TOWARD A LEGAL-BASED ONTOLOGY AGAINST FINANCIAL FAKE NEWS

***Minh Duc Nguyen* [a] *and Cuong H. Nguyen-Dinh* [b, *]**

[a] *Department of Economic Information Systems, University of Economics, Hue University, 99 Ho Dac Di, Hue, Viet Nam*

[b] *School of Engineering and Technology, Hue University, 01 Dien Bien Phu, Hue, Viet Nam*

Abstract: *Under the context of information sharing over internet, financial news is the significant reference for financiers to make investment decisions. In fact, fake financial news is widely produced with negative intent. The detection of such fake news has raised in many fields, especially in the field of Artificial Intelligence (AI). There is a need of a financial knowledge model integrating valid legal resources that is used as a basis for AI detection models. This study introduces a legal-based ontology of financial news named as FiLO. The iterative process of FiLO development method is based on the NeOn methodology combined with the collaborations of domain experts and ontology engineers. The FiLO ontology was validated by SPARQL queries. Ongoing works focus on the development of AI-based fake news detection systems using the FiLO semantic knowledge model.*

Keywords: legal ontology; knowledge representation; financial fake news; artificial intelligence

1. INTRODUCTION

With the Internet growth in Industry 4.0, fake news has been widely spread without effective supervision (Lazer et al., 2018; Zhang & Ghorbani, 2020). Fake financial news are able to mislead readers, damage the credibility of formal financial news and has become one of the most concerned socio-political topics (Shao et al., 2017; Vosoughi et al., 2018). Financial fake news detection has gained interest in the subareas of Artificial Intelligence such as Data Mining or Natural Language Processing, which try to reduce the human time and effort (G. Martín et al., 2021; Liu et al., 2021).

[*] Corresponding author

The methodology of content based fake news detection, also known as fact-checking, aims to analyse the content of news (Conroy et al., 2015). This research line reduces the manual fact-checking process effectively by seeking the reachability in a knowledge graph for a given triple (G. Martín et al., 2021; Pan et al., 2018). Various knowledge representations for fake news detection have been introduced, however, to the best of our knowledge, the usage of legal resources especially in the financial domain which are reliable and valid were unnoticeable.

Ontologies, the core of Semantic Web, have proven to be the key factor for knowledge representation and reasoning by reducing conceptual vagueness and terminological confusion (Berners-Lee et al., 2001). Legal ontologies have been successfully applied across multiple disciplines like finance (Bak et al., 2010), commerce (Trappey et al., 2021), and information systems (Sitthithai et al., 2018) to mention a few. This study introduces a legal ontology against financial fake news, called as FiLO, constructed through a NeOn-based collaborative process among ontology engineers and domain experts. The methodology provides an iterative process with the integration of ontological resources. The FiLO ontology was validated to confirm it was richly populated and the proposed approach was adequate.

The rest of this paper is organized as follows: Section 2 reviews the related works of the fake news detection and ontology. Section 3 details the ontology engineering method of FiLO. Section 4 introduces how the FiLO ontology is validated. Lastly, section 5 concludes and suggests future research directions.

2. RELATED WORK

Fake news (e.g., disinformation, misinformation, rumours, opinion spams, or satire), which come from different human's motivations and targets, have flooded online information in terms of velocity, veracity and volume amazingly. To understand the intention of fake news makers under the view of psychology, the detail survey of Pennycook and Rand (2021) is suggested. Within the scope of this section, we review the recent studies of detecting fake news under the umbrella of computer science field.

