ENHANCED MULTIMODAL LEARNING FOR DISASTER DETECTION: A DEEP ATTENTION-BASED APPROACH TO SOCIAL MEDIA ANALYSIS

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ABSTRACT

Twitter and other microblogging sites are becoming essential for sharing important information, particularly during natural and man-made catastrophes. Multimedia elements including photographs and/or videos are often posted by individuals to provide critical information about events like fatalities, infrastructure damage, and the immediate needs of those impacted. Humanitarian organisations may prepare an appropriate reaction in a timely way with the use of such information. It is a laborious effort to detect disaster-related information from a large number of postings, thus an autonomous system that can separate out actionable from non-actionable disaster-related information from social media is required. Even though a number of studies have demonstrated the value of combining text and image contents for disaster identification, the majority of earlier research concentrated solely on textual analysis and/or used conventional recurrent neural networks (RNNs) or convolutional neural networks (CNNs), which may cause performance issues with lengthy input sequences. In order to categorise tweets, this research provides a multimodal disaster detection system that synergistically uses textual and visual data by combining the influential word aspects with the visual features. To be more precise, we use a bidirectional long-term memory (BiLSTM) network with attention mechanism to extract textual data and a pretrained convolutional neural network (like ResNet50) to extract visual features. Next, we use a feature fusion technique to combine textual and visual information, and then we use the softmax classifier. The assessments show that the suggested multimodal system improves performance over the current baselines, which include both unimodal and multimodal models, by achieving gains in performance of around 1% and 7%, respectively.

I. INTRODUCTION

Social media platforms may be quite helpful in disseminating a lot of crucial information during catastrophe occurrences like hurricanes, floods, and earthquakes [1]– [3]. These social media platforms are widely used by people to communicate across several hierarchies, including those between individuals, the government, the community, and the government and the people [3], [4]. Victims often use Twitter to convey information about catastrophe occurrences, including updates about those who have died or been wounded as well as infrastructure damage. Affected individuals also share videos, tweets, and photos asking for immediate assistance. Humanitarian organisations might greatly benefit from analysing these social media postings and deriving practical information in real-time to aid the impacted individuals [5, 6]. Nevertheless, manually sifting through a vast number of crisis-related tweets to extract meaningful information is an extremely laborious and time-consuming operation.

In an effort to tackle the aforementioned problem, the humanitarian computing community has created automated algorithms that can identify and categorise social

media postings on crises [7]–[9]. For instance, classifiers have been developed by academics to detect event kinds (e.g., storm, flood) [10], whether or whether a post is instructive [11], and the sorts of humanitarian information (e.g., damages types) [12]. The current efforts are mostly restricted in two respects, even with this recent development. First, textual or visual content analysis on its own has been the primary focus of the majority of publications on damage or disaster response from social media postings. Nevertheless, new research indicates that learning from both text and picture data often yields insightful information about an occurrence, leading to more accurate conclusions than learning from unimodal data [13]. Second, only a small number of multimodal feature-using research [7, 8] concentrate on using CNN or RNN models for text feature representation, which may not be effective for lengthier phrases.

Our objective in this study is to create a computational model that can effectively recognise information linked to disasters via the synergistic integration of elements from both textual and visual modalities. More precisely, we use a pre-trained visual (ResNet50) model to extract the picture characteristics. In order to solve the long-range dependence issue with conventional RNN and CNN design, we further extract the textual characteristics by combining an attention mechanism with the BiLSTM network. Next, we use the Deep level fusion to combine the two kinds of features, and then we apply the soft max layer to categorise the supplied tweet. Our objective is to identify the kind of damage (such as fire, floods, or infrastructure destruction) from an image-tweet combination via a series of comprehensive experiments on a multimodal damage dataset. We contrast our models with a number of baselines (Section IV) that neither use attention processes nor make use of multimodal information. The main conclusions drawn from these studies are that: (i) using multimodal features is more successful than using unimodal features; and (ii) an attention mechanism added to an RNN model may significantly improve performance when compared to a model without such a mechanism.

