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# BRAIN TUMOR DETECTION AND CLASSIFICATION - A BIBLIOMETRIC SURVEY

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**Abstract :** In this paper, Bibliometric survey has been carried out on Brain Tumor Detection and Classification from 1980 to 2021. Recent trends in research are based on AI (Artificial Intelligence) and ML (Machine learning). More specifically NN (Neural Networks) are used to detect abnormal region in Images and to classify the Images. Good number of papers are published in Scopus indexed journals and conferences on this topic. Scopus database has been used to analyze the documents published on this topic. There was total 1385 documents found on the topic of Brain Tumor Detection and Classification. The statistical analysis is carried out source wise, methods used to detect tumor region specifically Image processing methods, AI, NN and advanced methodologies. Network analysis is also carried out. The analysis shows that the number of papers published is increasing year wise from 2003 to 2020. This show that still there is a great scope for research on this topic. Highest number of publications is in the year 2020 and the number of documents published in this year is 252. VOSviewer1.6.16 software is used for the statistical analysis and network analysis on the database. The Source for all Tables and figures is www.scopus.com, The data is assessed on 5thJuly, 2021.

**Key Words:** Artificial Intelligence, Brain Tumor, Classification, Detection, Statistical Analysis, Network Analysis, Neural Network.

## 1. INTRODUCTION

Brain tumor is a collection of brain cells that grow in an uncharacteristic way. Brain tumor damages the neural network of the brain which disorders brain's work. Magnetic Resonance Imaging (MRI) and Computed Tomography (CT) Scans are preferred to detect abnormal region in brain tumor. To classify this abnormal region, researchers are commonly using AI (Artificial Intelligence) techniques. Some of the familiar methods are SVM, CNN, ANN, ML, etc.

The search conducted on topic Brain Tumor Detection and Classification and obtain as a result 1385 documents. Several methods are implemented in these documents like image processing techniques, Artificial Intelligence methods, Neural Networks so on. The number of papers published on the topic brain tumor detection and classification using image processing techniques is 443 for the period 1980 to 2021. Even though search is made for the period 1980 to 2021, the papers on this said topic started publication from the year 1992 in Scopus. In the years 1992 and 1993 only one paper in each year is published. But from the years 1994 to 2001 no papers were published. From 2006 onwards papers published on this topic is increasing and from 2013 onwards increasing in publication is significant. Out of 443 papers, quite good number of papers is from India. The number of documents from Indian territory is 254. Next to India, United States published 35 papers and Pakistan 21. The document published by Irshad H, et al., received 381 number of citations which is highest and this document is published in the year 2014.

The search made based on the topic brain tumor detection and classification using Artificial Intelligence has obtain 79 documents. Out of 79 documents 63 documents are published in the period 2015 to 2021(5th July). In the year 2019, 16 documents were published which is the highest number. Highest citations were received by the article authored by Bi W.L., et al with 259 citations. This document was published in the year 2019. The search made based on the topic brain tumor detection and classification using NN has obtained 434 documents. The document published in the year 2014 by EI-Dahshan received highest number of citations 363.

Literature Survey is presented in Section 2, Results and discussions were presented in Section 3 and Conclusions were presented in Section 4.

## 2. LITERATURE SURVEY

The following search is carried out on Scopus Database. As there are quite good number of documents published in the above said years, the survey presented consists of two phases. First phase is from 1980 to 2015. In this period, the survey is based on the concept, methodology proposed first. From the period 2015 to 2021 literature survey is carried out based on citation. In this period minimum citations considered is 75. The document published by Doi K, received highest number 955 citations. This document is published in year 2007 [1].

TITLE-ABS-KEY ( brain AND tumor AND detection AND classification ) AND PUBYEAR > 1979

Plewes et al., published a document in proceedings of SPIE with title "Tissue characterization with contrast enhancement of the brain". In this paper, authors proposed method to detect and

identify various lesions using the contrast of CT images [2]. An automatic measuring device constructed by Sachs Ch., et al. and they used the method in screen of neurological patients [3].