Zhang and Ghorbani (2020) analysed the characteristics of fake news which compose four major aspects including creator, news content, social context, and target victims. The authors also figured out the three main categories of research approaches to fake news detection which include component-based, data mining based and implement-based methods. Typically, in the line of component-based research, fake news can be detected by analysing user profiles (Yang et al., 2019), elaborating news content (Dong et al., 2018) or inspecting news context (Della Vedova et al., 2018) just to name a few. For the data mining-based methods, the classification models and the clustering models have dominated this approach. Specifically, the golden data sets of fake news (e.g., LIAR (Wang, 2017)) were used for training process as well as validating process of different machine learning models like Naïve Bayes, SVM and Random Forests (Cușmaliuc et al., 2018), deep learning (Nasir et al., 2021) or the ensemble method (Hakak et al., 2021). In the financial field, a novel model based on CNN-LSTM which integrate news body, comments, sources and market data has been proposed (Zhi et al., 2021). For the implementation category, a real time fake news detection for Twitter had been introduced to the literature by Zhao *et al.* (2014), however the literature received a very small number of studies in this category. Another research of this line is an online platform for checking fact records and tracing real-time misinformation (Shao et al., 2016).

Berners-Lee *et al.* (2001) introduced the Semantic Web initiative, which uses ontology as its key knowledge model. While machine learning requires data for building and validating its knowledge models, ontology enables human's knowledge can be transferred directly to the machine-understandable formats of knowledge models through the use of ontological editing software (e.g., Protégé (Musen, 2015)) and the Semantic Web languages (e.g., RDF[1], RDFS[2] or OWL[3] language family). Based on these solid foundations, a number of ontologies for news domain has been introduced to the literature.

Fernández *et al.* (2010) presented an ontology for news engine web service – NEWS ontology – which managed and distributed the big amounts of digital contents to end-user. The NEWS ontology focused on the context of the production and distribution process of a news agency. Practical use cases were also presented to demonstrate its efficiency. Specifically, Mellouli *et al.* (2010) introduced a specific ontology for financial headline news which had the testing results at 99% of financial headline news were properly captured by the proposed ontology. In a deeper study, Mao *et al.* (2021) investigated the ability of predicting news event based on an ontological framework. Moreover, the Financial Industry Business Ontology (FIBO) has been popularly used by a wide range of AI applications.

In recent decades, the efforts of transferring legal knowledge to ontological knowledge models has formed up a research line named legal ontology. In which, a wide range of legal ontologies in different sub-domains like information sharing (Casellas et al., 2010), intellectual property rights (Lu et al., 2012; Lu & Ikeda, 2007), consumer protection (Agnoloni & Tiscornia, 2010), or criminal domain (Shankhdhar et al., 2014) has been introduced to the literature. However, to the best of our knowledge, the legal knowledge relating to financial news content did not mention in previous studies.

In this study, our approach differs from previous studies at the following point. We present a legal ontology for financial domain which is a knowledge model for financial and legal foundation. Section 3 introduces this proposed approach in details.

---

[1] https://www.w3.org/RDF/

[2] https://www.w3.org/TR/rdf-schema/

[3] https://www.w3.org/OWL/

3. THE ONTOLOGY ENGINEERING METHOD OF FILO

In this section, the NeOn-based methodology of ontology engineering is first introduced as a foundation for constructing the FiLO ontology. Then, steps of the development process are described in details including identification of requirement specification, knowledge reuse and ontology modelling, and ontology implementation.

3.1. NeOn-based methodology

The NeOn methodology of ontology development was introduced as easy to understand, scenario oriented, and available for supporting documentation (Suárez-Figueroa et al., 2015). Ontology Requirement Specification (ORS) has been introduced in the NeOn methodology including the requirement specification that the ontology should satisfy and consider to cover knowledge about the predefined domain. The development of ORS includes the development of competency questions that aim at determining purpose and scope, user and use case, and requirements of ontology to be developed. Through the ORS, ontology engineers and domain experts are able to figure out existing knowledge resources to be reused and then model the FiLO ontology. Finally, the FiLO ontology is able to be implemented with resources collected and axioms defined. This process is suggested to be iterative several times until the resulting ontology reaches complete validity.

3.2. Identification of requirement specification

Fig. 1 depicts an overall of the financial fake news detection system. The input is news collected from social network services such as Facebook, Twitter. The system including two major components of detection algorithms and ontology analyses the input then gives alert notification.

