ISSN-2347-2227
Subscribers copy
Not for sale

Volume 7. No. 1
March - May 2019

i-manager's

Journal on Computer Science

Disseminating new ideas in Information and Computation

i-manager® Publications

ENHANCING WORDNET AGAINST OVERLAPPING RETURNS OF SENSES FOR EFFICIENT POLYSEMY REPRESENTATION IN ONTOLOGY DEVELOPMENT

By

ENESI FEMI AMINU * QASIM ADEWALE FAJOBI ** ISHAQ OYEBISI OYEFOLAHAN ***

MUHAMMAD BASHIR ABDULLAHI **** MUHAMMADU TAJUDEEN SALAUDEEN *****

** Lecturer, Department of Computer Science, Federal University of Technology, Minna, Nigeria.*
*** Department of Computer Science, Federal University of Technology, Minna, Nigeria.*
**** Senior Lecturer, Department of Information and Media Technology, Federal University of Technology, Minna, Nigeria.*
***** Head, Department of Computer Science, Federal University of Technology, Minna, Nigeria.*
****** Senior Lecturer and Head, Department of Crop Production, Federal University of Technology, Minna, Nigeria.*

Date Received: 11/01/2019 Date Revised: 28/01/2019 Date Accepted: 29/04/2019

ABSTRACT

In order to have a web of relevant information retrieval otherwise, known as semantic web, ontology has been identified as its core stronghold to actualize the dream. Ontology is a data modeling or knowledge representation technique for structured data repository premised on collection of concepts with their semantic relationships and constraints on particular area of knowledge. Example is wordNet which is linguistic based and popular ontology which has been greatly used to be part of ontology based information retrieval system development. However, the existing wordNet would affect the expected accurate results of such system owing to its overlapping return of senses. Therefore, this research aimed to design algorithm with the aid of extended Levenshtein similarity matching function and WordWeb to proffer solution to the militating problem. At the end, an enhanced wordNet that devoid of overlapping returns of senses for efficient polysemy representation in terms of user's time and system's memory would be achieved.

Keywords: Semantic Web, Ontology, Wordnet, Wordweb, Senses, Polysemy, Levenshtein.

INTRODUCTION

Presently, the existing web is often described to be machine readable, but not machine understandable. Thus, there is a need for web that allow computer to manipulate data and information (Berners-Lee, Hendler, & Lassila, 2001). Web with such capacity is referred to as Semantic Web. More importantly, the application of linguistic databases such as WordNet to the realization of this dream web (semantic web) is highly indispensible. Semantic web reorganizes the huge amount of information that is accessible to user on the internet in a way like that is inline with user's intent. It also serves as a connection between human and computer by making the computer think more like a human while still allowing the human to do the real thinking. Semantic web allows search, integration, complex inquiries, and the likes. However, the technologies drive behind the web is on one hand ontologies and on the other hand the information retrieval techniques (Sánchez, Isern, & Millan, 2011). Stressing further, (Lutz & Klien, 2006; Wache et al., 2001) reported that one suitable means of achieving semantic web is by exposition of knowledge via the means of ontologies.

There are different definitions of ontology. However, one of the popular definitions of ontology is that of (Gruber, 1993), which states that ontology is an explicit and formal specification of a conceptualization. Similarly, ontologies are formal structures that give a shared comprehension of a specific domain (Al-Yahya, George, & Alfaries, 2015). Thus, based on the literatures review, Ontology is defined in this research as data modeling technique for structured data repository premised on collection of concepts with their semantic relationships and constraints on particular area of knowledge or domain. The research work of (Rodríguez-García, Valencia-García, García-Sánchez, & Samper-Zapater, 2014) described five components to formalize ontologies as classes, relations, attributes, axioms, and instances. In various areas, ontologies play a vital role in assisting information processes (Fensel, Van Harmelen, Horrocks, McGuinness, & Patel-Schneider, 2001). Example of a very popular and general ontology is the WordNet (Devi & Gandhi, 2015).

Information Retrieval (IR) is a mechanism of retrieving relevant information based on the query search of user's intent. There are different techniques for information retrieval processes, which includes ontological process. Generally speaking, Information Retrieval Systems (IRSs) are categorized into two folds: The syntactic search systems, otherwise known as keyword-based systems and semantic search systems also called conceptual-based systems. A typical example of the latter is the ontology-based IR. Their major difference lies on their capacity to handle word mismatch that poses a serious challenge to IRS (Singh & Sharan, 2017; Carpineto & Romano, 2012; Wei, Wang, Hu, & Xue, 2012).

