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Election Prediction Based on Sentiment Analysis using Twitter Data

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ABSTRACT

Election prediction has always been of interest to many people. In the last decade, an increasing influence of social networks and the possibility of sharing opinions and ideas has rendered election prediction based on social network data analysis. This paper, drawing on Twitter data and sentiment analysis, uses the proportion of positive messages rate to negative messages rate as an effective indicator for predicting elections. Then, using the aging estimation method, it predicts the values of this indicator in future time windows. The experiments conducted on Twitter data related to the 2020 United States presidential election in a four-month time window indicate that the indicator values and eventually the election results can be predicted with high accuracy.

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1. INTRODUCTION

With the advent of virtual social networks, communication between people and sharing of opinions and significant social events are easier than ever. Hence, social networks are currently considered an important source of public opinions. Election, as an important social event, attracts a great deal of attention in societies as well as in social media. The prediction of elections is particularly important from such perspectives as planning future political and economic programs, investigating its impacts on economic development and preventing some social crises. Traditionally, people made predictions by conducting surveys through phone calls or distributing questionnaires. Several models for making survey-based predictions were provided in literature [1]. Such surveys, apart from their considerable cost, lack of sufficient accuracy because they usually do not target the right population, and some respondents do not approach them appropriately. Salunke et al. [2] cited several survey-based predictions which did not turn out to be true. But, social media, which are easily accessible, constitute a valuable source of survey data [3]. Twitter, as the biggest source of news [4], with over 250 million active users per month, provides a user friendly environment for expressing opinions and sharing viewpoints in the form of short messages. Making predictions based on Twitter data analysis has attracted considerable attention in recent years. The prediction of stock prices [5], sports competition results [6], spread of diseases [7], and election results [4] are instances of such predictions.

Using Twitter data analysis, this paper introduces a new method for predicting the 2020 United States (US) presidential election result based on sentiments analysis. In the proposed method, the proportion of positive messages rate to negative messages rate at a specific time interval is defined as an effective indicator for predicting elections. Next, the election result is predicted by predicting the indicator values at future time intervals. The next indicator values are predicted by calculating the exponential average or by the aging estimation method. The aging estimation method is a dynamic method of estimating the process execution time. In some process scheduling methods using the operating system such as the Shortest Process First, the process execution times should be estimated to choose the shortest one possible [8].

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Although sentiment analysis has previously been used for predicting election results, the innovation and features of the proposed method include the simplicity of its implementation using only the rate of sending tweets, the introduction of a new and effective indicator in predicting election, the possibility of making predictions at favorite time intervals prior to the election, and considering the impact of electoral events such as debates and speeches on the outcome of prediction using a coefficient.

The remaining sections of this paper have been organized as follows. In section 2, related studies on the prediction of elections are reviewed. In section 3, the proposed method is explained, and in section 4, the experiments, results and evaluation of the proposed method are discussed.

2. RELATED STUDIES

For the first time in use of social media for election prediction, the 2009 German election results were predicted through Twitter data analysis [9]. The authors made predictions on the basis of the number of tweets related to each political party. As it will be shown in this paper, comparing the number of tweets sent by the supporters of one party with those sent by the supporters of another party cannot be a suitable criterion for predicting election results, because the supporters of a particular candidate are likely to be more active in social networks.

Consideration of the sentiments in people's tweets contributes to the accuracy of election predictions [10]. Burnap et al. [11] proposed a model for predicting the results of the 2015 British election based on sentiment analysis. On the basis of the sentiment analysis method [12], they assigned a score between -5 and +5 to each tweet as indexes of strongly negative to strongly positive sentiments, and made predictions about the number of seats to be held by the members of each party in the Parliament based on the total sentiment scores of that party. Nugroho [13] predicted the US election results on the basis of lexicon-based sentiment analysis. First, based on the geographical information of each tweet, they identified the state from which the tweet had been sent. Next, they counted the positive and negative sentimental tweets for both parties in each state and announced the party with more tweets as the winner in that state. Finally, they predicted the eventual winner based on the total counts in all the states. Of course, the data that they collected from Twitter was limited to the last week remaining to the election.

Xia et al. [14] collected a dataset of 260000 tweets related to the 2020 US presidential election and classified them into positive, negative, and neutral sentimental tweets using a multilayer neural network. Examining the number of positive and negative tweets, they predicted that the election results would be very close. In addition, they showed that analysing sentiments using social media data is a low-cost and accurate method to gain general feedback on candidates and predict election results.

