Available online at http://scik.org
J. Math. Comput. Sci. 11 (2021), No. 4, 4917-4929
https://doi.org/10.28919/jmcs/5966
ISSN: 1927-5307

ILLUSTRATION OF THE IMAGE PROCESSING CAPABILITIES OF CONVOLUTION NEURAL NETWORKS THROUGH PROTOTYPE IMPLEMENTATIONS

SUJA CHERUKULLAPURATH MANA[†,*], T. SASIPRABA

Department of Computer Science and Engineering, Sathyabama Institute of Science and Technology, Chennai, India

Abstract: Convolution neural network is a deep learning algorithm which is prominently applicable for image processing applications**.** The high feature learning capacity of convolution neural networks make it beneficial for applications involving image processing. Based on the learned features CNN network can easily classify data. This paper describes the capabilities of CNN network through three implementations. The first implementation on uses convolution neural networks for plant leaves disease detection. The second implementation uses CNN based implementation for the railway track's crack detection. An underwater fish species classification implementation also discussed. These implementations show how efficiently CNN can perform the task in comparison with manual counterparts.

Keywords: convolution neural networks; classification; pooling.

2010 AMS Subject Classification: 92B20.

[*]Corresponding author

E-mail address: cmsuja@gmail.com

[†]Research Scholar

Received May 1, 2021

1. INTRODUCTION

Processing the image for retrieving useful information is important in many of the scientific studies. Most of the time data will be available in the form of images or videos. The main issue with these data is that they contain high level of noises. Noise can be any unwanted information present in the input file which is insignificant for the particular study. Removing that unwanted data is called pre-processing of input.

Convolution neural network has high feature learning capabilities, so the amount of pre processing needed is very less. This feature makes CNN highly beneficial for image processing applications. In this paper authors discuss about some implementations using CNN. The first one is the plant leaf disease detection using CNN. In this implementation images of plant leaves are given as an input to the CNN implementation. The CNN model can effectively predict the diseases from these images. The second implementation is that of a railway crack detection system. In this implementation also CNN based model is used to detect the cracks in the railway platform images. The third one is the fish species classification application. Here a CNN based model is used to classify the fish species from a publically available image dataset. These implementations are capable of proving the efficiency of CNN model for image processing.

The paper progresses in such a way that in upcoming sections authors have discussed about related studies, overview of CNN model, three implementations followed by conclusion and future works.

2. RELATED STUDIES

C. Narvekar et al. [1] describe about a prototype CNN based architecture foe flower species classification. They have used a publically available dataset to do the classification. P. G. M. Sobha et al. [2] perform a survey on how CNN can be used for plant species classification. This survey is capable of showing the efficiency of CNN in plant species classification. D. Pechebovicz et al. [3] talks about a mobile based system using CNN for plant recognition. The proposed mobile application is capable of detecting various types of medicinal plants. This implementation focuses on optimization of architecture on mobile devices.

M. Sardogan et al. [4] present a learning vector quantization and CNN based method to detect diseases on tomato plant leaves. CNN is used for feature extraction and classification. Colour information is used to make the prediction. M. K. R. Asif et al. [5] describe a CNN based approach for disease detection in potato leaves. Various CNN models are tested on the dataset to get better result. This model is highly helpful in detecting diseases in potato plant leaves at an early stage [5]. In paper [6] authors talk about the application of mask R-CNN. P. A. H. Vardhini et al. [7] describe how convolution neural network based implementation can be used for detection of paddy field disease detection. Raspberry pi is also used in this implementation. B. V. Deep et al. [8] talks about CNN based fish species classification. Max pooling is used in between the CNN layers to improve the efficiency of the network. D. S. Y. Kartika et al. [9] talks about a koi fish classification method. This method uses K-Means algorithm for pre processing.