Word mismatch is described as a situation of IR system, where the concept of query terms of user are at variance with the concepts of documents or indexers. This is attributed to the vocabulary issues of synonyms, polysemy, and the likes (Devi & Gandhi, 2015). Synonyms mean similar words in meaning such as maize and corn. Polysemy in a simple definition means word that has more than one meaning or an individual word or expression that is ambiguous in nature such as ear which could be a human part or maize part. The term polysemy may also describe as a characteristic of semantic ambiguity that has to do with variety of word meanings. For instance, sheep can refer to animal (as in the sheep pressed through the gap) or to a food thing (as in Sue had sheep for lunch) (Jiamjitvanich & Yatskevich, n.d). Generally, about 40% of English words are polysemous. And of course, polysemous words can result to challenges in contexts according to Frankfurt International School.

As a result, with polysemy there is always a high chance of irrelevant results; thereby cause decrease in recall value and a decrease/increase in precision results as the case may be. Also, one of the main challenges people encountered in computational semantics is the polysemous nature of natural language words (Boleda, Walde, & Badia, 2012). To this end and based on literatures, WordNet has been found to as a useful technology to solve or ameliorate the problem of word mismatch. However, the number of senses return after query search overlaps and therefore presented difficulties in how these polysemous words are being represented.

WordNet, a linguistic based upper ontology or lexical database organizes English words into semantic relations called synonym sets (or synsets for short). It has been applied in numerous human languages related applications, for example, sense disambiguation, information retrieval, and text categorization. A similar English word database is the Wordweb. It is an English dictionary and thesaurus containing a classified list of synonyms (Nandini, 2014).

If for example, the word “arm” is searched in the existing wordNet, instead of returning six senses which are overlapping in meaning, the proposed system is therefore aimed that the algorithmic framework should be able to solve the problem of senses overlapping. Thereby, increases the precision of results in order to save time.

1. Related Studies

For over three decades, WordNet has been in existence, developed by linguists and psycholinguists as a conceptual dictionary rather than an alphabetic one (Freihat, Dutta, & Giunchiglia, 2015). It was created with the initial goal of proving psycholinguistic models about the mental organization of concepts (Basile, 2015). In the graph of WordNet, vertices stand for word grouping of synonyms, while edges are labeled relations between either two synonyms or specific words in a grouping. The lexical database organizes English words into semantic relations called synonym sets (or synsets for short). According to the research of (Vijayarajan, Dinakaran, Tejaswin, & Lohani, 2016), WordNet is considered an upper ontology by some, but it is not strictly ontology.

Three databases in WordNet were identified in (Uthayan & Anandha Mala, 2015). Noun is the initial one, Verbs; the second database, and adjectives/adverbs; the final one. Synsets is a set of synonyms which designate a concept or a sagacity of a set of terms. Synsets available make diverse semantic relations for instance synonymy (similar) and antonymy (opposite), hypernymy (super concept)/hyponymy (subconcept) (also known as a hierarchy/taxonomy), meronymy (part-of), and holonymy (has-a). Depending on the grammatical category, the semantic relatives with the synsets will vary.

In addition, (Jiamjitvanich & Yatskevich, 2008) presented an account of synset as a WordNet structure for storing senses of the words. Synsets contains a set of synonym words and their concise depiction called gloss. Every synset signifies a concept which is associated with different concept by means of many semantic relationships, including hypernym/hyponymy, metonymy/ homonymy, and antonym (Laparra, Rigau, & Cuadros, 2010). WordNet is essentially a semantic network hierarchically structured using lexical relations like hyponymy and meronymy (Barque & Chaumartin, 2009).

In the research work of (Laparra & Rigau, 2009), a methodology to automatically extract, with a good precision, new lexical relations in WordNet based on metonymy and metaphor relations was proposed. Metaphor, Metonymy, and as well as Specialization were considered in the article as popular categories of regular polysemy. Two forms of results were reported. They are: methodological result; with the automatic detection of occurrences of regular polysemy relations with a rather good precision and a descriptive one with the classification of regular polysemy relations. Thus, the work concluded that with the results obtained a lexical disambiguation task to deduce meanings would be handled which were not identified in WordNet.

