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A Brief Bibliometric Survey of Leukemia Detection by Machine Learning and Deep Learning Approaches

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ABSTRACT

Background: This study aims to analyze the work done on leukemia detection and diagnosis using machine learning, deep learning and different image processing techniques from 2011 to 2020, using the bibliometric methods.

Methods: different articles on leukemia detection were retrieved using one of the most popular database- Scopus. The research articles are considered between 2011 to 2020. Scopus analyzer is used for getting some analysis results such as documents by year, source, county and so on. VOSviewer Version 1.6.15 is used for the analysis of different units such as co-authorship, co-occurrences, citation analysis etc.

Results: In our study, a database search outputs a total of 617 articles on leukemia detection from 2011 to 2020. Statistical analysis and network analysis shows the maximum articles are published in the years 2019 and 2020 with India contributed the largest number of documents. Network analysis of different parameters shows a good potential of the topic in terms of research.

Conclusions: Scoups keyword search outcome has 617 articles with English language having the largest number. Authors, documents, country, affiliation etc are statically analyzed and indicates the potential of the topic. Network analysis of different parameters indicates that, there is a lot of scope to contribute in the further research in terms of advanced algorithms of computer vision, deep learning and machine learning.

Keywords: blood cells, microscopic images, disease detection, image processing, red blood cells, white blood cells, leukemia detection, sickle cell, citation, co-occurrence

I. INTRODUCTION

Cancer proves to be a major health problem worldwide and is the cause of death in many cases. Out of different types of cancers, blood cancer proves to be very dangerous in its later stages. Leukemia is a type of blood cancer which produces the blasts cells. These blast cells, in turn affect the production of white blood cells (WBC) and red blood cells (RBC). According to leukemia and lymphoma society, it is expected that 60,500 people will be affected by leukemia in 2020[4].

Detection and diagnosis of leukemia is best possible by microscopic analysis of blood cells[]. The following figure shows how the morphological changes indicate the leukemia cells from normal cells. The body's blood-forming tissues and lymphatic framework gets influenced seriously because of harmful reason, named as Leukemia. In leukemia, the white blood cells created by bone marrow are anomalous. It has two significant subtypes, acute leukemia, and chronic leukemia. Leukemia can further be classified into other following types namely, acute lymphocytic (ALL), acute myelogenous (AML), chronic lymphocytic (CLL), and chronic myelogenous (CML). It is found to be very dangerous in its later stages. Recognition of these malignant growth cells is generally done by microscopic image analysis manually and requires an exceptionally capable pathologist. An improved automated system of leukemia detection is designed based on image processing and machine learning techniques, which ends up being proficient when contrasted with manual detection [8-15].

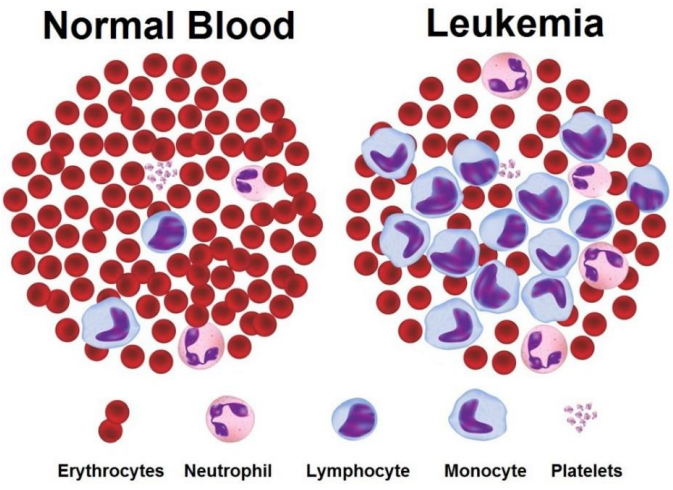

Figure 1: Normal and Leukemia cells

For detection of these cells, first the blood sample is taken by a trained pathologist followed by the staining of the blood slide. Staining enables to observe the cells under a quality microscope for the detection of morphological characteristics of different components

of blood cells viz. WBC, RBC, platelets, parasites, blasts and any other abnormal condition [1-3].

This detection and diagnosis is very critical and it requires a trained and experienced pathologist to conclude about the diagnosis. Hence it is always necessary and required to provide an automated system for this diagnosis.

Different algorithms in image processing are generally employed for the implementation of this automated system. In addition to these, machine learning, deep learning is also proving to be very effective in this implementation.

There are very effective and wide range of algorithms used by the researchers for detection and diagnosis of leukemia. The most popular algorithms include, watershed transform[16] [20], Zack algorithm[8], gray scale transformation[17][21][22-25][27-28], edge detection, otsu's algorithm [25][31],filtering[18][26], thresholding [24][30] for pre-processing and segmentation purpose.

Different features are extracted for the purpose of selecting the region for classification. These include statistical features, texture features, color features, geometrical features, correlation features.

After selecting the required features the classifiers are used to detect the leukemia cells. Different classifiers that are used for the detection purpose are decision tree, random forest, K-nearest neighbor (KNN)[9][34], convolutional neural network (CNN)[31-33], logistic and ordinal regression, Naïve Bayes and support vector machine (SVM)[10][12]. In addition to these algorithms, some researcher also initiated the use of different bio-inspired optimization algorithms [43].

II. MATERIALS AND METHODS

2.1 Primary Database Collection

There are many popular databases worldwide, such as scopus, web of science, google scholar, scimago etc. These databases are having a very wide range of publications. Out of these scopus- the most popular and one of the largest database, is used for the analysis. The keywords are used for search have given a total of 617 number of publication results. The different keywords are used for the searching of the databases across the world. There is no any restriction on country, language etc. Each publication has the information such as author, country, citations, documents, sources etc. This information is used for the analysis.

Fundamental Keywords

Table 1: List of Primary and Secondary Keywords

Fundamental Keyword	**Leukemia Detection by Microscopic Analysis of Blood Cells**
Primary Keywords using (AND)	**Leukemia AND image AND learning AND deep**
Secondary Keywords using (OR)	**Intelligence OR neural OR learning OR artificial OR processing OR machine OR learning OR deep**

Thus the query for searching the documents in Scopus is:

(TITLE-ABS-KEY (leukemia) AND TITLE-ABS
KEY (image AND processing) OR TITLE-ABS-
KEY (machine AND learning) OR TITLE-ABS-
KEY (deep AND learning) OR TITLE-ABS-
KEY (artificial AND inteligence) OR TITLE-ABS-KEY (neural)) AND (LIMIT-
TO (PUBYEAR , 2021) OR LIMIT-TO (PUBYEAR , 2020) OR LIMIT-
TO (PUBYEAR , 2019) OR LIMIT-TO (PUBYEAR , 2018) OR LIMIT-
TO (PUBYEAR , 2017) OR LIMIT-TO (PUBYEAR , 2016) OR LIMIT-
TO (PUBYEAR , 2015) OR LIMIT-TO (PUBYEAR , 2014) OR LIMIT-
TO (PUBYEAR , 2013) OR LIMIT-TO (PUBYEAR , 2012) OR LIMIT-
TO (PUBYEAR , 2011)) AND (LIMIT-TO (SUBJAREA , "COMP") OR LIMIT-
TO (SUBJAREA , "ENGI") OR LIMIT-TO (SUBJAREA , "MULT"))

2.2 Initial Search Outcomes

On the Scopus database, using the different keywords related to our work, the publications are obtained. These are analyzed according to the language. It is found that, English language has the highest number of publications of 606, followed by Chinese.

Table 2: Language Trends of Publications

Language of publishing	Publication count
English	606
Chinese	8
Turkish	2
Spanish	1
Total	617

Source: http://www.scopus .com (assessed on 17th Oct. 2020)

2.3 Publication outcome based on Top 15 Keywords

During the search, many keywords are found in addition to the fundamental keywords. Top 15 keywords are listed here in the table. Disease is the keyword having the highest publications. Generally all these keywords are found to be related to health and technology.