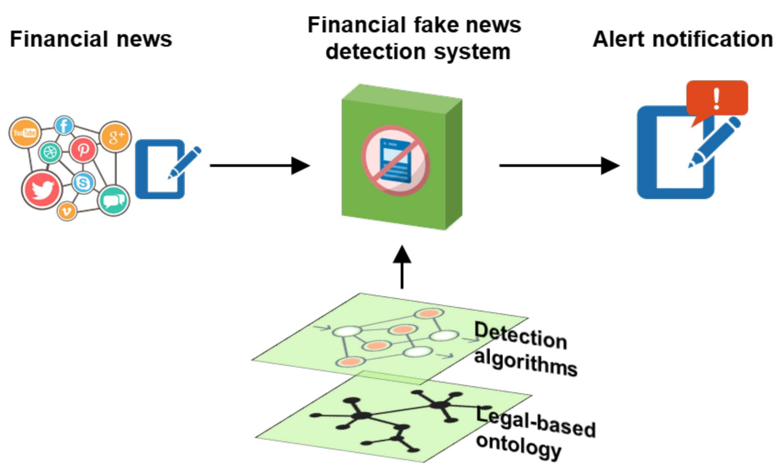

Fig. 1. Conceptual model of the financial fake news detection system.

Following the application shown in Fig. 1, the Ontology Requirement Specification Document (ORSD) including tasks of ORS is introduced (see Table 1). The primary purpose of the legal-based ontology is supporting the detection system. Another purpose is to represent legal knowledge in the financial domain which is a knowledge model for financial news and a legal foundation for financial news publishing activities.

Table 1. ORSD

Purpose	Supporting the detection of financial fake news in accordance with legal constraints
Scope	News related to financial issues
User and use case	User: web services providing text contents Use case: financial fake news detection with legal knowledge management
Knowledge used	Existing ontologies and experts' knowledge
Requirements	An excerpt of competency questions listed in Table 2

Requirements of the FiLO ontology are constructed by competency questions. In order to form up a collection of competency questions, a list of questions expected to be answered by a financial fake news detection system were provided by domain experts supporting their collaborative works. Competency questions are useful to find major concepts and discover relations among them. Table 2 shows an excerpt of the competency questions used to determine concepts and relations in the FiLO ontology. The collection of competency questions was also used to validate the FiLO ontology introduced in section 4.

Table 2. An excerpt of the competency questions used to build the FiLO ontology

Competency question	Example concept
When was the news posted?	Time
Who posted the news? (which account?)	User
Which is the topic of the news?	Bond, Stock
Which legal documents are in relation with the news?	Decree, Decision

3.3. Knowledge reuse and ontology modelling

There are two types of knowledge resources: non-ontological resources (terminologies, dictionaries, databases, XML, JSON, etc.) and ontological resources. Reuse of existing ontological resources helps the development of an ontology more effective and efficient. Ontology experts would just devote time and effort to develop the primary components of ontology while the others are able to be reused.

In term of purpose and scope, the FiLO ontology utilizes various ontological resources such as NEWS (Fernández et al., 2010), FIBO (Bennett, 2013), FOAF (Brickley, D and Miller, 2000), Event (Raimond & Abdallah, 2007) or Time (Hobbs & Pan, 2006). The NEWS ontology covers the different types of metadata that can be attached to a news item: management, categorization and content metadata (Fernández et al., 2010). The FIBO ontology is a standard for defining business terms and relationships associated with financial (Bennett, 2013). FOAF describes persons, their activities and their relations to other people and objects (Brickley, D and Miller, 2000) (e.g. a promulgator promulgates a legal document, a person publishes a financial news). Event (Raimond & Abdallah, 2007) and Time (Hobbs & Pan, 2006) ontologies are utilized to present what happened at what time to an event, person or object.

Fig. 2 shows the FiLO ontology modules at abstraction level which categorizes entities in ontologies reused and ones in competency questions in systematic form. FiLO consists of two major modules including Financial and News, and other related modules such as Person, Legal Document, News, Time and Event. The aforementioned ontological resources were used for such modules and can be replaced by more suitable resources.