3. Materials and Methods

3.1 Overview of CNN

Convolution neural network is a deep learning algorithm that is highly effective in image processing applications. A typical CNN model consists of convolution layer, fully connected layer with pooling layer in between. Feature extraction is performed by the convolution and pooling layer. There are three types of pooling available namely max pooling, min pooling and average pooling. The max pooling returns the maximum value for the feature from the selected window. Similarly the average pooling will return the average value from the selected window. The python code for the implementation of max pooling is given below in figure 1[fig.1].

```
import numpy as np
from keras.models import Sequential
from keras.layers import MaxPooling2D


image = np.array([[2, 3, 4, 50],
                  [8, 9, 10, 31],
                  [14, 15, 16, 17],
                  [18, 19, 20, 25]])
image = image.reshape(1, 4, 4, 1)


model = Sequential(
    [MaxPooling2D(pool_size = 2, strides = 2)])


output = model.predict(image)


output = np.squeeze(output)
print(output)
```

```
[[ 9 50]
 [19 25]]
```

Fig. 1. Python code to implement max pooling

The above given program provides a python implementation of the max pooling function. Here window stride size and pool size are set to 2 . An illustration of max pooling is shown in figure 2[fig.2].

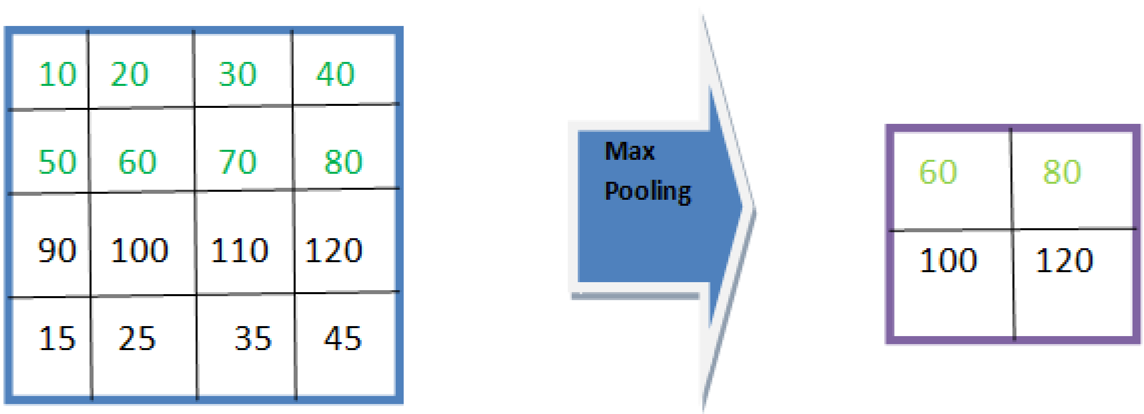

Fig. 2. Illustration of Max pooling

In the following sections authors describe about some prototype implementations which shows the ability of CNN in image classification.

3.2 Plant Disease Detection Using CNN

This section describes a plant disease detection implementation using convolution neural networks. The implementation tries to identify the diseases on apple leaf using CNN. Deep-CNN based model is proposed here. The model analyses various types of spots present on apple leaf and identify the diseases using deep-cnn based architecture. The architecture diagram of the implementation is given below. Figure 1 shows the architecture diagram of a plant leaf disease identification model using CNN. Compared to its human counterpart this model displays better performance in terms of various evaluation parameters.

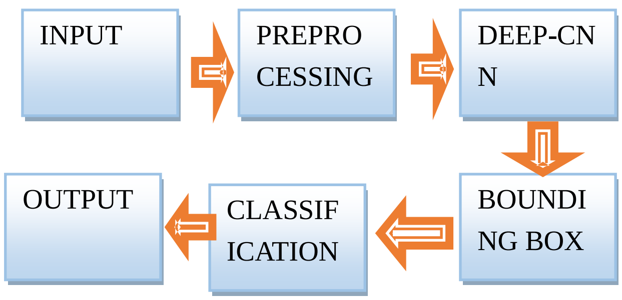

Fig. 3. Architecture diagram of the plant disease classification system

Figure 3[fig.3] shows the architecture diagram of the plant disease classification system.

The output screen captures are given below in figure 4[fig.4].

Fig. 4. A sample output screen capture.

This deep-CNN implementation provides an efficient detection of plant leaf diseases. It can also able to classify the leaves as healthy and unhealthy. Various types of diseases like Alternaria leaf spot, Brown spot, Mosaic, Grey spot can be identified by this model.

