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Bibliometric Survey on Multipurpose Face Recognition System using Deep Learning

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ABSTRACT

Face recognition is a new concept coming up lately and flourishing in the field of network access and multimedia information systems. Since humans are at the focus of attention in variety of applications containing videos, the concept of face recognition is rising in popularity. Several areas involving network security, retrieval and indexing of the content, and compression of videos gain a lot of benefit from the face recognition systems and related technology. Controlling the access of the networks with the help of facial recognition not only makes it difficult for the hackers to steal the information but also makes the system more fool proof, user friendly and manageable. Out of all the available tools for processing the biometric information, the face recognition system is the most popular one and used worldwide due to its ease of use and adaptability along with a wider range of working. The overall system may consist of hardware and software modules where in the detection of the facial features can be done using the available hardware and deep learning algorithms can be used to process the retrieved information. To this end, a system can be built considering face detection and face recognition as two major parts. This article shows the systematic bibliometric survey of the existing literature for the face recognition system using deep learning techniques. The survey is undertaken using the Scopus database for data analysis and several other tools like Gephi, science scape and minivan for visualisation of the fetched data. In this article, the information drawn from the Scopus database is articulated with respect to the vital aspects of bibliometric analysis such as documents fetched by affiliation, country or territory, funding sponsor, source, subject area, type and year. The information is then related to each other with the help of network diagrams for coappearance of information like - authors and source titles, authors and keywords, authors linked by co-publication etc. This survey reinforces the point that there are ample opportunities for the researchers to work in the field of face recognition system especially using deep learning techniques.

Keywords: Multipurpose, Bibliometric, Face Recognition, Deep Learning, survey, Convolution Neural Network .

1. Introduction

The concept of face recognition is an intricate and multifaceted process owing to lot of uncertainties involved in the photos clicked. Reasons for the variations involves different poses, angles, facial expressions, occlusions, backgrounds and illumination, camera resolutions etc. The Fig. 1 shown below depicts these different factors that affect facial recognition.

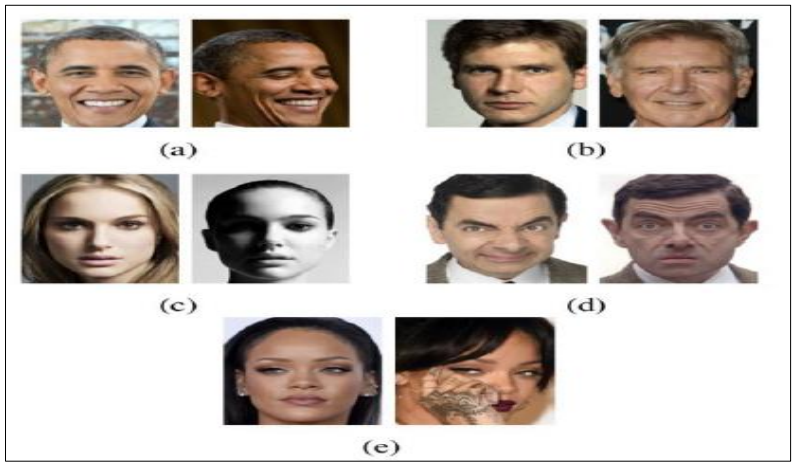


Fig. 1: Example of facial poses and related factors [1]

Over the years, the mechanics of recognition of facial features has undergone a lot of transformation. Face detection, alignment, representation and matching are the building blocks of the face recognition system [1-9]. The goal of the face detector is to find a position and return a bounding box and face alignment scales and crops the images. In face representation phase, a template is created based on the pixel values of the image and in the face matching phase the templates are compared to produce a similarity score [14-20]. Initially traditional approaches in combination with different machine learning techniques based on handcrafted features were used. These features were extracted from the numerous images fed to the system. However, the approach has significantly changed over the years with different approaches like illumination, age and pose invariant methods being considered [10-13]. For this purpose, deep learning-based approaches viz. Convolution neural networks (CNN) have been widely used. Abundant availability of the data especially variety of pictures on the internet, the process of learning the features to training of the model with higher accuracy is easier. Implementing of computer vision and deep learning algorithms has made the task of object detection, segmentation, object recognition, estimation and analysis of facial characteristics easier [21-

25]. Earlier all the analysis was based on the image processing techniques which is tedious and become obsolete in the current scenario due to their operation in the restricted environment.

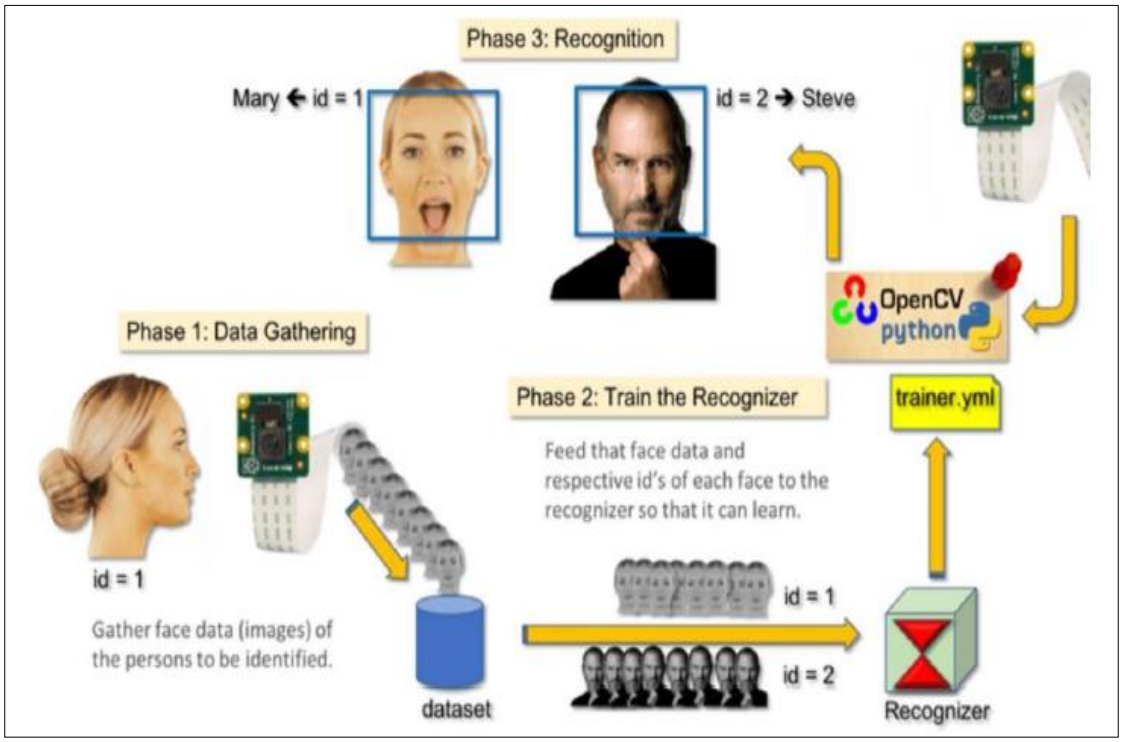


Fig. 2: Schematic representation for Face Recognition [2]

The schematic process for the facial recognition system is depicted in the Figure 2. The data i.e., the face images are gathered of the persons to be identified and a dataset of the same is formed which is fed to the recognizer. The data is further trained and tested and the person is identified. In CNN, the feature learning phase includes convolution and pooling layers whereas fully connected layers contribute towards the task of classification [30-35].

In the light of the previously mentioned application, there was a sudden offshoot in research in this domain and its understanding. Thus, this study focusses on the bibliometric analysis which help a thorough understanding and comprehension of this topic. Bibliometric analysis thus is a best practice to support the new researchers by putting up the data on the open access portal [26-30]. It is an important way in which the new researchers can keep up with the advances in this field with relevant analysis, proof-based depictions, correct representations based on the data available from the Scopus database [36-38]. Role of different authors and their contribution in the research field, related countries and journals have been highlighted in the analysis given in this paper. Thus, the Scopus based Bibliometric analysis helps the researcher to meet the goals by comprehending the qualitative and quantitative indicators [39-43].

