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Removing the noise from X-ray image using Image processing Technology: A Bibliometric Survey and Future Research Directions

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Abstract: The retrieval of superior-quality photographs with a minimal exposure is an interesting subject in radiography. Pre-processing is a key phase in signal and image processing such as healthcare, telecommunications, and satellite, and it focuses on reducing or eliminating the extent of noise in the image. Denoising aids in the recovery of finer data and relevant material. Medical images including ECG, Ultrasound, CT-scan, and X-ray provide incredibly fine data that has to be precise and noise-free in order for the knowledge and aspects of interest to be retained during diagnosis. Various noise reduction technologies for medical images, such as wavelet transform, Neural Network, real-time digital filter, efficiently enhancing image contrast and mean and median filters, are discussed in this article. Even so, quantum noise appears to affect x-ray photos captured with a low dose. One of its techniques for obtaining high-quality photographs with a limited dosage is to reduce noise and efficiently enhance image contrast.

Keywords: Scopus; removing the noise from X-ray, Digital Image processing Technology; Bibliometric; Survey

1. Introduction

Although working with medical images such as MRI, ultrasound, PET, CT, and so on, noise reduction seems to be the most significant pre-processing phase in digital image processing. The Bulk of medical photographs have a low signal-to-noise level. When compared to the original scenes captured with a camera, the original scenes have low spatial resolution and poor contrast, restricting the human eye's ability to recognize and resolve finer points. It is necessary to correctly integrate the useful information from the various images while also controlling changes to ensure that clinical decision-making is error-free. The biggest challenge in medical images is preserving low-level relevant information. This pre-processing step should be done adequately in order to retain the required, relevant, and valuable results. Even during acquisition, reallocate, retrieval, and handling of medical images, noises may also be tried to introduce. Medical images can be distorted by noise as well as interference from nearby equipment, artefact mobility, and sound to digital signal transformation. As a result, eliminating noise from these images has become a crucial task and one of the most important in the field of digital image processing. The methodology used for denoising the image is chosen by the image type and noise model. Denoising technologies are designed to enhance image quality by enhancing the signal to noise ratio and protecting finer details.

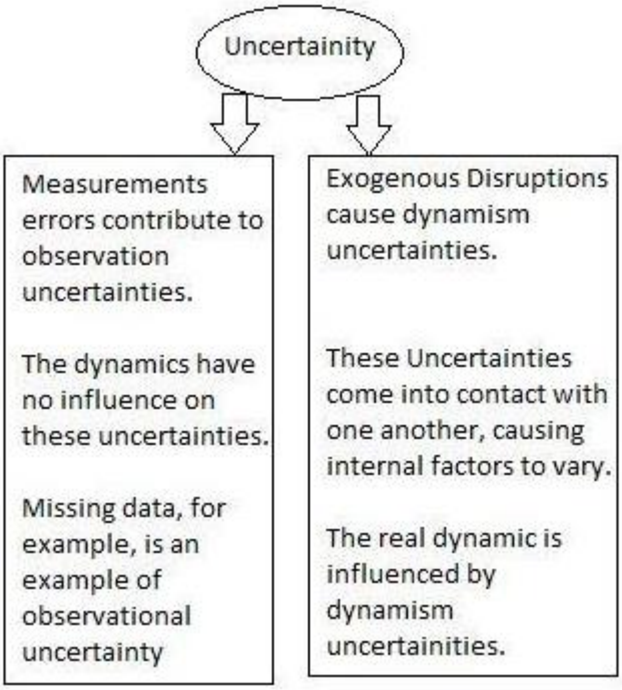

Figure1. Shows the Type of Uncertainty

Various image restoration processes and tools are used to eliminate the effect of information loss during image capture, with the goal of deleting, limiting, or minimizing the noise present throughout the image. The image quality may deteriorate as a result of blurring effects or the presence of noise. Distortion may occur as a result of an inappropriate, deficient, or improper image acquisition process, while noises diminish image visual appearance by intruding with the image's original signals. Various spectral methodologies, including notch filters, are being used to eliminate the effects of electricity supply. There are different sorts of sources of uncertainty that could really affect medical images: observational and dynamical uncertainties show in figure 1.