The flow diagram of this model is given in figure.5 [fig.5]

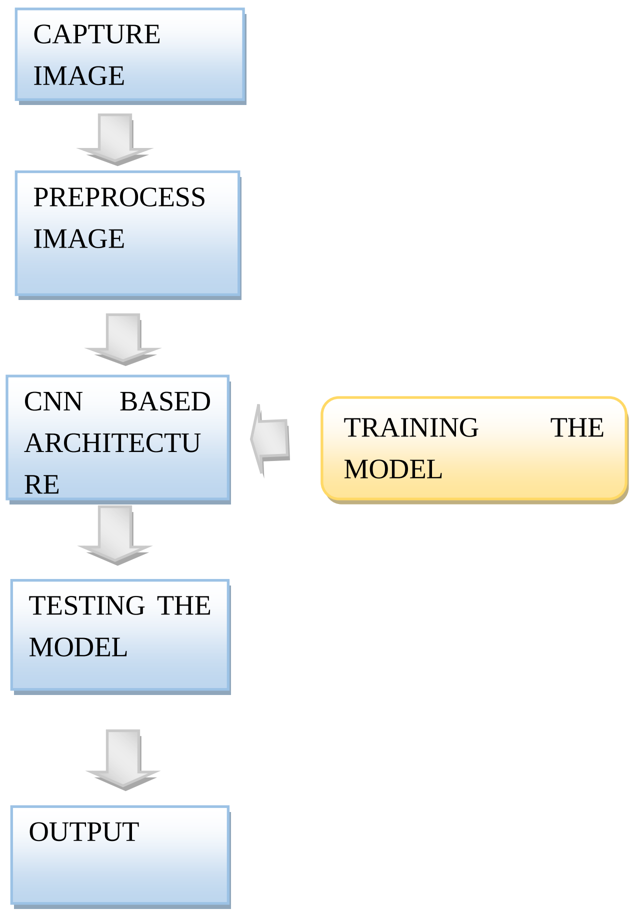

Fig. 5 Activity diagram of the system

The figure 5 shows the activity diagram of the system. As shown in the diagram first the captured image will be pre processed to remove the noises involved in the image. As the CNN based architecture has high level of feature learning capability the amount of pre processing required is less compared to other similar architecture. The CNN based architecture is trained by using the training data, and then the same will be tested on the input data. The architecture can effectively predict the diseases present in the plant leaves. This implementation is clearly an evidence of the effectiveness of CNN in image processing.

3.3 Railway Track Crack Detection Using CNN

This section describes another implementation using CNN which is the railway track crack detection. Here a prototype model has been designed which can take the images of railway tracks and can identify and classify any cracks present in the tracks. This implementation has used masked CNN to implement the railway crack detection model. The model has been trained using some sample dataset and tested with input dataset and the model is giving high level of accuracy. If we are using manual methods then it will be highly time consuming to manually inspect the tracks and identify the cracks. But this CNN based model can detect the cracks very effectively with less amount of time. The architecture diagram of the model is given below in Fig 6.

