EXPLORING AN INTELLIGENT APPROACH IN KNOWLEDGE MAPPING WITH ONTOLOGY AND TEXT MINING: SYSTEMATIC LITERATURE REVIEW

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ABSTRACT

A collection of explicit knowledge is increasing, and the tendency is for each person to get knowledge easily through various sources on the internet, so their knowledge changes will be faster. This vast and rapidly changing knowledge is a challenge in conducting knowledge mapping. Therefore a smart approach is needed so that changes in the knowledge possessed by someone, we can identify easily and quickly. This study led to identifying kinds of smart aspect in knowledge mapping construction. The method refers to the systematic literature review as guidelines from Kitchenham, this research gathers, synthesises, and analyses some paper-based on keyword ("knowledge mapping" OR "knowledge map") AND "knowledge management" AND (ontology OR "text mining" OR intelligent OR algorithms OR computation), where it published from 2009 until 2018 on four international electronic databases and using pre-defined review protocol. We obtain 224 articles and select it base on Kitchenham process; witch finally remains 35 articles used in this study. We find the tendency to use the combination method between ontology and text mining (onto-text mining) methods is increasingly developing in the application of knowledge mapping.

Key words: Knowledge Mapping, Text mining, Systematic Literature Review.

1. INTRODUCTION

A collection of explicit knowledge is increasing, and the tendency is for each person to get knowledge easily through various sources on the internet, so their knowledge changes will be faster, and a large amount of explicit knowledge continues to increase. This vast and rapidly changing knowledge is a challenge in conducting knowledge mapping. Therefore a smart approach is needed to construct a knowledge map from vast explicit knowledge to identify what kind of knowledge is possessed by a particular person.

Artificial intelligence (AI) is currently experiencing very significant developments, through its application in various fields, AI has contributed in helping humans to solve complex problems with machine learning approaches big data (big data). Mapping knowledge (knowledge mapping) in the context of Knowledge Management has become a major part of one in order to identify important knowledge in an organisation (Jin-song *et al.*, 2009). To identify the knowledge possessed by the organisation is very much related to the knowledge of someone who is part of the organization.

Knowledge management, in this case, specifically on knowledge mapping, is inseparable from the use of ICTs in its application. Therefore the development of artificial intelligence (AI) in the ICT field has encouraged many studies that study artificial intelligence in knowledge mapping through text mining and ontology to be able to identify critical knowledge possessed by the organisation.

Many studies have knowledge map implementation, with various context. By this Systematic literature review (SLR), we will focus on literature analysis related mapping knowledge where involve intelligent aspect. Base on this objective, we formulated into research questions:

RQ: What are the methods in applying intelligent aspects through text mining and ontology in knowledge mapping?

To do a standard literature review in this study, we refer to systematic literature review guidelines proposed by Kitchenham and Charters (2007), this guideline was adopted in information & technology, especially in the software engineering domain. This systematic literature review has a strict sequence and good methodological pace related to an aprioristically protocol. There are three procedures, which are: 1. Define the research protocol; 2. Create the inclusion and exclusion criteria, and 3. verify the quality of articles from data extraction.

We will provide to practitioners or researcher a comprehensive study about the smart aspect that can be used to construct a knowledge map and also to find further research and technical approach. This paper has five-section, which are an introduction, methodology, SLR result, discussion and conclusion.

2. METHODOLOGY

To conduct this systematic literature review we use six-step as guidelines from Kitchenham and Charters (2007), which are: 1) formulate review protocol formulation, 2) criteria identification of exclusion and inclusion, 3) explain the process of search strategy; 4) selection process, 5) consider quality, 6) synthesis and extraction data.

2.1 Review Protocol

A review protocol is taken form Kitchenham and Charters (2007) method for Systematic Literature Review (SLR) in computer engineering study. These components are: 1) The reason of study, 2) Research question, 3) Strategy of literature searching, 4) Criteria selection, 5) Procedure selection, 6) Quality assessment checklist and procedures, 7) Strategy of data extraction, 8) Synthesis of the extracted data. First and the second component already described above and the rest will describe below.

2.2 Search Strategy

In this study, we use keywords ("knowledge mapping" OR "knowledge map") AND “knowledge management” AND (ontology OR “text mining” OR intelligent OR algorithms OR computation). This combination of ware used to obtain article related to the implementation of smart aspect in knowledge mapping for knowledge management context into some online digital database. We query the following database, are: Scopus-Elsevier, IEEE Explore, ACM Digital Library and Emerald Insight.

