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Natural Language Processing Based Disaster Management Framework

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Abstract: In times of crisis, more and more people are turning to social media to reach out to others and ask for assistance. Such requests must be mined from the large data pool in order to provide prompt assistance during emergency circumstances. How well relief efforts and disaster recovery go depends on how people feel during and after a crisis. In order to aid in the speedy recovery of the afflicted area, we want to investigate and comprehend the underlying tendencies in sentiment to disasters and geographically connected sentiment. The proposed DRM Framework (Disaster Recovery and Management Framework) takes in information about disasters from various sources, organises it according to the needs of the affected people, and uses a custom-built Natural Language Processing (NLP) model to categorise the severity level for a given geographical location. A machine learning algorithm is used to categorise the disaster data and analyse public opinion. The suggested methodology has important implications for disaster response and recovery, including the real-time categorization and classification of Big Data. Using the results of this investigation, first responders and rescue workers will be better prepared to deal with the dynamic nature of crisis situations.

Key words: Sentiment Analysis, Machine Learning, Natural Language Processing, Data Analysis, Big Data.

Introduction

To detect, extract, or classify information in a text, a group of computational and natural language processing-based methods known as sentiment analysis is employed [1]. Sentiment analysis seeks to determine whether a given text is positive, negative, or neutral about a given issue. Several fields can benefit from sentiment analysis [2]. The frequency and severity of natural disasters have been on the rise at an alarming rate in recent years [3]. If we want to improve our ability to monitor and foresee natural disasters, we need to ditch the antiquated, centralised ways we've been using and instead adopt decentralised, end-to-end systems. Everyone can now communicate with the rest of the globe because to the pervasiveness of social media [4]. Because of this capability, it can serve as a reliable data source in the aftermath of a catastrophic event. Reading the mood of social media users at large can speed up the deployment of detection, monitoring, and relief personnel to a disaster zone [5].

When all other forms of communication are cut off, rescue workers' attention will be drawn to social media platforms where they can learn about safe havens and appeals for assistance [6]. Social media users who need help have been monitoring records and hashtags (such as #cyclonegaja, #gajapuyal, #AustralianBushFires, #AustralianWildFires, etc.) that are helping to organise the rescue and recovery effort [7-12]. The National Disaster Response Team, military faculties, rescue teams, and other grassroots volunteer organisations can all be better coordinated in the event of a disaster provided solid frameworks are in place to guide their deployment [13-17]. This motivates an experiment in coordinating large amounts of data from many social levels in order to build a system. DRM-Framework (Disaster Recovery and Management Framework) is a versatile, natural language processing (NLP), sentiment-based social sensing framework designed to make educated guesses about the aftermath of natural catastrophes as soon as they begin [18-21]. In this work, we examine whether or not rescue operators may benefit from situational awareness and crisis management when they use information shared by users on social media during natural disasters and emergencies [22]. In particular, we will discuss how we can leverage sentiment analysis, sentiment mining, and Natural Language Processing in social media and other outlets to better understand how people react during a disaster and use this understanding to enhance disaster management and aid in the subsequent recovery of the affected area [23-25].

Bidirectional Neural Networks are recurrent neural networks with connections between two opposing neural networks, where one neural network depends on the other neural network to produce the output result [26-31]. The RNN splits in two, one for forward states and one for reverse states, creating the two opposing neurons. Because the neurons firing in opposite directions do not interact, BNN can be taught with the same techniques as RNN [32]. Training in the forward pass involves passing the forward and backward states, followed by the output neurons, while training in the backward pass involves passing the output neurons, followed by the forward and backward states [33]. The weights are modified following the completion of two processes, forward and backward passes [34].

LSTMs are used because they can learn to bridge minimal time lags of more than 1000 discrete time steps by enforcing constant error flow through "constant error carrousels" (CECs) within special units, called cells; this is because the bidirectional neural network has a higher hit ratio in obstacles like vanishing error problems and time delays [35-39].

The two main subfields of machine learning are supervised and unsupervised learning [40]. An example of unsupervised learning is clustering, which can be accomplished in two ways: hard clustering, as with the k-means algorithm, and soft clustering, using the gaussian mixture model [41]. The normal distribution serves as the basis for this approach [42]. From then, it clusters the data based on the mean and covariance, with the mean indicating the cluster's centroid and the covariance its width [43].