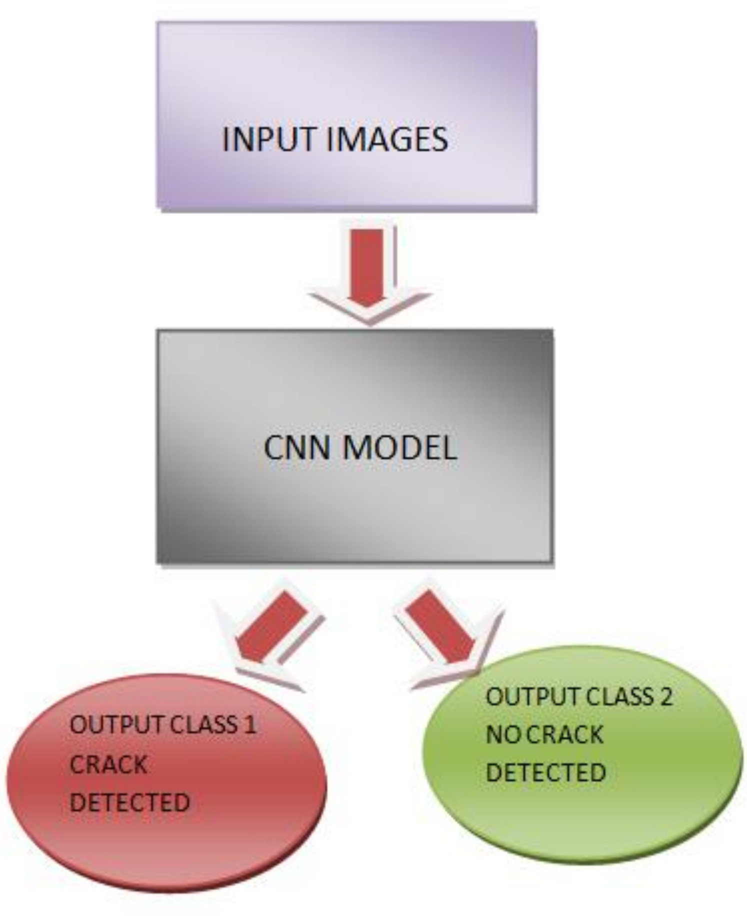

Fig. 6 Architecture diagram of the system

The model is first trained using a set of training data, and then the testing images are given to the model as shown in Figure 6 [fig.6].CNN model then process the images and classify it to either with crack or without crack output classes. In comparison with manually checking the tracks to see whether or not cracks are present, this CNN based model is highly efficient and work in less amount of time. Manual process are highly time consuming and a lot of manpower need to be spent , whereas here by using the CNN classification can be performed in minimum amount of time with high accuracy . Some screen captures of the implementation is given below. The training and validation accuracy is given in Figure 7[fig.7]. Figure 8[fig.8] shows the screen capture of the output screen.

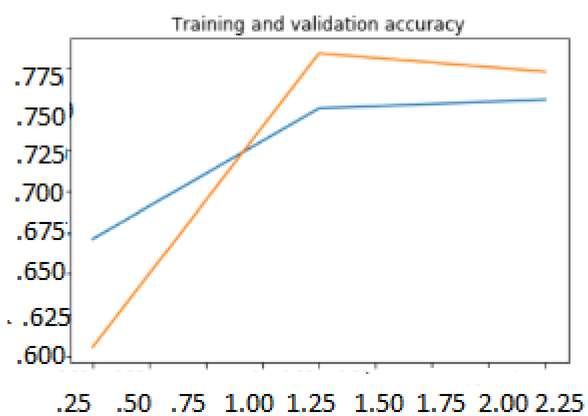

Fig. 7. Training and validation accuracy graph

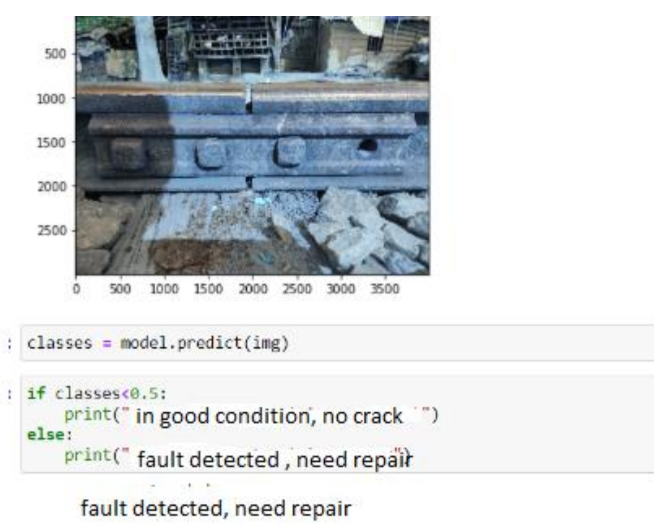

Fig. 8. Screen capture of an output

This implementation is an evident of how efficiently CNN model can process image and classify information.

3.4 Fish Species Classification Using CNN

A fish species classification prototype model is implemented using CNN. This model takes the underwater fish species images as inputs and it will be able to identify species from that image. We have used fish images from fish4knowledge dataset as inputs.