2.3 Selection Criteria

We considered the selection criteria for inclusion in this article review include a written in English, has full texts, published from 2009 to 2018, related to domain knowledge management were focused on knowledge mapping and smart, and research article from workshop, conference, and a journal.

For the exclusion, we consider to eliminate paper that not English article, irrelevant to our domain, no available full text, and published after 2008 and before 2019. Table 1 shows the summary criteria for this selection.

Table 1. Selection Criteria.

Include	Exclude
• Written in English • The domain in Knowledge Mapping with an smart aspect • Published 2009 and 2018 • Full-text	• Not related to the research question • Published before 2009 • Duplicated Studied • No full-text

2.4 Selection Procedure

Starting with using search keywords into each database literature (Scopus-Elsevier, IEEE Explore, ACM Digital Library, Emerald Insight). We got some 224 articles.

To ascertain that papers are related to the topic raised, Kitchenham and Charters (2007) suggested making a further selection of the subject. To answer the research question, we review from this subject conformity article, witch look in the title, abstract and the conclusion of an article that. And the rest article after this selection is 59 article to be studied more deeply. Selection procedure for this SLR depicted in Fig 1.

2.5 Quality Assessment Checklist and Procedures

In order to assess the quality of the article from the filtering step, we define quality assessment questions. This assessment will generate article score which meets to a passing grade (with a total score greater than or equal to 6), this calculation method inspired by Balaid *et al.* (2016). The question for assessment of quality are:

1. Does the paper explain the smart aspects of the application of the knowledge mapping studied?
2. Is there a context for the knowledge mapping research case study raised in the paper?
3. Do the contents of the paper explain the method for using text mining or ontology?
4. Is there an explanation of the data sources used in conducting knowledge mapping?
5. The approach of the AI Algorithm used is sufficient detail?

With five QA criteria written before, we examined 59 selected papers to verify our certainty in the reliability of a study. We give a score for each QA criteria from high (2), medium (1), and low (0). And then every QA criteria score in the article summed up. This final score, we determine passing grade as high, if last score greater than or equal to 6, medium if the last score is five and less than five as low. Base on this grade, we eliminate the medium and low last score. We exclude 24 articles for this step, and the result from this QA remains 35 articles to be studied.

2.6 Data Extraction Strategy

Using spreadsheet software we Extract data from 59 articles, the columns we provide are paper Information, type of paper, year, description, context, data source, ontology model, text mining algorithm, smart aspect, type of smart aspect, database source, quality assessment score, approach type id and steps description.

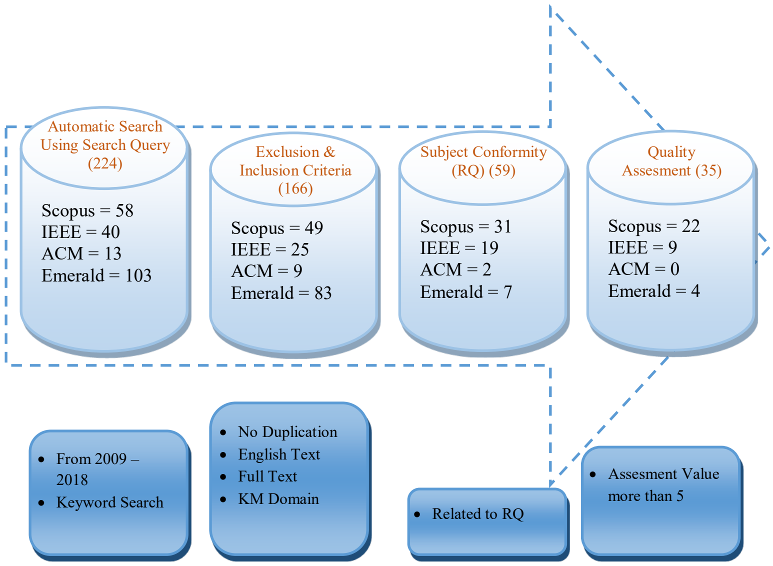

Fig. 1. Selection procedure and Search Strategy

Every article read deeply and write down the pointers in every column, and we can synthesise with analysing the correlation in the research question. In the next section, we will describe the synthesis.