In this review document, we attempted to execute a survey of the work accomplished over the course of the last ten years in the field of Denoising the X-ray Image by using Image Processing Technology. We draw attention to documents from 2010 to the present. In this paper we tried to conclude the problems that we faced while removing the noise from the X-ray image and what the numerous methodologies and methods are there which helps to maintain the quality of image and useful data of the image.

Table1. Shows the list of Acronyms

Serial No.	Abbreviation	Full Form of Abbreviation Used
1.	NPS	Noise Power Spectrum
2.	MTF	Modulation Transfer Function
3.	CF	Coherence Filter
4.	ELM	Extreme learning Machine
5.	CT	Computer tomography
6.	LDCT	Low-dose computed tomography
7.	FBP	Filtered back projection
8.	GAN	Generative adversarial network
9.	MSE	Mean Square Error
10.	GPU	Graphics Processing Unit
11.	ESAR	Extraction of strong association rule
12.	LDCT	Low-dose Computed Tomography
13.	ROR	Robust Outlyingness Ratio
14.	DCT	Discrete Cosine Transform
15.	CHO	Channelized Hotelling observer
16.	GDSIR	Global Dictionary-Based Statistical Iterative Reconstruction
17.	ADSIR	Adaptive Dictionary-Based Statistical Iterative Reconstruction
18.	BCT	Breast Computed Tomography
19.	CHD	Coronary Heart Disease

23.	ROI	Region Of Interest

2. Reviews

2.1. Waterstein stochastic adversarial systems are used to rectify artefacts in low dose dental CT imaging [1]

In this paper the author explains about the risk of high dose radiation of X-ray on health. The adoption of LDCT technology, the CT screening domain must have emerged as a primary focus according to the author of this paper. Photo capture with down - sampling throughout low-dose x-ray radiography procedures is one of these LDCT systems. Reduced radiation dose, on the other hand, may have a negative impact on CT picture features by injecting distortion as well as artefacts into the final picture, which potentially jeopardise clinical findings. The authors suggest a deep learning-based artefact correction technique for downsampling CT reconstruction in this paper [1].

- Results: The suggested algorithm successfully eliminates low-dose artefacts from dental CT scans, according to the findings of the experiments. Furthermore, we demonstrated that the recommended technique is more effective than conventional systems at eliminating noise from low-dose CT scan images. The author compared the general GAN, convolution neural networks, and mWGAN performance. We showed that the proposed mWGAN approach resulted in improved artefact correcting efficiency while keeping the texture in dental CT scanning after a monitoring and evaluation analysis of the results.
- Conclusion: Whenever employed as a pre-processing methodology for dental CT pictures, the proposed model successfully increases image quality, according to the image quality assessment metrics. According to author experience, this is the 1st time an artificial learning model has already been employed along with a cone beam dental CT scanner. The effectiveness of artefact correction was determined mainly and proven to be efficient. As a result, we think the suggested methodology algorithm represents a novel path in low-dose dental CT artefact correction research.

2.2. An x-ray CT polymer gelatine microscopy design: I. Residual artefact elimination [2]

The author formulated the notion of polymeric gelatine dosimetry (PGD) filtration technology in this study. It is demonstrated that the distortion in x-ray imaging is really not completely unpredictable. In this scenario, the classic signal elimination methodology is revived, with the ‘signal' removed being formalised distortion and residual artefacts, resulting in the best polymer gel doses allocation. The method has been expanded to two dimensions, and the input constraints have been optimised for the suggested protocol. When compared to high-performance filtering, RAR has proven to be a superior solution. RAR filtering is simplistic to accomplish and execution times for standard picture databases are short [2].

