Dr. Jin Wei and Sifat Shahriar Khan

Electrical & Computer Engineering

The University of Akron

Real-Time Power Outage Detection System using Social Sensing and Neural Networks

The University of Akron
College of Engineering

Outline

- **Introduction and Motivation**
- **Social Sensing-Enabled Power Outage Detection**
- **Performance Evaluations**
- **Conclusion and Future Work**

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Introduction and Motivation

Social Media: Twitter

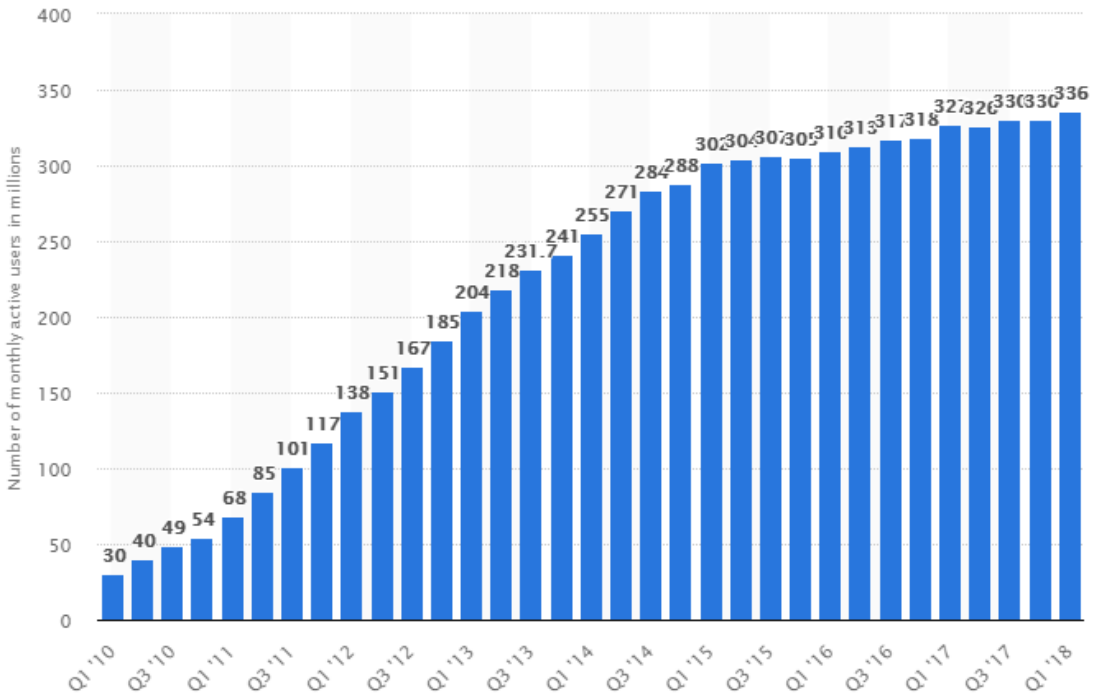

Figure1: Number of Active Monthly Users in Millions

- In the first quarter of 2018, Twitter had 336 million monthly active users.
- Users tweet more than 500 million tweets per day (2016).
- 74% Twitter users say that they use the network to get their news.
- 100 million daily active Twitter users
- 80% users use Twitter on smartphones.

Introduction

Tweets regarding Power Outage

Time	Tweet
3/16/2018 17:31	1.) Trump's Twitter going dark. 2.) A transformer fire causing a power outage ¦ https://t.co/qklOocvDH6
3/16/2018 17:41	Anyone else get a power outage?
3/16/2018 17:43	Power failure.. or did someone fall asleep on the e-stop button? https://t.co/wr2NwbZ8hm
3/16/2018 18:13	Happy Birthday okay ...that one time you become a hostage because of a power outage
3/16/2018 18:25	hi guys, my mother in law is babysitting at my house at the moment and suffered a power outage. Can I send you¦ https://t.co/Cz0VcD10jz
3/16/2018 18:39	POWER OUTAGE - AVONHEAD - TRAFFIC SIGNALS OUT - 11:30AM SAT 17 MAR Due to a power outage the signals at Maidstone ¦ https://t.co/TA1PLQBUdK
3/16/2018 19:35	I never realized how much I'm on technological devices until I have a power outage.
3/16/2018 19:38	Remember the power outage in the mid west and Canada, back in August 2003? I was visiting¦ https://t.co/n3CagFP7o1
3/16/2018 20:15	@WeatherNation @Schef56 @KTCHRadio @NWSSiouxFalls @NWSOmaha Power outage going on 2 hours in Concord ¦ https://t.co/FFZUsTWk3A
3/16/2018 19:45	Due to a power outage at the @SinBinThunder casa, pregame will start at 7:55 p.m. CST time.

