

# Applying IoT for Sentiment Classification and Tone Analysis of Urdu Tweets

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## Abstract

Social media sites such as Facebook, Twitter and Flickr are becoming integral parts of social network users. The sentiment classification and tone analysis are two important applications of social media analytics. Most of the existing studies pertaining to the two aforementioned tasks are based on the machine learning approaches. However, a more recent trend is to take advantage of the Internet-of-Things (IoT) based platforms for efficient classification of users' sentiments and tones (emotions), which could be of a great assistance to the business community aiming to monitor and satisfy the needs their customers. The IBM Watson Cloud equipped with Tone Analyser and Natural Language Understanding services could provide a best avenue for the sentiment classification and tone analysis tasks. Some works are performed on IoT-based sentiment analysis tasks. However, there is lack of such applications for sentiment analysis in Urdu language, which is widely spoken in major parts of the Indian sub-continent. In this work, we propose an IoT-based Urdu sentiment classification and tone analysis framework, capable of crawling Urdu tweets from Twitter in real time and then performing sentiment classification and tone analysis using IBM Watson Cloud services. The results obtained show the efficacy of the proposed system with respect to baseline methods.

## Keywords:

*Twitter, IoT, Sentiment Classification, Tone Analysis, Emotion Classification, Urdu Sentiment Analysis, IBM Watson*

## 1. Introduction

The Internet of Things (IoT) aims at connecting each entity in the globe via the Internet. IOT is an advanced next generation version of the Internet with the emphasis to assist in embedding and connecting computing and Internet-enabled devices to everyday objects for sending and receiving data[1]. The emergence of mobile devices and ubiquitous computing provide a gateway to people to connect with everyone round the globe. Nowadays, researchers in different fields such as government, business, health, education and others are focusing on bringing the Internet in every walk of the human life including smart transportation, smart homes, smart cities, intelligent healthcare amongst others [2, 3, 4, 5].

In recent times, IoT is considered as a dream platform for providing solutions in the form applications for our everyday issues and challenges, such as water, soil, health, agriculture, climate change etc. [6]. Another direction

regarding the utilization of IoT is the development of automated social media analytics applications [7, 8].

Social media analytics applications make use of social network-based big data for capturing, cleaning and analyzing public opinion, sentiments, emotions and feelings about products, services, policies and many other entities[ 9].

The Integration of social media analytics with IoT can help in designing smart applications [10.]. Such applications could assist business organizations to monitor and analyze public feedback about their products in real time streaming mode and make decisions accordingly for the quality improvement of their delivered goods [10.]. Similarly, IOT-based Sentiment Analysis (SA) applications can assist government organizations to analyze public mood regarding their policies in the form of smart and sophisticated dashboards available on their personnel's computers and hand-held devices [11].

IOT-based SA is a new paradigm in social media analytics and few studies are conducted [12,13, 14, 15, 16] on analyzing public feedback in English language. However, to the best of our knowledge, IoT-based SA system for Urdu language is yet be investigated and developed.

Urdu is the national language of Pakistan and widely spoken in other parts of the world like Indian sub-continent. Prior works carried out on developing Urdu-based SA systems [17, 18, 19] are based on the IoT-less frameworks, where supervised and unsupervised methods are applied for the sentiment classification of online Urdu reviews. Unfortunately, such methods are not fulfilling the philosophy of IOT driven SA systems, where end users can have interactive applications in their smart phones for analyzing and visualizing public sentiments about their products, services and policies in real real time.

This study aims to investigate the viability of IoT for sentiment classification and tone analysis of Urdu tweets acquired from Twitter. For this purpose two research questions are posed: RQ1: Can IoT be used for the sentiment classification of Urdu tweets?, RQ2: Can IoT platform be used for tone analysis of Urdu tweets, and RQ3: What are suitable IoT platforms for the sentiment classification and tone analysis of Urdu tweets?