Identifying fish species manually is a tedious process .The amount of noises present in the image also creates problems in manual classifications. But the CNN based model can effectively classify the species with high accuracy in less amount of time. The architecture diagram of the proposed model is given below in figure 9 [fig.9]

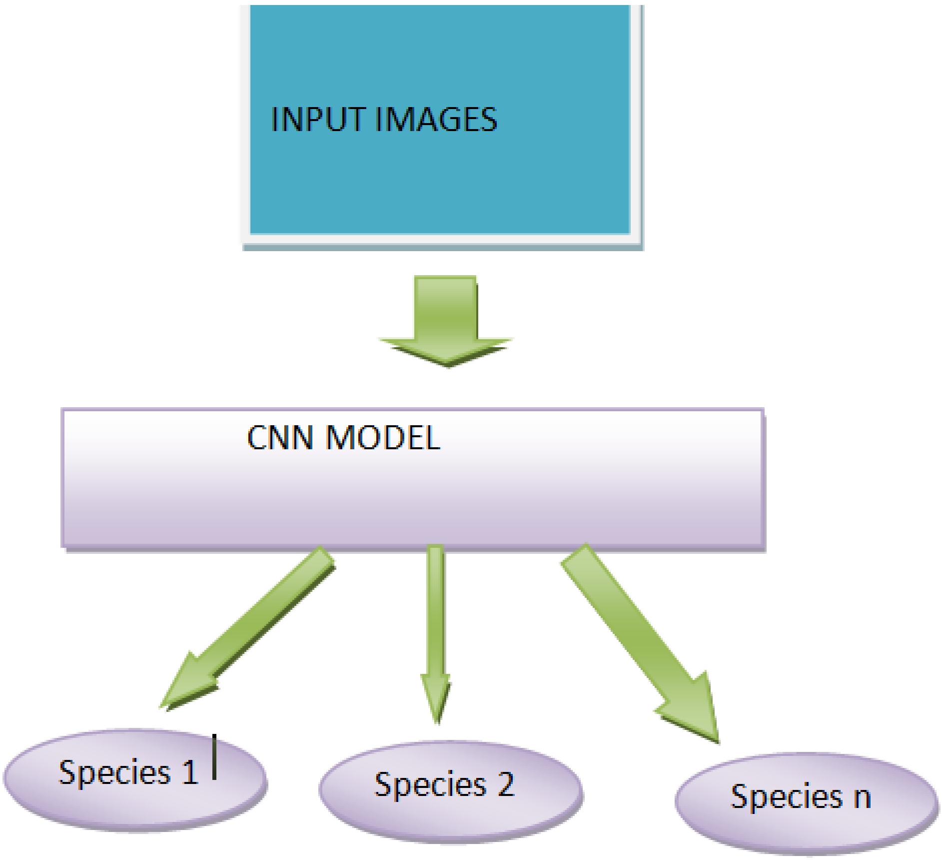

Fig 9: Architecture diagram

The model is tested using the performance measures accuracy, precision and recall. The graph showing the performance measures are given below in figure 10 [fig.10].