Introduction

Social Media and Situational Awareness

- Considering that physical sensors may be damaged during natural disasters, social media, such as Twitter, Facebook, and Neighborhood App can be a value lifeline.
  - During Hurricane Sandy in 2012, many regarded Twitters' use for reporting issues, danger and power outages as a "lifeline".
  - During this major natural disaster, the United States Department of Homeland Security declared social media as a "critical component of emergency preparedness, response, and recovery".

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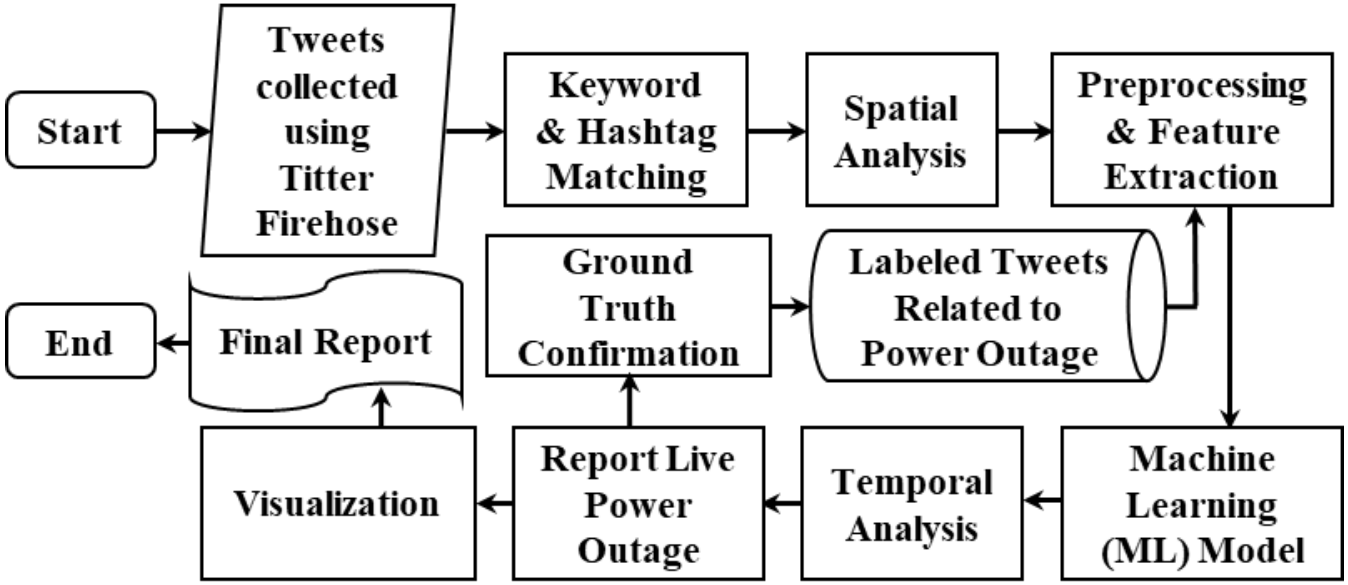
Social Sensing-Enabled Power Outage Detection

- We developed a real-time situational-awareness mechanism to detect the ongoing power outages and extract useful information for power outage management.