3. RESULT

In this section, before further discussing our Systematic Literature Review study, we will present descriptive statistical data regarding the articles to be reviewed. This statistical overview will provide a demographic overview of article data on publication sources, publication database sources, and year of publication.

3.1 Publication Type and Source Overview

Through the results of the review on the final paper selection results of 35 articles, as shown in Fig. 2, there were 20 articles (57%) from the conference paper types, while 15 articles for journal articles (43%), with the majority of the papers reviewed, were conference papers.

There are four sources of database publications that we use in article collection, after the final selection of articles remaining for review only comes from 3 sources of publication, namely Scopus consisting of 22 articles, IEEE Explore 9 articles and Emerald Insight for four articles. The majority of the articles reviewed were 63% from the Scopus database, as shown in Fig. 3.

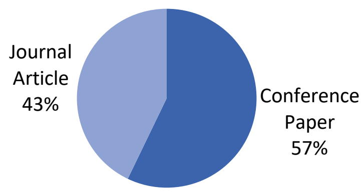

Fig 2. Publication sources distribution

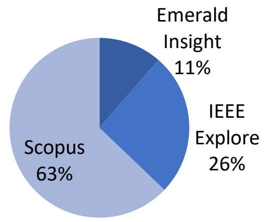

Fig 3. Online Database of publication sources

3.2 Year of Publication

Within ten years, from 2009 to 2018, shown in Figure Fig. 4. That article is spread every year, but most of the articles published in 2014 and 2018 are seven articles and six articles in sequence.

4. DISCUSSION

After synthesis of the extracted data from 35 article, we can analyse from research question mentioned in section 1 and will be described below for a question. Therefore, each study was assigned to the most relevant question, and similar studies were compiled. We will explain the results of RQ below:

What are the methods in applying intelligent aspects through text mining and ontology in knowledge mapping?

We synthesis the article from smart aspect to identify what typical smart focused those article study about in according to knowledge mapping implementation. There are three types of smart focus, namely: Fist, KMap construction, where this paper is focused on how to construct knowledge maps from various resources to generate knowledge maps automatically and dynamically based on the data sources used (Zhu and Wang, 2009). Second, Recommender retrieval, with a primary focus in smart for giving recommendations, this suggestion is not only giving knowledge in cash but also can be in the concept keywords. Third, semantic retrieval was focused on ontology implementation for adopting smart aspect in knowledge map.

Fig 5 shows the distribution of smart aspect with a focus on three types. Where the most typical is KMap construction with 52% article study about how to create KMap dynamically, followed by semantic retrieval 31% and 17% focus on recommender retrieval.

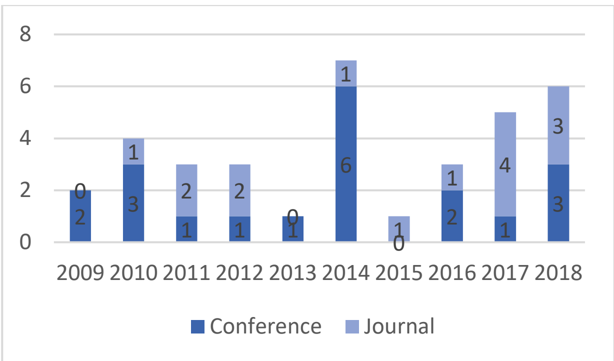

Fig 4. Year of Publication

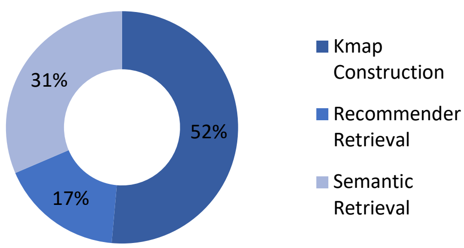

Fig 5. Intelligent Aspect of Knowledge mapping

The forwarding of knowledge mapping in the field of knowledge management has taken into account the application of artificial intelligence, an approach that is widely used in text mining and ontology. Where text mining focuses more on how to extract and retrieval information. Whereas ontology provides more functions of meaning on keywords so that it can help users in getting the purpose in the search for knowledge. Also, a combination of ontology and text mining has been carried out in applying knowledge mapping(Wang *et al.*, 2009; Wartena, 2013), in this article, we use the terminology onto-text mining.

We display article distribution based on the three smart approaches to knowledge mapping in Fig. 6. 16 articles only use the text mining approach in knowledge mapping and nine articles that only use ontology. While studies that combine both onto-text mining, there are ten articles.