Our work's main contributions are as follows: _ We suggest a multimodal architecture that makes use of the attention mechanism and recurrent neural network ResNet50 to categorise damage-related postings by using both visual and textual information.

We assess how well the suggested model performs in comparison to a number of current unimodal (text, picture) and multimodal categorisation methods.

_ Using an intrinsic assessment, we experimentally test the suggested model on a benchmark dataset and show how adding attention might improve system performance.

_ In order to get a better understanding of the different mistake kinds and to identify future paths for model improvement, we conduct both quantitative and qualitative analysis.

Problem Statement:

Increasing frequency and severity of natural disasters pose a significant threat to human safety and well-being. Social media platforms have emerged as valuable sources of real-time information during such events, with users sharing crucial data through various modalities such as text, images, and videos. However, the sheer volume and diversity of information make it challenging to identify and prioritize relevant posts for effective disaster management.

Existing approaches to disaster identification from social media posts often struggle to provide accurate and timely insights due to their limited capacity to understand and integrate information from multiple modalities. The lack of a robust and deep learning model capable of effectively capturing the contextual nuances and

correlations between textual and visual elements in social media posts hinders the development of efficient disaster identification systems.

Therefore, there is a pressing need for a novel approach that leverages deep attentive multimodal learning techniques to enhance the accuracy and efficiency of disaster identification from social media posts. This approach should address the challenges of processing large-scale, unstructured data while effectively integrating both textual and visual information. Developing such a comprehensive model holds the key to advancing the capabilities of disaster response teams, enabling them to make more informed decisions and allocate resources more effectively in the face of natural calamities.

II. LITERATURE SURVEY

K. K. Kapoor, K. Tamilmani, N. P. Rana, P. Patil, Y. K. Dwivedi, and S. Nerur, "Advances in social media research: Past, present and future," Information Systems Frontiers, vol. 20, no. 3, pp. 531–558, 2018.

Social media comprises communication websites that facilitate relationship forming between users from diverse backgrounds, resulting in a rich social structure. User generated content encourages inquiry and decision-making. Given the relevance of social media to various stakeholders, it has received significant attention from researchers of various fields, including information systems. There exists no comprehensive review that integrates and synthesises the findings of literature on social media. This study discusses the findings of 132 papers (in selected IS journals) on social media and social networking published between 1997 and 2017. Most papers reviewed here examine the behavioural side of social media, investigate the aspect of reviews and recommendations, and study its integration for organizational purposes. Furthermore, many studies have investigated the viability of online communities/social media as a marketing medium, while others have explored various aspects of social media, including the risks associated with its use, the value that it creates, and the negative stigma attached to it within workplaces. The use of social media for information sharing during critical events as well as for seeking and/or rendering help has also been investigated in prior research. Other contexts include political and public administration, and the comparison between traditional and social media. Overall, our study identifies multiple emergent themes in the existing corpus, thereby furthering our understanding of advances in social media research. The integrated view of the extant literature that our study presents can help avoid duplication by future researchers, whilst offering fruitful lines of enquiry to help shape research for this emerging field.

J. Kim and M. Hastak, "Social network analysis: Characteristics of online social networks after a disaster," International Journal of Information Management, vol. 38, no. 1, pp. 86–96, 2018.

Social media, such as Twitter and Facebook, plays a critical role in disaster management by propagating emergency information to a disaster-affected community. It ranks as the fourth most popular source for accessing emergency information. Many studies have explored social media data to understand the networks and extract critical information to develop a pre- and post-disaster mitigation plan.