Watanabe S et al., presented a technique to detect tumors using CT. Authors were able to detect small lesions [4]. MR images are used by Asari S. et al., to detect brain tumor. They used T2-weighted images [5]. The presence of SS-R in tumors were studied by Reubi J C et al., [6]. Dingle A A et al., developed an automatic system that can detect epileptiform activity in EEG's [7]. K M et al., presented novel model for segmenting Brain tumor [8].

The perfusion MRI for glioma grading are assessed by Weber et al. [9]. Menze et al., described the optimal high-level post-processing of single-voxel [10]. Fang et al., developed a classifier for brain tumor [11]. Iftekharuddin K M et al., SOM for tumor segmentation [12]. Eichler A F et al., reviewed important prognostic factors [13].

Patriarche et al., created an algorithm to quantitatively compare serial MRI studies of brain-tumor patients. Authors also constructed a standard classify-subtract algorithm were constructed[14]. Brain tumor detection algorithm from cerebral MRI images are proposed by Kharrat A et al. [15]. Iftekaruddin K M et al., investigated the effectiveness of MR images for brain tumor segmentation and classification [16]. A new method for segmenting 3D MR images was proposed by Khotanlou et al. [17].
Joshi D M et al., designed and developed a system to Detection and Classification Brain Tumor. [18].

A NN based method was presented by Jafari et al. for automatic classification of MR images [19]. Noreen et al., used FTIR (Fourier transform infrared) imaging as a molecular histopathology tool [20]. Mohsen, Heba, et al. [21] proposed a hybrid system. Widhiarso et al. [22] presented a novel technique using a CNN. The best accuracy achieved was 82.27%.

A DCNN based system was proposed by Seetha, J. and S. S. Raja [23] for automated brain tumor detection and grading. Cheng, Jun, et al. used region of Interest [24]. Sasikala, M., and N. Kumaravel [25] proposed a genetic algorithm feature selection. Khawaldeh Saed, et al. [26] proposed a system for non-invasive grading of glioma brain tumors.

Sajjad, Muhammad et al. [27] proposed an CNN for brain tumor classification. WhileÖzyurt. Fatih et al. [28] combine the CNN with neutron sophic expert maximum fuzzy (NSCNN) sure entropy for brain tumor classification. Karthik R et al., introduced an efficient approach for brain tumor detection using curvelet transform-based statistical features combined with Grey Level Cooccurrence Matrix (GLCM) texture features[29]. Helen R et al., developed a CAD scheme for Brain Tumour detection from MRI using active contour models [30]. Damodharan S and Raghavan D presented an effective brain tumor detection technique based on NN [31].

A CAD system was designed by Dandil E et al., to detect brain tumors [32]. Kohler et al., prepared annual report on the status of cancer and published in 2015 [33]. Chandra R et al., presented an overview of the active MSI for various medical applications [34].

Praveen and Singh proposed a new hybrid method for brain tumor classification which is based on SVM and fuzzy c-means [35]. Sahm et al., developed a customized enrichment/hybrid-capture-based next-generation sequencing (NGS) gene panel [36]. Interpretation of images and explicit classification of brain MRI techniques are proposed by Anitha et al., They proposed two tier classifier [37]. Bahadure N B et al., have investigated Berkeley wavelet transformation (BWT) for brain tumor segmentation [38].

Soltaninejad M et al., proposed a fully automated method for detection and segmentation brain tumour using MRI [39]. Brain tumor detection and classification using ML-based back propagation NN is proposed Mohamed S P et al.,[40]. Lahmiri S proposed Glioma detection on on multi-fractal features of segmented brain MRI [41]. Survey on brain tumor grade classification conducted by Mohan et al.,[42]. Varuna Shree N et al., proposed DWT and Probabilistic NN to identify and classify brain tumor MRI images [43]. Amin J et al., used Big data analysis for brain tumor detection using DCNN [44]. Bi W L et al., reviewed the current state of AI applied to medical imaging of cancer and describe advances in 4 tumor types (breast lung, prostate and brain) [45]. Kavitha P. Prabakaran S implemented two contributions to detect brain tumors [46]. Most of the papers published in the last few years based on the method AI, Neural Network, Deep learning, machine learning [47-55].