Fig. 7 shows the development of using the ontology approach, text mining and onto-text mining in this review model. It is seen that the use of text mining and ontology is still ongoing from 2009 to 2018, but for the combined approach, onto-text mining is only starting in 2013, even though it has begun at 2009. However, the development was only continuing in 2013.

To describe the use of ontology, text mining and onto-text mining in knowledge mapping, a process description is generally carried out in mapping knowledge. This stage generally refers to research (Sasson *et al.*, 2017) by dividing into four parts/stages, namely:

1. Resource collection, the stages in the process of collecting sources of explicit knowledge in the form of text (acquisition of knowledge). This source can come from the knowledge management system, information system, website, social media etc.
2. Preprocessing, after knowledge acquisition is carried out, the next step is to do processing preparation. Usually done is to do tokenisation, stemming, glue and weighting such as using TF-IDF in text mining while on ontology using extraction concept.
3. Core processing, this stage is the core formation of knowledge maps from the results of preprocessing. Many methods, techniques and tools can be used in their implementation.
4. Presentation, this final stage is the part of the interface that appears for the user. The formation of this knowledge map display is like using Gephi for the SNA approach or for ontology, one of which can use OWL Viz, Web VOWL tool and others.

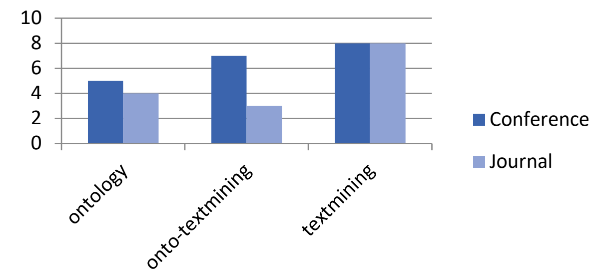

Fig 6. Ontology and text mining in knowledge mapping

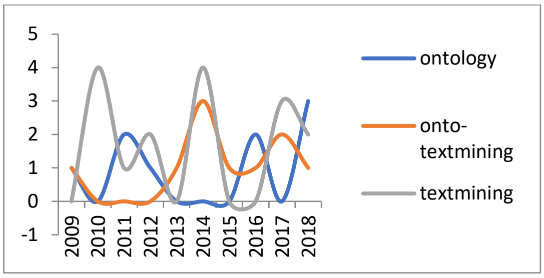

Fig 7. Ontology, text mining and onto-text mining expansion from 2009 – 2018 in knowledge mapping

Table 2 consist description method, tool and resource to construct knowledge mapping with an smart approach. We create a matrix by dividing it into three types as a column, are text mining, ontology and onto-text mining, and process or step as rows. With this matrix, we can choose what the possible method/tools to implement knowledge mapping.

5. CONCLUSION

The development of knowledge mapping in assisting the implementation of knowledge management has been carried out with an automated approach through intuitive approaches, such as text mining (Hakim, 2018).

Besides, the approach to give an understanding of the meaning (semantic) of the results of codification of the text group is a necessity that needs to be done, so that it can help humans to understand the relationship between the knowledge identified in the concept. Concepts have a relationship that is usually called meaning/semantic relations. This mentor, known as ontology, is used to explain the semantic information among the vast amount of data (Zhu and Wang, 2009).

In this study, we found a combination of ontology and text mining, which we later termed onto-text mining. This merger arises because the pattern of ontology development requires an automatic approach so that with the help of the text mining technique it can identify the meaning/semantics between concepts in the keywords described in the form of relations between concepts. This onto-text mining approach has begun to be developed in the application of knowledge maps from 2013 until now it continues. Therefore this approach is recommended to be applied in future studies to produce dynamic and adaptable knowledge map content.

Of course, this study still has limitations on identifying the most appropriate method, because the context and character of the research that has been carried out in these publications are very diverse and indeed not easy to justify the conformity of the method with the environmental context at hand. But in general, the approach methods used on the onto-text mining pattern are considered the complete choice.

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Table 2. Intelligent Methods/Tool for Knowledge Mapping.