2.3. Medical Image Database Images Retrieval Employing an Association Method [3]

The notion of data analysis is introduced for using association rules to detect recurrent image layouts in mammogram pictures. The presented method has two stages. The first step is to segment the digital mammogram to locate the area of interest (AOI) [3]. The second phase involves using the Association rule to detect common image patterns in mammogram images. To obtain robust, efficient, and strongly correlated associate norms derived from the preceding step's Apriori algorithmic processes, the recommended technique implements a new ESAR technique. The outcome demonstrates that picture retaining is possible as well as provides good association norms. All of the norms created for the mammogram image database using the Apriori algorithm are weak, and only a few of them provide redundancy details. The findings demonstrate that image mining is possible, with 252 powerful and efficient association rules resulting from the Apriori methodology. As a result, the recommended procedure can achieve and boosts the accuracy of mammogram diagnosis. Future research will focus on improving Association rules that use a genetic algorithm, as well as diagnosing mammogram images effectively.

2.4. A Innovative Method for Eliminating Pectoral Muscle from Virtual Mammograms [4]

In this paper the author suggested technology for determination of cancer and for removal of noise. For both the detection and removal of noise, this study combines the Resistant Outlyingness Ratio (ROR) procedures in conjunction with an improved NL-Means (ROR-NLM) filter relying on the Discrete Cosine Transform [4]. This method simply eliminates Gaussian and impulse interference does not cause any loss of data. The main objective of this research is to recommend an automated technique for removing two artifacts from a mammogram image. The outcomes demonstrate that the proposed efficiently eliminates Gaussian and impulse noise without sacrificing information needed, yielding an overall precision of 90.06 percent.

2.5. Chest radiographs using the bone suppressing technique

In this paper the author explains that in chest radiographic photography, bone patterns with great intensity are a significant source of interference. The high intensity bone patterns in the nearby region of a chest radiograph may either partly or entirely obscure or "overshadow" a signal of interest. To enhance the effectiveness of soft tissue density. The author of this paper suggested an innovative technology for suppressing bone [5] structures on traditional chest x-ray images, such as posterior ribs and clavicles. The bone-suppression technology generates a picture that is devoid of the rib and clavicle structures. The findings also found that after seeing rib-suppressed companion views, radiologists were significantly more assured in determining the prevalence or absence of abnormalities.

2.6. The effect of radioactive contamination and reconstruction approaches on human observer performance in a two-alternative forced choice low contrast recognition task using a channelized Hotelling observer [6]

In this paper the author explained that a determinable research to analyse human observer success on particular obligations at different scanning and reconstructive parameters is required for effective CT protocol implementation. The objective of the research was to see how the suggested approach would forecast humanoid investigator success on 2 distinct lesion detection methods using two separate reconstruction methods: FBP as well as IR. For both FBP and IR, the experimental and computational observations were positively associated at every dosage amount for each lesion scale.

2.7. A Unique Example-Based Approach for Biomedical Image Super-Resolution and Noise removal [7]

The author of this work presents a creative exemplar strategy for healthcare image noise removal as well as super-resolution. Using a specified dataset of high and low-resolution picture patch pairings, the goal is to interpolate a high-resolution image from a single distorted low-resolution image. The high-resolution replica of the whole specified input low-resolution patch is determined by seeking a non – negative sparse linear description of the entrance patch over the database's low-resolution patches, where the co - efficiency of the portrayal is greatly influenced by commonalities between the incoming patching and the database's sampled patch. A nonnegative quadratic programming problem is used to model the hardship of locating the nonnegative representation. The recommended analysis is especially helpful in the case of images that are distorted and not visible clear.