Table 3: Publication Analysis based on Top 15 keyword Analysis

Sr. No.	Keyword	Publications
1.	Disease	262
2.	Human	**155**
3.	Article	144
4.	Blood	138
5.	Humans	125
6.	Cytology	124
7.	Image Processing	118
8.	Machine Learning	114
9.	Cells	113
10.	Classification	113
11.	Diagnosis	108
12.	Leukemia	99
13.	Image Segmentation	98
14.	Gene Expression	96

15.	Acute Lymphoblastic Leukemia	92

Source: http://www.scopus.com (assessed on 17th Oct. 2020)

III. PERFORMANCE ANALYSIS

VOSviewer 1.6.15 [19][28] is the software that is used for the database analysis in addition to the analysis form Scopus. It provides a very effective way to analyze the co-citations, co-occurrences, bliometric couplings etc.

Following types of analysis is performed.

Statistical Analysis of Databases

1. Documents by Source
2. Documents by year
3. Documents by subject area
4. Documents by Type
5. Documents by Country
6. Documents by author
7. Documents by affiliation
8. Documents by top funding agencies

Network Analysis of Databases

1. Co-authorship: Authors, organizations, country
2. Co-occurrence: All keywords, Author keywords, Index keywords
3. Citation Analysis: Sources, authors, organizations, country
4. Bibliographic coupling: Documents, Authors

IV. RESULTS AND DISCUSSION

Analysis is performed by two different ways, statistical analysis of database and network analysis.

4.1 Statistical Analysis

4.1.1 Document Analysis by Sources

Database indicates different sources such as conferences, journal, book chapter, notes, and reviews and so on. Year-wise publication statistics are shown in the table. Figure shows the graphical representation of the different sources with number of documents published year-wise.

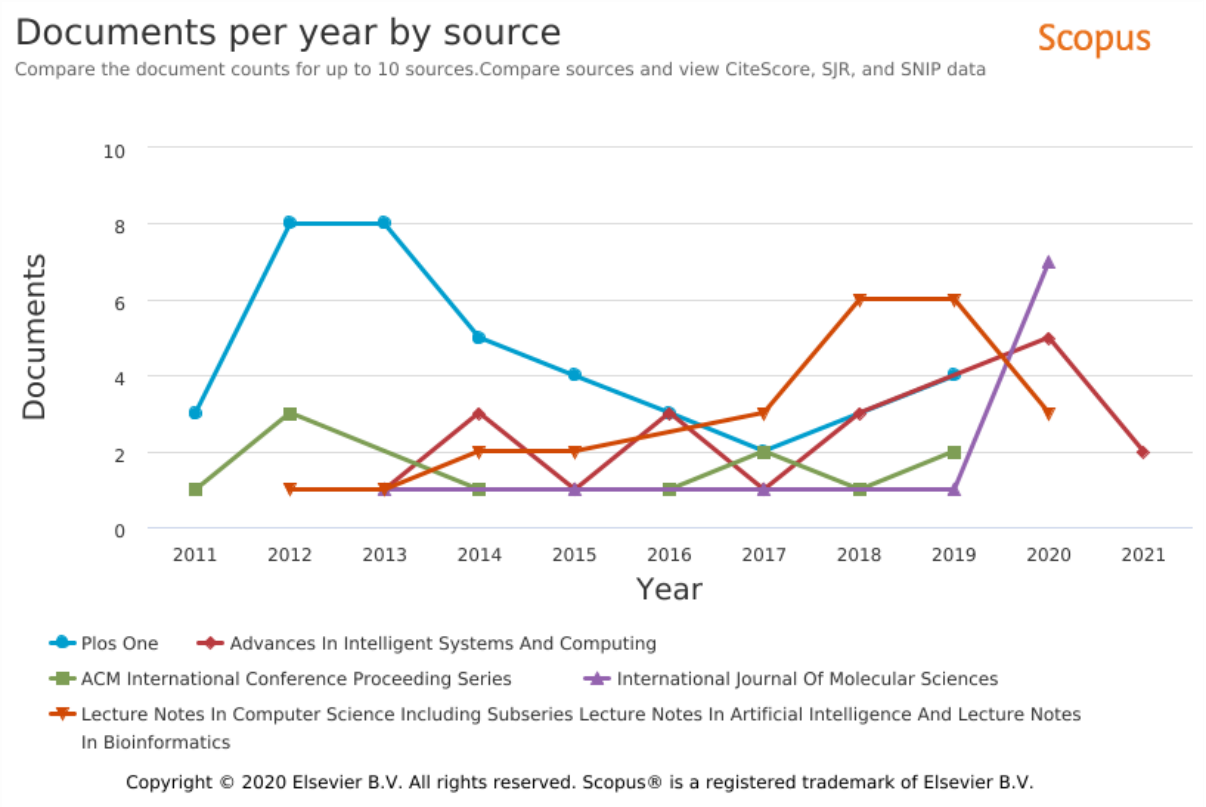

Figure 2: Analysis of Documents by Sources

Source: http://www.scopus .com (assessed on 17th Oct. 2020)

4.1.2 Documents Analysis by year

Documents are collected from scopus database in the year 2011 to 2021 including different sources such as conferences, journal, book chapter etc. The table shows the statistical information and graphical representation is as shown in figure. It is observed from the analysis that, highest number of publication is in the year of 2019 followed by 2020. This shows that, there is a good scope for working in this area in the preceding years.

Table 4: Number of Publication by Year

Year	Number of Publications
2021	5
2020	95
2019	109
2018	97
2017	65
2016	43
2015	54
2014	48
2013	34

2012	30
2011	37
Total	**617**

Source: http://www.scopus.com (assessed on 17th Oct. 2020)

4.1.3 Documents by Subject Area

Leukemia detection is done through morphological characteristics of different components of blood cells that are observed under the microscope. Hence for the detection and diagnosis of leukemia, maximum papers are coming under computer science and engineering field (30.9%). Although pure engineering filed covers 18.5% of the papers and 30.1% documents are published on other subject area. The main reason for this is, the topic is related to biomedical science and hematology which comes under health science also.

