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Bibliometric Analysis of One-stage and Two-stage Object Detection

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Abstract

Object Detection using deep learning has seen a boom in the recent couple of years. Observing the trend and its research, it is important to summarize bibliometrics related to object detection which will help researchers contribute to this subject area. This paper details bibliometrics for one-stage object detection and two-stage object detection. This uses Scopus database for data analysis. This also uses tools like Sciencescape, Gephi, etc. It can be observed that the advancements to the field of object detection are seen in recent years and explored to its full extent. It is observed that Chinese universities and researchers are the foremost in the research studies focused on object detection.

Keywords – object detection, deep learning, one-stage object detection, two-stage object detection.

Introduction

Object Detection is one of the most famous and vastly researched topics in the field of Computer Vision and Machine Learning. It has attracted many researchers working in different areas such as computer vision, robotics, medical imaging, mechanical engineering, and telecommunications. Object Detection is a methodology in Machine Learning focused on localizing and recognizing distinct objects in images and videos. Every object has discrete features that help in distinguishing it in a photo or a video frame. Object Detection methodologies use those features in determining objects, identifying, and labeling them. Methods for object detection can fall under machine learning-based approaches and deep learning-based approaches. In this paper, we are doing a bibliometric analysis of the approaches used in deep learning-based object detection methodologies. Deep Learning methodologies are able to do end-to-end object detection using Convolutional Neural Networks. The algorithms designed to do object detection are based on two

approaches - one-stage object detection and two-stage object detection. One-stage detectors have high inference speeds and two-stage detectors have high localization and recognition accuracy.

The two stages of a two-stage detector can be divided by a RoI (Region of Interest) Pooling layer. One of the prominent two-stage object detectors is Faster R-CNN. It has the first stage called RPN, a Region Proposal Network to predict candidate bounding boxes. In the second stage, features are by RoI pooling operation from each candidate box for the following classification and bounding-box regression tasks [1]. In contrast, a one-stage detector predicts bounding boxes in a single-step without using region proposals. It leverages the help of a grid box and anchors to localize the region of detection in the image and constraint the shape of the object. The outline of this paper is section 1 presents introduction, section 2 details out preliminary data collection, section 3 gives network analysis, section 4 gives conclusion. References referred to formulate this paper are at the end.

Reference No.	Year	Key Points	Method Used
[1]	2014	R-CNN: Region based CNN detector	Two-stage detection
[2]	2015	Fast R-CNN: faster version of R-CNN	Two-stage detection
[3]	2017	Faster R-CNN: uses novel RPN	Two-stage detection
[4]	2017	Mask R-CNN: extension of Faster R-CNN	Two-stage detection
[5]	2017	FPN: Feature Pyramid Network	Two-stage detection
[6]	2016	YOLO: You Only Look Once	One-stage detection
[7]	2017	YOLOv2: second version of YOLO	One-stage detection

Reference No.	Year	Key Points	Method Used
[8]	2018	YOLOv3: third version of YOLO	One-stage detection
[9]	2016	SSD: Single Shot Detector	One-stage detection
[10]	2017	DSSD: Deconvolutional Single Shot Detector	One-stage detection
[11]	2017	RetinaNet	One-stage detection
[12]	2018	M2Det	One-stage detection
[13]	2018	RefineDet	One-stage detection
[14]	2018	Relation Networks for Object Detection	Two-stage detection
[15]	2017	DCN	One-stage detection
[16]	2018	DCNv2	One-stage detection
[17]	2019	NAS-FPN	One-stage detection
[18]	2017	Faster R-CNN G-RMI	Two-stage detection
[19]	2016	Faster R-CNN+++	Two-stage detection

Reference No.	Year	Key Points	Method Used
[20]	2017	Deformable R-FCN	Two-stage detection
[21]	2018	Cascade R-CNN	Two-stage detection
[22]	2018	DCNv2+Faster R-CNN	Two-stage detection
[23]	2018	CornerNet512	One-stage detection
[24]	2020	EfficientDet	One-stage detection
[25]	2020	Deeply Supervised Salient Object Detection with Short Connections	Two-stage detection
[26]	2020	Fast-D	One-stage detection
[27]	2020	Yolov4	One-stage detection
[28]	2018	PANet	Two-stage detection

2. Preliminary Data Collection

This bibliometric research paper is formulated by querying the Scopus DB. Table 1 and Table 2 mention the information about the queries used to obtain bibliometric information for the topic researched.

Table 1. Scopus DB search query (One-stage Object Detection)

Main Keyword	Object Detection
Supporting Keywords	(AND) Single Stage Detector (OR) One Stage Detector (OR) Single Stage Method (OR) One Stage Method

(Source: Scopus DB accessed on 25th December 2020)

Table 2. Scopus DB search query (Two-stage Object Detection)

Main Keyword	Object Detection
Supporting Keywords	(AND) Multi Stage Detector (OR) Two Stage Detector (OR) Multi Stage Method (OR) Two Stage Method

(**Source: Scopus DB accessed on 25th December 2020**)

Based on the query mentioned in Table 1, we obtained 138 documents from Scopus DB. All the documents collected are in the English language, as shown in Table 3.

Table 3. Publication Language Details (One-stage Object Detection)

Publication Language	Count
English	138

Based on the query mentioned in Table 2, we obtained 93 documents from Scopus DB. All the documents collected are in the English language, as shown in Table 3.

Table 3. Publication Language Details (Two-stage Object Detection)

Publication Language	Count
English	93

3.Bibliometric Analysis

This section highlights details related to the undertaken topic for bibliometric. There are a total of 34 figures. Each figure highlights vital information on the research topic that researchers can use to contribute to this area.

Following are the information extracted by doing bibliometric analysis of One Stage Object Detection and Two Stage Object Detection:

1. Publications by year, prominent authors, source statistics, subject area-specific contribution, document type details, documents by source yearly details, affiliation statistics, and details about funding sponsors
2. Second important aspect is to showcase the information using networked diagrams based on authors, author keywords, source titles, reference scape, Sankey graph showing tri-information like principal authors, main keywords, and prominent journals, to name a few.

3.1 Publication Analysis by Year

Fig. 1 shows a year-wise publication analysis for One Stage Object Detection. It can be inferred that a boom in the field of one-stage object detection is observed from the years 2017 to 2019. The year 2019 is marked with the highest number of publications.

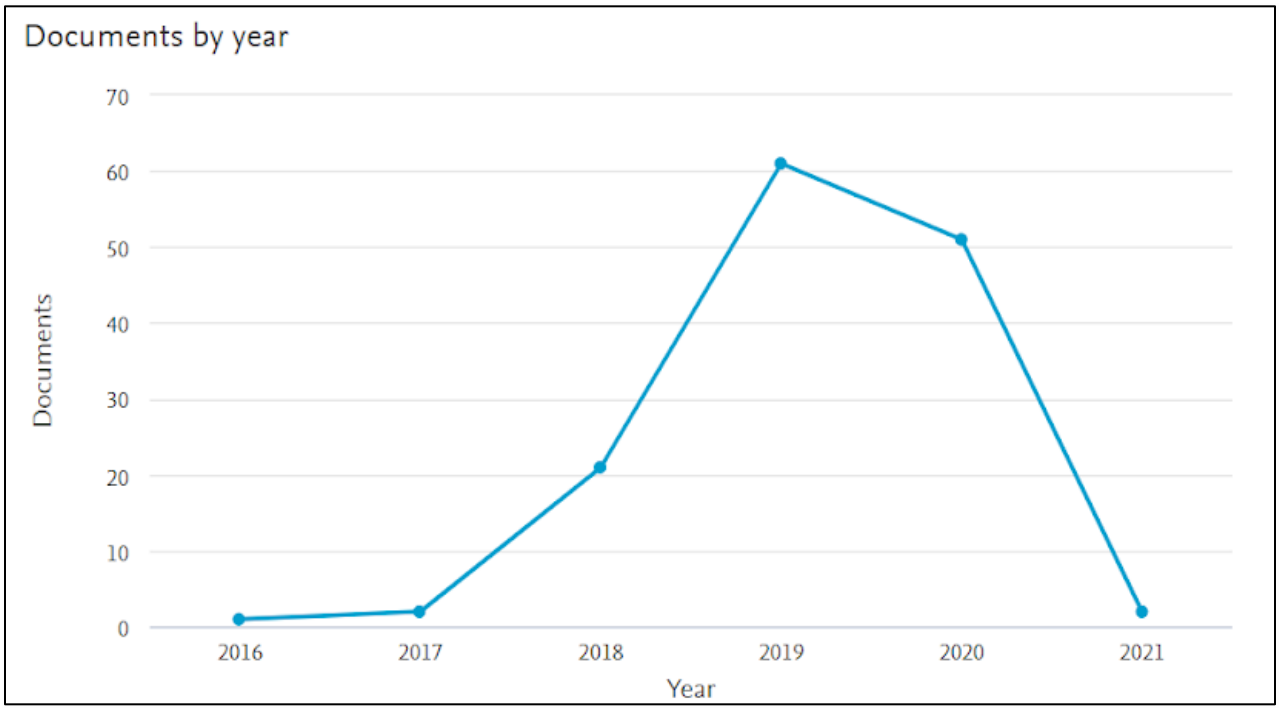


Fig. 1. Yearly publication count for One Stage Object Detection

(Source: Scopus DB accessed on 25th December 2020)

Fig. 2 shows a year-wise publication analysis for Two Stage Object Detection. It can be inferred that a boom in the field of two-stage object detection is observed from the years 2017 to 2020. The year 2020 is marked with the highest number of publications.

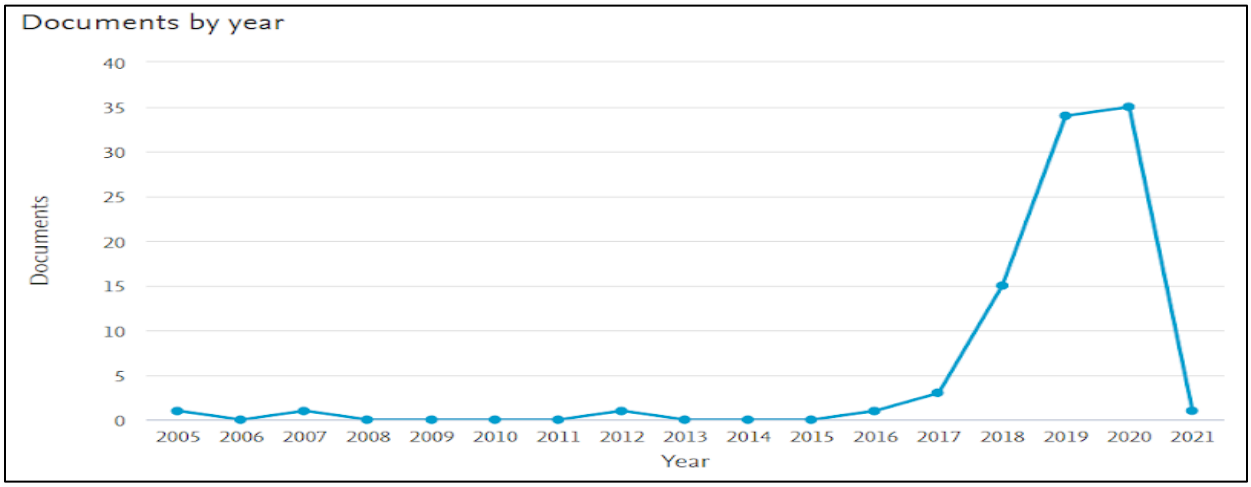


Fig. 2. Yearly publication count for Two Stage Object Detection

(Source: Scopus DB accessed on 25th December 2020)

3.2 Publication Analysis by Source

Fig. 3 shows a source-wise publication analysis for One Stage Object Detection. The highest number of publications were published in "Proceedings of The IEEE International Conference on Computer Vision" in 2019.

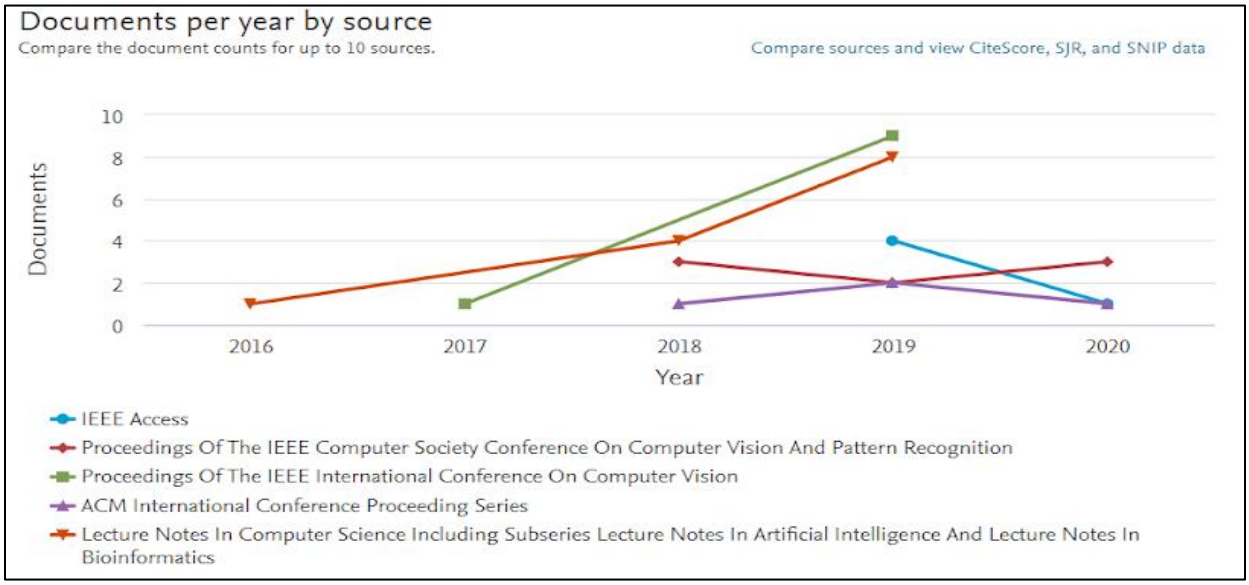


Fig. 3. Source publication count for One Stage Object Detection

(Source: Scopus DB accessed on 25th December 2020)

Fig. 4 shows a source-wise publication analysis for Two Stage Object Detection. The highest number of publications were published in "Lecture Notes in Computer Science Including Subseries Lecture Notes in Artificial Intelligence and Lecture Notes in Bioinformatics" in the year 2019.

