

Magnus L. Kirø May 26, 2014

Sentiment analysis of Tweets in correlation with financial investments

Work in progress,
to be completed by 1. jun 2014.
<https://github.com/magnuskiro/master>

Masters Thesis,

Artificial Intelligence Group
Department of Computer and Information Science
Faculty of Information Technology, Mathematics and Electrical Engineering



NTNU – Trondheim
Norwegian University of
Science and Technology

Abstract

English version

Background:

As Twitter has become a global microblogging site, its influence in the stock market has become significant. This makes tweets an interesting medium for gathering sentiment. A sentiment that might influence trends in the stock market.

Motivation:

If twitter can be used to predict trends in the stock market the casual investor would gain an advantage over the day-trader or the modern trading algorithms.

Another interesting aspect is the role of twitter in sentiment analysis. And how twitters role as a data source influences trends in the stock market.

Methods and experiments:

Twitter is used as the data source. It provides easy access, lots of data, and many possibilities to utilise the available metadata.

To improve and verify the sentiment classification and trend comparisons we use a variation of methods. Simple statistical methods, such as counting positive and negative words. More advanced methods such as part of speech and other NLP related magic. We also explore the use of meta data such as location and language tags.

Results:

Rough results of my research.

Conclusion:

All OK ? No?

Abstrakt

Norsk versjon

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Acknowledgements

Many thanks to the people bla bla bla.
TODO Arivd + Pinar TODO add proof readers.

Metadata

Metadata?
github repository for code an thesis.
word count for fun.

Keywords Twitter Finance Trading Social media Sentiment analysis Moving
average NLP Classification Trend detection/analysis

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Chapter 1

Introduction

1.1 What

TODO introduction of stock market prediction. TODO describe sentiment analysis as a new element in stock market prediction. TODO Express Twitter as an actor in sentiment analysis.

TODO rewrite this section. This thesis looks into twitter as a data source for sentiment classification. The sentiment classification of tweets. And the correlation between tweets, sentiment and finance.

How we can create dictionaries from labeled tweets. The sentiment classification of tweets. And trends in association with twitter and finance.

We will try to unveil connections between tweets and sentiment. And expand on the use of tweets in trends and finance.

1.2 Motivation and the Why

We have an interest to find out how sentiment can be extracted from twitter and how it effects finance trends. Further we are motivated by the social media aspect of trends and how that effects finance.

Why is this work done? Why do we benefit from this? Why do I want to do this? We believe that microblogging and social media plays a role in todays trends and we would like to explore that. Twitter as a social media platform is a huge place for companies to post updates and provide customer support, so it is a natural place to gather data for analysis.

If everything works out and we strike gold, we would hopefully find relations between twitter content and financial trends. And use that to prove increase revenue in trade. Our work is relevant for further endeavors about twitter, sentiment and it's relation to finance.

1.3 Research questions

TODO specify a bit better.

1.3.1 How do we determine the sentiment of a tweet?

Can we extract knowledge from tweets to find a sentiment?

We will look at the usefulness of tweets as a way to extract sentiment.

Which parts of a tweet is useful for the classification of a tweets sentiment?

Which methods are best to classify tweets?

How do we best find the sentiment of tweets?

1.3.2 How can twitter be used to aggregate a trend?

Can we build a trend based on information from tweets?

Can Twitter as a microblogging site be used as a data source in aggregation of trends.

Credibility, what sort of credibility level has to be attained to certify the quality of the trend prediction.

Which parts of twitter are most useful to generate a trend?

1.3.3 How does trends on twitter compare to technical analysis in the stock market?

Technical analysis compared with the tweet trend.

We will look at possible applications for the sentiment in the stock market.

Which twitter sources are most suitable for predicting the stock market trend?

In finance, the moving average is a technique in technical analysis. This and other trend defining qualities of financial data is used to compile trends.

Twitter has data such as the amount of tweets posted today, the location where tweets are posted from, and which users has posted. Aggregated, these data become represents a trend.

Previously researchers have managed to predict direction of the market the next few days based on the volume of tweets.

1.4 Methods

TODO describe the methods used in the thesis and their differences. svm, bayes, bag of words, moving average,

1.5 Findings

We explore the usage of lists of words, dictionaries, in sentiment analysis. And we look at data retrieval from twitter and the trend we can create from it. With varying results we get positive results with the dictionaries, while the trend aggregation lacks the finesse and results it should have had.

1.6 Outline

The nine chapters of this thesis all describe different aspects of the work done. First we have this introduction, 1. Naturally we follow with previous work, 2, the state of the art part, where we discuss the newest research in this field. The data retrieval is next in chapter 3.

Proceeding the data chapter we go for the core of the thesis, the sentiment analysis, 4. The sentiment naturally leads up to the trend in chapter 5. Code, A, comes next to explain how we did things and go deeper in the specifics of implementation. Results and discussion comes in chapter 7. While conclusion, 8, and future work, 9, rounds off the thesis.

Chapter 2

Background and Previous Work

TODO write a summary of the newest techniques and inventions in the field of twitter research related to finance.

TODO read and rewrite this chapter.

Somewhat a starting point for this thesis: <http://www.cs.ucr.edu/~vagelis/publications/wsdm2012-microblog-financial.pdf>

TODO writer outline of this chapter.

2.1 Twitter

Twitter is a social informations network. It's a real-time service for sharing and gathering small messages. These messages can represent everything from a persons opinion of ice cream, to the latest changes in the financial market or pictures from a Mars rover.

At the core of Twitter you have the Tweet. The Tweet is the 140 character message. Tweets lets you communicate with other users, share photos and post all kinds of information. The small size of the tweets are not a hindrance for the flow of information. ¹

¹About Twitter: <https://twitter.com/about>

The fast growing messaging service handles 1.6 billion search queries every day. In 2012 the 500 million users would generate 3.2 queries each day. 340 million tweets were posted every day. ²

Most medium and large companies have a presence on Twitter today. Posts can contain any type of information, from promotional content to service status to financial reports. [Jubbega, 2011, p8] says that 77 of the Fortune 100 companies have a twitter account.

Companies use Twitter to communicate with customers. Customers can post questions and feedback, while the company posts answers and information. Questions can be asked with a specific hashtag. Or with an at sign to target a specific user. This makes it easy to filter the messages, and therefore easier to get in contact with the customer. Best Buy demonstrated the successfulness of twitter in customer relations by answering questions with a specific hashtag. In 2009 they had answered nearly 20 thousand questions using twitter. [Li and Li, 2013, p1] Market Intelligence is also a major aspect of the microblogging sphere.

Twitter represents one of the largest and most dynamic datasets of user generated content. Along with Facebook twitter data is in real time. This has major implications for anyone who are interested in sentiment, public opinion or customer interaction. [Speriosu et al., 2011]

A typical tweet contains about 11 words and provides an opinion or state of mind or a piece of information. Tweets can contain hashtags: '#something', user: '@username', or other adaptations of prefixes such as '\$STO' which represents a stock. The different prefixes or tags (\$, #, @) easily distinguishes the content of the tweet. This also makes it easier to search and classify the content of tweets. Figure:2.1 and figure:2.2 are examples of tweets as shown on twitter.

The retrieval of tweets seems like a challenge. But Twitter has made this easy by providing an API ³. With the API you can write tweets and update the status of a user. But the best part of the API is that it provides search capabilities. To get a certain subset of all tweets, we can use the search function and view only the tweets we want.

On the front page of twitter we have the search function at the top right of the page. The search provides the ability to specify which types of tweets you want. And gives you the opportunity to find the information you are looking for.

²Wikipedia: <http://en.wikipedia.org/wiki/Twitter>

³API: Application programming interface



Figure 2.1: Typical tweet from Twitter.



Figure 2.2: Typical tweet from Twitter.

2.2 Sentiment

Opinion mining on the web is not new. In recent years it has become attractive to traders. The use of Twitter and social media is increasing in increasing. Both in business and with private users. This means a surplus of raw data with easy access. Companies all over the world has started to use the social networks to their benefit. The use of information from social media has become part of the trend, although there are some drawbacks and shortcomings. Noise and garbage is one of them. Even if you're right 80% of the time, the last 20% can prove devastating. [Stevenson, 2012]

Sentiment broadly refers to a persons state of mind. Based on the opinion the person will do optimistic or pessimistic choices. A positive mindset leads to optimistic judgements of future events, and a negative state of mind leads to pessimistic choices. [Doukas et al., January 10, 2010, p4]

The users may have different roles and intentions in different communities in the microblogging sphere, [Java et al., 2007]. A users intentions and its reasons for participation might be a factor in the sentiment analysis.

2.2.1 What is Sentiment Analysis

There are two main categories of approaches to sentiment analysis. The first is to use a classifier. The classifier can use methods such as naive Bayes, maximum

entropy or support vector model [Li and Li, 2013] This is typically a method where it would be natural to use machine learning of evolutionary algorithms to increase the classification correctness over time. The other is to use linguistic resources, such as corpora of negative and positive words. The developed linguistic resources are used to classify the sentiment of the text [Li and Li, 2013].

Li and Li has created a framework for sentiment analysis. The system consists of four main steps and is tested with experiments on twitter. First they do topic detection, identifying and extracting the topics mentioned in the tweet. Secondly opinions are classified. The polarity of the opinion is decided and the users impression is captured. Third. Credibility is assessed. This creates a better summarization of the expresser's credibility. Fourth, step one, two, and three is aggregated to reflect the true opinion and point of view. Combining the first three steps in the fourth results in a truer reflection of the expresser's opinion. [Li and Li, 2013]

One way of classifying tweets is to use predefined lexicon of positive and negative words. Consumer confidence and fluctuations of voting polls can be tracked in this way [Connor et al., 2010].

The work of [Diakopoulos and Shamma, 2010] describes a methodology for better understanding of temporal dynamics of sentiment. The system uses visual representation to achieve this. This is investigated in the reaction to debate video. Further [Diakopoulos and Shamma, 2010] detects sentiment pulse and controversial topics with the help of visualisation and metrics. [Diakopoulos and Shamma, 2010] used crowdsourcing⁴ to classify batches of tweets. This was accomplished with Amazon Mechanical Turk, a crowdsourcing site⁵.

[Barbosa and Feng, 2010] explores the problem of noise in biased and noisy data. They focus on noisy labels and add features to the tweets to increase the classification properties of the tweets. To filter out tweets that don't project a sentiment tweets are classified as subjective or objective. The subjective tweets are classified as positive or negative.

Classification of tweets can be generalised by using features. Features are elements such as unigrams, bigrams, and part-of-speech tags. An abstract representation of a tweet would be beneficiary to the classification. In this abstract representation [Barbosa and Feng, 2010] propose to use characteristics about how tweets are written and meta-information about the words in tweets.

⁴Crowdsourcing is the practice of obtaining needed services, ideas, or content by soliciting contributions from a large group of people, and especially from an online community, rather than from traditional employees or suppliers. <http://en.wikipedia.org/wiki/Crowdsourcing>

⁵Amazon Mechanical Turk (AMT): <https://www.mturk.com/mturk/>

Meta-features and tweet syntax features are further features that can improve classification. Meta-features are information about the tweet, such as location, language, and number of retweets. The tweet syntax features are things such as hashtags, retweet, reply, links, punctuation and emoticons [Barbosa and Feng, 2010].

Another approach to the sentiment challenges with twitter is explored by [Becker et al., 2013]. They explore techniques for contextual polarity disambiguation and message polarity classification. Constrained and supervised learning is used to create models for classification. They describe a system that solves these tasks with the help of polarity lexicons and dependency parsers. Expanded vocabulary is one of the main aspects of their success, as they say in their findings: "We hypothesize this performance is largely due to the expanded vocabulary obtained via unlabeled data and the richer syntactic context captured with dependency path representations." [Becker et al., 2013]

In contrast to [Becker et al., 2013], [Speriosu et al., 2011] has used distant supervision and labeled propagation on a graph based data structure. The data structure represents users with tweets as nodes. And tweets with bigrams, unigrams, hashtags, etc as subnodes of the tweets. A label propagation approach rivals a model supervised with in-domain annotated tweets and outperforms the noisily supervised classifier and a lexicon-based polarity ratio classifier. [Speriosu et al., 2011]

2.2.2 Sentiment analysis in Finance

[Brown and Cliff, 2004, p2] writes the following on over-reaction of investors: "*He(Siegel (1992)) concludes that shifts in investor sentiment are correlated with market returns around the crash. Intuitively, sentiment represents the expectations of market participants relative to a norm: a bullish (bearish) investor expects returns to be above (below) average, whatever "average" may be.*". In the light of recent changes in the financial world and the use of sentiment from social media, the notion that opinions and sentiment of investors and market actors affect the market is not a new observation.

Use of sentiment can potentially predict changes and trends in the market. Bad news in an optimistic period creates cognitive dissonance in the small investors. This impacts the market by slowing down the selling rate of losing stocks. [Doukas et al., January 10, 2010, p29] Further we can see that optimistic sentiment has a 2% monthly average return. While the investor sentiment is pessimistic we see a drastic reduction in returns. Down to 0.34%, [Doukas et al., January 10, 2010, p5]. After optimistic periods it is indicated that the monthly

return is reduced to -0.49%. On the contrary there is no equivalent change after a pessimistic period, [Doukas et al., January 10, 2010, p6-7]. Momentum profits are only significant when the sentiment is optimistic, [Doukas et al., January 10, 2010, p29].

