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Pre-Flood and Post-Flood Classification of Remote Sensed Data-Review of Existing Methods and Future Research Scopes

Amit Maru

PhD Research Scholar

Department of Computer Engineering

Gokul Global University, Sidhpur, Patan, Gujarat,

Dr. Dhaval Vyas

Faculty of Computer Science and Applications

Gokul Global University, Sidhpur, Patan, Gujarat,

Abstract:

There are so many natural disasters and Flood is among that which affects the humankind in large way. Basically, temperate, and tropical regions are the majorly affected area by food. It is harmful for various properties and plants, and also sometimes we loss human lives. So, it is mandatory to identify flood affected area or to get instant data of flood-affected area. Nowadays remote sensing is very popular and appropriate practice to identify flood or flood affected area without close contact of land. Identification of Pre-Flood and Post-Flood images form very large amount of remote sensing data is very critical task. In this paper, we review different recent research papers, realize the gap of knowledge, and discuss future research scope in same area. Here we try to focus on different types of techniques which is used for mapping the flood. In this paper we have compared result of different approaches in terms of accuracy it shows

that deep learning models are far better than the traditional method. We can also use other factors apart from the accuracy such as Recall, Precision, F1 factor etc.

Keywords: Pre-Flood, Post Flood, Classification, Flood Mapping, Deep Learning, Machine Learning, Change detection, Remote sensed data.

1. INTRODUCTION

There are so many reasons of Flood such as Storm surges from tropical cyclones Rapid snowmelt, cloudburst, etc. Floods can district large areas, also can damage properties and public health amenities.

1.1 Major Causes of Flood:

a) There is no good enough capacity within the banks of the rivers to maintain the high flows get down from the upside catchments because of heavy rainfall.

b) Floodplains' Encroachment

c) Synchronization of floods in the tributaries and its main rivers.

d) Few areas of the country, like coastal areas of Andhra Pradesh, Tamil Nadu, Orissa, experience cyclones, which are often accompanied by heavy rainfall leading to flooding.

e) Rapid growth of urban areas without planning, etc.

1.2 Floods – Broad Categories

a) Coastal Floods

It is very fast and very dangerous flooding of a coastal area. It happens due to temporary rise in water levels carried on by high tides and cyclone flows.

b) Flash Floods

Flash Floods can be possible due to many reasons, but it is happened most frequently because of very heavy rainfall from thunderstorms. Dam Breaks or Mudslides are the also causes of Flash Floods.

c) Urban Floods

Urban Flood occurs due to heavy rain and other reasons such as storm surge or a snowmelt etc. Because of heavy population in Urban areas and heavy infrastructure some time we loss human lives also. In most of the cities, harm to crucial foundation contains a bearing not as it were for the state and the nation but it harmful worldwide.

d) Pluvial Flooding

It happens when the sum of precipitation surpasses the volume of urban storm water seepage frameworks or the ground to assimilate it. Pluvial is a type of flooding that can be occurred in quite flat areas.

2 BACKGROUND

There are different approaches such as thresholding, segmentation, visual interpretation and textural analysis and Normalized Difference Water Index (NDWI) were used. These all are the classic techniques which have some limitations to detect the flood in complex environment. To solve this problem Machine Learning is the best choice. In Machin Learning there are so many algorithms like Artificial Neural Network, K-Nearest Neighbour, and Logistic Regression and Decision tree are used. Machine Learning itself has also some limitation like some ML techniques are time consuming and feature dependent. To overcome this limitation nowadays Deep Learning can be used.

Flooding is very harmful natural hazards. It happens frequently in some area which directly affect human life and also overall economy every year. Nowadays this natural hazard some time becomes very dangerous due to climate change. To reduce the overall impact of flood on property and human lives it is necessary to take emergency measures which is essential and also preventive measures which is very important.

Actions taken immediately before, during or after a flood event are known as Emergency measures. In similar situations, the ability to implement countermeasures requires real-time knowledge about the flood's size and the locations that are in danger. Rather, the goal of preventive measures is to lessen the likelihood that a particular location will flood. Maps that show the risk of flooding, or the possible features of an event, can be used to determine those.

When implementing such precautions, the following three flood maps are typically used: Maps that show the observed extent of flooding during or after an event are known as flood extent or inundation maps, and they are used for emergency response. Another is the Maps which give the spatial distribution of variables which can describe the flood risk of a particular event, such as flood depth and water extent, are known as flood hazard maps, and they are used for both emergency and preventive responses.