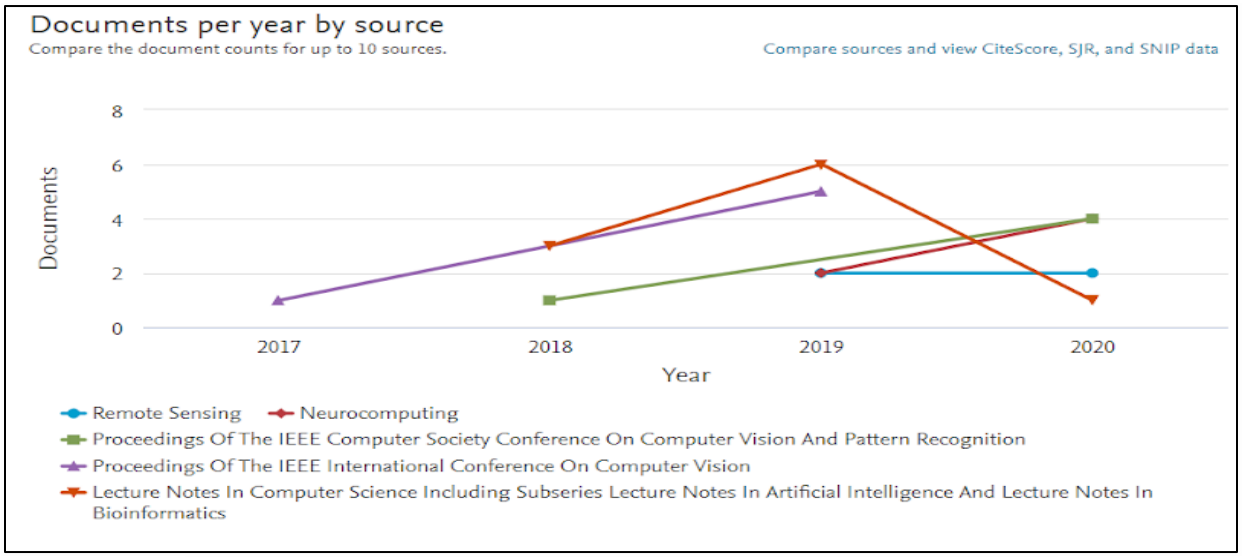


Fig. 4. Source publication count for Two Stage Object Detection

(Source: Scopus DB accessed on 25th December 2020)

3.3 Publication Analysis by Author

Fig. 5 shows the number of publications of different authors for One Stage Object Detection. Pang, Y. published the highest number of documents, followed by Cao, J., Fu, K., and Sun, X.

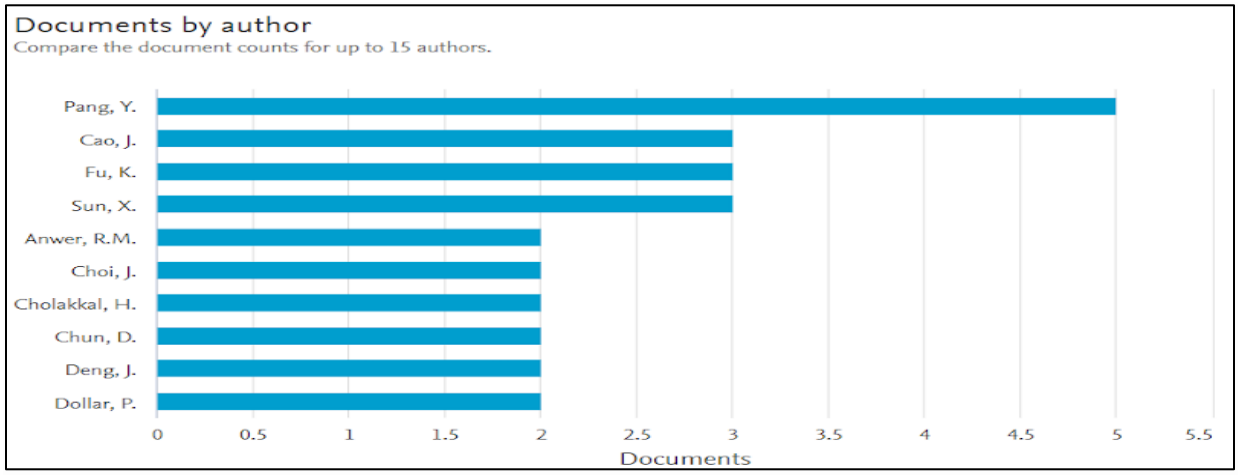


Fig. 5. Author publication count for One Stage Object Detection

(Source: Scopus DB accessed on 25th December 2020)

Fig. 6 shows the number of publications of different authors for Two Stage Object Detection. The maximum number of documents published by any author is capped at 2.

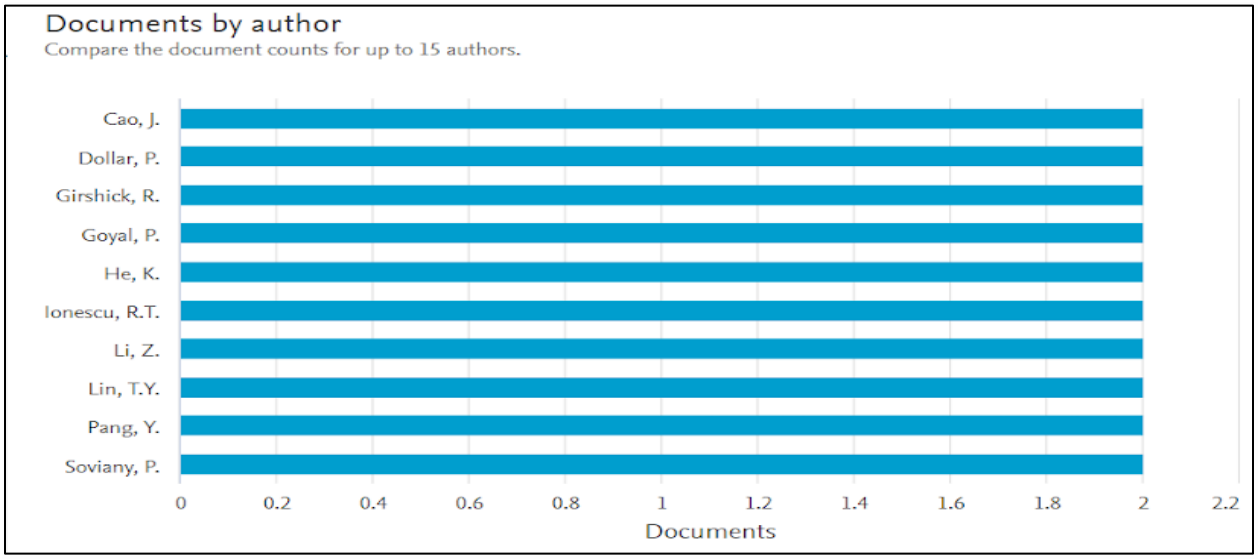


Fig. 6. Author publication count for Two Stage Object Detection

(Source: Scopus DB accessed on 25th December 2020)

3.4 Publication Analysis by Affiliation

Fig. 7 shows the number of publications with different affiliations for One Stage Object Detection. Most documents are published in the affiliation with the Chinese Academy of Sciences following by the University of Chinese Academy of Sciences, and the National University of Defense Technology.

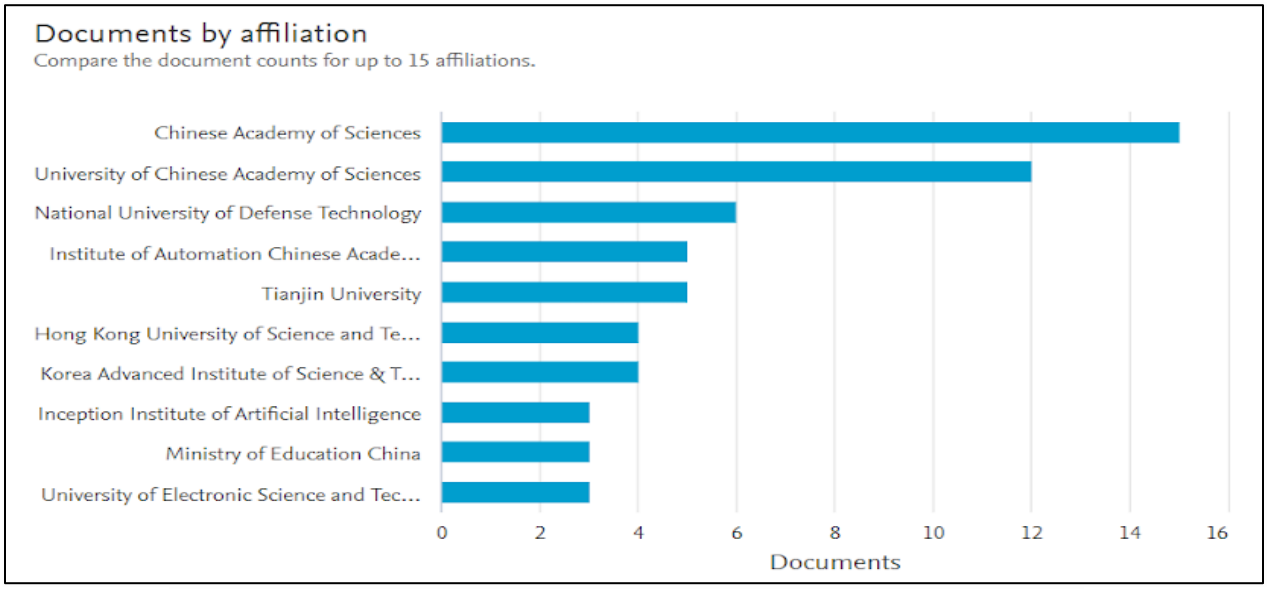


Fig. 7. Affiliation publication count for One Stage Object Detection

(Source: Scopus DB accessed on 25th December 2020)

Fig. 8 shows the number of publications with different affiliations for Two Stage Object Detection. Most documents are published in affiliation with the Chinese Academy of Sciences following by the University of Chinese Academy of Sciences and the Peking University.

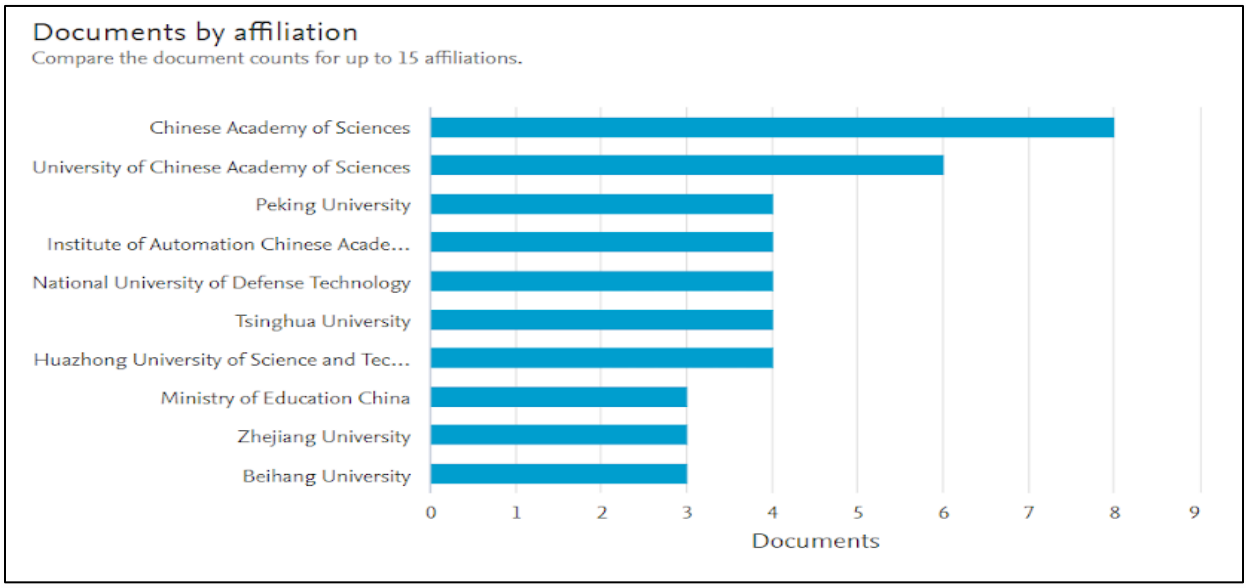


Fig. 8. Affiliation publication count for Two Stage Object Detection

(Source: Scopus DB accessed on 25th December 2020)

3.5 Publication Analysis by Country

Fig. 9 shows the number of publications from different countries for One Stage Object Detection. The highest number of documents were published by China at 85, followed by the United States and South Korea.

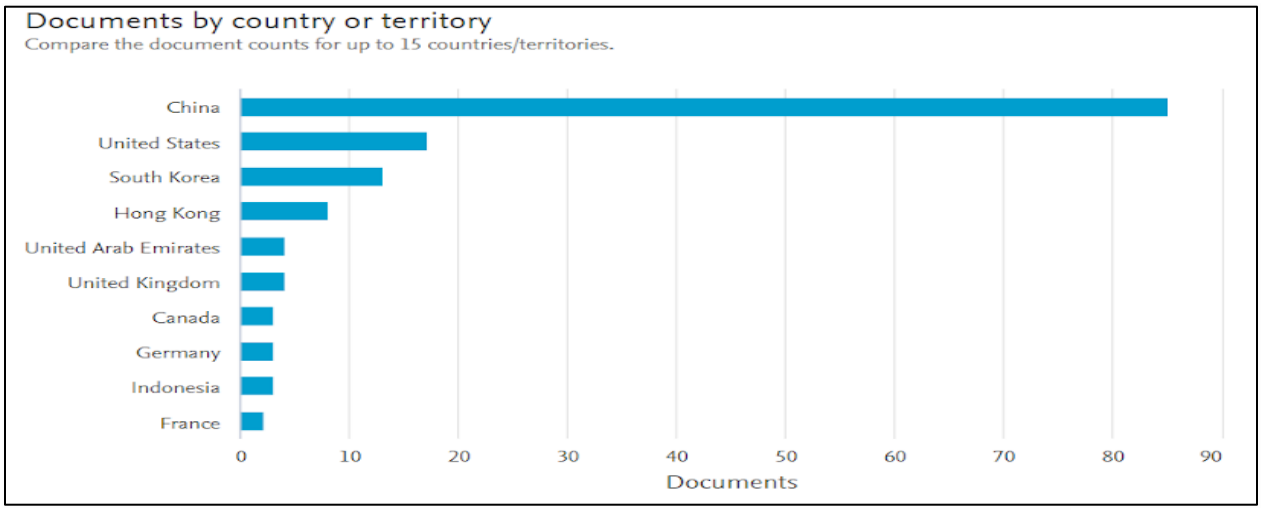


Fig. 9. Country publication count for One Stage Object Detection

(Source: Scopus DB accessed on 25th December 2020)

Fig. 10 shows the number of publications from different countries for Two Stage Object Detection. The highest number of documents were published by China at 60, followed by the United States and South Korea.