Hope and fear is used by [Zhang et al., 2011] to decide the movement of the market. The sentiment is aggregated to be hopeful or fearful. This basically focuses on positivity and negativity of the sentiment of that particular day. The daily sentiment is then compared to the market indicators of the same day to create a prediction of the market. [Zhang et al., 2011] finds that calm times give little hope or other emotions. Little turmoil results in few fluctuations in the market. And opposite, lots of emotions(hope, worry, fear), gives speed to the market.

[Brown and Cliff, 2004, p3] indicates that the sentiment does not cause subsequent market returns. For a short-term marketing timing this is bad news. However with the changes in social media over the last decade how is the situation today? With the microblogging sphere of today we can easily see the correlation of sentiment and the market indicators, [Jubbega, 2011]. But does the sentiment cause changes in the market-return? [Brown and Cliff, 2004, p3] also says that optimism is associated with overvaluation and subsequent low returns.

[Brown and Cliff, 2004, p] concludes that aggregated sentiment measures has strong co-movement with changes in the market. He also indicates that sentiment doesn't appear to be a good trading strategy. This, in the view of [Zhang et al., 2011], indicates a leap in sentiment research and what is possible with the microblogging of today.

2.3 Finance and Trading

The management of assets or liabilities and the management of funds over a period of time is called Finance. In finance the valuation of assets are time dependant. The same asset is not worth the same now and in a few minutes. Assets are priced based on expected returns and risk level. The three sub categories of finance are: personal, corporate and public.⁶ These categories describes very different parts of the financial world.

Trading is the action of buying or selling financial instruments. Financial instruments can be stocks, bonds, derivatives or commodities⁷. Trades takes

⁶Wikipedia:<http://en.wikipedia.org/wiki/Finance>

⁷Wikipedia:[http://en.wikipedia.org/wiki/Trader_\(finance\)](http://en.wikipedia.org/wiki/Trader_(finance))

place in markets, stock markets, derivatives markets or commodity markets.

TODO write about technical analysis. Technical analysis in finance.

2.4 The Trend

TODO find some articles to reference for trends/trending. And finance. TODO rewrite to get a better description of what a trend is in trading. TODO rewrite

The trend is the general opinion of the masses. As defined by the Free Dictionary: "The direction and momentum of a market, price, economy, or other measure. For example, if the price of a security is going mainly downward with only a few gains, it is said to be on a downward trend. Identifying and predicting trends is important finding the right moment to buy and sell securities. Trends are especially important in technical analysis, which recommends buying at the bottom of a downward trend and selling at the top of an upward trend." ⁸

Trends work in much the same way as opinions. An opinion is uttered then others start to think the same thing or feel the same way. The first group of people that move in the same direction are called trend setters. They are the people that show others how this trend works and what this trend is about.

On twitter we have lots of subcultures that all express themselves on their specific topic. Whether it's technology, art, finance or any other thing. In the sense of twitter we can take a step back and look at the content of messages and from there see if we can find common topics that people talk about, this being the topic of a subculture or a subspace of twitter. To get the trend we have to look at the content of the messages in a subspace. Given that the trend is the collective general collective opinion of the subspace we can look into this and see if we can find certain topics or areas of interest that aggregates to a trend.

When looking for twitter and trends there are few of far between those who work on it. No material or indication is found to suggest that trending on twitter is researched in regards to sentiment analysis of tweets.

⁸Dictionary description of trend: <http://financial-dictionary.thefreedictionary.com/Trend>

Chapter 3

Data, retrieval and structure

We aim to describe the structure, the characteristics, the metadata and usage for the data used.

In this data chapter we have three sections.

The section about twitter and tweets, 3.1, is where we describe how we use tweets, what tweets to use and how we acquire them.

Then we have a section describing the dictionaries, 3.2. How we compile the dictionaries from tweets and how we use them. Their shortcomings and the possible improvements.

And last we have a section that describes the financial data, 3.3, that we use. Where we get them, the structure and how the data is used.

3.1 Tweets

A tweet is a message posted on twitter. The message in many ways resemble the well known SMS¹.

Tweets are posted to the users profile. When a user post an existing tweet again, it is referred to as a retweet.

¹Wikipedia on Short Messaging Service:https://en.wikipedia.org/wiki/Short_Message_Service

All users can follow other users on Twitter. Tweets from users you follow will appear in your stream of tweets on Twitter. The stream is the collection of tweets from users you are following.

3.1.1 Tweet Structure

Structure

There are a lot of metadata in the tweets. In fact most of the data in a tweet object is metadata.

The data we acquire from Twitter is in the JSON data format. JSON or *JavaScript Object Notation* is an open standard format that uses human-readable text to transmit data objects consisting of attribute–value pairs².

For an example of the data structure of a tweet, see appendix E.

Content

TODO fix examples.

A tweet is an astonishing compilation of data about who, where and when a tweet was posted.

As for the content we have the text, the message itself. With the content we have fields for all the links, all the emoticons, and all hashtags that are present in a tweet.

Every tweet is posted by a user. All the data of a user is also present for each tweet. Here we have data on follower count, profile images, friend count, time zone, and many other profile related items.

For the sharing of a single tweet we have data fields such as `favorite_count` and `user_mentions`. We also have `favorited`, `retweet_count`.

In addition we have the location of a given tweet. Where the tweet was posted, the name of the place, the coordinates of the tweet, the country, and the id of this place.

See all the different metadata types in appendix: E.

3.1.2 Twitter API

The twitter API is a convenient way for lots of people to access data from twitter. Tweets, streams, timelines, profiles and more are available through the api.

²Wikipedia on JSON:<https://en.wikipedia.org/wiki/Json>

To provide easy access and conformity to industry standards, the api provides data in the JSON format.

While the api does not give access to 100% of the data from twitter, it gives a good representation of the tweets from the last 7 days.

Setup

To get access to the api there are a few requirements. You must have a twitter account. The application to be used has to be registered with Twitter. Registering the application gives access to API keys. Then you have to use the keys to authenticate with twitter before you access the api.

For a simple guide to this we have <http://datascienceandprogramming.wordpress.com/2013/05/14/twitter-api/> as a good example.

The 4 authentication tokens you get from Twitter, app_key, app_secret, oauth_token, and oauth_token_secret, is used with the Twython library³ as described below.

A simple example of how to use the API with Twython is shown below.

- Authenticate towards twitter.
- Execute search query on twitter.
- Print ID's of all retrieved tweets.

The code of the example is as follows:

```
1 | twitter = Twython(APP_KEY, APP_SECRET, OAUTH_TOKEN, OAUTH_TOKEN_SECRET)
2 | results = twitter.search(q='Search query', count='15')
3 |
4 | for status in results['statuses']:
5 |     print status['id']
```

For more advanced use we have generators, and lots of parameters and api endpoints to use. Endpoints and search parameters will be described under section 3.1.2, *API endpoints options*. The twython framework and its advanced usage can be explored more in the code and in the documentation of the framework⁴.

³<https://pypi.python.org/pypi/twython/>

⁴https://twython.readthedocs.org/en/latest/usage/advanced_usage.html

Restrictions

The api has some access restrictions. Or rather rate limitations. This is to be expected, as unlimited access would cripple the api.

Twitter limits request of a particular kind at 180 requests per 15 minutes. Which means that we can do 180 searches spread evenly over the time interval. Or we could do 180 requests as fast as possible and then wait. The rate limits can be explored thoroughly in the twitter documentation⁵

As for the practical implications of the limitations. They are not a problem in our case. We get more then enough data. By using a generator and pour out tweets we get 1000 tweets in about 60 seconds. But then we have to wait 15 minutes. This is suboptimal. As we will crash the program at access denied from the api.

API endpoints

Twitter has made a lot of different endpoints available. The endpoints are divided into these categories: *Timelines*, *Tweets*, *Search*, *Streaming*, *Direct Messages*, *Friends & Followers*, *Users*, *Suggested Users*, *Favorites*, *Lists*, *Saved Searches*, *Places & Geo*, *Trends*, *Spam Reporting*, *OAuth*, and *Help*.

Of these categories we mainly use *OAuth*, *Help* and *Search*. Listing the endpoints used with parameters we get this list:

Searching

To perform a search we use the parameters described in the *API endpoints* table in section 3.1.2.

Mainly we need a query. The query is a normal search string where twitter will find tweets containing all words in the string.

```
1 | query = "Finance Increase"
```

Further we can expand the search by using logic.

```
1 | query = "Finance OR Investment AND Economy OR Growth"
```

The following query is the one used to create the original tweet sets. The original tweet sets are later used as the basis for the dictionaries. We get all tweets containing one of the words: *Finance*, *Investment*, *Economy*, and *Growth*.

```
1 | query = "Finance OR Investment OR Economy OR Growth"
```

⁵Twitter: <https://dev.twitter.com/docs/rate-limiting/1.1>

Table 3.1: Used Twitter API endpoints table

Category	Parameter	Description
<i>search</i>	-	Used for acquisition of tweets. A query can take the following parameters:
	q	A UTF-8, URL-encoded search query of 1,000 characters maximum, including operators. Queries may additionally be limited by complexity.
	count	The amount of tweets acquired in each request. Standard = 15, max = 100.
	geocode	Get tweets close to these coordinates.
	lang	The language we want tweets in. Very limited by the number of people that speaks that language.
	locale	Language specific. If the query is in Norwegian we get tweets in Norwegian.
	result_type	mixed, recent or popular. This is the general mix of tweets returned in a search. Recent is the newest tweets, while popular are tweets that are retweeted a lot and tweets from users with many followers.
	until	Gets tweets before the given time.
	since_id	We get tweets posted after the given time.
	max_id	We get tweets with ids lower then the one given.
	include_entities	This parameter has no practical application to us.
	callback	An optional place where twitter can post tweets back to us.
<i>authenticate</i>	-	How we login and get access to the api.
	oauth_token	It is the authentication code or password to access the api.
<i>rate_limit_status</i>	-	The way we know if we are still inside the request limitations.
	resources	The elements that we want the status of. Currently that is search and help.

Adding other parameters such as count and language we can further improve our search. To execute such a search we get python code like the following, where 'results' is a data structure containing tweets.

```
1 | query = "Finance OR Investment OR Economy OR Growth"
2 | results = twitter.search(q=query, count='15', language='no')
```

Mining optimization

The acquisition of tweets, or the mining operation went quite well. We got lots of tweets. But we ran into a problem. Retweets. In some cases we got up to 90% retweets in a mining session. Many of the tweets being essentially the same one, only retweeted multiple times.

When we are using tweets to create dictionaries duplicate data was a problem. Retweets are mostly duplicate data, so we removed them to increase the quality of the tweet set.

As nearly all retweets start with 'RT' we can easily sort them out. Then we get a query like this.

```
1 | query = "Finance OR Investment OR Economy OR Growth AND -RT"
```

When using the twython framework and its cursor function we get a continuous stream of tweets. A problem with this is that twython's cursor basically executes multiple searches. Thus yielding the same tweets multiple times, unless you change the search. So we change the search to accommodate this and use the *max_id* parameter.

```
1 | query = "Finance OR Investment OR Economy OR Growth"
2 | results = twitter.cursor(
3 |         twitter.search,
4 |         q=query,
5 |         count="100",
6 |         language=language,
7 |         max_id='the id of the last tweet')
8 |
9 | for result in results:
10 |     print result
```

API Caveats

The main caveats of the twitter API is the request limitations and the limitations of the search engine.

As twitter says themselves: *'Please note that Twitter's search service and, by extension, the Search API is not meant to be an exhaustive source of Tweets. Not all Tweets will be indexed or made available via the search interface.'* and *'The limitations of the search engine of twitter indexes only about a weeks worth of tweets.'*⁶

Although this is not a big problem, coding and data acquisition could have been simpler. The solution for the week limitation was to broaden the search to include more words. This resulted in a more varied dataset, but also more tweets. We initially wanted to analyse tweets related to finance, so the diversity of the dataset could be a problem.

Further caveats of the request limitations. This means that we have to mine tweets over time. We should really have set this up on a server and mined tweets with a cron job every 15 minutes Wikipedia on Cron: <https://en.wikipedia.org/wiki/Cron>.

3.1.3 Tweet sets

We ended up with two datasets to be used. The obama tweetset⁷, which is a set of tweets containing around 1300 tweets about obama and the election of 2008/2009. And a self compile dataset, referenced as the kiro dataset, based on the words: *Finance, Investment, Economy, and Growth*.

TODO connect obama dataset to finance and trading.

Search terms

The kiro dataset is based on only four words. This is a very limited part of twitter and in no way representative for it's full content. Neither does the search terms represent a full range of finance words.

An improvement would use a wide variety of finance words to mine tweets. This would improve the relation to finance and the relevance of the dictionaries afterwards.

Structure

The self compiled datasets has one tweet per line. This is the JSON data object that is automatically imported into python.

The obama tweet set only have the tweet text. We have one tweet per line. And no metadata present.

⁶Twitter: <https://dev.twitter.com/docs/faq#8650>

⁷Neal Caren of University of North Carolina. Tweet file: http://www.unc.edu/~ncaren/haphazard/obama_tweets.txt

Caveats

Obama tweets is not ideal for sentiment analysis. It has too much political content to be easily comprehended. A political statement is not positive or negative. It is positive in the eyes of some and negative in the eyes of others. And there are people that think it is neutral because they do not care. Retweets are also present, so the actual data we get out of the tweet set is limited.