2.8. Using digitised mammograms, autonomous breast profile segmentation for ROI diagnosis [8]

In this paper the author explained that radiologists commonly use mammography as being the most important imaging modality for breast cancer screening. Developing an appropriate, reliable, and effective breast profile segmentation method in digital mammography is still a difficult task. Since the involvement of pectoral muscle in mammograms [9] allows spotting processes to be skewed, it is advised that the pectoral muscle be withdrawn throughout pre-processing. In this article the author explains about an automatic procedure for mammogram [10] segmentation. Morphological pre-processing and the seeded area expanding (SRG) methodology are used in the proposed algorithm [8]. The collected analysis shows that the breast regions derived correctly match the corresponding GT images.

2.9. Rehabilitation of low-dose CT images employing gain intervention-based dictionary learning [11]

In this paper the author proposed the concept of improving inclusion in the acquiring of vocabulary for low-dose CT image restoration. In medical diagnosis, the computed tomography (CT) method is ubiquitously employed. X-ray radiation in the human body, on the other hand, can cause somatic effects such as cancer. Because of the possibility of radiation, study has concentrated on the amount of radiation provided to patients during CT scans. The benefit intervention-based filter is often used to extract objects from low-dose CT renovation pictures as a post-processing method. Thorough research has revealed that the proposed methodology surpasses current methods.

2.10. Technique for correcting X-ray scatter in specialised breast computed tomography [12]

In this paper the author proposed the concept by eliminating the x-ray scattered sign from BCT predictions, image clarity and precision in devoted breast computed tomography (BCT) can be improved. A procedure for calculating and subtracting the low-frequency x-ray scatter sign used in each BCT perception post acquisition and pre-reconstruction is proposed in this analysis. After restoration, a noise filter is used to minimize the overall frequency quantum distortion emerging by the scatter signal. The evaluation of project acquisition exposes the imaged breast to a negligible amount of radiation. The suggested scatter correction system for specialized breast CT is realistic, therefore can increase image quality significantly.

2.11. Utilizing non-contrast and contrast CT images, an automated coronary calcium scoring system was developed [13]

The author of this paper recommended that a fully automated calcium scoring system be built to relieve radiologists and cardiologists of their workload. Calcium scoring is a prominent process of measuring the risk of heart disease. Since the structure of coronary arteries is impossible to see in non-contrast CT photographs, the aorta, heart, and coronary arteries are extracted from a contrast CT image of the same patient. Finally, a SVM [14-15] classifier is used to optimise the output by eliminating all distorted pictures.

2.12. Elimination of background noise in x-ray ptychography

The author of this study demonstrates background noise elimination in x-ray ptychography. Ptychography is an x-ray microscopy process that focuses on diffraction that avoids the resolution limitations set by image-forming optical components. Since spatial-frequency diffraction patterns are eventually obliterated along with the distortion, eliminating background noise [16] from a ptychography datasets is an essential but somewhat uncertain pre reconstruction data analysis phase. The author of this paper discusses many recently developed methods for extracting background noise from observational psychographic statistics.

2.13. Noise Cancellation in Presence of Transient Noise using Spectral Clustering [17]

The author of this paper focuses on removing the short term noise. The author of this article proposed a VAD based algorithm in which the input signal divides into two clusters. This article's author uses labelled data to correct the kernel parameters used throughout the spectral clustering process for calculating the comparative matrix. In the presence of transient noise, research outcomes show that the proposed solution outperforms traditional arithmetic model-based VAD algorithms.

2.14. Attenuation indices of renal parenchyma in digital noncontrast features captured through multi - phase renal dual-energy CT: comparative to traditional noncontrast CT [18]

In paper [18] the non-contrast scanning is still frequently utilised and provides advantages for finding abnormalities in CT images of the abdomen was discussed. Evaluating the attenuator difference after contrasting injection may show enrichment, and the amount of attenuator in the non-contrast image is significant for detecting the characteristics of obesity, calcification, stone, and blood clotting. The equalization of image sequences serves as the foundation for spatiotemporal imaging analysis methods that require photo sequence location correlation [19].

