Twitter User Geolocation Using Deep Multiview Learning

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Social Networks and Location of Users

2.2B active users

330M active users

255M active users

- Location of users enable many applications
- User location profile information might be missed or ambiguous: e.g. "Small town", "Everywhere"
- ~3% of tweets are geo-tagged [3]

Reference: https://www.statista.com/statistics/272014/global-social-networks-ranked-by-number-of-users/

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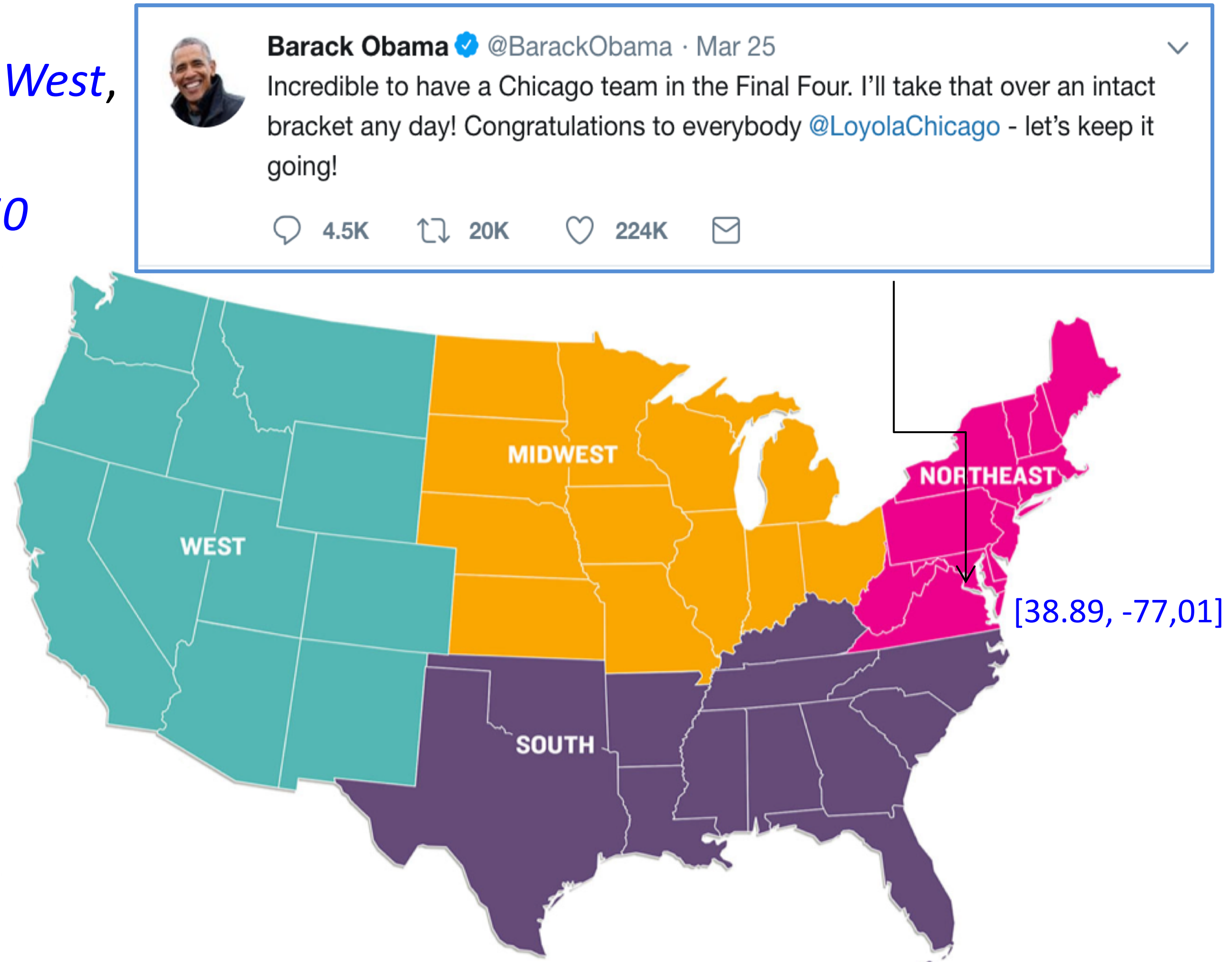
The Tasks of Twitter User Geolocation

