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Transfer Learning Approaches for Emergency Event Detection Through Crowd Sourced Social Media Imagery

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Abstract
Social media is platform where people share their day today activities and information flows in social networks like whirlwind. Emergency events are very critical information which needs to be passed to required people so that they can take necessary actions. Data that flows in social media is crowdsourced using different people, most of the time the disaster or emergency event information flows not only in the closed group but it disseminates in open space. Data that flows here can be used to extract important information like what is the emergency situation and how this information can be disseminated to help the people and send it to people who uses it to provide the response activity. Most of the works are related to identifying the emergency using tweets posted, satellite images but all these techniques have many challenges which can be overcome by using crowdsourced images by applying transfer learning techniques. Work has used the image dataset which has been collected from social networks by crowd sourcing. Transfer learning methods used for conduction of this experiment is VGG16, Resnet50, Inception V3 out of all the models the Resnet50 out performed all the other model with very good accuracy of 94.

Keywords: Disaster Classification, Transfer learning, Resnet50, Social media data, Crowd source.

1. Introduction

Social media is place where people have shared their personal experiences experienced during pleasant and unpleasant scenarios. Many used social media like twitter, YouTube, and Facebook to share their experiences about earthquake, floods or any disaster or emergency event. Despite its potential to positively impact disaster relief efforts, social media does not inherently possess the coordination capability to facilitate the easy sharing of information, resources, and plans among diverse relief organizations. Nevertheless, crowdsourcing applications, rooted in social media platforms such as Twitter and Ushahidi, offer a potent capacity for gathering information from disaster scenes and visualizing data to inform relief decision-making [1]. Disaster relief and crowdsourcing have close relation with respect to social media. We share our personal events with friends but when events like disaster occurs data shared will be between unknow users. Intention of sharing public related information among unknow users is to make everyone aware of the events and if it's a disaster like events then it's very important for everyone to know that too people near to area of events. B. Huberman [2] mentions how content creation changed from traditional way to crowdsourcing way in digital world. People with no direct connection are using same kind of websites. Crowd sourcing is occurring in the digital world but it is not directly observed. Many use websites such as You Tube, Facebook and Wikipedia, consume and produce the contents. Author also gives a brief information about how crowdsourcing is occurring in social networks. Also addresses challenges in terms of data dissemination in ad hoc networks and authentication of information. Xu, Z et.al [3] discusses due to internet availability how the online platforms have become places to share the information about emergency events. When such events occur, there is a explosion of posts about the event occurred in the online platforms. Authors have developed crowdsourcing based burst computation algorithm which can convey the information about urban emergency events. How emergency managers can make use of crowdsourced data and which kind of crowdsourcing is useful for getting information about the disaster events to help in sending the relief activities. [4] with heterogenous crowd how best the disaster managers can make sure that their volunteers are comfortable in using the application to help in emergency management. Christoph et.al are inspiring, and emergency services should give rise to a general dialogue on prospects and tasks of location-based crowdsourcing for emergency management [4].

Crowdsourcing acts as means to solve many problems, like providing solution to difficulty problem, sharing the tasks to complete it fast. It also been used to take help during natural calamities and crowd is always at ground who witnesses events and report it to required authority and take preliminary actions to help the victims of

natural calamities. Natural calamities are dynamic in nature and cannot be predicated well before but we can be prepared to minimize the effects. Social media is one of the platforms for crowdsourcing. the context considered for crowdsourcing is social media has connected and unknow members in which some information is shared among unknow members as well. For example, a disaster related information or any political news will be posted in connected network or unconnected network. Consider the work of Yadav et.al [5] who provides the answer for two important questions how social media helped during Chennai floods and how social media can help in disaster communication and relief activities. During cyclone Ockhi,2017 how Tamil Nadu weatherman is being engaged in social network for sharing the content of cyclone. Study uses two step is being utilized and using two step model communication they found how messages are passed in weatherman network in Facebook. [6] Pamuji et.al had considered the example of Tsunami to evaluate the use of tweets during the events and also mentioned in future work that there is a need for model to extract the tweets from social media effectively and also analyze the information to extract important information about disaster. Use of machine learning mod- els will reduce the error rates compared to manual extraction of information. Considering [8] thoughts we proceeded with the following research objectives.