There is no correlation between different word sets and the vectors encoded in the words in the word2vector model [44]. The continuous bag of words, on the other hand, is able to accomplish numerous input corpus to the target word. The words "virus" and "pandemic" would work well as context for the goal word "corona" [45]. Using the words in the context as input and a target word to be predicted, we can now model this CBOW architecture as a deep learning classification model [46-51].

Rule-based POS tagging is one of the earliest tagging methods. Rules-based taggers look up words in a dictionary or lexicon to determine which categories to assign to them [52]. Rule-based taggers rely on pre-established rules to determine the most appropriate tag whenever multiple options exist for a given word [53]. Words and their contexts are analysed for their linguistic properties and relationships in order to disambiguate them in rule-based tagging. Consider the case where the article comes before a word. So, it must be a noun [54-59].

Social media is a potent medium for communicating feelings and spreading knowledge. Information [60]posted or shared on social media sites following catastrophes is used in a variety of research initiatives p [61-65]. The primary goal is to develop an app that analyses the needs of the impacted regions based on data gathered from social media in the aftermath of a disaster and determines the Impact of the event at that location [66-71]. Due to the rapid increase in crisis-related microblogging, the number of studies of this type is rapidly expanding [72]. These studies make it clear that the social media posts people post during a crisis contain timely and crucial details that may be utilised to map out the situation and examine its development in real time [73-78]. There have been a lot of related proposals in the past. Numerous authors have contributed to the development of this concept by publishing numerous academic works. The pieces discussed here are just a sampling [79].

People's social relationships during disasters have been the subject of investigation and discussion by Palen and Vieweg [1]. The author provided supporting data for his proposal, which entails forming a community group on the social network and keeping tabs on their interactions during a crisis. The concepts of communal creativity and collective intelligence are growing in stature as they are given concrete expression in a variety of contexts. When there are widespread casualties, an even greater audience is needed to raise funds and awareness. Rapid online social convergence means rapid social ordering during disasters and calamities, allowing for people to both help one another and continue to function normally in the public eye as they seek and provide aid and form sympathetic alliances. The settings of online forums, and social networking sites in particular, increasingly allow for widespread, instantaneous, and diversified participation, and these are some of the mechanisms involved in widescale engagement[80-84].

Mandel et al. [2] analysed the mood of tweets during Hurricane Sandy based on the users' gender and region. The author has compiled information shared on Twitter during Hurricane Irene and organised it into useful and actionable chunks of information. The categorised data was then analysed based on sex and geography [85-88]. The author has come to the conclusion that social media analysis is a useful supplement to traditional survey methods, as it provides immediate understanding of how people feel about a crisis. Because of the inherent demographic bias in social media, it will be necessary to infer a wider range of demographic traits [89-91]. According to this model's predictions, (1) the number of tweets about Hurricane Irene in affected areas peaks just before the storm makes landfall; (2) the level of concern in the days before the storm's arrival varies by region; and (3) females are more likely than males to express concern about the storm [92]. The data quality is substantially better than alternative models, and the stated data gathering and pre-processing procedures are quite encouraging [93-95].

Because of this, the hashtag method greatly expands the pool of information and paves the way for heightened knowledge via data from specialised web-sharing services, such as photos and videos [96-99]. The proposed method is flexible enough to be used to obtain geolocated social media content for any event (riots, festivals, exhibitions) [100]. It's possible that the geographical element is meaningless due to the widespread nature of biological calamities like infections [101-103]. Disaster hashtags, as contrast to the standard procedure, allow for the differentiation of concurrent activities. When more conventional approaches, such the analysis of overlapping occurrences, are inadequate, the proposed method leads to a dramatic improvement in the usefulness of the gathered data. Keywords and geolocation data are used to find tweets [104]. The impact area at a specific location is evaluated by using spatial information derived from a disaster database. Messages containing embedded coordinates are picked using the area polygon, and toponyms (cities, towns, and villages) from the region are utilised as keywords to extract those messages [105]. The messages are retrieved, and the hashtags are then extracted from them, with the help of multiple heuristics that weed out the irrelevant ones. The filtering procedure relies heavily on the content classification of messages [106]. Once trained, our classifier can recognise messages about a wide range of natural and technological disasters, and its quality is far higher than that of previous models [107]. Therefore, we anticipate that our model will be applicable to future studies, even those that have nothing to do with the hashtag retrieval technique [108].