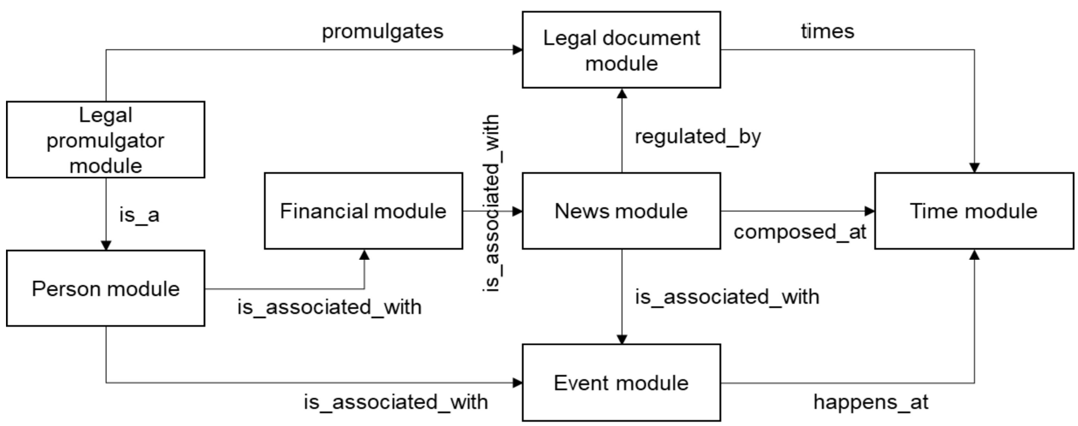

Fig. 2. The FiLO ontology modules

3.4. Ontology implementation

The FiLO ontology was implemented in Protégé[4] which is a tool for developing and maintaining ontologies. In Protégé, classes and object properties (relationships) are used to create and modify classes and relationships. The source of a relationship is called the domain class and the destination of the relationship is called the range class. An excerpt of the FiLO ontology is shown in Fig. 3, presented by the OntoGraf plugin. Normally, the relationships between a class and its subclasses are represented by light-blue solid arcs (e.g. the arc between

[4] https://protege.stanford.edu/

the class of foaf:Person and filo:LegalPromulgator). Other relationships between the various classes defined by domain and range classes are illustrated in different colours of dashed arcs.