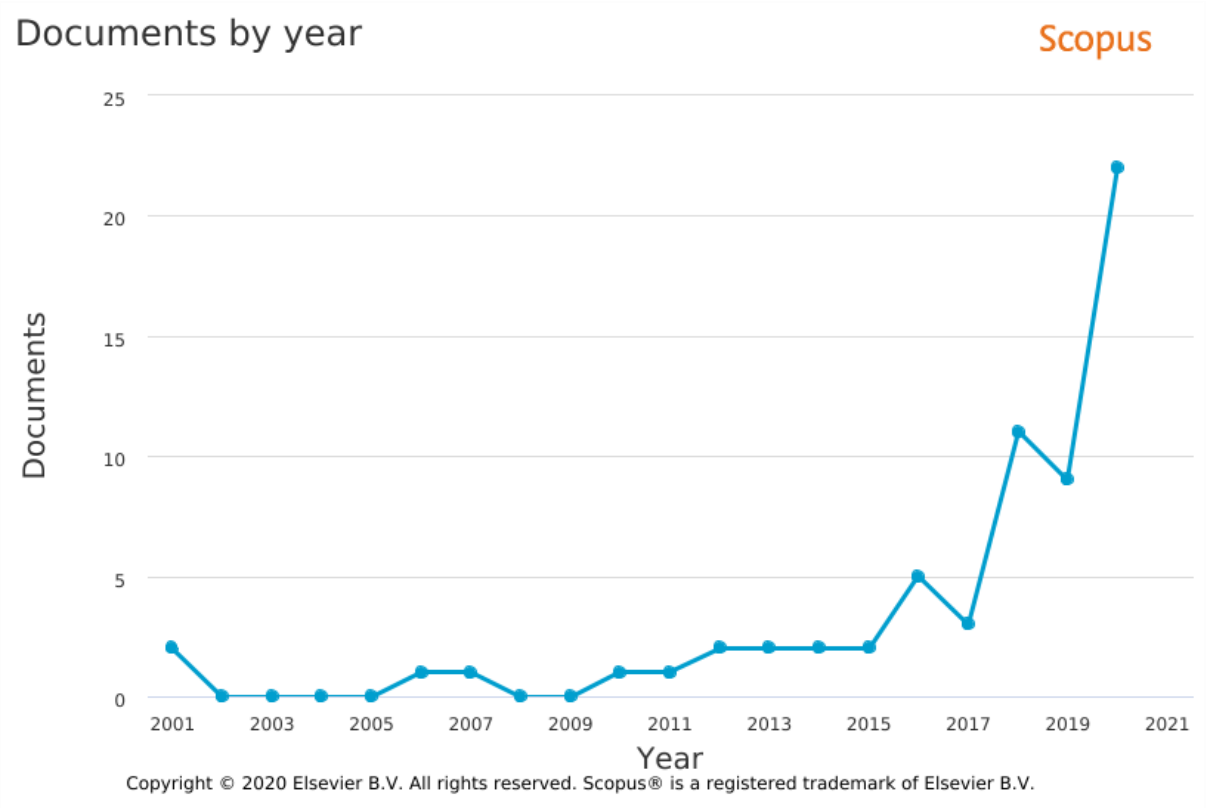

Figure 3: Analysis of Documents by Sources

Source: http://www.scopus .com (assessed on 17th Oct. 2020

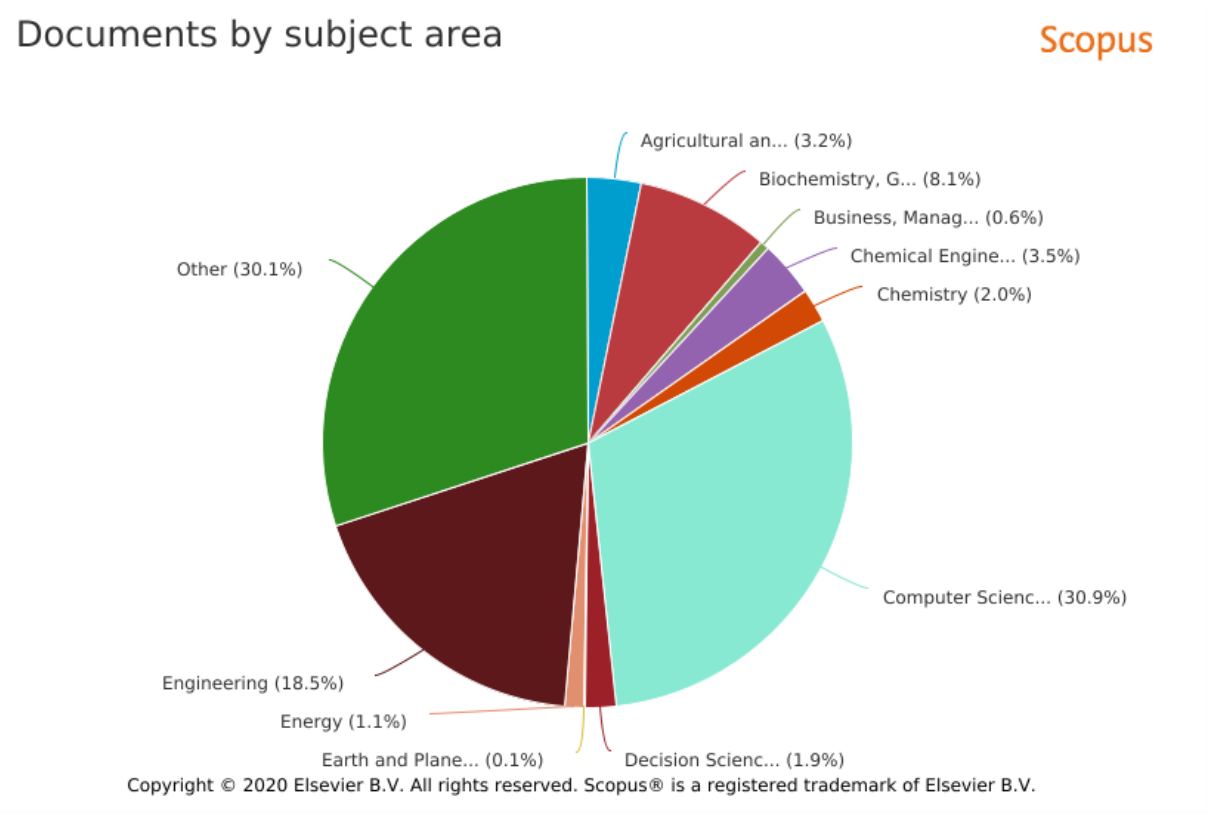

Figure 4: Analysis of Documents by Subject Area

Source: http://www.scopus .com (assessed on 17th Oct. 2020)

4.1.4. Documents by Type

It is seen form the analysis that, most of the publications are journal articles followed by conference papers.

Table 5: Analysis by Document Types

Sr. No.	Document type	Publications
1.	Article	313
2.	Conference Paper	238
3.	Conference Review	24
4.	Review	18
5.	Book Chapter	16
6.	Short Survey	3
7.	Editorial	2
8.	Erratum	1

9.	Letter	1
10.	Note	1
Total		**617**

Source: http://www.scopus .com (assessed on 17th Oct. 2020)

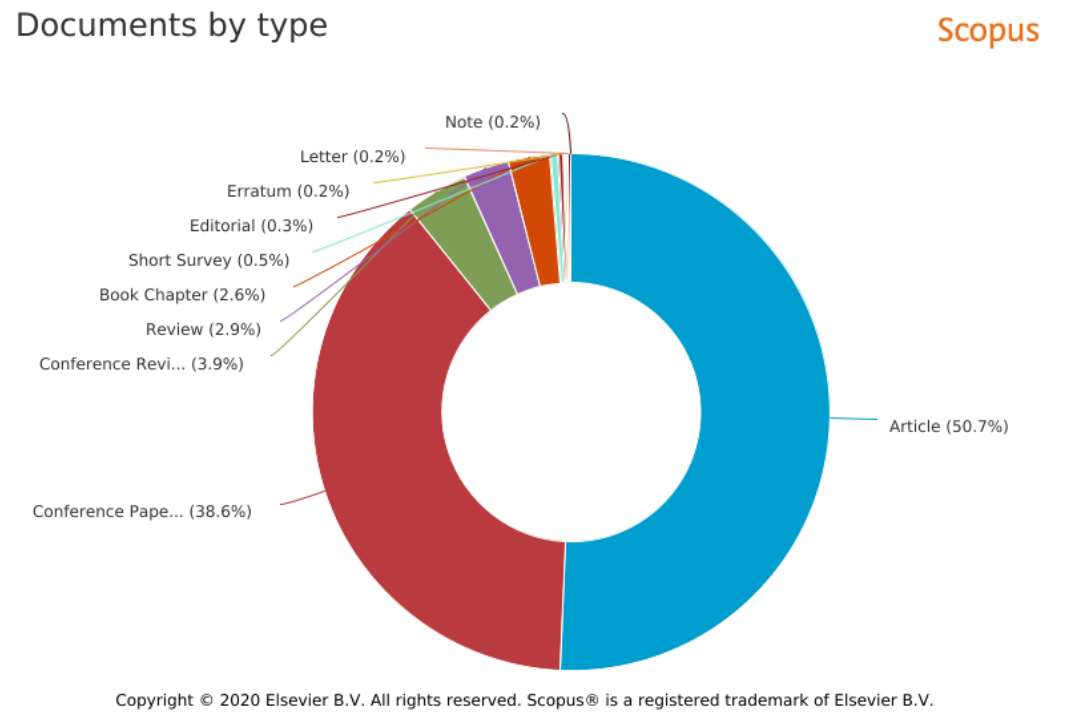

Figure 5: Analysis of Publications by Document Type

Source: http://www.scopus .com (assessed on 17th Oct. 2020)

4.1.5 Analysis of Publications by Country or Territory

Scopus database is analyzed for countries by considering the number of documents published. It shows that India has the highest number of documents published between the elected timeline. It is followed by United States and then China.