2. Preliminary Data Collection

This article is articulated by sending a query to the SCOPUS database using main keywords - "Face Recognition" AND "Deep Learning" AND "Classifier" Or "CNN" OR "Image Processing" OR "Filter" as shown in Table 1.

Table 1 List of Keywords: Primary and Secondary

Primary Keywords	"Face Recognition"
Secondary Keywords	"Deep Learning" AND "Classifier" Or "CNN" OR "Image Processing" OR "Filter"

Source: http://www.scopus.com (accessed on 8th January 2021)

The basis for the research is the Scopus database using the keywords mentioned above as query strings. By using these keywords, 52 documents were retrieved out of which 50 were in English language and 2 in Russian language as shown below in the Table 2.

Table 2 Trend for the Publishing Language

Language of Publication	Total Count
English	50
Russian	2

Source: http://www.scopus.com (accessed on 8th January 2021)

3. Bibliometric Information and Performance Analysis

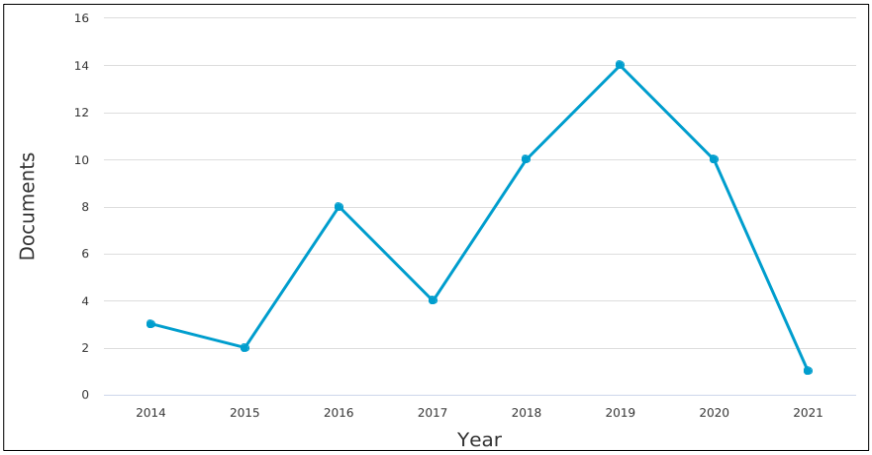
After posting a query using the mentioned keywords on the Scopus database, the necessary information is retrieved in *.csv* format and expressed in terms of the following for the further analysis -

1) The information of the documents by – prominent authors, funding sponsors, source, year, type, contributing country, subject area and key affiliations is used for statistical analysis of the data.
2) Data representation is undertaken in the form of network diagrams and graphs which is based on the co-authorship, citation analysis, co-occurrence and bibliographic coupling.

4. Results and Discussion

4.1 Preliminary Data Analysis

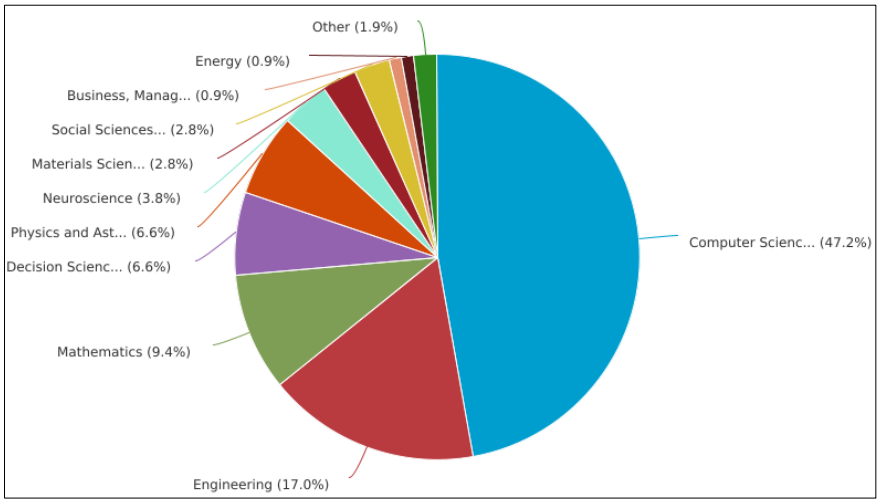
The documents related to the face recognition system using deep learning algorithms is derived for the interval of past few years and the data since 2014 to the year 2021 is depicted in the Figure 3.



Year	Documents
2021	1
2020	10
2019	14
2018	10
2017	4
2016	8
2015	2
2014	3

Fig. 3 Documents by Year
Source: http://www.scopus.com (accessed on 8th January 2021)

Fig. 4 depicts the subject area wise categorisation of the given research area. It is evident from the figure that maximum research happens in the field of computer science followed by engineering, mathematics, decision science, physics and astronomy, neuroscience, material science and social sciences.



Subject Area	Documents
Computer Science	50
Engineering	18
Mathematics	10
Decision Sciences	7
Physics and Astronomy	7
Neuroscience	4
Materials Science	3
Social Sciences	3
Business, Management and Accounting	1
Energy	1
Medicine	1
Psychology	1

Fig. 4 Documents by Subject Area
Source: http://www.scopus.com (accessed on 8th January 2021)

Analysis of Documents per year by Source is shown in Fig. 5 and *Neurocomputing* and *Proceedings Of The IEEE Computer Society Conference On Computer Vision And Pattern Recognition* have 3 documents published whereas *Communications In Computer And Information Science , IEEE Access, Computer Optics , Lecture Notes In Computer Science Including Subseries Lecture Notes In Artificial Intelligence And Lecture Notes In Bioinformatics, Pattern Recognition* have 2 documents each published from the year 2014 to 2020.

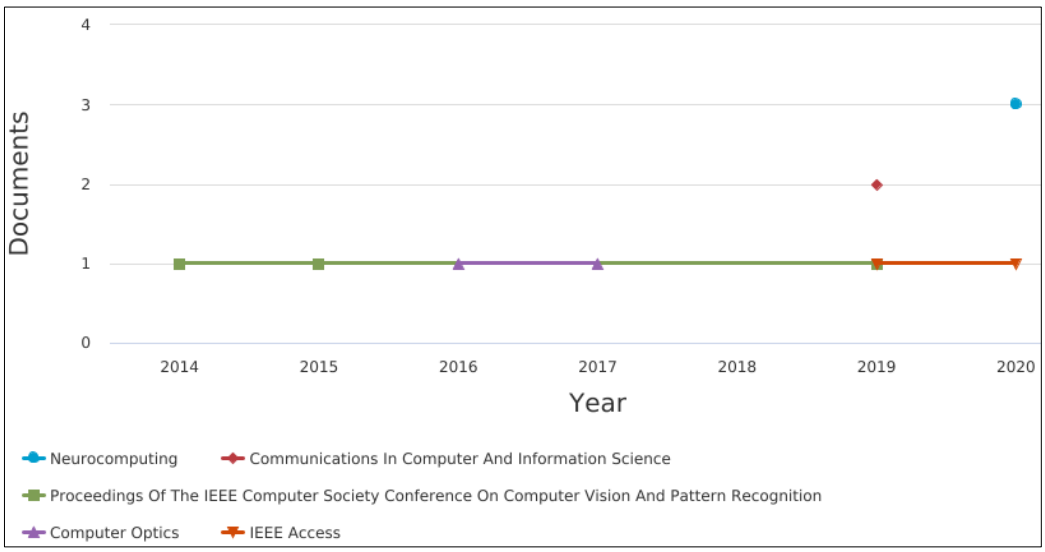


Fig. 5 Documents per year by Source
Source: http://www.scopus.com (accessed on 8th January 2021)

Funding sponsors like National Natural Science Foundation of China have 11 documents on their name whereas National Basic Research Program of China (973 Program) and National Research Foundation of Korea has 3 documents as per the record. Ministero dell'Istruzione, dell'Università e Della Ricerca, Ministry of Education, Science and Technology. Department of Homeland Security has 2 documents each on their names as per the Scopus database. This is clearly depicted in the bar graph as shown in Fig. 6.