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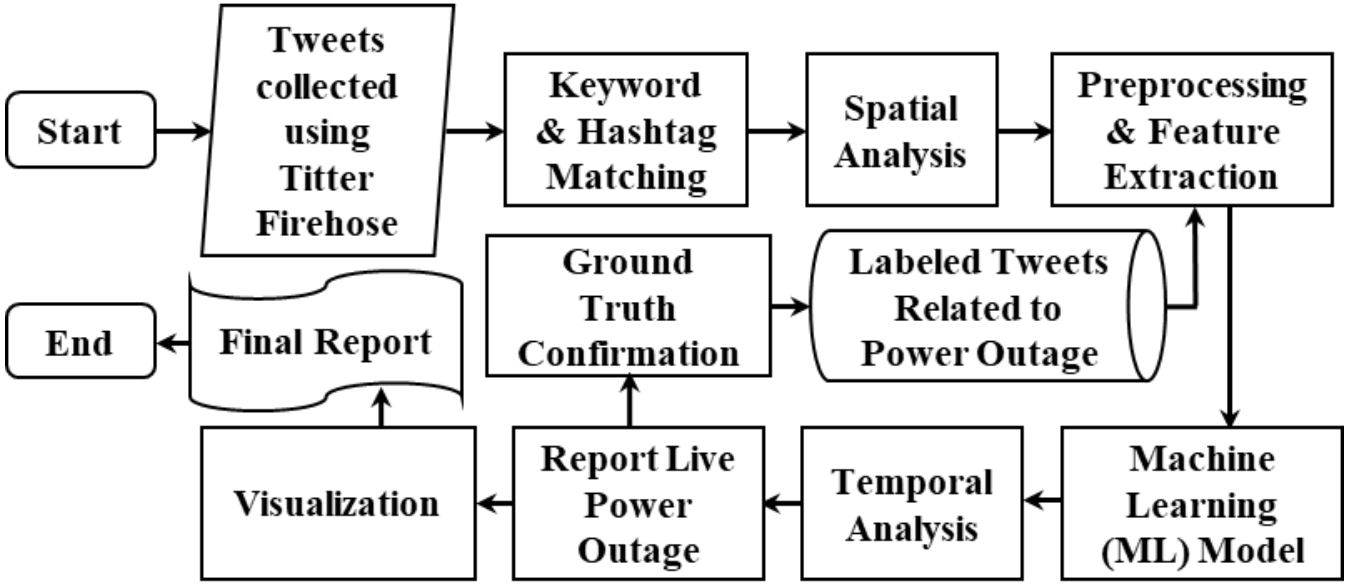

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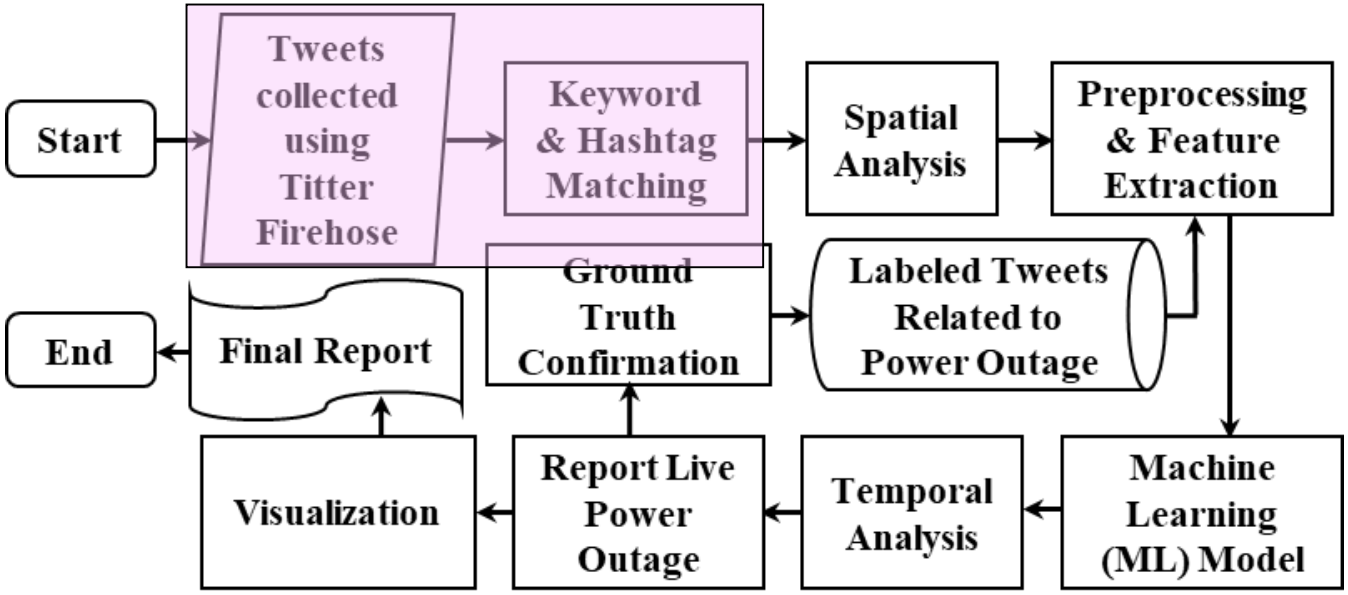

