reviewed about 203 research papers ranging from 1960 to 2010. Also, they present the importance of expanding the query for better search results and examine different approaches that could be used to address vocabulary mismatch issues. Unlike [1], they discuss how efficiency, effectiveness, and critical matters in query expansion performance would be achieved.

TABLE I
SUMMARY OF THE PREVIOUS SURVEY OF QUERY EXPANSION RESEARCH PAPERS

Research papers	Summary of the Research Paper			
	Publishers	Range of review years	Total number of papers reviewed	% of reviewed articles from 1999 - 2018
Bhogal *et al* [1],	Elsevier	1969 – 2006	123	63%
Carpineto and Romano, [2]	ACM	1960 – 2010	203	75%
Ooi et al. [3]	IEEE	1980 - 2014	33	70%

In another previous query expansion survey, Ooi *et al* [3] reviewed query expansion approach research papers between 1980 to 2014. Their works focused not only on query expansion but also query suggestion and refinement because the terms go near each other in web search improvement. Also, their research paper was not thoroughly examined but served as an introductory level. However, we can conclude that there was the absence of a comprehensive study on query expansion methods since 2012.

In terms of novelty and contributions, [2] paper has been valuable to researchers because more citations were given. For instance, as of 31st August 2018, it has 595 sources that show how it contributed to the knowledge body. Also, [1] received significant citations. All the sources are based on Google scholar citation. However, there is a need for a further review of contemporary techniques because previous papers have focused on a few approaches, while recently, more systems have been proposed. These new approaches generate new ideas and directions for the research. The new research direction can positively impact the query expansion methods for improving search engine results.

Moreover, the query expansion research area has extended to other research fields, generating the number of publishing works with query expansion. Consequently, there is an urgent need to classify the current query expansion methods research based on application areas. It is also essential to provide a new survey that combined both journals and conferences.

The contributions of this paper are as follows:

- Examines a comprehensive query expansion research publication from different domains
- Provide a more recent review on query expansion, which does not cover by previous research papers
- Examine broad query expansion methods
- Review query expansion issues

The aims of this paper are as follows:

- To identify query expansion research areas for improving search engine results.
- To describe query expansion methods been used in a different environment.
- To suggest new research opportunities for query expansion towards improving the search engine.

Other sections of the paper are organized as follows: the methodology used in conducting the review is in section 2. Section 3 is Data Synthesis, and section 4 is discussion and future works

II. MATERIAL AND METHOD

Five (5) phases have been considered for this review process (see Figure 1).

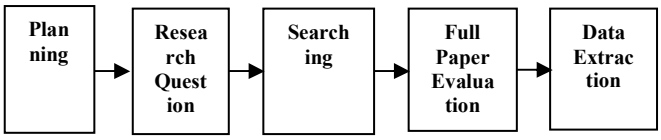

Fig. 1 Review Process

A. Planning

We considered Google scholar as our first avenue for planning our research process. The keyword has been used via Google scholar search engine to search relevant papers related to query expansion application areas and methods. This keyword provides us with an insight into major search engines that our review process would depend on and the areas to focus on our search. Based on the search results from Google Scholar, we found four (4) electronic search engine bibliographic libraries where many results of our query were indexed in IEEE Xplore, Elsevier, the Association for Computing Machinery (ACM), and Springer digital libraries. These search engines also provide us with the need to plan and formulate our research questions to guide our review. Therefore, we outline our research questions in the next phase.

B. Research Questions

To clarifies the purpose of our review, three (3) research questions were formulated to explain why this comprehensive review has been carried out.

- Q1: What are the query expansion application areas?
- Q2: What are the query expansion methods?
- Q3: What are the new research opportunities for query expansion?

Each of these three research questions has its rationale behind its formulation. Therefore, this will lead to the search phase, where each paper's title serves as a guide.

C. Searching

We intent to reasonably review as many research papers as possible. Consequently, we considered the titles of published research articles and conferences ranging from 1999 to 2018 (20 years). We used the term “query expansion” to search a bibliographic database of IEEE Xplore, Elsevier (Scopus), Springer, and The Association for Computing Machinery (ACM). The preliminary results are shown in Table 2 that 670 conference proceedings and 78 research articles were obtained from IEEE Xplore. Springer has 4,368 conference proceedings and 2,296 research article papers.

