. Parameters are also calculated at this stage by comparing the results with the actual images. Based on MATLAB R2022a language, Alex Net is easily trained and tested, executing all CNN codes, in PC and MSI having specifications like Intel(R) Core (TM) i7- 10750H @ 2.60 GHz CPU, windows11Home, 16GB of RAM, 64-bit OS and GPU (RTX3060).

7. Evaluation results:

With the recommended method, we were able to obtain 98.14% accuracy using 190 images from Forest. The dataset yielded an accuracy of 98% and contained 125 images from the local database collected at different times of the day and in different weather conditions (sunny, cloudy, and rainy). Furthermore, while applying transfer learning to local database images using Alex Net trained on the Forest dataset Our recommended method, which remained hidden from the network, achieved 100% accuracy. Principal classification criteria derived from the Forest dataset are shown in. Table 2 presents the outcomes of the suggested model classification standards. Standard Forest dataset evaluation

Evaluation	Forest dataset	Local dataset
Accuracy	98.14%	98%
Precision	96%	99%
Recall	97.65%	97.22%
F-score	97.11%	97.33%

8. Marketing potential:

71 samples (photos of fires) from the local data set were used in Alex Net's testing.

It has 2,201 locations, and every space that has fire or does not have fire was diagnosed without any errors. This indicates that the network performed flawlessly on photos that you have never seen before. Half a second was the average testing time for images. Because the system is ready to be put in any street or outdoor business spot in residential regions, this suggests that there may be a chance to sell it. Without any training, all you need to do is enter the fire photo coordinates of this fire stop, and it will begin operating as soon as it is installed, efficiently providing its services. The system's enormous potential cane high degree of accuracy and is cheaper than a sensor-based system.[13]

9. Conclusion:

In this study, vector CNN Alexnet was used to create an image-based framework for the amount of milk in the surrounding environment. The framework demonstrated great reliability, scoring 98.14% Forest dataset on the public training dataset and 98% Local dataset accuracy on the research dataset of interest. These results suggest that the framework is suitable for testing, as it offers a dependable and affordable option. Regarding FDCN. systems in outdoor settings. This indicates that, based on the Alex Net algorithm, the proposal makes various suggestions. The occurrence of a fire outside the approved area or an area defined prior to firefighting, as well as the culture of the training data used, are some obstacles that may have an impact on the impact on learning transfer. AlexNet is a popular algorithm in the field of machine learning and artificial neural networks. It was developed by Alex Krzyzewski and Evan Suskinder in 2012. It was first used in the ImageNet Large Scale Visual Recognition Challenge (ILSVRC) where it achieved great success. AlexNet has several features that make it distinct from other algorithms such as ResNet and DenseNet. ResNet is another algorithm in the field of machine learning and artificial neural networks, which is short for "Residual Network". It was developed by Karim Heng and Zhang in 2015. ResNet features a new idea called "residual learning" where the original inputs are added to the expected outputs of the layers, allowing for easier training of deep networks. DenseNet is another type of artificial neural network, which is short for "Densely Connected Convolutional Networks". It was developed by Jean-François Bruel and Andrew Zeller in 2017. DenseNet features that each layer benefits from the outputs of all the layers before it, making it more resource efficient. AlexNet has several features that make it unique from ResNet and DenseNet,[16]. including: Iterative Correction (Local Response Normalization): AlexNet uses an iterative correction process to improve network performance. Benefit of GPU: AlexNet was the first artificial neural network to fully leverage the power and utility of graphics processing units (GPUs).Cultural Impact: AlexNet success in the ILSVRC competition has increased people's interest in artificial intelligence and the development of artificial neural networks.[17]

REFERENCES

[1] Muhammad, K., Ahmad, J., & Baik, S. W. (2018). Early fire detection using convolutional neural networks during surveillance for effective disaster management. *Neurocomputing*, *288*, 30-42.

[2] Wang, K., Zhang, Y., Wang, J., Zhang, Q., Chen, B., & Liu, D. (2018, July). Fire detection in infrared video surveillance based on convolutional neural network and SVM. In *2018 IEEE 3rd International Conference on Signal and Image Processing (ICSIP)* (pp. 162-167). IEEE.

[3] Al Mahrouqi, A. S. M. (2021). *Patient-Centered Care and Self-Management of Type-2 Diabetes in Oman: A Mixed-Methods Study* (Doctoral dissertation, George Mason University).

[4] Ahmad, F., Adnan, M., Amin, A. A., & Khan, M. G. (2022). A comprehensive review of fault diagnosis and fault-tolerant control techniques for modular multi-level converters. *Science Progress*, *105*(3), 00368504221118965.

[5] Gray, P. C., Chamorro, D. F., Ridge, J. T., Kerner, H. R., Ury, E. A., & Johnston, D. W. (2021). Temporally generalizable land cover classification: A recurrent convolutional neural network unveils
[6] Loftus, C. A., Soler, Z. M., Koochakzadeh, S., Desiato, V. M., Yoo, F., major coastal change through. Nguyen, S. A., & Schlosser, R. J. (2020, February). Revision surgery rates in chronic rhinosinusitis with nasal polyps: meta-analysis of risk factors. In *International forum of allergy & rhinology* (Vol. 10, No. 2, pp. 199-207).

[7] Gaur, A., Singh, A., Kumar, A., Kumar, A., & Kapoor, K. (2020). Video flame and smok based fire detection algorithms: A literature review. *Fire technology*, *56*, 1943-1980.

[8] Li, P., & Zhao, W. (2020). Image fire detection algorithms based on convolutional neural networks. *Case Studies in Thermal Engineering*, *19*, 100625.

[9] Gaur, A., Singh, A., Kumar, A., Kulkarni, K. S., Lala, S., Kapoor, K., ... & Mukhopadhyay, S. C. (2019). Fire sensing technologies: A review. *IEEE Sensors Journal*, *19*(9), 3191-3202.

[10] Roni, M. S., Chowdhury, S., Mamun, S., Marufuzzaman, M., Lein, W., & Johnson, S. (2017). Biomass co-firing technology with policies, challenges, and opportunities: A global review. *Renewable and Sustainable Energy Reviews*, *78*, 1089-1101.

[11] National Fire Protection Association. (2007). *NFPA 70: National electrical code*. NationalFireProtectionAssoc.

[12] Iandola, F. N., Han, S., Moskewicz, M. W., Ashraf, K., Dally, W. J., & Keutzer, K. (2016). SqueezeNet: AlexNet-level accuracy with 50x fewer parameters and< 0.5 MB model size. *arXiv preprint arXiv:1602.07360*.

[13] National Fire Protection Association. (2007). *NFPA 70: National electrical code*. NationalFireProtectionAssoc.

[14] Hosni Mahmoud, H. A., Alharbi, A. H., & Alghamdi, N. S. (2022). Time-Efficient Fire Detection Convolutional Neural Network Coupled with Transfer Learning. *Intelligent Automation & Soft Computing*, *31*(3).

[15] Muhammad, K., Ahmad, J., & Baik, S. W. (2018). Early fire detection using convolutional neural networks during surveillance for effective disaster management. *Neurocomputing*, *288*, 30-42.

[16] McKiernan, G. (2000). arXiv. org: the Los Alamos National Laboratory e-print server. *International Journal on Grey Literature*, *1*(3), 127-138.

[17] Huang, C., Zha, X., Yan, Y., & Wang, Y. (2019). Understanding the social structure of academic social networking sites: The case of ResearchGate. *Libri*, *69*(3), 189-199.