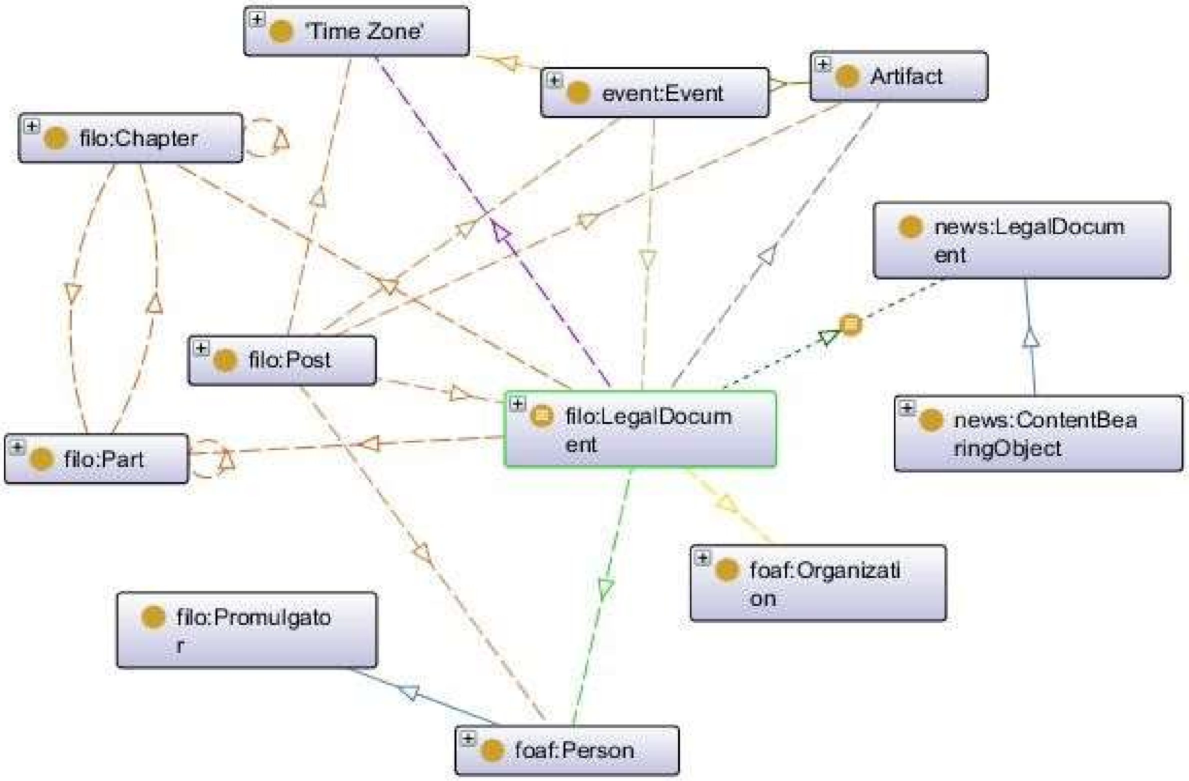

Fig. 3. An excerpt of the FiLO ontology

Axioms are assertions in a logical form that together make up the overall theory that the ontology presents in its domain. The FiLO ontology utilizes axioms to make inferences and detect inconsistencies through Description Logics syntax. The syntax used in below axioms are explained as follows:

- $\sqsubseteq$ is subclass of
- $\equiv$ is equivalent of
- $\exists$ existential restriction
- $\sqcap$ conjunction

Typical example axioms implemented in the FiLO are as follows:

$$\text{filo:LegalPromulgator} \sqsubseteq \text{foaf:Person} \equiv \text{fibo:Person} \tag{1}$$

$$(\text{filo:LegalDocument} \equiv (\exists \text{ news:LegalDocument})) \sqsubseteq \text{news:ContentBearingObject} \quad (2)$$

$$\text{filo:FakeNews} \equiv \text{filo:Post} \sqcap \exists \text{violation.filo:Post} \quad (3)$$

Finally, concepts and relationships should be unambiguous, which could require the refinement of axioms or the reconstruction of the ontology model. This is an iterative process until reaching complete validity which aims to ensure the ontology has been richly populated.

4. SPARQL-BASED EVALUATION OF FILO PERFORMANCE

The performance of FiLO ontology was tested through the implementation of SPARQL queries over real data retrieved from Vietnamese legal documents and the collected posts in social websites. Specifically, the related legal documents were retrieved from national database of laws[5], while the financial posts were collected in financial websites. These posts, which were labelled as either fake or normal, were also populated to FiLO knowledge base. The ViLO ontology of Vietnamese law was used as the reference of legal ontological resource (Nguyen et al., 2022). The hardware settings for this experiment included a 64-bit Ubuntu-based server which was deployed a i7 core CPU, 32 GB of RAM and 1 TB of HDD. And the open source edition of Virtuoso[6] was deployed as the endpoint for implementing SPARQL queries.

In the following examples, SPARQL-based evaluation of FiLO was twofold: (i) investigating the structure of FiLO knowledge model; and (ii) retrieving semantic data. The former serves the task of developing FiLO knowledge model, while the latter targets at providing semantic data for advanced data-driven tasks (e.g., data summary, data visualization). Table 3 and Table 4 show the results and performances of query implementation.

Table 3. Investigating structures of FiLO knowledge model.