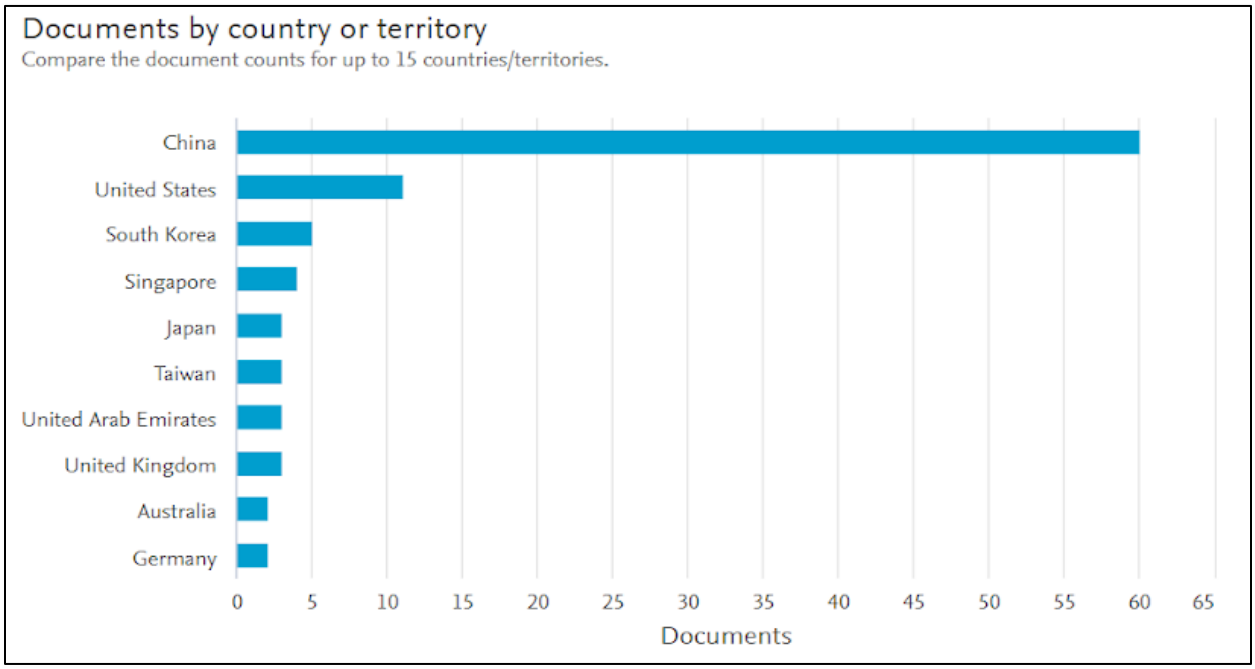


Fig. 10. Affiliation publication count for Two Stage Object Detection

(Source: Scopus DB accessed on 25th December 2020)

3.6 Publication Analysis by Document type

Fig. 11 shows the distribution of different document types published for One Stage Object Detection. Conference Papers contribute the most publications while there is a significantly less number of Book Chapters.

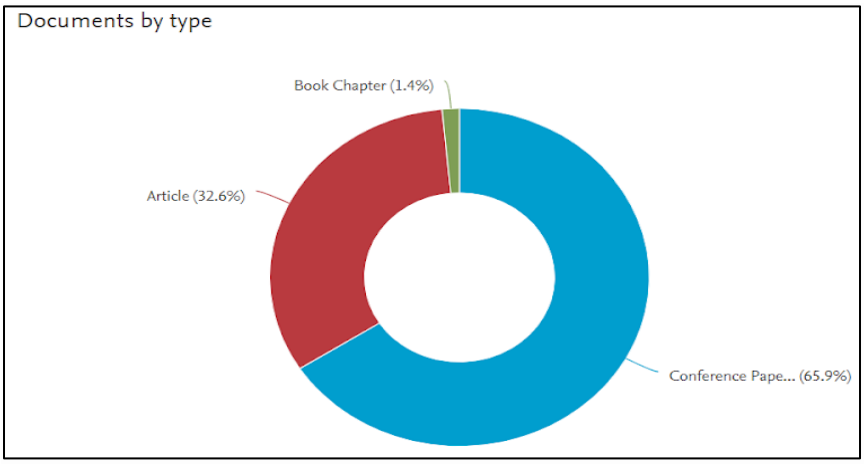


Fig. 11. Document type statistics for One Stage Object Detection

(Source: Scopus DB accessed on 25th December 2020)

Fig. 12 shows the distribution of different document types published for Two Stage Object Detection. Conference Papers contribute the most publications while there is a significantly less number of Book Chapters.

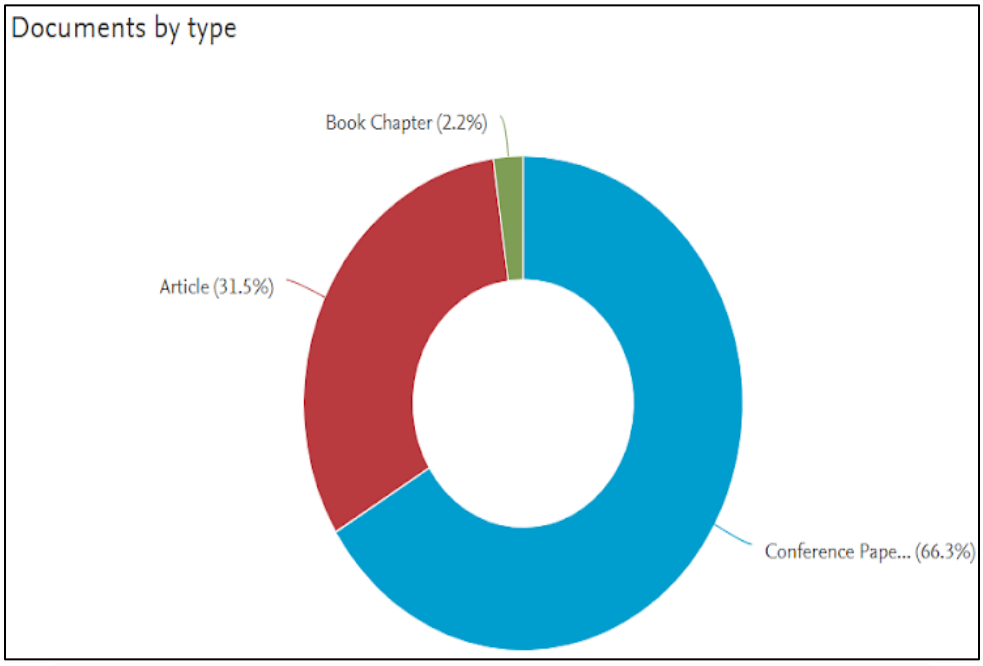


Fig. 12. Document type statistics for Two Stage Object Detection

(Source: Scopus DB accessed on 25th December 2020)

3.7 Publication Analysis by Subject Area

Fig. 13 shows the distribution of publications across various subject areas for One Stage Object Detection. Most publications are in Computer Science, followed closely by Engineering.

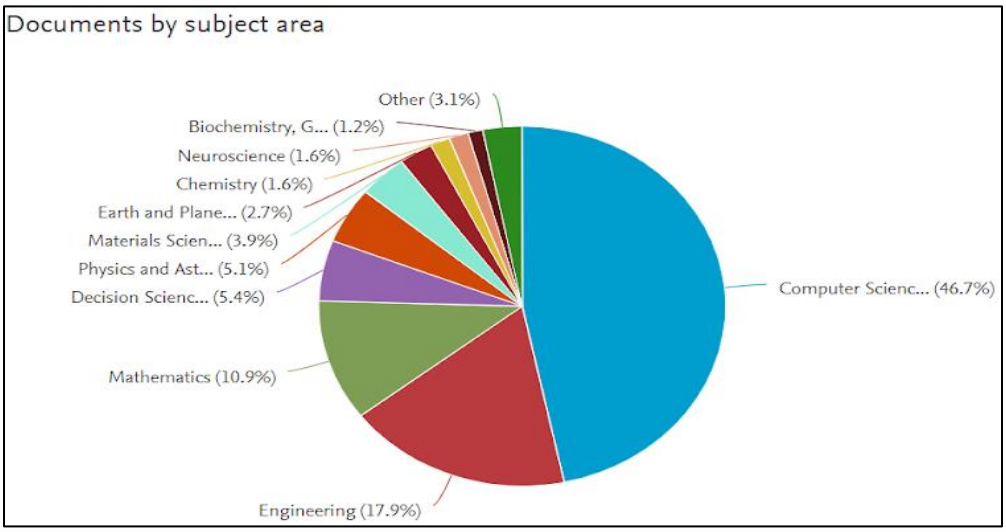


Fig. 13. Subject Area statistics for One Stage Object Detection

(Source: Scopus DB accessed on 25th December 2020)

Fig. 14 shows the distribution of publications across various subject areas for Two Stage Object Detection. Most publications are in Computer Science, followed by Engineering and Mathematics.

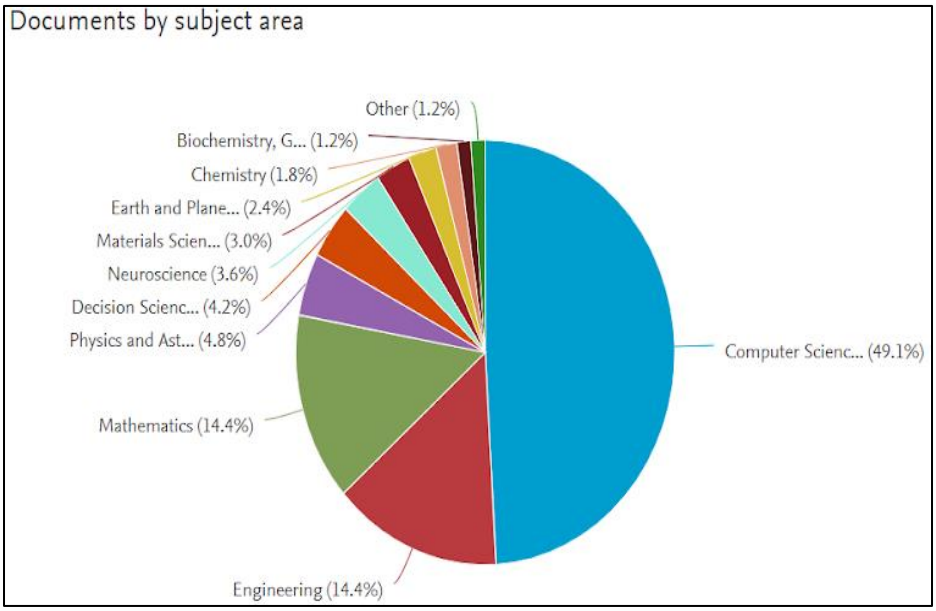


Fig. 14. Subject Area statistics for Two Stage Object Detection

(Source: Scopus DB accessed on 25th December 2020)

3.8 Publication Analysis by Funding Sponsor

Fig. 15 shows the distribution of publications by different Funding Sponsors for One Stage Object Detection. National Natural Science Foundation of China sponsored most publications.

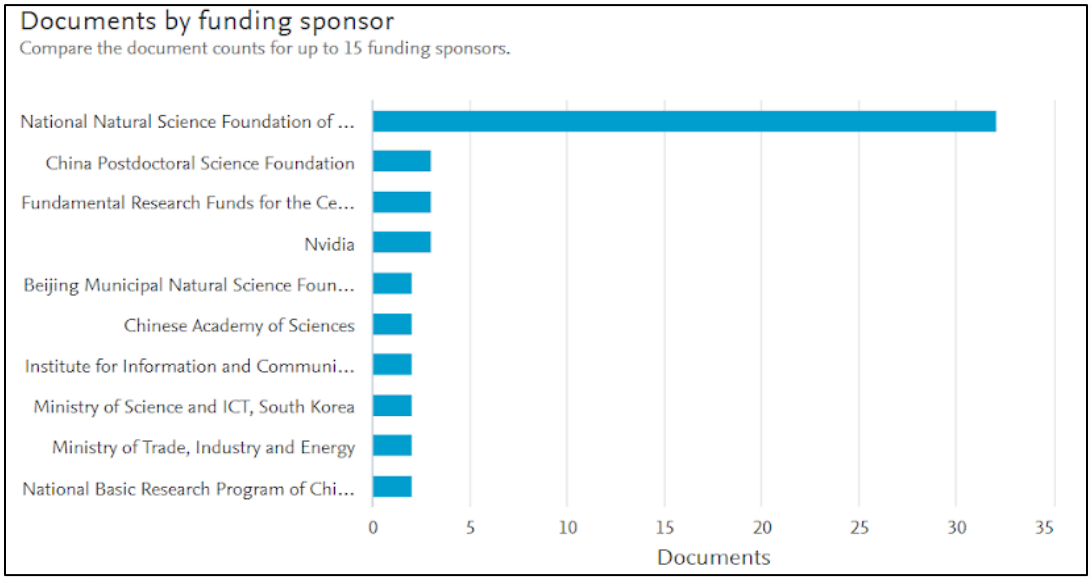


Fig. 15. Funding Sponsor statistics for One Stage Object Detection

(Source: Scopus DB accessed on 25th December 2020)

Fig. 16 shows the distribution of publications by different Funding Sponsors for Two Stage Object Detection. National Natural Science Foundation of China sponsored most publications.