- How government is using social media for emergency management.
- Importance of image data, text data and both [5].
- Need for extraction of information about disasters with better classification techniques.

The above research question will be verified with experimental results and answers to the research questions will be validated with other research papers. Aim of researcher here is to bring in the analysis with respect to Indian society. Research work is carried out on social network data set taken from multiple sources [20]. The paper is organized as follows literature review provide insights of existing work, problem statement to explain the problem that we are addressing, Dataset as section 4 followed by methodology, which explains techniques used in solving the addressed problem. Section 6 will discuss the results and followed by conclusion and future work.

2. Literature Survey

The study has explored multiple angles of the problem domain. Crowdsourcing and how it's being used in disaster management. Social network as the platform for the crowdsourcing and use of social media for emergency situation or disaster management. The concept of crowdsourcing has been used my many for different reasons but the word was coined in the year 2016 and different researcher has multiple definitions. Websites like Flickr, YouTube and Wikipedia have taken the complete advantage of crowd as content generator and consumer. [2] Consider the social media as new platform for the crowdsourcing and crowdsourcing is the way to ideation. Many companies post the challenges in social media to get bet- ter solution and even branding can be done on social media using crowdsourcing. Crowd can generate idea, disseminate, and validate the ideas and information. Pamuji et.al has collected 2018 Tsunami disaster tweets and analyzed the tweets to understand how people have responded and they have found that most of the people were either praying for victims or providing the support. A Social net- working site transferred the safety information of the earthquake in Nepal. In the year 2015 Nepal people used a feature "safety-check" [10]. Facebook had the crisis response means with a view to permit the users to transfer their safety status [11]. The same tool was also used in the TamilNadu for checking the status of safety of their friends and family. Many users used this tool to check the safety of their loved ones. Twitter is one more widespread social network- ing site widely leveraged for disaster information propagation across the world and during the Kashmir floods the twitter had provided a button for the re-gion so that users can help army to find them by pressing that alert button.

The Kashmir flood response activity was completed effectively only because of twitter social networking site [12]. With rising occurrences of recurrent disasters across the world, social networking sites have become incontrovertible message medium during various stages of mass crises. [7] Discusses about the Indonesia's worst disaster in the year of 2018. They have web scarped the tweets related to event and they analyzed what can be done with tweets. Authors have categorized the tweets into six category and they have plotted many visuals to understand the pattern of the tweets during disaster. They have acknowledged in the future work that there is a need for machine learning models to process the social network data to get better insights. Their main work is to check whether we can use social networks during disaster to get some support apart from normal response activity. Bird et.al have investigated Queensland and Victorian flood event for the first time in with the help of Facebook. The concern of the re- searcher is how authentic is to use social media for disaster like event and also check how feasible is it. The survey done by authors [9] confirms that people are using social media for normal communication and to join common interest group to share their thought and ideas. Similarly, during 2010 flood disaster the people conveniently used Facebook for commination regarding disaster. Ockhi which was started in northern region of India took its speed towards southern Tamil Nadu and Kerala killing over 350 people during