The 2016 flood in Louisiana damaged more than 60,000 homes and was the worst U.S. disaster after Hurricane Sandy in 2012. Parishes in Louisiana actively used their social media to share information with the disaster-affected community − e.g., flood inundation map, locations of emergency shelters, medical

services, and debris removal operation. This study applies social network analysis to convert emergency social network data into knowledge. We explore patterns created by the aggregated interactions of online users on Facebook during disaster responses. It provides insights to understand the critical role of social media use for emergency information propagation. The study results show social networks consist of three entities: individuals, emergency agencies, and organizations. The core of a social network consists of numerous individuals. They are actively engaged to share information, communicate with the city of Baton Rouge, and update information. Emergency agencies and organizations are on the periphery of the social network, connecting a community with other communities. The results of this study will help emergency agencies develop their social media operation strategies for a disaster mitigation plan.

J. Son, H. K. Lee, S. Jin, and J. Lee, "Content features of tweets for effective communication during disasters: A media synchronicity theory perspective," International Journal of Information Management, vol. 45, pp. 56–68, 2019.

Users' ability to retweet information has made Twitter one of the most prominent social media platforms for disseminating emergency information during disasters. However, few studies have examined how Twitter's features can support the different communication patterns that occur during different phases of disaster events. Based on the literature of disaster communication and Media Synchronicity Theory, we identify distinct disaster phases and the two communication types—crisis communication and risk communication—that occur during those phases. We investigate how Twitter's representational features, including words, URLs, hashtags, and hashtag importance, influence the average retweet time—that is, the average time it takes for retweet to occur—as well as how such effects differ depending on the type of disaster communication. Our analysis of tweets from the 2013 Colorado floods found that adding more URLs to tweets increases the average retweet time more in risk-related tweets than it does in crisis-related tweets. Further, including key disaster-related hashtags in tweets contributed to faster retweets in crisis-related tweets than in risk-related tweets. Our findings suggest that the influence of Twitter's media capabilities on rapid tweet propagation during disasters may differ based on the communication processes.

A. Elbanna, D. Bunker, L. Levine, and A. Sleigh, "Emergency management in the changing world of social media: Framing the research agenda with the stakeholders through engaged scholarship," International Journal of Information Management, vol. 47, pp. 112–120, 2019.

The use of social media and Web 2.0 platforms is proliferating and affecting different formal and highly structured organisations including public safety agencies. Much of the research in the area has focussed on public use of social media during an emergency as well as how emergency agencies benefit from the data and information generated by this process. However, there is little understanding of "what are the operational implications of this public use on emergency management agencies and how does social media either positively or negatively impact these operations"? In order to progress research into this topic, we chose an engaged scholarship framework to shape a research agenda with the active participation of stakeholders. Hence, we conducted a series of workshops primarily involving over 100 public safety practitioners working in the area of disasters and emergency management who work

in public safety agencies, humanitarian organisations, volunteering online platforms and volunteer groups in addition to 20 academics working on this area of enquiry. The findings highlight six different challenges that emergency responding organisations currently face in relation to social media use. We conceptualise these challenges as creating six operational tension zones for organisations. We discuss these tensions and their implications for future research and practice.

III. SYSTEM ANALYSIS

EXISTING SYSTEM

- Aipe et al. [22] also proposed a CNN-based approach but they focus on multi label classification rather that simple binary classification to label disaster-related tweets. Similarly, Yu et al. [23] used CNN, logistic regression, and SVM to classify the tweets related to different Hurricanes into multiple categories. Their CNN-based model outperformed SVM and LR. In contrast to CNN-based approaches we consider BiLSTMs with attention mechanisms with an aim to better captures dependencies between word tokens.

- Li et al. [24] studied the feasibility of domain adaption for analyzing the disaster tweets by applying the naive Bayes classifier on the Boston Marathon bombing and Hurricane Sandy dataset. Graf et al. [25] focused on cross-domain classification so that the classifier can be used across different types disaster events. They employed a cross-domain classifier and utilized emotional, sentimental, and linguistic features extracted from the damage-related tweets. Others have focused on text mining and summarization approaches [26], [27]. For example, Rudra et al. [26] assign tweets into different situational classes and then summarizes those tweets. Cameron et al. [27] proposed an Emergency Situation Awareness-Automated Web Text Mining (ESAAWTM) system that detects informative damage-related Twitter messages to inform charitable organizations about the incidents of a disaster. Unlike these systems that broadly focused on text mining and summarization, we only focus specifically on a multi-class classification problem on disaster-related tweets.