Proposed Framework

Keyword and Hashtag Matching

- We use Twitter API, such as Twitter Firehose, to collect and filter tweets based on a set of keywords and hashtags.
  - Select the list of possible keywords manually to achieve the first list of keywords.
  - Include all the possible synonyms of the keywords from the first list to make a second list of keywords.
  - Use the keywords from the second list and the name of target region to create a list of possible hashtags.
  - Combine the second list of keywords and the new list of hashtags to make the final list of keywords and hashtags.
  - Use these keywords and hashtags, tweets are collected.

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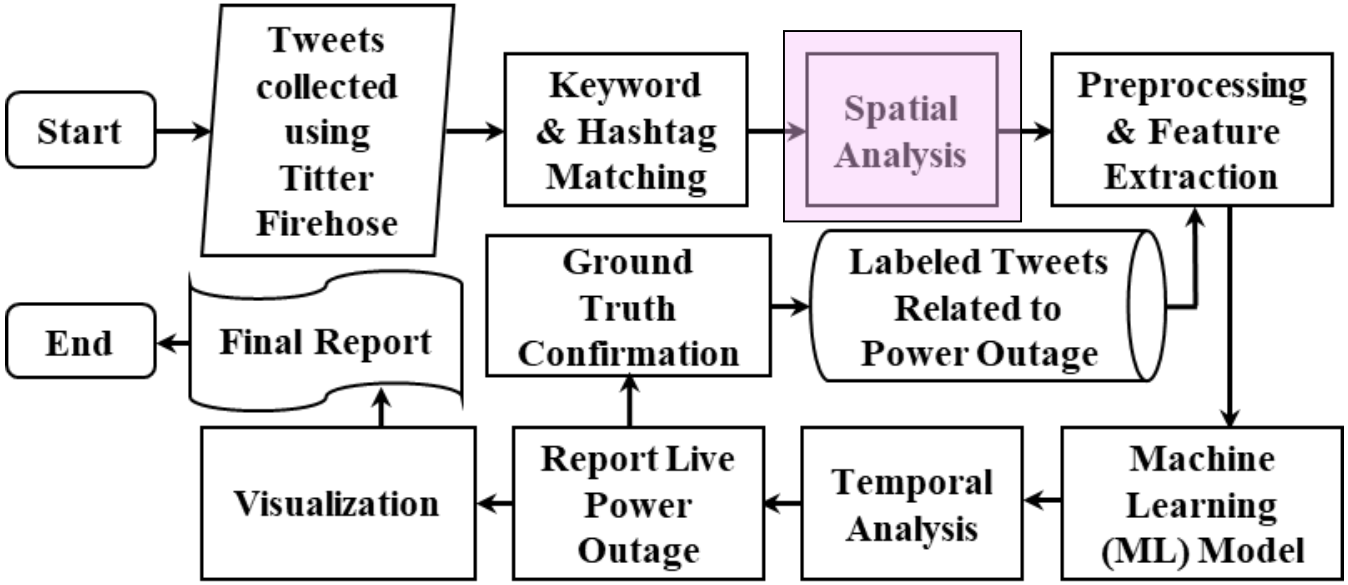

Proposed Framework

Spatial Analysis

- Extract location information from tweets
  - Geo-tagged tweets have location information in the form of Latitude and Longitude.
  - Tweet content: Users sometimes mention the location of power outage in their tweets. (NER)
  - User Information: Users have a registered location with their account.