Year 2017. [6] Considers to find the network communication and do the network analysis of the Facebook page "TamilNadu Weatherman" during Ockhi cyclone. Selvaraj et.al conducted experiment in two phases. first phase they collected all information based on the timeline of the disaster event and then considering collected data they have analyzed the network pattern for disaster event. Work is related to only one page of the Facebook that is "TamilNadu Weatherman." The work of wei et.al is related to metrics development to measure the urban area resilience toward the disasters. They have investigated the city of chengdu which has imbalanced vulnerability to disasters. Work mainly assessed the infrastructure, and other facility at city to check how resilient the city towards disaster is. The factors verified are social, economic, institutional, infrastructural, and environmental or ecological components [13]. Kollipara et.al discussed the behavior of the team members in the organization, patterns of the behavior show the similar traits in the social media user in the community group and even during emergency situations [16]. Social science is directly related to the societal factors. Social response research has been old due to change in factors like social, cultural and political. Due to digital era, authors of [14] have changed the path of research as computational social science of disaster (CSSD) [14]. CSSD is study of behavioral dynamics of disaster using computational methods. It is a new research domain with lots of challenges and opportunities. Authors identified many re- search gaps in literature of new domain and discussed how data science and social science can together help in disasters. Distributed environment has a major challenge in terms of data dissemination and capture of the data. [29] Analyze the challenges posed by the client-server model in mining large distributed databases and how mobile agent technology addresses these issues in a globalized business environment. Combination of social and computing science together aids in effective response activity during disaster is called as crisis informatics. But there is no full pledge theory related to this domain and there are many research gaps which are identified by authors of research work. When information disseminated in social network and if its critical information ten it needs to reach intended user for further action so we need intermediate node with proper leadership quality [31]. [32] proposed routing protocol utilizes the location history and access patterns of mobile users as key features to infer both their geographical locations and social relationships, enhancing routing efficiency and adaptability, as opportunistic networks (OppNets), the routing protocol leverages a store-carry-and-forward approach to transmit messages between nodes opportunistically, addressing challenges such as network partitioning, long delays, and dynamic topology to improve delivery success. Muller et.al considers the traditional definition of the crowdsourcing and then further investigates the other definitions that can be considered for current trend. The existing technology has made use of crowd in different aspects due which the definition of the crowdsourcing is also extended [17]. Authors clearly investigated the potential use of crowdsourcing for atmospheric data collection. Paper also mentions the need for defining procedure to collect such sensitive data with quality also mentions that such research work is still not being done in current literature [15]. Following section, we will define the problem statement which gives clear picture of the work.

3. Problem Statement

In recent years, the role of social media in emergency management has become more and more significant. Governments worldwide are leveraging platforms like Twitter, Facebook, and Instagram to disseminate crucial information rapidly during catastrophes. Despite this progress, the active use of image data, text data, and a combination of both remains a critical area of focus. These types of data provide unique insights that can enhance situational awareness and improve response efforts. Social media serves as a valuable tool during disaster events, offering real-time updates and a means for affected people to communicate their needs. The term "social media" encompasses a variety of online platforms that facilitate the creation, sharing, and exchange of information and ideas through virtual groups and networks. However, there is a demanding need to improve the taking out of relevant data from these platforms. Current classification techniques must be enhanced to better identify and categorize disaster-related data. By developing more sophisticated methods for information extraction and classification, governments and emergency responders can more successfully harness the power of social media to accomplish and alleviate the influences of catastrophes.

4. Methodology

Base Dataset

The dataset utilized in the research comprises a total of 4251 images divided into four categories that are earthquakes, floods and wildfires, with 1650, 1373 and 1228 images respectively. The images were preprocessed and normalized into NumPy arrays with a shape of (3, 224, 224), representing the size 224 * 224 pixels and three RGB color channels. The Image Data Generator library was employed to enhance the pictures for improved precision. This included rotating the images by 40 degree or -40 degree, and some images by 30 degree to -30 degree. The 'width shift range' and 'height shift range' parameters were used to arbitrarily shift the images

horizontally and vertically within the range of [-30%, 30%]. Additionally, the images were slightly slanted and stretched at an angle of 0.15 degrees. During model training, the 'horizontal flip' parameter was setto 'True' to enable arbitrary horizontal flipping of the images.Figure 1 is the dataset used in the research work ,which is the sample dataset of the whole.

Fig. 1: Sample images used in research work.

Data Synthesis

We have considered the four-research question as part of the work. To answer the all four questions, we have done an extensive survey which will help us in the answering the questions.