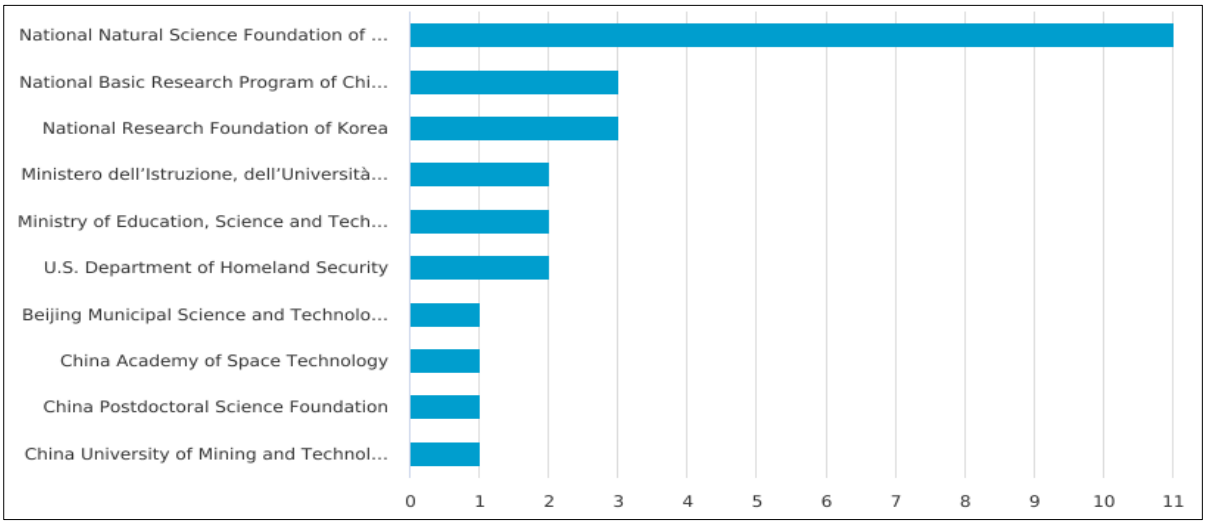
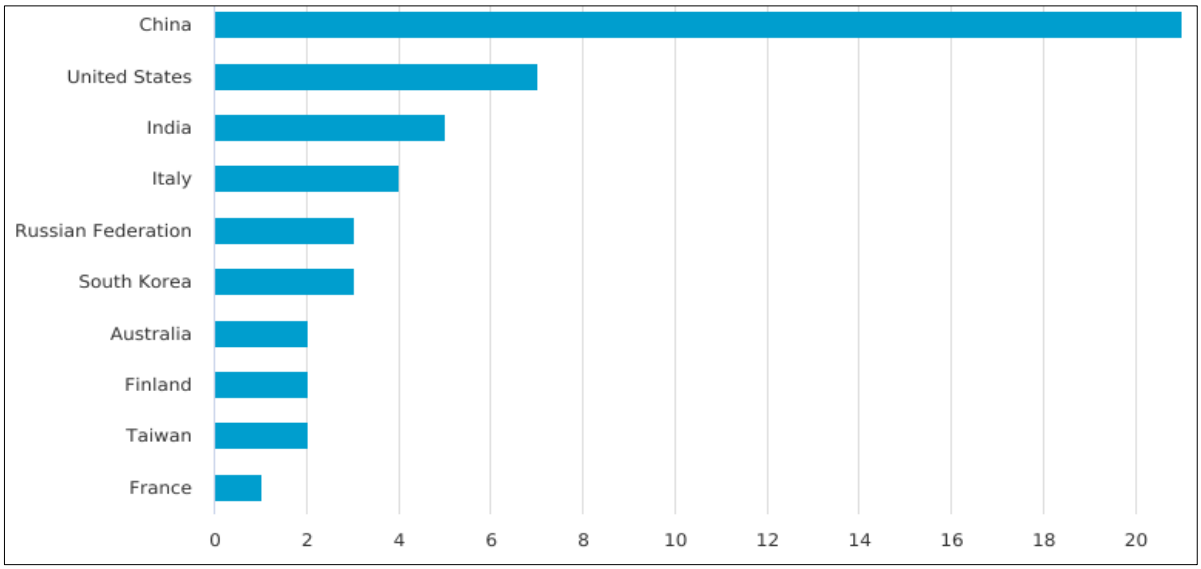


Fig. 6: Documents by Funding Sponsor

Source: http://www.scopus.com (accessed on 8th January 2021)

As seen in Fig. 7, China has maximum number of publications which is 21 followed by United States of America, India, Italy, Russia, South Korea and Australia. China which is leading in the publication count shows that there is a lot of ongoing research in this area and other countries have to improve on that front.



Country/Territory	Documents
China	21
United States	7
India	5
Italy	4
Russian Federation	3
South Korea	3
Australia	2
Finland	2
Taiwan	2

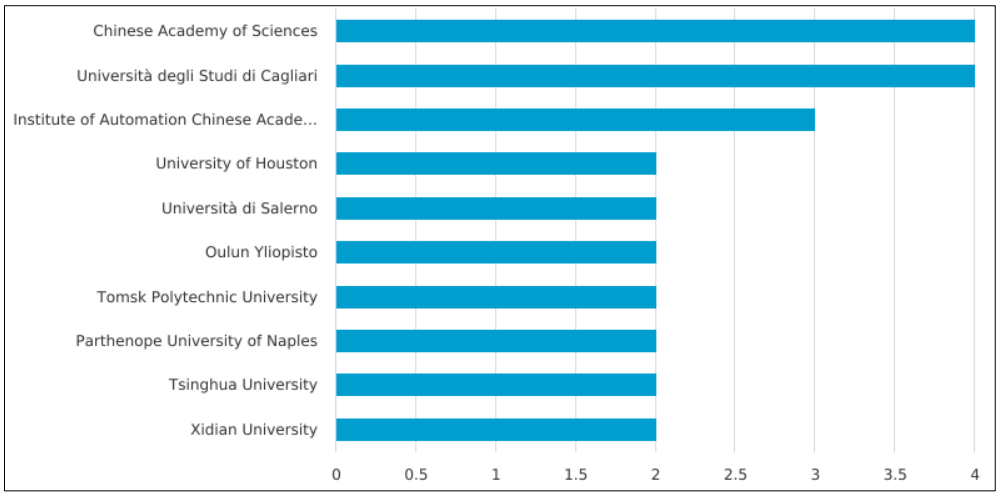
Fig. 7 Documents by Country or Territory
Source: http://www.scopus.com (accessed on 8th January 2021)

As per the Scopus database, there are multiple documents published by different authors. The list of the authors and the number of articles published by them in mentioned in the Fig. 8 shown below.

Author Name	Documents
Barra, P.	2
Barra, S.	2
He, R.	2
Kakadiaris, I.A.	2
Kalinovskii, I.A.	2
Nappi, M.	2
Narducci, F.	2
Roli, F.	2
Spitsyn, V.G.	2
Tan, T.	2

Fig. 8 Documents by Author
Source: http://www.scopus.com (accessed on 8th January 2021)

The bar graph as shown in the Fig. 9 depicts the documents published as per the affiliations wherein Chinese Academy of Sciences and Università degli Studi di Cagliariis ranked at the top followed by Institute of Automation Chinese Academy of Sciences, University of Houston, Università di Salerno, Oulun Yliopisto, Tomsk Polytechnic University, Parthenope University of Naples, Tsinghua University, Xidian University and Huazhong University of Science and Technology. None of the Indian University has made it in the top rank which shows the need for research in developing countries.