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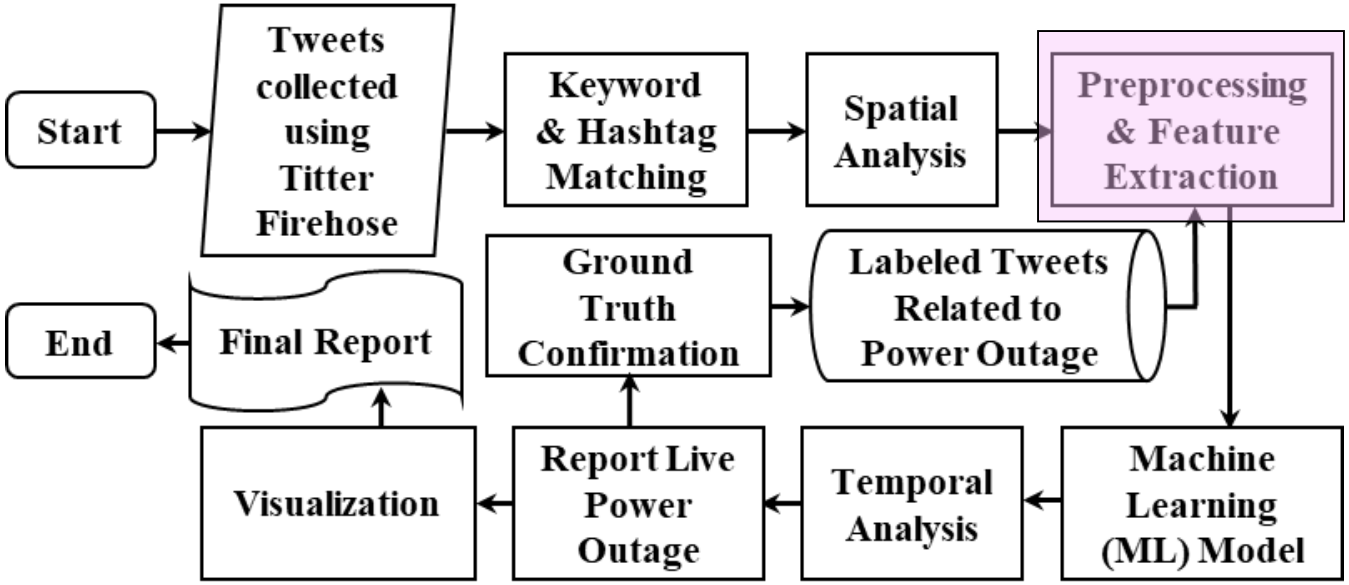
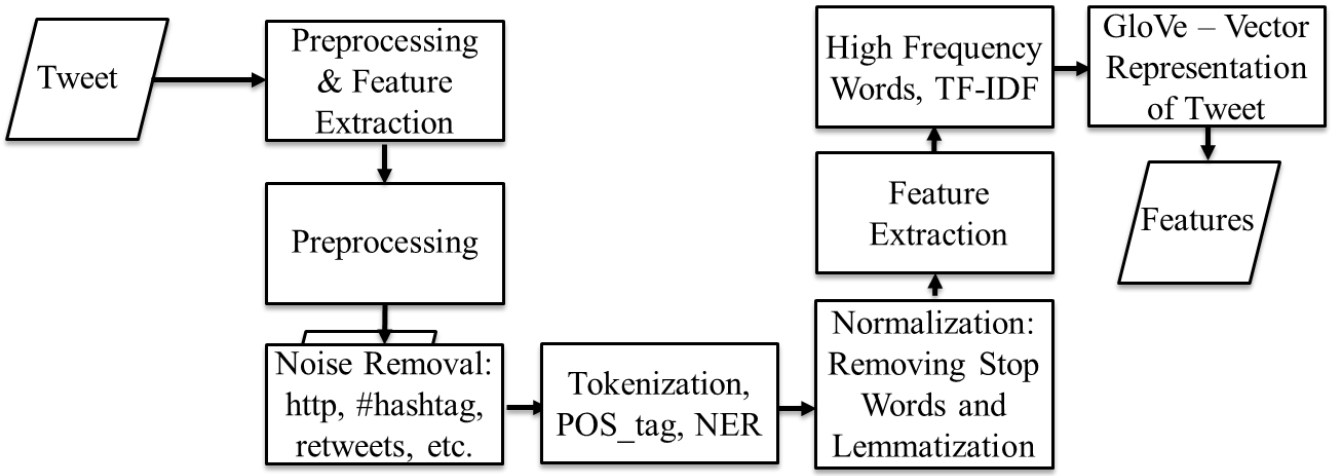


Proposed Framework

Preprocessing and Feature Extraction

- Preprocessing techniques exploited: Noise Removal: links and retweets, Tokenizing, POS_Tagging, Named Entity Recognition, Normalizing, Removing stop words, and Lemmatizing.