Process/ Type	Text mining	Ontology	Onto-Textmining
Resource Collection	Publication Database (Zhang *et al.*, 2018; Hao *et al.*, 2014; Watthananon and Mingkhwan, 2012; Tao, *et al.*, 2012), Domain Knowledge (KD) from Medical Examinatin (NMEC) and Question and Answer (QA) between lay users with answers from professionals (www.xywy.com) (Li *et al.*, 2018) , Google Alert (Sasson, *et al.*, 2017), online communities of practies in medical mailinglist (PPML & SURGINET)(Stewart and Abidi, 2017), Information System (Moradi, *et al.*, 2017)(Moradi and Mirian, 2014), Google alert and search (Sasson, *et al.*, 2014), database proposal (Yoon, *et al.*, 2010), website (Fu, *et al.*, 2010), e-learning (Zheng, *et al.*, 2010), SNA employee (Zhang *et al.*, 2010), database of NSFC(Qingfeng, *et al.*, 2010), Robot TW Portal (Chan and Yu, 2010).	Information System(Zhao, *et al.*, 2018), Indor Space Ontology (Wu *et al.*, 2018), radiopedia.org (Zhao *et al.*, 2018), University (Essaid, *et al.*, 2016), learning course (Sheng-Hung, 2016), Organizational ontology (Rao, *et al.*, 2012), selling product (Khaled, *et al.*, 2011), Robot TW Portal (Chao-Chi Chan, 2011), car assembly information(Jin-song, *et al.*, 2009).	Publication Database (Qin *et al.*, 2018; Zhang, *et al.*, 2017; Wang, *et al.*, 2009), Product manufacture (Zhang *et al.*, 2017), Document Management Systems (DMS)(Cai *et al.*, 2014; Zenkert, et al., 2016), KMS (Huang *et al.*, 2015; Huang and Jiang, 2014), crowler4j (Wartena, 2013).
Preprocessing	Seed Tag (ST)-NLP(Zhang *et al.*, 2018), NLP word segmentation (KD and QA)(Li *et al.*, 2018), IBM's SPPS/PASW Text Analytics Version13 (formerly SPSS TM Modeler) and AlchemyAPI were used in parallel with a domain-specialized related dictionary add-on (Sasson, *et al.*, 2017; Sasson, *et al.*, 2014), a medical lexicon based semantic tagging method, Mesh Term (Stewart and Abidi, 2017), IEEE taxonomy (Moradi, *et al.*, 2017; Moradi and Mirian, 2014), TF-IDF (Hao *et al.*, 2014; Wu *et al.*, 2011), Cartesian Product (Watthananon and Mingkhwan, 2012), Field Classification (Tao, *et al.*, 2012), Process-oriented knowlege retrieval (Zhang *et al.*, 2010).	RDB2RDF data conversion process (Zhao, *et al.*, 2018), OWL (interior spatial semantics dan indoor space ontology concepts) (Wu *et al.*, 2018), Knowledge model (Zhao *et al.*, 2018), data instantiation (Rao, *et al.*, 2012), association rules (Khaled, *et al.*, 2011), functional ontology (Chao-Chi Chan, 2011), classification with grouded theory (Chan and Yu, 2010), The ontology relationship model of the factory (Jin-song, *et al.*, 2009).	TF-IDF (Qin *et al.*, 2018; Huang *et al.*, 2015; Huang and Jiang, 2014; Wang, et al., 2009), Knowledge subject ontology, knowledge source ontology and knowledge form ontology (Zhang *et al.*, 2017), Natural Language Toolkit programming language (Zhang, *et al.*, 2017), tokenized (Cai *et al.*, 2014), disambiguated and analyzed with Named Entity Recognition (NER) (Zenkert, *et al.*, 2016), semantic structure of Knowledge Unit (Huang, *et al.*, 2014), STW Thesaurus for Economics (Wartena, 2013).
Core Processing	NLP (mapping Research Problem[RP] dan Propose Techniques[PT]) (Zhang *et al.*, 2018), a transfer learning using latent factor graph (TLLFG) (Li *et al.*, 2018), SVM (Wu *et al.*, 2011) dan PTA (Pair-wise temporal analysis) (Sasson, *et al.*, 2017; Sasson, *et al.*, 2014), Metamap (NLP Parser) (Stewart and Abidi, 2017), Bayesian reasoning map (IPC alg) (Moradi, *et al.*, 2017), Radius Calculation and node strength, MDS, expertness level (Moradi and Mirian, 2014), LSA dan efficiency reduction threshold (ER) (Hao *et al.*, 2014), Pearson Correlation Coefficient (PCC) (Watthananon and Mingkhwan, 2012), SNA (UCINET) (Tao, *et al.*, 2012), growth rate, HI, SNA (Yoon, *et al.*, 2010), The Generation Algorithm for Web Document Classification Association Rules (Fu, *et al.*, 2010), ETM (Extended Topic Map) toolkit (Zheng, *et al.*, 2010), expert recommeder algorithm (Zhang *et al.*, 2010), correlation degree of cosine similarity (Qingfeng, *et al.*, 2010), Zhou Yi based fuzzy clustering (Chan and Yu, 2010).	Knowledge graph (Zhao, *et al.*, 2018; Wu *et al.*, 2018), Unified Medical Language System (UMLS) semantic types (Zhao *et al.*, 2018), the ontology of Strasbourg University (Essaid, *et al.*, 2016), concept level (Sheng-Hung, 2016), Structure, Source, Application, Asset and, Development Map (Rao, *et al.*, 2012), TreeP (Khaled, *et al.*, 2011), CmapTool Ontology Editor (Chao-Chi Chan, 2011), Protegee (Jin-song, *et al.*, 2009).	Ontology concept Tree (the fuzzy mathematics-based classification), similarity measurement of tree-structure knowledge structures (Qin *et al.*, 2018), ontology-based knowledge map (subject, source dan form ontology) (Zhang *et al.*, 2017), algoritma step-by-step model (Zhang, *et al.*, 2017), The Concept of the Imitation of the Mental Ability of Word Association (CIMAWA) (Zenkert, *et al.*, 2016), SRC-TSP-TSD-RSISF (Huang *et al.*, 2015; Huang and Jiang, 2014), Cognitive overload feature, average retrieval time feature, long-range correlation feature (Huang, *et al.*, 2014), TF-IDF (Wartena, 2013), Fuzzy concept map mining (Cai *et al.*, 2014), FCA, Probability Model and Criterion Weighting algorithms (Wang, *et al.*, 2009).