Most important thing in this area is better classification of preflood and post flood using remote sensed data. Remote Sensing system is able to give better data to identify flood affected areas.

Figure-1 Pre-Flood and Post-Flood Image

2.1 Why Remote sensed Data?

Without coming into direct contact with the land, remote sensing has emerged as a very useful method for detecting flooding.

Nowadays Remote Sensing is very important techniques to detect flood affected area without close contact of land.

- The basic advantage of remote sensing for flood monitoring is the easy accessibility of multi-sensor and multi-temporal data. While passive sensors, such as Sentinel-2, operate in the visible and infrared regions of electromagnetic spectrum, active sensors, such as Sentinel-1, operate in the microwave region, providing all the necessary information about areas affected by flooding.
- The ability to gather multi-modal data in real-time has been made feasible by the progress of satellites equipped with many types of sensors. Consequently, the information from another sensor might be required to fill in the gaps available due to the data from a single sensor. Data fusion is a useful method for producing high-quality information by combining data from several sources.
- Remote sensing has been used to identify a high flood-risk area by using different satellites and sensors, including optical images from Landsat TM and satellite images from Sentinel-1. The GIS needs to be added with remotely sense data to provide spatial analysis. Coordination between remote sensing and GIS has been used to analyse natural disasters, including floods, landslides, and land subsidence.

2.2 Why Deep Learning approach?

Identification of best architecture and model which has high speed and high accuracy in flood area identification. So that immediate steps can be taken to save lives, damage crops and property.

- For flood detection there are many methods like

  → Segmentation using fuzzy logic

  → Thresholding

  → Visual interpretation

  → Chromatic and textural analysis

  → and Normalized Difference Water Index (NDWI) were used.

- As discussed early these all are classics methods which have limitations to detect the flood affected area in complex environment [11].
- Machine learning algorithms is best choice to solve this weak point.

  Example:

  → Artificial Neural Network [23],

  → K-Nearest Neighbour [2],

  → Logistic regression [8] and Decision tree [23] were used.

Machine Learning also have some weak points such as it is time consuming and feature dependent [24].

So finally Deep Learning technology which has ability to overcome this weak point and very popular to solve various problems.

3 REVIEW

Here various publication was observed for comparison of different technology and mostly compare accuracy of each.

3.1 The Normalized Difference Water Index

It is used to point out water feature on the satellite images. As the NDWI index evaluates humidity accurately, it is frequently compared to the NDMI index. This approach has an accuracy of 83% for SAR and MS images.

3.2 Relevance Vector Machine (RVM)

To map flooded area, RVM - Relevance Vector Machine [14] has been applied on SAR. If we talk about flood detection accuracy for SAR alone then it is relatively high, but by bearing benefit of other sensor data can rise the accuracy. Overall accuracy of Relevance Vector Machine is 89% for SAR images.

3.3 Convolutional Neural Network (CNN)

Deep Learning is one of the best approaches for the better solution. CNN (Convolutional Neural Network) is deep learning algorithm [15] which normally used to identify flood from multi-sensor data. It has not good accuracy because of smaller training. For normal CNN the accuracy is 80% for SAR (Synthetic Aperture Radar) and MS (Multispectral) images.

3.4 Flood Detection in time series of Optical and SAR images.

Usually the case for weather-related disaster like flood or storms, which are for the most part related with huge clouds cover. However, Machine Learning on SAR information is believed very difficult as the need of availability of labelled information. To assist the community, go forward, we present a unused dataset made up of co-registered optical and SAR pictures time arrangement for location of flood occasions and modern neural organize approaches to use these two modalities. In general exactness of this approach is 79% (MS), 75% (SAR).

