Contextual Information Based Market Prediction using Dynamic Graph Neural Networks

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1. Introduction

Stock-related news can shadow the confidence and expectations of various stakeholders. From risk management to return volatility, shares or trade strategies will be adapted accordingly. Stock prices will change due to the supply-demand relationship changes, interest rates, investors, political in a dynamic macroeconomics environments.

2. Dataset

Reddit top news:
Ranked by Reddit users' votes, only the top 25 headlines are considered for a single date. (Range:2008-06-08 to 2016-07-01). We aim to predict the Dow Jones Industrial Average (DJIA) trend.
Trump's twitter:
We crawl some twitters of Trump from 2009 to 2018.
News about apple:
The dataset here consists of Stock Value of Apple(AAPL) from 2006 to 2016 and News summary, abstract and snippets on News featuring Apple during the same period.

Data Cleaning
m days of time series input to predict the stock price of the next day n
x n dimension adjacent matrices for each day, n is the number of all the words in m days
Setting for each dataset
Reddit: m=7. n: 7*25 articles to predict DJIA goes up or down.
Trump: m=7. n: twitter in 7 days to predict DJIA goes up or down.
Apple: m=2. n: words from 2*7 days of news summaries. We predict whether the AAPL goes up or down.

Data Preprocessing
Stop word
Words that appears too often gives no information: "a", "the".
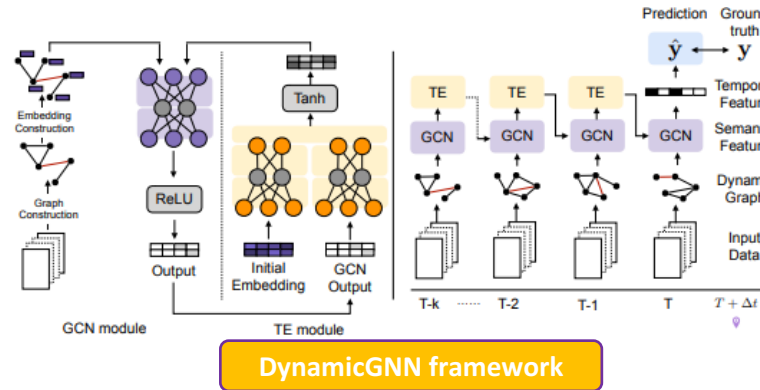**Word stemming**
Word with the same meaning or root. Transfer them to the initial root word: "work", "works", "worked"

3. Document-based point-wise mutual information (PMI)

d(i,j): total number of articles containing word i,j at time t.
d(i): the total number of articles containing i.

$$PMI_t(i,j) = \log \frac{d(i,j)}{d(i)d(j)/D}$$

$$A_t[i,j] = \begin{cases} PMI_t(i,j) & PMI_t(i,j) > 0 \\ 0 & otherwise \end{cases}$$

DynamicGNN framework

4. Graph Neural Network and Optimization

$$H_{t+1} = g\left(\hat{A}_t \tilde{H}_t W^{(t)} + b^{(t)}\right)$$ GCN Layer.

$$H_{t+1} = MLP_t\left(\hat{A}_t \tilde{H}_t\right)$$ GIN Layer.

Notations:

$\hat{A}_t \in \mathbb{R}^{n \times n}$ the normalized symmetric adjacency matrix at time step t.

$W^{(t)} \in \mathbb{R}^{F(t) \times F(t+1)}$

$b^{(t)} \in \mathbb{R}^{F^{(t+1)}}$ model parameters of the GCN layer at time step t .

$\tilde{H}_t$ the temporal encoded (TE) embeddings calculated from the last TE layer

MLP_t the multi-layer perceptron of the GIN layer at time step t .

$$\mathcal{L} = -\sum y \ln \hat{y}$$

5. Analysis

Table 1: Performance comparison on test set.

	Reddit				Trump				Apple			
	Prec.	Rec.	F1	Acc.	Prec.	Rec.	F1	Acc.	Prec.	Rec.	F1	Acc.
Random Guess	0.525	0.4884	0.506	0.4836	**0.5714**	0.5569	0.5641	0.5278	0.525	0.6176	0.5676	0.5362
Naive Bayes	**0.5602**	0.4977	0.5271	0.5164	0.5374	0.5	0.518	0.4895	0.6666	0.1765	0.2791	0.5507
DynamicGCN	0.5498	**0.8465**	**0.6667**	**0.5416**	0.5374	**0.9742**	**0.6927**	**0.5347**	0.6875	0.8049	0.7416	**0.6667**
DynamicGIN	0.5587	0.6419	0.5974	0.5315	0.5365	0.9484	0.6853	0.5312	0.6	0.75	0.6667	0.6087
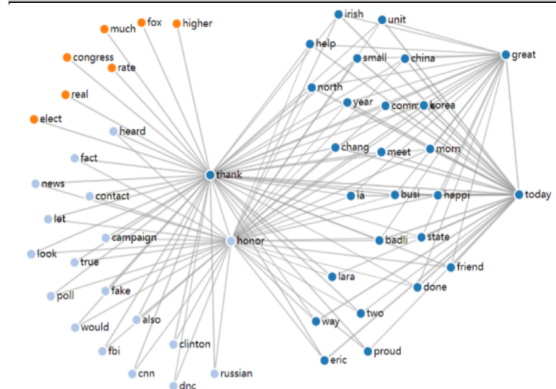
"Thank you Brock – it is my honor. We (@FEMA) have never had the support that we have had from this President. @FEMABrock. – Sat Sep 15 20:41:45 +0000 2018

More datasets to evaluation
Instead of a particular stock, we can try more indices such as SNP, MSCI World, FTSE All-World, etc.
More possibilities to explore
We have implemented DynamicGIN, however, we might have tried the combination of other variants of the state-of-the-art neural networks given more time

6. Conclusion

We conduct a series of experiments to apply DynamicGNN to stock trend prediction. The results show both DynamicGCN and DynamicGIN are effective compared to machine learning method given limited data.As far as we know, adopting dynamic graph embedding into finance industries with twitter data have great potential.