## 3. RESULTS AND DISCUSSIONS

### 3.1 Statistical Analysis

There are 1385 documents found on the topic of "Brain Tumor Detection and Classification". Scopus Database is used for collecting the data of publications.

Fig. 1 shows the number of documents by source. Table 1 shows the number of documents published by each source. LNCS Including Subseries LNAI And Lecture Notes In Bioinformatics has published 44 documents during the period of study which is highest under the category of sources. This is followed by Advances In Intelligent Systems And Computingwith 36 documents. Next to it is International Journal Of Imaging Systems And Technology with 34 documents.

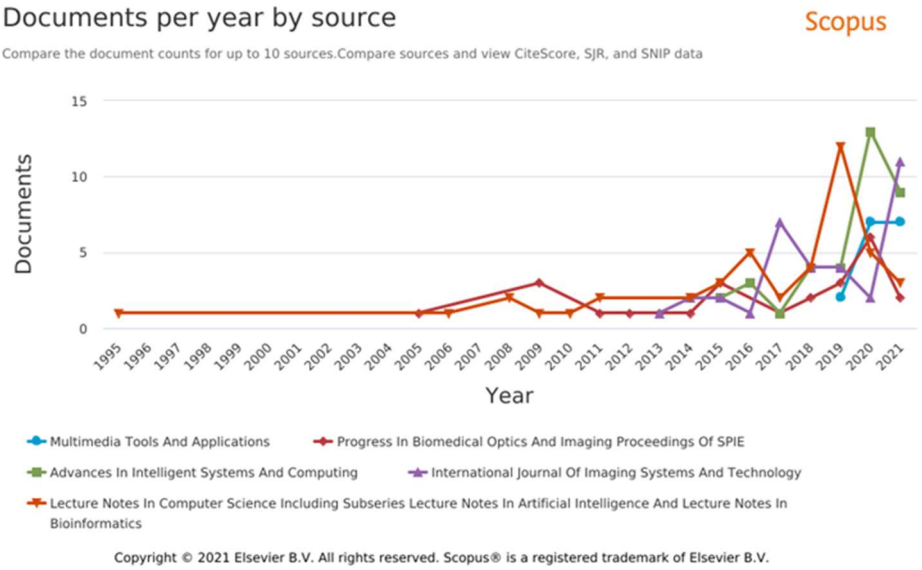


Fig. 1. Documents by Source

**Table 1. Number of Documents by Source**

| SOURCE TITLE | NO. OF DOCUMENTS |
|---|---|
| LNCS Including Subseries LNAI And Lecture Notes In Bioinformatics | 44 |
| AISC | 36 |
| International Journal Of Imaging Systems And Technology | 34 |
| Progress In Biomedical Optics And Imaging Proceedings Of SPIE | 25 |
| Multimedia Tools And Applications | 16 |

Fig. 2 Shows the documents published year wise. Table 2 shows the number of documents by year. The highest number of documents are published in year 2020 with 252 followed by 2019. In the year 2019, there are 217 documents published. Both Fig.2 and table 2 clearly give us information that the documents published year by year are increasing. That means great research is continuing on this topic.

**Table2. Documents by Year**

| YEAR | Number of Documents |
|---|---|
| 2021 | 141 |
| 2020 | 252 |
| 2019 | 217 |
| 2018 | 143 |
| 2017 | 105 |