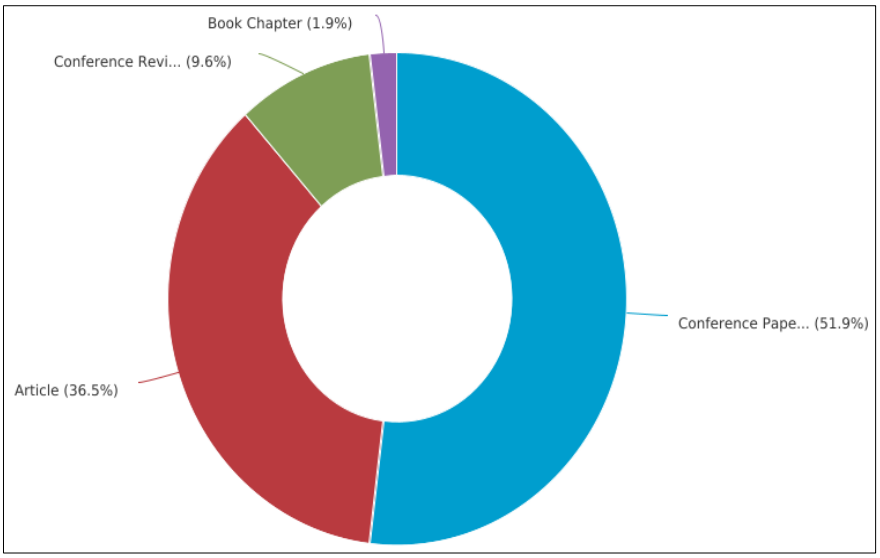


Affiliation	Documents
Chinese Academy of Sciences	4
Università degli Studi di Cagliari	4
Institute of Automation Chinese Academy of Sciences	3
University of Houston	2
Università di Salerno	2
Oulun Yliopisto	2
Tomsk Polytechnic University	2
Parthenope University of Naples	2
Tsinghua University	2
Xidian University	2
Huazhong University of Science and Technology	2

Fig. 9 Documents by Affiliation

Source: http://www.scopus.com (accessed on 8th January 2021)

The pie chart as shown in the Fig. 10 shows the number of documents published as per the document types. Maximum number of documents published on this topic that is 27 are the conference papers whereas 19 journal articles are published. Also, there are 5 conference reviews and 1 book chapter published on the refereed research subject. Over the next few years, a greater number of quality journals are expected to be published with respect to the current research area.



Document Type	Document
Conference Paper	27
Article	19
Conference Review	5
Book Chapter	1

Fig. 10 Documents by Type
Source: http://www.scopus.com (accessed on 8th January 2021)

4.2 Bibliometric Analysis through Networked Diagrams

The bibliometric analysis done by the means of network diagrams in shown in the following figures viz. - Fig. 11 to Fig. 23. They are drawn using https://medialab.github.io/sciencescape/link and enhanced using tools available on the link https://medialab.sciencespo.fr/en/tools/minivan/ link.

The networked diagram involving the main keywords, authors and journals and their interconnection is represented by the Sankey diagram as shown in Figure 11 and the keywords involved in the same are represented in the Figure 12. Top keywords from the year 2014 to the year 2021 are fetched from the Scopus database and shown in Figure 13. From fig. 11 to 13, one can easily get the idea about the prominent authors, keywords and journals. These figures carry numbers related to these prominent entities. Entities with bigger number are basically the current research trend and entities with lesser number need to be paid attention.

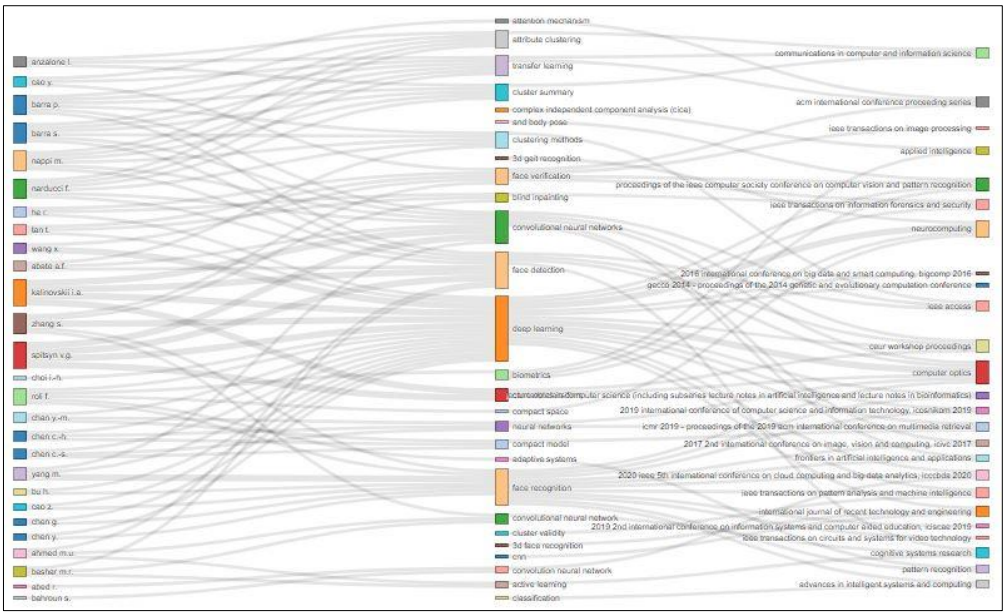


Fig. 11: Sankey Diagram: Authors-Keywords-Journal [44-48]
Source: http://www.scopus.com (accessed on 8th January 2021)

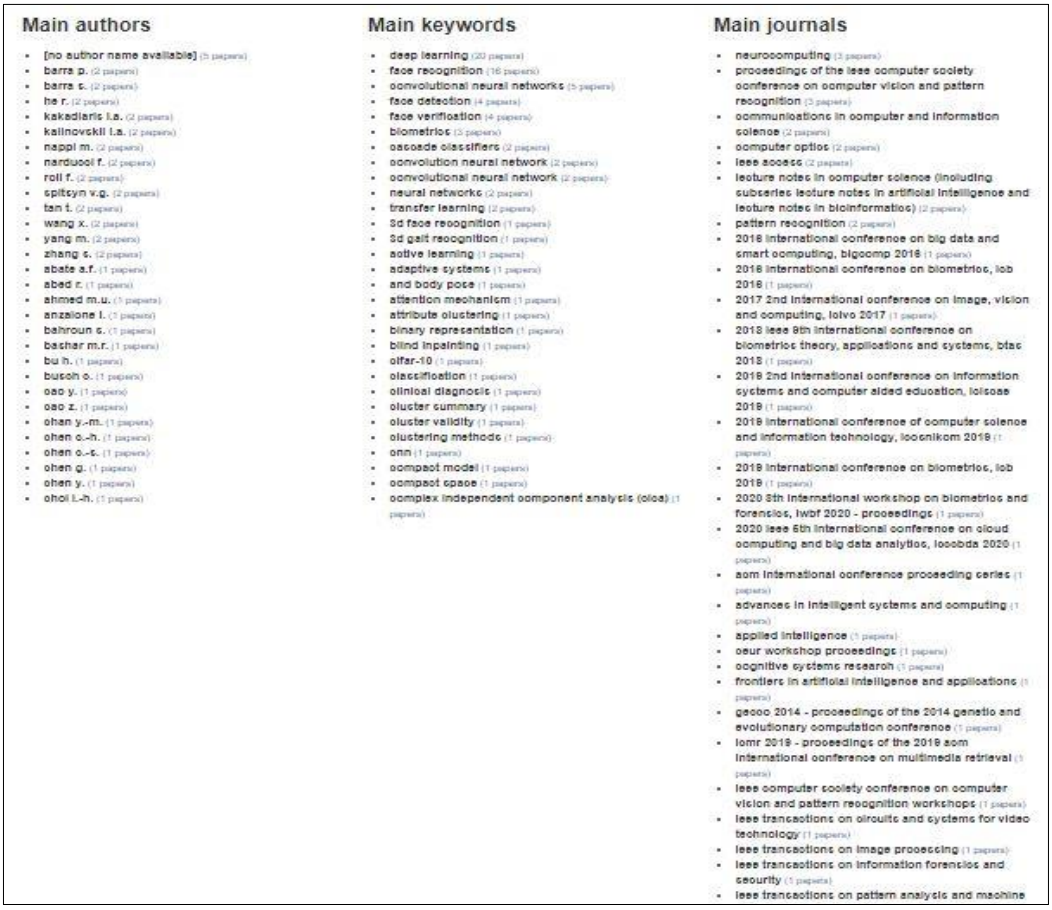


Fig. 12: Sankey Diagram: Authors-Keywords-Journal [44-48]
Source: http://www.scopus.com (accessed on 8th January 2021)