- Nguyen et al. [29] developed a deep CNN architecture to label the social media images into multiple disaster categories (i.e., severe, mild, and no-damage). Similarly, Alam et al. [30] proposed a pretrained CNN (VGG16) based framework that can identify the disaster images uploaded on the online platforms. Daly and Thom [31] culled flicker images to detect the fire event using pretrained classifiers. Finally, Lagerstrom et al. [32] developed a system to classify whether the image indicates a fire event or not. In contrast to these works that broadly developed binary classifier for classifying disaster vs.
- Chen et al. [34] studied the relation between the images and texts and utilize visual features along with socially relevant contextual features (e.g., time of posting, the number of comments, retweets) to identify disaster information. Mouzannar et al. [7] explored damage detection by focusing on human and environmental damage related posts. They used the Inception

pre-trained model for visual feature extraction and designed a CNN architecture for textual features.

- Similarly, Rizk et al. [35] proposed a multimodal architecture to classify the Twitter data into infrastructure and natural damage categories. Ferda et al. [8] also presented a multimodal approach for classifying the tweets into two categories: informative task (e.g., informative vs. non-informative) and humanitarian task (e.g., affected individuals, rescue volunteering or donation effort, infrastructure and utility\ damage). They used CNN based approach for extracting the visual and textual features. Gautam et al. [36] showed a comparison between unimodal and multimodal methods on CrisisMMD [37] dataset. They utilized the late fusion [38] approach for combining the image-tweet pairs. All the works reported significant performance improvement using multimodal information in contrast to their counterparts that utilize uni-modal information.

DISADVANTAGES

- Proposed a CNN-based approach but they focus on multilabel classification rather that simple binary classification to label disaster-related tweets.
- Used CNN, logistic regression, and SVM to classify the tweets related to different Hurricanes into multiple categories.

Proposed System

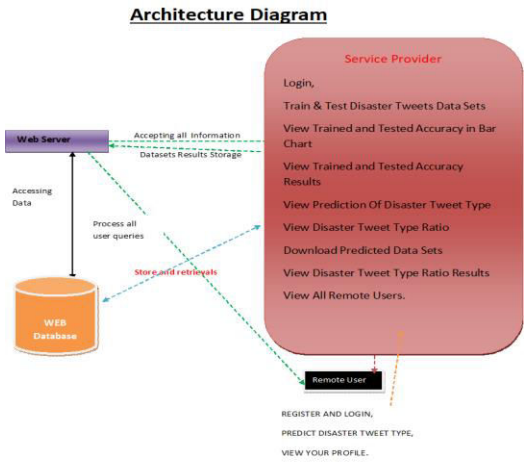
- The primary contributions of our work are: We propose a multimodal architecture that utilizes ResNet50 and BiLSTM recurrent neural network with attention mechanism to classify the damage-related posts by exploiting both visual and textual information.
- We compare the performance of the proposed model with a set of existing unimodal (i.e., image, text) and multimodal classification techniques.
- We empirically evaluate the proposed model on a benchmark dataset and demonstrated how introducing attention could enhance the system performance through an intrinsic evaluation.
- We perform both quantitative and qualitative analysis to get deeper insights about the error types which provide future directions for improving the model.

Advantages

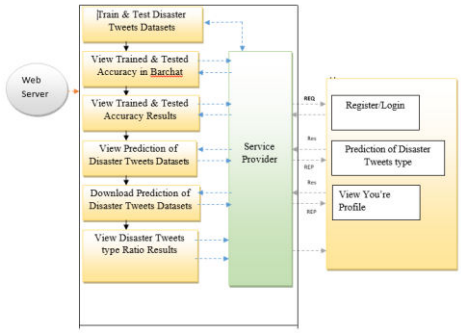
- In the proposed system, the system develops an effective computational model for identifying disaster-related information by synergistically integrating features from visual and textual modalities.
- In the proposed system, the system transforms the tweet into a vector representation and then use an embedding layer to obtain semantic representations (embedding features) of the words.