- Region classification: *Northeast*, *Midwest*, *West*, and *South*
- State classification: *50 states*
- Geo-coordinates prediction: (*latitude, longitude*)



Region and state boundaries are from the US census shape files

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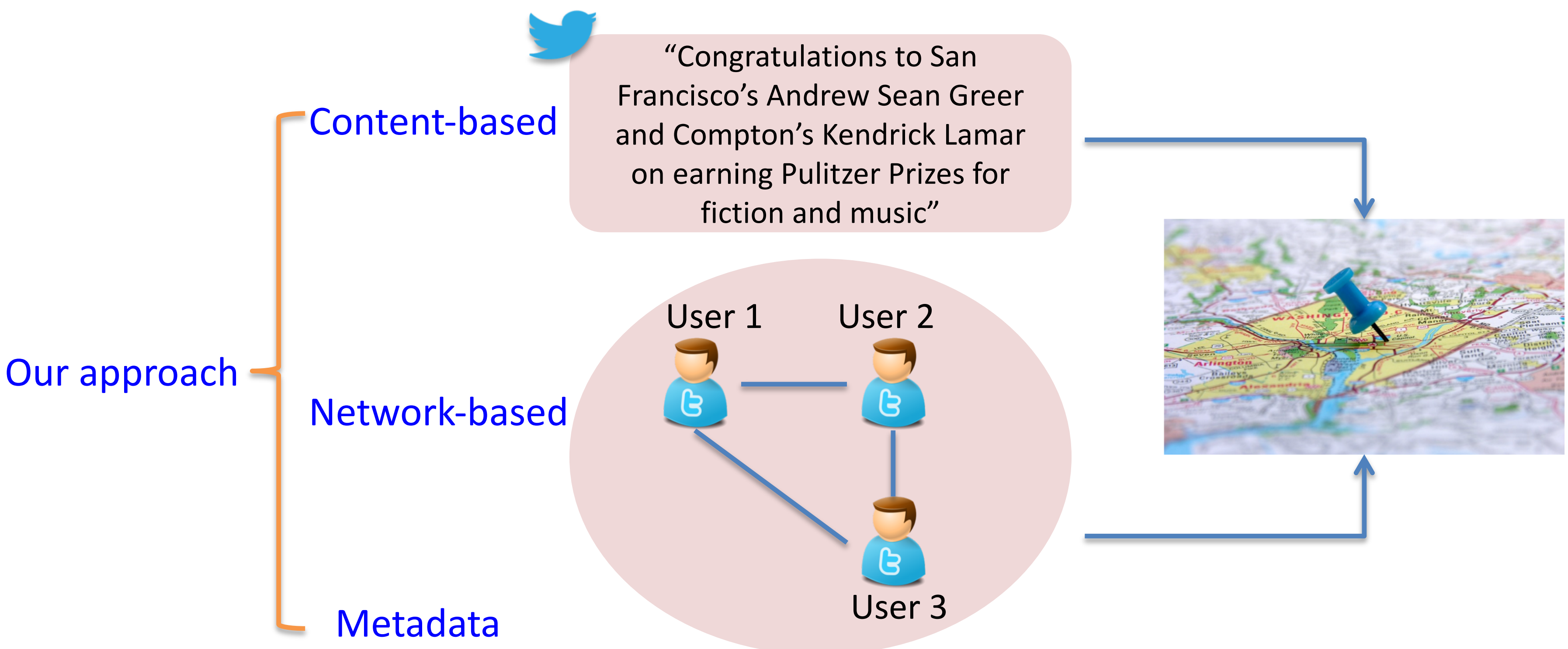
Our Approaches



