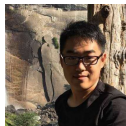
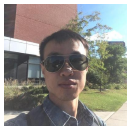
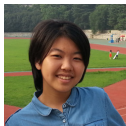


TIMME: Twitter Ideology-detection via Multi-task Multi-relational Embedding



Zhiping (Patricia) Xiao, Weiping Song, Haoyan Xu,
Zhicheng Ren, Yizhou Sun

KDD'20 Applied Data Science Track



TIMME

Motivation

Data

Preliminaries

Contribution

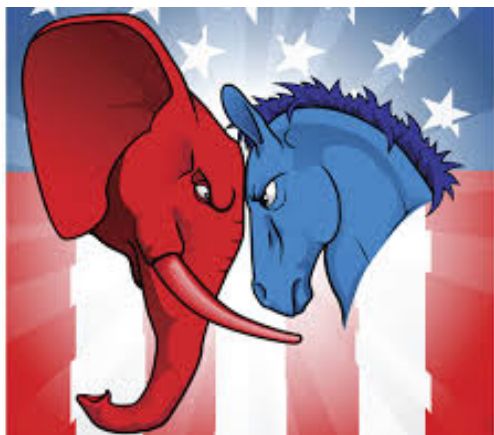
Model

Highlighted Results

Resources

TIMME





The picture comes from <http://www.marekrei.com/blog/political-ideology-detection/>.

The screenshot shows the Congress.gov website interface. At the top, the URL is [congress.gov/congressional-record](https://www.congress.gov/congressional-record). The main navigation bar includes "CONGRESS.GOV", "Advanced Searches", and "Browse". A search bar contains the text "homeland security", medicare. Below the search bar, there are links for "Home", "Congressional Record (Most Recent Issue)", and "Daily Digest". A message states: "The Congressional Record dated June 25th, 2020 is not yet available. To receive an email when the issue becomes available on Congress.gov, [subscribe to alerts](#)." The main heading is "Congressional Record" with the subtitle "Proceedings and Debates of the U.S. Congress". Navigation links include "Most Recent Issue", "Browse By Date", "CR Index", "About", "App for iPhone or iPad", and "Get alerts". The date "June 26, 2020" is prominently displayed, followed by "116th Congress (2019 - 2020), 2nd Session" and "Issue: Vol. 166, No. 118 — Daily Edition". A link for "Entire Issue (PDF)" is provided. A search section titled "Find an issue of the Record (1995-Present)" has a "Date:" label and a text input field containing "mm/dd/yyyy". Below this is a link: "Or enter year and page number." At the bottom, a "Sections in This Issue:" section shows "Daily Digest" as the selected section, with other options being "House of Representatives" and "Extensions of Remarks". A "Daily Digest" section is also visible, with a link for "Daily_Digest_Section (PDF)".

<https://www.congress.gov/congressional-record>



Barack Obama 
@BarackObama

Dad, husband, President, citizen.

Washington, DC  [obama.org](https://www.obama.org)  Born August 4, 1961
 Joined March 2007

604.2K Following 120.2M Followers

Not followed by anyone you're following

Tweets Tweets & replies Media Likes

 Pinned Tweet

 **Barack Obama**  @BarackObama · Jun 1

I wrote out some thoughts on how to make this moment a real turning point to bring about real change—and pulled together some resources to help young activists sustain the momentum by channeling their energy into concrete action.



Donald J. Trump 
@realDonaldTrump

45th President of the United States of America 

Washington, DC  [Instagram.com/realDonaldTrump](https://www.instagram.com/realDonaldTrump)
 Joined March 2009