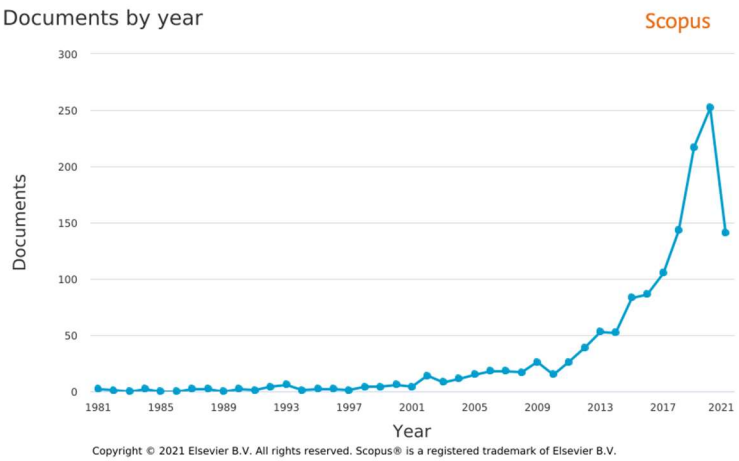


Fig. 2. Documents by year

Fig. 3 shows the documents by subject area. Table 3 shows documents by Area. Highest percentage of documents published in the Computer Science area equal to 25.3% and followed by Engineering with 18.5%.

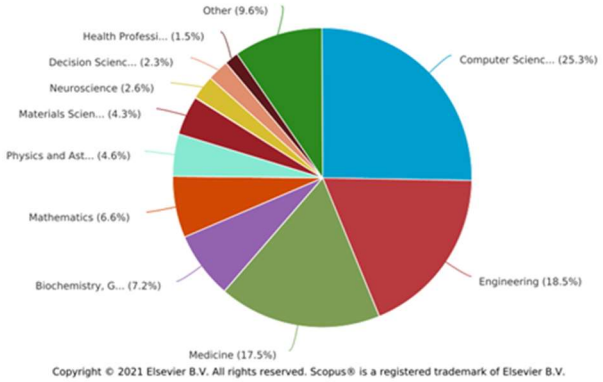


Fig. 3. Documents by Subject Area

**Table3. Documents by Area**

| SUBJECT AREA | No. of Documents Published |
|---|---|
| Computer Science | 687 |
| Engineering | 502 |
| Medicine | 476 |
| Biochemistry, Genetics and Molecular Biology | 194 |
| Mathematics | 179 |
| Physics and Astronomy | 124 |
| Materials Science | 116 |
| Neuroscience | 71 |
| Decision Sciences | 63 |
| Health Professions | 40 |
| Energy | 37 |

Fig. 4 Shows the distribution based on type of documents. Majority of the published documents are articles followed by conference papers. There are 54.4% Articles, 27.1% Conference papers and 8.4% review documents.

Fig. 5 shows documents by country/territory. India has published 535 documents followed by US and Germany. US has published 180 documents and Germany has published 94 documents during 1981-2021.