4.1.6 Documents by Author

In this analysis, authors with the number of publications are considered. Publications with a very large number of authors (15) are excluded. Top 10 authors with this comparison are shown here. It is found that Mashor M.Y [5-7] has the highest number of publications of 14 in this area. Maximum authors have an approximate average publication count 4 to 6.

4.1.7Documents by Affiliations

In this analysis, top 10 affiliations are considered. It is found that, University Saries Malaysis, Health Campus. More than half of the affiliations have at least 5 publications related to this field.

4.1.8 Analysis by Funding Sponsors

In this case, China is ahead amongst all, with highest funding to the National Nature Science Foundation, China. Analysis found most of the funding institutes are form health science field.

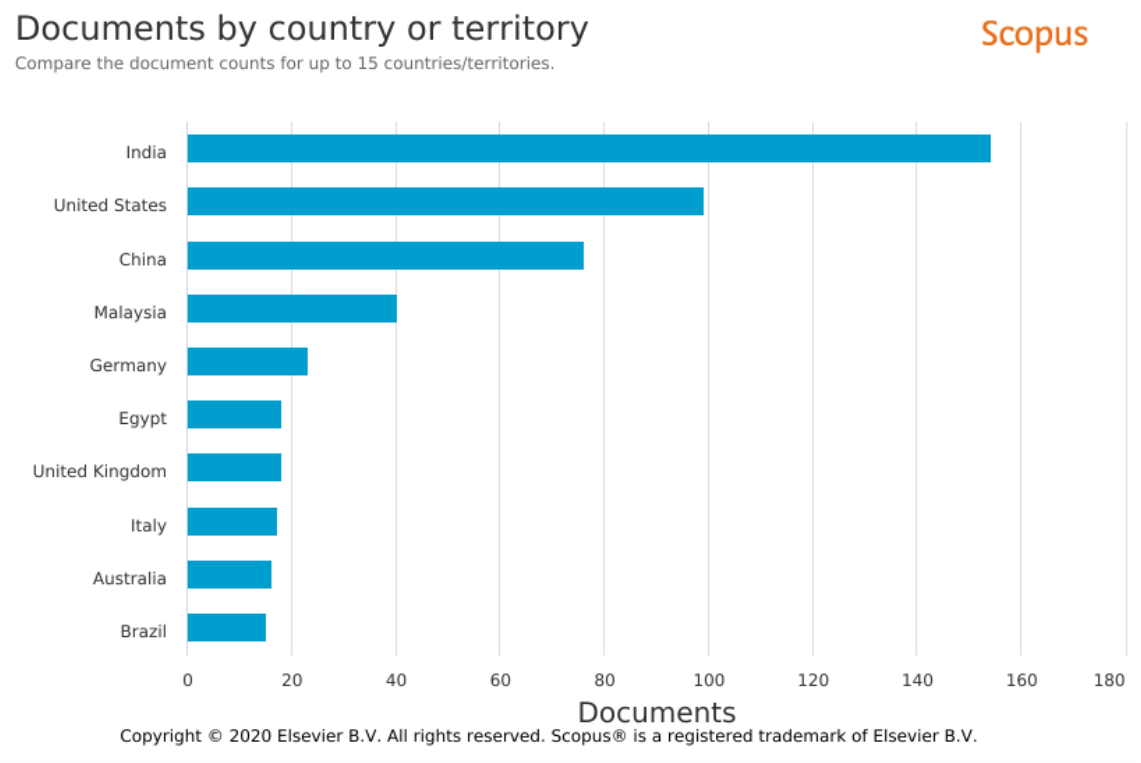

Figure 6: Analysis by Country

Source: http://www.scopus .com (assessed on 17th Oct. 2020)

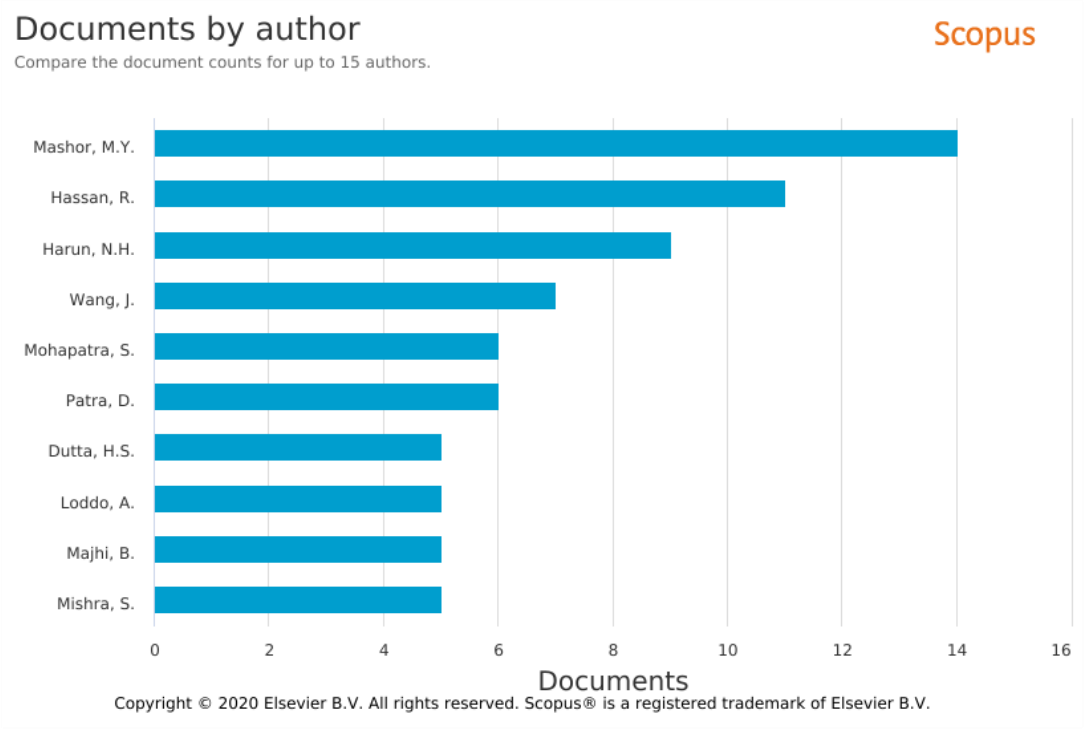

Figure 7: Analysis of Documents by Author
Source: http://scopus.com, assessed on 17th Oct.2020