The kiro dataset has a lot of retweets and neutral tweets in it. Therefore we have only used positive and negative tweets later, ignoring all the neutral ones. This gives us more relevant data to work with and less noise. Although we should have used the neutral tweets to improve the dictionaries.

3.1.4 Trend Data

TODO add examples.

TODO why a challenge?? When mining larger sets of tweets, the rate limitations and week limitation is a challenge. The mining in itself is quite easy. Just execute a search and store all the new unique tweets.

To get a broad search we have a list of search terms. The terms are mostly usernames, but also some hashtags and other words. A drawback with the search terms are that they might not resemble the area of research, finance.

The trend tweets are stored in files named with the search term. Each term having its own file with tweets. Before using the trend tweets they are sorted by date.

All the used search terms are stored in the file: '_search-terms'⁸. Most of the search terms are based on an article from 'Teknisk Ukeblad' where they list the twitter handles that are most significant in the oil industry.

TODO describe how Norway's economy as OSEBX is largely based on oil. And why we take this assumption. Since Norway has a lot of oil, the financial market and the trend is greatly dependent on it. And we can see if there are any relations between the compiled trend and the value of the stock exchange.

3.1.5 Problems, Shortcomings, and Possible Improvements

Retweets are a source of concern, they provide no information that is not present in other tweets. But they can provide information about sharing and the importance of a given tweet. Retweets should be investigated more thoroughly in the future.

⁸Search term file: https://github.com/magnuskiro/master/blob/master/code/trend/_search-terms

A shortcoming of the data mining is the search terms. Are the terms representative? Do we get good data or not? Are there other terms that are better suited to get accurate results? A wide array of tests and analysis should be done to improve this factor of the problem.

3.2 Dictionaries

The dictionaries are lists of words used in the classification process. There are sets of dictionaries. In each set there are a list of positive words and a list of negative words.

The dictionaries are self compiled or downloaded. The downloaded dictionaries are very specific in their area. The LoughranMcDonald dictionaries only contain financial terms, while the self compiled dictionaries contains words of all sorts.

The purpose of the dictionaries are to separate groups of words. And further to give a quantitative way to classify positive and negative tweets. We also want to look at the quality of the different dictionaries. And the method for dictionary compilation.

TODO define mono, bi and trigrams. We use the dictionaries to count mono-, bi-, and tri-grams. And we can say something about the quality of the dictionaries and the method for compilation.

The dictionaries are used in both classification methods. The simple word-count(4.2.1) classification and the more advanced classification using SVM(4.2.3) and Naive bayes(4.2.3) classifiers.

3.2.1 Downloaded Dictionaries

The downloaded dictionaries are dictionaries found on the Internet. They are compiled by others, and their quality can be questioned. The most significant feature of the downloaded dictionaries are that they contain words from a certain domain. The obama dictionary contains words linked to politics, while the LoughranMcDonald dictionary only has words from the financial domain.

Obama

The obama dictionary was created for the obama tweet set ⁹ in relation to the us presidential election of 2008.

⁹Neal Caren of University of North Carolina. Tweet file: http://www.unc.edu/~ncaren/haphazard/obama_tweets.txt

Table 3.2: LoughranMcDonald available dictionaries

Negative words	General list of negative words.
Positive words	General list of positive words.
Uncertainty words	Words like <i>may</i> , <i>maybe</i> , and <i>nearly</i> . Words that flag content to have no concrete sentiment.
Litigious words	Law related words, not much use for us.
Modal words strong	Strong descriptive words, such as <i>Always</i> , and <i>Strongly</i>
Modal words weak	Weak words on moods, such as <i>Somewhat</i> , and <i>Depends</i> .

In the positive list ¹⁰ there are 2230 words. Whether or not the frequency of political words are higher than other types of words are uncertain. *wisdom*, *truthful*, *profit*, and *intact* are words found in the positive list. Neither *intact* nor *wisdom* are words that can be described as positive or negative. This gives a clear indication that the dictionary can be improved.

There are 3905 negative words in the list of negative words¹¹. The negative list include words such as *decrease*, *worried* and *tricky*. Duplicate words are also present, so some sort of improvement of this dictionary should be done.

Loughran McDonald

Tim Loughran and Bill McDonald has a set of dictionaries available from the websites of University of Notre Dame ¹².

These dictionaries have a lot of potential. We only use the positive and negative lists of words. The other lists could be used for a better measure of polarity or weighting of bigrams. The best use of this dictionary is for comparison of the different dictionaries.

3.2.2 Compiled Dictionaries

The compiled dictionaries are based on the two manually labeled tweet sets. The kiro tweet set, and the obama tweet set.

¹⁰Neal Caren of University of North Carolina. Positive words: <http://www.unc.edu/~ncaren/haphazard/positive.txt>

¹¹Neal Caren of University of North Carolina. Negative words: <http://www.unc.edu/~ncaren/haphazard/negative.txt>

¹²Bill McDonald, University of Notre Dame: http://www3.nd.edu/~mcdonald/Word_Lists.html

Details about the process of manually classifying tweets can be found in section 4.1.

Dictionary Compilation

The compilation of a dictionary is quite simple.

- 1: We import manually labeled the tweets
- 2: We take all the positive tweets and extract words from them.
- 3: We repeat step 2 with the negative tweets.
- 4: We remove words that are present in both the positive and negative dictionaries. Removal of duplicate words. Resulting in two dictionaries of unique words either positive or negative.

Characteristics For both datasets we compiled mono-, bi-, and trigrams. Giving us 6 sets of compiled dictionaries to test. All dictionaries has the drawback of personal bias. The personality of the person labeling the dataset also effects the dictionaries.

3.2.3 List of dictionaries

Table 3.2.3, listing all the different dictionaries used. For each entry in the table there is a dictionary of negative words and a dictionary of positive words.

3.3 Finance Data

TODO what does the finance data consist of?

The values we use are: *quote_date*, and *close*.

Data acquisition

Obtaining the financial data is easy. Point and click to receive a csv file containing the data we need. [Netfonds.no](http://www.netfonds.no) provides the content we need.

More specifically we get the data for the Oslo Stock exchange¹³.

By creating a little script we get fresh data every time we run the script.

¹³Netfonds data on OSEBX http://www.netfonds.no/quotes/paperhistory.php?paper=OSEBX.OSE&csv_format=csv

Table 3.3: Dictionary table

Name of dictionary	Description
Downloaded:	
Obama original	Monograms, in relation to the obama tweet set.
LoughranMcDonald	Monograms, acquired from Bill McDonald's webpage.
Combined Obama original and LoughranMcDonald	Monogram. A combination of the previous two dictionaries.
Compiled:	
Kiro, Monogram	Compiled from the kiro dataset. Containing monograms.
Kiro, Bigram	Containing terms consisting of two separate words. (<i>an example</i>)
Kiro, Trigram	Containing terms consisting of three separate trigrams. (<i>example of trigram</i>)
Obama, Monogram	Compile from the obama tweet set, mono-grams.
Obama, Bigram	Containing terms consisting of two separate words. (<i>another example</i>)
Obama, Trigram	Containing terms consisting of three separate trigrams. (<i>also an example</i>)

```
1 stock_exchange_history = urllib.urlopen(urli_of_datafile).readlines()
2     for record in stock_exchange_history:
3         # do something with the data
4         print record
```

Structure

The data file contains data back to 1997. Data for one day on each line. Only the days the exchange have been open are present. Fields in the csv file are: *quote_date,paper, exch, open, high, low, close, volume, and value.*

Chapter 4

Sentiment Classification

TODO redo outline. Sections in this chapter are as follows. Manual classifications, 4.1, where we see how people classify tweets. Then we count words with 'Word count classification', 4.2.1. Expanding with the use of classifiers in section 4.2.3. A comparison of the classifiers and associated results can be found in section 4.3. And a brief discussion on comments come last, 4.4.

Sentiment is described as "an attitude toward something; regard; opinion."¹. The sentiment is the perceived positivity of the message that the user tries to communicate. Sentiment is in many cases a personal thing, and can change from person to person or from setting to setting. We think of the sentiment as a conveyed meaning of a message.

Some of the motivation for acquiring the sentiment of a tweet or a sentence, is that we can say something about a persons state of mind and from that predict behaviour. Further the aspect of sentiment in trading is interesting. Can sentiment improve trading in any way? And how can the sentiment be used to predict trends.

In this thesis we have two main ways of classifying tweets. Word counting and training a classifier. Both methods require dictionaries of positive and negative words, 3.2. In the classifier we use the dictionary to extract features from a tweet. And with the word counting we count the number of positive and negative words.

¹Dictionary.com on Sentiment: <http://dictionary.reference.com/browse/sentiment?s=t>

4.1 Manual Classification

When labeling tweets manually there are a number of factors that affect the process. Among them are the quality of the tweet, state of mind, language, and political affiliation.

The quality of the tweet describes the content in many ways. Does the tweet contain links or hashtags? Are users mentioned?

State of mind for a person dictates that person's actions in many cases. This also has an effect on labeling tweets. A positive state of mind classifies more actual negative tweets as positive than others.

Note that all this happens in the brain during 3 to 60 seconds while reading the tweet text and is a very rough description of the thoughts happening. Labeling a tweet follows this algorithm in many ways:

Step	Thought	Description
1	Have we seen this tweet before?	Skip it or use previous classification.
2	#Hashtags or links present?	Some hashtags are automatically positive or negative. Also remove noise such as users and links.
3	Sarcasm?	If sarcasm is present, put up a warning flag saying that it is the opposite of step 4.
4	Special words?	Find a word that triggers positive or negative impression.
5	Done	Label tweet as positive or negative.

Result files

When classifying manually we create files with the results. These files are comma separated files with three fields.

- Sentiment: Positive, neutral or negative. Represented by 1, 0 or -1.
- Tweet id, if it exists, else 'id'. It is a long number.
- The tweet text.

Obama tweet set

When labeling the Obama tweet set we found that there were many retweets of other tweets in the dataset. Whether or not the data is representative for Twitter in general is difficult to say. Tweets favoring Obama are positive for people who support Obama and negative for supporters of Romney at the same

time. This makes the tweet sset difficult to work with because tweets can be positive and negative at the same time, depending on who are reading them.

Kiro tweet set

The kiro tweet set also has a lot of retweets, but they are not used later. Removing the retweet increased the uniqueness of the data, as the same content do not show up multiple times. The search terms the dataset is based on could be broader to increase the diversity of the tweets.

4.2 Classification

4.2.1 Word Count Classification

We describe the classification process and the different parts of it. Then the results and discuss section looks at the drawbacks and results of this method. The algorithm counts the positive and negative words. More positive words than negative means the tweet is positive and vice versa.

Polarity

The polarity of a given tweet is based on the difference in the amount of positive versus negative words.

Polarity is the difference in positive and negative words. The difference is expressed in the percentage of the total amount of words.

We look at the difference between the negative and the positive word percentage. If the difference is positive we have a positive tweet. And if the difference is negative we have a negative tweet.

Drawbacks

There are some drawbacks to the word count classification. The dictionaries and the threshold.

The threshold gives inaccuracy because tweets that have a polarity value that is the same as, or close to, the threshold might be classified wrong.

The quality of the dictionaries affects the word count classification. If the dictionaries had better quality we would get better results. An example of improvements would be to remove stop words before creating bi and monograms.

4.2.2 Threshold in Word Count Classification

Threshold is line where tweets are either positive or negative. It is compared to the polarity value. For a tweet to be classified as positive the ration of positive and negative words has to be above the threshold value.

The percentage of positive words minus the percentage of negative words gives the polarity value, or the positivity(how positive a tweet is) of a tweet. When actually deciding if a tweet is positive or negative we look at the polarity value. If the polarity value is greater than the threshold, the tweet is classified as positive.

The threshold is given to the classifier on initialization. We find out which threshold is best in section 6.3, on page 45.

Examples of classification

Example tweets:

- t1 = “good that he was decreasing badly”
- t2 = “he was good for increase”
- t3 = “good or bad”

Classification of t1:

- $\text{pos} = 1 / 6 = 0.16666$
- $\text{neg} = 2 / 6 = 0.33333$
- $\text{polarity} = \text{pos} - \text{neg} = -0.1667$
- threshold of 0 gives negative classification
- threshold of 0.1 gives negative classification
- threshold of -0.2 gives positive classification

Classification of t2:

- $\text{pos} = 2 / 5 \text{ (to av fem ord)} = 0.4$
- $\text{neg} = 0 / 5 = 0$

- $\text{polarity} = \text{pos} - \text{neg} = 0.4 - 0.0 = 0.4$
- $\text{threshold} = 0.4$ positive
- $\text{threshold} = 0.5$ negative
- $\text{threshold} = -0.1$ positive

Classification of t3:

- $\text{pos} = 1 / 3 = 0.3333$
- $\text{neg} = 1 / 3 = 0.3333$
- $\text{polarity} = \text{pos} - \text{neg} = 0$
- $\text{threshold} = 0$ positive
- $\text{threshold} = 0.1$ negative
- $\text{threshold} = -0.1$ positive

Drawbacks with the Threshold

When classifying with the word count classifier a problem is when we get an equal amount of positive and negative words. Then the polarity value becomes 0. This results in a situation where we have no indication of a tweet being positive or negative. This is an area where we can improve the classification.