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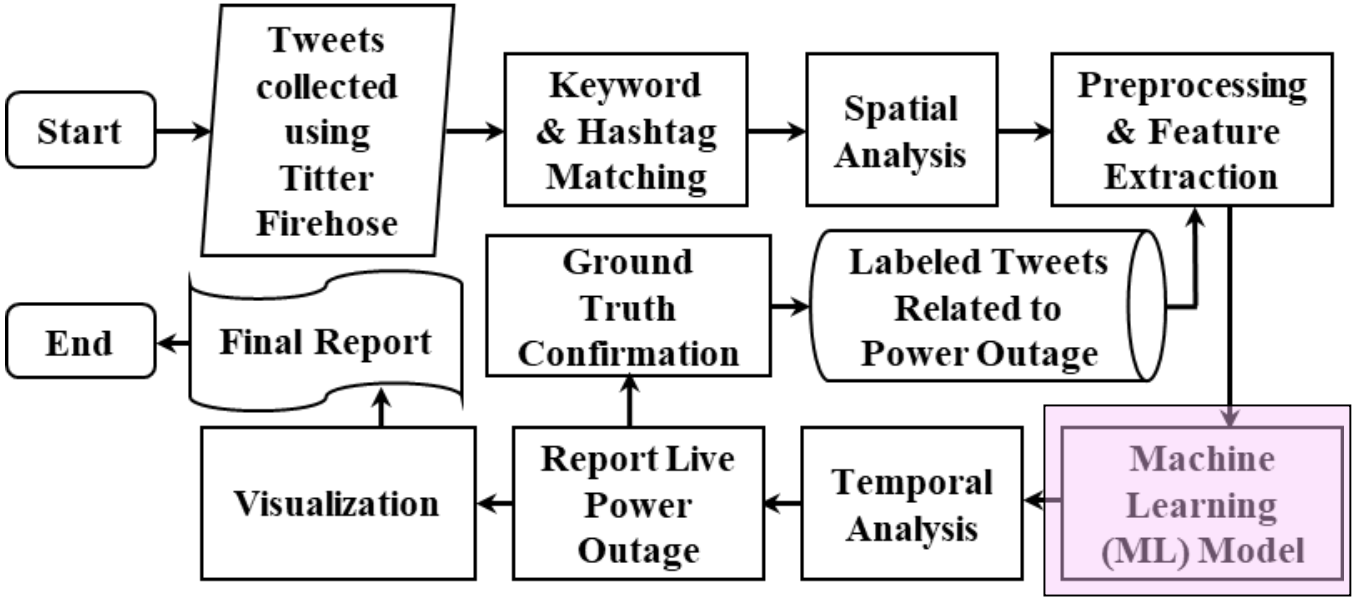

Proposed Framework

Machine Learning Model

- We develop a predictive model to identify whether the twitter data stream is related to power outage by exploiting multi-layer neural network.
  - **Hidden Layer:** 3 hidden layers with 128 hidden units for the first hidden layer, 64 hidden units for the second layer, and 32 hidden units for the third layer.
  - **Activation Function:** Rectified Linear Units (ReLU) for the hidden layers and Sigmoid function for the output layer.
  - **Loss Function:** Binary Cross Entropy (BCE) loss function.
  - **Regularization:** a dropout of 0.2 was applied in the hidden layers.
  - **Learning Rate:** It is the step size in the optimizer. It was set to be 0.001 in our model.
  - **Batch Size:** This is the size of each mini-batch which is used to compute the gradients. It was set to be 64 in our model.