TABLE II
SUMMARY OF THE PRELIMINARY RESULTS OF A SEARCH QUERY

Publisher	Preliminary results of a search query		
	Conferences proceedings	Research articles	Total publications
Elsevier	42	1,841	1883
ACM	29,852	2,220	32072
IEEE	670	78	748
Springer	4,368	2,296	6664

In Association for Computing Machinery (ACM), 29,852 conference proceedings and 2220 research articles papers were obtained. While the result for Elsevier shows 42 conference proceedings and 1,841 research papers were also obtained. Considering this large number of the results obtained, we quickly go through the obtained results to identify their relevance to our search query. We removed any paper title that does not consider text retrieval but considered other multimedia elements such as images, audio, and graphics. We also removed all papers with only keywords but not our search terms. For instance, thousands of results have been returned by these search engines with only the keyword "query" which was irrelevant to query expansion.

This keyword reduces our search results to 257 conference proceedings and 40 research articles papers for the Association for Computing Machinery (ACM). In Springer, we reduced the conference proceedings to 302 and the research article papers to 101. Also, five conference proceedings and 72 research articles were obtained in Elsevier. Moreover, 277 conference proceedings and 27 research articles were obtained in IEEE Xplore. The total number of conference proceedings and research articles papers obtained is 1,081, which is summarized in Table 3. These results lead us to the next phase to evaluate their relevancies to our research questions.

TABLE III
SUMMARY OF THE REDUCED PRELIMINARY RESULTS

Publishers	Reduced preliminary results		
	Conferences proceedings	Research articles	Total publications
Elsevier	05	72	77
ACM	257	40	297
IEEE	277	27	304
Springer	302	101	403
Total			1081

D. Full Paper Evaluation

In this phase, the 1,081 research papers were examined based on relevancy. We evaluate each abstract of the paper to get its purpose. We also looked at the introduction in the glance and conclusions of these papers. This evaluation reduced the total number of publications reported as 573 research papers (see Table 4). Figure 2 shows the various breakdown of these numbers according to each publisher's articles and conferences each year.

TABLE IV
FINAL REPORTED RESULTS

Publishers	Final reported results		
	Conferences proceedings	Research articles	Total publications
Elsevier	0	58	58
ACM	144	06	150
IEEE	197	08	202
Springer	113	50	163
Total			573

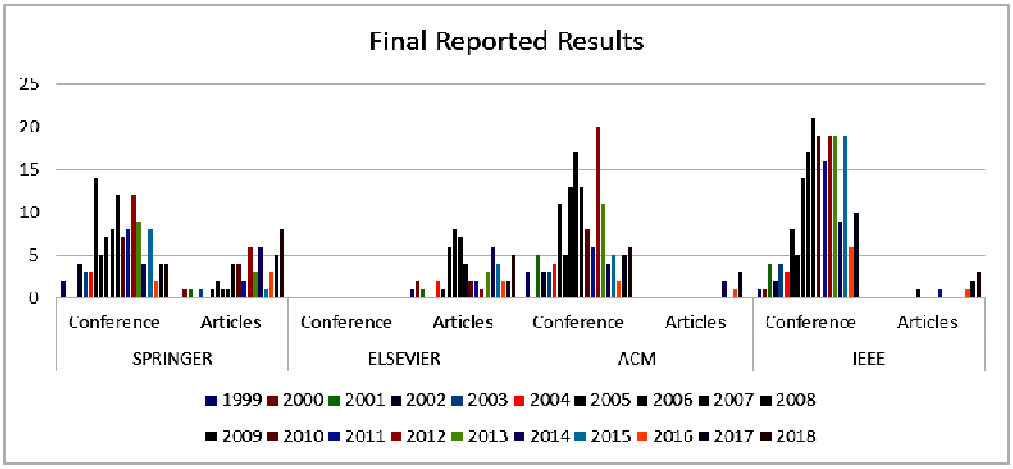

Fig. 2 Number of conferences and articles by years of publication

Inclusion:

- Research papers presenting query expansion using text to improve search results
- Research papers addressing query expansion methods using text
- Research papers from conference proceedings and journal articles
- Research papers published from 1999-2018
- Research papers that are written in English
- Seminar and workshop research papers on query expansion

Exclusion:

- Research papers that do not tackle query expansion issues
- Research papers tackle query expansion but not use text retrieval
- Research papers that tackle both text and other multimedia elements such as voice, images, and others.

- Theses, dissertation, book chapters, and unpublished research work
- Research papers that we do not have full access.