(a) retrieve all concepts (classes) of FiLO ontology	
SELECT DISTINCT ?concept WHERE { ?s a ?concept	Output (124 records in 0.39s) filo:LegalPromulgator/1/ filo:LegalDocument/1/ …

[5] http://vbpl.vn/pages/portal.aspx

[6] http://vos.openlinksw.com/owiki/wiki/VOS

FILTER(STRSTARTS(STR(?type), str(filo:))) }	*(filo is the prefix abbreviation for the URI of FiLO ontology)*
(b) retrieve all relations between two concepts	

SELECT DISTINCT ?relation
WHERE {
?concept1 a filo:LegalPromulgator
?concept2 a filo:LegalDocument
?concept1 ?relation ?concept2
}
	Output (1 record in 0.002s)
	filo:promulgate

Table 4. Retrieving and Inferencing semantic data.

(a) count the posts of a specific user	

SELECT count(DISTINCT ?post) as ?count {
?user a filo:User.
?user filo:ID "FB-1001"^^xsd:string.
?post a filo:Post.
?user filo:publishes ?post.
}
	Output (1 record in 0.25s)
	18
	- *"FB-1001" is filled in the query through template*
	- *filo is the prefix abbreviation of the URI of FiLO ontology*

(b) display the list of users who posted the financial fake news	
SELECT DISTINCT ?username { ?user a filo:User. ?post a filo:Post; filo:label "fake"^^xsd:string.	Output (162 records in 0.52s) An Van Ngo Anh Nguyen ….

?user filo:publishes ?post. } ORDER BY ASC(?username)	- *filo is the prefix abbreviation for the URI of FiLO ontology*
(c) inference users who were affected by the financial fake news	

CONSTRUCT{
?user filo:affected_by_fake_news "true"^^xsd:Boolean.
} WHERE {
?user a filo:User.
?post a filo:Post;
filo:label "fake"^^xsd:string.
?user filo:liked post.
}
	Implementation time: (1 minutes 7 seconds)
	
	- *filo is the prefix abbreviation for the URI of FiLO ontology*

Specifically, Table 3 provides examples of investigating structure of the FiLO ontology by retrieving its concepts and relations, while Table 4 shows examples of summarizing, listing and inferencing semantic data in the FiLO knowledge model. These two tables present the measurements of query results and their performances in terms of the total returned records and the implementation time, respectively. The results demonstrate the efficient usage of the FiLO knowledge model in semantic computation tasks and the success integration of real financial news data into FiLO knowledge.

5. CONCLUSION

This paper proposed a legal ontology against financial fake news which represents a knowledge model in detection systems. The NeOn-based ontology engineering method was conducted to construct the FiLO ontology by the collaborations of domain experts and ontology engineers. The proposed ontology engineering method includes three major steps: identification of requirement specification, knowledge reuse and ontology modelling, and ontology implementation. The methodology provides the iterative process with the integration of ontological resources. The implementation of SPARQL queries confirmed the proposed ontology development was reliable and the resulting ontology was richly populated. By using Semantic Web technology where ontology is a core component, the task of financial fake news detection is shared with the knowledge model. Further research works focus on the integration of software applications to FiLO, automatic extraction of knowledge from financial news aligned to entities in the ontology.

References

Agnoloni, T., & Tiscornia, D. (2010). Semantic web standards and ontologies for legislative drafting support. *International Conference on Electronic Participation*, 184–196.

Bak, J., Jedrzejek, C., & Falkowski, M. (2010). Application of an ontology-based and rule-based model to selected economic crimes: fraudulent disbursement and money laundering. *Semantic Web Rules*, 210–224.

Bennett, M. (2013). The financial industry business ontology: Best practice for big data. *Journal of Banking Regulation*, *14*(3), 255–268.

Berners-Lee, T., Hendler, J., & Lassila, O. (2001). The semantic web. *Scientific American*, *284*(5), 34–43.