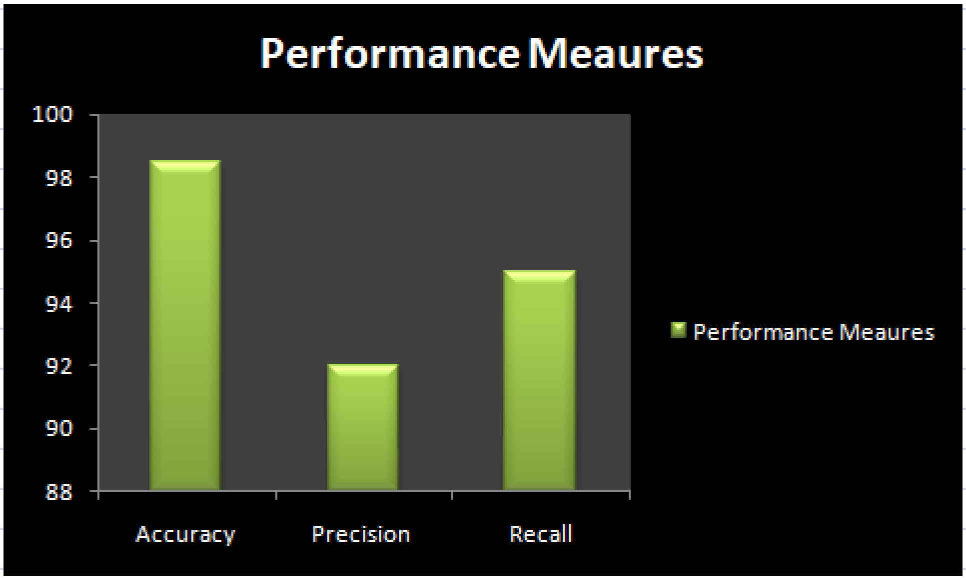

Fig.10 Performance measures of the model

Manual classification of fish species is a tedious task and it requires a lot of time and effort. It is highly error prone also. In comparison with manual classification CNN based method is highly efficient and less error prone. This prototype implementation is evident of how effectively image processing can be done using convolution neural network based models.

4. RESULTS AND DISCUSSION

This paper goes through three implementations which display the effectiveness of convolution neural networks in image processing. The first implementation talks about a plant leaf disease detection model using CNN . In this model the plant leaf diseases can be effectively detected using the CNN based model. Manual detection is highly time consuming whereas CNN based implementation can perform the same task with less amount of time.The accuracy of CNN based model is very high. The second prototype implementation is that of a railway track crack detection system. This implementation can effectively detect the cracks in railway track image with high level of accuracy. Third implementation is a fish species classification system. In this implementation underwater fish images are given as an input and the system can effectively detect the species from the input images. These implementations are evident for the ability of convolution neural network in image processing task. Compared to manual methods CNN based methods provide high level of accuracy and they are very useful in many of the image processing applications. The authors are currently working on developing CNN based model marine species classification. These prototype implementations are first step towards developing an efficient system for marine species classification.

5. CONCLUSION

This paper provides a study of the image processing capability of CNN model through some prototype implementation. These implementations are evident of the efficiency of convolution neural network in image processing. Manual processing of image is highly time consuming and error prone , while the CNN based model make the processing highly efficient with high accuracy . The high feature learning capability of CNN also decrease the requirement of a pre processing of input images. In all aspect convolution neural network can contribute highly to the image processing area.

DATA AVAILABILITY

Data will be made available on request. Data is publically available at https://groups.inf.ed.ac.uk/f4k/GROUNDTRUTH/RECOG/

CONFLICT OF INTERESTS

The author(s) declare that there is no conflict of interests.

REFERENCES

[1] C. Narvekar, M. Rao, Flower classification using CNN and transfer learning in CNN- Agriculture Perspective, in: 2020 3rd International Conference on Intelligent Sustainable Systems (ICISS), IEEE, Thoothukudi, India, 2020: pp. 660–664.

[2] P.G.M. Sobha, P.A. Thomas, Deep Learning for Plant Species Classification Survey, in: 2019 International Conference on Advances in Computing, Communication and Control (ICAC3), IEEE, Mumbai, India, 2019: pp. 1–6.

[3] D. Pechebovicz, S. Premebida, V. Soares, T. Camargo, J.L. Bittencourt, V. Baroncini, M. Martins, Plants recognition using embedded Convolutional Neural Networks on Mobile devices, in: 2020 IEEE International Conference on Industrial Technology (ICIT), IEEE, Buenos Aires, Argentina, 2020: pp. 674–679.

[4] M. Sardogan, A. Tuncer, Y. Ozen, Plant Leaf Disease Detection and Classification Based on CNN with LVQ Algorithm, in: 2018 3rd International Conference on Computer Science and Engineering (UBMK), IEEE, Sarajevo, 2018: pp. 382–385.

[5] Md.K.R. Asif, Md.A. Rahman, Most.H. Hena, CNN based Disease Detection Approach on Potato Leaves, in: 2020 3rd International Conference on Intelligent Sustainable Systems (ICISS), IEEE, Thoothukudi, India, 2020: pp. 428–432.

[6] C. Dongye, H. Liu, A Pavement Disease Detection Method based on the Improved Mask R-CNN, in: 2020 5th International Conference on Information Science, Computer Technology and Transportation (ISCTT), IEEE, Shenyang, China, 2020: pp. 619–623.