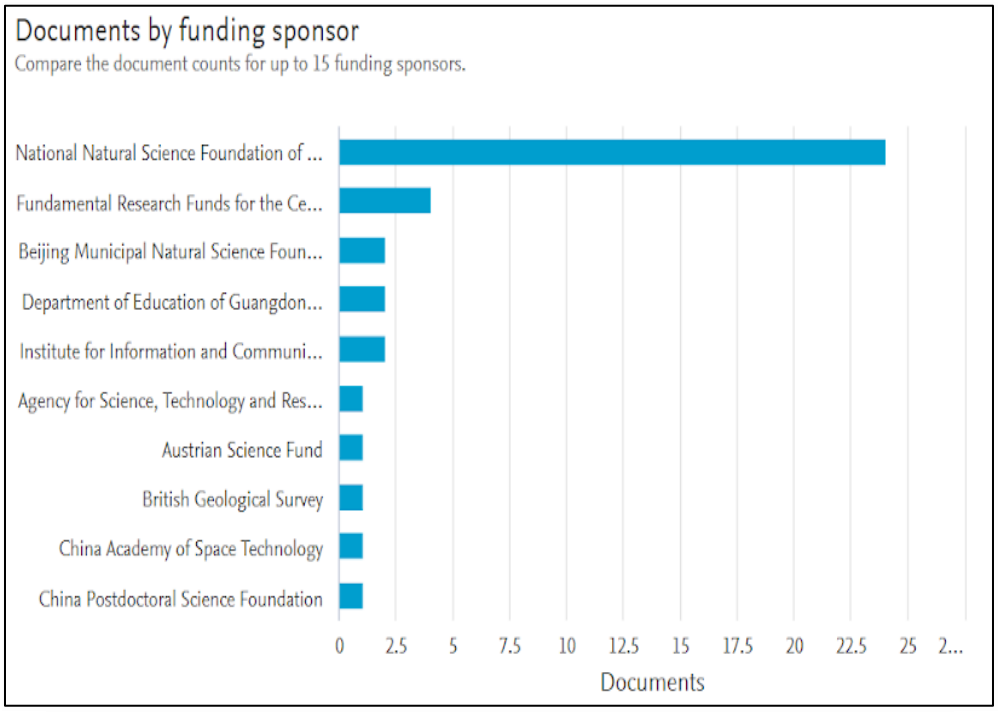


Fig. 16. Funding Sponsor statistics for Two Stage Object Detection

(Source: Scopus DB accessed on 25th December 2020)

3.9 Networked Analysis of Authors and Author Keywords

Fig. 17 depicts a networked diagram emphasizing authors and their keywords co-appearance in the same papers for One Stage Object Detection. The graph is useful to find out information about the same authors among different papers. Xie h., Li X., Li C., Gao Y., Zheng Y. are the co-appearing authors for the given keywords. There are a total of 975 nodes connected by 2511 edges. A total of 60 disconnected nodes were removed.

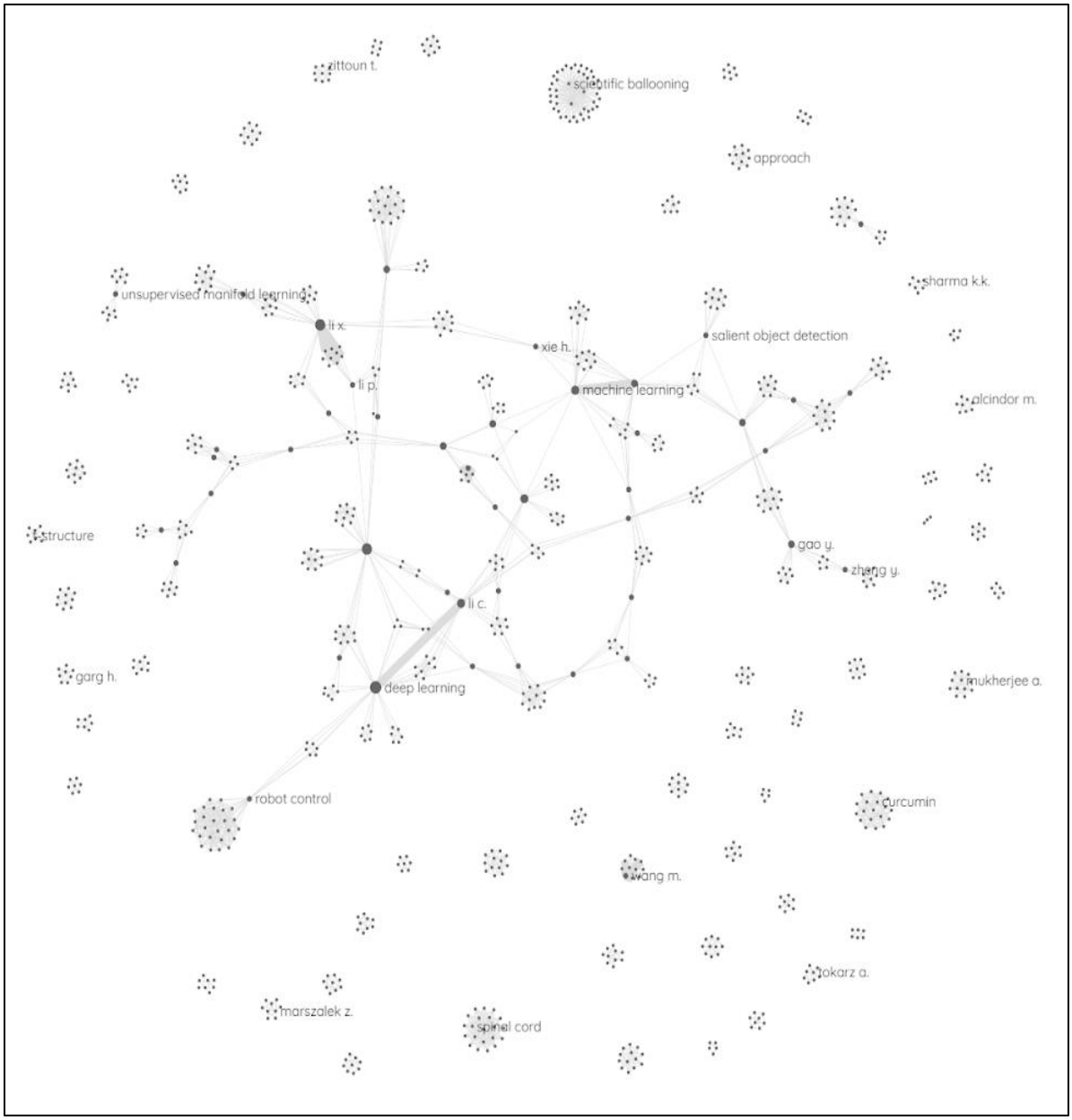


Fig. 17. Authors and Author Keywords co-appearance for One Stage Object Detection

(Source: Scopus DB accessed on 25th December 2020)

Fig. 18 depicts a networked diagram emphasizing authors and their keywords co-appearance in the same papers for Two Stage Object Detection. The graph is useful to find out information about the same authors among different papers. There are a total of 646 nodes connected by 1726 edges. A total of 60 disconnected nodes were removed.

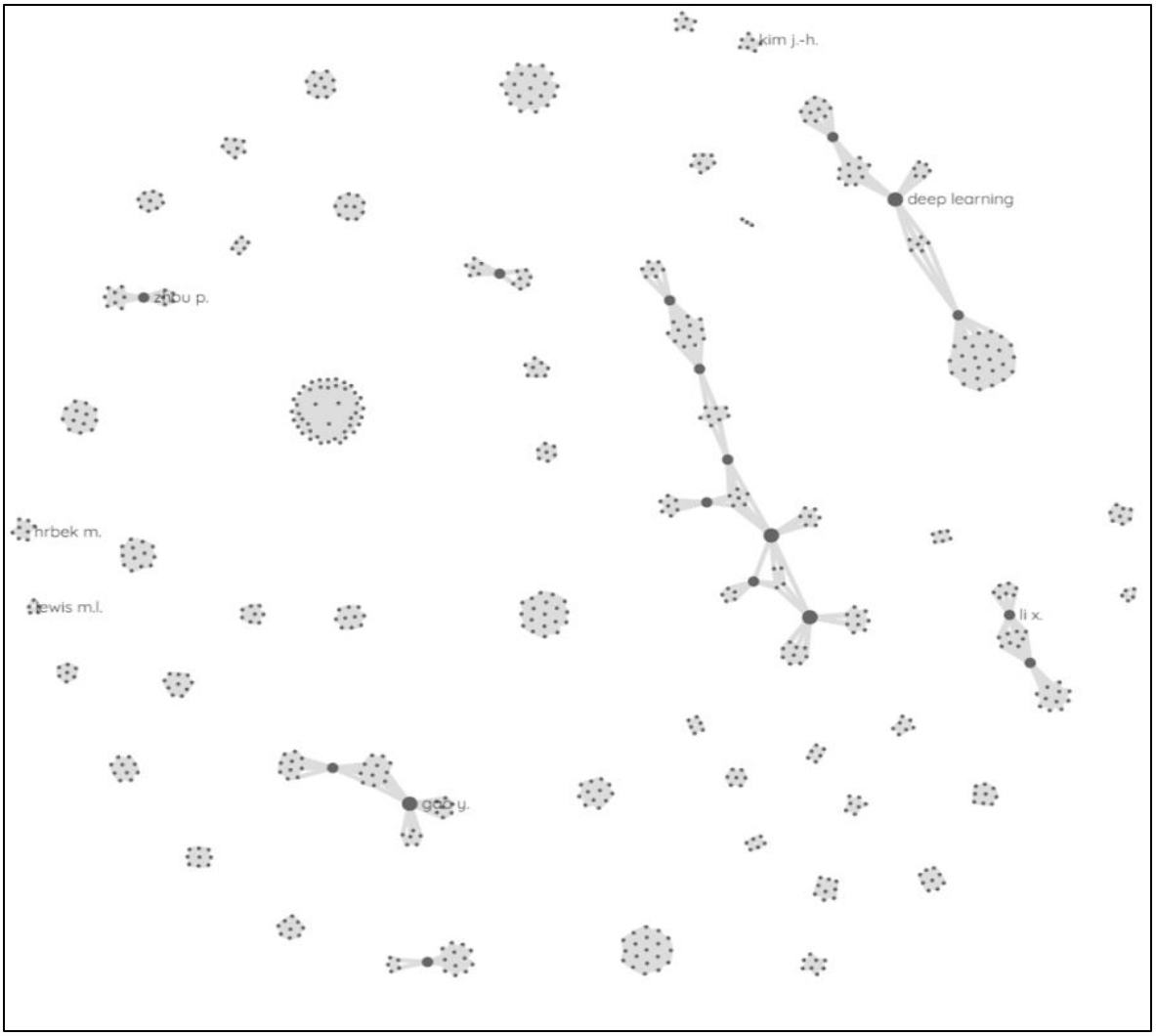


Fig. 18. Authors and Author Keywords co-appearance for Two Stage Object Detection

(Source: Scopus DB accessed on 25th December 2020)

3.10 Networked Analysis of Author and Source titles

Fig. 19 depicts a networked diagram emphasizing authors and source titles co-appearance in the same papers for One Stage Object Detection. It can be inferred that pattern recognition, current opinion in psychology, machine vision and applications, the Journal of pure and applied algebra, and the Journal of alloys and compounds are the prominent source titles.

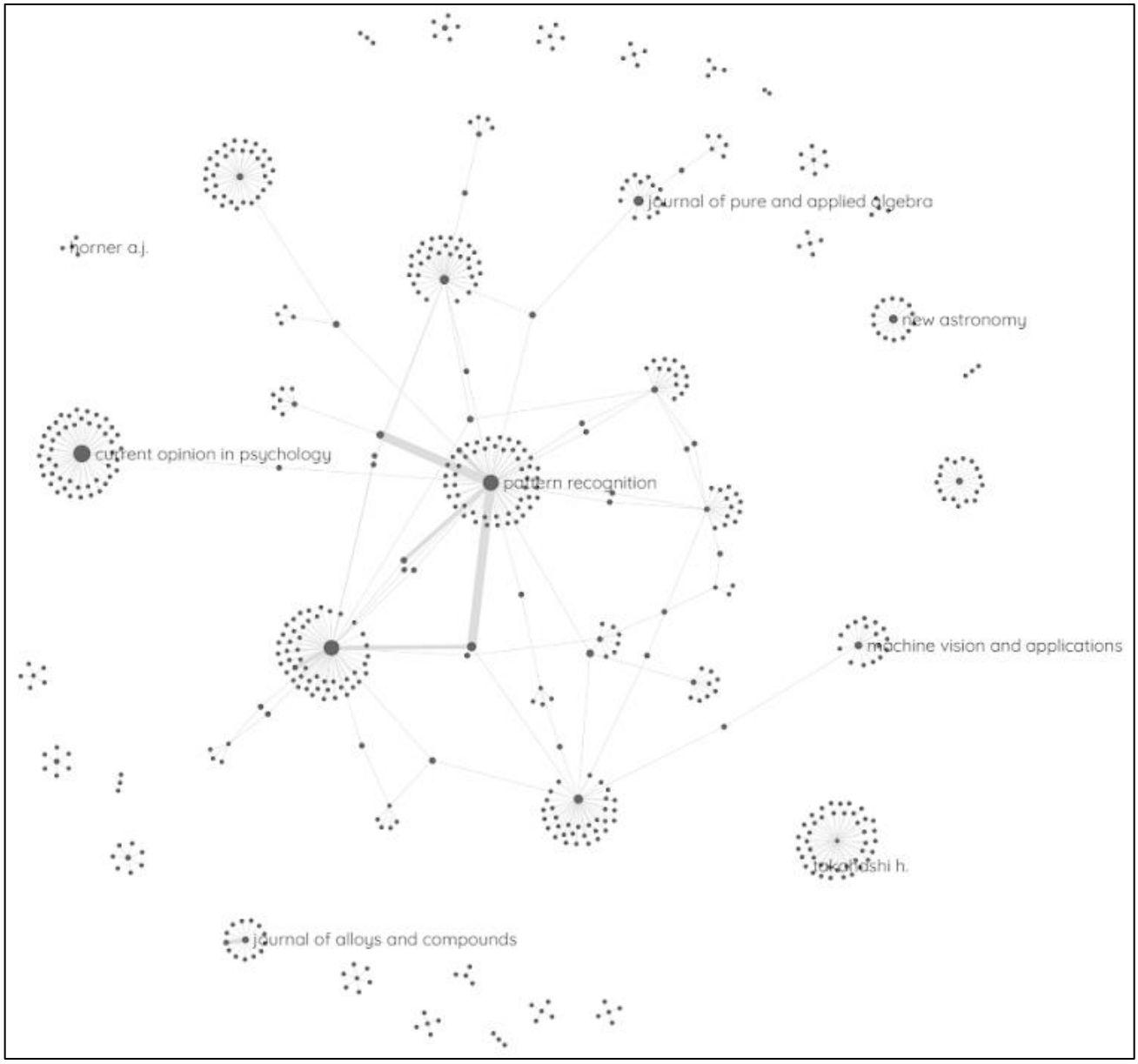


Fig. 19. Authors and Source Titles co-appearance for One Stage Object Detection

(Source: Scopus DB accessed on 25th December 2020)

Fig. 20 depicts a networked diagram emphasizing authors and source titles co-appearance in the same papers for Two Stage Object Detection. It can be inferred that neural regeneration research, current opinion in psychology, optics, and lasers in engineering, journal of pure and applied algebra, pattern recognition, expert systems with applications are the prominent source titles.