A novel automatic approach to partly integrate both FrameNet and WordNet using Structural Semantic Interconnections (SSI-Dijkstra) of a knowledge-based Word Sense Disambiguation algorithm was the research work of (Freihat, Giunchiglia, & Dutta, 2016). The work aimed to enrich wordNet with FrameNet semantic information and equally expand the language's scope of FrameNet other than English language. Thus, evaluation of the proposed algorithm along with the other available graph based algorithms was not carried out.

Taxonomic principles for sorting out the polysemy types in Wordnet considering specialization, metaphoric, and homonymy were presented in the work of (Singla & Garg, 2012). A semi-automatic method for discovering and identifying three polysemy types in WordNet was introduced. The strength of the approach lies on its ability to ascertain subsets of the metaphoric and metonymy structural patterns and all specialization polysemy structural patterns. However, the research intends to find out the metonymy patterns in the upper level of WordNet hierarchy.

Basile (2015) identified sense enumeration in WordNet as one of the prime causes of high level polysemous nature of WordNet predicated on compound noun polysemy. The authors presented a new approach in the form of disambniguation algorithm to solve the problem. However, the research did not study the relation between missing terms and sense enumeration in WordNet. Similarly, test of the new approach using the precision and recall metrics have not been sufficiently established.

Therefore, to address the senses returns overlapping challenges of wordNet, this paper proposed to engage another related lexical database called WordWeb by designing hybridization algorithms that can explore and filter the senses returns of noun databases. Levenshtein Edit Distance Similarity Matching Algorithm is adapted in this research to measure the semantic similarity of senses returns from the two databases and thereby hybridize. WordWeb is an English dictionary and thesaurus available across different platforms such as Microsoft Windows, iOS, Android, and Mac OS X, which can equally be used to realize semantic web (Freihat et al., 2015).

2. Levenshtein Edit Distance Similarity Matching Algorithm

In order to compute the gloss, senses or conversely, the matching words or senses of the two databases in the proposed hybridization algorithm, a semantic similarity measure function is required. Therefore, in this section; Levenshtein Edit Distance Similarity Matching Algorithm is adapted. The algorithm represents a metric for measuring the amount of difference between two sequences (Freeman, Condon, & Ackerman, 2006). But in this paper, the algorithm is extended in order to take care of more sequences. Sequences represent senses that return from the two databases. Edit distance operation includes deletion, insertion, or replacement of a character. The essence is to make the two strings match, and in a situation where we have a perfect match then; a score of zero is allotted. Generally, from the formula in this section, the algorithm returns an integer value representing the number of edits essential to make the two strings match.

$$\text{Lexical Similarity}(s,t\ldots n) = 1 - \frac{levens\,h\,tein\,(s,t\ldots n)}{s+t\ldots n} \quad (1)$$

where s, t…n represent any given senses from database.

3. Proposed Algorithm for Efficient Polysemy Representation

In order to achieve an efficient polysemy representation in ontology development using WordNet, the following algorithms in this section set out the framework. The algorithms are broken down into three parts. Algorithm 1 represents how senses would return from WordNet after user inputs a search word. Similarly, Algorithm 2 depicts how senses would equally return from WordWeb after user inputs a similar search word. Finally, Algorithm 3 presents a solution on how similar senses returns are being filtered and harmonized with the aid of the extended Levenshtein similarity function.

Considering Algorithm 1, whenever user enters word or term whether normal noun-term (such as ear, house, knife) or inflected noun-term (such as ears, houses knives), the system will get all indexes as the wordID of the term in a data structure called wordindex_List. Then, in order to find the set of synonyms (synset) of the terms index, another data structure is created called gloss list.

Similarly, in order to ensure efficient polysemy representation, WordWeb is also considered for Algorithm 2 since it is similar to WordNet. Same terms would also be searched in WordWeb and the return synsets are stored in the created data structure.

Algorithm 3 which is described as the pivot point of this work enhances WordNet by trying to; firstly, resolves overlapping senses of a term searched by user in WordNet and WordWeb then store it in the GlossList data structure. Secondly, the lexical similarity of the senses returns in WordNet and WordWeb are compared before hybridizing if need arise as would be the case of the last construct (else) of the algorithm; where the senses return of both databases are equal. The comparison would be achieved using the adapted distance similarity matching algorithm for each senses return in a database ranges and denoted by sense s, sense t, to sense n with their respective indices i, j to k.