- Content-based: Tweets are used for location prediction
- Network-based: Online relationships (e.g. following, mentioning) are used for location prediction

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Learning from Multiple Views

- Processing: Tweets from the same user are concatenated making up a tweet document
- Feature extraction:
  - Individual word level: Term frequency-inverse document frequency (*TF-IDF*)
  - Semantic level: *Doc2vec*
  - User connection structure: *Node2vec*
  - Metadata: Posting *timestamps* of tweets

Content features

Network feature

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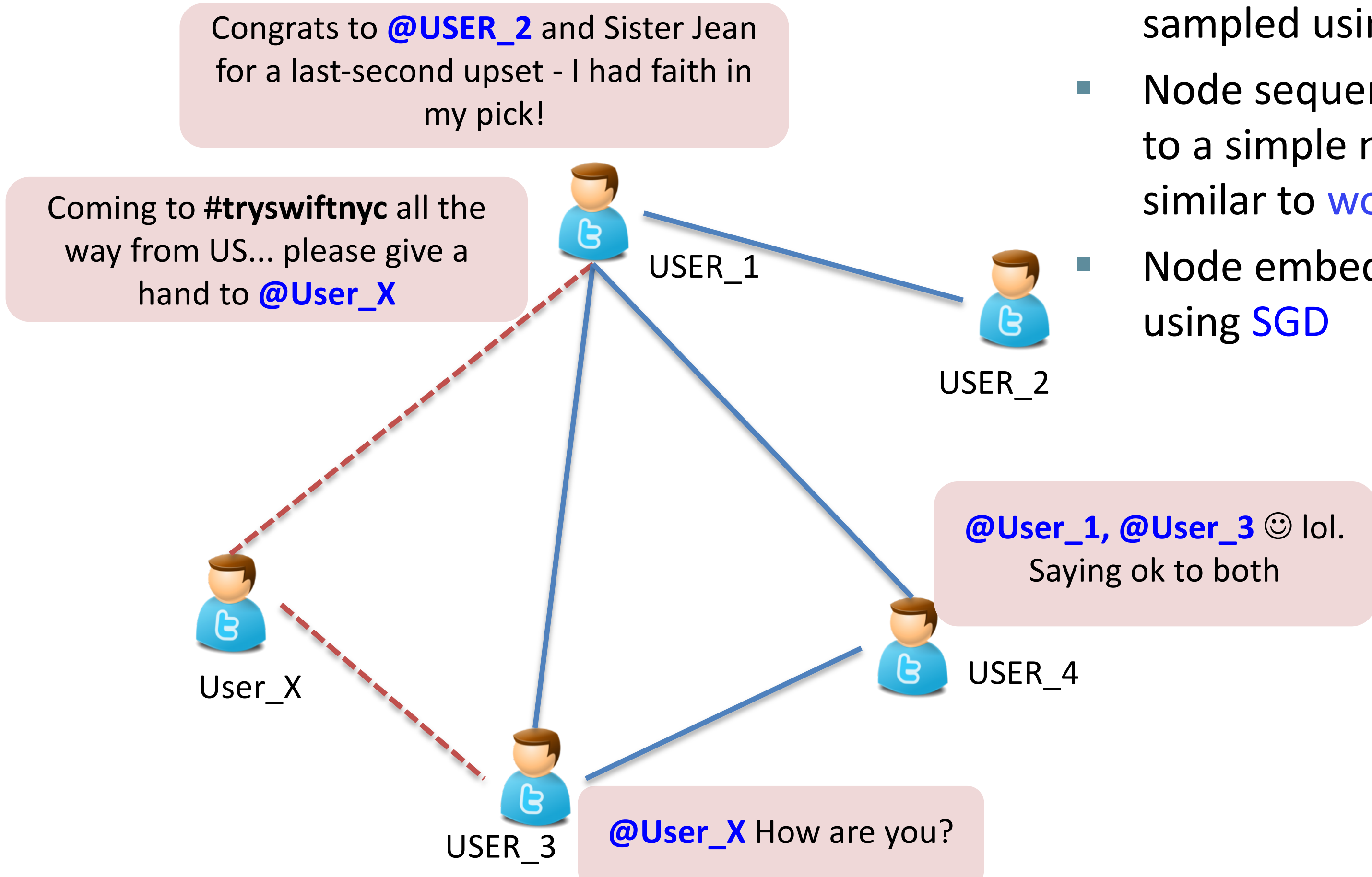
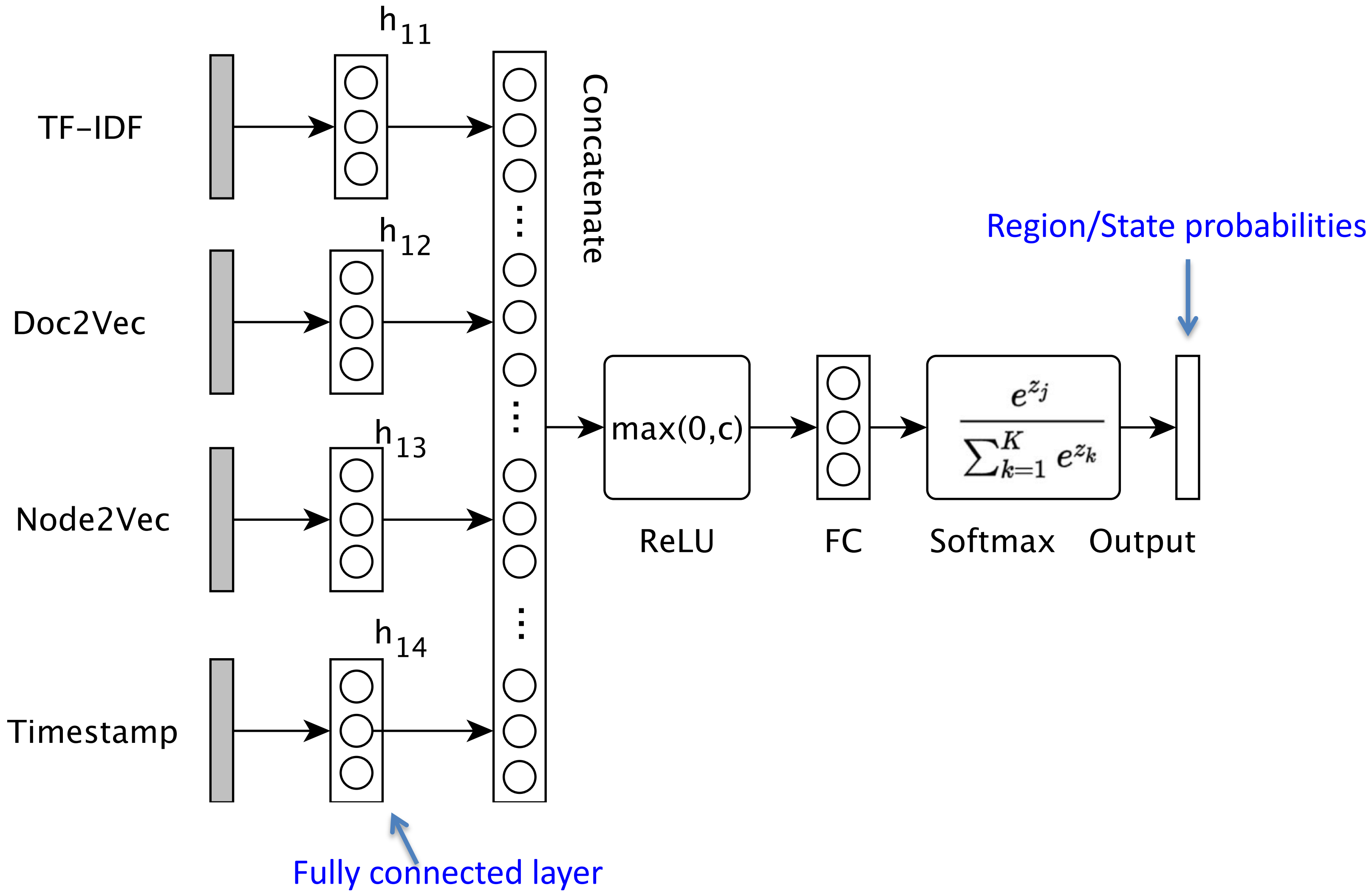
User Representation as Node Embedding