46 Following 82.5M Followers

Not followed by anyone you're following

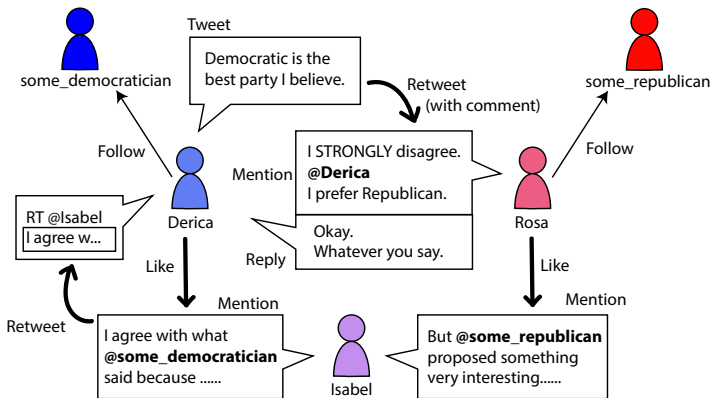
Tweets Tweets & replies Media Likes

 Donald J. Trump Retweeted

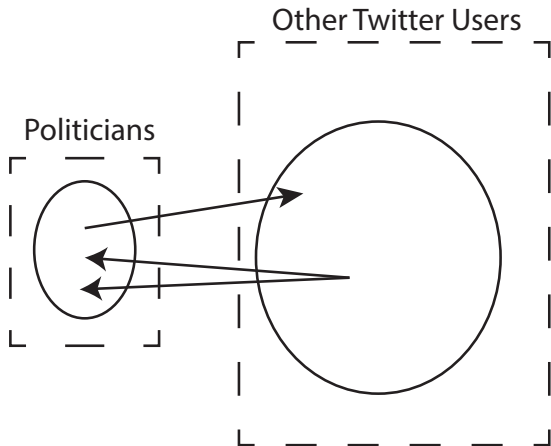
 **Dan Scavino**  @DanScavino · Jun 21



Example: US Presidents on Twitter
API: <https://developer.twitter.com/en>



Problem: Ideology Classification on Twitter



	PureP	P50	P20~50	P+all
# User	583	5,435	12,103	20,811
# Link	122,347	1,593,721	1,976,985	6,496,107
# Labeled User	581	759	961	1,206
# Featured User	579	5,149	11,725	19,418
# Follow-Link	59,073	529,448	158,746	915,438
# Reply-Link	1,451	96,757	121,133	530,598
# Retweet-Link	19,760	311,359	595,030	1,684,023
# Like-Link	14,381	302,571	562,496	1,794,111
# Mention-Link	27,682	353,586	539,580	1,571,937

Political-Centered Social Network Dataset

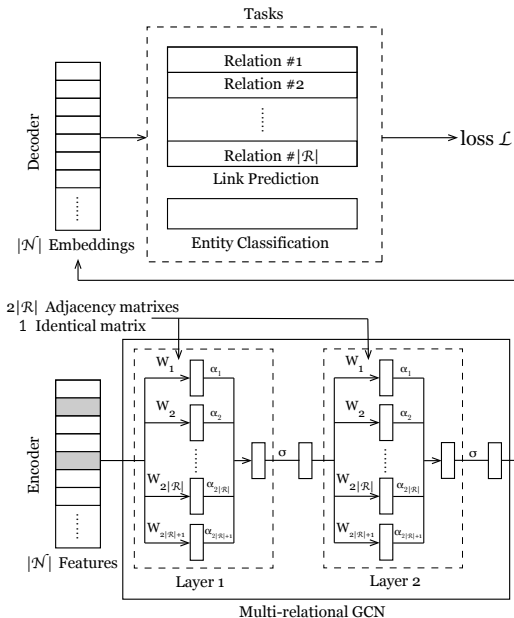
Literature Review:

- ▶ GCN (Graph Convolutional Network)
http://web.cs.ucla.edu/~patricia.xiao/files/Reading_Group_20181204.pdf
- ▶ MTL (Multi-Task Learning)
http://web.cs.ucla.edu/~patricia.xiao/files/Reading_Group_20200121.pdf

- ▶ Political-Centered Social Network Dataset
 - ▶ Described in Appendix, released with code

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 - ▶ Described in Appendix, released with code
- ▶ TIMME: learning embeddings on sparsely-labeled heterogeneous graph
 - ▶ MTL: handles the sparsity of labels
 - ▶ *Optionally* handles incomplete input features



In homogeneous GCN layers:

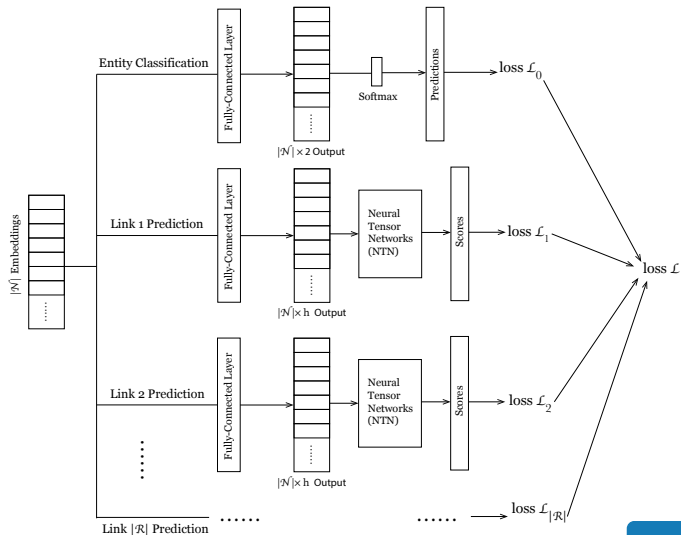
$$H^{(l+1)} = \sigma\left(\hat{A}H^{(l)}W^{(l)}\right)$$

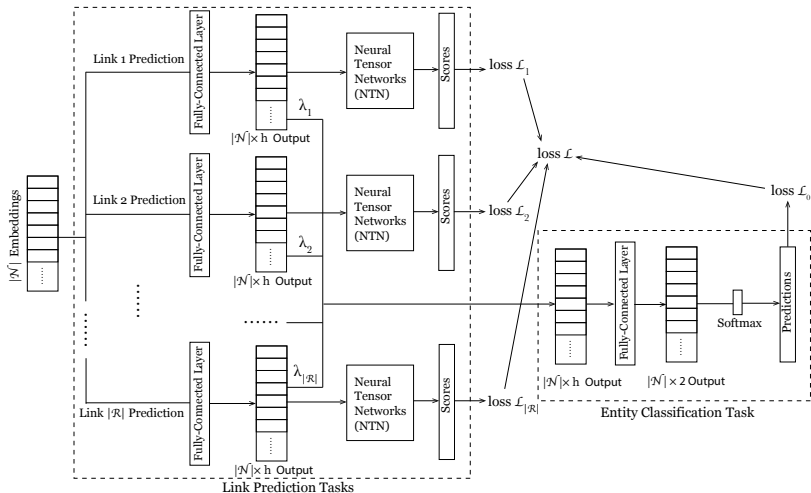
\hat{A} : the normalized adjacency matrix; $H^{(l+1)}$: layer- l output;
 $H^{(l)}$: layer- l input; $W^{(l)}$: layer- l weight.

In our heterogeneous design:

$$H^{(l+1)} = \sigma\left(\sum_{r \in \hat{R}} \alpha_r \hat{A}_r H^{(l)} W_r^{(l)}\right)$$

α_r : attention weight; $|\hat{R}| = 2R + 1$ includes R relations, R reversed relations, 1 identical matrix I .





TIMME and **TIMME-hierarchical**:

$$\mathcal{L} = \sum_{i=0}^{|\mathcal{R}|} \mathcal{L}_i$$

loss is the sum of losses from all $|\mathcal{R}| + 1$ tasks.

- ▶ **TIMME-hierarchical** gives us clues on each relation's importance to ideology classification via λ .

TIMME-single:

$$\mathcal{L} = \mathcal{L}_i$$

for a single task i , $i \in \{0, 1, 2, \dots, |\mathcal{R}|\}$.

- ▶ **TIMME-single** proves that multi-task version is better.

Evaluate on task level:

- ▶ Node-Classification Task:

- ▶ Accuracy
- ▶ F1-Score

- ▶ Link-Prediction Task:

- ▶ ROC-AUC (Receiver Operating Characteristic Area Under Curve)
- ▶ PR-AUC (Precision-Recall Area Under Curve)

Case study:

- ▶ State-level
- ▶ County-level
- ▶ Account-level

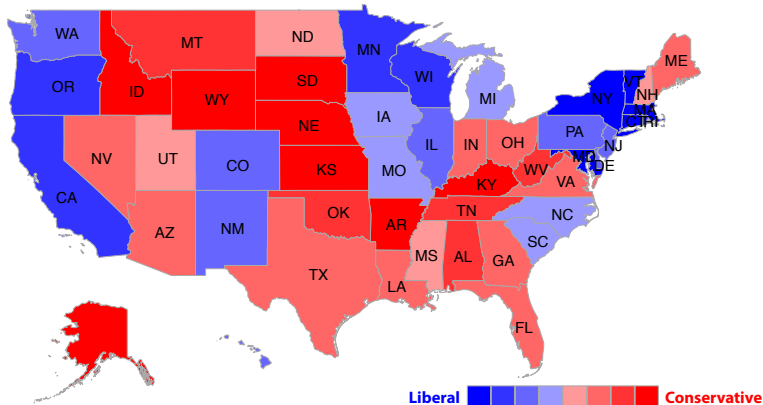
Ablation study

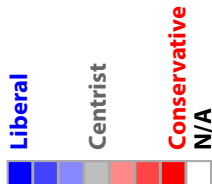
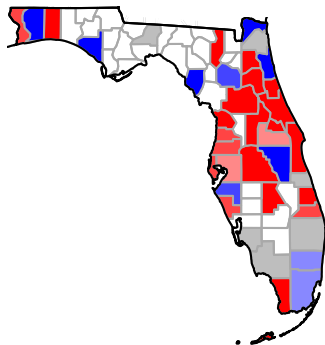
Model	PureP	P50	P20~50	P=all
GCN	1.0000/1.0000	0.9600/0.9600	0.9895/0.9895	0.9076/0.9083
r-GCN	1.0000/1.0000	0.9733/0.9733	0.9895/0.9895	0.9327/0.9333
HAN	0.9825/0.9824	0.9466/0.9467	0.9789/0.9789	0.9238/0.9250
TIMME-single	1.0000/1.0000	0.9733/0.9733	0.9895/0.9895	0.9333/0.9324
TIMME	0.9825/0.9824	0.9867/0.9867	1.0000/1.0000	0.9495/0.9500
TIMME-hierarchical	1.0000/1.0000	0.9733/0.9780	0.9895/0.9895	0.9580/0.9583

Table 2: Node classification measured by F1-score/accuracy.

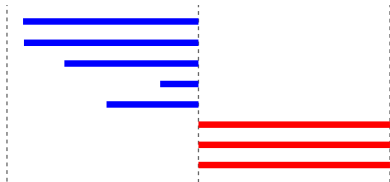
Model	PureP	P50	P20~50	P=all
Follow Relation				
GCN+	0.8696/0.6167	0.9593/0.8308	0.9870/0.9576	0.9855/0.9329
r-GCN	0.8596/0.4091	0.9488/0.8023	0.9872/0.9537	0.9685/0.9201
HAN+	0.8891/0.7267	0.9598/0.8642	0.9620/0.8550	0.9723/0.9256
TIMME-single	0.8809/0.6325	0.9717/0.8792	0.9920/0.9709	0.9936/0.9696
TIMME	0.8763/0.6324	0.9811/0.9154	0.9945/0.9799	0.9943/0.9736
TIMME-hierarchical	0.8812/0.6409	0.9809/0.9145	0.9984/0.9813	0.9944/0.9739
Reply Relation				
GCN+	0.8602/0.7306	0.9625/0.9022	0.9381/0.8665	0.9705/0.9154
r-GCN	0.7962/0.6279	0.9421/0.8714	0.8868/0.7815	0.9640/0.9085
HAN+	0.8445/0.6359	0.9598/0.8616	0.9495/0.8664	0.9757/0.9210
TIMME-single	0.8685/0.7018	0.9695/0.9307	0.9593/0.9070	0.9775/0.9508
TIMME	0.9077/0.8094	0.9718/0.9417	0.9747/0.9347	0.9819/0.9612
TIMME-hierarchical	0.9224/0.8152	0.9766/0.9409	0.9737/0.9341	0.9854/0.9629
Retweet Relation				
GCN+	0.8955/0.7145	0.9574/0.8493	0.9351/0.8408	0.9724/0.9303
r-GCN	0.8865/0.6895	0.9411/0.8084	0.9063/0.7728	0.9735/0.9326
HAN+	0.7646/0.6139	0.9658/0.9213	0.9478/0.8962	0.9750/0.9424
TIMME-single	0.9015/0.7202	0.9754/0.9127	0.9673/0.9073	0.9824/0.9424
TIMME	0.9094/0.7285	0.9779/0.9181	0.9772/0.9291	0.9858/0.9511
TIMME-hierarchical	0.9105/0.7344	0.9780/0.9190	0.9766/0.9275	0.9869/0.9543
Like Relation				
GCN+	0.9007/0.7259	0.9527/0.8499	0.9349/0.8400	0.9690/0.9032
r-GCN	0.8924/0.7161	0.9343/0.7966	0.9038/0.7681	0.9510/0.8945
HAN+	0.8606/0.6176	0.9733/0.8851	0.9611/0.9062	0.9894/0.9481
TIMME-single	0.9113/0.7654	0.9725/0.9119	0.9655/0.9069	0.9796/0.9374
TIMME	0.9249/0.7926	0.9753/0.9171	0.9759/0.9292	0.9846/0.9504
TIMME-hierarchical	0.9278/0.7945	0.9752/0.9175	0.9752/0.9271	0.9851/0.9518
Mention Relation				
GCN+	0.8480/0.6233	0.9602/0.8617	0.9261/0.8170	0.9665/0.8910
r-GCN	0.8312/0.6023	0.9382/0.7963	0.8938/0.7563	0.9640/0.8902
HAN+	0.9000/0.7206	0.9573/0.8616	0.9574/0.8891	0.9724/0.9119
TIMME-single	0.8587/0.6502	0.9713/0.8981	0.9614/0.8923	0.9725/0.9096
TIMME	0.8684/0.6689	0.9730/0.9035	0.9730/0.9185	0.9839/0.9446
TIMME-hierarchical	0.8643/0.6597	0.9732/0.9046	0.9723/0.9166	0.9846/0.9463