REFERENCES

Balaid, A., Abd Rozan, M.Z., Hikmi, S.N., and Memon, J. (2016). Knowledge maps: A systematic literature review and directions for future research. *International Journal of Information Management*, 36(3), 451–475. https://doi.org/10.1016/j.ijinfomgt.2016.02.005

Cai, Y., Wang, H., Ye, X., and An, L. (2014). Combining Bottom-up and Top-down Generation of Interactive Knowledge Maps for Enterprise Search, *International Conference on Knowledge Science, Engineering and Management*. doi: 10.1007/978-3-642-39787-5.

Chan, C.C., and Yu, S.R. (2010). Analytic Hierarchy Process and Zhou-Yi tagging method for knowledge map navigation, In: *Proceedings - 2010 IEEE 17th International Conference on Industrial Engineering and Engineering Management, IE and EM2010*. IEEE, 1652–1656. doi: 10.1109/ICIEEM.2010.5646103.

Chao-Chi, Chan, and S.-R. Y. (2011). Functional Ontology and Concept Maps for Knowledge Navigation: An Application Example for Contest Robot, *Information Technology Journal*, 10, 1740–1746.

Essaid, A., Thi, Q.N., and Zanni-Merk, C. (2016). Data Integration and Visualization for Knowledge Mapping in Strasbourg University, In: *Proceedings of the 8th International Joint Conference on Knowledge Discovery, Knowledge Engineering and Knowledge Management*, 2(Ic3k), 163–170. doi: 10.5220/0006069301630170.

Fu, X., Liu, G., and Dang, Y. (2010). Research on knowledge map construction in intelligentized content website, In: *2010 International Conference on Computer, Mechatronics, Control and Electronic Engineering, CMCE 2010*, 1, 406–409. doi: 10.1109/CMCE.2010.5610524.

Hakim, S.A.D.I.S. (2018). Knowledge Mapping System Implementation in Knowledge Management : A Systematic Literature Review, In: *2018 International Conference on Information Management and Technology (ICIMTech)*. IEEE, (September), 1–6.

Hao, J., Yan, Y., Gong, L., Wang, G., and Lin, J. (2014). Knowledge map-based method for domain knowledge browsing, *Decision Support Systems*. Elsevier B.V., 61(1), 106–114. doi: 10.1016/j.dss.2014.02.001.

Huang, X., Zheng, Q., and Zhang, C. (2014). Extracting learning features of knowledge unit in knowledge map, In: *Proceedings - 2014 10th International Conference on Intelligent Information Hiding and Multimedia Signal Processing, IIH-MSP 2014*. IEEE, 345–348. doi: 10.1109/IIH-MSP.2014.92.