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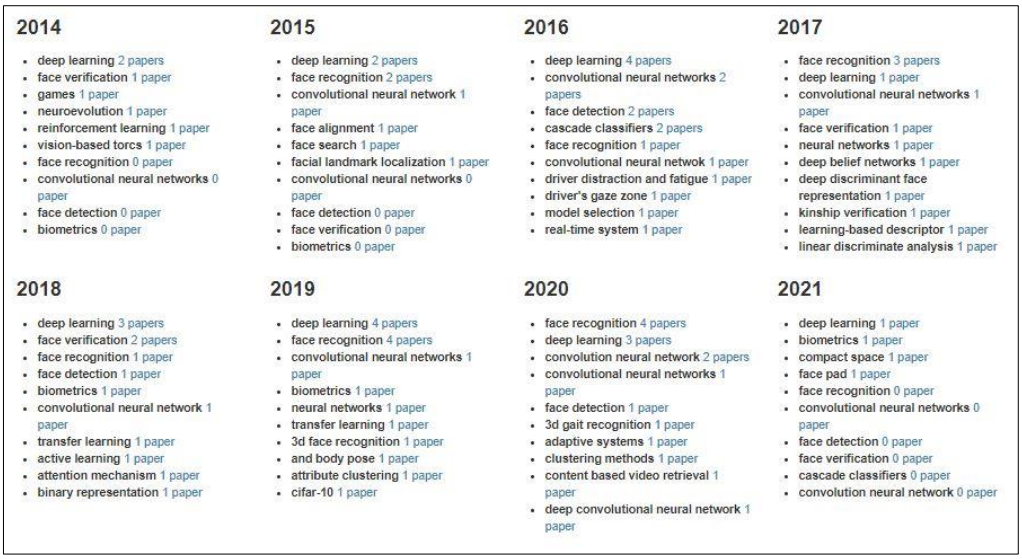

Fig. 13: Top Keywords from 2014 to 2021 [44-48]
Source: http://www.scopus.com (accessed on 8th January 2021)

From fig. 14 to fig. 23, these figures carry special importance in bibliometric research as these are the networked diagrams showing coappearance among authors and keywords, authors and source titles, among references, linkage among papers having citations, authors linked via co-publications etc. Fig. 14 shows that deep learning, compact space, neural networks, biometrics, exclusivity regularized softmax, convolution neural network, face detection, stacked image descriptor (sid), transfer learning, kinship verification, entropy measurement, face verification, self-update, games, principal component analysis, face in video recognition are the keywords related to each other. Abed r. (face in video recognition), Gong h. (face verification), Yi d. (sid), Hu g. (face) are the authors related to particular keywords.

Fig. 15 shows authors and related source titles. Tan t. (Journal of electronic imaging), Wang n. and Wang x. (neurocomputing) are the authors related to the source titles mentioned in the bracket against their name. Apart from this *IEEE Access*, *Applied Intelligence*, *Cognitive Systems Research*, *Neural Computing and Applications* are the related source titles. The main observation from fig. 15 is that authors are linked with each other through mainly through conference proceedings. From 2014 the trend of research publications through conference is observed. These conferences are related to computer vision and pattern recognition, multimedia, genetic and evolutionary computing, multimedia retrieval, big data and smart computing, biometric theory, systems and applications, image, vision and computing etc. From these conferences' topics, one can clearly get an idea about the breadth of utility of the considered research topic.

Fig. 16 on the other hand shows keywords related to the source titles. From this figure it is again validated majority of the research is through the conferences. Deep learning and face recognition are the prominent keywords. Source titles mentioned in the fig. 15 are again confirmed from the fig. 16.

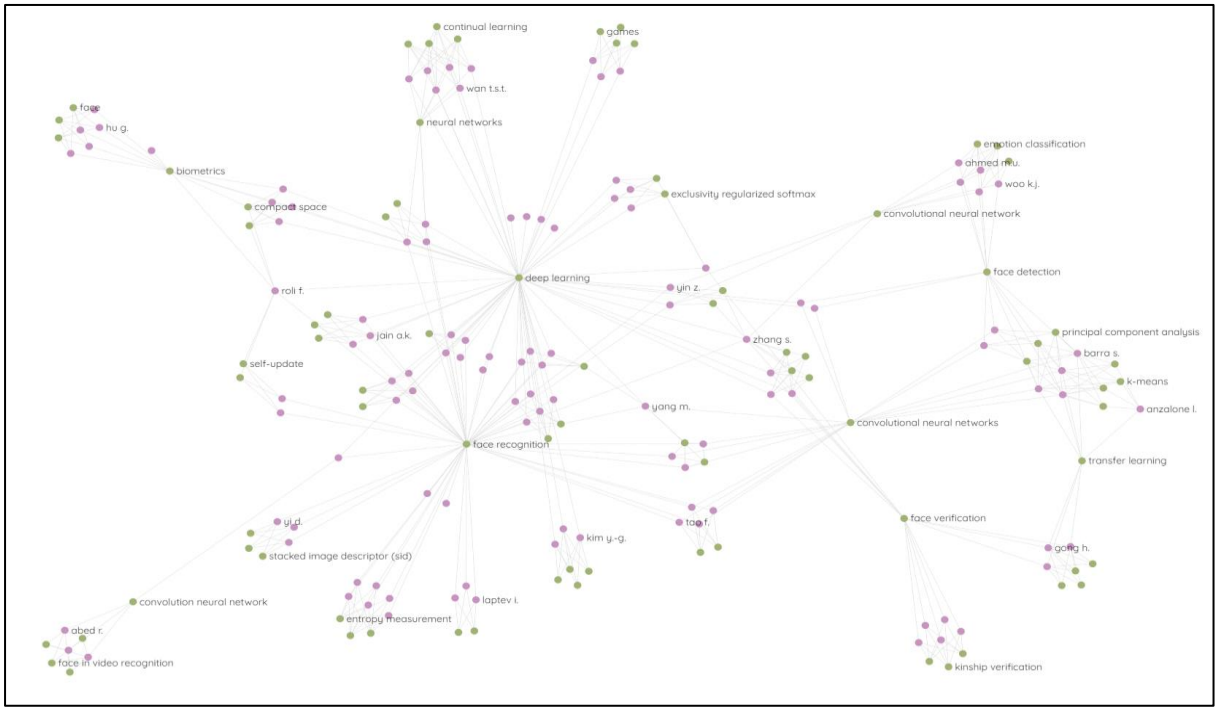

Fig. 14 Authors and Author Keywords co-appearing in the same papers [44-48]
Source: http://www.scopus.com (accessed on 8th January 2021)

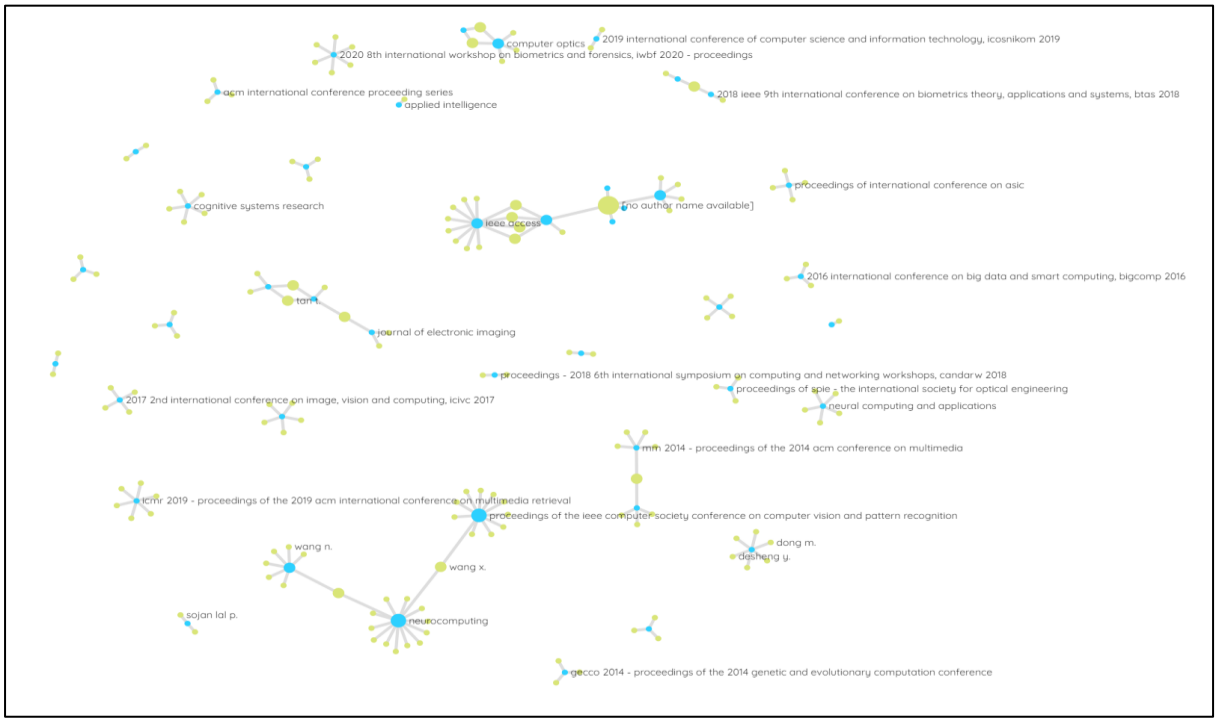

Fig. 15 Authors and source titles co-appearing in the same papers [44-48]
Source: http://www.scopus.com (accessed on 8th January 2021)