3. Bibliometric [20] Analysis of removing the noise from X-ray image using Image processing Technology

This paper highlights numerous bibliometric studies of noise removal from X-ray images using Image Processing Technology for various applications. The appropriate database is sourced from Scopus and covers the years 2010 to 2020. The major purpose of this study is to investigate the amount of work that has been performed to diminish interference in X-ray images employing Image Processing Technology, the depth of work, and the best tools for denoising X-ray images.

3.1 Analysis based on the number of publication per year

In figure 2 graphs demonstrate the amount of publications issued annually. In 2010, the graph shows 4 documents published but in 2011 the amount of paper published reached zero. It seems that in the year 2011 the number of papers published was zero. Then again in the 2012 plot shows the increment and amount of paper issued in 2012 is 4. But again in 2013 it depicts a negative slope and indicates the amount of the paper issue in 2013 was 1. In 2014 again the slope was increasing and 2 papers were published. Again the slope is increasing and in 2015 it shows 4 papers were published. It seems that there is a continuous increment in slope and it reaches 8 in 2016. In 2017 again the graph shows the negative slope which indicates again a decrease in the number of papers published. In 2017, the number of papers published was 6. Again in 2018, it shows 5 papers were published. Again in 2019 a sudden increment in slope and it shows the maximum number of papers was published in 2019 which is 9. Again in 2020 the graph shows a decrement, it shows that 8 papers were published in 2020. As we can see in Figure 2 the graph is varying. It shows that the majority of paper issued is 9 which were published in the year 2019 and the lowest amount of paper issued is zero (0), which was published in 2011. The maximum number of papers was published in 2019 which was 9, while the minimum number of papers was published in 2011 which was zero (0).

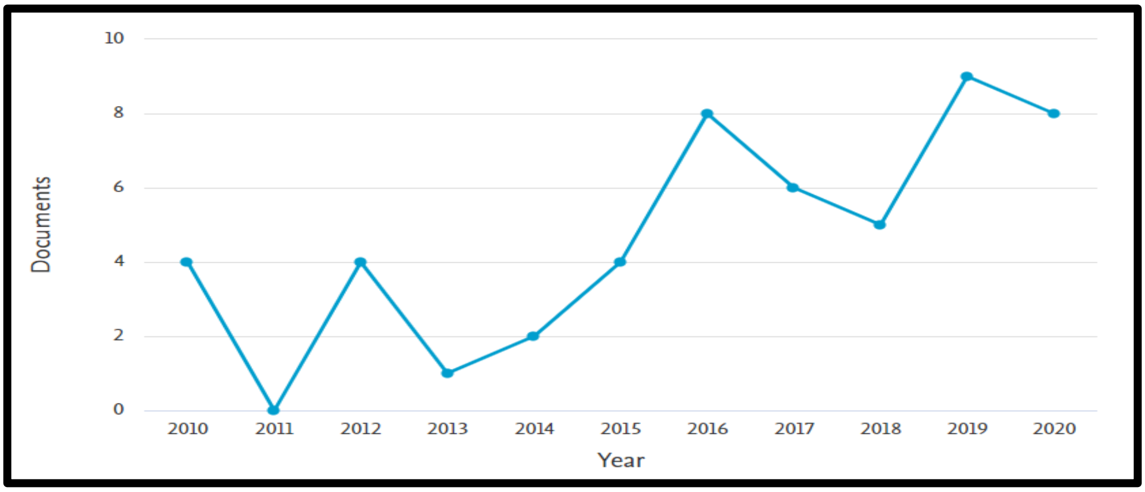

Figure 2. Shows the documents per year

3.2 Analysis based on the amount of publications released each year by various sources

Figure 3 depicts the amount of publications released each year by various sources. It shows that in the Journal of Physics Conference series two papers were published, one in 2010 while the other document in 2020. In Aip conference proceedings two papers was published, which was in the year of 2015.