The contributions of this work is summarized as follows:

- Acquiring Urdu tweets in real time using Twython

- Cleaning Urdu tweets using tweet-preprocessor API
- Sentiment classification of Urdu text using IBM Watson's IOT-based natural language understanding Toolkit
- Tone analysis of Urdu text using IBM Watson's IOT-based tone analyzer toolkit
- Comparing performance of the IoT-based Urdu SA and tone analysis system with the baseline methods.

The rest of the article is organized as follows: Related work is presented in section 2; section 3 presents the proposed methodology; In section 4, we analyze the results obtained, conclude the article, and provide directions for future research.

## 2 Related Work

In this section, we present some related works performed on IoT-based SA systems in English language and furthermore, works performed on Urdu SA are also summarized and finally, we highlight the need and literature gap for the development of IoT-based Urdu SA and tone analysis system.

Sarma et al. [12] proposed an integration of IoT devices with Twitter for analyzing emotions by connecting Arduino (an IoT device) with Twitter. The second component is an application, based on Twitter APIs to visualize Twitter data (fruit mentions) like apple, pineapple and others.

Schroete et al. [20] applied social graph analysis for analyzing the mood of a driver through mood analysis with respect to a particular location for maximizing safety and joy. They used data collected from Facebook, Twitter and Google+.

In their work on social media enabled smart city application, Vakali et al. [16] proposed the integration of IoT-based platforms with social media sites like Facebook, Twitter and Flickr for exchanging information among online community by focusing on content analysis and pattern analysis.

Biondi et al. [4] proposed an emotion recognition system based on IBM Watson cloud platform for Italian language. A prototypical system is developed using Bluemix Alchemy API and some basic results are presented.

Twitter SA is becoming popular in the online communities especially, in business intelligence, election campaigns and decision making. Users post short text containing sentiments, emotions and feelings, which need efficient classification algorithms for harvesting useful information. Alzahrani [5] proposed an IoT-based opinion mining system by Twitter streams with Raspberry Pi microcontroller kit. Machine learning algorithm, namely Naïve Bayes is used for the sentiment classification of user's tweets trained on a benchmark dataset. An accuracy

of 92% is achieved and the results are visualized on a bidirectional smart mirror [5].

### 2.1 Urdu SA Systems

Mukhtar and Khan [21] acquired Urdu blogs from different websites and applied machine learning classifiers for the sentiment classification. The applied classifiers include Naïve Bayes (NB), Support Vector Machine (SVM), Decision Tree (DT—J48) and K Nearest Neighbor (KNN—IBK). The results showed that IBK performs better than the other classifiers. However, large datasets and concept level SA may improve the system's performance.

In their work on Roman Urdu sentiment classification, Bilal et al. [22] applied different ML classifiers like NB, DT and KNN and achieved promising results. It is reported that NB performed better than the other classifiers. However, major limitation of such classifiers is that such techniques require large datasets for improved performance.

A lexicon-based SA system is proposed by [18] for the SA of Urdu reviews. Different lexical resources, such as lexicons and bilingual dictionaries are used in the SA process. An average accuracy of 66% is achieved, however, there is a lack of proper efficient sentiment scoring technique and the system is dependent on different manually created lexical repositories.

A bi-lingual SA scheme is proposed by Dauad et al. [23] for analyzing sentiments in English and Roman Urdu. The sentiment classification of English to Roman Urdu tweets is accomplished by employing a bilingual classifier, supported by WordNet [24], SentiStrength [25] and a list of English words with Roman Urdu translation. The major limitation of this scheme, however, is the lack of handling pure text.

The major objective of the paper is detection and classification of emotions in Roman Urdu Text [26]. The authors make use of knowledge-based approach for this problem and developing emotion ontology is built. The machine learning-based approach proposed by [27], is implemented and tested by using a set of Urdu reviews. The experimental results show the improved accuracy of 80.5% and 81.09%. In another work, Asghar et al. [28] proposed an Urdu sentiment lexicon by assigning sentiment scores to Urdu opinion words and polarity shifters.