[7] P.A.H. Vardhini, S. Asritha, Y.S. Devi, Efficient Disease Detection of Paddy Crop using CNN, in: 2020 International Conference on Smart Technologies in Computing, Electrical and Electronics (ICSTCEE), IEEE, Bengaluru, India, 2020: pp. 116–119.

[8] B.V. Deep, R. Dash, Underwater Fish Species Recognition Using Deep Learning Techniques, in: 2019 6th International Conference on Signal Processing and Integrated Networks (SPIN), IEEE, Noida, India, 2019: pp. 665–669.

[9] D.S.Y. Kartika, D. Herumurti, Koi fish classification based on HSV color space, in: 2016 International Conference on Information & Communication Technology and Systems (ICTS), IEEE, Surabaya, Indonesia, 2016: pp. 96–100.

[10] P.L.D. Roberts, J.S. Jaffe, M.M. Trivedi, Multiview, Broadband Acoustic Classification of Marine Fish: A Machine Learning Framework and Comparative Analysis, IEEE J. Oceanic Eng. 36 (2011) 90–104.

[11] L. Yang, Y. Liu, H. Yu, X. Fang, L. Song, D. Li, Y. Chen, Computer Vision Models in Intelligent Aquaculture with Emphasis on Fish Detection and Behavior Analysis: A Review, Arch. Comput. Meth. Eng. 28 (2021), 2785–2816.

[12] A.B. Tamou, A. Benzinou, K. Nasreddine, L. Ballihi, Transfer Learning with deep Convolutional Neural Network for Underwater Live Fish Recognition, in: 2018 IEEE International Conference on Image Processing, Applications and Systems (IPAS), IEEE, Sophia Antipolis, France, 2018: pp. 204–209.

[13] K. Ko, S. Park, H. Ko, Convolutional Feature Vectors and Support Vector Machine for Animal Sound Classification, in: 2018 40th Annual International Conference of the IEEE Engineering in Medicine and Biology Society (EMBC), IEEE, Honolulu, HI, 2018: pp. 376–379.

[14] B.J. Boom, P.X. Huang, C. Spampinato, et al. Long-term underwater camera surveillance for monitoring and analysis of fish populations, in: Proc. Int. Workshop on Visual observation and Analysis of Animal and Insect Behavior (VAIB), in conjunction with ICPR 2012, Tsukuba, Japan, 2012.

[15] B.J. Boom, P.X. Huang, J. He, R.B. Fisher, Supporting Ground-Truth annotation of image datasets using clustering, in: Proceedings of the 21st International Conference on Pattern Recognition (ICPR2012), 2012, pp. 1542-1545.

[16] B.K. Samhitha, P. Yaswanth, Y.G. Srinivasulu, S.C. Mana, J. Jose, Analysis of Brain Tumor Segmentation using Convolutional Neural Network with Magnetic Resonance Imaging, in: 2020 International Conference on Communication and Signal Processing (ICCSP), IEEE, Chennai, India, 2020: pp. 1256–1260.

[17] B. Keerthi Samhitha, M.R. Sarika Priya., C. Sanjana., S.C. Mana, J. Jose, Improving the Accuracy in Prediction of Heart Disease using Machine Learning Algorithms, in: 2020 International Conference on Communication and Signal Processing (ICCSP), IEEE, Chennai, India, 2020: pp. 1326–1330.

[18] S.C. Mana, M. Saipriya, S.K. Sangeetha, Identification of Land Document Duplication and Black Money Transaction Using Big Data Analytics, in: 2019 Fifth International Conference on Science Technology Engineering and Mathematics (ICONSTEM), IEEE, Chennai, India, 2019: pp. 114–118.

[19] V. Ramamoorthy, S. Divya, S.C. Mana, B.K. Samhitha, Examining and sensing of artificial knee with multi sensors networks, J Adv. Res. Dyn. Control Syst. 10 (2018), 115-120.

[20] A. Brodsky, Suja Cherukullapurath Mana, Mahmoud Awad, N. Egge, A decision-guided advisor to maximize ROI in Local Generation & utility contracts, in: ISGT 2011, IEEE, Anaheim, CA, USA, 2011: pp. 1–7.