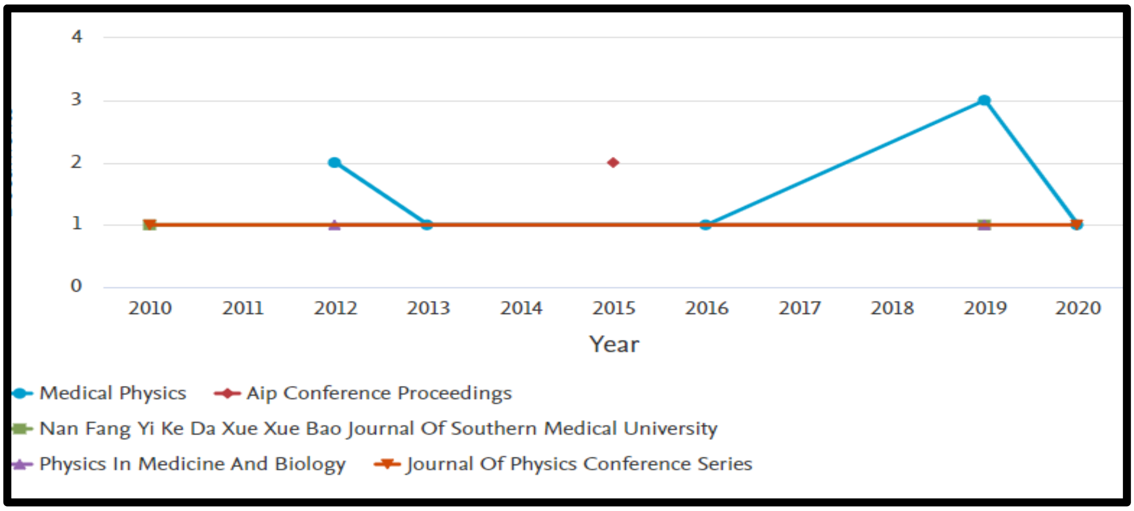

Figure 3. Depicts the quantity of publications per year by source.

While Physics in Medicine and Biology, two papers were published in the year of 2012 followed by the year 2019. In medical physics, a total of 8 papers were published. In Nan Fang Yi Ke Da Xue Bao Journal of Southern Medical University a total of two papers was published, one in 2010 while the second paper in 2019.

3.3 Analysis based on the contribution of top by top fifteen authors

In figure 4 the bar chart explains the amount of documents issued by fifteen authors. We conducted a bibliometric survey of the last 10 years and complete data is taken from

Scopus. The contributions of top fifteen authors are summarized in figure 4 and Table 1. Klestov, S.A. published the majority of paper which was 4 followed by a count of 3. While Abdul Kareem, S., Bataller, J., Bauer, M.A., Bhosle, U. Published minimum number of papers which was 1.