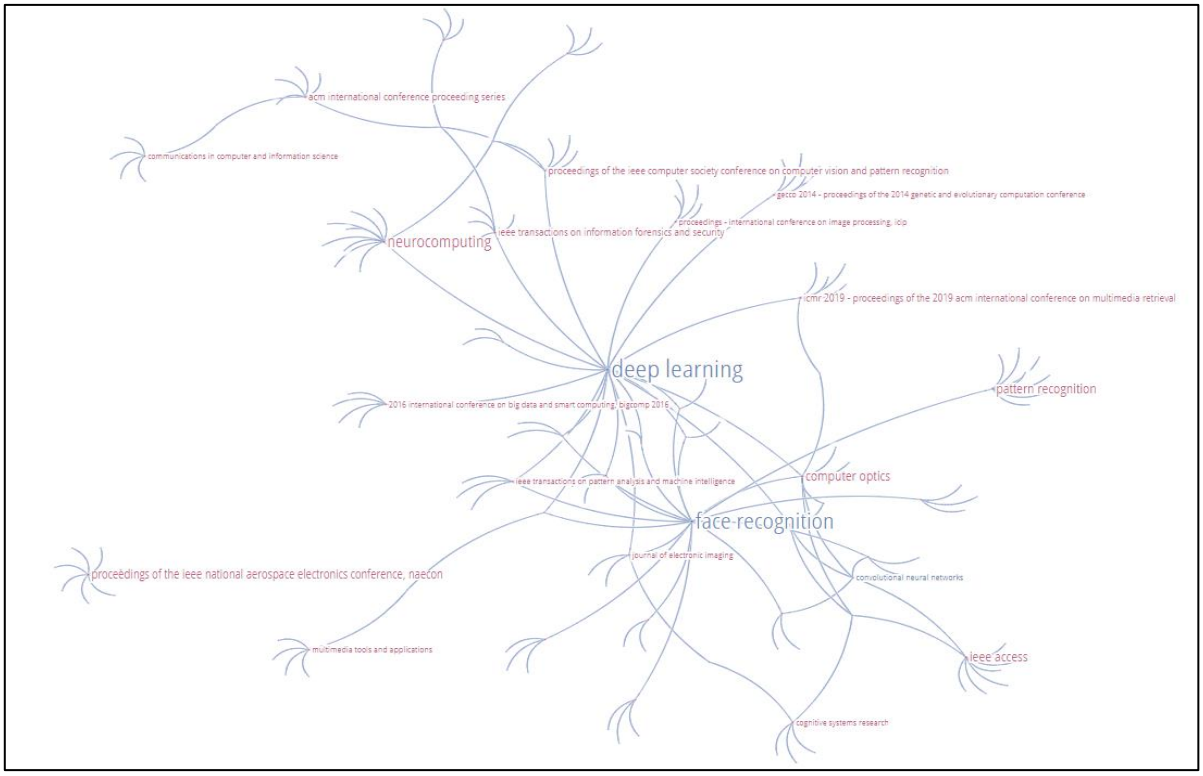

Fig. 16 Source Titles and author keywords co-appearing in the same papers [44-48]
Source: http://www.scopus.com (accessed on 8th January 2021)

Fig. 17 authors linked through their publications. Colour codes play an important role here as by observing it one can easily get an idea about the linkage among the authors through their research. Few of the related examples are Wang x. and Tan t., Wan t. s. t. and Prahara a. etc.

Fig. 18 shows papers linked by citations. Here also colour palette plays an important role in getting the idea about the citation-based paper linkage. Faint green colour is dominant. It shows source titles used in the majority of the related research.

Fig. 19 shows confirms some new keywords co-appearing in the considered research. They are facial informatics, composite sketch, face verification, kinship verification, demeshnet, squeezenet in addition to the earlier identified keywords.

Fig. 20 shows scape of used references. It is evident from fig. 20 that majority of the references are related to deep learning.

Fig. 21 show network visualization for keywords. Nodes with bigger size show keywords that are considered frequently. They are viz. face recognition, convolution, neural networks, convolution neural network, feature extraction, biometrics, computational fluid dynamics, active learning etc. On the other hand, keywords that need to be paid attention are quality control, loss functions, data mining, Euclidian spaces, bounding box, adjustment mechanisms,

classification criterion, attribute clustering, real time systems, empirical evaluations, proposed architectures, attention mechanisms, classification criterion, binary codes etc.

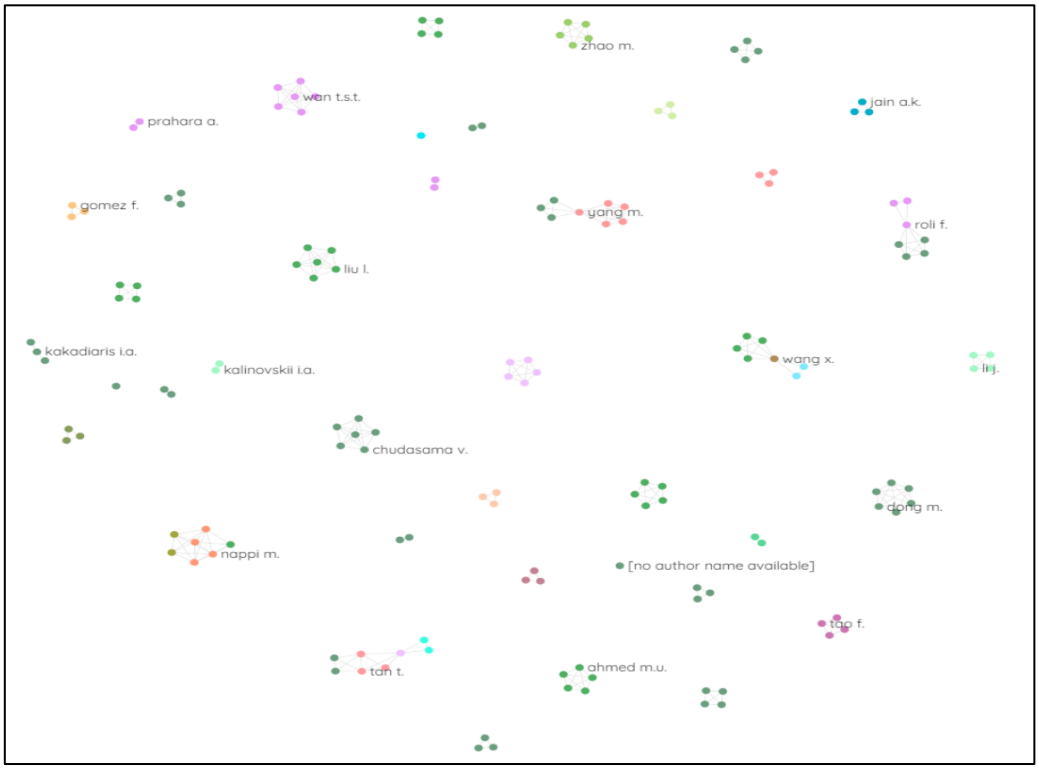

Fig. 17 Authors Linked by Co-Publication [44-48]
Source: http://www.scopus.com (accessed on 8th January 2021)