The amount of tweets where the threshold and polarity are equal is shown in table on page 32. The number of cases where we get an equal amount of positive and negative words are significantly reduced if the threshold is set to 0.1. We can also see indications that the diversity and quality of the dictionary plays a role in the classification correctness. The more words in the dictionary the more likely it is that we do not get an equal amount of positive and negative words.

4.2.3 With Classifiers

To test and compare to other classification methods we used Naive Bayes and Support Vector Machine classifiers.

Comparing the two classifiers we found that SVM proved to be the better classifier in this case. Although we see quite a span within the SVM results. Details of the results and classifiers are described in section 6.5.

Table 4.1: Word Count results where Threshold value=0 table
 id Dictionary Polarity=0 Tweets

– Kiro compiled dataset –			
1	Monogram, obama	234	997
2	Monogram LoughranMcDonald	543	997
3	Monogram, combined Obama and LoughranMcDonald	178	997
4	Kiro, Monogram, self compiled	53	997
5	Kiro, Bigram, self compiled	7	997
6	Kiro, Trigram, self compiled	28	997
7	Obama, Monogram, self compiled	14	997
8	Obama Bigram, self compiled	446	997
9	Obama Trigram, self compiled	931	997
– Obama tweet set –			
10	Monogram, obama	335	1365
11	Monogram LoughranMcDonald	854	1365
12	Monogram, combined Obama and LoughranMcDonald	345	1365
13	Kiro, Monogram, self compiled	233	1365
14	Kiro, Bigram, self compiled	462	1365
15	Kiro, Trigram, self compiled	1221	1365
16	Obama, Monogram, self compiled	37	1365
17	Obama Bigram, self compiled	52	1365
18	Obama Trigram, self compiled	92	1365

The self compiled dictionaries based on the kiro dataset was used to compare the two types of classifiers.

Each test with a classifier uses the kiro monogram dictionary for feature extraction, and the described dataset as training set and the dataset to be classified.

SVM

TODO what is svm TODO how does it work.

When using SVM there are different kernel modules that can be used to improve results. The kernel is often chosen based on knowledge about the dataset. In the `nlTK2` library for python there are a number of different kernels.

The kernels were tested to find out which kernel gave the best results. Section 6.4 describes the experiment and the results. As seen in the experiment the LinearSVC kernel performed best and was used in further experiments.

Naive Bayes TODO what is Naive Bayes. TODO how does it work.

4.3 Comparison

The Classifiers

We have looked at three classifiers, Naive Bayes, SVM, and the word classifier. Together they have classified the two dataset we have with varying results.

All methods of classification uses the manually labeled tweet sets as the data source. And we use the self compile dictionaries for feature extraction.

Experiments

In section 4.2.1, 6.3, 6.4, and 6.5 the methods described in this chapter are tested to validate the research questions, 1.3.

Results

The results of the classifiers are described in 7.3.4. There the good and bad parts of the classifiers are presented and discussed.

²Natural Language Toolkit <http://www.nltk.org/>

4.4 Comments

Improvements

There are a lot of improvements that could be done.

The word count classification is merely a convenient way to say something about the dictionaries used. We should expand our knowledge toward the quality of the dictionaries. And look for ways to eliminate terms that are neither positive or negative.

We should cross classify and test the classification with the SVM classifier and do quality assurance on the work with it. We should also look at other classifiers and other data to confirm the findings we have so far.

Biased Mind

The datasets of manually labeled tweets are biased based on a personal opinion and the state of mind in the moment of classification. Therefore we have to keep in mind that all the results are based on the assumption that everyone agrees on the manual labeling. This is of course a source of errors to be explored more in 9.

We should explore the psychology of perception and classification. How do people perceive content differently? Is finance easier to label than politics?

Drawbacks

The quality of the dictionaries is a problem. Some of our observations give insight into the use of natural language in association with dictionaries. Further drawbacks are the threshold of the word count classification. This should be addressed in some smart way.

Code wise we should improve the testing of the classifiers, and remove the static use of dictionaries in the feature extraction.

Conclusions

Dictionaries can be compiled and used in classification of sentiment. While classifiers work better than word counting, we still rely on the manually labeled tweets for accuracy. We also know that the data we use to check the classification are biased and should be improved.

Future Work

Analysis of the dictionaries and improvement of them is a natural place to continue research. While we should also look at the input data and sort the

data smartly to remove spam. And find another way to decide the sentiment in the word count classification.

Chapter 5

Trending

We looked at trends in regard to twitter and finance. And tried to see if there was any correlations between them. The feeble attempt is described in this chapter.

We start of by describing and defining a trend in section 5.1. Continuing with trends on an in relation to twitter, 5.2. To be followed by trends in finance, 5.3. An last we Compare twitter trends with finance trends, 5.4.

5.1 The trend is your friend

A trend is a series of changes that moves in the same direction over a period of time. It is often associated with fashion or stock trading. The definition of trend is "the general course or prevailing tendency"¹.

In finance especially the trend can be a deciding factor in buying and selling of goods. You typically do not want to sell during a bullish trend, value going up. And you want to sell before you get to the bearish trend, value going down.

When trading based on the trend, the problem is to find the trend and predict it into the future. And there Twitter comes into the mix. If we could predict the trend based on public opinion mined from twitter we would have an advantage over other traders.

If the trend is your friend, you know how the market will move and make good decisions in accordance with the trend.

¹Dictionary.com: <http://dictionary.references.com/browse/trend>

5.2 Trends from Twitter

There are two parts to trends with twitter. The trends Twitter themselves create based on words of hashtags that appear in many tweets. And the trend we compile ourselves based on data we choose.

On Twitter

The trends on twitter is largely predictable and gives little new information to the trend compilation. The trend on twitter is also specialised for each user, based on that users subscriptions and location. As an example at the Norwegian national day(Mai 17.) we would have trending words like Norge, *Norway*, and *17Mai*. Today we already know that this will happen again next year.

As the Twitter trend depends on the volume of tweets to be updated we have to look at individual tweets, users or volume of some sort to predict a trend.

Our own

To begin with we narrowed down our area of data gathering to a set of search words. Most of them based on an article on tu.no². Taking tweets from everywhere on twitter might give us large amounts of spam or other content about breakfast or similar.

The article lists the most important oil related account on twitter. In two parts. One for the Norwegian ones, and one for international ones. The international ones are the search terms used in the actual trend compilation and graph plotting.

After sorting the mined tweets by day, we calculated the change in tweets between two days. More specifically we looked at the change in positive and the change in negative tweets between today and yesterday. This giving us an average change graph.

To be even more precise we took the percentage average change of change in positive and change in negative tweets.

```

1 | # difference from yesterday til today.
2 | # change in positive tweets between this and the previous day.
3 | pos_diff = (positive_tweets_today - positive_tweets_yesterday) / (
4 |     total_amount_of_tweets * 1.0)
5 |
6 | # change in negative tweets between this and the previous day.
7 | neg_diff = (negative_tweets_today - negative_tweets_yesterday) / (

```

²Tu.no: <http://www.tu.no/petroleum/2014/04/05/dette-er-de-viktigste-twittrerne-for-oljebransjen>

```

8 |         total_amount_of_tweets * 1.0)
9 |
10 | # median = the mid point between the positive and negative change points.
11 | # change in sentiment volume between this and the previous day.
12 | median = min([neg_diff, pos_diff]) + abs(pos_diff - neg_diff) / 2
13 | results.append(median)

```

Plotting this we get the average change graph, figure: ??.

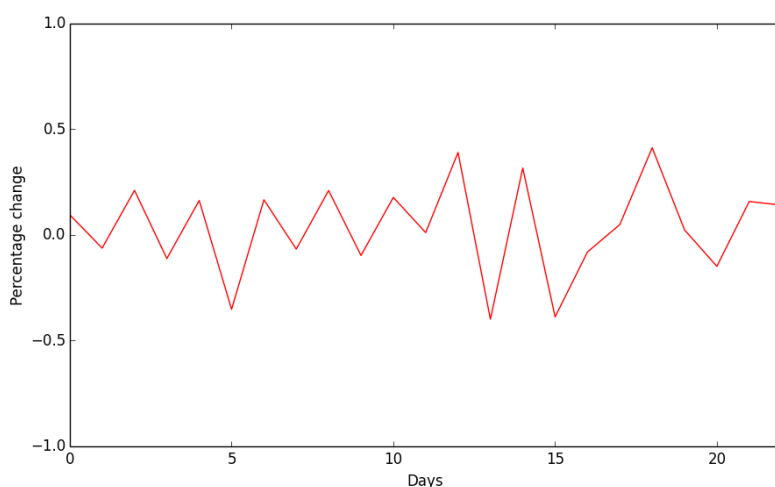


Figure 5.1: Tweet trend plot

The graph show the average change in tweet sentiment between two days, over a 23 day period.

5.3 Trending in Finance

We looked at the change at Oslo stock exchange in the same period as the tweets above (Apr 30 - May 16). For the days the stock exchange was closed we padded out the dataset with the previous open day. So that Saturday and Sunday would have the same values as Friday. This is mainly to make the coding and plotting of the graph easier.

To describe the calculation of the finance trend: we took the percentage of change in closing value from yesterday and today. Then we scaled the graph by a value of 100 to make the changes visible in the same plot as the tweet trend.

```

1 | # calculate percentage diff between this and the previous day.
2 | diff = (closing_value_today - closing_value_yesterday) / (
3 |     average_value_today_yesterday * 1.0)
4 |
5 | # scaled to work with the tweet trend.
6 | results.append(diff * 100)

```

Plotting the graph we got figure 5.3.

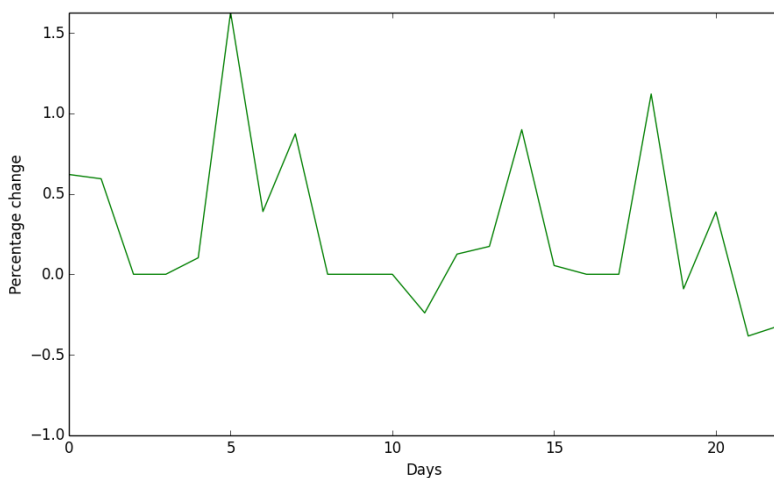


Figure 5.2: Finance trend plot

The graph show the average change in closing value between two days, over a 23 day period. Note that the graph is scaled to be comparable with the tweet trend graph.

5.4 Comparing the trends

TODO describe the conceptual parts of trend comparison.

And continuing with everything that is wrong with it.

As correlations go between the two graphs we have very few. There are two areas where the peaks are quite alike. At least the change is in the same directions. This is at day 14 and 18. Besides those two points the graphs have no likeness at all.

What we can see from the plots is that the trend compilations have no correlations. From this we can say for certain that the amount of data and way of plotting the trends do not work.

The two things that are likely to play a big part in the results is the data we used and the way we compiled the tweet trend.

To narrow and to little data makes the result rather inconclusive. We should have used something like a million of a billion tweets to get statistically significant results.

And we should look closer on how we aggregate the twitter trend. Further we should look at other fields of a tweet that can be significant for a trend. Like followers and retweets.

From this we learn that data matters a lot and that it is difficult to find a good way to aggregate a trend.

Chapter 6

Experiments

TODO chapter description an purpose

TODO experimental setup, explaining a plan and execution of experiments.

TODO By using my methods, described in earlier chapters, we can execute the necessary experiments to test the research questions.

TODO chapter outline.

TODO list the experiments done to achieve results. The concrete ones.

TODO link these experiments to methods in other chapters.

TODO link the experiments to research questions.

6.1 Dictionary compilation

Section 3.2 describes dictionaries and what they are used for. This section describes how the dictionaries are tested. The dictionaries are compiled from manually labeled tweets.

As a step in the sentiment classification dictionaries was created for the word count classification 4.2.1. To find out which dictionaries performed well or not we tested the dictionaries with two data sets, the kiro dataset and the obama dataset.

This experiment enlightens part of research question 1, 1.3.1, how we can find the sentiment of a tweet.

Dictionary quality

To test the dictionary quality the word count classification 6.2 does it for us. All the dictionaries are tested with the two datasets and we can compare the results. How the dictionaries are compiled are described in 3.2.2 and A.4.

Removal of duplicate words

When creating the different dictionaries we remove duplicates from the positive and negative dictionary set. Words that are present in both the positive and negative dictionary is removed. By doing this we remove words that has no significance in the classification. But we also risk removing words with significance.

The code is described in appendix A.4 on page 73.