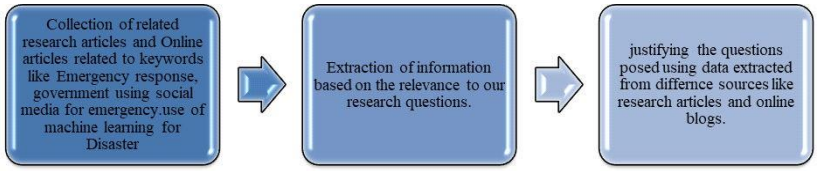

Fig. 2: Data Synthesis Process

Figure 2 is the process followed to collect the data required to answer the questions posed in the research. First question which we are trying to address is "how government is using the social media for emergency."

We have considered the three case studies for analysis. First one is Kashmir floods during 2014, it was very huge flood with devastating situation where a user starting posting about the flood and situation near him turned out to be a whole platform of rescue shifting to twitter. [26] discuss the whole story of Kashmir flood rescue. An automated SOS service was enabled for the users near to Kashmir. As per the Major General Shokin Chauhan of the army's public information office that the army saved over 12,000 people based on information from social media during the Kashmir floods. Twitter also helped in channelizing relief material to areas [19]. But the task was challenging as information arrival was constant and people who were trying to extract important information and classify it. Classifying the sending SOS related information was very much challenging [26].

Second case study is Chennai floods in the year 2015 [5]. Mayank et.al dis- cusses how Facebook as social media was able to help in finding the safety of the people near the flood hit areas. Similarly, the Google's crisis page was able to help in finding the lost person and help the other relatives to know that their family and friends are safe. Google's spreadsheet helped in people to know where the shelters are available for them[18]. All these was a step towards how social medias can contribute to emergency. In all these cases we did not find anyone these applications informing the people at crisis hit area that disaster is sever or not. Is it possible them to step out in flood hit area to move to safe house or to wait for relief team to come to them. Here one more flaw exists these apps did not give inform relief team about severity of the event so that they can prepare before providing relief.

Third case study is Nepal Earthquake in the year 2015[10] which discusses how tele and mobile communication were cut off during disaster and only data network was working. Using data network many people confirmed their safety after the disaster event. Even relief activity was planned by NGOs and emergency response team considering the data network. All the above analysis comprehends that social media can act as new tool for disaster and emergency situations. Social media has redefined communication and made it even better, especially during emergencies [23]. When we consider the social media posts and its analysis, most of the researcher have considered the implementation of any work using text i.e. tweets. We have seen how twitter was allowing users to

scrape the data for research purpose and initial days of social media all users were posting text data not multimedia data due to applications constraints.

Figure 3 shows the trend in usage of the different types of data from year 2015 to 2024. [15–24] are the research articles where most researcher have used text data for analysis, some have used images and few have used both images and text both for analysis.

Research objective 2 can be explored by considering Figure 3 results. Considering the research papers in which researchers have conducted experiments for emergency or disaster. From year 2015, we observed that most of the works are related to text data and some are using images. By witnessing the trend of datasets used for experiments we can conclude that text data was used by most of the researcher, then followed by images and very few have tried to combine text data and image data for analysis[21].