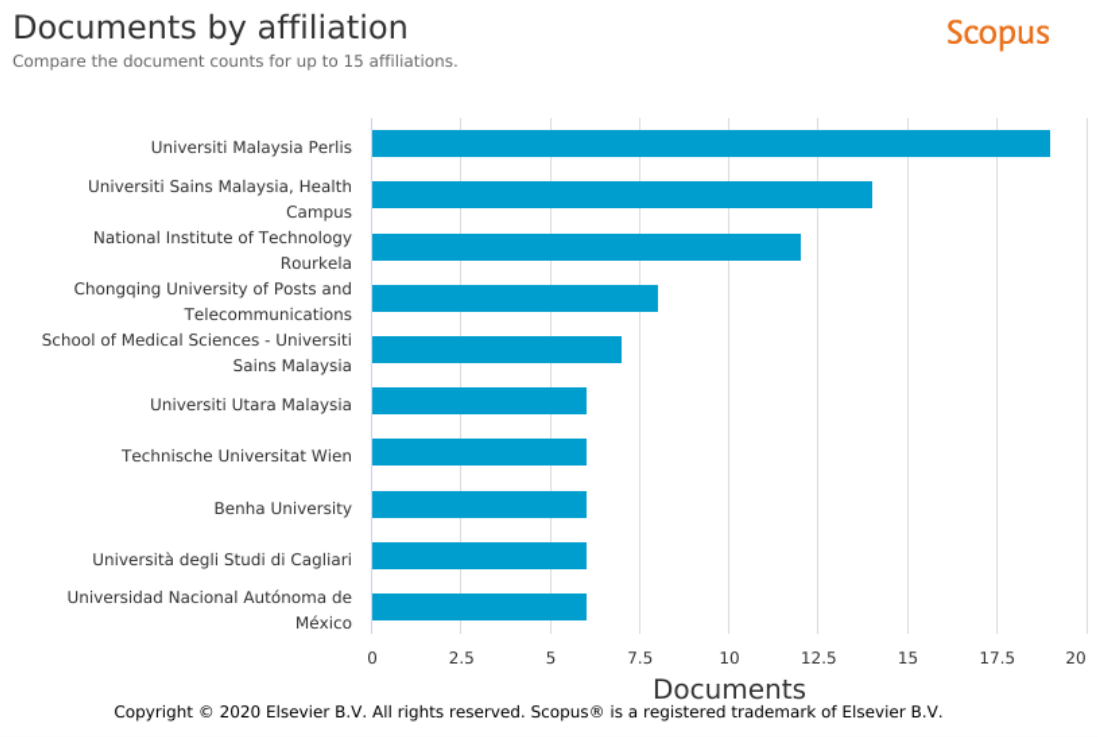

Figure 8: Analysis of Documents by Affiliation

Source: http://scopus.com, assessed on 17th Oct.2020

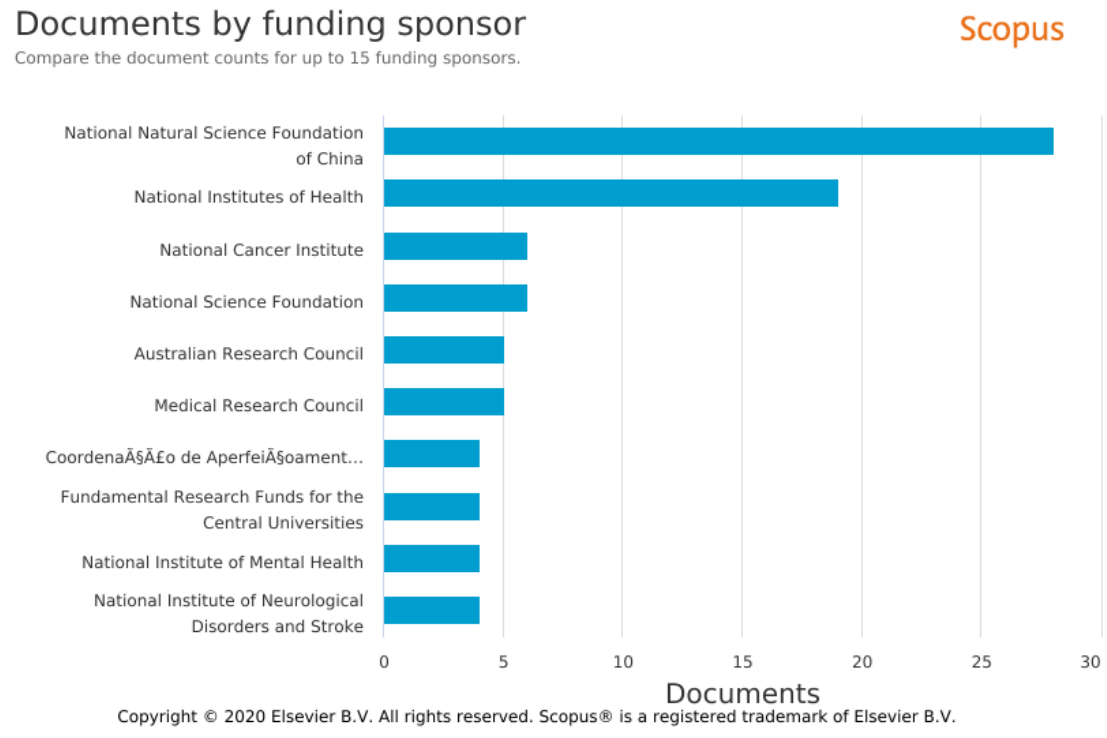

Figure 9: Analysis of Documents by Funding Sponsor

Source: http://scopus.com, assessed on 17th Oct.2020

4.2 Network Analysis

4.2.1 Co-authorship Analysis

A) Co-authorship in terms of Authors

This parameter of analysis is considered with 03 different parameters related to it. The authors, organizations, and countries are considered for analyzing this parameter.

Documents with a very large number of authors are ignored in this analysis. This number is considered to be 25. Threshold is considered as 2 for minimum number of documents of an author.

It is seen that out of 2069 authors, 277 authors met the criteria. The total strength of the co-authorship is calculated with other authors. By this method, the link strengths are obtained. msshoye m y found the highest link strength of 35 with the total number of citations to be 109 for 14 different documents. Here total of 62 authors found to have the relation in terms of co-authorship. So these are only shown in the figure.

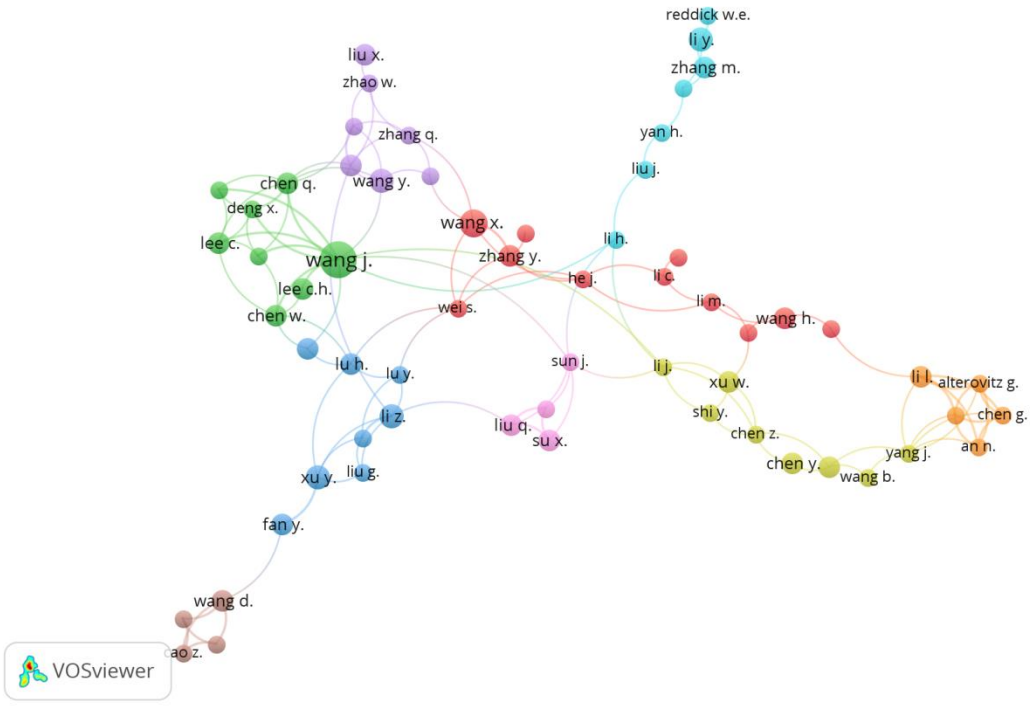

Figure 10: Co-authorship Network Analysis in Terms of Authors

Source www.scopus.com, accessed on 17 Oct 2020

B) CO-authorship in terms of Organizations

Co-authorship in the unit of organizations is calculated considering minimum 02 documents in organizations with neglecting the citation of the same,

49 organizations meet the criteria out of 1384 number of total organizations, that are shown

in the figure. A total of 9 organizations have highest link strength of 4 with the highest citations of 47 by center for biomedical informatics, Harvard medical school, Boston, United States (with 2 documents).