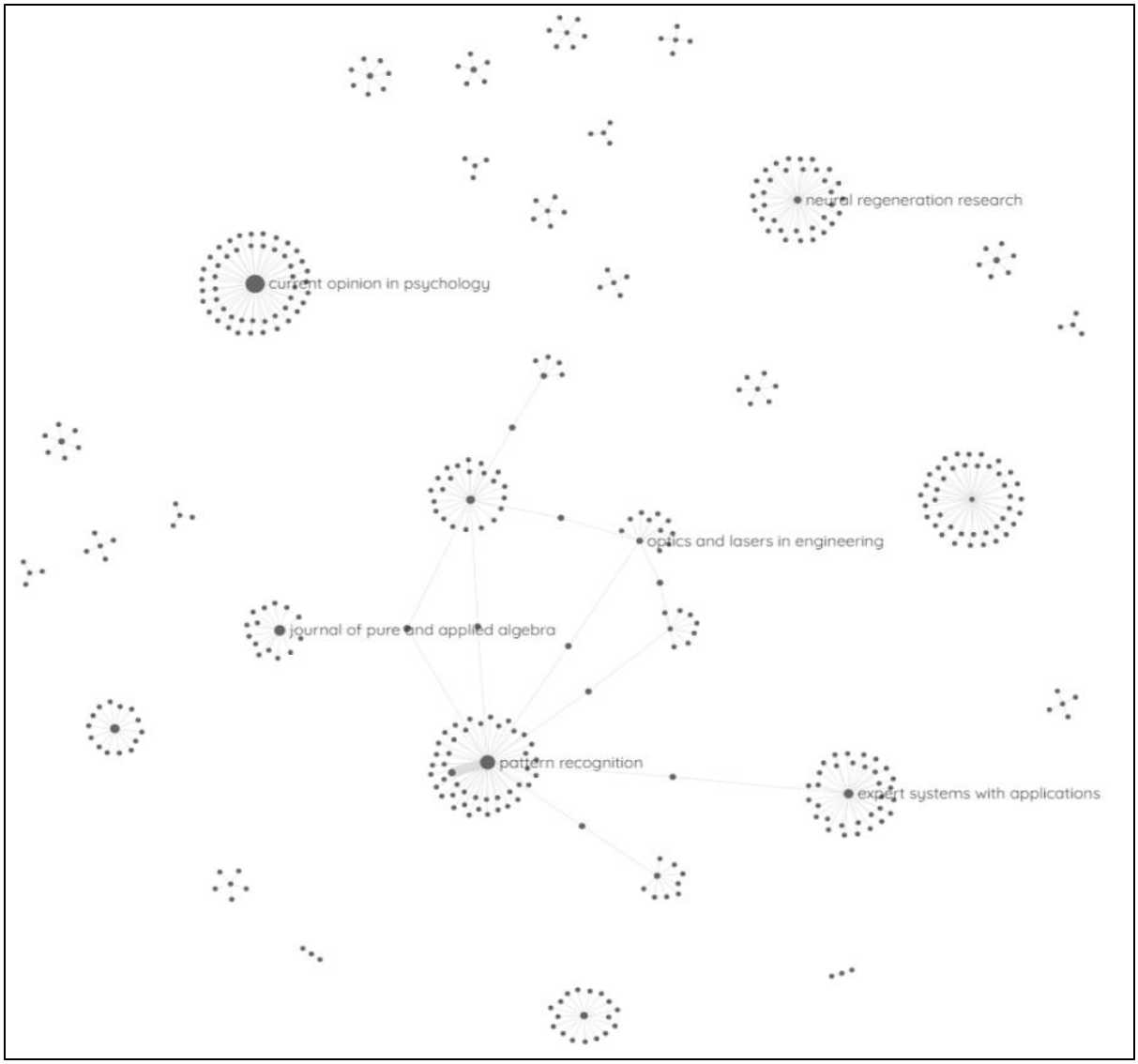


Fig. 20. Authors and Source Titles co-appearance for Two Stage Object Detection

(Source: Scopus DB accessed on 25th December 2020)

3.11 Networked Analysis of Source titles and Author keywords

Fig. 21 depicts a networked diagram emphasizing authors keywords and source titles co-appearance in the same papers for One Stage Object Detection. The diagram clarifies the relationship between the keywords used by authors and journal titles.

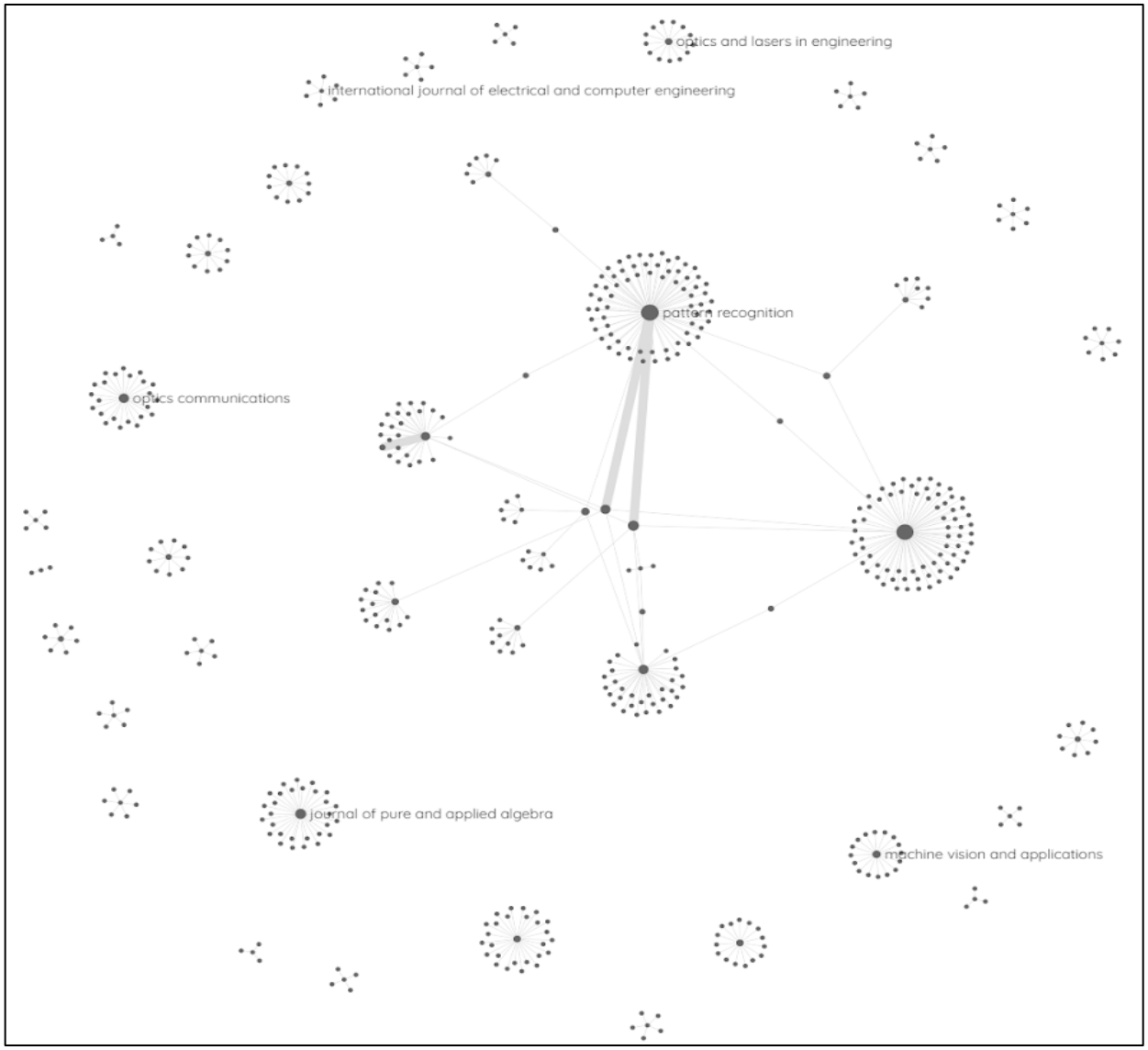


Fig. 21. Author Keywords and Source Titles co-appearance for One Stage Object Detection (Source: Scopus DB accessed on 25th December 2020)

Fig. 22 depicts a networked diagram emphasizing authors keywords and source titles co-appearance in the same papers for Two Stage Object Detection. The diagram clarifies the relationship between the keywords used by authors and journal titles.

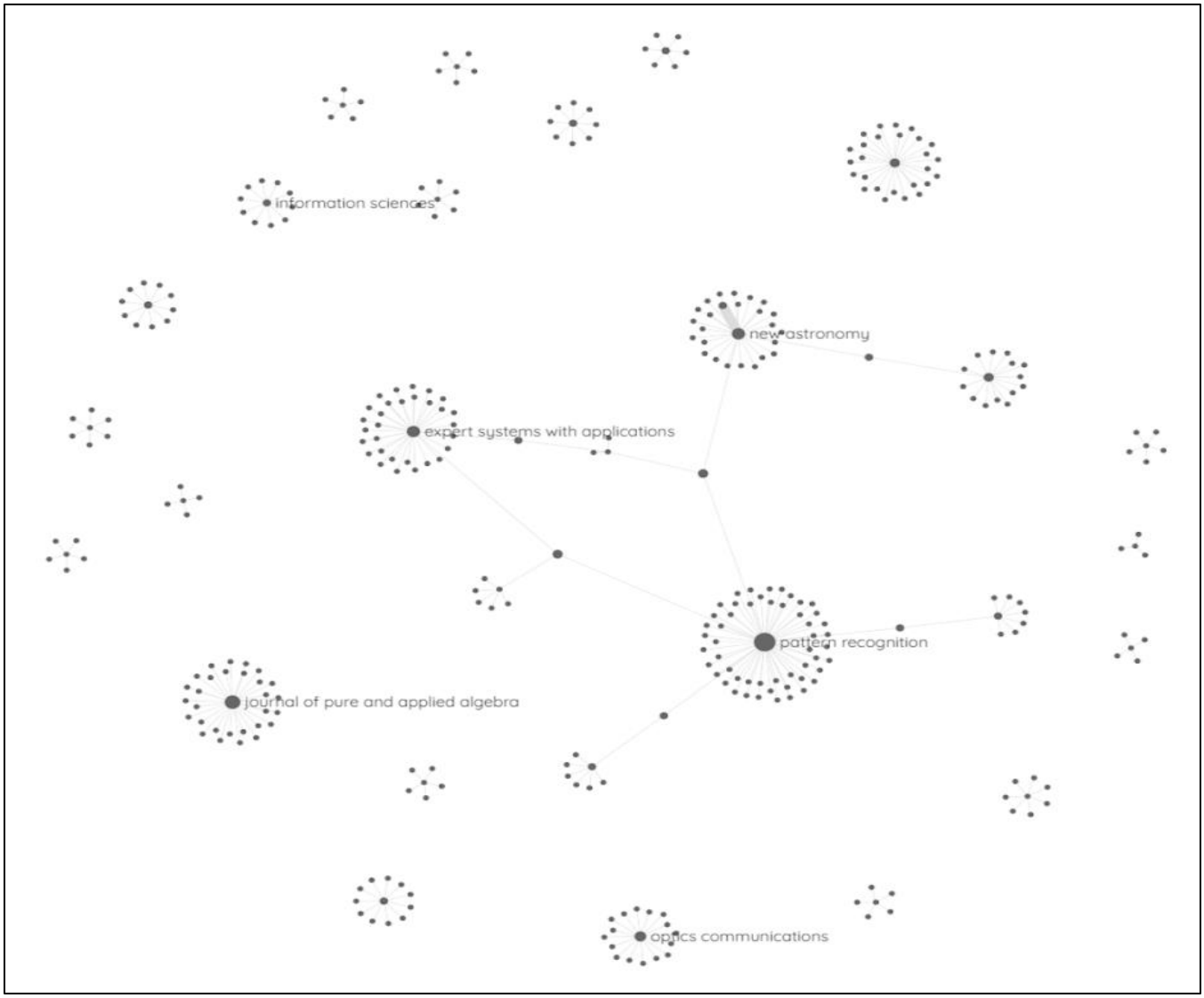


Fig. 22. Author Keywords and Source Titles co-appearance for Two Stage Object Detection (Source: Scopus DB accessed on 25th December 2020)

3.12 Networked Analysis of Authors linked by co-publication

Fig. 23 shows light on authors linked through their co-publication for One Stage Object Detection. There are many small clusters depicting the same; however, it can be observed that the prominent authors linked through their co-publications are Zhang Y., Li X., Wang H. This networked diagram is the next level information related to authors through their collaborative research.