4. The System Architecture

The system architecture as shown in this section by Figure 1 depicts the structural view of the proposed system and tasks that user can perform in order to use the system.

The architecture is described as three-tier design which can be elaborated as follows.

- The Users Tier: The first tier accounted for user search state: At this state, user will launch the application and type in a desired word via a text box and click on search button. The system checks for the meaning associated to the word being searched from the improved database of WordNet, which is a derivation of both WordNet and WordWeb databases.
- The Enhanced System Tier: The second tier is termed as Enhanced System. This is where senses from both databases are filtered and hybridized. At this stage, the system will process the meanings of the word searched by the user from both databases (WordNet and WordWeb), and return the best meaning based on the hybridization algorithm developed for the proposed system.
- The Databases Tier: The database is the third tier of the system which comprises of WordNet and WordWeb. Both databases consist of English lexical of words. When the user search for a word, the hybridize system will look up for the meaning of word from both databases (WordNet and WordWeb) and the system will return the best meaning via the enhanced system.

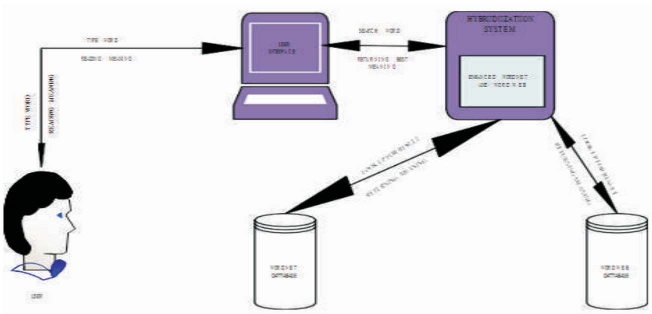

Figure 1. System Architecture of the Proposed System

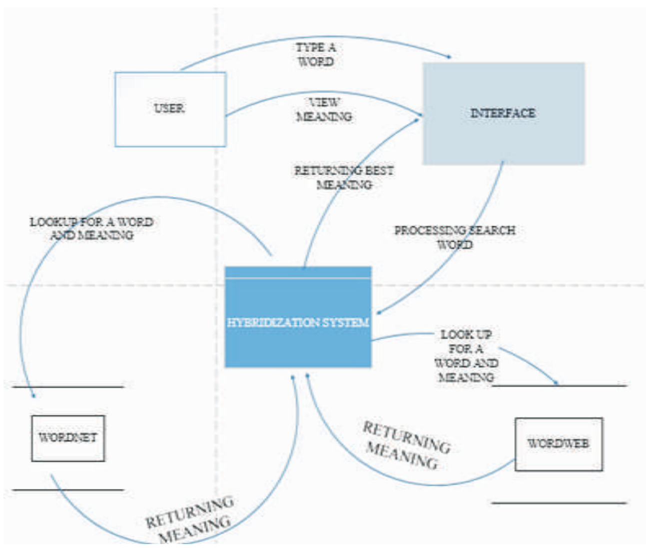

Figure 2. Data Flow Diagram of the Proposed System

Moreso, the conceptual framework of the proposed system is furthered represented by Figures 2 using Data Flow Diagram.

Figure 2 represents the flow of data within the three tiers of the system. That is, user type in search term from the user tier via an interface to the enhanced system, where appropriate lookup messages as may necessary will communicate to the various databases (WordNet and WordWeb). And the appropriate response will be communicated back to the user via the same proposed graphical interface. It is a diagram that represents the flow of data through an information system. Data Flow Diagram is a graphical approach of an information system data model that shows how data move from input to output. In other words, it is used to analyze an existing system or to model a new system.

5. Discussion and Results

As a proof of concept, at preliminary stage some normal or inflected noun terms are queried using the existing (WordNet) system. The returned senses as results are presented in Table 1. Inflected noun term means the plural forms of noun terms. For example: Kings, Knives, and Houses while normal noun terms are King, Knife, and House. It is very important to mention that the existing WordNet returns the same meaning of senses for both normal and inflected noun terms.