This research is meant to guide future efforts to use information extraction (IE) methods to glean actionable data during times of crisis [109]. To get tweets with search phrases that are case-insensitive, the author used the Twitter Search API [110]. Red river and driver were used to collect tweets about the Red River Flood, whereas oklahoma, okfire, grass fire, and grassfire were used to collect tweets about the Oklahoma Grassfire [111]. The author has described aspects of the tweets in each data set that are important to grasping the full context of the events in question. Information about "high yield Twitterers," retweeted content, and markedness are all examples of this. Two data sets focused on natural hazards were analysed for geo-location, location references, and situational updates in Twitter data [112-115]. Both types of emergencies saw Twitter users sharing comparable but to differing degrees of effectually dire news. Certain other aspects of tweets could help raise awareness of a given problem [116]. Analysis of Twitter data from the Spring 2009 Red River Floods and Oklahoma grass fires reveals characteristics of data created during crises. As a result, a practical framework may be created to guide the development of software systems that use information extraction techniques [117-121].

Pre-processing and transformation into operational data occurred on the extracted data. Twitter has been categorised as both a participant and an observer [122-125]. This method employs a keyword-based categorization, with the keywords falling into various buckets such as: weather reports, prayer or rescue, relief supplies, impact describer, etc [126-129]. All participant tweets' sentiment was predicted using a subjectivity classification model that distinguished between subjective and objective tweets. Afterward, a sentiment classification model was used to assign an overall positive or negative tone to each of the subjective tweets [130]. It was explained how participants' and observers' tweets covered different ground in terms of frequency and depth of coverage [131]. Tweets requesting prayer or seeking help were the most frequently shared. The participants' linguistic practises were also a point of interest. While most people tweet in English most of the time, when a crisis strikes they are more likely to tweet in their home language [132].

System Design

Below you'll find graphics depicting the architecture of a system designed for managing disaster recoveries using natural language processing [133-138]. There are essentially three stages to this:

- Scraping/Data Collection Process, Including the All-Purpose Scrapper Sub-Component.
- The Text Filtering and Extensive Classifier Module are part of the learning and Classification Phase.
- The Dispatcher Module is a component of the Execution Engine.
- The Live Feed/User Interface Module is part of the Front End Feed.

Live-feed/User Interface

Users will engage with the Live Feed Module primarily through its User Interface, which is a collection of dynamic web pages that dynamically adapt to the entities using the software [139-141]. The general public, who are interested in knowing how far along recovery from the disaster is, and

Organizations, who update the recovery status for the locations they serve, are the two main types of users who engage with the application [142]. The Data That Has Been Processed Is Obtained From A Remote Server. Drop off Points allow users to see where aid is most needed and drop off donations in person. When a user registers in to our platform, a session is established and kept alive by this module until the user explicitly terminates it. All of the front-end work was done in React.Js, and Node was used for serving [143].

Back-end Framework

The data is prepared for the dispatcher by a series of modules in the back-end framework that perform tasks including scraping, pre-processing, filtering, classifying, and categorizing [144-147]. Ultimately, it's the Users who make it possible for them to act in the right way [148]. This structure has three primary parts:

1. Universal Scraper Module.
2. ML Core Module.
3. Dispatcher Module.

Universal Scrapper Module

The process of downloading tweets from the internet and saving them locally for further analysis is the focus of this section [149].

1. Capturing Tweets: A custom-built scrapper was primarily utilised to gather real-time tweets from the web and parse them as String objects during the data extraction process. These String objects can be worked upon further by the storage and manipulation programme [150].
2. The application may record the same tweet multiple times if the user retweets it or if it is recaptured from an earlier time [151-156]. To circumvent this, we employ a regular expression series method based on a predetermined threshold, in which we sample a subset of incoming tweets (minimum character length = 35) and compare them to our current tweets. If a significant percentage of the tweet's pattern is matched, the tweet is ignored [157-161].
3. Storage: Tweets that make it past the Redundancy Check sub-module are saved to files in reverse-chronological order, based on when they were posted [162-167]. The tweet's content, the user's username, and the tweet's time-stamp are all saved in the system [168]. Even more information, such as the number of retweets and comments on the tweet, can be saved in the system [169].