E. Data Extraction

Data can be extracted from the 573 research papers. We resolved to extract data by focusing on the following characteristics:

- Title of the publication
- Research issues
- Application areas
- Methods
- Contributions
- Publication types, example, Conference proceedings, or research articles
- Publishers
- Year of publications

To record this information, we created a new spreadsheet to store this data.

III. Results and Discussion

A. Results

To better understand this research work, the research questions raised will be answered in this section.

RQ1: What are the query expansion application areas?

1) Medical: Medical is one of the query expansion application areas that attract many researchers. Based on our review, the medical area appears in 60 papers. The primary emphasis was on medical term mismatch, which includes terms ambiguous, concise, and inconsistency. Other studies focus on plagiarism detection of medical terms, improve medical search optimization, and medical ontology development of disease (e.g., Hepatitis). Research articles are typical for this area as 33 articles and 27 conference proceeding papers were reported (see Table 5).

TABLE V
SUMMARY OF RESEARCH PAPERS IN THE MEDICAL AREA

Publishers	Research papers in the medical area		
	Conferences proceedings	Research articles	Total publications
Elsevier	0	09	09
ACM	05	01	06
IEEE	15	04	19
Springer	07	19	26
Total	27	33	60

Zingla et al [4] recently used query expansion in the medical area to integrate semantic and sequences of medical terms to improve biomedical search engine results for articles. The MEDLINE was selected to use as a corpus for the study. The MEDLINE has been widely accepted as a medical domain corpus because of its large vocabularies and concepts, and this demonstrates how beneficial to apply query expansion methods to the medical area for search improvement.

2) Microblog: Microblog is another query expansion application area that many authors considered beneficial. Forty (40) conferences and articles papers mostly focused on Twitter and blogs were found in this area (see Table 6). Twelve studies were found in IEEE, 14 for Springer, and eleven were found for ACM. Elsevier has only three articles. This area mostly concentrates on the people's opinions about a topic such as tweets and how such tweets are relevant to the topic under discussions and within different users' grammar.

TABLE VI
SUMMARY OF RESEARCH PAPERS IN MICROBLOG AREA

Publishers	Research papers in the microblog area		
	Conferences proceedings	Research articles	Total publications
Elsevier	0	03	03
ACM	11	0	11
IEEE	12	0	12
Springer	10	04	14
Total	33	07	40

Zingla, Chiraz, and Slimani [5] presented how the query expansion could retrieve information from microblogs, especially Twitter. They considered Twitter because of large tweets information available that require search improvement to obtain a relevant one. In addition to that, [4] also presented how different methods can be integrated for microblog retrieval. This method shows how research in this area has been increasingly advancing. In the microblog application area, many tweet conversations are available that could be used for any specific query expansion method. We believe it is one of the reasons why researchers found this area as useful.

3) Web Search: Web search is now considered as the most promising direction of the query expansion research area because most of the other areas depend on the web application to enable convenient searching within the globe. A total of 295 research papers were found based on our review. Out of these figures, we have been able to identify12 papers that fell into other query expansion application areas simultaneously (see Table 7). Many papers in this area used the keyword search query to search for relevant information.

TABLE VII
RESEARCH PAPERS IN WEB SEARCH AREA

Publishers	Research papers in web search		
	Conferences proceedings	Research articles	Total publications
The web search for text	96	35	131
Web search in medical	25	17	42
Web search in Microblog	47	0	47
Web search in cross lingua	58	17	75
Total	226	69	295

Recently, Zhang *et al.* [6] identified how query expansion could be used in a web service search, specifically service discovery. This is an important area because the web is now providing services to many clients for convenience. Web search is typically now used by different users with ease because of the nature of interface search engine and network connectivity. As such, search results need to be improved. However, the opportunity for these improvements is to focus on improving web search results within other query expansion application areas.