IV. SYSTEM DESIGN

System Architecture



DETAILED DESIGN
BLOCK DIAGRAM



V. SYSTEM IMPLEMENTATION

MODULES

Service Provider

In this module, the Service Provider has to login by using valid user name and password. After login successful he can do some operations such as Login, Train & Test Disaster Tweets Data Sets ,View Trained and Tested Accuracy in Bar Chart, View Trained and Tested Accuracy Results, View Prediction Of Disaster Tweet Type, View Disaster Tweet Type Ratio, Download Predicted Data Sets, View Disaster Tweet Type Ratio Results, View All Remote Users.

View and Authorize Users

In this module, the admin can view the list of users who all registered. In this, the admin can view the user's details such as, user name, email, address and admin authorizes the users.

Remote User

In this module, there are n numbers of users are present. User should register before doing any operations. Once user registers, their details will be stored to the database. After registration successful, he has to login by using authorized user name and password. Once Login is successful user will do some operations like REGISTER AND LOGIN, PREDICT DISASTER TWEET TYPE,VIEW YOUR PROFILE.

VI. CONCLUSION AND FUTURE ENHANCEMENT

We have introduced a multimodal method that can efficiently learn from text and visual data to categorise Twitter topics linked to damage. We use the attention mechanism with a BiLSTM model to extract tweet features, and the pre-trained ResNet model for visual feature extraction. The properties of both modalities are combined using the early fusion technique. Additionally, this study explored several textual (BiLSTM, CNN, BiSTM+CNN, BiLSTM+ Attention) and visual (VGG19, Inception) methodologies for the baseline assessment and built many multimodal models by using them. The assessment findings showed that the suggested model achieves the greatest weighted F1-score of 93:21%, outperforming the baseline unimodal (i.e., picture, text) and multimodal models. Furthermore, the comparison study showed that the suggested method's output is between 1% and 7% better than that of the current state-of-the-art models. As a consequence, the outcomes validated the suggested method's efficacy in locating the catastrophe material using multimodal data. The error analysis also revealed that identifying the

contents that are damaged and those that are not by using a single modality of analysis is challenging. Simultaneously, the investigation of intrinsic performance revealed that the addition of an attention mechanism improves overall performance.

Although the suggested strategy outperformed unimodal alternatives in terms of performance, there is still potential for improvement. For the catastrophe detection job, we would want to investigate several multimodal fusion methodologies in the future in addition to multitask learning techniques. Furthermore, by using the most advanced visual (Visual transformer [58]), textual (BERT [59], XLM-R [60]), and multimodal (VL-BERT [61], Visual BERT [62]) transformer models, we hope to more successfully capture the combination of visual and textual information.

REFERENCES

[1] K. K. Kapoor, K. Tamilmani, N. P. Rana, P. Patil, Y. K. Dwivedi, and S. Nerur, "Advances in social media research: Past, present and future," Information Systems Frontiers, vol. 20, no. 3, pp. 531–558, 2018.

[2] J. Kim and M. Hastak, "Social network analysis: Characteristics of online social networks after a disaster," International Journal of Information Management, vol. 38, no. 1, pp. 86–96, 2018.

[3] J. Son, H. K. Lee, S. Jin, and J. Lee, "Content features of tweets for effective communication during disasters: A media synchronicity theory perspective," International Journal of Information Management, vol. 45, pp. 56–68, 2019.

[4] A. Elbanna, D. Bunker, L. Levine, and A. Sleigh, "Emergency management in the changing world of social media: Framing the research agenda with the stakeholders through engaged scholarship," International Journal of Information Management, vol. 47, pp. 112–120, 2019.