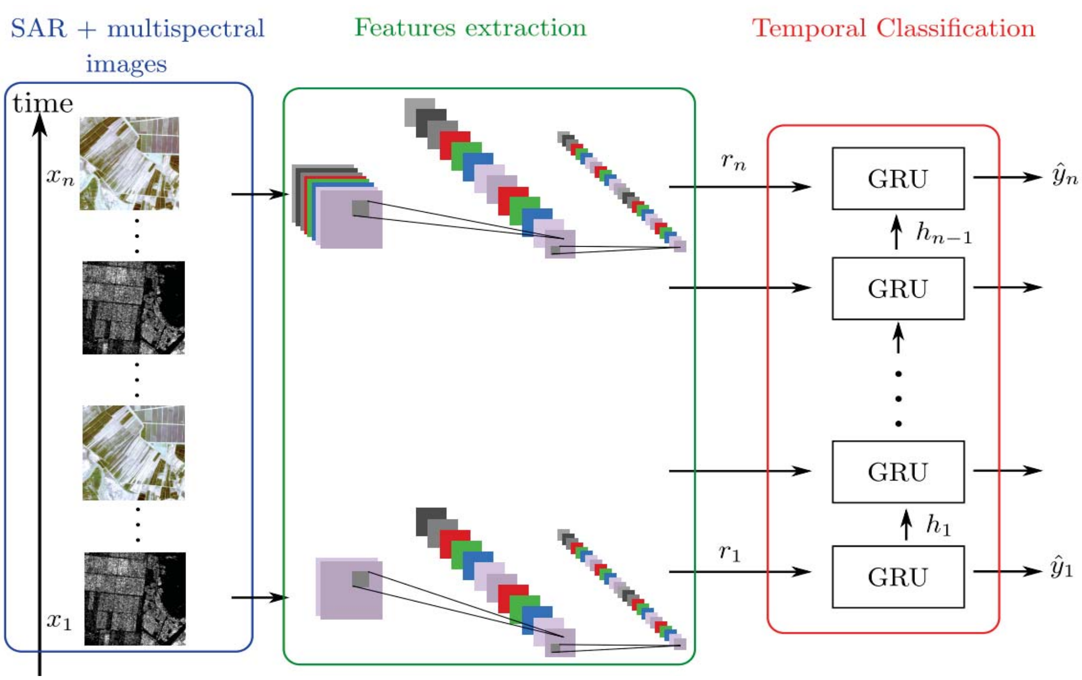


Figure 2 The proposed pipeline for flood detection in sequences of remote sensing images

3.5 DeepFood [17]

For executing Deep Learning based feature fusion in this paper they have used dual patched fully Convolutional Network to identify the flood affected area. Here SAR and MS images are used to train FCNs for better signify flooding. Here to find the flood Random Forest Classifier (RFC) is used using combined features. The information we got is really helpful for helping people in flood areas. Using this approach they got accuracy 94.17%.