Brickley, D and Miller, L. (2000). *Friend of a Friend (FOAF)*. http://www.foaf-project.org/

Casellas, N., Nieto, J.-E., Meroño-Peñuela, A., Roig, A., Torralba, S., Reyes, M., & Casanovas, P. (2010). Ontological semantics for data privacy compliance: The NEURONA project. *AAAI Spring Symposium: Intelligent Information Privacy Management.*

Conroy, N. J., Rubin, V. L., & Chen, Y. (2015). *Automatic Deception Detection: Methods for Finding Fake News*. https://doi.org/10.1002/pra2.2015.145052010082

Cușmaliuc, C.-G., Coca, L.-G., & Iftene, A. (2018). Identifying Fake News on Twitter using Naive Bayes, SVM and Random Forest Distributed Algorithms. *Proceedings of The 13th Edition of the International Conference on Linguistic Resources and Tools for Processing Romanian Language (ConsILR-2018) Pp*, 177–188.

Della Vedova, M. L., Tacchini, E., Moret, S., Ballarin, G., DiPierro, M., & de Alfaro, L. (2018). Automatic online fake news detection combining content and social signals. *2018 22nd Conference of Open Innovations Association (FRUCT)*, 272–279.

Dong, M., Yao, L., Wang, X., Benatallah, B., Sheng, Q. Z., & Huang, H. (2018). Dual: A deep unified attention model with latent relation representations for fake news detection. *International Conference on Web Information Systems Engineering*, 199–209.

Fernández, N., Fuentes, D., Sánchez, L., & Fisteus, J. A. (2010). The NEWS ontology: Design and applications. *Expert Systems with Applications*, *37*(12), 8694–8704. https://doi.org/https://doi.org/10.1016/j.eswa.2010.06.055

G. Martín, A., Fernández-Isabel, A., González-Fernández, C., Lancho, C., Cuesta, M., & Martín de Diego, I. (2021). Suspicious news detection through semantic and sentiment measures. *Engineering Applications of Artificial Intelligence*, *101*, 104230. https://doi.org/10.1016/j.engappai.2021.104230

Hakak, S., Alazab, M., Khan, S., Gadekallu, T. R., Maddikunta, P. K. R., & Khan, W. Z. (2021). An ensemble machine learning approach through effective feature extraction to classify fake news. *Future Generation Computer Systems*, *117*, 47–58.

Hobbs, J. R., & Pan, F. (2006). *Time Ontology in OWL*. http://www.w3.org/2001/sw/BestPractices/OEP/Time-Ontology

Lazer, D. M. J., Baum, M. A., Benkler, Y., Berinsky, A. J., Greenhill, K. M., Menczer, F., Metzger, M. J., Nyhan, B., Pennycook, G., Rothschild, D., & others. (2018). The science of fake news. *Science*, *359*(6380), 1094–1096.

Liu, J., Wang, C., Li, C., Li, N., Deng, J., & Pan, J. Z. (2021). DTN: Deep triple network for topic specific fake news detection. *Journal of Web Semantics*, 100646. https://doi.org/10.1016/j.websem.2021.100646

Lu, W., & Ikeda, M. (2007). A uniform conceptual model for knowledge management of international copyright law. *Journal of Information Science*, *34*(1), 93–109. https://doi.org/10.1177/0165551507079418

Lu, W., Xiong, N., & Park, D. S. (2012). An ontological approach to support legal information modeling. *Journal of Supercomputing*, *62*(1), 53–67. https://doi.org/10.1007/s11227-011-0647-8

Mao, Q., Li, X., Peng, H., Li, J., He, D., Guo, S., He, M., & Wang, L. (2021). Event prediction based on evolutionary event ontology knowledge. *Future Generation Computer Systems*, *115*, 76–89. https://doi.org/https://doi.org/10.1016/j.future.2020.07.041

Mellouli, S., Bouslama, F., & Akande, A. (2010). An ontology for representing financial headline news. *Web Semantics: Science, Services and Agents on the World Wide Web*, *8*(2), 203–208. https://doi.org/https://doi.org/10.1016/j.websem.2010.02.001

Musen, M. A. (2015). The protégé project: a look back and a look forward. *AI Matters*, *1*(4), 4–12.

