

Fake News: Fundamental Theories, Detection Strategies and Challenges

Xinyi Zhou, Reza Zafarani
Data Lab, EECS Department
Syracuse University
{zhouxinyi,reza}@data.syr.edu

Kai Shu, Huan Liu
Computer Science and Engineering
Arizona State University
{kai.shu,huan.liu}@asu.edu

ABSTRACT

The explosive growth of fake news and its erosion to democracy, justice, and public trust increased the demand for fake news detection. As an interdisciplinary topic, the study of fake news encourages a concerted effort of experts in computer and information science, political science, journalism, social science, psychology, and economics. A comprehensive framework to systematically understand and detect fake news is necessary to attract and unite researchers in related areas to conduct research on fake news. This tutorial aims to clearly present (1) fake news research, its challenges, and research directions; (2) a comparison between fake news and other related concepts (e.g., rumours); (3) the fundamental theories developed across various disciplines that facilitate interdisciplinary research; (4) various detection strategies unified under a comprehensive framework for fake news detection; and (5) the state-of-the-art datasets, patterns, and models. We present fake news detection from various perspectives, which involve news content and information in social networks, and broadly adopt techniques in data mining, machine learning, natural language processing, information retrieval and social search. Facing the upcoming 2020 U.S. presidential election, challenges for automatic, effective and efficient fake news detection are also clarified in this tutorial.

CCS CONCEPTS

• **Human-centered computing** → *Collaborative and social computing theory, concepts and paradigms; Empirical studies in collaborative and social computing*; • **Social and professional topics** → *Computer crime*; • **Applied computing** → *Computer forensics*;

KEYWORDS

Fake news; fake news detection; news verification

ACM Reference Format:

Xinyi Zhou, Reza Zafarani and Kai Shu, Huan Liu. 2019. Fake News: Fundamental Theories, Detection Strategies and Challenges. In *The Twelfth ACM International Conference on Web Search and Data Mining (WSDM '19)*, February 11–15, 2019, Melbourne, VIC, Australia. ACM, New York, NY, USA, 2 pages. <https://doi.org/10.1145/3289600.3291382>

Permission to make digital or hard copies of part or all of this work for personal or classroom use is granted without fee provided that copies are not made or distributed for profit or commercial advantage and that copies bear this notice and the full citation on the first page. Copyrights for third-party components of this work must be honored. For all other uses, contact the owner/author(s).

WSDM '19, February 11–15, 2019, Melbourne, VIC, Australia

© 2019 Copyright held by the owner/author(s).

ACM ISBN 978-1-4503-5940-5/19/02.

<https://doi.org/10.1145/3289600.3291382>

1 CONTEXT AND MOTIVATION

Fake news is now viewed as one of the greatest threats to democracy, journalism, and economies. It has weakened public trust in governments and its potential impact on the contentious “Brexit” referendum and the equally divisive 2016 U.S. presidential election - which it might have affected [1] - is yet to be realized. The reach of fake news was best highlighted during the critical months of the 2016 U.S. presidential election campaign, where top twenty frequently-discussed false election stories generated 8,711,000 shares, reactions, and comments on Facebook, ironically, larger than the total of 7,367,000 for the top twenty most-discussed election stories posted by 19 major news websites [12]. Our economies are not immune to fake news either, impacting stock markets and leading to massive trades. For example, fake news claiming that Barack Obama was injured in an explosion wiped out \$130 billion in stock value [8].

The generous benefits in fake news activities are one of the motivations for people to initiate and engage in such activities. Consider dozens of “well-known” teenagers in the Macedonian town of Veles who produced fake news for millions on social media and became wealthy by penny-per-click advertising during the 2016 U.S. presidential election [13]. Such stories attach greater importance to fake news detection and intervention as they provide an incentive for individuals to become the next “Macedonian teenagers” in the upcoming 2020 U.S. presidential election. On the other hand, with fake news detection research in its early stages, greater opportunities exist for malicious individuals to create and spread fake news in the absence of a worry. To facilitate further development in this area, we address both theoretical and technical aspects of fake news detection in this tutorial:

- (1) Interdisciplinary fake news research is encouraged, where fundamental theories developed across disciplines can facilitate qualitative and quantitative studies, as well as developing well-justified and explainable fake news detection techniques.
- (2) A comprehensive framework and strategy to systematically understand and detect fake news is necessary. Such strategies attract and unite researchers mastering knowledge and technologies in related areas to work on fake news topic.
- (3) Open issues and challenges for fake news studies should be clarified to highlight future research directions and priorities.