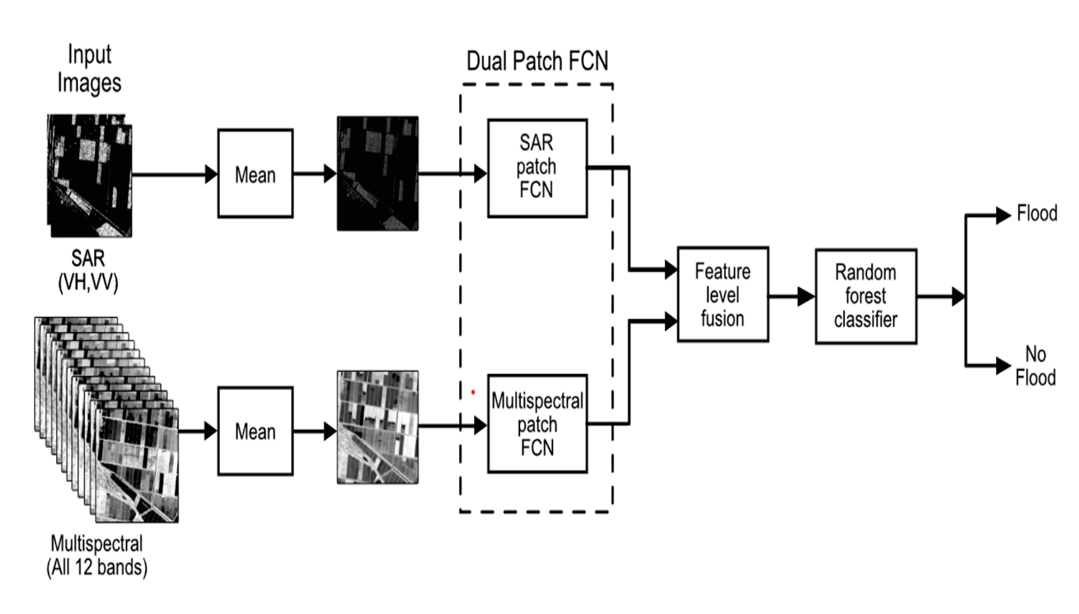


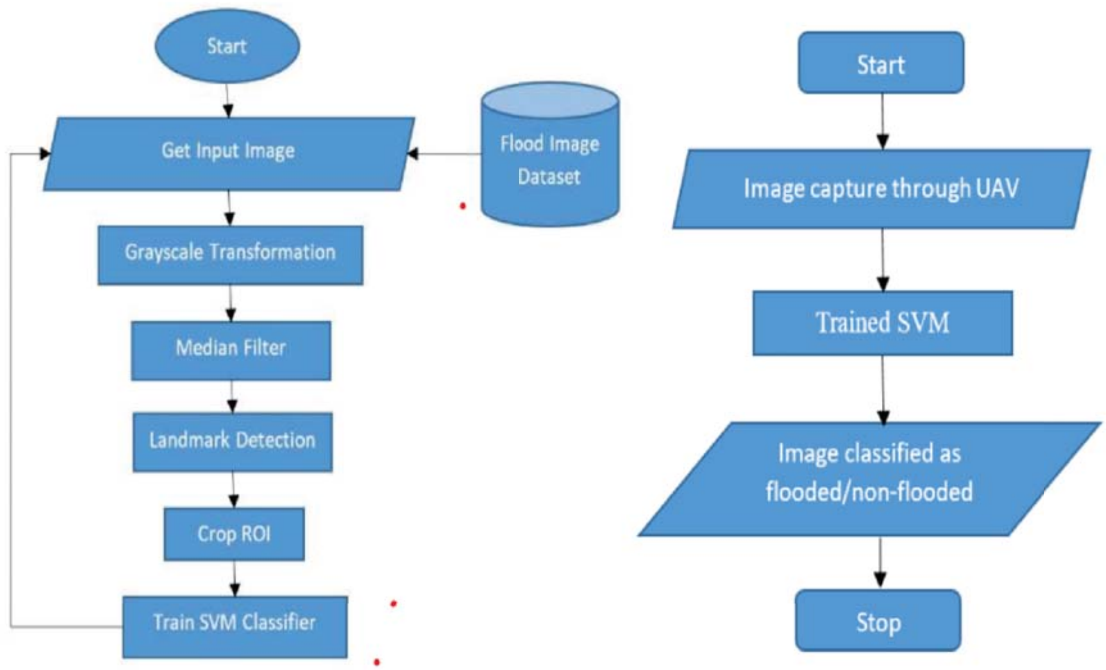
Figure 3 DeepFlood with Dual Patched Fully Convolutional Network

Table-1: Performance Metrics – SAR patch FCN

Class	Precision	Recall	F1-Score
Flood	0.83	0.87	0.85
No Flood	0.86	0.82	0.84

3.6 NAIP-ML [18]

Nowadays use of Machine learning can be the best approach in flood identification or management. Machin learning can be used to identify flood affected area using image classification. Here they have used the concept of Machine Learning to identify the flood affected arear using three step approach. These three proposed steps are: Detection of Landmark from the images, Machine Learning Training and Classification of images in to flooded or non-flooded. Accuracy gained by proposed approach is 90%.



3.7 OCRNet [19]

The context aggregation problem in semantic segmentation was examined in this study. They offer an easy-to-use but efficient method called object-contextual representations, which characterize a pixel by utilizing the illustration of the associated object class. This technique is motivated by the fact that a pixel's label indicates the category of the object to which the pixel fit in. There were three basics steps like understand object areas under the observation of the ground truth separation, then determine the object area representation by gathering the

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illustrations of the pixels staying in the object region. And finally, determine the relationship between each pixel and each object region. Then, add the object-contextual depiction, which is a slanted sum of all the representations of the object regions, to each pixel's representation. Here the accuracy is 96.12%.