ML Core Module

In order to generate important data points for Geo-location-based classification of impact and Resource categorization, this module's primary goal is to analyse and extract features from the scraped data [170-174]. There are three primary sections to the module:

1. A technique known as "pre-processing" is used to clean and transform the raw, unstructured data gathered by the scraper module into usable, operational information. There are three sections inside it:

a) Tokenization: Tokenization is the process of breaking down large amounts of text into smaller chunks called tokens [175].

b) The term "normalisation" refers to a procedure that standardises the order of words in a given list. In this process, we perform both lemmatization and stemming. By conforming the text to a common format, we can more easily input it into our model and process it [176].

c) Parts of Speech (POS) tagging entails assigning a category to every word in a sentence. Different taggers were compared and CRF was selected to tag nouns, verbs, adverbs, adjectives, pronouns, conjunctions, and their respective sub-categories [177].

2. Data Analysis: After the data has been preprocessed, it is sent to yet another module where it is analysed and translated [178]. This section is broken down into four sub-sections that each perform their own separate function in determining the data's underlying sentiment, frequency of occurrence, geo-tag, and distribution of disasters [179].

a) In catastrophe analysis, the location of the disaster is of utmost importance, hence the need of geo-tagging [180]. A geo-location filter tag is applied to tweets to determine the tweet's point of origin, thereby separating the area from the tweets. Few people in the disaster zone use digital media to communicate with others. Google's Maps-API for python is used to manage the inferred position, and the incoming data is processed by a Function that parses it into words before making an effort to determine its geo-location using the API. If the word is found anywhere in Google Maps' database, the method gives its coordinates; otherwise, an exception is generated. Therefore, the possible locations mentioned in the data are identified and marked [181-183].

b) This section analyses the global distribution of tweets mentioning disaster-affected places and classifies them into distinct categories [184]. It takes the coordinates from the preceding module and organises the tweets geographically according to the data provided by the Google Maps API [185]. After analysing the clusters throughout time, we can classify the frequency with which various levels of disaster strike. As a result, we can estimate the length of time it will take for a specific area to recover [186].

c) Each tweet is then placed into a sentiment-analyzing engine after it has been categorised. This process compares the tweets to a dictionary where each word has been assigned a score based on its frequency and other factors [187]. Each tweet is broken down into its component parts and then tested against a dictionary. Each word's sentiment weight contributes to the overall favourable opinion/sentiment assumption in the tweet [188].

3. Classifying the Impact of a specific disaster-affected area and the resources needed—that is, the urgently essential supplies needed at a given area—follows data cleansing and analysis [189].

a) Categorization of Resources: This step takes the information gleaned from Geo-Tagging, Distribution, and Sentiment Analysis and applies it by classifying the various types of resources that were referenced in the collected information [190]. This is accomplished by training an Entity Recognition Model in spaCy using a dataset of more than 20,000 tweets and *660 resources. The custom label "RqrER" was developed for this purpose.*

Dispatcher Module

During an emergency, the dispatcher directs the various organisations to where they are required [191-192]. The optimal routes for each vehicle are calculated using a driver routing optimization solution [193-195]. This makes use of an input-feedback loop in a Machine Learning-based parameter-tuned genetic algorithm, which allows for high throughput [196-197].

Database Schema

Except for the massive amounts of text data stored on AWS-S3, the present Database structure is NO-SQL based. Both the live feed and the dispatcher depend on the information included in this Schema [198-199].

The output of the ml core module is a schema, which is described below.

```
{
"Locations":
[
{
"locationName" : "UniqueLocationName",
"locationCount" : "LocationCountforLocationName",
"locationResouces" : {
"water" : "count1",
"shelter" : "count2",
"medical" : "count3"
},
"totalResourceCount" : "summation(count[i])",
"locationScore" : "locationCount + totalResourceCount"
}

]
}
```


API Design

The term "API design" is used to describe the process of creating programming interfaces for applications that make data and features accessible to programmers and end users.