One of the primary reasons of using WordWeb along with WordNet to correct the overlapping effects of WordNet is because senses overlapping in WordWeb have been slightly minimized. For instance, the noun "King" returns ten senses in WordNet and seven in WordWeb. But notwithstanding, there is still a research gap that can be filled or improved. And that is exactly what this research is

Algorithm 1: Query WordNet

```
Input: Normal noun-terms and inflected noun-terms
Output: Returns synsets for term
getSenses From Wordnet (word) {
wordindex_List = get all indexes of the words;
Create an empty List for lemma or gloss
for each wordindex in wordindex_List {
get the wordID from the wordindex;
get the synset present in the worded
get the synset gloss and add into gloss
list;
}
return glosslist;
}
```

Algorithm 2: Query WordWeb

```
Input: Normal noun-terms and inflected noun-terms
Output: Returns synsets for term
Get Senses From word web (word){
Create a gloss list;
For a Word get all pages of occurrence;
Get the first index of the page which is a noun;
Get all senses of the page;
For each sense in senses{
Get its entry word and gloss meaning
Add gloss meaning to gloss list;
}
Return gloss list;
}
```

Noun Terms	Senses Return
King	i. Male monarch ii. Queen, world-beater iii. Baron, business leader iv. Preeminence in a particular category or group v. Billie Jean King, etc vi. B. B. King, etc vii. Martin Luther King viii. A checker that has been moved to the opponent first row ix. One of the four playing card x. Chess (the weakest but the most important piece)
Arm	i. A human limb ii. Weapon iii. Subdivision, branch iv. Branch, limb v. The part of an armchair or sofa vi. The part of a garment that is attached at the armhole
Sheep	i. Woolly usually horned ruminant mammal related to the goat ii. A timid defenseless simpleton whom is readily to preyed upon iii. A docile and vulnerable person
Conference	i. A prearranged meeting for consultation or discussion ii. An association of sports iii. A discussion among participants who have agreed on topic

Table 1. Senses Return From Existing WordNet

Algorithm 3: Snapshot of the Enhanced System

```
Input: Normal noun-terms and inflected noun-terms
Output: Returns filter synsets for term
Search(word){
Wordnetsensecount = getSensesFromWordnet
(word).size(); wordwebsensecount =
getSensesFromwordweb
(word).size();
for each i from 0 to |s|
for each j from 0 to |t|
for each k from 0 to |n|
.......
If(wordnetsensecount == 0 && wordwebsensecount ==
0) Print word not found;
WordnetGlossList = getSensesFromWordnet(word);
wordwebGlossList = getSensesFromwordweb (word);
If(wordnetsensecount > wordwebsensecount){
Show WordnetGlossList data;
}else if(wordwebsensecount >
wordnetsensecount){Show wordwebGlossList data;
}else{
Show both WordnetGlossList and wordwebGlossList data;
}else{
Show both WordnetGlossList and wordwebGlossList data;
}}
```

aimed to achieve.

Clearly, from Table 1 so many senses or polysemous words are overlapping and therefore results to user's time and system's memory wastage. From the noun term King, senses 1 to 4, 5 to 7, and 8 to 10 are overlapping senses. Senses 1 to 4 are all about leadership, senses 5 to 7 are mere names to people, and senses 8 to 10 have to do with game. Similar issues to the other terms. Therefore, with the aid of the proposed algorithm; Table 2 presented an efficient polysemy representation of the noun terms and more. Still in the same direction as presented in Table 2, from the noun conference, senses 1 and 3 with the aid of the algorithm would be considered as overlapping and thereby treated as one sense (that is, an association). The project is still work in progress.

Noun Terms	Senses Return
King	i. Leadership, Title (senses 1-4) ii. People's Name (senses 5-7) iii. Game's Name (senses 8-10)
Arm	i. A human limb (senses 1and 4) ii. Weapon (sense 2) iii. Part of Non-Living Noun (senses 3, 5 and 6)
Sheep	i. Ruminant mammal related to the goat (sense 1) ii. Vulnerable persons (senses 2-3)
Conference	i. A formal Discussion (senses 1 and 3) ii. An Association (sense 2)

Table 2. Senses Return from Enhanced WordNet

Furthermore, for terms that have equal number of senses in both databases, the proposed algorithm would still be executed to check for any overlap senses. The noun fruit, conference among others are examples of this scenario.