A multi-factor method for prediction the 2020 US presidential election was introduced by Sabuncu et al. [15]. They used various factors such as number of positive and negative tweets, number of people, number of likes, and retweets simultaneously on a dataset of 11 million tweets. Other studies reported in literature [16-18] have predicted elections based on sentiment analysis.

Liu et al. [19] proposed a combined model for predicting elections. They combined the sentiment analysis method with the traditional models of political sciences and predicted election results locally in Georgia. The *traditional models of political sciences* is meant to refer to such issues as the rate of economic development or decrease in the rate of unemployment which take place in the current government or are proposed as election promises by candidates.

3. THE PROPOSED METHOD

The prediction of elections only based on the number of tweets sent by the supporters of one party, irrespective of other factors especially the hidden sentiments in tweets, will not be accurate [10]. Therefore, other criteria, especially the hidden sentiments in each tweet, have been taken into consideration in different studies. The positive sentiments in the tweets associated with a particular party are considered an advantage for that party, while the tweets containing negative sentiments are considered a weakness. The methods which extract sentiments from a tweet are often based on a dictionary. In such dictionaries, each word is experientially assigned a score relative to its sentimental load. Then, the sentimental score of a sentence or tweet is calculated based on the words which comprise it. Hence, each sentence can contain positive, negative or neutral sentiments. This paper excludes the tweets with neutral sentiments.

The index or indicator which has been used in the proposed method as the determining factor in predicting elections is the proportion of positive tweets rate to negative tweets rate in a fixed time window i:

$$A_i = \frac{(Positive\ Tweets\ Rate)_i}{(Negetive\ Tweets\ Rate)_i + 1} = \frac{(Positive\ Tweets\ Count)_i}{(NegetiveTweets\ Count)_i + 1} \quad (1)$$

The prediction indicator (A_i) in Equation (1) is obtained from the proportion of positive tweets rate to negative tweets rate in the time window i. As the rate of sending tweets is calculated in a fixed time window, this equation is equal to the proportion of positive tweets number to negative tweets number. As the number of

negative tweets in a time window might be equal to zero, number 1 has been put in the denominator. The comparison of the values of this indicator for the candidates in each time window indicates their chances of success. Therefore, the length of the time window is decided based on how long before the election we are going to make a prediction. In other words, to predict the result of an election d days earlier, the length of the time window will be equal to d. In the proposed method, to predict the indicator value in the next time window, the aging estimation method is used. The aging estimation method functions on the basis of an exponential averaging of previous observations:

$$A_{i+1} = \alpha O_i + (1-\alpha)A_i \quad (2)$$

In Equation (2), the indicator prediction value A_{i+1} is for the next time window $(i+1)$. O_i is the real, observed value of the indicator in the current time window and A_i is its predicted value at stage i. α is a parameter between zero and one which predicts the relative weight of the prediction history and the weight of the recent observation value. The closer the value of α to one, the greater the effect of recent observations on the calculation of exponential average; and the closer its value to zero, the greater the effect of previous observations on the calculation of average (Equation (3)).

$$A_{i+1} = \alpha O_i + (1-\alpha)\alpha O_{i-1} + \cdots + (1-\alpha)^{i+1} A_0 \quad (3)$$

As α and (1 –α) are both smaller than one, the next sentences in Equation (3) will gradually become smaller. The value of α as a function of its position in Equation (3) is shown in Figure 1. For α = 0.8, the weight is almost totally assigned to the four recent observations. In other words, the four recently observed values of the indicator will have the greatest effect on the prediction of its next value, while for α = 0.5, averaging is distributed on almost the last eight observations.

The advantage of using a close-to-one value for α is that the quick changes in observations are reflected in the average value faster and the accuracy of prediction increases considerably. Therefore, in the months remaining to election, especially the month leading to the election, when election debates and candidates' final propaganda increase, closer-to-one α values will be more effective in making predictions.