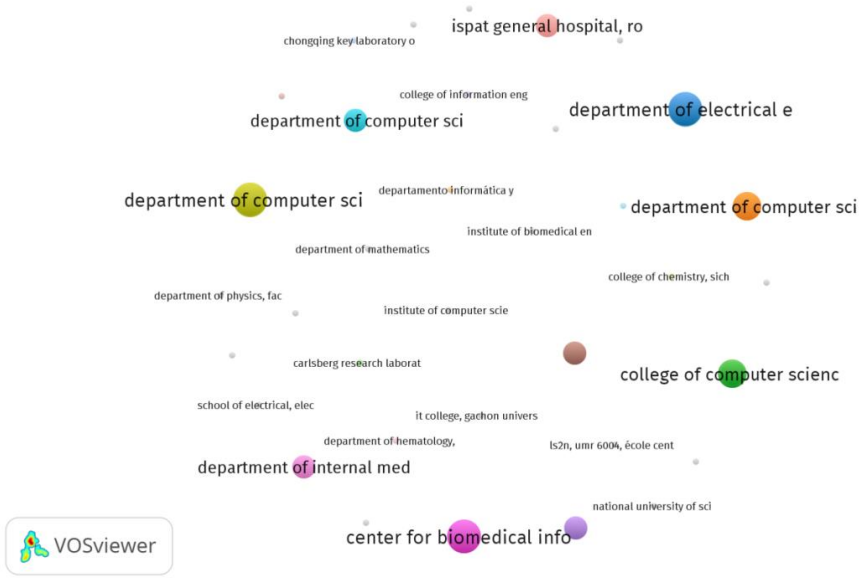

Figure 11: Co-authorship analysis in terms of Organizations

Source www.scopus.com, accessed on 17 Oct 2020

C) Co-authorship in terms of Country

Co-authorship can also be obtained in relation to the country. A total of 63 countries are there, in which this databases are present. After considering the threshold of minimum 5 documents in a country, 31 countries met the threshold.

Here, United States found to have the highest citations of 2883, and the link strength of 59, that is also highest amongst all. As far as the number of document are concerned, India has the highest of all that is 154.

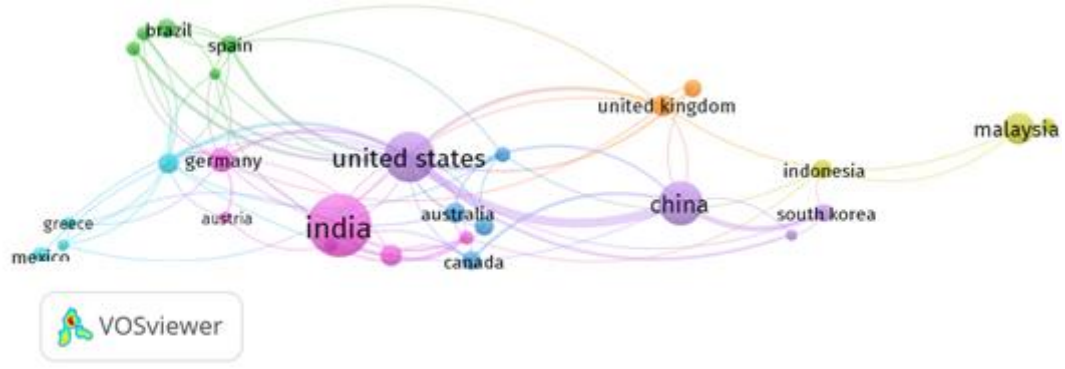

Figure 12: Co-authorship analysis in terms of Countries (Scale is with number of documents)

Source www.scopus.com, accessed on 17 Oct 2020

4.2.2. Network Analysis of Co-occurrences

A) Co-occurrence analysis in terms of all keywords

For the analysis of co-occurrences, different keywords are considered. Minimum number of occurrences in the keywords is considered to be 5. Out of 5644 keywords, 469 keywords met the threshold.

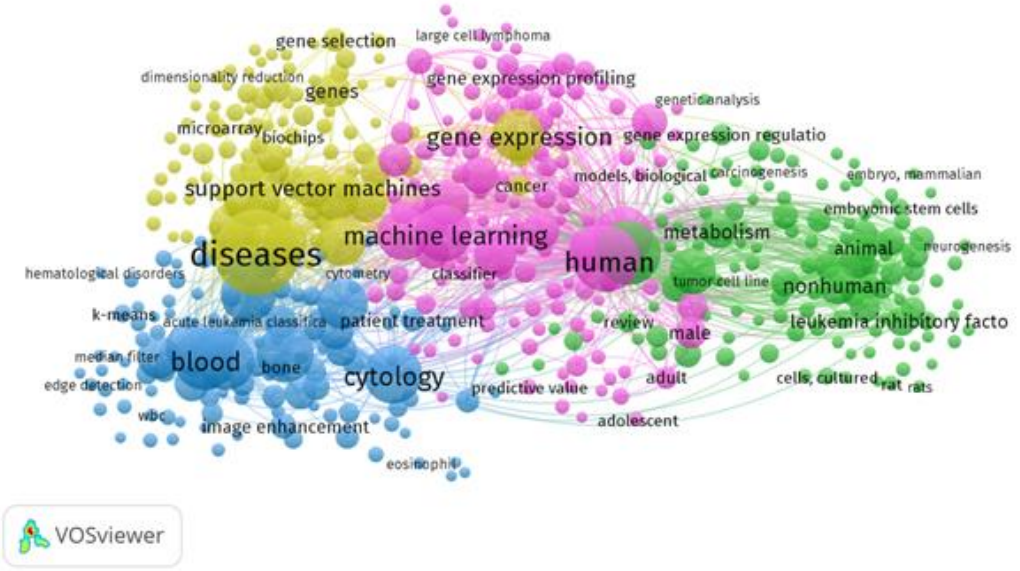

Figure 13: Co-occurrence Analysis in Terms of All Keywords

Source www.scopus.com, accessed on 17 Oct 2020

B) Co-occurrence analysis in terms of Author keywords

Co-occurrence of author keywords is analyzed with the minimum threshold of 5 per author. Out of 1380 keywords by the authors, 49 keywords met the threshold.

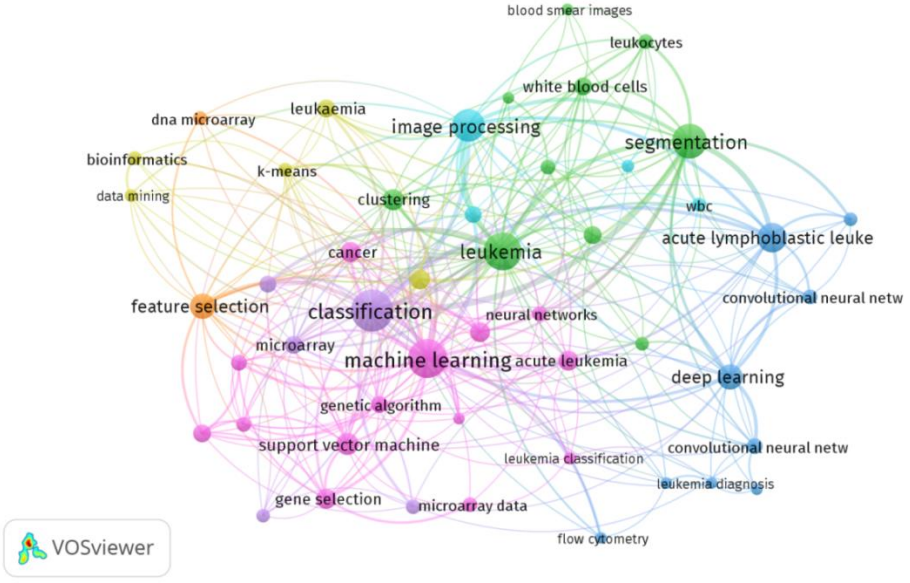

Figure 14: Co-occurrence Network Analysis (Author Keywords)

Source www.scopus.com, accessed on 17 Oct 2020

C) Co-occurrence in terms of Index Keywords

Co-concurrence is also considered by index keywords of 4866, only 437 met the threshold.