[5] R. Dubey, A. Gunasekaran, S. J. Childe, D. Roubaud, S. F. Wamba, M. Giannakis, and C. Foropon, "Big data analytics and organizational culture as complements to swift trust and collaborative performance in the humanitarian supply chain," International Journal of Production
Economics, vol. 210, pp. 120–136, 2019.

[6] S. Akter and S. F. Wamba, "Big data and disaster management: a systematic review and agenda for future research," Annals of Operations Research, vol. 283, no. 1, pp. 939–959, 2019.

[7] H. Mouzannar, Y. Rizk, and M. Awad, "Damage identification in social media posts using multimodal deep learning." in ISCRAM, 2018.

[8] F. Ofli, F. Alam, and M. Imran, "Analysis of social media data using multimodal deep learning for disaster response," arXiv preprint arXiv:2004.11838, 2020.

[9] F. Ofli, P. Meier, M. Imran, C. Castillo, D. Tuia, N. Rey, J. Briant, P. Millet, F. Reinhard, M. Parkan et al., "Combining human computing and machine learning to make sense of big (aerial) data for disaster response," Big data, vol. 4, no. 1, pp. 47–59, 2016.

[10] P. Jain, B. Schoen-Phelan, and R. Ross, "Automatic flood detection in sentinei-2 images using deep convolutional neural networks," in Proceedings of the 35th Annual ACM Symposium on Applied Computing, 2020, pp. 617–623.

[11] A. Kumar, J. P. Singh, Y. K. Dwivedi, and N. P. Rana, "A deep multimodal neural network for informative twitter content classification during emergencies," Annals of Operations Research, pp. 1–32, 2020.

[12] T. Ghosh Mondal, M. R. Jahanshahi, R.-T. Wu, and Z. Y. Wu, "Deep learning-based multi-class damage detection for autonomous post-disaster reconnaissance," Structural Control and Health Monitoring, vol. 27, no. 4, p. e2507, 2020.

[13] M. Imran, F. Ofli, D. Caragea, and A. Torralba, “Using ai and social media multimodal content for disaster response and management: Opportunities, challenges, and future directions,” 2020.

[14] L. Dwarakanath, A. Kamsin, R. A. Rasheed, A. Anandhan, and L. Shuib, “Automated machine learning approaches for emergency response and coordination via social media in the aftermath of a disaster: A review,” IEEE Access, vol. 9, pp. 68 917–68 931, 2021.

[15] C. Castillo, M. Imran, P. Meier, J. Lucas, J. Srivastava, H. Leson, F. Ofli,and P. Mitra, “Together we stand—supporting decision in crisis response: Artificial intelligence for digital response and micromappers,” by OCHA and partners. Istanbul: Tudor Rose, World Humanitarian Summit, pp. 93–95, 2016.

[16] C. Caragea, N. J. McNeese, A. R. Jaiswal, G. Traylor, H.-W. Kim, P. Mitra, D. Wu, A. H. Tapia, C. L. Giles, B. J. Jansen et al., “Classifying text messages for the haiti earthquake.” in ISCRAM. Citeseer, 2011.

[17] M. Imran, C. Castillo, J. Lucas, P. Meier, and S. Vieweg, “Aidr: Artificial intelligence for disaster response,” in Proceedings of the 23rd international conference on world wide web, 2014, pp. 159–162.

[18] Q. Huang and Y. Xiao, “Geographic situational awareness: mining tweets for disaster preparedness, emergency response, impact, and recovery,” ISPRS International Journal of Geo-Information, vol. 4, no. 3, pp. 1549– 1568, 2015.

[19] D. Nguyen, K. A. Al Mannai, S. Joty, H. Sajjad, M. Imran, and P. Mitra, “Robust classification of crisis-related data on social networks using convolutional neural networks,” in Proceedings of the International AAAI Conference on Web and Social Media, vol. 11, no. 1, 2017.

[20] O. Sharif, E. Hossain, and M. M. Hoque, “Combating hostility: Covid-19 fake news and hostile post detection in social media,” 2021.