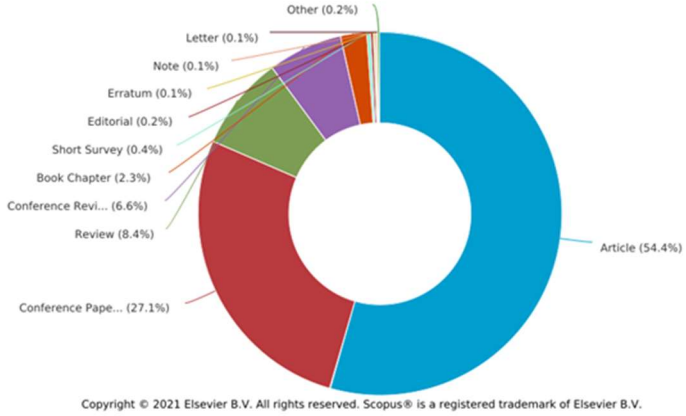


Fig. 4. Distribution based on type of document

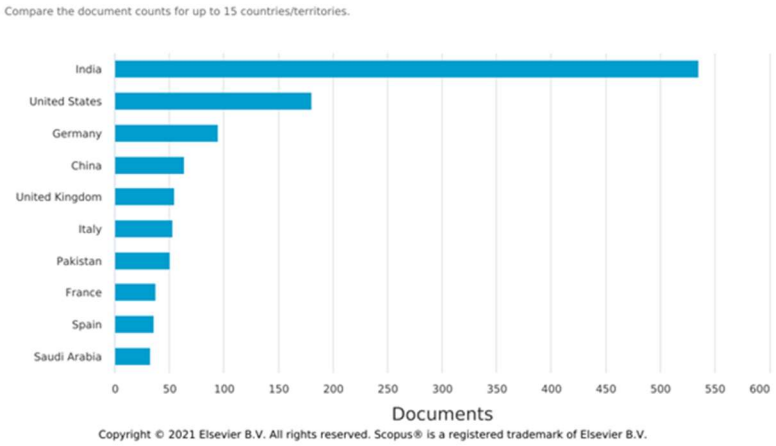


Fig. 5. Documents by Country

Fig. 6 shows documents by author. Fabelo H has published 17 documents in the area of Brain Tumor Detection and Classification which is highest and followed by Ortega S and Sharif M with 15 documents each.

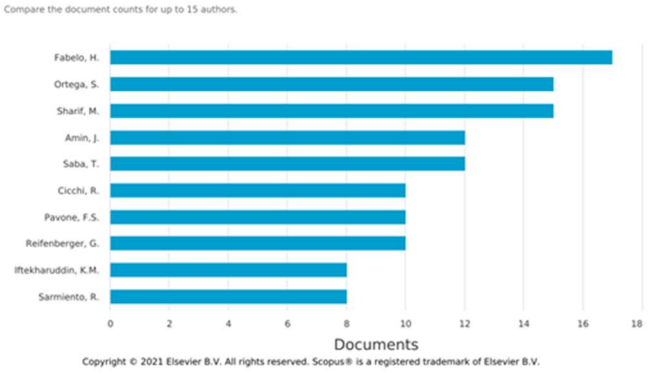


Fig. 6. Documents by author

Fig. 7 shows documents by author's affiliation. Anna University and PSNA College of Engineering and Technology have published 21 number of documents which is highest followed by Sathyabama Institute of Science and Technologywith 20 documents.

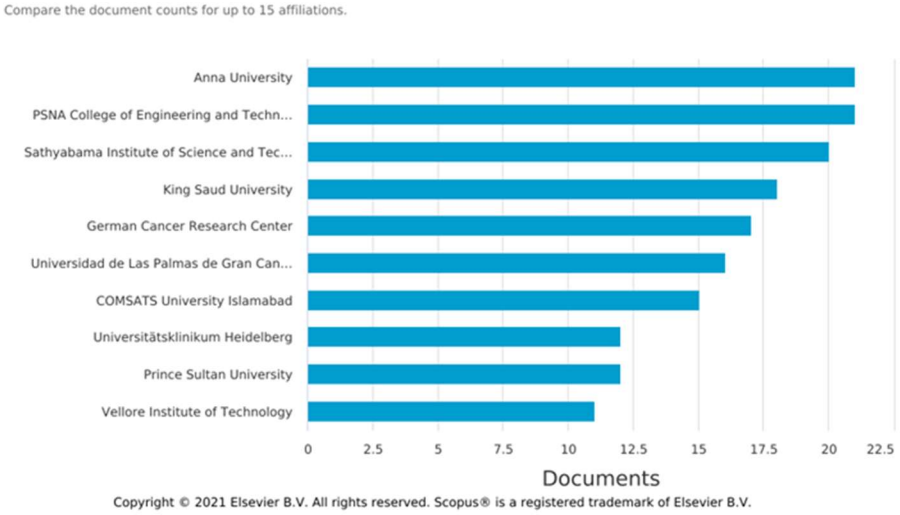


Fig. 7. Documents by affiliation

Fig. 8 shows the documents by funding agency. National Institute of Health has sponsored 39 documents which is highest in the category of funding agencies. Next to it is U.S. Department of Health and Human Services with 38 documents.