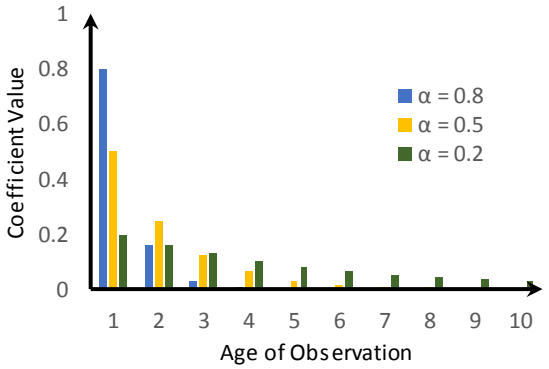

Figure 1. The Effect of Alpha Coefficient on Recent Observation Values

4. RESULTS AND EVALUATION

In this section, two Twitter datasets related to the 2020 US presidential election are evaluated in order to examine the ability of the proposed method to predict the election results. First, the accuracy of the proposed method is checked by performing various experiments on a dataset and then its output is compared with three other methods in the field of election prediction.

4. 1. Accuracy of The Proposed Method The first dataset has been extracted from literature [20]. It includes about 24 million tweets related to the 2020 US presidential election collected within the time interval between July 1st and November 12th. Each tweet has been assigned to one of democratic and republican parties based on the keywords used such as "The Democrats", "Joe Biden", "real Donald trump", or "Keep America Great".

Of course, as some tweets contain keywords associated with both parties, they are labeled *both*, but they are not used in the proposed method. Using the sentiment analysis method VADER (Valence Aware Dictionary and sEntiment Reasoner) [21], each tweet is assigned a score within the [–1 +1] interval. The values +1 and –1 indicate strongly positive sentiments and strongly negative sentiments, respectively. VADER is a tool for analyzing sentiments based on rules and a dictionary. In fact, it calculates the strength of hidden sentiments in a tweet by combining the syntactic rules of a language with a set of terminologies which have gradually been assigned their sentimental weight.

Figure 2 displays the changes in the number of tweets sent by both parties in a one-day time window. Considering the final 2020 US presidential election result, this figure shows that the number of tweets sent by the supporters of a particular party cannot be a reliable index for predicting elections.

Figure 3 shows the number of tweets sent with positive sentimental loads for the two parties in a one-day interval. If the number of positive tweets is normalized, the obtained result will be interesting in terms of its concordance with the eventual result of the election in which the Democratic Party was the eventual winner (Figure 4).

Figure 5 displays the proportion of positive tweets number to negative tweets number for both parties in a one-day time window. In comparison to Figure 4, there

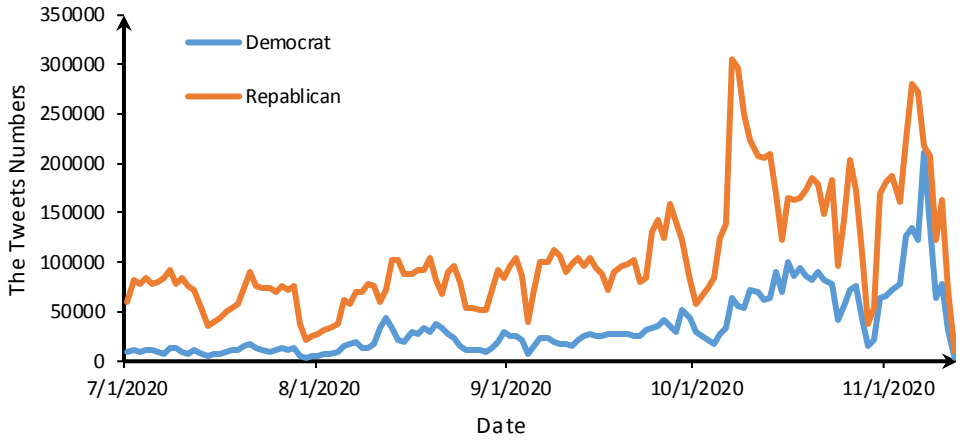

Figure 2. Number of tweets associated with Democratic and Republican parties in a one-day interval