Results

Results from the testing of dictionaries are closely linked to the word count classification in 6.2 and described in table 7.3.1 on page 52.

6.2 Word Count Classification

Inspiration from section 2.2, with knowledge of tweets and dictionaries in section 3.1, builds this experiment. The background for the experiment and how it's purpose is described in section 4.2.

This experiment used the technique described in section 4.2.1, the word count method of classifying a tweets sentiment.

This experiment tries to expand on the matter of how to determine the sentiment of a tweet, 1.3.1. And how Twitter can be used, indirectly, to aggregate a trend, 1.3.2. The method looks at at the amount of positive and negative words and use that to decide the sentiment.

For all the dictionaries and datasets, the classification process is run. This gives the accuracy for all dictionaries and the two datasets. This in turn describes the efficiency of the word count classification.

The code for calculating the sentiment is as follows. It is also described in appendix A.5.1, on page 74.

```

1 | positivity = positive_words_count / total_number_words
2 | negativity = negative_words_count / total_number_words
3 |
4 | polarity = positivity - negativity
5 |

```



```
6 | if polarity > 0:  
7 |     tweet is positive  
8 | else:  
9 |     tweet is negative
```

The results of the classification can be found in section 7.3.1 on page 51.

6.3 Threshold Variation

In section 4.2.2 the description and purpose of the threshold variation is described. The threshold aims to find out how positive a tweet has to be before it is actually positive. Or rather how many more positive words than negative words do we need to call the tweet positive.

By varying the threshold we hoped to find an optimal point of which we could separate tweets based on polarity. From the following graphs, figure 7.3.2, we can see no clear distinction of one value being better than the other ones.

In essence what is done is that the word count classification is run multiple times where the threshold value is changed between -0.9 and 0.9. This gives a distribution of results which is plotted in graph 7.3.2 on page 54. The results will give an indication of what threshold is best for word counting.

The results of the threshold variation is described in section 7.3.2, on page 53. And in table 7.3.2 on page 53.

6.4 Choice of SVM Kernel

In extension of 4.2.3 all the SVM kernels were tested. While testing which kernel was best we used the kiro dataset for training, and the kiro monogram dictionary for feature extraction.

Using the self compile monogram dictionaries and all the different SVM kernels we get these results:

6.5 With Classifiers

For the classifiers the two datasets were tested with the two classifiers. This was done to find the best classifier and compare the results with the word count classification. By confirming that classifiers are better than word counting we can eliminate a factor in the classification uncertainties.

Table 6.1: SVM kernel test results table

Kernel	Failed	Correct	Accuracy
LinearSVC	7	990	0.9930
NuSVC	29	968	0.9709
NuSVR	422	575	0.5767
OneClassSVM	575	422	0.4233
SVC	422	575	0.5767
SVR	422	575	0.5767

Table 6.2: SVM classifier results table

Dataset	Type	Failed	Correct	Accuracy
Kiro	Monogram	7	990	0.9930
Kiro	Bigram	422	575	0.5767
Obama	Monogram	35	1330	0.9744
Obama	Bigram	507	858	0.6286

The description of the comparison on a conceptual level is described in section 4.3. Also of interest there is the element of the dictionaries in section 3.2. While we have taken inspiration and ideas for the experiment from section 2.2.

For the research questions to be enlightened further here is the trend aggregation in section 1.3.1 and the sentiment determination in section 1.3.2.

SVM

Results from testing SVM with different dictionaries are described in table 6.5 on page 46.

Naive Bayes

Results from testing Naive Bayes with different dictionaries are described in table 6.5 on page 47.

6.6 Trend aggregation

TODO link to 5, 4.3, 3.3, 2.1, 2.4

Table 6.3: Naive Bayes classifier results table

Dataset	Type	Failed	Correct	Accuracy
Kiro	Monogram	29	968	0.9709
Kiro	Bigram	29	968	0.9709
Obama	Monogram	59	1306	0.9568
Obama	Bigram	59	1306	0.9568

Before executing this experiment section 5.4 describes the conceptual parts of the trend comparison. This is the basis for the results of this experiment.

This experiment aims to test the relevance of positive and negative tweets in correlation with change in finance. There are two parts of this experiment. The finance part, and the twitter part. Can twitter be used to create a trend, 1.3.2. And how can we compare this to a finance trend, 1.3.3.

In the execution of the experiment the methods described in chapter 5 has been used. More specifically the trend aggregation under trends on twitter, 5.2. And the finance trend aggregation, 5.3.

To get results out of this experiment section 4.2.3, and section 4.3. They are used to give indications of what methods, previously described, gives results. Specifics of how the trend aggregation happens are described in appendix A.6.

For the execution of the experiment the results of the two trend attempts are plotted in a graph. The graph plotting code is described in appendix A.7.

The trend plot in figure 6.6, on page 48.

The results of the experiment are discussed in section 7.4.

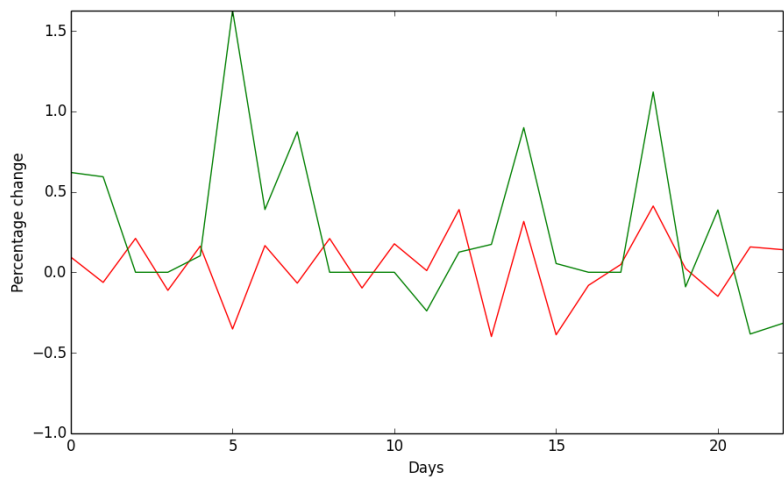


Figure 6.1: Comparing trend plot
The graph shows the two previously compiled trends. The red one is the tweet trend, while the green one is the finance trend.

Chapter 7

Results and Discussion

The results of our research and the following discussion of them happen here. We touch the three main parts of the thesis. The data sources, section ??, Classification of sentiment in section ??, And the trend in section 7.4. Last we have a general discussion about the results.

7.1 Data Source

Twitter as a data source proved to be OK. It was quite easy to obtain data. But increasingly difficult to get good amounts of data and unbiased data. All the initial data have some restriction to search term or other limits. In total we should have mined a lot more data and classified more of it.

As far as the dictionaries go they work well. We have different results for different dictionaries and different datasets, but all in all the way to compile datasets work good. The dictionaries depend on the manually classified tweets, so a lot of the improvement lies there. Although we can improve the dictionaries by removing stop words and other words we know have no clear positive or negative contribution.

TODO link to research question 1 and 3. ??

7.2 Dictionaries

Error analysis

When looking at the duplicate words from the monogram dictionary based on

the kiro dataset we found some errors. As a selection of words found, we have *dangerous, bad, go, inc, let, up, or, need, good, if, no, are, and, of, on, the, is, as*. Here we can see that the words *good* and *bad* are represented. Which is not good. By removing the words from the dictionaries we have removed significant words in further classification, thus reducing correctness of the algorithm. This is one of the drawbacks of the monogram dictionaries.

When looking at the removed duplicate words for bigram and trigrams we found no indication of the same problem. As the uniqueness of bigrams and trigrams are a lot greater we end up with very few duplicates and only duplicates that has no significance to the over all classification. Although we might have other unknown problems.

Most stop words and other insignificant words are removed with the removal of duplicate words. The same thing cannot be said about the bigram and trigram dictionaries. There we have no stop words present in themselves, but they are frequently part of other terms. For further improvements of classification with word counting and dictionary quality we should remove stop words, such as *as, is, on, off, and, or* etc, from the tweet/sentence before creating bi- and trigrams.

7.3 Classification

Manual labeling is a bit of a challenge to keep unbiased. The whole classification process is based on a persons opinion, which makes the results somewhat biased. To eliminate this error we should have multiple people do the manual classification and combine the results.

Word counting works to some extent. But presents varied results based on the dataset and the dictionary used. Again this comes down to the dataset and the dictionaries created. Also the way we separate tweets from each other with a threshold can be improved. All in all word counting works, but it is not very good.

Classifiers improve the classification quite a bit. With the svm classifier we get around 98 percent correct classification on both data sets. Which is good.

The uncertainties lie in the biased, or potentially biased, data. We do not know if the data in itself is fully representable for the content on twitter. Neither do we know if the manual classification is completely correct.

In total we gained some knowledge about dictionaries and their effect on classification. And we can confirm that classifiers work better than word counting.

TODO link to research question 1 and 2 1.3.1 1.3.2.

7.3.1 Word Count Classification

The results from the word count classification can be plotted in the table 7.3.1 and in the graph 7.3.1.

5, 6, 17, 18 are the dictionaries with best accuracy. Which is to be expected for the classification of the dataset the dictionary was created from.

But more interestingly, if we take the dictionaries created from one dataset, and look at the results of the classification on the other dataset. We compare 7, 8, 9 with each other and 13, 14, 15 with each other. Then we can see that the bigram and trigram dictionaries perform overall better than the monogram dictionaries.

Further we see indications that the quality of the dictionary plays an important role. The LoguhranMcDonald monogram dictionary performs quite good with both datasets. Even on par with the compiled dictionaries on opposite dataset. This indicates that a well crafted dictionary can perform as well as compiled dictionaries.

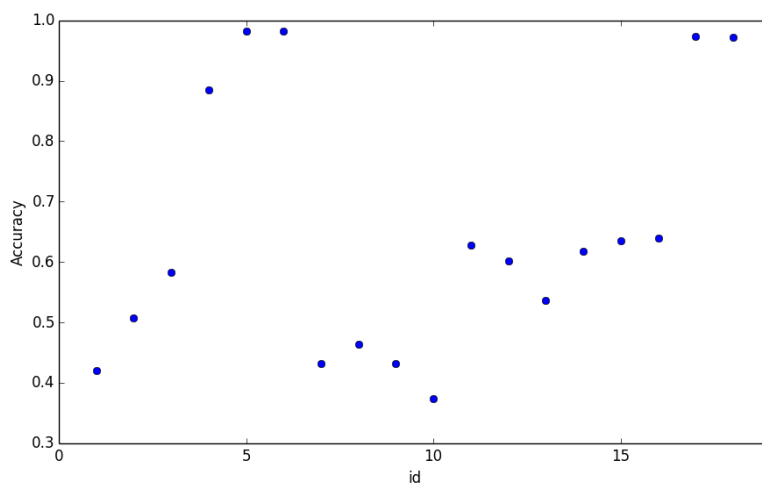


Figure 7.1: Dictionary Accuracy plot

The graph shows the plotted accuracies from the word count classification.

The ids represents the ids from the table above, 7.3.1

Table 7.1: Word Count classification results table

id	Dictionary	Failed	Correct	Accuracy
	– Kiro compiled dataset –	a	b	$b/(a+b)$
1	Monogram, obama	578	419	0.4203
2	Monogram LoughranMcDonald	491	506	0.5075
3	Monogram, combined Obama and LoughranMcDonald	416	581	0.5827
4	Kiro, Monogram, self compiled	115	882	0.8847
5	Kiro, Bigram, self compiled	17	980	0.9829
6	Kiro, Trigram, self compiled	18	979	0.9819
7	Obama, Monogram, self compiled	567	430	0.4313
8	Obama Bigram, self compiled	534	463	0.4644
9	Obama Trigram, self compiled	567	430	0.4313
	– Obama tweet set –	a	b	$b/(a+b)$
10	Monogram, obama	855	510	0.3736
11	Monogram LoughranMcDonald	508	857	0.6278
12	Monogram, combined Obama and LoughranMcDonald	544	821	0.6015
13	Kiro, Monogram, self compiled	632	733	0.5370
14	Kiro, Bigram, self compiled	521	844	0.6183
15	Kiro, Trigram, self compiled	498	867	0.6352
16	Obama, Monogram, self compiled	493	872	0.6388
17	Obama Bigram, self compiled	37	1328	0.9729
18	Obama Trigram, self compiled	39	1326	0.9714

Table 7.2: Average threshold accuracy table.

Threshold	Accuracy	Threshold	Accuracy
-	-	0.0	0.6479
-0.1	0.6316	0.1	0.6516
-0.2	0.6161	0.2	0.6511
-0.3	0.6059	0.3	0.6430
-0.4	0.5988	0.4	0.6305
-0.5	0.5888	0.5	0.6122
-0.6	0.5711	0.6	0.5934
-0.7	0.5423	0.7	0.5712
-0.8	0.5083	0.8	0.5457
-0.9	0.4881	0.9	0.5307

When comparing the results from one dataset to the other we can see indications of how the content of the dataset also plays a huge role in the results. Some tweets are more difficult to classify than others.

7.3.2 Threshold Variation

Further we found the best average threshold value to be 0.1. From the table under we have the threshold value, and the average classification accuracy among the 18 entries for each threshold value.

In figure 7.3.2 we list the results of the experimentation with the threshold. Table 7.3.2 lists the dictionaries and dataset used for which graphs in figure 7.3.2. 'kiro dataset' and 'obama dataset' columns tells which dataset that was classified in which graph.