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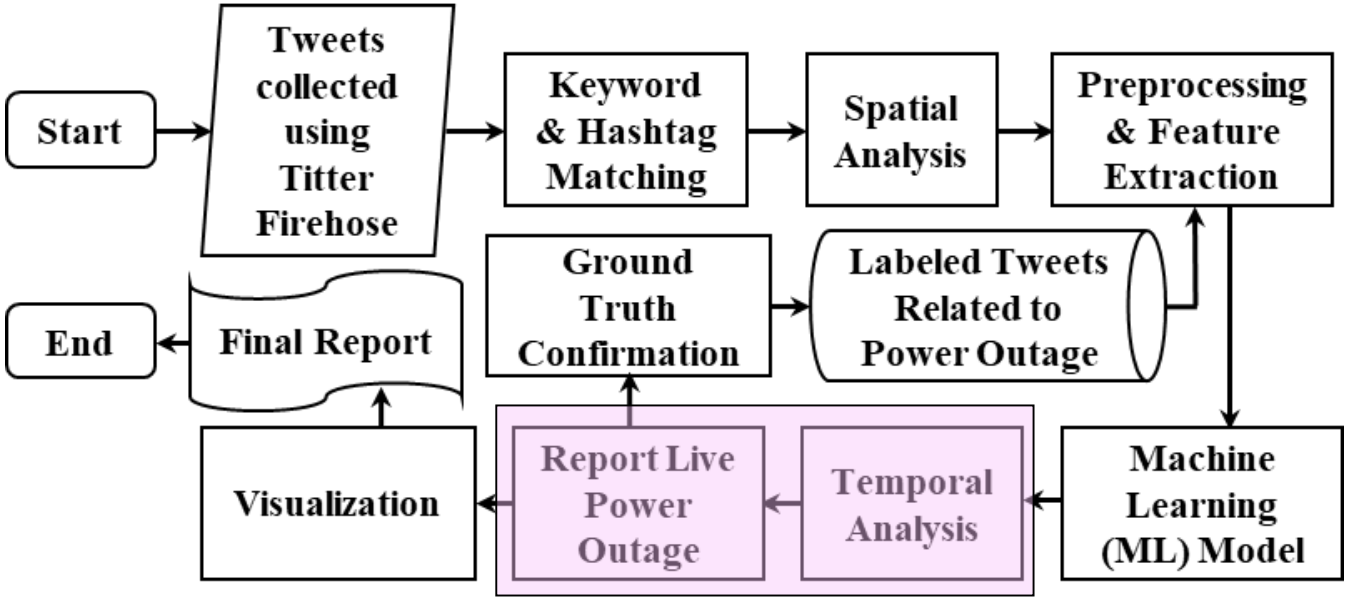

Proposed Framework

Temporal Analysis

- We develop a revised Kleinberg's burst detection to detect whether a tweet refers to a live event.
  - Whenever a relevant tweet is received by the system, the burst detection technique checks if there are any other existing burst in that location at that time.
  - If there is no existing burst, this burst is still in the initial state.
  - Then the system checks all the incoming tweets. Any relevant tweet within the same region within a time period threshold is identified as a part of the previously detected burst state.
  - As the number of relevant tweets within the time period for that location increases, the state of the burst also increases.
  - The higher the state of the burst, the higher the chance of a true case of real-time power outage.

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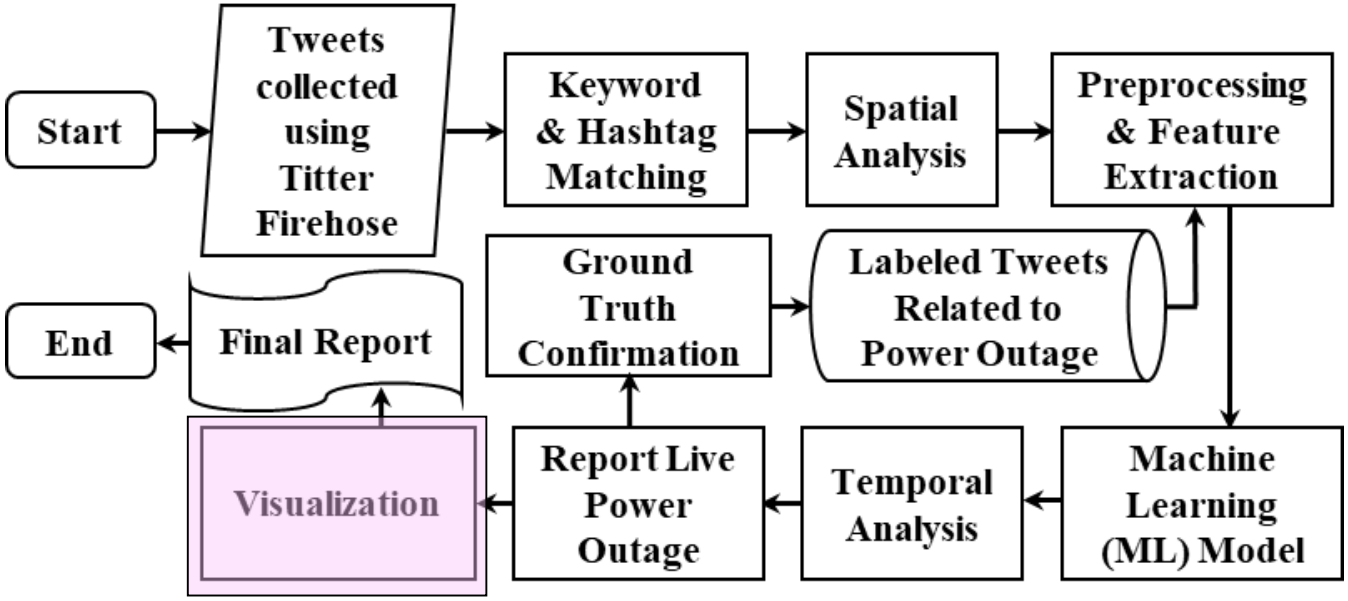