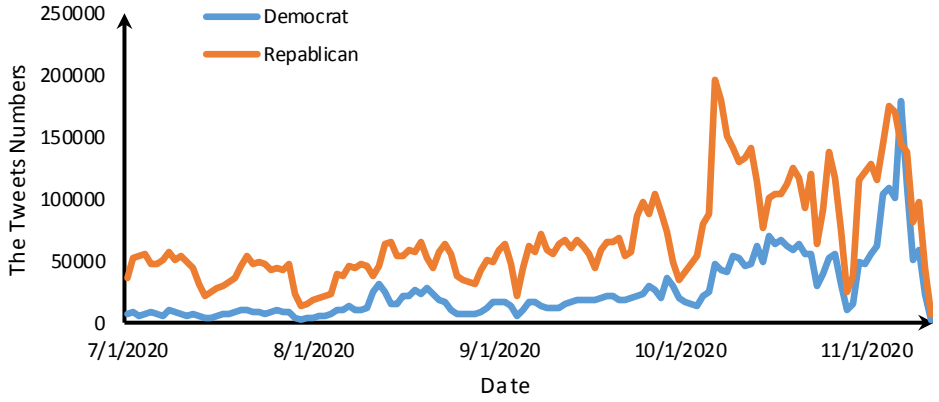

Figure 3. Number of positive tweets for Democrats and Republicans on a daily basis

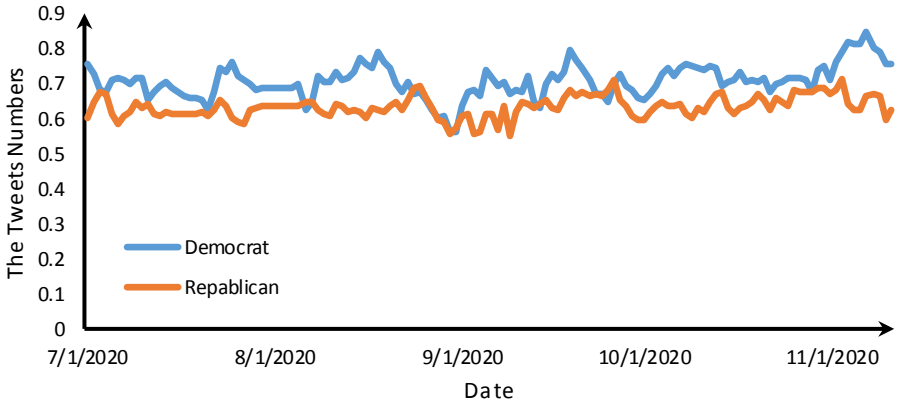

Figure 4. Number of normalized positive tweets for Democrats and Republicans on a daily basis

is a bigger difference between the graphs for the two parties and there are more noticeable peaks and valleys. Each peak and valley in this figure can be associated with a real event. For example, peak 1 occurred after Kamala Harris was nominated as Vice President by Joe Biden. Trump's support for the followers of the right-wing extremism as a controversial and incorrect act led to peak 2. Peak 3 stands for the announcement of Joe Biden's victory by the Associated Press after the election.

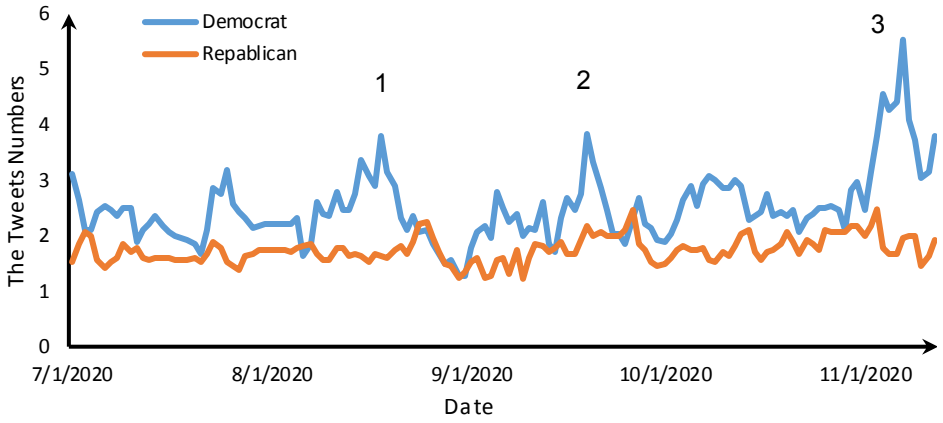

Figure 5. Proportion of positive tweets number to negative tweets number for both parties on a daily basis

In another experiment, the prediction accuracy of the indicator value at different time intervals and the effects of different α values have been studied. Table 1 shows the prediction value of the indicator based on the aging method at different time intervals and the criterion for measuring accuracy. The prediction accuracy of the indicator value for each party is obtained based on Equation (4).

$$Accuracy = 1 - mean\left[\frac{abs(A-O)}{O}\right] \quad (4)$$

In Equation (4), A stands for predicted values and O stands for observed values. The obtained accuracy average is presented in Table 1.