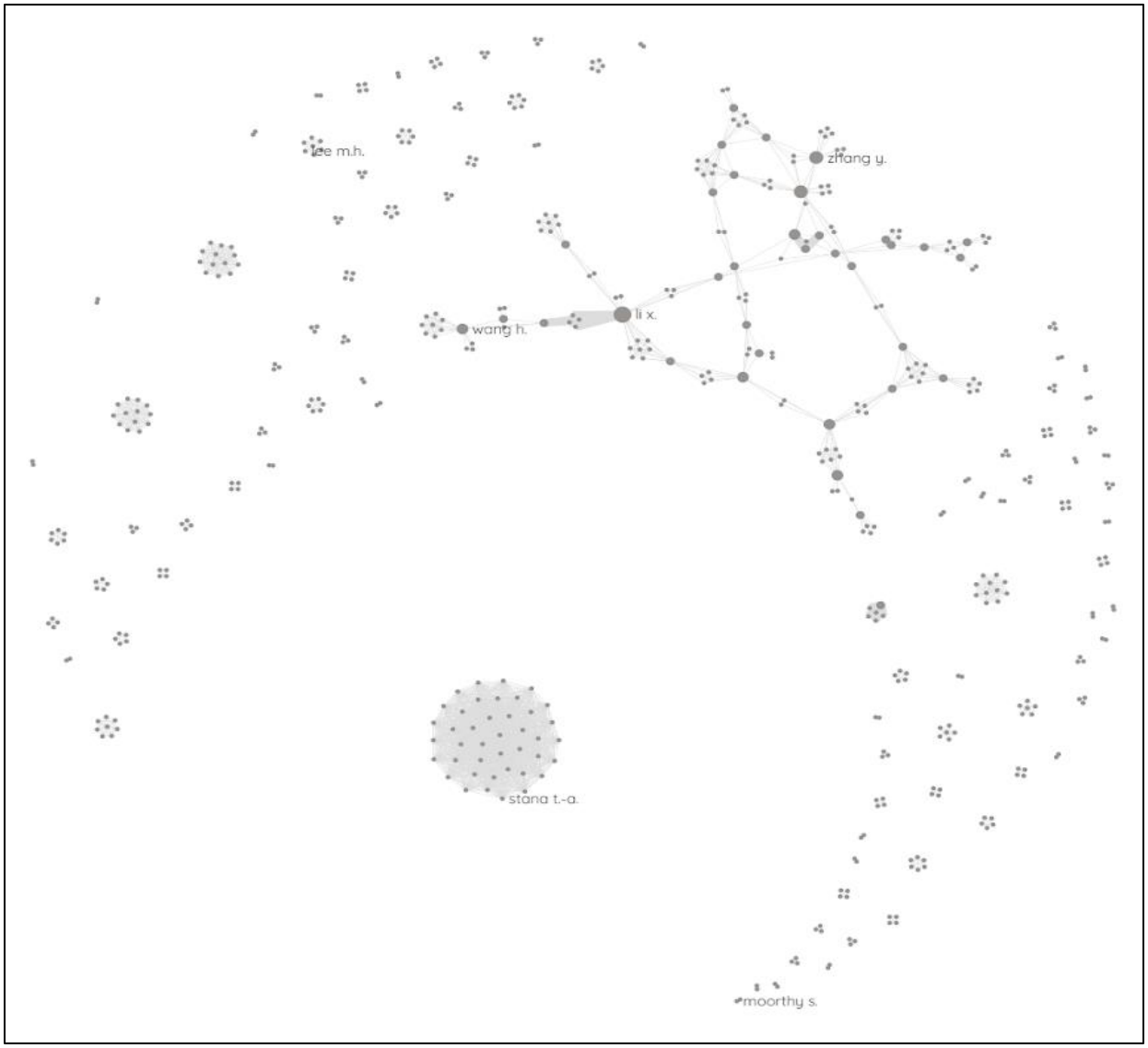


Fig. 23. Authors linked by co-publication for One Stage Object Detection

(Source: Scopus DB accessed on 25th December 2020)

Fig. 24 shows light on authors linked through their co-publication for Two Stage Object Detection. There are 20-22 clusters depicting the same. From this networked diagram, author names are visible who did co-publications.

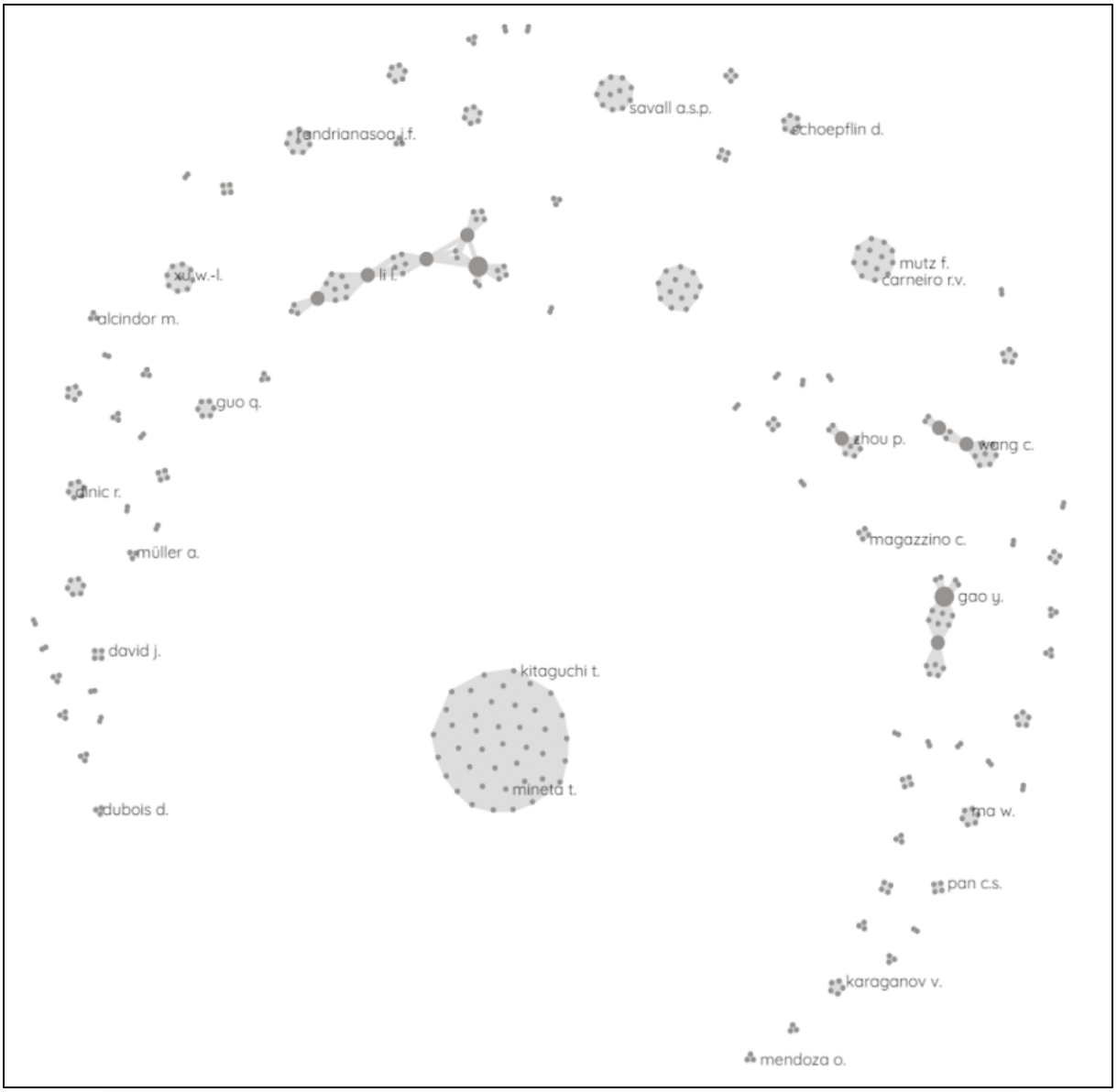


Fig. 24. Authors linked by co-publication for Two Stage Object Detection

(Source: Scopus DB accessed on 25th December 2020)

3.13 Networked Analysis of Authors keywords appearing in same papers

Fig. 25 depicts author keywords appearing in the same papers for One Stage Object Detection. This network diagram gives a summary of the principal author keywords that appear in the same paper.

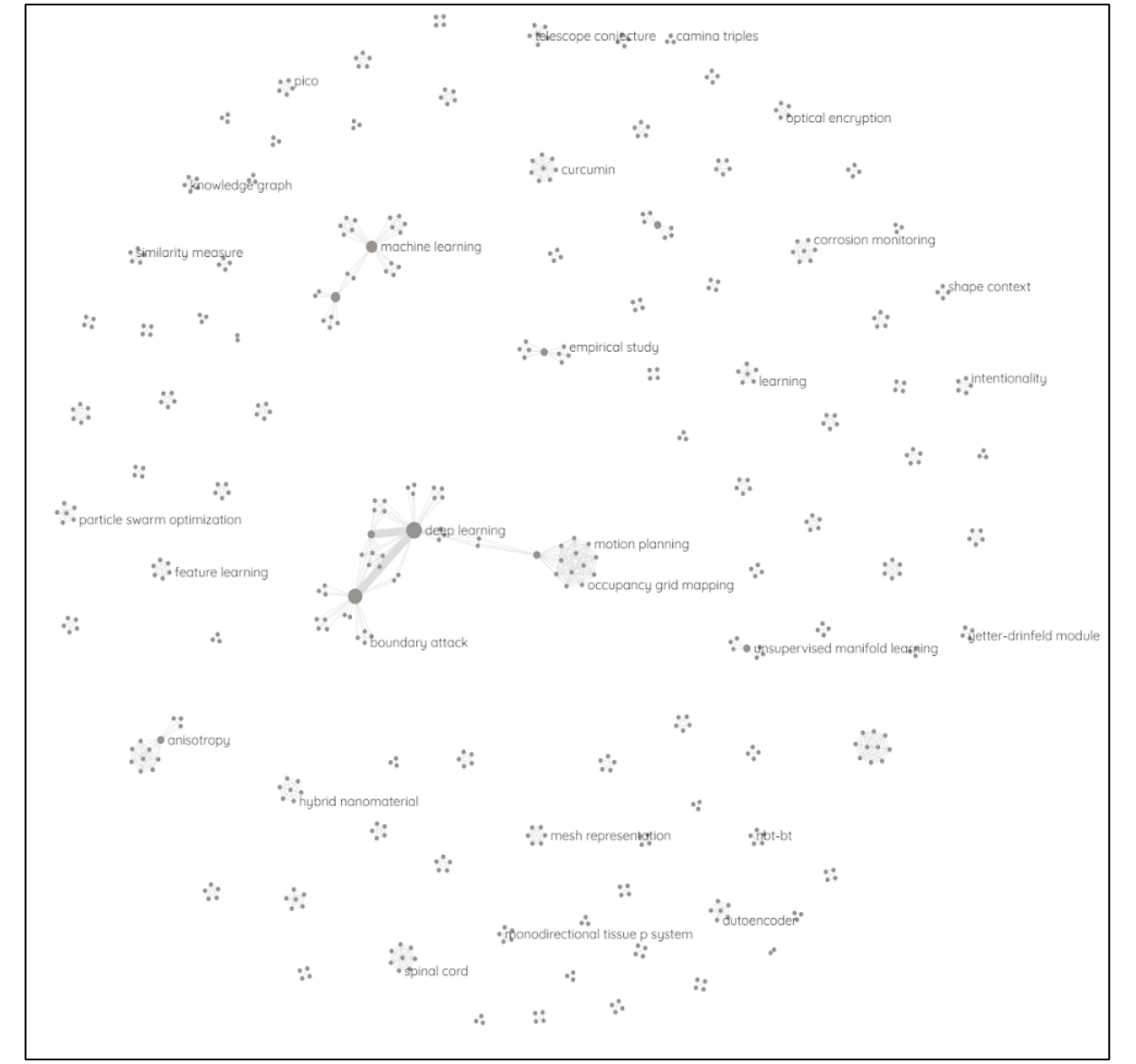


Fig. 25. Author keywords appearing in same paper for One Stage Object Detection

(Source: Scopus DB accessed on 25th December 2020)

Fig. 26 depicts author keywords appearing in the same papers for Two Stage Object Detection. Unsupervised machine learning, machine learning, deep learning, neurons, robot control, self-driving cars, pattern recognition are some of the significant keywords appearing in the same paper.

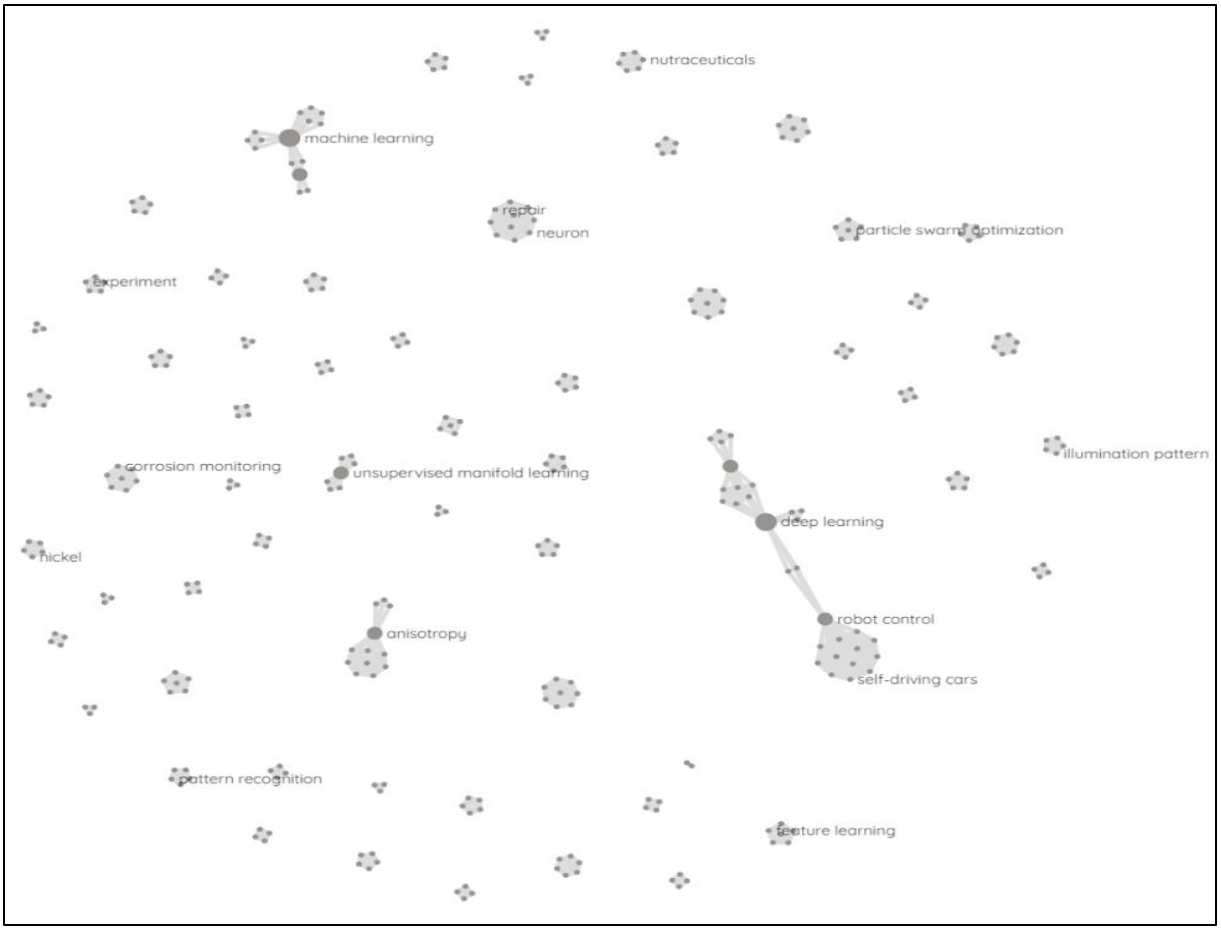


Fig. 26. Author keywords appearing in same paper for Two Stage Object Detection

(Source: Scopus DB accessed on 25th December 2020)

3.14 Reference Scape

Reference scape shown in Fig. 27 and Fig. 28 highlights some of the crucial references. References are spatialized independently to the rest of the network. Exactly as if we spatialized the references alone, then fixed them, then spatialized the rest of the nodes - except we do it simultaneously. We use a modified version of ForceAtlas2 to do so.