Nasir, J. A., Khan, O. S., & Varlamis, I. (2021). Fake news detection: A hybrid CNN-RNN based deep learning approach. *International Journal of Information Management Data Insights*, *1*(1), 100007. https://doi.org/https://doi.org/10.1016/j.jjimei.2020.100007

Nguyen, M. D., Nguyen-Thi, G. H., & Nguyen-Dinh, C. H. (2022). ViLO—A Core Ontology of Vietnamese Legal Documents. *Vietnam Journal of Computer Science*, 1–16.

Pan, J. Z., Pavlova, S., Li, C., Li, N., Li, Y., & Liu, J. (2018). Content based fake news detection using knowledge graphs. In D. Vrandečić, K. Bontcheva, M. C. Suárez-Figueroa, V. Presutti, I. Celino, M. Sabou, L.-A. Kaffee, & E. Simperl (Eds.), *The Semantic Web -- ISWC 2018* (pp. 669–683). Springer International Publishing.

Pennycook, G., & Rand, D. G. (2021). The Psychology of Fake News. *Trends in Cognitive Sciences*, *25*(5), 388–402. https://doi.org/https://doi.org/10.1016/j.tics.2021.02.007

Raimond, Y., & Abdallah, S. (2007). *The event ontology*.

Shankhdhar, G. K., Singh, V. K., Darbari, M., Yagyasen, D., & Shukla, P. (2014). Legal semantic web-a recommendation system. *International Journal of Applied Information Systems*, *7*(3), 21–27.

Shao, C., Ciampaglia, G. L., Flammini, A., & Menczer, F. (2016). Hoaxy: A platform for tracking online misinformation. *Proceedings of the 25th International Conference Companion on World Wide Web*, 745–750.

Shao, C., Ciampaglia, G. L., Varol, O., Flammini, A., & Menczer, F. (2017). The spread of fake news by social bots. *ArXiv Preprint ArXiv:1707.07592*, *96*, 104.

Sitthithai, S., Manaskasemsak, B., & Rungsawang, A. (2018). Legal search system using ontology for government agencies in Lao PDR. *2018 Seventh ICT International Student Project Conference (ICT-ISPC)*, 1–5. https://doi.org/10.1109/ICT-ISPC.2018.8523866

Suárez-Figueroa, M. C., Gómez-Pérez, A., & Fernandez-Lopez, M. (2015). The NeOn Methodology framework: A scenario-based methodology for ontology development. *Applied Ontology*, *10*(2), 107–145.

Trappey, C. V, Chang, A.-C., & Trappey, A. J. C. (2021). Building an internet-based knowledge ontology for trademark protection. *Journal of Global Information Management (JGIM)*, *29*(1), 123–144.

Vosoughi, S., Roy, D., & Aral, S. (2018). The spread of true and false news online. *Science*, *359*(6380), 1146–1151.

Wang, W. Y. (2017). " liar, liar pants on fire": A new benchmark dataset for fake news detection. *ArXiv Preprint ArXiv:1705.00648*.

Yang, S., Shu, K., Wang, S., Gu, R., Wu, F., & Liu, H. (2019). Unsupervised fake news detection on social media: A generative approach. *Proceedings of the AAAI Conference on Artificial Intelligence*, *33*(01), 5644–5651.

Zhang, X., & Ghorbani, A. A. (2020). An overview of online fake news: Characterization, detection, and discussion. *Information Processing & Management*, *57*(2), 102025. https://doi.org/https://doi.org/10.1016/j.ipm.2019.03.004

Zhao, J., Cao, N., Wen, Z., Song, Y., Lin, Y.-R., & Collins, C. (2014). #FluxFlow: Visual analysis of anomalous information spreading on social media. *IEEE Transactions on Visualization and Computer Graphics*, *20*(12), 1773–1782.

Zhi, X., Xue, L., Zhi, W., Li, Z., Zhao, B., Wang, Y., & Shen, Z. (2021). Financial fake news detection with multi fact CNN-LSTM model. *2021 IEEE 4th International Conference on Electronics Technology (ICET)*, 1338–1341. https://doi.org/10.1109/ICET51757.2021.9450924