2 TUTORIAL OUTLINE

Preventing fake news from impacting democracy, journalism and economies demands researchers, practitioners, and industry leaders to attach great importance to understanding and detecting fake news. Given a clear definition of fake news, this tutorial presents a

comprehensive survey of fake news research. In particular, the tutorial (1) identifies fundamental theories across various disciplines; (2) elaborates the detection strategies under a comprehensive framework and further introduces the related datasets, patterns, models, and algorithms; (3) clarifies the open issues in the state-of-the-art, and challenges to be faced for the development of fake news studies.

Fundamental Theories. Human vulnerability to fake news, which can bring in useful clues or further complicate fake news detection, has been a subject of interdisciplinary research. For instance, achievements in forensic psychology such as *Undeutsch hypothesis* [14] have pointed out the style difference between truth and deceptive information. Similarly, interdisciplinary research has looked at why individuals spread fake information, considering that the borderline between malicious and normal users becomes unclear – normal people can frequently and unintentionally participate in fake news activities as well, due to, e.g., social identity [2] or self-preexisting knowledge [6]. This tutorial conducts a comprehensive literature study across various disciplines. We review more than twenty well-known theories that can contribute to our understanding of fake news and participants in fake news activities. We present and discuss the problems arising as explained by these theories, ranging from the patterns they can reveal, the qualitative and quantitative fake news studies one can conduct based on these studies, to the specific roles they can play to detect fake news.

Detection Strategies. Detecting fake news is a complex and multidimensional task due to the characteristics of fake news. The detection strategies exploit multiple news-related (e.g., headline, body text, publisher) and social-related (e.g., feedback, propagation paths and spreaders) types of information. Each information type can be in the form of text, multimedia, network, etc., corresponding to various applicable techniques and usable resources. The tutorial reviews the detection of fake news from four perspectives of *knowledge, style, propagation* and *credibility*. Specifically, from a knowledge perspective, fake news detection is a “comparison” between the relational knowledge extracted from the to-be-verified news articles and that of knowledge-bases representing facts/ground truth [7]. Style-based fake news detection aims to capture and quantify the differences in writing styles between fake and true news. Propagation-based fake news detection uses information provided in news dissemination. Finally, credibility-based fake news detection assesses the credibility of headlines (e.g., using click-bait detection [11]), publishers (i.e., source websites), comments (e.g., using opinion spam detection [4]), and users to indirectly detect fake news. Each perspective carries its own usable set of tools [3], datasets [10] and various detection strategies in data mining, machine learning, natural language processing, information retrieval and social search. Various perspectives can be integrated under a unified framework for fake news analysis, which looks at fake news from the time being created and published to the time being disseminated. We review, summarize, compare and evaluate current studies within this framework during the tutorial.

Challenges. News characteristics such as timeliness and oddity¹ indicate that the detection of fake news does not follow that of other fake information, e.g., fake statements and fake reviews, and thus

brings about new challenges. The tutorial presents the open issues that are important but have not been (well) addressed in recent studies. It points out the potential resources (e.g., fact-checking websites) and techniques (e.g., deep learning) that are able to address the open issues and challenges. The tutorial also highlights several tasks as future research directions, which can improve the performance of fake news detection, and promote our understanding of fake news (e.g., identifying check-worthy content).

2.1 Target Audience and Prerequisites

The tutorial would be interesting for researchers, students, practitioners, and project managers in areas such as Computer Science and Engineering, Information Science and Management, Journalism, Political Science, Social Sciences, Psychology and Economics. Preliminary background in data mining, machine learning, natural language processing is recommended for tutorial participants.