7.3.3 With Classifiers

TODO main results from the classifier classification

SVM

From results of the experiment, 6.5 we can draw some conclusions. The monogram dictionary performed better than the bigram dictionary. Probably due to

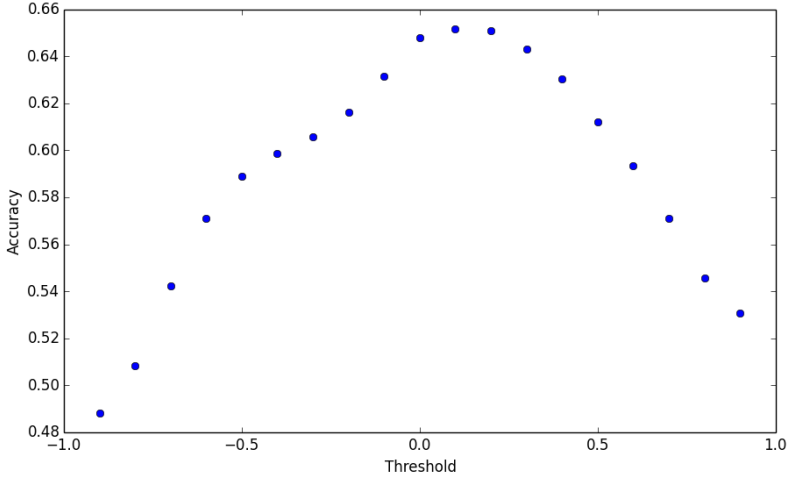


Figure 7.2: Average threshold accuracy
Graph plots of the 'Average threshold accuracy' table.

the number of features we can extract from each tweet. Also classifiers are more accurate than the word count classification method.

Naive Bayes

As we can see from the experiment, 6.5, the different dictionaries makes no difference for the Naive Bayes classifier. But if we compare the classifier with the results from the word count classification we can clearly see improvement.

7.3.4 Comparison

In the following table, 7.3.4, we highlight the results from the different classifications. We list the most noteworthy results from our experiments and compare them.

As we can see the classifiers give better results then the word count classification. And SVM is a bit better than Naive Bayes. Although the results from the word count classification indicates that the dictionaries play an important

Table 7.3: Dictionary to threshold graph plot table

Dictionary name and description	kiro dataset	obama dataset
Obama original, Monogram	1	10
LoughranMcDonald, Monogram	2	11
Combined Obama original and LoughranMcDonald, Monogram	3	12
Kiro, Monogram, self compiled	4	13
Obama, Monogram, self compiled	5	14
Kiro, Bigram, self compiled	6	15
Obama, Bigram, self compiled	7	16
Kiro, Trigram, self compiled	8	17
Obama, Trigram, self compiled	9	18

Table 7.4: Comparison of classifiers table

Classifier	Dataset	Dictionary	Failed	Correct	Accuracy
Word Count	Kiro	Obama Bigram	534	463	0.4644
Word Count	Obama	LoughranMcDonald Monogram	508	857	0.6278
Word Count	Obama	Kiro, Trigram	498	867	0.6352
Naive Bayes	Kiro	Kiro Monogram	29	968	0.9709
SVM	Kiro	Kiro Monogram	7	990	0.9930

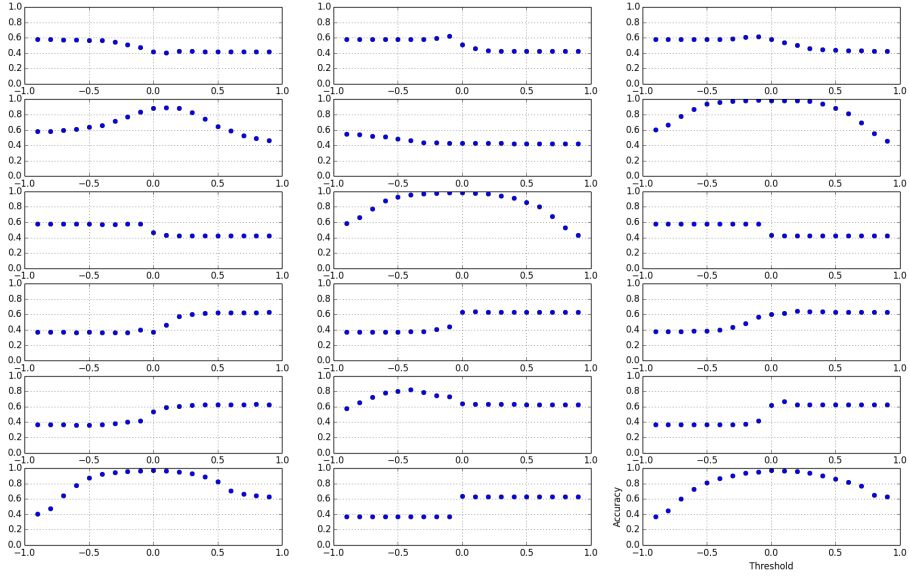


Figure 7.3: Threshold variation accuracy plot

The graphs plot the different variations of threshold. Counting is columns first; top left is 1, top mid is 7, top right is 13.

role in the results. We can also see that monograms are better for classifiers, while trigrams are better for word counting.

For the classifiers and the good results with the monogram dictionaries, we think that has to do with the number of features we get from a tweet. The more features we have the easier it is to classify and the more accurate the result.

7.4 The Trend

The attempt to create a trend succeeded, but it was not were good. The average change in sentiment between two days did not have any correlations with the average change in closing value of the stock exchange.

One of the limitations here is the low test coverage. This should have been tested with multiple exchanges and much more tweets. We used around 30

thousand tweets to create the tweet trend. But the amount does not matter if the data is used wrong.

Partial success, with plenty flaws. New knowledge gain and lots of new questions to be asked.

TODO link to research question 2 and 3 ??.

7.5 Discussion

From the three parts we have satisfying and unsatisfying results. We have good results and vague results. The vague results should be frowned upon. While the reasonable results should be expanded, retested and improved. Most notably we have clear indications that dictionaries, automatically compiled from a manually classified tweets set, can be used when classifying sentiment.

TODO discuss the achieved research questions.

Chapter 8

Conclusion

We worked hard, and achieved very little.

TODO link up to research questions. TODO write stuff about data, datasets and dictionaries. TODO write classification and such stuff. TODO trend conclusions?

TODO overall work progress and process.

TODO evaluate accordance with the research questions.

Chapter 9

Future Work

All the things I didn't have time to do my self.

9.1 Twitter

TODO further use of twitter as data source and such.

Twitter API TODO the unused parts of the API Look at the different endpoints and see how we can use them smartly. Twitter: <https://dev.twitter.com/docs/api/1.1>

search terms for the tweet sets TODO search parameters and the query. the tweet sets should be expanded to use a wide range of finance words. then create dictionaries from the sets.

implications of special twitter content TODO specifics of tweets to be used? @users, hashtags, links? Does any of them matter much?

Language analysis TODO How is abbreviations used in tweets? Same as in SMS? example: bc=because

Not computer science

9.2 Dictionaries

TODO the future of dictionaries.

9.3 Sentiment

TODO future of classifiers and research there. classifiers: should have crosstested. used kiro set for training and obama set for classification.

Is neutral negative or positive? TODO if a tweet is classified as neutral, aka the amount of positivity and negativity is the same how do we then classify the tweet?

Word weighting TODO How can we use weighting of words in sentiment classification ?

How people express sentiment TODO more of a psychology thing. But still relevant.

Use of sentiment analysis on news TODO not the whole part of the news, but the title and ingress.

9.4 trend

TODO future of trend aggregation

Trend Data The analysis of the trend data. There we have over 30k of tweets waiting to be analysed.

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Appendix A

The Code

TODO examples of running in a conceptual spirit can be moved other places in the thesis. To their respective chapters.

The code is complete in the sense of doing what it should. Or making an attempt to. The results of the coding are up for discussion.

For functionality we have code for mining tweets, compiling dictionaries, classifying tweets, and aggregating a trend based on data from twitter.

For this chapter we start of with the structure of the code, A.1. Then touch the technology and libraries, A.2, used up to this point. Before we look at the data mining, A.3, dictionary compilation, A.4, classification, A.5, and trend aggregation, A.6. Last we describe the comparison, A.7, of the finance trend and ending with the issues, A.8, of the code.

A.1 Structure

There are four main folders. One for classification, one for mining tweets, one for the dictionaries and on for the files associated with trend.

Code for classification is split into four files. One file for utilities, helper functions that does not touch logic. And the three was of classifying tweets, manual, word counting and with a classifier. `List_threshold.results` plots the results from the threshold variation in graphs with pyplot.

The dictionary code is split onto two files, helpers and utility in one, and logic and execution in the other.

Trend code is in the trend folder. There we have `mining_utils`, which is

a replica of the same file in the twitter folder. This file only helps with the acquisition of tweets. The trend_mining file executes the mining operations, and acquires tweets from twitter based on a set of search terms. The trend_tweet_sorting file sorts tweets from all the raw search term data files into files based on date. So all tweets from the same date ends in the same file. And last we have the trend_compilation file, which contains code for compiling and plotting trend data and financial data.

Last we have the 'twitter' directory which has code for extracting tweets from twitter. This code is used for creating the datasets that the dictionaries are built from. We have the mining_utils which is helper code for connection and writing files and such. While the mining_operations file does the logic of managing the acquired tweets.

The important files are listed under. '- something' are folders, while the others are actual python files. The indentation shows which files are in which folders.

```
- code
  - classification
    classification_utils.py
list_threshold_results.py
  manual_classification.py
  svm_bayes_classification.py
  word_count_classification.py
  - dictionaries
    dictionaries.py
    dictionary_utils.py
  - trend
    mining_utils.py
    trend_classification_utils.py
    trend_compilation.py
    trend_mining.py
    trend_tweet_sorting.py
  - twitter
    mining_operations.py
    mining_utils.py
graph_plots.py
```


A.2 Technology and Libraries

The technology used, frameworks etc.

The used python libraries are: ConfigParser, ast, codecs, io, os, twython, time, matplotlib, urllib, re, nltk, sklearn. Most of them are quite standard, while some are not. And some are self explanatory.

The libraries that are not shipped with standard python are described in the following paragraphs.

Twython Library for connection and integration with the twitter api. The source and documentation can be found on github: <https://github.com/ryanmcgrath/twython>

nltk The natural language tool kit (nltk) is a library that provides functionality for working with human language. It has functionality such as classifiers and tokenization tools. See more at <http://www.nltk.org/>.

sklearn Scikit-learn provides functionality for learning algorithms, machine learning and classification. We use this library to provide the kernels for out classification with classifiers. <http://scikit-learn.org/>

matplotlib Matplotlib is a library for graph plotting. And that is what we use it for. <http://matplotlib.org/>.

A.3 Data retrieval

As we have to data sources we split it into finance data and data from twitter.

A.3.1 Twitter

The mining operation can be seen as three steps. This happens in *mining-operations.py* and *mining-utils.py*.

Step 1

Authenticating and connecting to twitter.

```

1 | conf = open('auth.cfg').read()
2 | config = ConfigParser.RawConfigParser(allow_no_value=True)
3 | config.readfp(io.BytesIO(conf))
4 |
5 | # getting data from conf object.
6 | APP_KEY = config.get('twtrauth', 'app_key')
7 | APP_SECRET = config.get('twtrauth', 'app_secret')
8 | OAUTH_TOKEN = config.get('twtrauth', 'oauth_token')
9 | OAUTH_TOKEN_SECRET = config.get('twtrauth',
10 |                                'oauth_token_secret')
11 |
12 | # creating authentication object for twython twitter.
13 | twitter = Twython(APP_KEY,
14 |                   APP_SECRET,
15 |                   OAUTH_TOKEN,
16 |                   OAUTH_TOKEN_SECRET)

```

Step 2

Query execution.

```

1 | results = twitter.cursor(twitter.search,
2 |                           q=query,
3 |                           count="100",
4 |                           lauage=language)

```

Where we have the query, and language as input variables to the *cursor_extraction* function.

Step 3

Data extraction and storage.

```

1 | # opens new file with today's date and time now as filename
2 | filename = destination_folder + "/dataset-" + \
3 |     strftime("%d-%b-%Y_%H:%M:%S")
4 | # opens the file for appending.
5 | data_set = open(filename, 'a')
6 |
7 | for result in results:
8 |     # skip previously acquired tweets
9 |     if str(result['id']) in str(previous_tweets_list):
10 |         continue
11 |     else:

```

```

12     previous_tweets_list.append(result['id'])
13
14     # store tweet to file for later use.
15     data_set.write(str(result) + "\n")

```

We open the storage file for writing and gives it a name based on the time of creation. Then we traverse all results and store tweets we have not seen before.

A.3.2 Finance

We get finance data from <http://www.netfonds.no/>. Specifically we get the data about Oslo stock exchange OSEBX data: http://www.netfonds.no/quotes/paperhistory.php?paper=OSEBX.OSE&csv_format=csv We also sort out the data we do not want by breaking at a certain date.