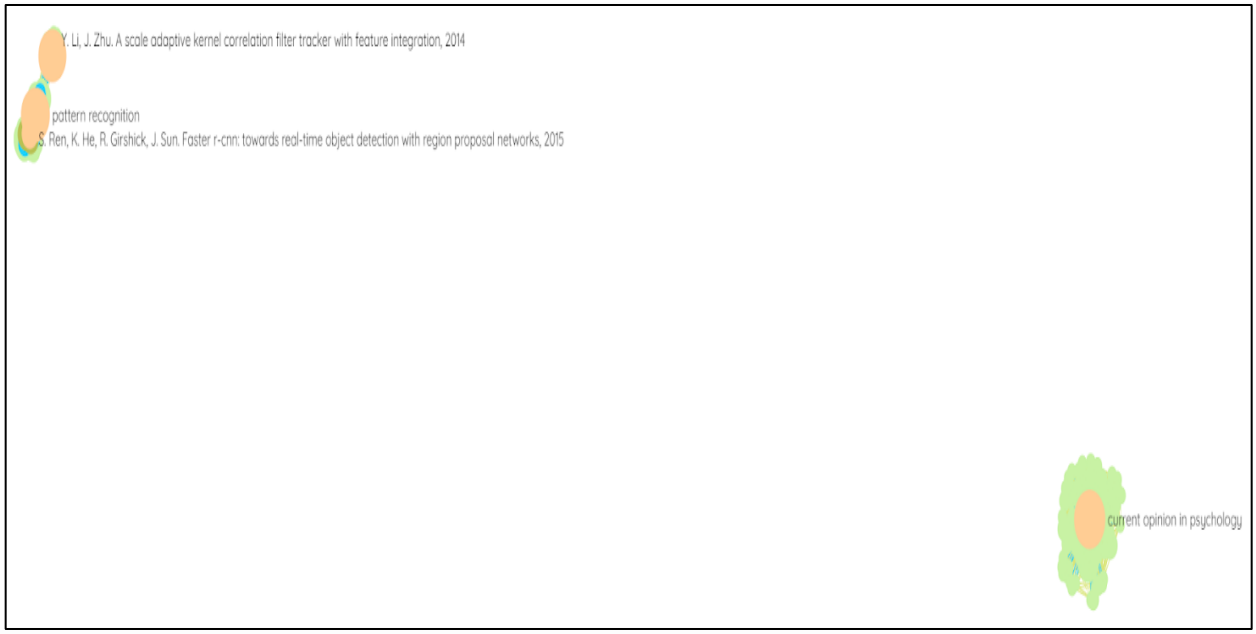


Fig. 27. Reference Scape for One Stage Object Detection

(Source: Scopus DB accessed on 25th December 2020)

Fig. 28. Reference Scape for Two Stage Object Detection

(Source: Scopus DB accessed on 25th December 2020)

3.15 Linked Tri-information viz. Main authors, main keywords, and main journals

Fig. 29, 30, and 31 for One Stage Object Detection are related to each other, and Fig. 32, 33, and 34 for Two Stage Object Detection are associated with each other. They show linked tri-information viz. main authors, main keywords, and main journals. These figures are, in a way consolidation of preliminary data and subsequent information discussed in networked diagrams. Fig. 29 and Fig. 32 are Sankey graphs of the main authors, main keywords, and main journals. Fig.

30 and Fig. 33 show the same in tabular format. Fig. 31 and Fig. 34 show journals in line for publications in 2021 and 2022.

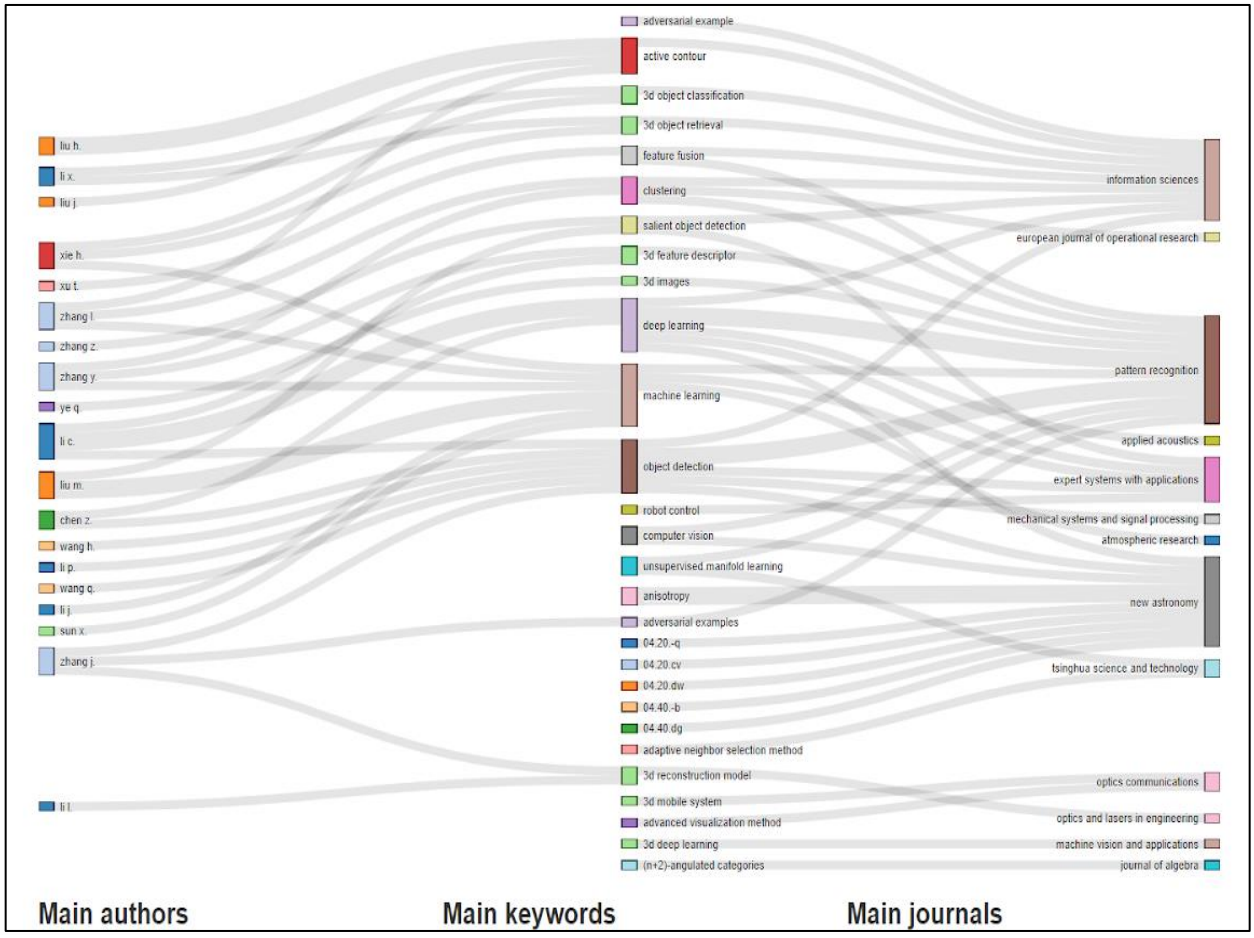
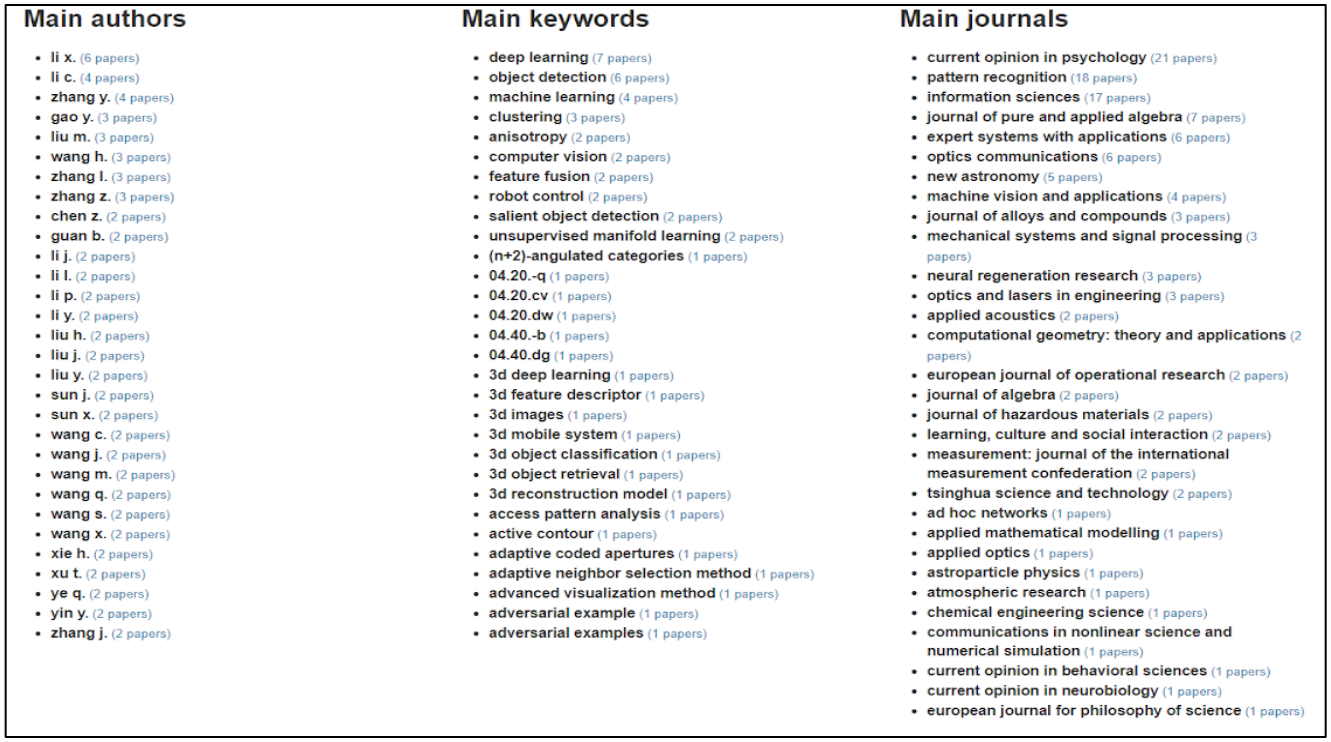


Fig. 29. Sankey Graph for One Stage Object Detection

(**Source: Scopus DB accessed on 25th December 2020**)



Main authors

- li x. (6 papers)
- li c. (4 papers)
- zhang y. (4 papers)
- gao y. (3 papers)
- liu m. (3 papers)
- wang h. (3 papers)
- zhang l. (3 papers)
- zhang z. (3 papers)
- chen z. (2 papers)
- guan b. (2 papers)
- li j. (2 papers)
- li l. (2 papers)
- li p. (2 papers)
- li y. (2 papers)
- liu h. (2 papers)
- liu j. (2 papers)
- liu y. (2 papers)
- sun j. (2 papers)
- sun x. (2 papers)
- wang c. (2 papers)
- wang j. (2 papers)
- wang m. (2 papers)
- wang q. (2 papers)
- wang s. (2 papers)
- wang x. (2 papers)
- xie h. (2 papers)
- xu t. (2 papers)
- ye q. (2 papers)
- yin y. (2 papers)
- zhang j. (2 papers)

Main keywords

- deep learning (7 papers)
- object detection (6 papers)
- machine learning (4 papers)
- clustering (3 papers)
- anisotropy (2 papers)
- computer vision (2 papers)
- feature fusion (2 papers)
- robot control (2 papers)
- salient object detection (2 papers)
- unsupervised manifold learning (2 papers)
- (n+2)-angulated categories (1 papers)
- 04.20.-q (1 papers)
- 04.20.cv (1 papers)
- 04.20.dw (1 papers)
- 04.40.-b (1 papers)
- 04.40.dg (1 papers)
- 3d deep learning (1 papers)
- 3d feature descriptor (1 papers)
- 3d images (1 papers)
- 3d mobile system (1 papers)
- 3d object classification (1 papers)
- 3d object retrieval (1 papers)
- 3d reconstruction model (1 papers)
- access pattern analysis (1 papers)
- active contour (1 papers)
- adaptive coded apertures (1 papers)
- adaptive neighbor selection method (1 papers)
- advanced visualization method (1 papers)
- adversarial example (1 papers)
- adversarial examples (1 papers)

Main journals

- current opinion in psychology (21 papers)
- pattern recognition (18 papers)
- information sciences (17 papers)
- journal of pure and applied algebra (7 papers)
- expert systems with applications (6 papers)
- optics communications (6 papers)
- new astronomy (5 papers)
- machine vision and applications (4 papers)
- journal of alloys and compounds (3 papers)
- mechanical systems and signal processing (3 papers)
- neural regeneration research (3 papers)
- optics and lasers in engineering (3 papers)
- applied acoustics (2 papers)
- computational geometry: theory and applications (2 papers)
- european journal of operational research (2 papers)
- journal of algebra (2 papers)
- journal of hazardous materials (2 papers)
- learning, culture and social interaction (2 papers)
- measurement: journal of the international measurement confederation (2 papers)
- tsinghua science and technology (2 papers)
- ad hoc networks (1 papers)
- applied mathematical modelling (1 papers)
- applied optics (1 papers)
- astroparticle physics (1 papers)
- atmospheric research (1 papers)
- chemical engineering science (1 papers)
- communications in nonlinear science and numerical simulation (1 papers)
- current opinion in behavioral sciences (1 papers)
- current opinion in neurobiology (1 papers)
- european journal for philosophy of science (1 papers)