2.2 Resources

The tutorial summarizes current state of fake news research. In particular, the tutorial has a companion survey paper [16]. Other resources we recommend are two overview papers [9, 11], a policy forum [5], and a related tutorial [15].

Resources Availability. The videos, slides, related papers, datasets and tools are all available and timely updated at the following website: <https://www.fake-news-tutorial.com/>.

REFERENCES

- [1] Hunt Allcott and Matthew Gentzkow. 2017. Social media and fake news in the 2016 election. *Journal of Economic Perspectives* 31, 2 (2017), 211–36.
- [2] Blake E Ashforth and Fred Mael. 1989. Social identity theory and the organization. *Academy of management review* 14, 1 (1989), 20–39.
- [3] Xin Dong, Evgeniy Gabrilovich, Jeremy Heitz, Wilko Horn, Ni Lao, Kevin Murphy, Thomas Strohmman, Shaohua Sun, and Wei Zhang. 2014. Knowledge vault: A web-scale approach to probabilistic knowledge fusion. In *Proceedings of the 20th ACM SIGKDD international conference on Knowledge discovery and data mining*. ACM, 601–610.
- [4] Nitin Jindal and Bing Liu. 2008. Opinion spam and analysis. In *Proceedings of the 2008 International Conference on Web Search and Data Mining*. ACM, 219–230.
- [5] David MJ Lazer, Matthew A Baum, Yochai Benkler, Adam J Berinsky, Kelly M Greenhill, Filippo Menczer, Miriam J Metzger, Brendan Nyhan, Gordon Pennycook, David Rothschild, et al. 2018. The science of fake news. *Science* 359, 6380 (2018), 1094–1096.
- [6] Raymond S Nickerson. 1998. Confirmation bias: A ubiquitous phenomenon in many guises. *Review of general psychology* 2, 2 (1998), 175.
- [7] Jay Pujara and Sameer Singh. 2018. Mining Knowledge Graphs From Text. In *Proceedings of the Eleventh ACM International Conference on Web Search and Data Mining*. ACM, 789–790.
- [8] K Rapoza. 2017. Can ‘fake news’ impact the stock market?
- [9] Kai Shu, H Russell Bernard, and Huan Liu. 2018. Studying Fake News via Network Analysis: Detection and Mitigation. *arXiv preprint arXiv:1804.10233* (2018).
- [10] Kai Shu, Deepak Mahudeswaran, Suhang Wang, Dongwon Lee, and Huan Liu. 2018. FakeNewsNet: A Data Repository with News Content, Social Context and Dynamic Information for Studying Fake News on Social Media. *arXiv preprint arXiv:1809.01286* (2018).
- [11] Kai Shu, Amy Sliva, Suhang Wang, Jiliang Tang, and Huan Liu. 2017. Fake news detection on social media: A data mining perspective. *ACM SIGKDD Explorations Newsletter* 19, 1 (2017), 22–36.
- [12] Craig Silverman. 2016. This analysis shows how viral fake election news stories outperformed real news on Facebook. *BuzzFeed News* 16 (2016).
- [13] Alexander Smith and Vladimir Banic. 2016. Fake News: How a partying Macedonian teen earns thousands publishing lies. *NBC News* 9 (2016).
- [14] Udo Undeutsch. 1967. Beurteilung der glaubhaftigkeit von aussagen. *Handbuch der psychologie* 11 (1967), 26–181.
- [15] Liang Wu, Fred Morstatter, Xia Hu, and Huan Liu. 2016. Mining misinformation in social media. *Big Data in Complex and Social Networks* (2016), 123–152.
- [16] Xinyi Zhou and Reza Zafarani. 2018. Fake News: A Survey of Research, Detection Methods, and Opportunities. *arXiv preprint arXiv:1812.00315* (2018).

¹<https://www.axiapr.com/blog/elements-of-news>