TABLE VIII
SUMMARY OF RESEARCH PAPERS IN WEB SEARCH AREA

Languages	Research papers in web search		
	Conferences proceedings	Research articles	Total publications
Arabic language	31	03	34
Chinese language	36	05	41
Italian language	01	0	01
Total	68	08	76

4) Cross-Lingual: Seventy-six (76) research papers, both conferences, and research articles were found in this area based on our review. Two major languages apart from English dominated this area. These languages are Arabic and Chinese. However, we came across a paper that tries to use the Italian language but concentrated mainly on questions and answering systems. Out of the76 papers mention earlier, we found34 papers that used the Arabic language and 41 used Chinese (see Table 8). We have discovered that these two languages have different character representations. Also, much information is available in these languages for retrieval. In Arabic text retrieval, two sub-fields were found within our reviews, which are Quran and hadith. Moawad, Alromima, and Elgohary [7] present a query expansion for Arabic retrieval. They concentrated on Quran Arabic retrieval. The cross-lingual query expansion application area represents words in different languages. A search engine's efficiency and effectiveness could be able to retrieve information relevant to a user's search query based on language use. It is, therefore, essential to continuous improvement for better search results.

5) Programming Code Search: Based on our review, 10 research papers focused on either codes or model's retrieval were found in this application area. Most of the research papers focused on code search, but only a few concentrated-on model retrievals. Out of the ten papers stated, six papers were reported based on conference proceedings while four reported on research articles (see Table 9). Query expansion has been stated as useful for improving programming code search [7]. This state shows how this area will significantly attract researchers because thousands of source codes are now available in a database for retrieval.

TABLE IX
SUMMARY OF RESEARCH PAPERS IN THE PROGRAMMING CODE SEARCH AREA

Publication Type	Number of publications
Conferences proceedings	06
Research articles	04
Total	10

RQ2: What are the query expansion methods?

1) Word Embedding: Word embedding is the query expansion method that many researchers now used to improve search engine results. A total of 18 research papers were found in this area (see Table 11) that focused on relevant search engine improvement for text retrieval. Many studies reported how semantic relations between a word or sentences within language modeling such as n-gram or skip-gram could improve search results. We found that many researchers significantly used word2vec to create word embedding, which other similar researchers did not thoroughly describe. Even though word2vec can be applied to text corpora for different purposes, there is a need to explore how vital word predictions within the word context. It was also observed that the word embedding method is usually used in conjunction with other methods.

2) Pseudo-relevant Feedback: Pseudo-relevant feedback is also a key method of query expansion. Many researchers explored using pseudo-relevant feedback to automatically expand the query without the intervention of an external assessor. Out of 83 research papers reported based on relevant feedback, 44 papers were based on pseudo-relevant feedback (see Table 10). This number means that the trend of relevant feedback is now going towards automatic relevance feedback. Another reason is that it can easily be integrated with other methods to produce quality search results if proper term selection methods have been applied.

TABLE X
SUMMARY OF RESEARCH PAPERS BASED ON RELEVANT FEEDBACK

Publication Type	Number of publications
Explicit Feedback	35
Implicit Feedback	04
Pseudo-Relevant Feedback	44
Total	83

Query Logs: Query logs are parts of the query expansion methods applied to improve search engine results. Although query log methods were found in only 40research publication (see Table 11) based on our review, further work using this method can still improve search results. We have identified that lower publications using this method compared to semantic and ontology-based is the issue of security and privacy. Many organizations do not want to reveal their data to the public for security reasons. However, we have been able to identify multi-reputation organizations that allow researchers to use their query logs.

3) Wordnet: Much earlier research papers use the wordnet query expansion method, specifically to expand word based on its actual meaning. Wordnet is still used in some recent publications as we reported 24 recent papers out of which 15 were on the web search application area had been found using this method (see Table 11). In addition to that, most of the papers were presented in conference proceedings, not research articles.

4) Fuzzy Rule: Another trend in query expansion research is the use of fuzzy rule methods. Research in this method focused on how to deduce search results based on the input assigned. This method has connectors such as "AND" and "OR" that connect "IF" and "THEN" statements. Based on the review, eighteen papers (see Table 11) discovered that most of them try to address term selection issues used fuzzy rules.

5) Deep Learning: Another interesting query expansion method we have found was deep learning in improving search performance. A total of 12 research papers were reported using deep learning architectures, such as the recurrent neural network, to produce relevant search results (see Table 11).