Conclusion and Further Studies

The application of WordNet in ontology development and semantic web in order to resolve the problem of word mismatch is crucial to research. From literatures, retrieval of queries results ontology and semantic web may not be sufficiently relevant in terms of high precision, low or high recall as the case may be as a result of overlapping returns of senses of polysemous words in the existing WordNet. Therefore, in this paper the authors have proposed an algorithms that would enhance the existing WordNet system that would resolve the issues of overlapping senses. Upon successful completion, the research work will be highly recommended for ontology curators and researchers in the field of Information Retrieval. WordNet has three databases, which include noun, verb, and adjective/adverb. However, in this paper, only noun database is under consideration and it is a project in progress. In addition, as earlier mentioned; in the course of this research, they aimed to further provide an algorithm that would enhance the WordNet capability to return accurate meaning for normal noun-terms and inflected noun-terms appropriately.

References

[1]. Al-Yahya, M., George, R., & Alfaries, A. (2015). Ontologies in E-learning: Review of the literature. *International Journal of Software Engineering and Its Applications,* 9(2), 67-84.

[2]. Barque, L., & Chaumartin, F. R. (2009). Regular polysemy in WordNet. *JLCL-Journal for Language Technology and Computational Linguistics,* 24(2), 5-18.

[3]. Basile, V. (2015). WordNet as an Ontology for Generation. *WebNLG 2015 1st International Workshop on Natural Language Generation from the Semantic Web.*

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

[5]. Boleda, G., Walde, S. S, I., & Badia, T. (2012). Modeling regular polysemy: A study on the semantic classification of catalan adjectives. *Computational Linguistics,* 38(3), 575-616.

[6]. Carpineto, C., & Romano, G. (2012). A survey of automatic query expansion in information retrieval. *ACM Computing Surveys (CSUR),* 44(1), 1-38.

[7]. Devi, M. U., & Gandhi. G. M. (2015). WordNet and Ontology based Query Expansion for Semantic Information Retrieval in sports domain. *Journal of Computer Science,* 11(2), 361-371.

[8]. Fensel, D., Van Harmelen, F., Horrocks, I., McGuinness, D. L., & Patel-Schneider, P. F. (2001). OIL: An ontology infrastructure for the semantic web. *IEEE Intelligent Systems,* 16(2), 38-45.

[9]. Freeman, A. T., Condon, S. L., & Ackerman, C. M. (2006, June). Cross linguistic name matching in English and Arabic: A one to many mapping extension of the Levenshtein edit distance algorithm. In *Proceedings of the Main Conference on Human Language Technology Conference of the North American Chapter of the Association of Computational Linguistics* (pp. 471-478). Association for Computational Linguistics.

[10]. Freihat, A. A., Dutta, B., & Giunchiglia, F. (2015). Compound noun polysemy and sense enumeration in wordnet. In *Proceedings of the 7th International Conference on Information, Process, and Knowledge Management (eKNOW)* (pp. 166-171).

[11]. Freihat, A. A., Giunchiglia, F., & Dutta, B. (2016, January). A taxonomic classification of wordnet polysemy types. In *Global WordNet Conference* (p. 105).

[12]. Gruber, T. R. (1993). A translation approach to portable ontology specifications. *Knowledge Acquisition,* 5(2), 199-220.

[13]. Jiamjitvanich, K. & Yatskevich, M. (n.d). *Reducing polysemy in WordNet.* Department of Information and Communication Technology, University of Trento, Italy.

[14]. Jiamjitvanich, K., & Yatskevich, M. (2008). *Reducing polysemy in WordNet.* University of Trento.

[15]. Laparra, E., & Rigau, G. (2009). Integrating WordNet and framenet using a knowledge-based word sense disambiguation algorithm. In *Proceedings of the International Conference RANLP-2009* (pp. 208-213).

[16]. Laparra, E., Rigau, G., & Cuadros, M. (2010, February). Exploring the integration of WordNet and FrameNet. In *Proceedings of the 5th Global WordNet Conference (GWC 2010).*

[17]. Lutz, M., & Klien, E. (2006). Ontology based retrieval of geographic information. *International Journal of Geographical Information Science,* 20(3), 233-260.

[18]. Nandini, D. (2014). *Semantic Web and Ontology* (eBooks and textbooks from bookboon. com). Retrieved from https://bookboon.com/en/semantic-web-and-ontology-ebook

[19]. Rodríguez-García, M. Á., Valencia-García, R., García-Sánchez, F., & Samper-Zapater, J. J. (2014). Ontology-based annotation and retrieval of services in the cloud. *Knowledge-Based Systems,* 56, 15-25.

[20]. Sánchez, D., Isern, D., & Millan, M. (2011). Content annotation for the semantic web: an automatic web-based approach. *Knowledge and Information Systems,* 27(3), 393-418.