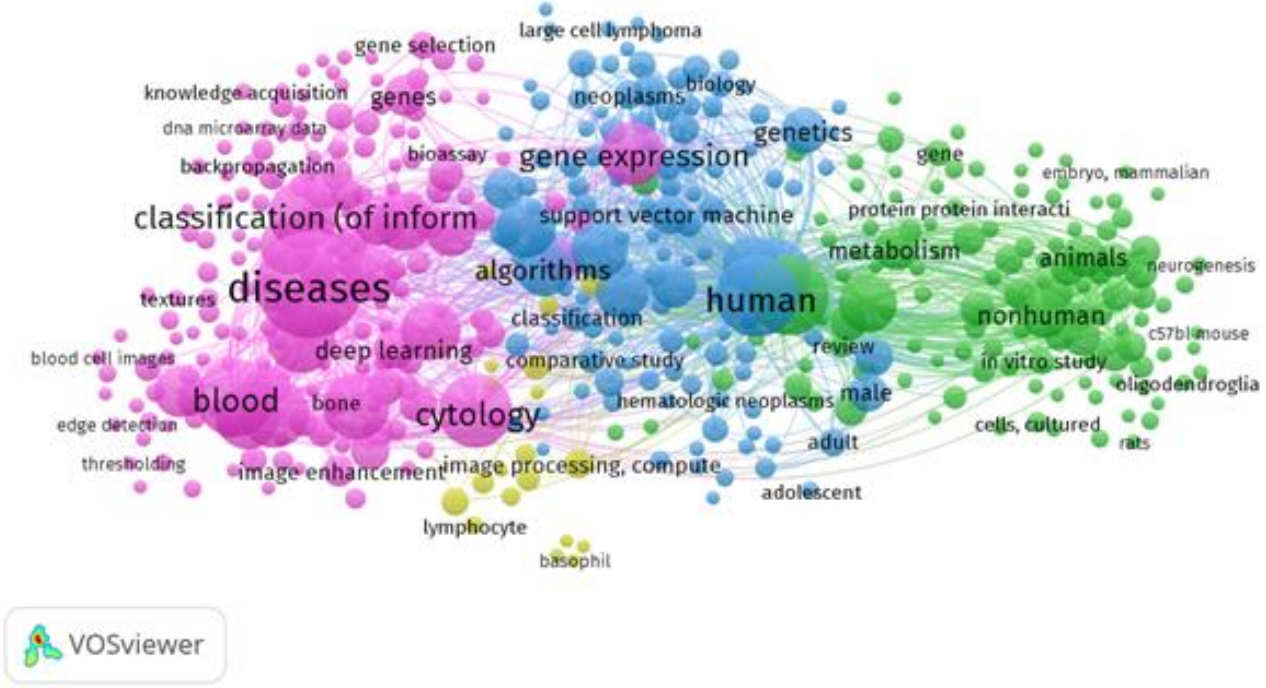

Figure 15: Co-occurrence of Index Keywords

Source www.scopus.com, accessed on 17 Oct 2020

4.2.3. Network Analysis of Citations

This analysis is done with the units of analysis including documents, sources, authors, country and organization.

A) Citation Analysis of Documents

Out of total of 616 documents, minimum 5 citations are considered as a threshold per document. So 238 documents met the threshold. Lu c (2012) has the highest number of citations 1098 while the link strength is the highest for putzu l (2014).

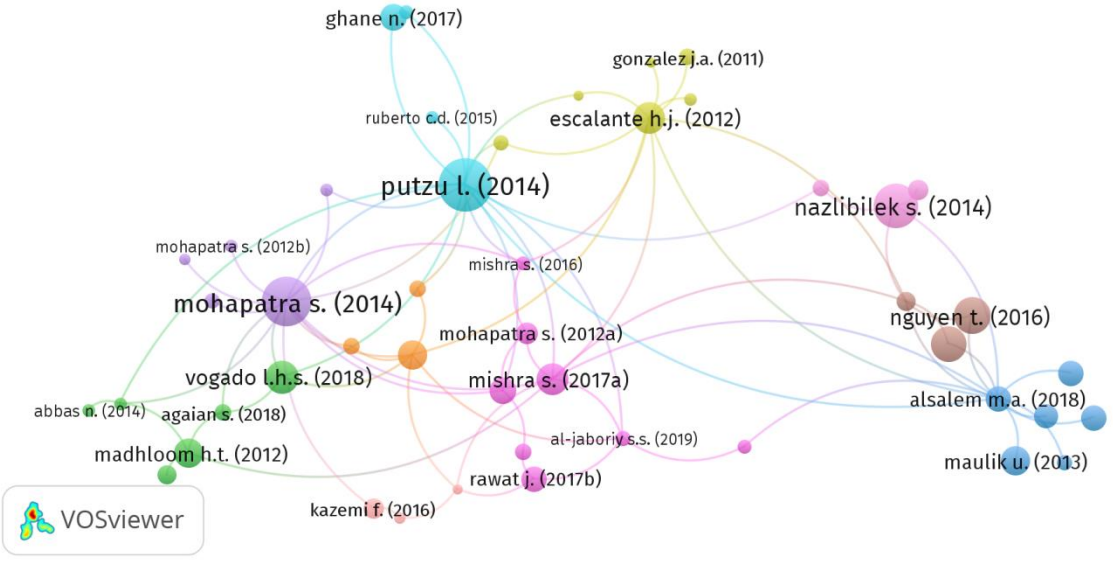

Figure 16: Network Analysis of Citations (In terms of Documents)

Source www.scopus.com, accessed on 17 Oct 2020

B) Citation Analysis of Sources

Citation analysis of sources is obtained by considering the threshold of 5 citations per source. Out of the 337 sources only 19 met the threshold. Nature journal has got maximum citations of 2025.

Figure 17: Network Analysis of citation by sources, Source www.scopus.com, accessed on 17 Oct 2020

C) Citation analysis by Authors

Threshold considered here is 3 citations per author. A total of 94 authors met the threshold amongst the total of 2069 authors. Wang x. has maximum citations of 243.

Figure 18: citation analysis by Authors, Source www.scopus.com, accessed on 17 Oct 2020

D) Citation analysis by organization

Considering minimum documents of 3 per organization as threshold, 9 organizations met the threshold out of 1384 organizations. department of mathematics and computer science, university of cagliari, via ospedale 72, cagliari, 09124, Italy has Maximum citations of 133.