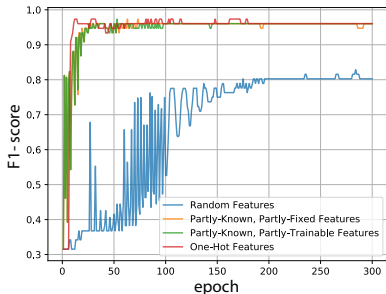
Table 3: Link-prediction measured by ROC-AUC/PR-AUC.



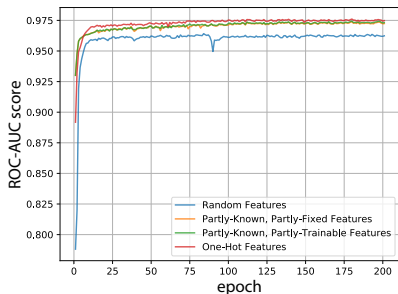


New York Times (@nytimes)
Guardian News (@guardiannews)
CBC News (@cbcnews)
CNN (@CNN)
Christian Science Monitor (@csmonitor)
The American Spectator (@amspectator)
Fox News Opinion (@FoxNewsOpinion)
National Review (@NRO)

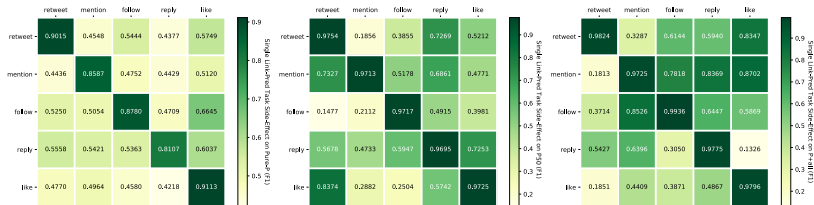




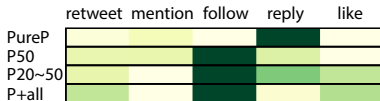
(a) Features' Impact on Node-Classification Task



(b) Features' Impact on "Follow" Link-Prediction Task



TIMME-single on Pure-P (left), P50 (middle), P+all (right)
 Figure 9 in paper; **typo: not “F1”, it should be “ROC-AUC”**.



TIMME-hierarchical model's λ values learned in the end.

Resources



Code with data available on Github:

- ▶ <https://github.com/PatriciaXiao/TIMME>

Presentation etc. on my personal website:

- ▶ <http://web.cs.ucla.edu/~patricia.xiao/timme.html>

Special thanks to: Haoran Wang, Zhiwen Hu, Yupeng Gu