Huang, Y., Jiang, Z., He, C., Liu, J., Song, B., and Liu, L. (2015). A semantic-based visualised wiki system (SVWkS) for lesson-learned knowledge reuse situated in product design, *International Journal of Production Research*, 53(8), 2524–2541. doi: 10.1080/00207543.2014.975861.

Huang, Y., and Jiang, Z. (2014). A Semantic-Based Topic Knowledge Map System (STKMS) for lesson-learned documents reuse in product design, *IEICE Transactions on Information and Systems*, E96-D(5), 1049–1057. doi: 10.1587/transinf.E97.D.1049.

Jin-song, G.A.O., Da-peng, L.I., and Xue-dong, W. (2009). Study on Knowledge Map Construction for Virtual Team Based on Ontology, In: *IT in Medicine & Education, ITIME'09. IEEE International Symposium*, 360–365.

Khaled, H., Kechadi, T., and Tari, A.K. (2011). Ontology for knowledge management and improvement of data mining result, In: *ICSDM 2011 - Proceedings 2011 IEEE International Conference on Spatial Data Mining and Geographical Knowledge Services*, 257–262. doi: 10.1109/ICSDM.2011.5969043.

Kitchenham, B., and Charters, S. (2007). Guidelines for performing Systematic Literature reviews in Software Engineering Version 2.3, *Engineering*, 45(4ve), 1051. doi: 10.1145/1134285.1134500.

Li, D., Madden, A., Liu, C., Ding, Y., Qian, L., and Zhou, E. (2018). Modelling online user behavior for medical knowledge learning, *Industrial Management and Data Systems*, 118(4), 889–911. doi: 10.1108/IMDS-07-2017-0309.

Moradi, R., and Mirian, M.S. (2014). Role-based knowledge mapping: An operational decision support media for research purposes, In: *2014 6th Conference on Information and Knowledge Technology, IKT 2014*. IEEE, 37–43. doi: 10.1109/IKT.2014.7030330.

Moradi, R., Taheri, K., and Mirian, M.S. (2017). Data-Driven Methods to Create Knowledge Maps for Decision Making in Academic Contexts, *Journal of Information & Knowledge Management*, 16(01), 1750008. doi: 10.1142/S0219649217500083.

Qin, C., Zhao, P., Mou, J., and Zhang, J. (2018). Construction of personal knowledge maps for a peer-to-peer information-sharing environment, *Electronic Library*, 36(3), 394–413. doi: 10.1108/EL-03-2017-0071.

Qingfeng, D., Xuefeng, W., and Donghua, Z. (2010). Text-mining-based funding monitoring for science foundation: A case study of NSFC, In: *2010 International Conference on Future Information Technology and Management Engineering, FITME 2010*. IEEE, 1, 520–523. doi: 10.1109/FITME.2010.5655818.

Rao, L., Mansingh, G., and Osei-Bryson, K.M. (2012). Building ontology based knowledge maps to assist business process re-engineering, *Decision Support Systems*. Elsevier B.V., 52(3), 577–589. doi: 10.1016/j.dss.2011.10.014.

Sasson, E., Ravid, G., and Pliskin, N. (2014). Modeling technology assessment via knowledge maps, In: *Proceedings of the Annual Hawaii International Conference on System Sciences*. IEEE, 924–933. doi: 10.1109/HICSS.2014.122.

Sasson, E., Ravid, G., and Pliskin, N. (2017). Creation of knowledge-added concept maps: time augmention via pairwise temporal analysis, *Journal of Knowledge Management*, 21(1), 132–155. doi: 10.1108/JKM-07-2016-0279.

Sheng-Hung, C. (2016). Course delivery and module learning via learning objects (knowledge map) in mobile learning environment, *Asian Association of Open Universities Journal*, 7(1), 43–54. doi: 10.1108/aaouj-07-01-2012-b004.

Stewart, S.A., and Abidi, S.S.R. (2017). Leveraging medical taxonomies to improve knowledge management within online communities of practice: The knowledge maps system, *Computer Methods and Programs in Biomedicine*. Elsevier Ireland Ltd, 143, 121–127. doi: 10.1016/j.cmpb.2017.03.003.