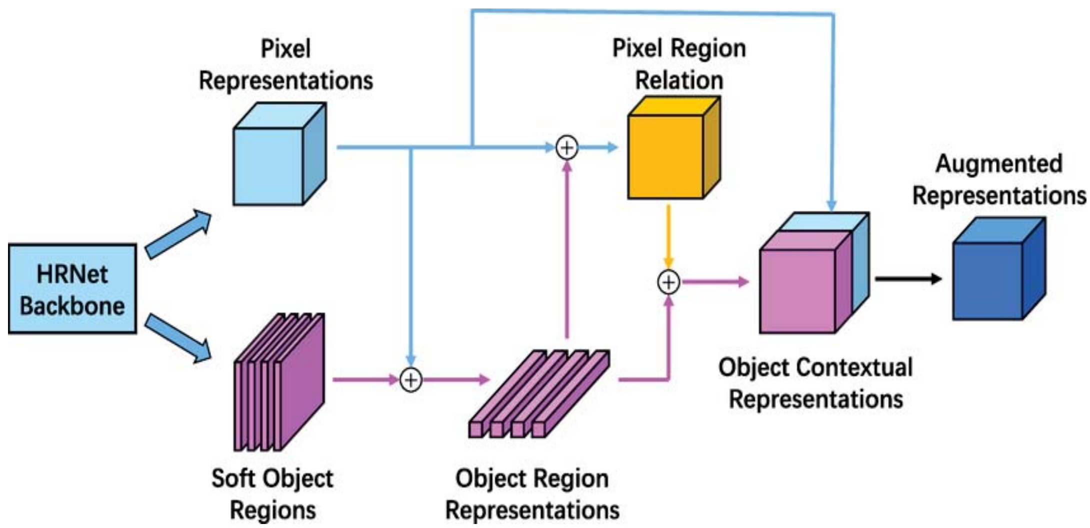

Figure 4 The pipeline of OCRNet

3.8 DeepLabv3+

In this paper they have proposed 'DeepLabv3' approach which is improved version of DeepLab. It is actually a semantic segmentation design which develops on DeepLabv3 by combining a yet effective decoder module to improve segmentation output. Overall accuracy of DeepLabv3+ is 96.52%.

3.9 MCANet [2022]

In this paper they have created very big size dataset WHU-OPT-SAR, which is combined optical and SAR land basically used classification dataset. It covered around 50,000 km^2 area and designed MCANet. It has basically three modules such as Module-1:The Pseudo-Siamese feature extraction module, Module-2 : Multimodal Cross attention module, and Module-3 : Low-High level feature fusion module.

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3.10 CMCDNet [2023]

In this paper author has prepared CAU-Flood dataset which is pre-flood and post-flood Sentinel-1 diverse flood mapping dataset contains 18 study plots with precise image processing and human mark. They developed proposed deep CNN which is known as CMCDNet (Cross-model change detection Network) for flood identification using SAR and multispectral images. Here system achieves feature fusion at more than one stages using gating and self-attention module and employs an encoder-decoder structure.