We do this by using the urllib library in python:

```

1  # get data file from internet. (csv)
2  stock_exchange_history = urllib.urlopen(url).readlines()
3  records = []
4  for record in stock_exchange_history:
5      # earlier records are not interesting.
6      if "2014" in record:
7          records.append(record.strip().lower().split(","))
8      if "20140414" in record:
9          break
10 return records

```

A.4 Dictionary compilation

For the dictionary compilation we use the manually classified datasets to create mono, bi and trigram dictionaries.

Starting off the process we run compilation for all datasets:

```

1  data_files = [
2      # [name/description, name of file containing tweets]
3      ["kiro", "tweets_classified_manually"],
4      ["obama", "obama_tweets_classified_manually"]
5  ]
6
7  for item in data_files:
8      # get labeled tweets

```



```

14         # combine tuple parts to bigram
15         word = m_obj.group(1) + " " + m_obj.group(2)
16         # if bigram don't exist
17         if word not in bigrams_list:
18             # add it to list.
19             bigrams_list.append(word)
20     return bigrams_list

```

Where we essentially generate sets of words in tuples and then extract the combined term by string conversion and regex.

Remove duplicate words Then we conveniently remove duplicates between the positive and negative dictionary before we write the dictionaries to file.

```

1 primary_dictionary = get_lines_from_file(
2     primary_dictionary_name)
3 secondary_dictionary = get_lines_from_file(
4     secondary_dictionary_name)
5
6 duplicate_words = []
7 # for all words in the primary dictionary.
8 for pw in primary_dictionary:
9     #print w
10    # for all words in the secondary dictionary.
11    for sw in secondary_dictionary:
12        # if primary word equals secondary word
13        if pw == sw:
14            # remove word from both dictionaries.
15            primary_dictionary.remove(pw)
16            secondary_dictionary.remove(sw)
17            duplicate_words.append(pw)
18            # as we don't have duplicates within a list,
19            # we skip to next pw
20            break
21
22 # rewrite the updated lists to file
23 write_array_entries_to_file(primary_dictionary,
24                             primary_dictionary_name)
25 write_array_entries_to_file(secondary_dictionary,
26                             secondary_dictionary_name)
27 write_array_entries_to_file(duplicate_words,
28                             "duplicate-words")

```

A.5 Sentiment Classification

For both classifiers we have utility code for loading data and dictionaries, but the important parts are the classification. Which is shown below.

A.5.1 Word Count

For each tweet we do the same thing. Count words and find the difference between positive and negative words. Here is the code for doing so.

```

1  # sanitize text.
2  tweet = sanitize_tweet(tweet)
3
4  # get word count for tweet
5  word_count = len(tweet.split(' ')) * 1.0
6
7  # get word count of pos and neg words.
8  pos = get_word_count(positive_dict, tweet) / word_count
9  neg = get_word_count(negative_dict, tweet) / word_count
10
11 # storing the polarity value
12 polarity.append(pos - neg)
13
14 if polarity[-1] == threshold:
15     edge_cases += 1
16
17 # adding sentiment value (True/False),
18 # for the last classified tweet.
19 if polarity[-1] > threshold:
20     # positive tweet
21     results.append(True)
22 else:
23     # negative tweet
24     results.append(False)

```

A.5.2 With classifier

The execution of the classification can be described in the following steps.

Classifier initialization First we have to initialize the classifier, then train it. We send the class of the kernel as an input argument, such that *classifier_class*

is 'SklearnClassifier(LinearSVC())'.

```

1 | # get the training set.
2 | training_set = nltk.classify.apply_features(
3 |     extract_features_from_text,
4 |     tweets)
5 |
6 | # create the classifier.
7 | classifier = classifier_class.train(training_set)

```

Where the `extract_features_from_text` function is rather important. Here the 'dictionary' variable is the combined list of the `kiro-monogram-negative.txt` and `kiro-monogram-positive.txt` dictionaries.

```

1 | dictionary = get_list_of_possible_words_in_tweets()
2 | document_words = set(text)
3 | features = {}
4 | # more precision to iterate the word of a tweet then the
5 | # whole dictionary.
6 | # extracts all words that are both in the dictionary and
7 | # in the tweet
8 | for word in document_words:
9 |     features['contains(%s)' % word] = (word in dictionary)
10 | return features

```

Classification The code for classifying a tweet is quite simple.

```

1 | # runs classify() on the given classifier class in the
2 | # nltk library.
3 | results.append(classifier.classify(
4 |     extract_features_from_text(tweet)))

```

A.6 Trend aggregation

The trend aggregation is a split process. Where the mining of tweets, sorting, classification, and trend compilation happens in separate steps. Most important is the trend compilation. The sorting process only reads tweets and stores them the file that corresponds with the posting date of the tweet. Mining is done on the same principles as described earlier, only with other search terms.

A.6.1 Compilation

First we get positive and negative tweets from the dataset. And store that in a dict, with the filename, or day, as key.

```

1 | pos, neg = 0, 0
2 |
3 | # get tweets for this day.
4 | trend_day_tweets = [ast.literal_eval(tweet) for tweet in
5 |     codecs.open(trend_base + trend_day_filename,
6 |                 'r',
7 |                 "utf-8").readlines()]
8 |
9 | # sentiment for each tweet.
10 | sentiment = []
11 |
12 | # for tweets in this day
13 | for tweet in trend_day_tweets:
14 |     # get words of two or more characters.
15 |     tweet_text = [e.lower() for e in sanitize_tweet(
16 |         tweet['text'])].split() if len(e) >= 2]
17 |
18 |     # get sentiment
19 |     sentiment.append(classifier.classify(
20 |         extract_features_from_text(tweet_text)))
21 |
22 |     # if the last tweet was positive.
23 |     if sentiment[-1]:
24 |         pos += 1
25 |     else:
26 |         neg += 1
27 |
28 | return [pos, neg, pos + neg]
```

Then we calculate the average change of positive and negative tweets between today and yesterday.

```

1 | keys = sorted(trend_days.keys())
2 | #print keys
3 | results = []
4 | for i in range(1, len(keys)):
5 |     # difference from yesterday til today.
6 |     # positive tweets
7 |     positive_tweets_today = trend_days[keys[i]]['pos']
```



```

8     positive_tweets_yesterday = trend_days[keys[i - 1]]['pos']
9
10    # negative tweets
11    negative_tweets_today = trend_days[keys[i]]['neg']
12    negative_tweets_yesterday = trend_days[keys[i - 1]]['neg']
13
14    # total amount of tweets
15    total_amount_of_tweets = trend_days[keys[i]]['tot'] + \
16                             trend_days[keys[i - 1]]['tot']
17
18    # change in positive tweets between this and the previous day.
19    pos_diff = (positive_tweets_today - positive_tweets_yesterday) / (
20        total_amount_of_tweets * 1.0)
21
22    # change in negative tweets between this and the previous day.
23    neg_diff = (negative_tweets_today - negative_tweets_yesterday) / (
24        total_amount_of_tweets * 1.0)
25
26    # median = the mid point between the positive and negative change
27    points.
28    # change in sentiment volume between this and the previous day.
29    median = min([neg_diff, pos_diff]) + abs(pos_diff - neg_diff) / 2
30    results.append(median)
31
32    #print keys[i], "%.4f" % median, trend_days[keys[i]]['tot']
33    #print "pos", keys[i], trend_days[keys[i]]['neg'] -
34    trend_days[keys[i-1]]['neg']
35
36    #print len(results)
37    return results

```

A.7 Comparison

We do the same for the finance data as with the tweet data above. And multiplies the result with 100 to scale the graph plot.

```

1  for i in range(1, len(stock_records)):
2      # calculate percentage diff sinse yesterday.
3      diff = (stock_records[i][6] - stock_records[i - 1][6]) / (
4          stock_records[i][6] + stock_records[i - 1][6] * 1.0)
5      results.append(diff * 100)

```

And last we plot the data:(xlen is the number of observations)

```

1 x = [e for e in range(0, xlen)]
2 plt.axis([0, len(x) - 1, -1.0, 1.0])
3 plt.xlabel('id')
4 plt.ylabel('Accuracy')
5
6 # plot changes in tweets
7 #y = get_median_change_tweets(trend_days)
8 if trend_days:
9     y = get_median_change_tweets(trend_days)
10 else:
11     y = get_median_change_tweets(get_tweet_trend_data())
12 plt.plot(x, y, '-r') # twitter data
13
14 y = get_stock_graph_data()
15 plt.plot(x, y, '-g') # finance data
16
17 plt.show()

```

And compares the two graphs plotted in the same view.

A.8 Issues

The quality of the code in general is quite good. But whether or not the logic works out all the time is uncertain. Some of the functions and methods can also be improved.

Operating System Impediments There might be some OS related specifics that we do not know about. Linux of the Debian family has been used. So we expect that you know what you are doing when testing the code on Windows or Mac.

If at all a problem, it will be with pre installed packages that will not show up in the requirements or library parts discussed earlier. That's because we do not know which packages were already installed.

Also some Linux tools have been used in scripts. Those will not work on Windows, but might on Mac.

Appendix B

Processed Articles

TODO merge into previous work chapter 2. and appendix a tweet usage thingy.

B.1 Article template

file:*filename.pdf* citation:[]

- * What did they use tweets for?
- * What do they do?
- * Event detection. Is the tweet about merging?
- * How is learning present? * Is the approach statistical of NLP? * Where can this article be useful later?
- * What does this article give answers to?

B.2 A Unified Model for Topics, Events and Users on Twitter

file: EMNLP192.pdf citation:[[Diao and Jiang, 2013](#)]

- * What did they use tweets for?
- Modelling topics, events and users in a unified way.

- * What do they do?

LDA-like topic model, Recurrent Chinese Restaurant Process(discover events), Event-topic affinity vectors to model association (events->topics), Detecting

meaningful events, Grouping events by topic. Tweet separation, topic(personal life)/event(global events)-tweet.

- * Event detection. Is the tweet about merging?

Online and offline detection. Online= early detection of major events, efficiency is the main focus. Offline, focusses on getting all the relevant tweets. Don't assume every tweet is linked to an event. LDA?

- * How is learning present?

- * Is the approach statistical or NLP?

- * Where can this article be useful later?

With event detection. Tweet separation. Financial tweets.

- * What does this article give answers to?

B.3 Twitter Part-of-Speech Tagging for All: Overcoming Sparse and Noisy Data

file:twitter-pos.pdf citation:[Derczynski et al., 2013]

B.4 Tweets and Trades: The Information Content of Stock Microblogs

file:SSRN-id1702854.pdf citation:[Sprenger and Welpe, December 2010]

- * What did they use tweets for?

"We find the sentiment (i.e., bullishness) of tweets to be associated with abnormal stock returns and message volume to predict next-day trading volume." [Sprenger and Welpe, December 2010]

- * How are tweets used?

- * Event detection. Is the tweet about merging?

- * Where can this article be useful later?

What twitter is used for, Twitter chapter.

Twitter incentives. [Sprenger and Welpe, December 2010, p4]

Description of bullishness, message volume and what it does etc.

[Sprenger and Welpe, December 2010, p52] suggest that stock microblogs can claim to capture key aspects of the market conversation.

Picking the right tweets remains just as difficult as making the right trades.

* What does this article give answers to?

Whether bullishness can predict returns. Whether message volume is related to returns, trading volume, or volatility. Whether the level of disagreement among messages correlates with trading volume or volatility. Whether and to what extent the information content of stock microblogs reflects financial market developments Whether microblogging forums provide an efficient mechanism to weigh and aggregate information

B.5 Exploiting Topic based Twitter Sentiment for Stock Prediction

file:*filename.pdf* citation:[[Si et al., 2013](#)]

* What did they use tweets for?

Predicting the stock market. Stock index time series analysis. daily one-day-ahead predictions.

* How are tweets used?

Dirichlet Process mixture model to learn the daily topic set. Vector regression. Topic-based prediction.

* Event detection. Is the tweet about merging?

* Where can this article be useful later?

Twitter's topic based sentiment can improve the prediction accuracy. [[Si et al., 2013](#), p28]

* What does this article give answers to?

B.6 Twitter as driver of stock price

file:*Twitter as driver of stock price-Jubbega.pdf* citation:[[Jubbega, 2011](#)]

* What did they use tweets for?

* How are tweets used?

* Event detection. Is the tweet about merging?

* Where can this article be useful later?

General about twitter.

* What does this article give answers to?

B.7 Twitter Polarity Classification with Label Propagation over Lexical Links and the Follower Graph

file:*twitter polarity classification.pdf* citation:[[Speriosu et al., 2011](#)]

* What did they use tweets for?

Polarity classification. Positive/negative.

* How are tweets used?

With label propagation. Distant supervision. Graph based data structure. user-¿tweet-¿bigram/unigram/hashtag/etc.

* Event detection. Is the tweet about merging?

* Where can this article be useful later?

Data section / sentiment /

Twitter section: What people uses twitter for.

Label propagation approach rivals a model supervised with in-domain annotated tweets and outperforms the noisily supervised classifier and a lexicon-based polarity ratio classifier. [[Speriosu et al., 2011](#)]

Twitter represents one of the largest and most dynamic datasets of user generated content.

* What does this article give answers to?

B.8 AVAYA: Sentiment Analysis on Twitter with Self-Training and Polarity Lexicon Expansion

file:*Sentiment Analysis on Twitter with Self-Training and Polarity Lexicon Expansion.pdf* citation:[[Becker et al., 2013](#)]

* What did they use tweets for?