Based on Table 1, for the larger α values in each time window, the prediction accuracy of the indicator value is higher, and vice versa. For instance, as shown in Table1, 14 days remaining to the election, the fact that the Democrats had a larger indicator value than the Republicans was predicted with an average accuracy of 97 percent. In other words, two weeks prior to the election, it was predicted that in the 14 days to come the proportion of positive tweets number to negative tweets number would be higher for the Democrats than for the Republicans, which was considered as strong evidence of the democrats' victory in the election. The third row in Table 1 shows how increasingly assigning values to α affects the indicator. To show this effect, between four months to one week remaining to the election, we have changed α value from 0.2 to 0.9. The accuracy of prediction is higher than when α is defined small and constant.

Figure 6 shows the increasing prediction accuracy of the indicator compared to the days remaining to the election. Hence, the closer it gets to the election, the more accurately the indicator vale is predicted.

Finally in another experiment, the indicator value was calculated only by analyzing the data related to the month leading to the election. The results are displayed in Table 2.

It can be understood from Table 2 that to make accurate predictions based on the data related to the

TABLE 1. The prediction of the indicator at different time intervals in four months

Time window length (day)	□	Democrat indicator	Republican indicator	Accuracy Average
14	0.8	2.47	1.94	0.97
	0.2	2.60	1.85	0.91
7	0.8	2.67	2.06	0.97
	0.2	2.56	1.98	0.93
7	Gradual increase	2.70	1.98	0.96
1	0.8	3.64	2.4	0.98
	0.2	3.29	2.15	0.96

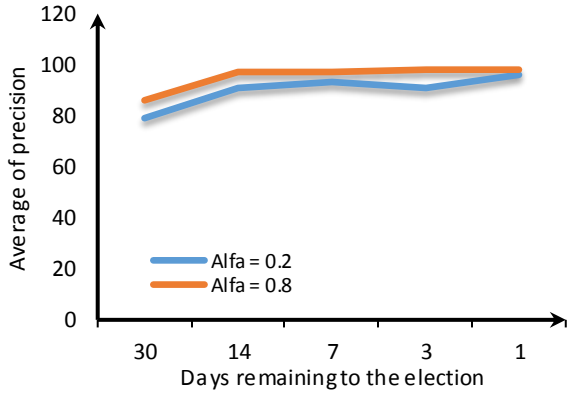

Figure 6. The prediction accuracy of the indicator value on the days remaining to the election

TABLE 2. The prediction of the indicator in different time windows on the month leading to the election.

Time window length (day)	α	Democrat indicator	Republican indicator	Accuracy Average
14	0.8	2.52	1.89	0.94
	0.2	2.59	1.76	0.89
7	0.8	2.67	2.05	0.97
	0.2	2.43	1.80	0.93
1	0.8	3.64	2.40	0.98
	0.2	2.90	2.14	0.91

month leading to the election when election events increase, assigning a larger value to α will be more effective.

According to the experiments conducted and Tables 1 and 2 in which the predicted indicator value for the Democrats was greater than that for the Republicans, Joe Biden's victory in the 2020 US presidential election was predictable.

4. 2. Comparison With Other Methods In this section, the proposed method is compared with the three methods of election prediction. For this experiment, in addition to the dataset reported by Sabuncu [20] described in the previous section, the dataset by Sabuncu et al. [15] has also been used. This dataset includes approximately 11 million tweets related to the 2020 US presidential election, collected from September 1, 2020 to November 2, 2020. The statistical summary of this dataset is given in Table 3.

In the first method, introduced by Singh et al. [22], each party's sentimental score is calculated based on Equation (5). Whichever party gets the higher score is expected to win the election.

$$SS(A) = \frac{pos(A) - pos(A)}{T(A)+T(B)} \quad (5)$$

In Equation (5), *SS(A)* is sentimental score of party *A*, *pos(A)* and *pos(B)* are the total number of positive and negative tweets for party A respectively, and *T(A)* and *T(B)* are the total number of tweets related to parties *A* and B.

In the second method [4], the popularity of each party is calculated based on Equation (6). Whichever party is more popular is expected to win the election.

$$P(A) = \left[\frac{pos(A)}{pos(A)+neg(A)}\right]\left[\frac{T(A)}{T(A)+T(B)}\right] \quad (6)$$

P(A) in Equation (6) is the popularity of party *A*.