The aforementioned studies on Urdu SA are based on lexicon-based and supervised learning techniques and to the best of our knowledge no work is carried out on IoT-based SA system development in Urdu language. Furthermore, there is a need to analyze tone/emotion of the user in Urdu tweets. This research gap can be bridged by proposing an IoT-based Urdu SA and tone analysis system.

### 3. Material and Methods

#### 3.1 IoT platforms and Tools

The following IoT platforms are used in this work for the sentiment classification and tone analysis of Urdu tweets.

##### 3.1.1 IBM Watson Cloud

The IBM Watson platform is comprised of the following tools:

- (i) **IBM Bluemix:** is a cloud computing service offering services like storage, computing power, network tools, infrastructure and software for runtime application development [4]
- (ii) **Watson Developer Cloud:** It assists in building cognitive applications and provides an entry point for programmers to the Watson API and provide a foundation for sentiment and emotion analysis [4].
- (iii) The natural language analyzer is IBM Watson's API designed for analyzing natural language text and to report sentiments expressed by the writer in the form +ive, -ive and neutral/objective classes along with the sentiment scores [29].

- (iv) The Tone Analyzer bundled with IBM Watson Platform is used to detect emotions and tones from written text at both the sentence and document levels. Business organizations can use this feature to monitor the tones of their customers and to satisfy their needs accordingly [30].

##### 3.1.2 Python Libraries

Python provides a powerful bunch of libraries for Twitter SA. We used Twython API (<https://twython.readthedocs.io/en/latest/>) for real time streaming of Urdu tweets and tweet-preprocessor API (<https://pypi.org/project/tweet-preprocessor/>) for removing special characters from tweets.

#### 3.2 IoT-based Framework for SA in Urdu Tweets

The proposed IOT-based SA system (Fig. 1) has four modules: (i) Urdu-based Twitter dataset, (ii) tweet cleaning, (iii) sentiment classification, and (iv) Tone Analysis. Details of each component is given in the subsequent subsections.

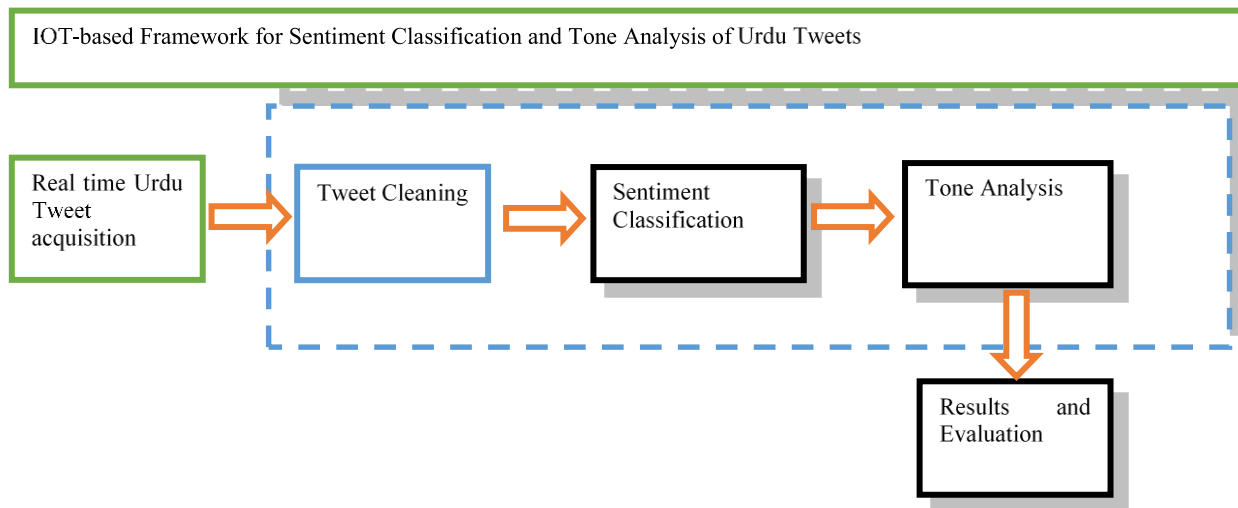


Fig. 3.1 IOT-based Sentiment Classification Framework of Urdu Tweets

##### 3.2.1 IoT-based Urdu Tweet Acquisition:

We used Twython (<https://twython.readthedocs.io/en/latest/>) by sending and responding to the tweets by looking for the hashtags. Firstly, registration is performed to access the Twitter API by receiving different authentication keys. Using registered keys, we created Twython object for transmitting messages.