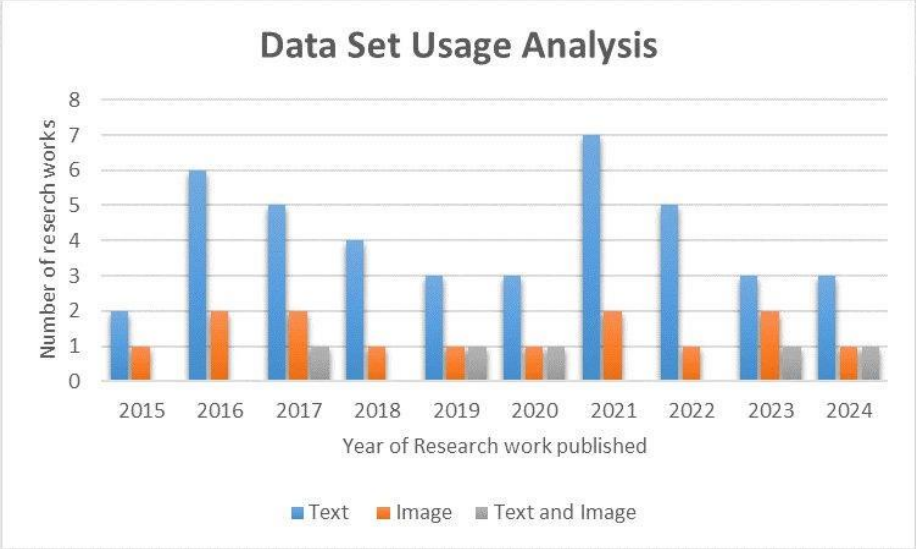

Fig. 3: Dataset usage in different research works

5. Models

To continue with further Modeling and analysis, we conducted experiments using images. We have done qualitative analysis of current research works which gave us an insight that most of the researcher have tried to use text data for crisis management. Our research work focuses on images data. We have divided the implementation of classification tasks in two phases. First is model training and second is model evaluation. In Figure 4, the first component is raw data and next step is preprocessing raw data. Preprocessed data is divided into training data and validation data in the ratio of 70:30. During preprocessing of the images the quality of the image has been checked and even the labels of the images have been verified. The model is trained on 4K images and based on the model performance and loss function value we have chosen a primary model which tested on the validation data and also the new data which was not part of 4K images. Resnet50 [28] has outperformed in all the cases compared to VGG16 and Inception V3. We will discuss the results of the model in the following section.

6. Results and Discussion

Earlier definition of crowdsourcing only related to ideation but today researcher have used crowdsourcing [25] in the different dimensions. The citizens reporting the disaster related information on social media can be considered as crowd- sourcing. The data set considered for experiment includes images collected from social media [22]. Every one report the disaster to social media first, it become as primary source for any kind of new information or event. The pattern of posting the data and then it is used by system or government agencies to decide on response activity is a type of passive crowd sourcing. Here person who posts data does not registered in crowd sourcing platform but he still reports event [27]. Images used are collected from different social media website and sites where new article related to disaster are mentioned.

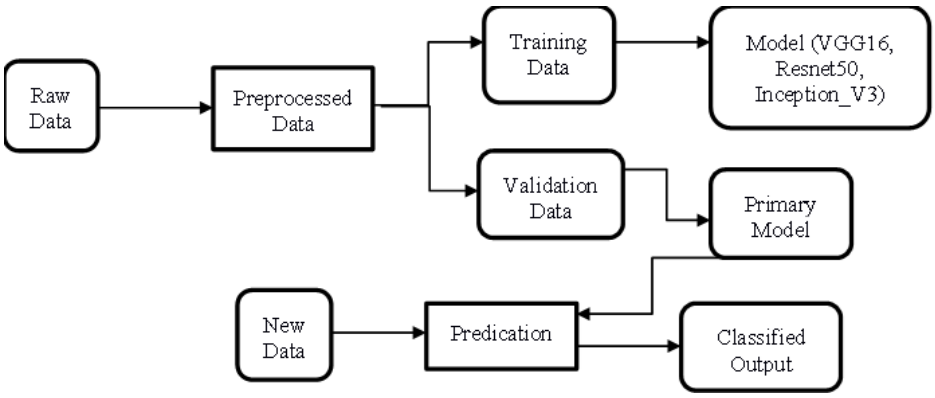

Fig. 4: Workflow of the Experiment

Usage of the pretrained models were the primary requirement of the implementation and these models performed better compared to classic CNN models [24]. When model was trained and tested on preliminary dataset without pre- processing, we got the results as shown in Figure 5