- Sequences of node indices are sampled using Random Walk [7]
- Node sequences are the input to a simple neural network similar to word2vec [8]
- Node embeddings are trained using SGD



MENET: Proposed Architecture



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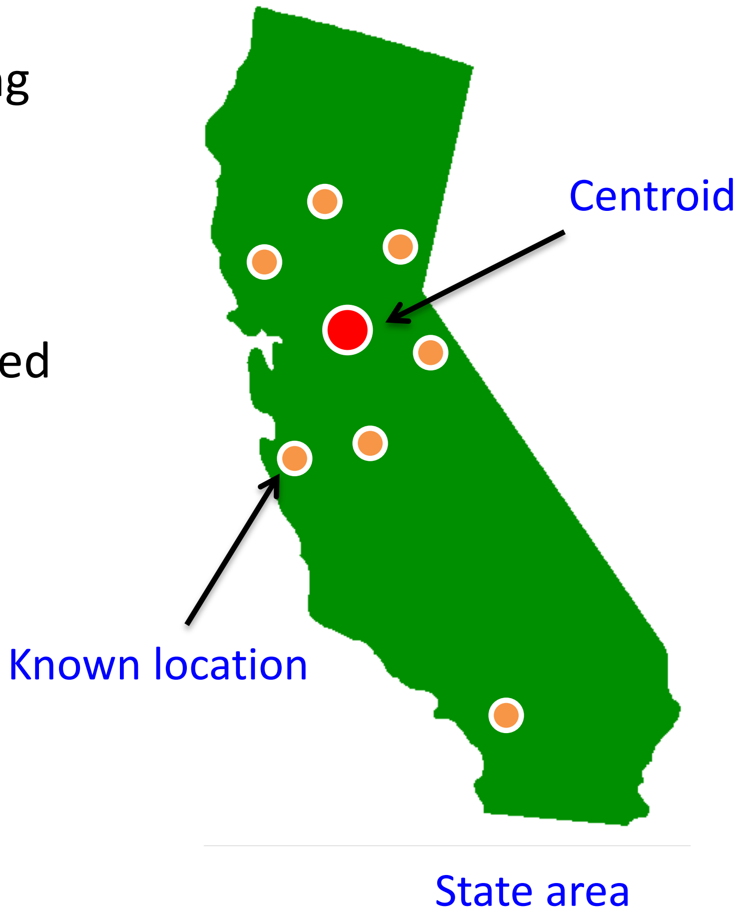
From Classification to Regression

1. Predict the state label
2. Predict geographical coordinates using the centroid of the state
3. State centroid = median {[latitude, longitude]}
4. The centroid coordinates are calculated from the geographical coordinates available in the training set