The proposed IOT-based tweet acquisition module keeps track of hashtags by scanning the Twitter stream and crawling the desired tweets for subsequent processing. In this study, we analyzed different national and international trends on Twitter by examining leading hashtags. In this way, we acquired 10,126 tweets appeared in different hashtags, such as tourism, health, career, politics and sports, detail is shown in Table 1.

Table 1: Dataset Description

Total number of tweets	Total number of words	Average number of words in a Tweet	average number of characters per tweet
10,126	111386	11	176

### 3.2.2 Tweet Cleaning

To remove noise from acquired tweets, we applied an elegant python tweet preprocessing library (<https://pypi.org/project/tweet-preprocessor/>). It assists in cleaning, tokenization, and parsing. The basic cleaning involves removal of hashtags, URLs, mentions, reserve words, emojis and smilies. Table 2 shows set of tweets before and after cleaning.

Table 2: Urdu Tweet Cleaning

Tweet#	Before Cleaning	After Cleaning
1	@politics اپوزیشن پارٹیوں کی اکثریت نے انتخابی نتائج کے بارے میں خدشات کا اظہار کیا ہے #KPK updates	اپوزیشن پارٹیوں کی اکثریت نے انتخابی نتائج کے بارے میں خدشات کا اظہار کیا ہے
2	مجھے بھائی نے #ہاک سپورٹس انڈسٹریس کی کٹ سالگرہ پر تحفہ میں دی۔شکریہ #بھیا	مجھے بھائی نے ہاک سپورٹس انڈسٹریس کی کٹ سالگرہ پر تحفہ میں دی۔شکریہ بھیا
3	اسے اپنے مستقبل @career کی فکر کھائے جا رہی #master trainer ہے۔	اسے اپنے مستقبل کی فکر کھائے جا رہی ہے۔
4	@weather موسلا دھار بارش نے چاول کی ساری #Dikhan فصل تباہ کر دی	موسلا دھار بارش نے چاول کی ساری فصل تباہ کر دی
5	مجھے @kalaam tour جنگلی بلیوں سے بہت #guide خوف آتا ہے	مجھے جنگلی بلیوں سے بہت خوف آتا ہے

### 3.2.3 IoT-based Bilingual Translation

To receive equivalent English translation of the Urdu tweets, we used Python-based Google Translate API (<https://pypi.org/project/goslate/>) for bilingual translation. For example, an input Urdu tweet “اپوزیشن پارٹیوں کی اکثریت نے انتخابی نتائج کے بارے میں خدشات کا اظہار کیا ہے”, is translated to equivalent English text as follows: “Majority of the

opposition parties have expressed concerns about the election results”. Table 3 shows a sample list of tweets in Urdu equivalent Roman transliteration, and the translated text in English.

Table 3: Urdu Tweets with their English Translation and Roman Transliteration

Tweet#	Urdu Text	English Text	Roman Transliteration
1	اپوزیشن پارٹیوں کی اکثریت نے انتخابی نتائج کے بارے میں خدشات کا اظہار کیا ہے	Majority of the opposition parties have expressed concerns about the election results	Opposition partiu ki aksariat ne intekhabi nataaaj ke baary me khadshat ka izhar kia ha
2	اسے اپنے مستقبل کی فکر کھائے جا رہی ہے۔	She is getting worried about her future.	Usay apnay mustakbil ki fikar khay ja rahi ha
3	موسلا دھار بارش نے چاول کی ساری فصل تباہ کر دی۔	The heavy rain destroyed all the rice crops.	Muladhar barish ny chawal ki fasl tabah kr di
4	مجھے جنگلی بلیوں سے بہت خوف آتا ہے	I am very scared of wild cats	Mujhy jangli bilyun se boht khof ata ha