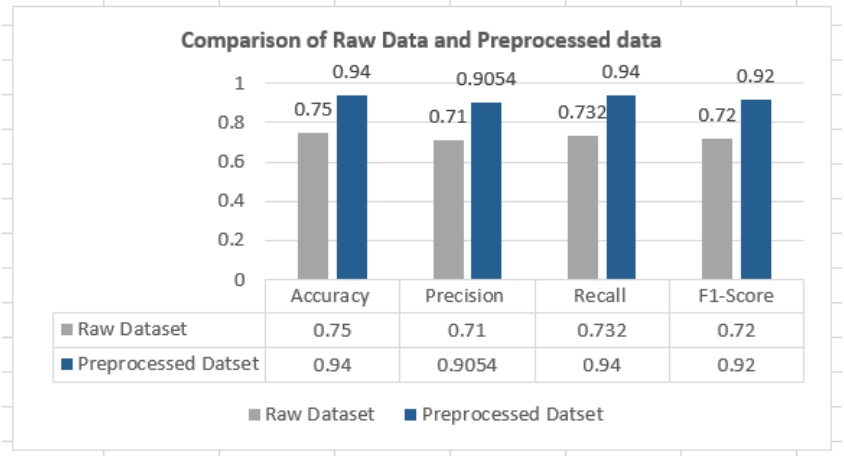

Fig. 5: Comparison of Raw Data and Preprocessed data

Figure 5 shows the results of raw dataset used without preprocessing and after the preprocessing. The dataset which was collected when trained and validated, the accuracy for validation is 75% which is very less compared to the accuracy of preprocessed data. Similarly, the precision, recall and F1score is better in preprocessed experiment.

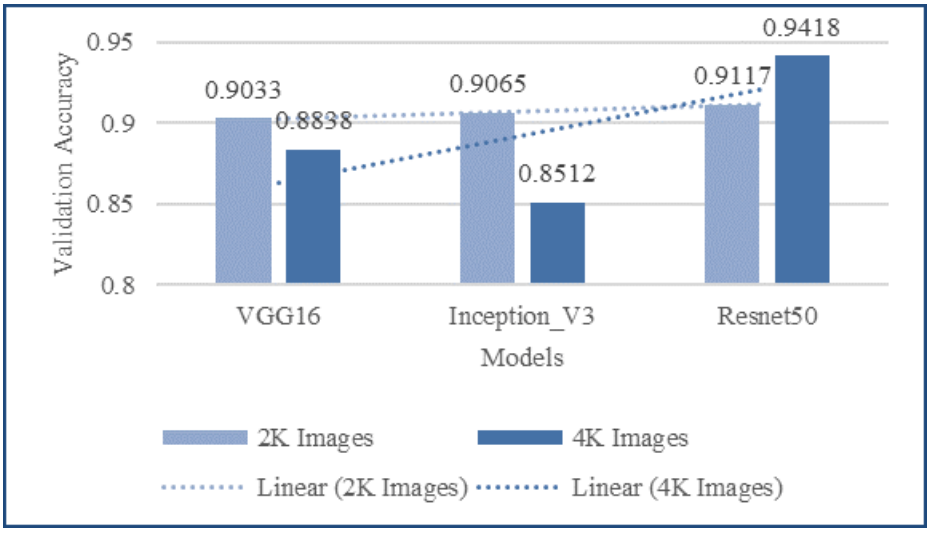

Fig. 6: Accuracy of models for 2K and 4K images

The major findings of the work are based on preprocessed dataset, it is important for experiment to be conducted with the proper and valid data. The model results are as shown in the Figure 6 and Figure 7 The training was on different size of the images that is 2k images are used first for the training and 4k images are used. The model as considered different epochs but at 11th epoch, the model achieved the optimal results. The model accuracy is displayed in Figure 5 for all models but Resnet50[28] has most optimal results compared to VGG16 and Inception V3. Similarly, loss function categorical cross entropy has been used and Inception V3, Vgg16 had more loss compared to Resnet50. Considering both the data of accuracy and loss, we can choose the Resnet50 as most suitable model for disaster classification.

The Figure 6 discusses the loss function values of each model for 2k and 4k image data. VGG16 has 4.3112,6.7351 loss function value. similarly, Inception v3 has loss function value of 5.1449 for 2k and 6.981 for 4k images. Resnet50 has less loss compared to VGG16 and Inception V3. The model which can be considered as best suitable for our work is Resnet50 based on accuracy and loss factors. The model has performed very well for seen data and even un seen data of disaster events.