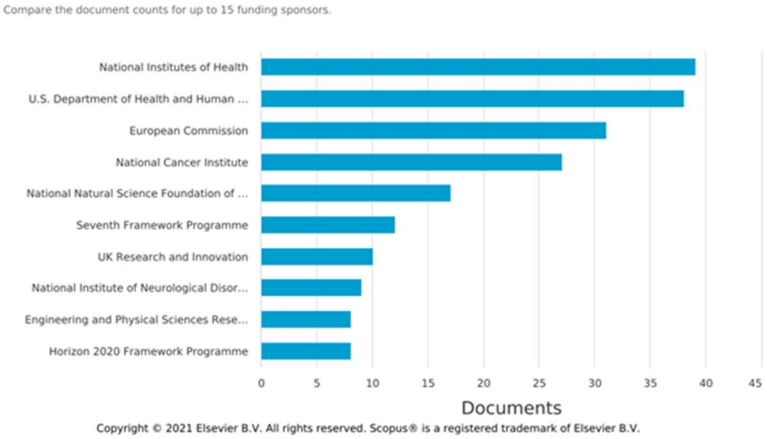


Fig. 8. Documents by Funding agency

## 3. 2 Network Analysis

### 3.2.1 Co-authorship Analysis

In this section, Co-authorship analysis is considered with 03 different parameters related to it.

**A) Co-authorship in terms of Authors**

The documents with more than 25 authors are ignored. Threshold is considered as 5 for minimum number of documents of an author. Fig.9 presets these details. It is seen that out of 3745authors, 33 authors met the criteria. Cicchi R and Pavone F S havetotal link strength of 52 each which is the highest in the co-authorship analysis. Sharif M has 26 links with 244citations for 10 documents.

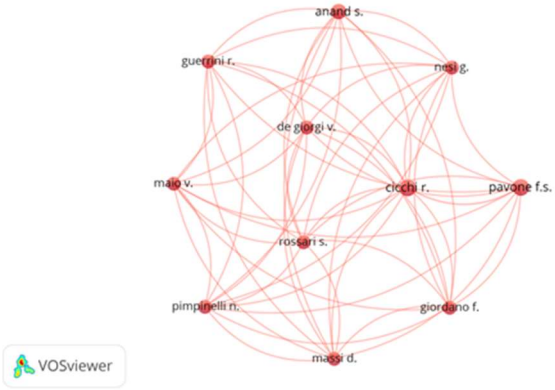


Fig. 9. Co-author relationship with each other

**B) Co-authorship in terms of Country**

A total of 91 countries are there, in this database. After considering the threshold of minimum 5 documents in a country, 33 countries met the threshold. US found to have the highest citations of 7282, and the link strength of 61. This is followed by United Kingdom with link strength of 46. The details are presented in Fig. 10 and table 4.

Table 4. Co-authorship in terms of Country

| Selected | Country | Documents | Citations | Total link strength |
|---|---|---|---|---|
| ☑ | united states | 150 | 7282 | 61 |
| ☑ | united kingdom | 42 | 2103 | 46 |
| ☑ | germany | 81 | 2599 | 36 |
| ☑ | pakistan | 36 | 387 | 32 |
| ☑ | india | 376 | 2704 | 31 |
| ☑ | france | 31 | 1146 | 30 |
| ☑ | saudi arabia | 24 | 205 | 28 |
| ☑ | italy | 34 | 696 | 27 |
| ☑ | malaysia | 26 | 355 | 25 |
| ☑ | china | 49 | 491 | 20 |
| ☑ | canada | 28 | 993 | 19 |
| ☑ | netherlands | 13 | 724 | 16 |
| ☑ | switzerland | 16 | 661 | 15 |
| ☑ | south korea | 18 | 196 | 13 |
| ☑ | spain | 27 | 419 | 12 |
| ☑ | sweden | 14 | 1132 | 11 |
| ☑ | iraq | 17 | 63 | 9 |
| ☑ | japan | 24 | 825 | 9 |
| ☑ | austria | 7 | 77 | 8 |