### 3.2.4 IoT-based Sentiment Classification

The sentiment classification module deals with the assignment of polarity score and class to each tweet. For this purpose, the IBM Watson’s IOT-based natural language understanding system is used, which returns the corresponding polarity in the form of polarity triplet: {mixed, weight, pol}. The first parameter “mixed” shows whether sentiment is polar or non-polar, i.e. 1 means sentiment is polar and 0 means sentiment is non-polar. The second argument represents “weight” in the range [-1; 1] and the third parameter is “pol”, showing the polarity, i.e. +ive, -ive or neutral [4].

To analyze the sentiment of the input text, a tweet in English language (Table 3) is analyzed by the IBM Watson’s IOT-based natural language understanding API [27], , which returns “negative sentiment” with a score of -0.36. After receiving the sentiment score, it is assigned to corresponding Urdu Tweet. This adhoc translation strategy

is used due the fact that currently, the IBM Watson API [4] is not equipped with the bilingual translation for Urdu , therefore, to receive equivalent Urdu translation, we used Python-based Google Translate API2 (see section 3.2.3). After obtaining the Urdu tweet (Table 3), the sentiment score (-0.36) of the original English text is assigned to the equivalent Urdu text. Table 4 shows a sample list of English tweets along with their Urdu translation and sentiment scores.

Table 4: Sentiment Class and Score Assignment to Urdu Tweets

Tweet#	Urdu Tweet (obtained from Table 3)	English Tweet (obtained from Table3)	Sentence-level Sentiment Score
1	اپوزیشن پارٹیوں کی اکثریت نے انتخابی نتائج کے بارے میں خدشات کا اظہار کیا ہے	Majority of the opposition parties have expressed concerns about the election results	-0.36 (negative)
2	مجھے بھائی نے ہاک سپورٹس انڈسٹریس کی کٹ سالگرہ پر تحفہ میں دی۔شکر یہ بھیا	My brother has gifted me Pak Sports Industries kit at my birthday. Thank you Brother	0.76 (positive)
3	اسے اپنے مستقبل کی فکر کھائے جا رہی ہے۔	She is getting worried about her future.	-0.54(negative)
4	موسلا دھار بارش نے چاول کی ساری فصل تباہ کر دی۔	The heavy rain destroyed all the rice crops.	-0.35(negative)
5	مجھے جنگلی بلیوں سے بہت خوف آتا ہے	I am very scared of wild cats	-0.80(negative)

### 3.2.5 Tone Classification using IoT

The tone analysis module of the proposed IOT-based SA system analyzes tweets and collects an overall tone of the text. The tone analyzer API [28] performs semantic analysis on the given tweet and detects following tones: anger, sadness, fear, joy, confident, analytical and tentative. For example, the detected tone for the input tweet “Majority of the opposition parties have expressed concerns about the election results”, is “analytical”. In subsequent step, the detected tone in English is translated into Urdu, i.e. “تجزیاتی” using python-based Google translate API (<https://pypi.org/project/goslate/>).

Table 5 shows a sample list of Urdu tweets and the respective tones detected by our IOT-based SA system.

Table 5: IOT-based Tone classification

Tweet #	Urdu Tweet	English Tweet	Detected Tone(English)	Detected Tone(Urdu)
1	اپوزیشن پارٹیوں کی اکثریت نے انتخابی نتائج کے بارے میں خدشات کا اظہار کیا ہے	Majority of the opposition parties have expressed concerns about the election results	analytical	تجزیاتی
2	مجھے بھائی نے ہاک سپورٹس انڈسٹریس کی کٹ سالگرہ پر تحفہ میں دی۔شکر یہ بھیا	My brother has gifted me Pak Sports Industries kit at my birthday. Thank you Brother	joy	خوشی
3	اسے اپنے مستقبل کی فکر کھائے جا رہی ہے۔	She is getting worried about	fear	خوف

	کی فکر کھائے جا رہی ہے۔	her future.		
4	موسلا دھ ار بارش نے چاول کی ساری فصل تباہ کر دی۔	The heavy rain destroyed all the rice crops.	sadness	غمگینی
5	مجھے جنگلی بلیوں سے بہت خوف آتا ہے	I am very scared of wild cats	fear	خوف

#### 4. Results and Discussion

##### 4.1 Answer to RQ1:

“Can IoT be used for the sentiment classification of Urdu tweets?”