Contextual Polarity Disambiguation and Message Polarity Classification * How are tweets used?

Constrained learning with supervised learning. Unconstrained model that used semi-supervised learning in the form of self-training and polarity lexicon expansion

* Event detection. Is the tweet about merging?

* Where can this article be useful later?

Technical approach of models and sentiment analysis. State of the art on sentiment analysis with twitter.

* What does this article give answers to?

dependency parses, polarity lexicons, and unlabeled tweets for sentiment classification on short messages

We hypothesize this performance is largely due to the expanded vocabulary obtained via unlabeled data and the richer syntactic context captured with dependency path representations. [Becker et al., 2013]

B.9 Robust Sentiment Detection on Twitter from Biased and Noisy Data

file:*Robust Sentiment Detection on Twitter from Biased and Noisy Data.pdf*

citation:[Barbosa and Feng, 2010]

* What did they use tweets for?

Sentiment analysis with focus on noise reduction.

* How are tweets used?

Noisy labels. Classifies tweets as subjective or objective. Then distinguishes the subjective into positive and negative tweets. Generalization of tweet classification. Meta-information. How tweets are written. More abstract representation.

* Where can this article be useful later?

Previous work, sentiment analysis, twitter, sentiment features. * What does this article give answers to?

It provides a better way to classify tweets.

B.10 Investor sentiment and the near-term stock market

file:*Investor sentiment and the near-term stock market.pdf* citation:[Brown and Cliff, 2004]

* Where can this article be useful later?

In the finance chapter for historic value and where we have come from.

[?, p2] on over-reaction of investors writes: " He(Siegel (1992)) concludes that shifts in investor sentiment are correlated with market returns around the crash. Intuitively, sentiment represents the expectations of market participants relative to a norm: a bullish (bearish) investor expects returns to be above

(below) average, whatever “average” may be.”. In the light of recent changes in the financial world and the utilisation of sentiment from social media, the notion that opinions and sentiment of investors and market actors affect the market is not a new observation.

[Brown and Cliff, 2004, p3] indicates that the sentiment does not cause subsequent market returns. For a short-term marketing timing this is bad news. However with the changes in social media over the last decade how is the situation today? With the microblogging sphere of today we can easily see the correlation of sentiment and the market indicators [TODO:Citation]. But does the sentiment cause changes in the market-return? [Brown and Cliff, 2004, p3] also says that optimism is associated with overvaluation and subsequent low returns.

* What does this article give answers to?

[Brown and Cliff, 2004, p] concludes that aggregated sentiment measures has strong co-movement with changes in the market. He also indicates that sentiment doesn’t appear to be a good trading strategy. This, in the view of [Zhang et al., 2011] indicates a leap in sentiment research and what is possible with the microblogging of today.

B.11 Predicting Stock Market Indicators Through Twitter

“I hope it is not as bad as I fear”

file:*Predicting Stock Market Indicators Through Twitter.pdf* citation:[Zhang et al., 2011]

* What did they use tweets for?

Gather hope and fear for each day using tweets. The sentiment indication of each day is compared to the marked indicators of the same day.

* How are tweets used?

Get the Positive/negative sentiment.

* Event detection. Is the tweet about merging?

* Where can this article be useful later?

Address the question of intention of users on twitter. Good summary of things done in regards to twitter. (Might be a bit outdated, from 2010).

* What does this article give answers to?

That hope, fear and worry makes the stock go down the day after. Calm times, little hope, fear or worry, makes the stock go up.

B.12 Deriving market intelligence from microblogs

file:*Deriving market intelligence from microblogs.pdf* citation:[[Li and Li, 2013](#)]

* How are tweets used?

Companies use twitter for feedback and customer relations. Questions can be asked with a hashtag of to a specific user. This makes it easy to sort filter the messages, and therefore easier to get in contact with the customer. Best Buy demonstrated the successfulness of twitter in customer relations by answering questions with a specific hashtag. In 2009 they had answered nearly 20 thousand questions using twitter. [[Li and Li, 2013](#), p1] Market Intelligence is also a major aspect of the microbloggin sphere.

* What did they use tweets for?

Sentiment classification. Topic detection, pos/neg classification.

* Event detection. Is the tweet about merging?

* Where can this article be useful later?

stateOf-twitter / state-sentiment / data /

* What does this article give answers to?

B.13 The social media stock pickers

file:*social_media_stock_pickers.pdf* citation:[[Stevenson, 2012](#)]

Opinion mining on the web is not a new phenomenon. But in resent years it has become much more attractive to traders in the financial world. Twitter and the social media's opinion is on the rise. This means a surplus of raw data with easy access. Companies all over the world has started to use twitter and readily available tweets to their benefit. Trading with social media is part of the trend. Although there are some drawbacks and shortcomings. Noise and garbage is one of them. It's difficult to accurately sort through all the data and get only the information relevant for your use. Even if your right 80% of the time, the last 20% can prove devastating. [[Stevenson, 2012](#)]

B.14 Sentiment and Momentum

file:*SSRN-id1479197.pdf* citation:[[Doukas et al., January 10, 2010](#)]

Not Twitter. Intra-day transaction data. Sentiment affects the profitability of price momentum strategies.

Use of sentiment can predict changes and momentum in the market. Bad news in an optimistic period creates cognitive dissonance in the small investors. This impacts the market by slowing down the selling rate of losing stocks. [Doukas et al., January 10, 2010, p29]

Sentiment broadly refers to the state of mind a person has. Whereas negative or positive. Based on the current state of mind the person will do optimistic or pessimistic choices. A positive state of mind leads to optimistic judgements of future events. And a negative state of mind leads to pessimistic judgements. [Doukas et al., January 10, 2010, p4]

Further we can see that optimistic sentiment has a 2% monthly average return. While the investor sentiment is pessimistic we see a drastic reduction in returns. Down to 0.34%. [Doukas et al., January 10, 2010, p5] After optimistic periods it is indicated that the monthly return is reduced to -0.49%. On the contrary there is no equivalent change after a pessimistic period. [Doukas et al., January 10, 2010, p6-7] Momentum profits are only significant when the sentiment is optimistic. [Doukas et al., January 10, 2010, p29]

B.15 Is Trading with Twitter only for Twits?

Document Description: Blog post that describes the findings of the article [TODO art:ref].

The article has developed a strategy for trading stocks based on the bullishness of the tweet. [TODO glossary bullishness] Bullishness as I understand it is the same as the negativity of the tweet.

The article bases its findings on three factors. The holding time of a stock (the time from you buy it until it's sold). The history of x days (how many of the past days are used to determine the tweet signal [TODO glossary tweet signal]). And the number of picks (how many stocks you hold at any given time).

It is also indicated that The main article has some good information about how tweets are built up. (Dollar-tagging for representation of a given stock, \$AAPL)

Has a good figure of the system.

Indicates that the message volume and trade volume are related.

RefArticle: ?? Twitter mood Predicts the Stock Market.

Tags: buy/sell-signals, tweet signals, dollar-tagged, OpinionFinder, GPOMS,

B.16 From Tweets to Polls: Linking Text Sentiment to Public Opinion Time Series

The article uses polling data and two years of tweets as their data.

Basically a comparison of the opinion expressed on twitter and the opinion from phone enquiries.

Uses word counting to distinguish relevant tweets from the rest.

The twitter dataset is huge, typically billions of tweets.

Daily sentiment = positive tweets / negative tweets.

Appendix C

Tweet usage overview

TODO Write what twitter has been used for in previous articles. Minimal Summary of stuff I could find. And reference articles.

- Time series
- Stock index time series analysis
- Message volume
- Message polarity, Bullishness/bearishness
- Predicting the stock market
- Predict next day-trading volume
- Daily one-day-ahead predictions
- Topic based prediction
- Vector regression
- Dirichlet Process mixture
- Label propagation
- Constrained and supervised learning.

Appendix D

Web resources

<http://hum.csse.unimelb.edu.au/emnlp2013/papers.html>

[http://neuro.imm.dtu.dk/wiki/Twitter_s*entiment_aanalysis*](http://neuro.imm.dtu.dk/wiki/Twitter_sentiment_analysis)

<http://provalisresearch.com/products/content-analysis-software/wordstat-dictionary/sentiment-dictionaries/>

[http://www3.nd.edu/~mcdonald/Word_L*ists.html*](http://www3.nd.edu/~mcdonald/WordLists.html)

Appendix E

Tweet Data Structure

```
{
  u'contributors': None,
  u'truncated': False,
  u'text': u'W02013149663A1 Estimating Anisotropic Resistivity Of A
Geological Subsurface $STO #G01V #G01V11 http://t.co/yyPFEJSdIj',
  u'in_reply_to_status_id': None,
  u'id': 390051769780142080,
  u'favorite_count': 0,
  u'source': u'<a href="http://w.pat.tc" rel="nofollow">TwittlyDumb</a>',
  u'retweeted': False,
  u'coordinates': {
    u'type': u'Point',
    u'coordinates': [
      5.7326363,
      58.9645836
    ]
  },
  u'entities': {
    u'symbols': [
      {
        u'indices': [
          77,
          81
        ],

```

```

        u'text': u'STO'
    }
],
u'user_mentions': [

],
u'hashtags': [
    {
        u'indices': [
            82,
            87
        ],
        u'text': u'G01V'
    },
    {
        u'indices': [
            88,
            95
        ],
        u'text': u'G01V11'
    }
],
u'urls': [
    {
        u'url': u'http://t.co/yyPFEJSdIj',
        u'indices': [
            96,
            118
        ],
        u'expanded_url': u'http://w.pat.tc/W02013149663A1',
        u'display_url': u'w.pat.tc/W02013149663A1'
    }
]
},
u'in_reply_to_screen_name': None,
u'in_reply_to_user_id': None,
u'retweet_count': 0,
u'id_str': u'390051769780142080',
u'favorited': False,

```

```

u'user': {
  u'follow_request_sent': False,
  u'profile_use_background_image': True,
  u'default_profile_image': False,
  u'id': 163877216,
  u'verified': False,
  u'profile_text_color': u'333333',
  u'profile_image_url_https': u'https://si0.twimg.com/profile_images/2309783804/355j4shhjrh4rqb5vsys_normal.jpeg',
  u'profile_sidebar_fill_color': u'DDEEF6',
  u'entities': {
    u'url': {
      u'urls': [
        {
          u'url': u'http://t.co/apqPEHN3aC',
          u'indices': [
            0,
            22
          ],
          u'expanded_url': u'http://w.pat.tc',
          u'display_url': u'w.pat.tc'
        }
      ]
    },
    u'description': {
      u'urls': [
        ]
    }
  },
  u'followers_count': 299,
  u'profile_sidebar_border_color': u'CODEED',
  u'id_str': u'163877216',
  u'profile_background_color': u'CODEED',
  u'listed_count': 8,
  u'profile_background_image_url_https': u'https://abs.twimg.com/images/themes/theme1/bg.png',
  u'utc_offset': 32400,
  u'statuses_count': 247688,

```

```

    u'description': u'New patent information from WIPO.
IPC-based hashtags for realtime subject searching.',
    u'friends_count': 203,
    u'location': u'Tsukuba, Japan',
    u'profile_link_color': u'0084B4',
    u'profile_image_url': u'http://a0.twimg.com/profile_images/
2309783804/355j4shhjrh4rqb5vsys_normal.jpeg',
    u'following': False,
    u'geo_enabled': True,
    u'profile_banner_url': u'https://pbs.twimg.com/profile_banners/
163877216/1359154591',
    u'profile_background_image_url': u'http://abs.twimg.com/images/
themes/theme1/bg.png',
    u'screen_name': u'w_pat_tc',
    u'lang': u'en',
    u'profile_background_tile': False,
    u'favourites_count': 10,
    u'name': u'World Patents Mapped',
    u'notifications': False,
    u'url': u'http://t.co/apqPEHN3aC',
    u'created_at': u'Wed Jul 07 14:08:23 +0000 2010',
    u'contributors_enabled': False,
    u'time_zone': u'Tokyo',
    u'protected': False,
    u'default_profile': True,
    u'is_translator': False
},
u'geo': {
    u'type': u'Point',
    u'coordinates': [
        58.9645836,
        5.7326363
    ]
},
u'in_reply_to_user_id_str': None,
u'possibly_sensitive': False,
u'lang': u'en',
u'created_at': u'Tue Oct 15 09:49:23 +0000 2013',
u'in_reply_to_status_id_str': None,

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u'place': {
  u'full_name': u'Stavanger, Rogaland',
  u'url': u'https://api.twitter.com/1.1/geo/id/dee2255bd015b52c.json',
  u'country': u'Norway',
  u'place_type': u'city',
  u'bounding_box': {
    u'type': u'Polygon',
    u'coordinates': [
      [
        [
          5.5655417,
          58.884420999999996
        ],
        [
          5.8687141,
          58.884420999999996
        ],
        [
          5.8687141,
          59.0608787
        ],
        [
          5.5655417,
          59.0608787
        ]
      ]
    ]
  },
  u'contained_within': [

  ],
  u'country_code': u'NO',
  u'attributes': {

  },
  u'id': u'dee2255bd015b52c',
  u'name': u'Stavanger'
},
u'metadata': {

```

```
    u'iso_language_code': u'en',  
    u'result_type': u'recent'  
  }  
}
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