TABLE XI
SUMMARY OF RESEARCH PAPERS ON QUERY EXPANSION METHODS

Query Expansion Method	No. of publication	Query Expansion Application Areas				
		Medical	*Microblog*	*Web Search*	*Cross Lingual*	*Code Search*
Word Embedding	18	04	05	07	02	
Pseudo-Relevant Feedback	44	06	06	26	03	03
Query Log	40	03	03	25	06	03
WordNet	24	03		15	04	02
Fuzzy Rule	18	04		14		
Deep Learning	12			09	03	
Wikipedia	24	01	03	15	05	
Social Tagging and Bookmarking	28	04	07	15	02	
Semantic/Ontology	174	23	13	112	26	
Thesaurus	35	05		11	17	02
Metaheuristic	16	06		09	01	
Association Rule	09		01	07	01	
Explicit Feedback	35		02	27	06	
Implicit Feedback	04	01		03		
Combination of Methods	92					
Total	573	60	40	295	76	10

6) Wikipedia: A total of 24 research papers associated with the Wikipedia method of query expansion were reported. Most of the documents examined how Wikipedia concepts could be used in expanding the query. Table 11 shows this total number and web search area offers the highest with more recent papers. Out of the 24 articles, 03 examined on microblog search area using Wikipedia, 15 papers on web search, 5 papers on cross-lingual, and only one essay on medical. Wikipedia has been used in many situations.

7) Social Tagging and Bookmarking: Social tagging adds keywords or terms to a query. We observed that some of the studies used social tagging to improve search results. A total of 28 research papers were reported (see Table 11) using query expansion to add keywords and other metadata to better quality results. Also, some of the papers were found using social bookmarking to add annotations to a query.

8) Semantic and Ontology-Based: This is the most widely used method to expand the query, which others refer to as linked data. One hundred and seventy-four research papers were reported used semantic and ontology-based query expansion. Many of the papers reported how the meaning or similarity of a term could be deduced from the ontology hierarchy of terms used within some domain. We identify some domains and the number of publications used in each (see Table 11). The web search domain has the highest number of publications. This number may be due to the need to clarifies and have special domain knowledge for other web search areas that will differ from ordinary meanings. Also, a trend was now moving towards proving ontology for a different specialty that uses a web application.

9) Thesaurus: We found35 research papers based on our review that used a thesaurus to expand the query (see Table 11). Most of the documents reported how vocabulary mismatch issues would be addressed. Few research papers were also seen used thesaurus to address word disambiguation is within sentences. We also believe that conducting more research for this method can significantly help to improve search results.

10) Metaheuristic Algorithm: Metaheuristic algorithms in query expansion have less explored. Only 16 research papers were reported (see Table 11). A total of 11 papers used a genetic algorithm to improve web search engine optimization. Five other papers focused on expanding query using Bat-inspired algorithms for medical search results (see Table 12). All the papers concentrate mainly on improving search results.

TABLE XII
SUMMARY OF RESEARCH PAPERS USED METAHEURISTIC

Publication Type	Number of publications	Application Areas		
		Medical	*Web Search*	*Cross-Lingual*
Genetic Algorithm	11		10	01
Bat-inspired algorithm	05	05		
Total	16	05	10	01

11) Association Rule: Like Metaheuristic, an association rule is another query expansion method that is less explored. Association rule has been reported in 9 research papers to discover the relationship of query terms within the larger corpus (see Table 11). Out of this figure, web search has the highest number of publications totaling 7 papers. Microblog and cross-lingual area both have 1 paper each.

12) Explicit feedback: Regarding explicit feedback, the most well-known application areas used ware web search, cross-lingual and microblog. Table 11 presents the outcomes of our review, with a total of 35 research papers found. Web search area obtained the highest number of publications with 27 papers.

13) Implicit feedback: Implicit feedback has a total of only 4 research papers (see Table 11). Three papers were also on the web search area, and the remaining 1 paper was on medical. This result shows that the implicit feedback was less used query expansion method. In this method, the most leading application area was web search with the highest number of publications.

What are the new research opportunities for query expansion?

The advances in query expansion for improving search engine results have boosted progress in search engine performance. Specifically, five research topics suggest advances over the upcoming years. These research topics replace the combination of methods to meet the specific required search results.

RQ3: What are the new research opportunities for query expansion?

The advances in query expansion for improving search engine results have boosted progress in search engine performance. Specifically, five research topics suggest advances over the upcoming years. These research topics replace the combination of methods to meet the specific required search results.

1) Neural Query Expansion: Much of the present research on neural information retrieval can be discovered by advancing the machine learning research area, specifically the deep learning research area. These advancements include neural and recurrent neural network architectures. Understanding neural query expansion becomes necessary for modifying the original query to provide better search engine results. Neural query expansion research is now moving towards using the recurrent neural network to obtain the complete semantic relationship between terms. Therefore, much research work through seminar, conferences and journal articles needs to be carried out.