To answer RQ1, we reviewed the relevant literature and after conducting experiments, we come up with the conclusion that IBM Watson’s IOT-based natural language understanding API [29] can be used for the sentiment classification of English tweets supported by an adhoc bilingual translation strategy (see section “IoT-based Bilingual Translation”) for classifying Urdu tweets. The results obtained are satisfactory, when compared with the baseline methods of Urdu sentiment classification. Therefore, we can say that IoT-based solution provided by IBM Watson’s natural language understanding API yielded improved results with respect to baseline method (Table 6).

Table 6: Comparative Results for Sentence level sentiment classification

Study	Technique	sentiment Class	Precision	Recall	F-measure
Rehman and Bajwa [18]	Lexicon-based Urdu SA	positive negative	83% 76	75 79	78 77
Mukhtar and Khan [21]	Urdu SA using Supervi	For both +ive and -ive	63%	68%	67%

	sed learning				
Proposed (this work)	Urdu SA using IoT-based	Positive	92%	83%	87%
		Negative	95%	87%	90%

##### 4.2 Answer to RQ2:

“Can IoT be used for the Tone Analysis of Urdu tweets efficiently?”

To answer RQ2, we performed Tone analysis or emotion recognition by using an integrated component of IBM Watson platform, namely: tone analyzer API [30], which performs tone/emotion analysis on given tweets with respect to different tones (see section 3.2.4). The results shown in Table 7 depict that the proposed IoT-based tone analysis system for Urdu tweets performs better than the comparing methods.

Table 7: Comparative Results of Proposed Tone Analysis System with Supervised ML Techniques

Classifier Name	Technique	Accuracy (%)	Precision (%)	Recall (%)	F1 measure (%)
Support Vector Classifier (SVC)	Supervised	0.80	0.82	0.81	0.81
Random Forest (RF)	Supervised	0.76	0.76	0.76	0.76
Naïve Bayesian (NB)	Supervised	0.74	0.74	0.74	0.73
K-nearest Neighbor (KNN)	Supervised	0.73	0.72	0.72	0.70
Urdu tone analysis system(Proposed)	IoT-based	0.92	0.88	0.86	0.90

##### 4.3 Answer to RQ3:

What are suitable IoT platforms for the sentiment classification and tone analysis of Urdu tweets?

To answer RQ3, we found that IoT-based platform like IBM Watson Cloud can be successfully utilized for sentiment classification and tone analysis of Urdu Tweets with some stop gap arrangement, i.e. an bilingual translation module for translating Urdu tweets to English and then sending it to IBM Watson cloud for further

analysis. Additionally, the real time Urdu tweet acquisition module based on python driven Twython API can be enriched with IoT-based Raspberry Pi platform.

## Conclusion and Future Work

This work presents IoT-based sentiment classification and tone analysis system in Urdu Language for classifying and recognizing sentiment and emotions in Urdu tweets posted on social media website. We applied different Python-based APIs for tweet crawling in real time and tweet cleaning. An IoT-based platform from IBM Watson is used for sentiment classification and tone analysis. The system outperformed comparing methods with respect to classifying and detecting sentiments and emotions (tone) in Urdu language. Results show that the proposed IoT-based method gives promising results.

The system, however, has few limitations like the dependency on bilingual translation of English to Urdu due to the lack of provision on the IBM Watson toolkit. Future research can use the proposed system in this work with the inclusion of emojis and slang terms, and we predict that such inclusive approach may enhance the overall performance of the system. Furthermore, the investigation of other IoT platforms like Raspberry Pi could be fruitful for future research endeavors.

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