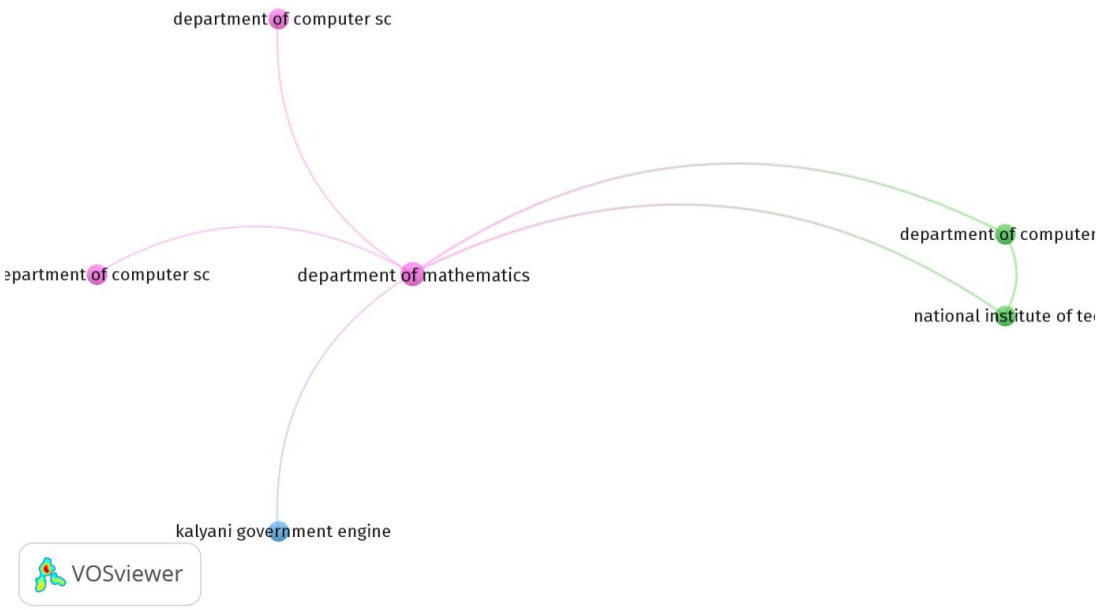

Figure 19: Citations by Organizations, Source www.scopus.com, accessed on 17 Oct 2020

E) Citation analysis by country

Total of 63 countries have the databases of the leukemia work. Out of which 31 met the citation criteria considering a threshold of minimum 5 citations per country.

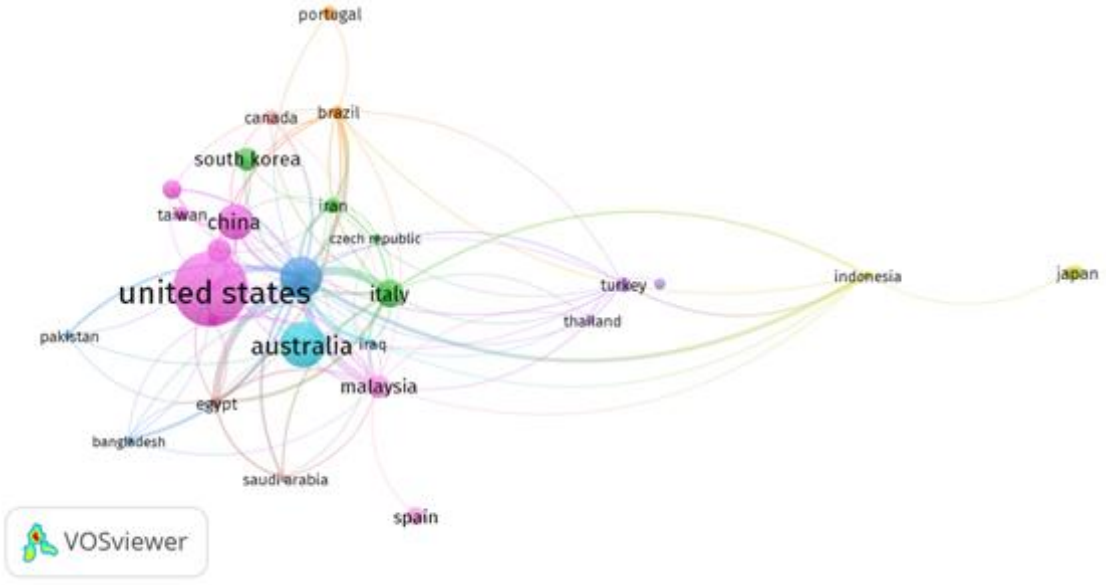

Figure 20: Citation analysis of country, Source www.scopus.com, accessed on 17 Oct 2020

4.2.4. Network Analysis of Bibliographic Coupling

A) Bibliographic Coupling of Documents

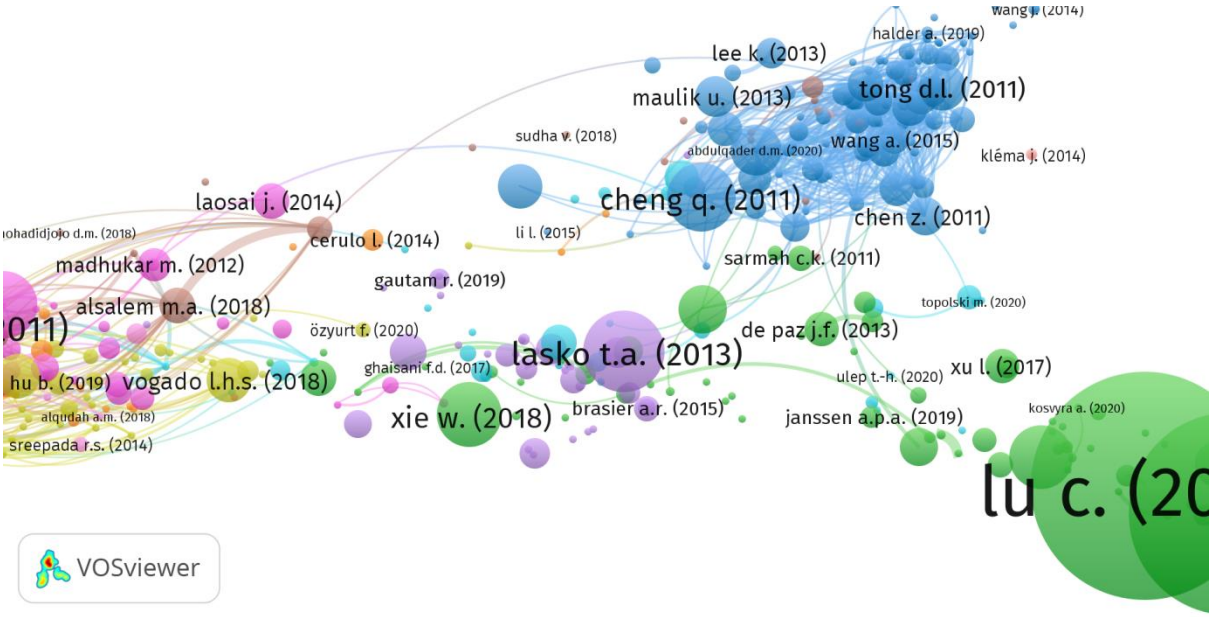

Figure 21: Bibliographic coupling of documents, Source www.scopus.com, accessed on 17 Oct 2020

B) Bibliographic coupling of Authors

Considering, 3 documents per author as a minimum threshold value. Out of total 2069 authors, 94 authors met the threshold criteria.

Figure 22: Bibliographic coupling of Authors, Source www.scopus.com, accessed on 17 Oct 2020

V. CONCLUSION

Bibliometric survey on leukemia detection by machine learning and deep learning is carried out by considering the most popular and the largest database used worldwide- Scopus. The database is considered from the year 2011 to 2020. By using the keyword search with AND

operator and OR operator the database searching is done. A total of 617 documents are obtained as the outcome of the search.

The different parameters are considered for analysis of this database. It is seen that English language has most of the documents 606 followed by Chinese. The outcome of Keyword search indicates that maximum publications are with the keyword "*disease."* Maximum documents are published in the year 2019 followed by the year 2020. The subject area Computer Science and Engineering covered almost 31% of the documents. As far as, the type of document is considered, article of journal are the major occupants followed by the conference papers. The analysis of countries proved, India as the highest number of documents within the period.

Documents by different authors also analyzed and maximum authors average Publications account 4 to 6. The highest number of documents are from University e sarees Malaysia health campus and China is the highest funding sponsor in this area.

The network analysis is also done by VOSVierer 1.65 version software. The different analysis types such as co-authorship analysis co-occurrence analysis citation analysis and bibliographic coupling are done with the same database. All these different network analysis indicates a quite significant information about different mentioned above. It could also be seen that the major work in leukemia detection is done in 2019 and 2020. In upcoming years a very vast and major work is expected in this area.

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