Tao, C.C., Wu, J.Y.J., and Jian, R.J. (2012). Knowledge mapping of ITS theses and dissertations in Taiwan using social network analysis, In: *2012 12th International Conference on ITS Telecommunications, ITST 2012*. IEEE, 563–567. doi: 10.1109/ITST.2012.6425242.

Wang, H., Su, X.N., and Liu, F. (2009). Semantic annotation for CSSCI academic resources based on ontology, In: *6th International Conference on Fuzzy Systems and Knowledge Discovery, FSKD 2009*. IEEE, 2, 374–385. doi: 10.1109/FSKD.2009.338.

Wartena, C. (2013). Challenges and Potentials for Keyword Extraction from Company Websites for the Development of Regional Knowledge Maps, 241–248. doi: 10.5220/0004660002410248.

Watthananon, J., and Mingkhwan, A. (2012). Optimizing knowledge management using knowledge map, *Procedia Engineering*, 32, 1169–1177. doi: 10.1016/j.proeng.2012.02.073.

Wu, B., He, M., Dong, Q.H., and Chen, R.X. (2011). A Study of the Safety Information Management System for Coal Mine Company Basing on the Knowledge Management System, *Advanced Materials Research*, 271–273, 949–953. doi: 10.4028/www.scientific.net/amr.271-273.949.

Wu, H., Chou, X., Li, G., and Shi, Y. (2018). Indoor Space Model Based on Knowledge Graph, In: *Proceedings - 2018 10th International Conference on Intelligent Human-Machine Systems and Cybernetics, IHMSC 2018*. IEEE, 2, 72–76. doi: 10.1109/IHMSC.2018.10123.

Yoon, B., Lee, S., and Lee, G. (2010). Development and application of a keyword-based knowledge map for effective R&D planning, *Scientometrics*, 85(3), 803–820. doi: 10.1007/s11192-010-0294-5.

Zenkert, J., Holland, A., and Fathi, M. (2016). Discovering contextual knowledge with associated information in dimensional structured knowledge bases, In: *2016 IEEE International Conference on Systems, Man, and Cybernetics, SMC 2016 - Conference Proceedings*. IEEE, 1923–1928. doi: 10.1109/SMC.2016.7844520.

Zhang, C., Zhou, G., Lu, Q., and Chang, F. (2017). Graph-based knowledge reuse for supporting knowledge-driven decision-making in new product development, *International Journal of Production Research*, 55(23), 7187–7203. doi: 10.1080/00207543.2017.1351643.

Zhang, Y., Zhang, C., Feng, T., and Liu, S. (2010). An approach for constructing knowledge map embedded in the social relationship network, In: *Proceedings of the International Conference on E-Business and E-Government, ICEE 2010*, 1750–1754. doi: 10.1109/ICEE.2010.443.

Zhang, Y., Saberi, M., Chang, E., and Abbasi, A. (2018). Solution and Reference Recommendation System Using Knowledge Fusion and Ranking, In: *Proceedings - 2018 IEEE 15th International Conference on e-Business Engineering, ICEBE 2018*. IEEE, 31–38. doi: 10.1109/ICEBE.2018.00016.

Zhang, Y., Saberi, M., and Chang, E. (2017). Semantic-based lightweight ontology learning framework, In: *WI'17: Proceedings of the International Conference on Web Intelligence*, 1171–1177. doi: 10.1145/3106426.3109053.

Zhao, Q., Li, Q., and Wen, J. (2018). Construction and application research of knowledge graph in aviation risk field, In: *MATEC Web of Conferences*, 151, 05003. doi: 10.1051/matecconf/201815105003.

Zhao, Y., Fesharaki, N.J., Li, X., Patrick, T.B., and Luo, J. (2018). Semantic-Enhanced Query Expansion System for Retrieving Medical Image Notes, *Journal of Medical Systems*. Journal of Medical Systems, 42(6), 1–11. doi: 10.1007/s10916-018-0954-1.

Zheng, Q., Qian, Y., and Liu, J. (2010). Yotta: A knowledge map centric e-learning system, In: *Proceedings - IEEE International Conference on E-Business Engineering, ICEBE 2010*. IEEE, 42–49. doi: 10.1109/ICEBE.2010.43.

Zhu, X., and Wang, Y. (2009). A relation combination model for knowledge maps, In: *Proceedings - 2009 International Conference on Information Engineering and Computer Science, ICIECS 2009*, 1-5. doi: 10.1109/ICIECS.2009.5364816.