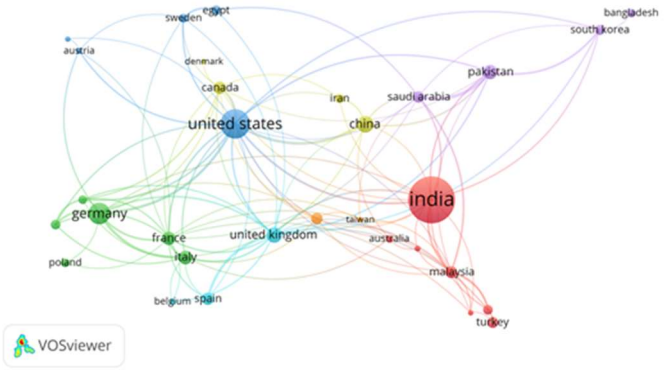


Fig.10. Co-authorship in terms of Country

### 3.2.2. Network Analysis of Co-occurrences

**A) Co-occurrence analysis in terms of all keywords**

Out of 8303 keywords, 864 keywords met the threshold value 5. The keyword "human" is having 10177 link strengths with 401 times occurrence in various documents as shown in figure 12. The keyword "humans" having 8018 link strengths with 287 times occurrence in various documents. Fig. 11 presets these details.

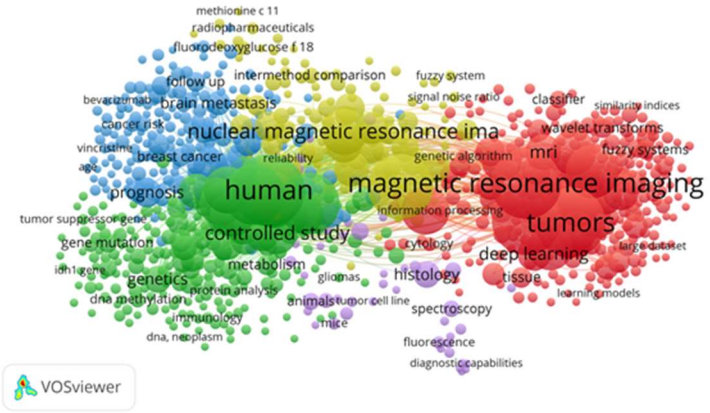


Fig. 11 Co-occurrence Analysis in Terms of All Keywords

**B) Co-occurrence analysis in terms of Author keywords**

Out of 2344 keywords by the authors, 119 keywords met the threshold value 5. 'Brain Tumor' keyword occurrence is 160 times with 354 link strength. This is followed by the keyword 'Classification' with 129 occurrences and link strength of 352. The details are presented in Fig. 12.

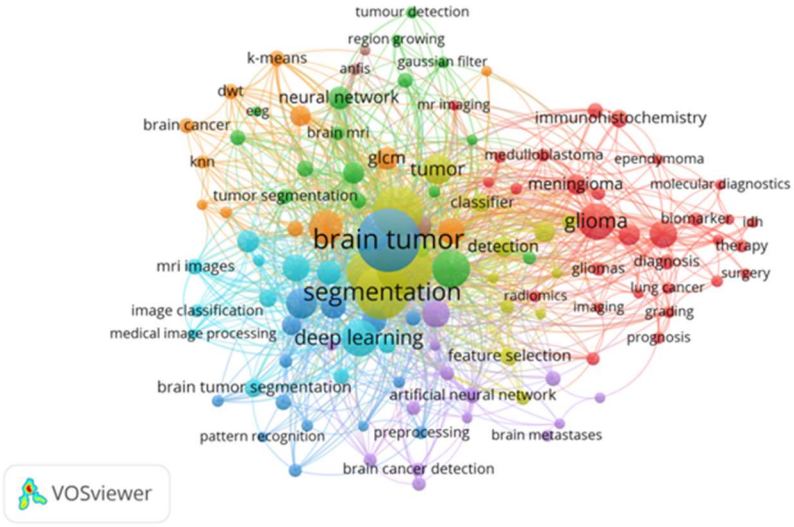


Fig. 12. Co-occurrence Analysis in Terms of Author Keywords

### 3.2.3. Network Analysis of Citations

**A) Citation Analysis of Documents**

Minimum 5 citations are considered as a threshold per document. Out of total of 1076 documents, 445 documents met the threshold. Document authored by El-dahshan E. (2014) has the citations 363 while the link strength is 26 which is the highest. Table 5 presents these details.