Proposed Framework

Visualization

- We design a dynamic platform to visualize the detected power outages by extracting the operation information.
  - Causation extraction
    - Keyword search and text classification
    - Keywords such as “car accident”, “tree”, “storm”, “squirrel”, etc.
  - Weather report extraction
    - Keyword search and text classification
    - Keywords such as “snow”, “rain”, “sunny”, etc.
  - Sentiment analysis
    - Text classification

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Performance Evaluations

- Performance is evaluated using the Twitter data collected online.
- Collected using the Twitter Streaming API using “power outage” keyword.
- 1610 collected tweets were labeled manually, giving 823 positive labeled tweets and 787 negative labeled tweets.
- Two different sets of features are used in the experiments.
  - Feature Set A is a vector representation of tweets acquired by concatenating the GloVe vectors of the words in the tweets and removing stop words and using lemmatization.
  - Feature Set B consists of the statistical features including number of words, position of the keyword or hashtag in the tweet, number of verbs in past tense, whether the tweet contains number (POS Tag : CD) or not (True/False), and whether the tweet contains location (NE Chunk : LOCATION, GPE) or not (True/False).

Performance Evaluations

	Accuracy	Precision	Recall
Logistic Regression	0.6654	0.6637	0.9433
Stochastic Gradient Descent	0.626	0.6259	0.9965
Random Forest Classifier	0.629	0.663	0.8301
Linear Support Vector Classifier	0.626	0.6259	0.9967
Bernoulli Naïve Bayes	0.626	0.6259	0.9987
Multilayer Neural Network	0.6578	0.6594	0.958
LSTM Recurrent Neural Network	0.6457	0.6512	0.9378

Table I: Numerical Analysis using the Power Outage dataset for Feature Set A.

Performance Evaluations

	Accuracy	Precision	Recall
Logistic Regression	0.7638	0.8176	0.8273
Stochastic Gradient Descent	0.7480	0.7988	0.8273
Random Forest Classifier	0.6969	0.7198	0.8869
Linear Support Vector Classifier	0.7677	0.8187	0.8333
Bernoulli Naïve Bayes	0.6203	0.7502	0.6428
Multilayer Neural Network	0.7835	0.8517	0.8715
LSTM Recurrent Neural Network	0.6614	0.6614	0.8729

Table II: Numerical Analysis using the Power Outage dataset for Feature Set B.

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Conclusion and Future Work

- We developed a real-time situational-awareness mechanism to detect the ongoing power outages and extract useful information for power outage management.
  - Investigated feature extraction and preprocessing techniques.
  - Proposed a revised Kleinberg's burst detection method for temporal analysis to ensure the detection of real-time power outages.
  - Tested different classifiers using social sensing data and analyzed different temporal and spatial analysis approaches were analyzed.
- In our ongoing work, we are developing probabilistic approximation approach to estimate location of potential power failures and location of the source power failure. We will also investigate other social media and improve our proposed visualization platform.

Thank you!

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Questions?

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Experimental Analysis

Accuracy, Precision, Recall

- $Accuracy = \frac{TP+TN}{TP+TN+FP+FN}$
- $Precision = \frac{TP}{TP+FP}$
- $Recall = \frac{TP}{TP+FN}$