Our APIs allow us to do the following three tasks:

- Explain the tasks that your users are attempting to accomplish.
- In the event of an emergency, critical communications are sent out immediately to all team members.
- Protecting against permanent data loss by regularly backing up your computer.
- Data sampling is used to identify patterns and trends in order to identify specific events.
- Specify the problems that users face, and find solutions to them.
- Multiple-attempts-to-send reliability, failure detection, multiple-attempts-to-send-worry, message-count concerns, and integrating with various message-delivery systems according to user location are all things to consider while delivering reliable messages.
- Safely delivering data while keeping bandwidth usage to a minimum is a top priority.
- Managing huge data sets and performing real-time correlations
- Third, briefly describe the benefits the user may experience.
- In contrast to alerts about potential dangers, some forms of notifications generate opportunity.
- Removing unnecessary forms of storage machinery if this one's dependability is adequate.

- instigating responses to events mechanically.

Model Training and Evaluation

Using our approach, we analysed over one hundred thousand tweets. Time required for evaluation differed considerably between disaster kinds. An Nvidia GTX 1060 with 6 GB of compute memory was used for the investigation. Its compute speed was 1997 MHz. Subjectivity and objectivity are analysed by a function using a simple Nave Bayes method. The outcomes, along with some illustrative instances, are displayed below (tables 1 and 2).

Table 1: Exemplar subjective and objective unigrams

Subjective unigram	Objective unigram
amazing, beautiful, cheap, decent, effective, fantastic, good, happy, impress, jittery, light, madly, nice, outstanding, perfect, quick, responsive, sharp, terrible, ultimate, wonderful.	access, because, chance, default, entire, few, go, half, inside, job, keep, know, last, matter, new, only, past, quality, read, several, text, use, version, was, young.

Table 2: Feature vectors for subjective/objective unigrams

TF-IDF	Position	POS	Opinion indicator seed word	Negation	Modifier
0.0058	1	*A*	1	0	0
0.0110	0	*D*	0	1	0
0.0232	1	*N*	0	0	0
0.0067	0	*D*	0	0	1
0.0044	1	*E*	0	0	0
0.0412	0	*A*	1	0	0
0.0032	0	*D*	0	1	0
0.0352	-1	*N*	0	0	0
0.0033	0	*D*	0	0	1
0.0062	0	*A*	0	0	0

System Implementation

The paper focuses on how the system was built. Python 3.8 was the programming language of choice. Due to its intricate make-up, the model is run in a separate setting from the one in which its training and consumption algorithms are implemented. Our app was converted to a PWA using the react library. We store data (scraped data from Twitter and other social media) in AWS S3 Buckets and utilise AWS SQS and SNS to communicate across different parts of the system.

Introduction to Python 3.8

Python is a high-level programming language that is interpreted, object-oriented, and has dynamic semantics. As a scripting or glue language, it may be used to connect preexisting components, and its high-level built-in data structures, as well as its dynamic typing and dynamic binding, make it a very attractive choice for Rapid Application Development. The low cost of Python's upkeep is a direct result of the language's focus on readability and its minimalist syntax. Python's module and package infrastructure promotes code modularity and reusability. Free and open source distribution of the Python interpreter and the entire standard library is possible on all major platforms.

Introduction to MicroService Architecture

Microservice architecture (MSA) refers to the use of modular, loosely-coupled services in the design of a software system. A micro-service is a small, self-contained part of a larger service that is designed to accomplish a single business task through the use of a standard, easily understood interface. As a result of their decoupled nature, micro-services make it possible to scale out different parts of an application independently. It reduces the possibility that a modification to one part of the programme would result in unintended modifications to other parts of the programme. Micro-services are independently deployable components that can be independently added, withdrawn, renamed, reconfigured, modified, and reorganised. In contrast to the monolithic design, where changes to one part of the programme affect the entire, the micro-services approach separates the programme into smaller, independent parts.