2) Term Selection Methods: Studying term selection methods can help choose the right word for expanding the query. A few years ago, there was significantly increasing research on term selection methods. This research provides an opportunity for researchers to understand the term selection methods for query expansion for better search results. Different models are now in placed ranges from simple to more complex ones that focused on aggregation for researchers to determine the best one that will provide better search performance. The successful models in this area should be maintained and improve so that the better results could be easily ascertained.

3) Weighting Scheme: Weighting scheme utilizes relevant and non-relevant of a words document. This utilization is based on user queries. A better understanding of ranking algorithms specifying relevant document with higher weight and non-relevant with lower weight will help the researcher reconstruct new algorithms that modified existing ones for future search performance. Advances in reweighting query terms for no retrieve terms in a document helped the query expansion field of research. The right corpus or test collection used usually determines the query expansion performance results. This corpus will allow the researcher to use different text collections and test the performance of different weighting schemes.

4) User Behavior on the Query: Over many times, the search engine and other information retrieval applications have improved user behavior. The user behavior on the query forms the basis of query expansion. Understanding the user behavior on a query, significantly differentiating general queries from specific queries would require new models capable of improving search results. Interdisciplinary research needs to be carried out in this area to focus on understanding user behavior. This requires the use of a psychologist from a social science background to query expansion-related issues.

5) The relationship among ontology classification hierarchy: Recently, the lack of ontologies for different domain areas has consequences for better search results. Developing domain-specific ontologies to improve search engine results of a domain area will require understanding the relationships among these domains' ontology classification hierarchy. The classes and properties hierarchy are specifically important areas that researchers need to be investigated. This investigation will require developing new classification algorithms to support query expansion methods and improving search results.

B. Discussion

Query expansion methods are using to improve the quality of search engine results. In this paper, we examined 573 research papers based on the three sets of research questions. These research questions are the query application areas, query methods, and the new research issues for query expansion.

With the advent of query expansion, search engine results have improved by integrating query expansion methods through which semantically related terms were added to improve search engine effectiveness [8]. This depends on good term selection methods [9]. Different types of queries exist, ranging from informational to navigational [10], which required expansion for better results. Query expansion methods present ways to improve search performance. The importance of query expansion in improving the precision and recall values has been identified in the research conducted by Gupta and Saini [11]. However, generating new terms to expand the query in different application areas for better results has brought many changes to search engines [4].

The findings of this study highlight some significant areas that query expansion has been applied. Many works regularly focus on web search areas to improve web search engine results, while fewer research papers investigate query expansion in medical, microblogs, cross-lingual, and programming code search application areas. This emphasizes that more research studies are required to improve search engine results, particularly in medical, microblogs, cross-lingual, and programming codes-search-related areas.

Most of the studies reviewed examine query expansion methods in different areas, specifically medical, microblogs, web search, cross-lingual, and programming code search. We categorized other application areas into web searches. This is because of difficulties to separate them from web search due to depending on web applications entirely. Therefore, further research should examine other areas from a web search. Query expansion methods differ in different application areas. Hence, the search results improvement should be based on the user's need in that area. It was argued in research conducted by Pérez *et al.* [12] that each query expansion application area has its reasons behind the search

improvement. Consequently, to obtain better search engine results, an appropriate query expansion method should be used for each application area for better search performance.

Query expansion methods must be able to expand the query and produce better search results. For instance, any method proposed that does not efficiently expand the query, the results cannot be appropriately accepted and can be quickly rejected by both the researchers and practitioners. On the other hand, a few methods are proposed that do not practically expand the query or use some complicated explanation to prove the efficiency of the methods. Such methods were found inappropriate for researchers to use for improving search engine results. In general, our review only focuses on query expansion methods to improve search engine results, not the entire information retrieval areas. However, further investigation of query expansion methods should be carried out on the entire information retrieval application area. The greatest challenge facing query expansion now is the term selection methods [13].

In addition to the term selection methods challenge, the weighting scheme in terms of ranking results is another problematic issue for some of the query expansion methods for efficient search engine results [14], [15]. Several research papers have emphasized the need to produce a reliable weighting scheme [11] to obtain a better search result. However, the weighting scheme challenge in query expansion methods has not been adequately resolved. Further research needs to be carried out on this area for search results improvements. Based on our review, the web search application area was used more than other application areas for expanding the query. Recently, most of the organizations' large databases, irrespective of the application areas, have now using a web search to get similar query results. Furthermore, improving web search can help to address vocabulary mismatch issues.