The third method is introduced by Wicaksono [23]. In this method, the success rate of each party in the elections is calculated based on Equation (7).

$$SR(A) = \frac{pos(A)+neg(B)}{T(A)+T(B)} \quad (7)$$

SR(A) is the success rate of party *A*.

Table 4 shows the output of the proposed method with three other methods based on the first dataset, for different time periods before the election. As can be seen in Table 4, the proposed method, unlike the other three methods, has been able to accurately predict the outcome in all pre-election time periods. Table 5 shows the output of the proposed method with the other three methods based on the second dataset in the day before the election.

According to Tables 4 and 5, the proposed method in both datasets has succeeded in correctly predicting the elections, while the first and second methods have only succeeded in the second dataset.

5. CONCLUSION AND FURTHER RESEARCH

In this study, a new approach based on sentiment analysis on Twitter data is introduced to predict election

TABLE 3. The statistical summary of the second dataset

	Total Tweet	Positive	Negative	Neutral
Democrats	3851293	1663373	1639495	548424
Republicans	7109941	2831179	3791732	487031
Total	10961234	4494552	5431227	1035455

TABLE 4. Comparison of the proposed method with three other methods based on the first dataset

	Party name	The number of days till the election			
		30	14	7	1
First method [22]	Dem	0.076	0.084	0.091	0.094
	Rep	**0.207**	**0.206**	**0.203**	**0.206**
Second method [4]	Dem	0.135	0.144	0.156	0.161
	Rep	**0.506**	**0.503**	**0.490**	**0.489**
Third method [23]	Dem	0.434	0.438	0.443	0.443
	Rep	**0.565**	**0.561**	**0.556**	**0.556**
Proposed method	Dem	**2.07**	**2.47**	**2.67**	**3.64**
	Rep	1.74	1.94	2.06	2.4

TABLE 5. Comparison of the proposed method with three other methods based on the second dataset

Party name	First method [22]	Second method [4]	Third method [23]	Proposed method
Democrats	**0.002**	0.177	**0.498**	**1.014**
Republicans	- 0.08	**0.277**	0.408	0.747

results. The proposed method was evaluated on twitter data related to the 2020 US presidential election as a case study. In this method, The proportion of positive tweets number to negative tweets number in a time window with fixed length was proposed as an indicator and, using the aging estimation method, the value of this indicator in the next time window was predicted for each party with a high degree of accuracy. Since the indicator value was greater for the Democrats than for the Republicans, the victory of the former was predictable using the proposed method. In the continuous of this study, fuzzy logic can be used for the sentimental score of tweets. In other words, in the proposed method, tweets with a sentimental score +0.1 and +1 are both labled as positive tweets, while applying fuzzy logic can be useful. Furthermore, as the eventual US presidential election result is determined based on Electoral votes and the number of Electoral votes for both parties is determined based on the votes cast in each state, predicting the number of Electoral votes based on analyzing Twitter data locally in each state can yield more accurate and reliable results. Also, this method can be used in other domains such as the prediction of stock prices, although, due to the complexity of the data in this domain, probably several different indicators should be used.

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Persian Abstract

چکیده

پیش‌بینی نتیجه انتخابات همواره مورد توجه بوده است. در دهه اخیر با افزایش ضریب نفوذ شبکه‌های اجتماعی مجازی و امکان اشتراک‌گذاری نظرات و عقاید افراد، پیش‌بینی نتایج انتخابات به کمک تحلیل داده‌ها در شبکه‌های اجتماعی بسیار مورد توجه پژوهشگران قرار گرفته است. در این مقاله، با استفاده از داده‌های توییتر و تحلیل احساسات، نسبت نرخ ارسال پیامهای احساسی مثبت به نرخ ارسال پیامهای احساسی منفی به عنوان یک اندیکاتور موثر جهت پیش‌بینی نتیجه انتخابات استفاده شده است. سپس با استفاده از روش تخمین سالمندی، مقادیر این اندیکاتور در پنجره‌های زمانی آینده پیش‌بینی می‌شود. نتایج آزمایشات بر روی داده‌های توییتر مرتبط با انتخابات ریاست جمهوری آمریکا در سال ۲۰۲۰ در یک بازه زمانی چهار ماه نشان می‌دهد که می‌توان با دقت بسیارخوبی مقدار اندیکاتور و نهایتا نتیجه انتخابات را پیش‌بینی نمود.