[21]. Singh, J., & Sharan, A. (2017). A new fuzzy logic-based query expansion model for efficient information retrieval using relevance feedback approach. *Neural Computing and Applications,* 28(9), 2557-2580.

[22]. Singla, N., & Garg, D. (2012). String matching algorithms and their applicability in various applications. *International Journal of Soft Computing and Engineering,* 1(6), 218-222.

[23]. Uthayan, K. R., & Anandha Mala, G. S. (2015). Hybrid ontology for semantic information retrieval model using keyword matching indexing system. *The Scientific World Journal,* 2015.

[24]. Vijayarajan, V., Dinakaran, M., Tejaswin, P., & Lohani, M. (2016). A generic framework for ontology-based information retrieval and image retrieval in web data. *Human-centric Computing and Information Sciences,* 6(1), 18.

[25]. Wache, H., Voegele, T., Visser, U., Stuckenschmidt, H., Schuster, G., Neumann, H., & Hübner, S. (2001, August). Ontology-based integration of information-a survey of existing approaches. In *IJCAI-01 Workshop: Ontologies and Information Sharing* (Vol. 2001, pp. 108-117).

[26]. Wei, Y. Y., Wang, R. J., Hu, Y. M., & Xue, W. (2012). From web resources to agricultural ontology: A method for semi-automatic construction. *Journal of Integrative Agriculture,* 11(5), 775-783.

ABOUT THE AUTHORS

Enesi Femi Aminu presently Lectures in the Department of Computer Science at Federal University of Technology, Minna, Nigeria and also a Ph.D student in the same Department. His teaching courses include Operating Systems, Database Design and Management, Object Oriented Programming, and Web Design. He obtained both his B.Sc and M.Sc Degrees in Computer Science from University of Jos, Jos and Ahmadu Bello University, Zaria, respectively. His current research interest is on Ontology Design and Semantic Search. He is also a Member of professional bodies, such as Nigeria Computer Society (NCS) and International Association of Computer Science and Information Technology (IACSIT).

Qasim Adewale Fajobi graduated from the Department of Computer Science at Federal University of Technology, Minna, Nigeria in 2017. He was a B.Tech project student under the supervision of Enesi Femi Aminu. Fajobi's research area of interest revolves around Ontology Based Information Retrieval.

Dr. Ishaq Oyebisi Oyefolahan is currently a Senior Lecturer in the Department of Information and Media Technology at Federal University of Technology, Minna, Nigeria. Prior to joining his current department, he was an Assistant Professor in the Department of Information Systems, International Islamic University Malaysia. His fields of interest are Business Intelligence, Web and Mobile Applications Development, Utilization and Evaluation, Business-IT Alignment, and Knowledge Management. He has published several technical papers in International, National Journals, and Conferences.

Dr. Muhammad Bashir Abdullahi is currently the Head of the Department of Computer Science at Federal University of Technology, Minna-Nigeria. He received B.Tech (Honors) in Mathematics/Computer Science from Federal University of Technology, Minna-Nigeria, and PhD degree in Computer Science and Technology from Central South University, P. R. China. His research interests are mainly in the areas of Network and Information Security, Internet of Things, Machine Learning, Big Data Technology, and Cloud Computing.

Dr. Muhammadu Tajudeen Salaudeen is currently a Senior Lecturer and Head in the Department of Crop Production at Federal University of Technology, Minna, Nigeria. He holds a PhD in Plant Pathology from the University of Ibadan, M.Sc Crop Protection from Ahmadu Bello University, Zaria, and B.(Agric) Tech. General Agriculture (First Class Honours) from the Federal University of Technology, Minna. He was a Research Fellow at the International Institute of Tropical Agriculture (IITA), Ibadan between 2009 and 2012 and a Visiting Scientist from 2013 – 2014 at the same Institute. He has received specialist training on Molecular Breeding and Analyses of Agricultural Research Data in the Netherlands (2012), Spain (2013 and 2014) and IITA, Ibadan. He won an International research grant in 2013 to investigate the status of Maize Lethal Necrosis Disease (MLND) in Nigeria. He conducts Research on Survey of Plant Viruses, Plant Virus Diversity, Virus Host Range, and Screening for Resistance. He teaches Biostatistics, Crop Protection, and Plant Pathology courses at undergraduate and postgraduate levels.