Fig. 18 Papers Linked by Citation (when they have DOI) [44-48]
Source: http://www.scopus.com (accessed on 8th January 2021)

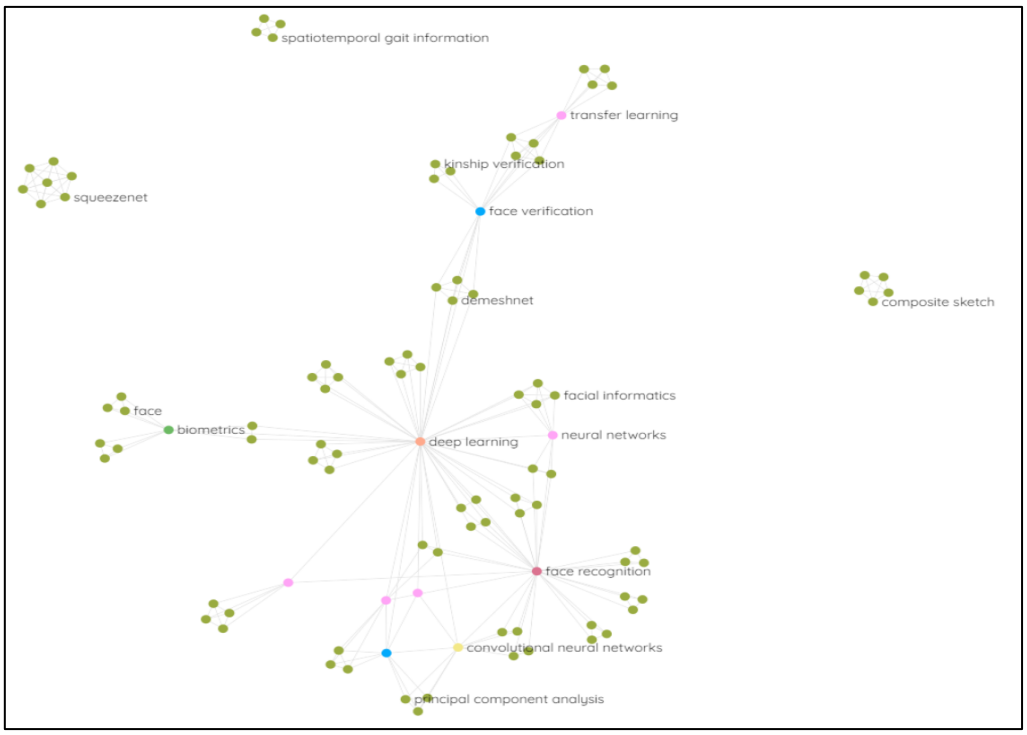

Fig. 19 Author Keywords coappearing in the same papers [44-48]
Source: http://www.scopus.com (accessed on 8th January 2021)

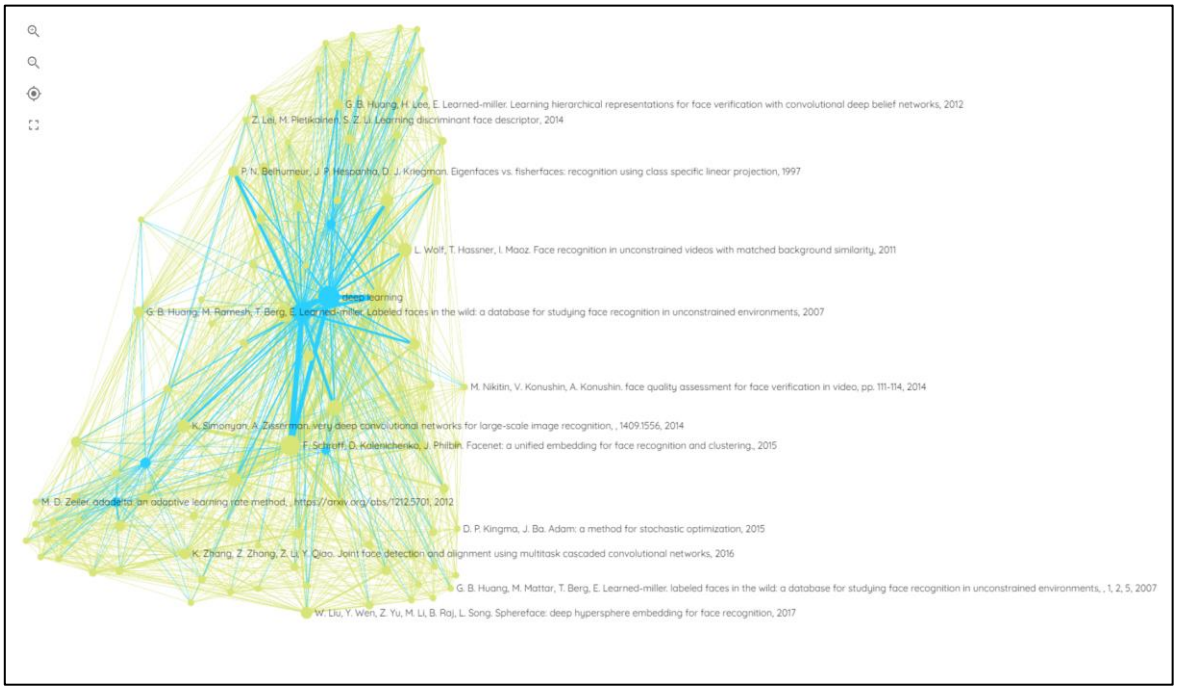

Fig. 20 Reference-scape [44-48]
Source: http://www.scopus.com (accessed on 8th January 2021)

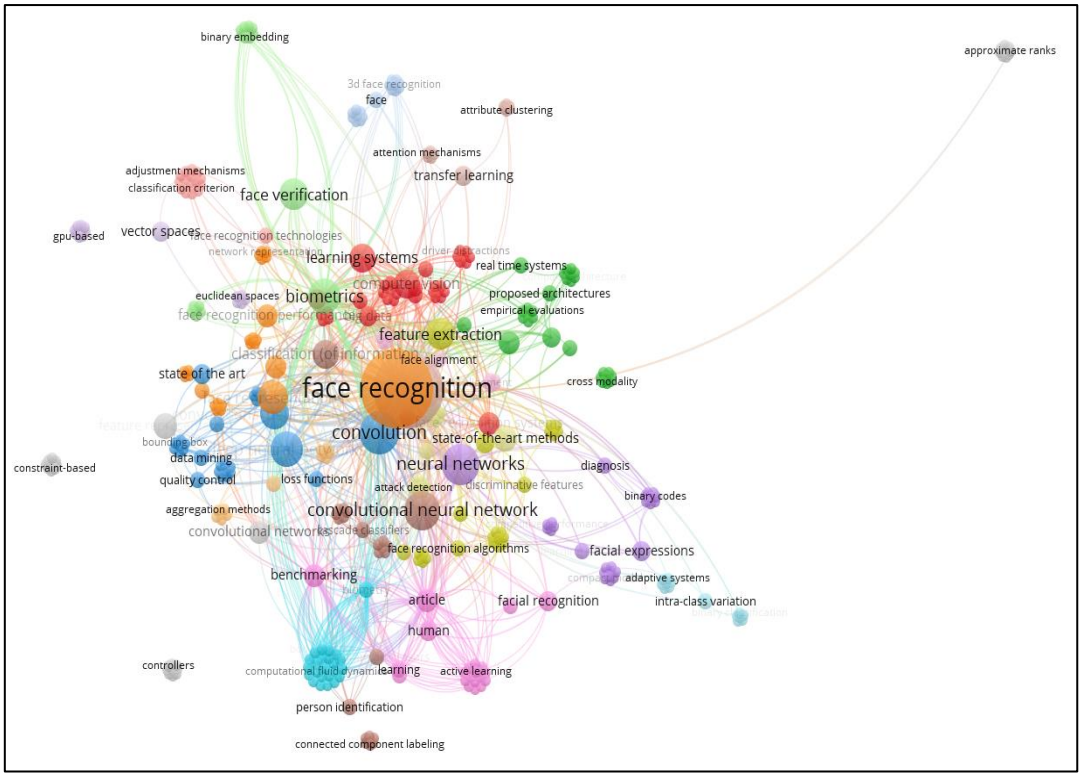

Fig. 21 Keywords network visualization [44-48]