**Table 5. Citation Analysis of Documents**

| Selected | Document | Citations | Links |
|---|---|---|---|
| ☑ | el-dahshan e.a.-s. (2014) | 363 | 26 |
| ☑ | mohan g. (2018) | 145 | 14 |
| ☑ | anitha v. (2016) | 107 | 14 |
| ☑ | talo m. (2019) | 151 | 13 |
| ☑ | islam a. (2013) | 157 | 13 |
| ☑ | abd-ellah m.k. (2019b) | 22 | 10 |
| ☑ | soltaninejad m. (2017) | 121 | 10 |
| ☑ | bahadure n.b. (2017) | 188 | 10 |
| ☑ | jalali v. (2020) | 0 | 9 |
| ☑ | amin j. (2019b) | 30 | 9 |
| ☑ | ghorpade n. (2021) | 0 | 8 |
| ☑ | khan m.a. (2019) | 54 | 8 |
| ☑ | lahmiri s. (2017) | 81 | 8 |
| ☑ | kaushal b. (2021) | 0 | 6 |
| ☑ | amin j. (2020a) | 26 | 6 |
| ☑ | elkorany a.s. (2020) | 0 | 6 |
| ☑ | sharif m. (2018) | 52 | 6 |
| ☑ | ari a. (2018) | 36 | 6 |
| ☑ | sahm f. (2016) | 118 | 6 |
| ☑ | khotanlou h. (2009) | 186 | 6 |

**B) Citation analysis by Authors**

Threshold considered here is 5 citations per author. A total of 33 authors met the threshold amongst the total of 3745 authors. Saba T has maximum link strength of 35 with other authors only for 10 documents with 165 citations. Table 6 shows the link strength.

**Table 6 . Citation analysis by Authors**

| Selected | Author | Documents | Citations | Total link strength |
|---|---|---|---|---|
| ☑ | saba t. | 10 | 165 | 35 |
| ☑ | sharif m. | 10 | 244 | 33 |
| ☑ | khan m.a. | 6 | 147 | 29 |
| ☑ | rehman a. | 6 | 75 | 29 |
| ☑ | yasmin m. | 5 | 141 | 20 |
| ☑ | amin j. | 7 | 131 | 12 |
| ☑ | raza m. | 5 | 88 | 11 |
| ☑ | iftekharuddin k.m. | 8 | 305 | 4 |
| ☑ | fabelo h. | 9 | 97 | 2 |
| ☑ | hamed h.f.a. | 5 | 62 | 1 |
| ☑ | ortega s. | 7 | 63 | 1 |
| ☑ | sarmiento r. | 5 | 57 | 1 |
| ☑ | anand s. | 6 | 2 | 0 |
| ☑ | ansari m.a. | 5 | 21 | 0 |
| ☑ | arús c. | 5 | 58 | 0 |
| ☑ | chellamuthu c. | 5 | 46 | 0 |
| ☑ | cicchi r. | 7 | 1 | 0 |
| ☑ | de giorgi v. | 5 | 1 | 0 |
| ☑ | dhanasekaran r. | 5 | 73 | 0 |

**C) Citation analysis by country**

Out of a total of 91 countries present in the database of the current search, 33 met the threshold criteria. Analysis has a threshold of minimum of 5 documents with minimum 0 citations. India has 181 highest link with 2704 citations. Fig. 13 shows these details.


Fig. 13. Citation analysis by country

## 4. Conclusions

Scopus Database is used to conduct Bibliometric Survey on the topic "Brain Tumor Detction and Classification" . There were 1385 documents found. Some of the highlights of observations are presented here. Majority of the published documents are articles followed by conference papers. Totally 41 documents received more than or equal to 100 citations and 106 documents have 51 or more citations. In the years 2020 and 2021, 393 documents are published. The maximum number of citations received is 43. The documents having one or more citations are 159. Extensive network analysis is carried out on Co-authorship in terms of Authors, organizations and country. It is concluded that 'Brain tumor detection and classification' has tremendous potential for research.

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