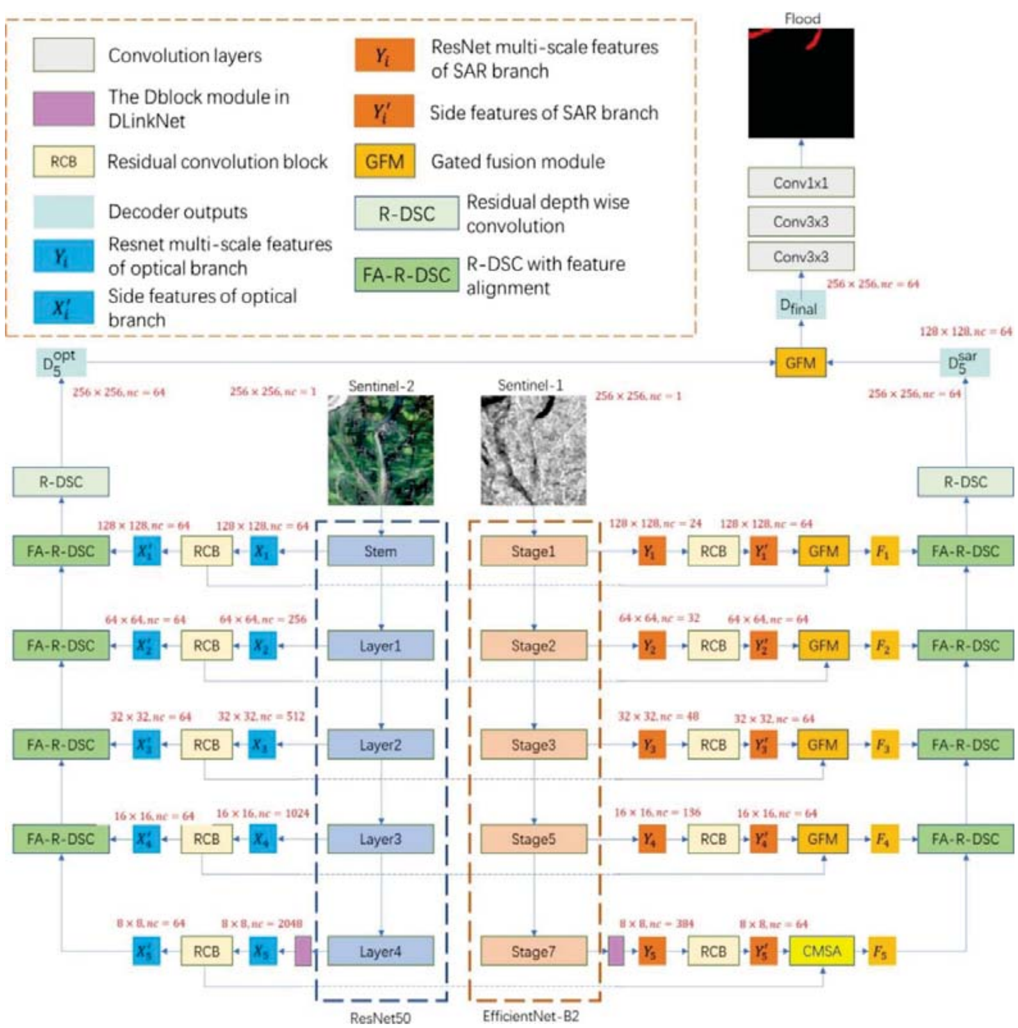

Figure 5 CMCDNet Architecture.

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Table 1. Performance of Different Approaches

Approach	Accuracy
NDWI [13]	83%(SAR+MS)
Hierarchical Split-based Approach	89%
RVM [14]	89% (SAR)
CNN [15]	80%(SAR+MS)
ResNet-50 [16]	79% (MS), 75% (SAR)
DeepFlood [17]	84.17% (SAR), 94.17% (SAR+MS), 76.67% (MS)
NAIP-ML [18]	90%
OCRNet [19]	96.12%
DeepLabv3+ [20]	96.52%
MCANet [21]	96.53%
CMCDNet [22]	97.27%

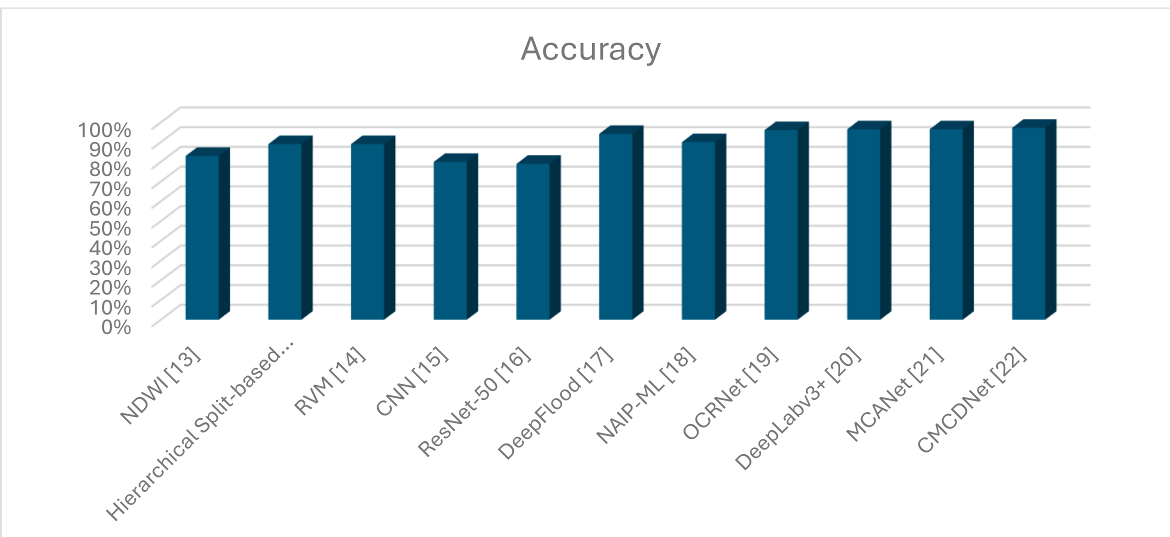

Figure 6 Performance Chart with different approaches

CONCLUSION

This paper presented a review of different approaches for Pre-Flood and Post-Flood Classification. For the comparison of various existing approaches, we can consider different factors such as accuracy, Recall, Precision, F1 factor etc. But for deep concentration we have used only accuracy. As per the result deep learning approach is far better approach for better accuracy. As per the result shown in above table best accuracy is 97.27% which is far better as compare to other methods. Still accuracy can be increased by finding new methodology.

Future Scope

By new methodology or approach it is still possible to increase accuracy which can be better than the existing methods. Other factors such as Recall, Precision and F1 factor can also be used to compare and also there are scope for improvement of these factors.

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