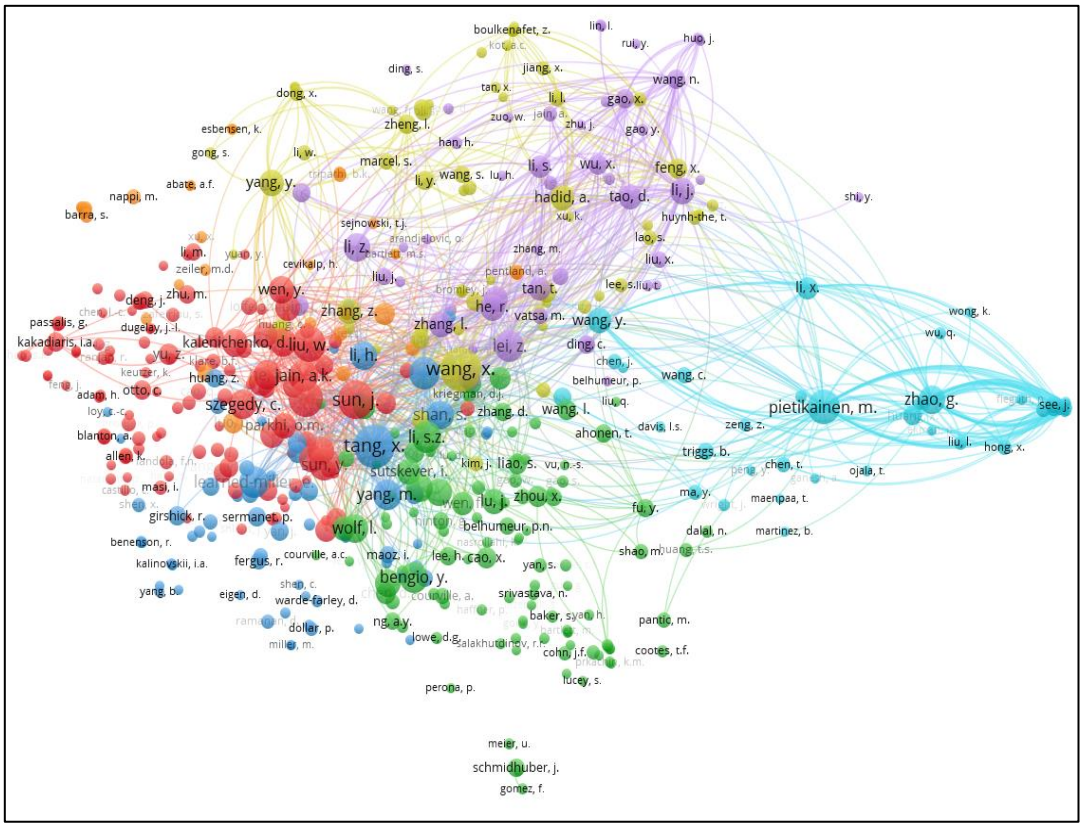

Fig. 22 Authors co-citation network diagram [44-48]

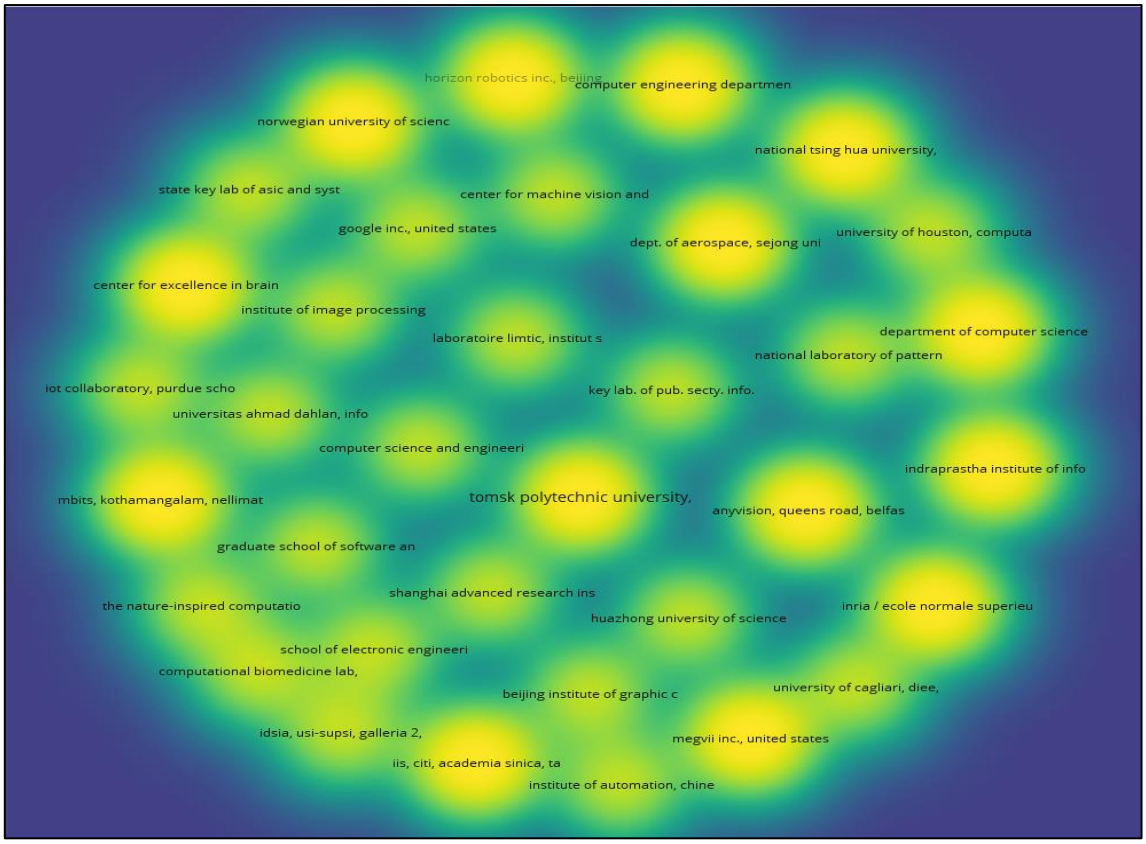

Fig. 23 Institutes involved in research network diagram [44-48]

Fig. 22 shows authors co-citation network diagram. Wang, X., Sun, J., Tang, X., Jain, A. K., Yang, M. etc. Fig. 23 highlights key institutes involved in the considered research. They are Institute of automation Chinese, Shanghai advanced research institute, Norwegian university of science, Tomsk polytechnic university, University of Houston, Huazhong university of science, University of Cagliari etc.

5 Research Implications

The bibliometric study that is undertaken has only considered the publications based on the Scopus database. There are several other journal articles, publications and book chapters from other sources like Google Scholar, Web of Science and PubMed which is not consider in this study hence not included in this analysis. However, limitation should be overcome and these databases should be included in all the further studies for a better articulation. In spite of the presence of many other databases on the public domain, Scopus database remains undeniably the most widely used and popular database amongst all in order to explore, compare and track several citations. Another limitation to be considered is that the research is limited only to one language i.e., English which may be a considerable drawback.

The considered research needs to be paid attention in India and research centres available at top-notch universities. As top companies like Google Inc. are involved in the considered research so there is a lot scope for patents too. Also, from analysed keywords it comes to notices this research can also be considered to interdisciplinary areas like computational fluid dynamics, optimization etc. The considered research is vastly related to distributed systems which will in a lead another important trending research.

6 Conclusion

From the bibliometric study and analysis, it is observed that there are several researchers involved in the field of Facial recognition and Deep Learning. Owing to the information retrieved from the Scopus database and represented using the graphs, it is evident that many conferences and journals all over the world are publishing their work in this domain. In this era of advanced technology, information – true or false, real or fake spreads quickly and verifying the truthfulness of such information is essential. Hence the research presented by the Scopus database is very vital in guiding the new researchers in the right direction.

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