Performance criteria

- Region and state classification: Accuracy (%)
- Geographical coordinates prediction:
  - Mean distance error (km)
  - Median distance error (km)
  - Accuracy within 161 km (~100 miles) or @161 (%)
- The distance between two locations is computed using the Haversine formula

$$a = \sin^2(\Delta\varphi/2) + \cos\varphi_1 \cdot \cos\varphi_2 \cdot \sin^2(\Delta\lambda/2)$$

$$c = 2 \cdot \operatorname{atan2}(\sqrt{a}, \sqrt{(1-a)})$$

$$d = R \cdot c$$

ϕ: Latitude
λ: Longitude
R: The Earth's radius

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Experimental Results

Table 1. Region and state classification result on GeoText[1] and UTGeo2011[4]

	GeoText		UTGeo2011	
	Region (%)	State (%)	Region (%)	State (%)
Eisenstein *et al.* [1]	58	27	N/A	N/A
Liu & Inkpen [2]	61.1	34.8	N/A	N/A
Cha *et al.* [3]	67	41	N/A	N/A
MENET	**76**	**64.8**	83.7	69

- 9% improvement for region classification
- 23.8% improvement for state classification

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Experimental Results

Table 2. Geo-coordinates prediction on GeoText[1] and UTGeo2011[4]

	GeoText			UTGeo2011		
	mean (km)	median (km)	@161 (%)	mean (km)	median (km)	@161 (%)
Eisenstein *et al.* [1]	900	494	N/A	N/A	N/A	N/A
Roller *et al.* [4]	897	432	35.9	860	463	34.6
Liu and Inkpen [2]	855.9	N/A	N/A	733	377	24.2
Cha *et al.* [3]	581	425	N/A	N/A	N/A	N/A
Rahimi *et al.* (2015) [5]	581	**57**	59	529	78	60
Rahimi *et al.* (2017) [6]	578	61	59	515	**77**	**61**
MENET	**570**	58	**59.1**	**474**	157	50.5

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Conclusion

- Twitter user geo-location is challenging due to noisy data.
- Combine the content and network features can improve the geo-location accuracy.
- Multi-view learning can exploit different views of Twitter data for location prediction.
- The proposed architecture can be extended with different types of features or by adding more hidden layers.
- The distribution of Twitter users will be considered in the future work.

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References

1. J. Eisenstein, B. O'Connor, N. A. Smith, and E. P. Xing, "A latent variable model for geographic lexical variation", in *Conference on Empirical Methods in Natural Language Process ing*, 2010, pp. 1277–1287.
2. J. Liu and D. Inkpen, "Estimating user location in social media with stacked denoising auto-encoders", in *Conference of the North American Chapter of the Association for Computational Linguistics - Human Language Technologies*, 2015, pp. 201– 210.
3. M.Cha, Y.Gwon, and H.T.Kung, "Twitter geolocationandre- gional classification via sparse coding", in *International AAAI Conference on Web and Social Media*, 2015, pp. 582–585.
4. S. Roller, M. Speriosu, S. Rallapalli, B. Wing, and J. Baldridge, "Supervised text-based geolocation using language models on an adaptive grid", in *Joint Conference on Empirical Methods in Natural Language Processing and Computational Natural Language Learning*, 2012, pp. 1500–1510.

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References

5. A.Rahimi, T.Cohn, and T.Baldwin, “Twitter user geolocation using a unified text and network prediction model”, in *Annual Meeting of the Association for Computational Linguistics and the International Joint Conference on Natural Language Processing*, 2015, pp. 630–636.
6. A. Rahimi, T. Cohn, and T. Baldwin, “A neural model for user geolocation and lexical dialectology”, in *Annual Meeting of the Association for Computational Linguistics*, 2017, pp. 209–216.
7. A. Grover and J. Leskovec, “node2vec: Scalable feature learning for networks”, in *ACM SIGKDD International Conference on Knowledge Discovery and Data Mining*, 2016, pp. 855-864
8. T. Mikolov, I. Sutskever, K. Chen, G. Corrado, and J. Dean, “Distributed representations of words and phrases and their compositionality”, in *Advances in neural information processing systems*, 2013, pp. 3111–3119.

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Thank you for your attention !

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