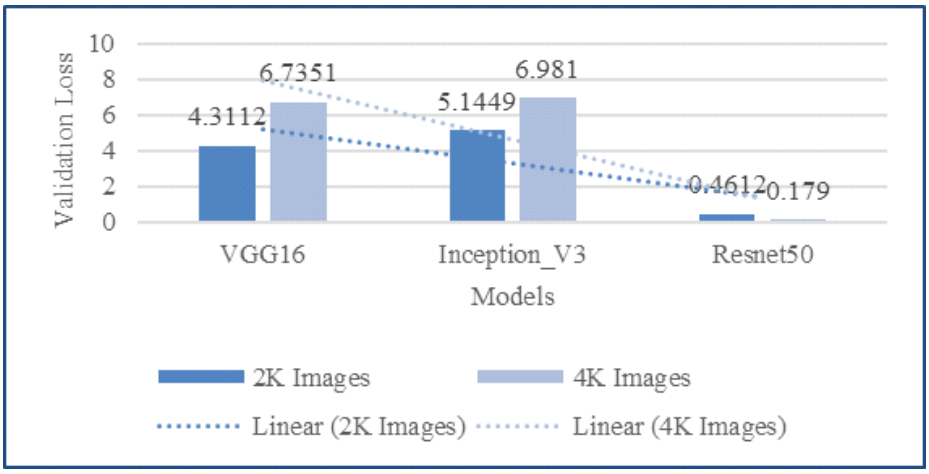

Fig. 7: Loss of the models for 2K and 4K images

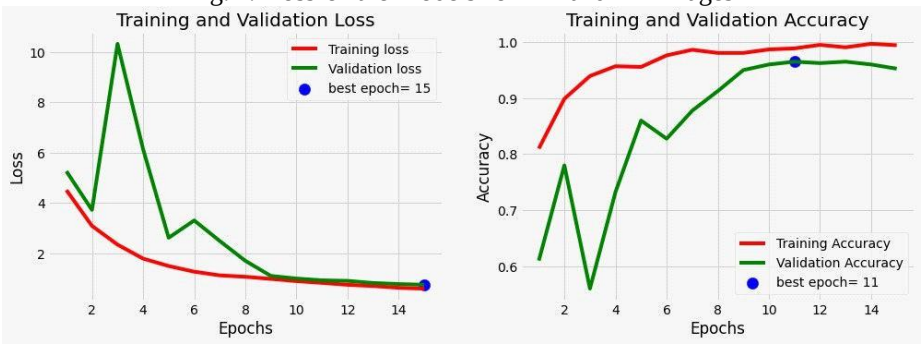

Fig. 8: Training and Validation Loss and Accuracy for 15 epochs

Fig. 9: Training and Validation Loss and Accuracy for 21 epochs

The use of different models with different size gave an insight that, Resnet50 can be best suited model for further experiments. Figure 9 shows the training and validation accuracy for Resnet50 for different epochs, the model was experimented with multiple epochs and in most of the cases got best results in 11th epochs.

7. Conclusion

The natural disaster or emergency events are unpredictable and non-stoppable. We can try to reduce the effect of these events after the events has occurred and try to send information to required government agency or volunteer group so that they can take necessary steps of provide the relief to the needy. Before sending information its very much important to classify it based on the type of disaster. Our work has examined the different machine learning models which can accurately classify the disaster events with less loss function value. The Resnet50 has validation accuracy of 94% when compared to VGG16 and InceptionV3. The data is sourced from social media it has been collected as crowdsourced approach. Model is trained and validated on social media data. Work also analyzed the different research work from the year 2015 to 2024. Researcher have used text data for analysis in early years and gradually they shifted to images. Problem with text is different language need to be considered and model must be trained and it's not easy task as we have thousands of languages worldwide. Its image which can be most suitable data for disaster classification task. Future work can be training and testing of other machine learning models using social media data. We have considered only four classes for classification. Researchers can use other types of disaster events and non-disaster events for classification technique. There is limited work related to multi modal data which can be explored.

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