Fig. 30. Tabular Information of Sankey Graph for One Stage Object Detection

(Source: Scopus DB accessed on 25th December 2020)

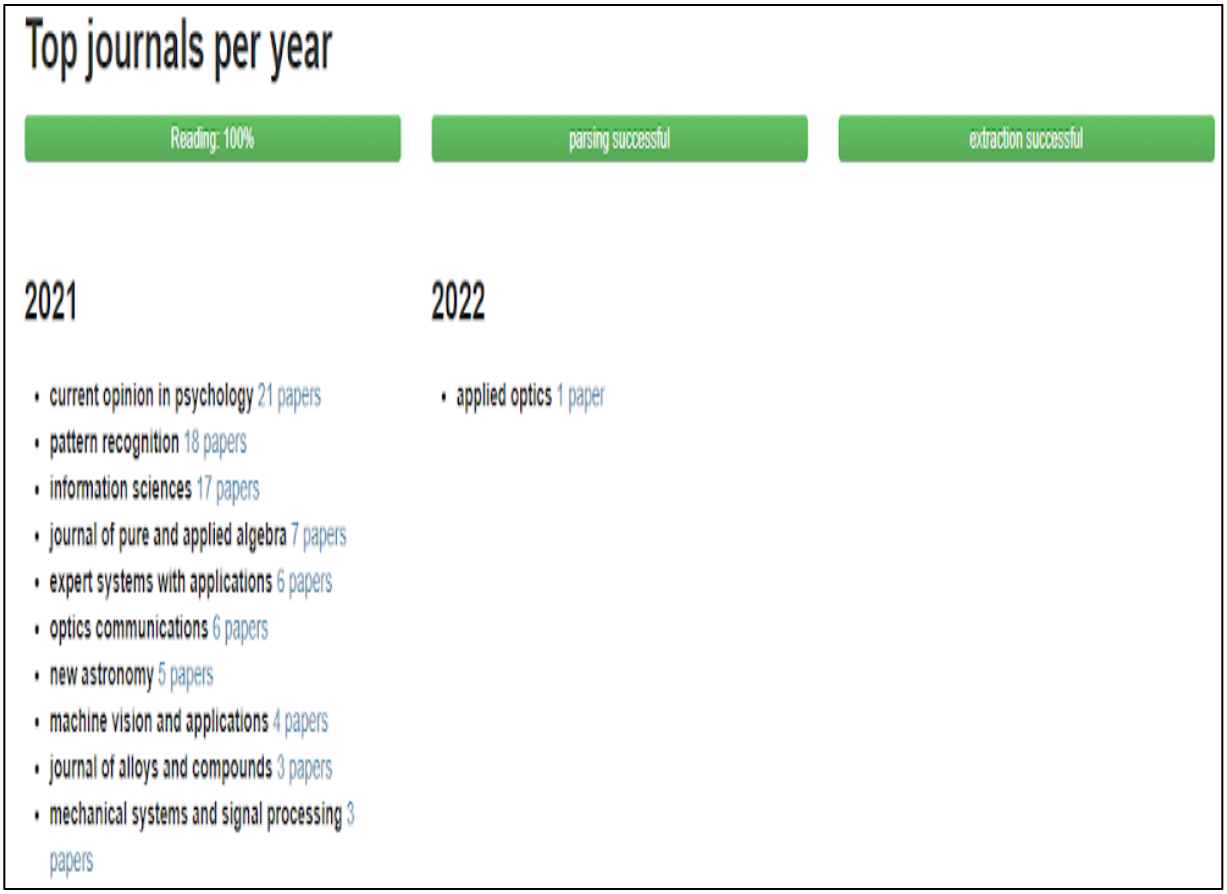


Fig. 31. Journals in line for One Stage Object Detection

(Source: Scopus DB accessed on 25th December 2020)

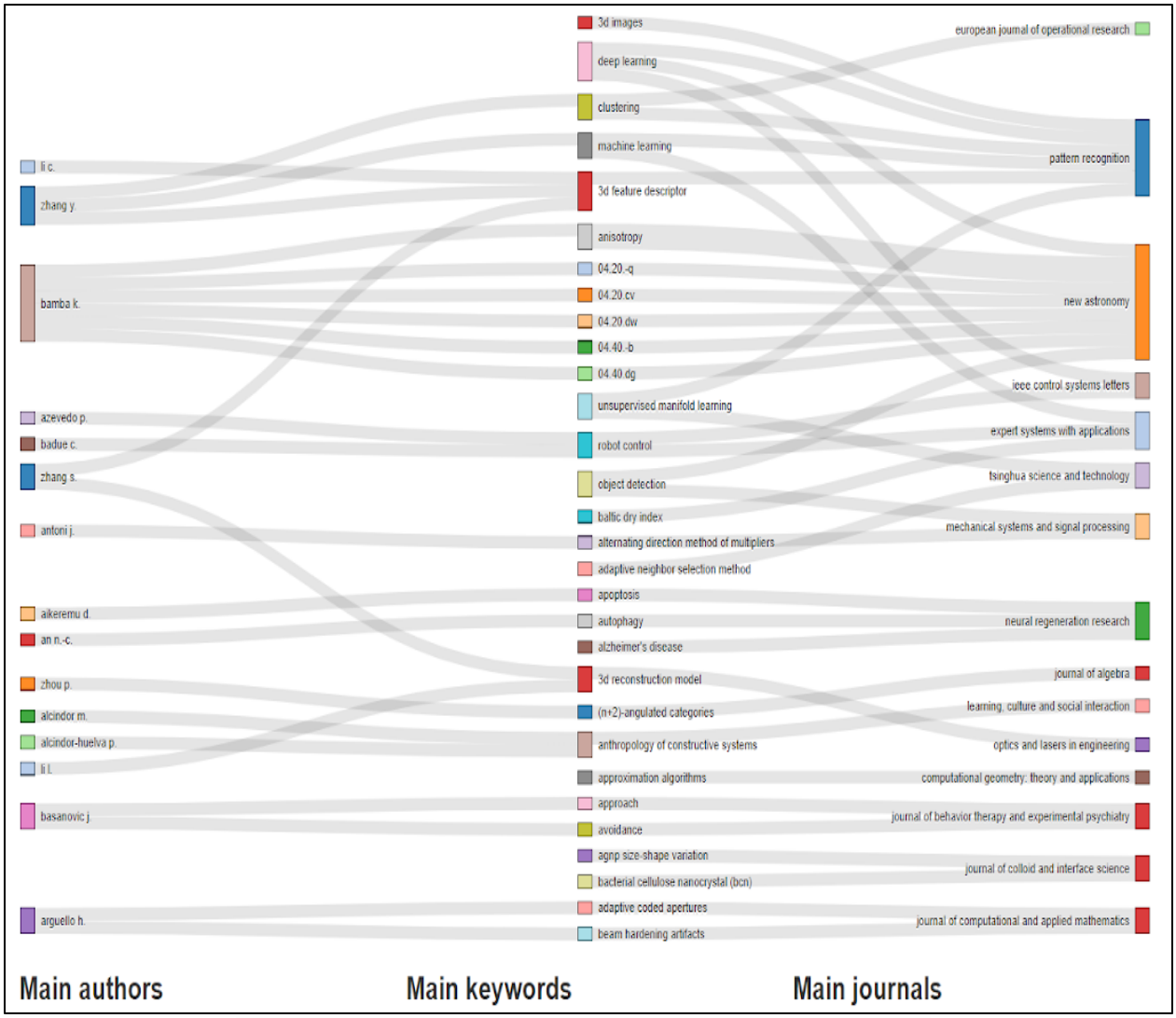
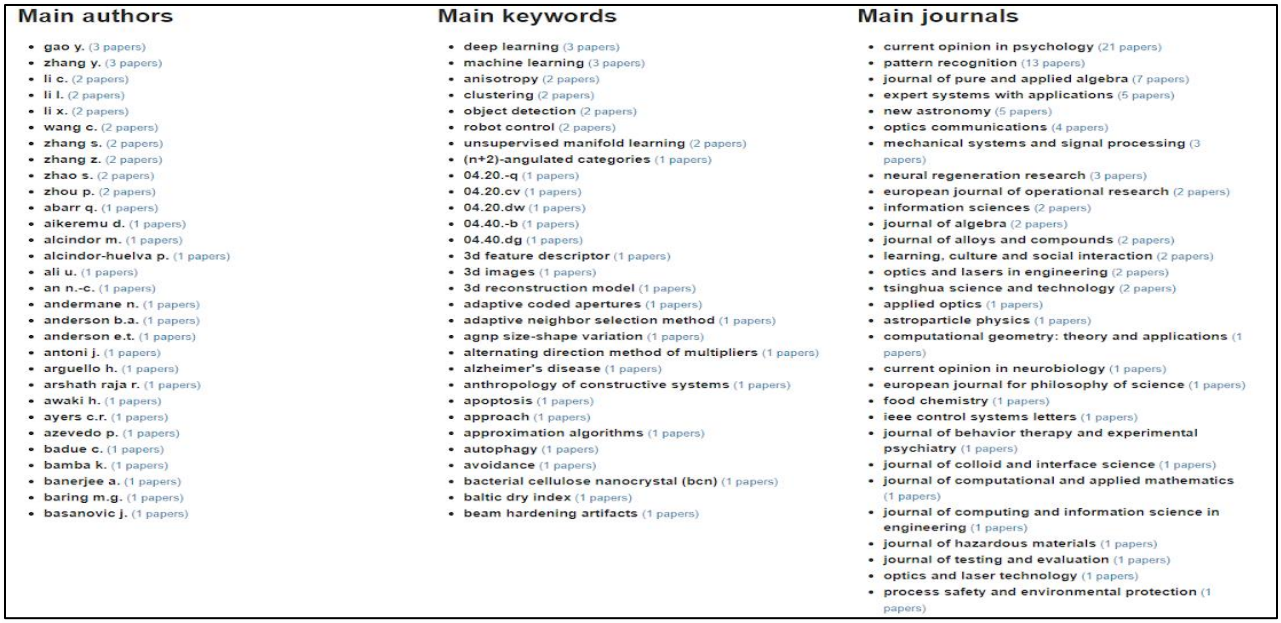


Fig. 32. Sankey Graph for Two Stage Object Detection

(Source: Scopus DB accessed on 25th December 2020)



Main authors

- gao y. (3 papers)
- zhang y. (3 papers)
- li c. (2 papers)
- li l. (2 papers)
- li x. (2 papers)
- wang c. (2 papers)
- zhang s. (2 papers)
- zhang z. (2 papers)
- zhao s. (2 papers)
- zhou p. (2 papers)
- abarr q. (1 papers)
- aikeremu d. (1 papers)
- alcindor m. (1 papers)
- alcindor-huelva p. (1 papers)
- ali u. (1 papers)
- an n.-c. (1 papers)
- andermane n. (1 papers)
- anderson b.a. (1 papers)
- anderson e.t. (1 papers)
- antoni j. (1 papers)
- arguello h. (1 papers)
- arshath raja r. (1 papers)
- awaki h. (1 papers)
- ayers c.r. (1 papers)
- azevedo p. (1 papers)
- badue c. (1 papers)
- bamba k. (1 papers)
- banerjee a. (1 papers)
- baring m.g. (1 papers)
- basanovic j. (1 papers)

Main keywords

- deep learning (3 papers)
- machine learning (3 papers)
- anisotropy (2 papers)
- clustering (2 papers)
- object detection (2 papers)
- robot control (2 papers)
- unsupervised manifold learning (2 papers)
- (n+2)-angulated categories (1 papers)
- 04.20.-q (1 papers)
- 04.20.cv (1 papers)
- 04.20.dw (1 papers)
- 04.40.-b (1 papers)
- 04.40.dg (1 papers)
- 3d feature descriptor (1 papers)
- 3d images (1 papers)
- 3d reconstruction model (1 papers)
- adaptive coded apertures (1 papers)
- adaptive neighbor selection method (1 papers)
- agnp size-shape variation (1 papers)
- alternating direction method of multipliers (1 papers)
- alzheimer's disease (1 papers)
- anthropology of constructive systems (1 papers)
- apoptosis (1 papers)
- approach (1 papers)
- approximation algorithms (1 papers)
- autophagy (1 papers)
- avoidance (1 papers)
- bacterial cellulose nanocrystal (bcn) (1 papers)
- baltic dry index (1 papers)
- beam hardening artifacts (1 papers)

Main journals

- current opinion in psychology (21 papers)
- pattern recognition (13 papers)
- journal of pure and applied algebra (7 papers)
- expert systems with applications (5 papers)
- new astronomy (5 papers)
- optics communications (4 papers)
- mechanical systems and signal processing (3 papers)
- neural regeneration research (3 papers)
- european journal of operational research (2 papers)
- information sciences (2 papers)
- journal of algebra (2 papers)
- journal of alloys and compounds (2 papers)
- learning, culture and social interaction (2 papers)
- optics and lasers in engineering (2 papers)
- tsinghua science and technology (2 papers)
- applied optics (1 papers)
- astroparticle physics (1 papers)
- computational geometry: theory and applications (1 papers)
- current opinion in neurobiology (1 papers)
- european journal for philosophy of science (1 papers)
- food chemistry (1 papers)
- ieee control systems letters (1 papers)
- journal of behavior therapy and experimental psychiatry (1 papers)
- journal of colloid and interface science (1 papers)
- journal of computational and applied mathematics (1 papers)
- journal of computing and information science in engineering (1 papers)
- journal of hazardous materials (1 papers)
- journal of testing and evaluation (1 papers)
- optics and laser technology (1 papers)
- process safety and environmental protection (1 papers)

Fig. 33. Tabular Information of Sankey Graph for Two Stage Object Detection

(Source: Scopus DB accessed on 25th December 2020)

Fig. 34. Journals in line for Two Stage Object Detection

(Source: Scopus DB accessed on 25th December 2020)

Conclusion

From the bibliometric study it is observed that many researches are working in the field of object detection using deep learning for different subject domains. The earlier information presented using bibliometric graphs depicts that many journals are publishing their work in this research domain. In today's world, visual information is widely spread out across the world so it is important to advance the field of object detection for further accurate analysis of visual information. This is one of reasons why object detection is the most valued field of research today. More researchers and universities are expected to contribute towards this research

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