Introduction to Amazon AWS

Cloud computing infrastructure and application programming interfaces (APIs) are offered by Amazon Web Services (AWS), an Amazon subsidiary, on a pay-per-use basis to individuals, businesses, and government agencies. These web services offer basic abstract technical backbone alongside distributed computing building blocks and instruments. Amazon Elastic Compute Cloud (EC2) is one such service that provides users with a scalable, always-on cluster of virtual machines accessible over the Internet. The virtual machines provided by Amazon Web Services (AWS) mimic most of the characteristics of real computers, including hardware CPUs and GPUs for processing, local/RAM, hard-disk/SSD storage, an OS of your choosing, networking, and pre-loaded application software like web servers, databases, and customer relationship management systems (CRM). Amazon Web Services (AWS) is a cloud computing platform that is deployed and managed throughout the company's global network of data centres. Boto is the Python AWS Software Development Kit (SDK). It paves the way for Python programmers to set up and control AWS services like EC2 and S3. Boto gives you direct access to AWS services and an intuitive object-oriented API.

Introduction to AWS EC2

Users can rent virtual servers from Amazon.com through Amazon Elastic Compute Cloud (EC2), which is a part of Amazon Web Services (AWS). By providing a web service by which a user can launch an Amazon Machine Image (AMI) to construct a virtual machine (which Amazon refers to as a "instance"), EC2 facilitates the scalable deployment of applications. The term "elastic" refers to the fact that a user can construct, launch, and terminate server instances on demand, with the cost of those servers calculated on a per-second basis. By letting users choose where their instances are hosted, EC2 facilitates latency optimization and provides for high degrees of redundancy.

Introduction to AWS S3

Amazon Simple Storage Service (S3) is a service provided by Amazon Web Services (AWS) that allows users to store objects over a web service. To power its global e-commerce network, Amazon.com relies on the same scalable storage technology that powers Amazon S3. Amazon Simple Storage Service (S3) supports a wide variety of use cases, including object storage for Internet applications, backup and recovery, disaster recovery, data archiving, data lakes for analytics, and hybrid cloud storage, among many more.

Introduction to AWS SQS

In late 2004, Amazon.com launched a distributed message queuing service called Amazon Simple Queue Service (Amazon SQS). It allows for automated Internet communication through the use of various web service protocols. SQS's primary goal is to fix the widespread producer-consumer dilemma by offering a scalable hosted message queue that can be accessed from anywhere. The concept of a messaging service has been commercialised by Amazon Simple Queue Service (SQS). IBM WebSphere MQ and Microsoft Message Queuing are two well-known messaging service technologies. Users of this technology don't have to worry about keeping their servers up to date.

Introduction to AWS SNS

Since 2010, Amazon has included the Simple Notification Service (SNS) as part of Amazon Web Services. It's a cheap system for sending lots of messages, mostly to mobile phones. For instantaneous message dissemination, SNS employs the publish/subscribe paradigm. Recipients might choose to follow a single topic or a wide variety of them within the social network. As a typically internal feature of a mobile app, this is usually not visible to the end user. Since this service is designed more for the internal processing of individual apps than as a universal email replacement, it is possible that the user will never know whether or not they have received a message.

Experimental Results and Discussion

The following graph is the result of a comparison of many point-of-sale taggers and their relative accuracy. Being a generative neural network, the Bidirectional Neural Network is useful for changing data. Because the difficulty of the sentence varies from style to style, dynamic data points are required. We hope to improve the reliability and performance of the current system in the near future by using sophisticated Machine learning and classifier models. Where the current project is a Web Application, we hope to develop Android and iOS apps as well. The system's adoption by the mobile platform will result in a massive uptick in the platform's user base.

Conclusion

By analysing data from several social media platforms, we have found and tested a novel approach that makes it possible to visually represent the mood of the masses in the wake of natural or man-made disasters. Moreover, we have analysed that our entity recognizer combined with a scalable model for calculating the impact factor makes the perfect deployable model during a catastrophic event. The approach is straightforward and efficient, and it takes into account all possible use cases and the severity of bugs. Tweets and other data are part of a massive dataset used to test the model's viability. The findings demonstrate that this model's processing of data mined from social media platforms can provide a useful tool in crisis management and restoration. Live Feed can also tell you a lot about how people are reacting to a tragedy and what they think about it. The prototype employs the Social Media platform to efficiently handle and recover from disasters, and it features a Dispatcher in conjunction with an ML core and a Live Feed. Using our approach, we analysed over one hundred thousand tweets. Time required for evaluation differed considerably between disaster kinds. The computation was executed on a Nvidia GTX 1060 with 6 GB of compute RAM, giving the analysis a speed of 1997Mhz.

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