IV. Conclusion

This paper presents a 20 years comprehensive review of query expansion research papers. These reviewed papers were indexed by Elsevier, Springer, IEEE, and ACM. A total of 573 papers were reviewed with emphasis on the recent ones. The work shows conference proceedings carried the largest percentage of these figures. Also, there was an increase in query expansion research in the web search application area. Semantic-ontology and pseudo-relevant feedback are the most popular query expansion method used. This result suggests additional research opportunities in the cross-lingual area because of much information now available in different languages. In future work, we intend to extend the more detailed review of each query expansion application areas

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References

[1] J. Bhogal, A. Macfarlane, and P. Smith, "A review of ontology based query expansion," *Inf. Process. Manag.*, vol. 43, no. 4, pp. 866–886, 2007.

[2] C. Carpineto and G. Romano, "A Survey of Automatic Query Expansion in Information Retrieval," *ACM Comput. Surv.*, vol. 44, no. 1, pp. 1–50, 2012.

[3] J. Ooi, X. Ma, H. Qin, and S. C. Liew, "A survey of query expansion, query suggestion and query refinement techniques," *2015 4th Int. Conf. Softw. Eng. Comput. Syst. ICSECS 2015 Virtuous Softw. Solut. Big Data*, pp. 112–117, 2015.

[4] M. A. Zingla, C. Latiri, P. Mulhem, C. Berrut, and Y. Slimani, "Hybrid query expansion model for text and microblog information retrieval," *Inf. Retr. J.*, vol. 21, no. 4, pp. 337–367, 2018.

[5] M. A. Zingla, L. Chiraz, and Y. Slimani, "Short Query Expansion for Microblog Retrieval," *Procedia Comput. Sci.*, vol. 96, pp. 225–234, 2016.

[6] N. Zhang, J. Wang, M. Yutao, H. Keqing, L. Zheng, and L. Xiaoqing(Frank), "Web service discovery based on goal-oriented query expansion," *J. Syst. Softw.*, vol. 142, pp. 73–91, 2018.

[7] I. Moawad, W. Alromima, and R. Elgohary, "Bi-Gram Term Collocations-based Query Expansion Approach for Improving Arabic Information Retrieval," *Arab. J. Sci. Eng.*, vol. 43, no. 12, pp. 7705–7718, 2018.

[8] F. C. Fernández-Reyes, J. Hermosillo-Valadez, and M. Montes-y-Gómez, "A Prospect-Guided global query expansion strategy using word embeddings," *Inf. Process. Manag.*, vol. 54, no. 1, pp. 1–13, 2018.

[9] J. Singh and A. Sharan, "Rank fusion and semantic genetic notion based automatic query expansion model," *Swarm Evol. Comput.*, vol. 38, no. September 2017, pp. 295–308, 2018.

[10] N. Yusuf, M. A. M. Yunus, and N. Wahid, "A Comparative Analysis of Web Search Query: Informational Vs Navigational Queries," *Int. J. Adv. Sci. Eng. Inf. Technol.*, vol. 9, no. 1, 2019.

[11] Y. Gupta and A. Saini, "A novel Fuzzy-PSO term weighting automatic query expansion approach using combined semantic filtering," *Knowledge-Based Syst.*, vol. 136, pp. 97–120, 2017.

[12] F. Pérez, J. Font, L. Arcega, and C. Cetina, "Automatic query reformulations for feature location in a model-based family of software products," *Data Knowl. Eng.*, vol. 116, no. April, pp. 159–176, 2018.

[13] G. Chandra and S. K. Dwivedi, "Query expansion based on term selection for Hindi - English cross lingual IR," *J. King Saud Univ. - Comput. Inf. Sci.*, 2017.

[14] L. Diao, H. Yan, F. Li, S. Song, G. Lei, and F. Wang, "The research of query expansion based on medical terms reweighting in medical information retrieval," *EURASIP J. Wirel. Commun. Netw.*, vol. 2018, no. 1, p. 105, Dec. 2018.

[15] R. Crimp and A. Trotman, "Automatic Term Reweighting for Query Expansion," in *Proceedings of the 22nd Australasian Document Computing Symposium on - ADCS 2017*, 2017, pp. 1–4.