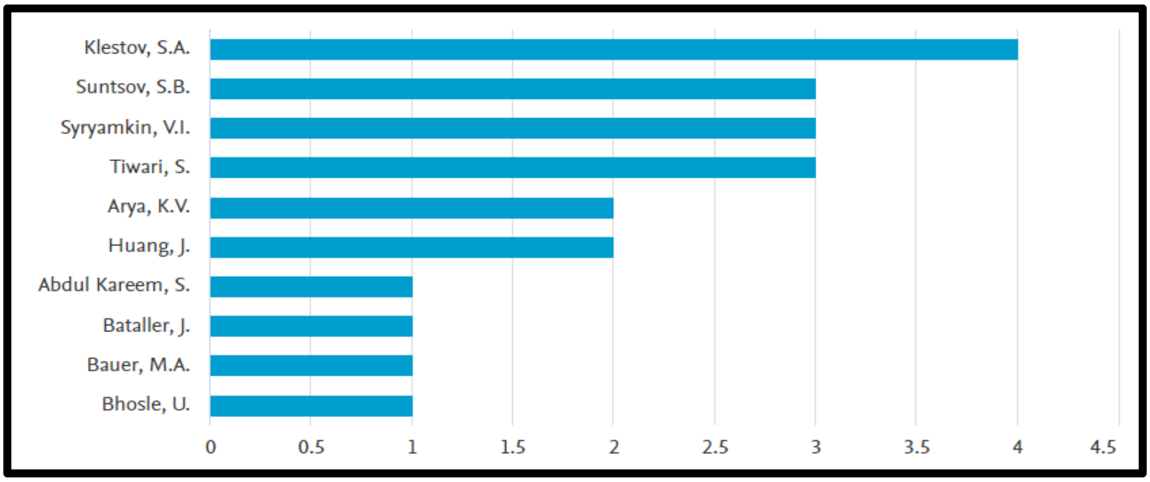

Figure 4. The bar diagram depicts the top 15 writers' work contributions

Table2. Relevant data on the amount of documents published by the top 10 writers

Sr. No.	Name of the Author	Count of paper published
1	Klestov, S.A.	4
2	Suntsov, S.B.	3
3	Syryamkin, V.I.	3
4	Twari, S.	3
5	Abdul Kareem, S.	3
6	Arya, K.V.	2
7	.Huang,J.	2
8	Bataller, J.	1
9	Bauer, M.A.	1
10	Bhosle, U.	1

3.4 Documents published by Type

The pie plot in figure6 depicts the publication by type. It shows that 60.8% documents were published as article while 37.3% Suntsov, S.B., Syryamkin, V.I., Twari, S. documents were published as conference paper followed by review paper with a tally of 2.09%.

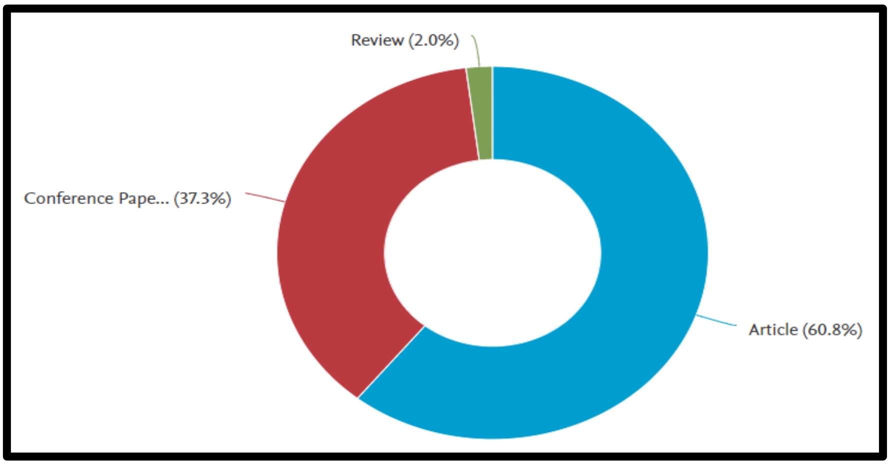

Figure 5. Shows the documents by type

3.5 Analysis based on affiliation

In figure 6 the bar graph shows the publications issued by the top 10 institutes. From the bar graph we can analyze that maximum number of documents published by Tomsk State University which was 4, followed by Thapar Institute of Engineering & Technology, Ministry of Education China, Southern Medical University, Mayo Clinic, Chinese Academy of Sciences, University of Chinese Academy of Science, ABV-Indian Institute of Information Technology, JSC Academician M.F. Reshetnev Information with a count of 2. The minimum number of documents was published by Instituto Tecnologico de Cd. Guzman which was 1.

Table3. Amount of publication published by top ten institutions

Sr. No.	Institution Name	Count of publication
1	Tomsk State University	4
2	Thapar Institute of Engineering & Technology	2
3	Ministry of Education China	2
4	Southern Medical University,	2
5	Mayo Clinic,	2
6	Chinese Academt of Sciences	2
7	University of Chinese Academy of Science	2
8	ABV-Indian Institute of Information Technology	2
9	JSC Academician M.F. Reshetnev Information	2
10	Instituto Technologico de Cd. Guzman	1

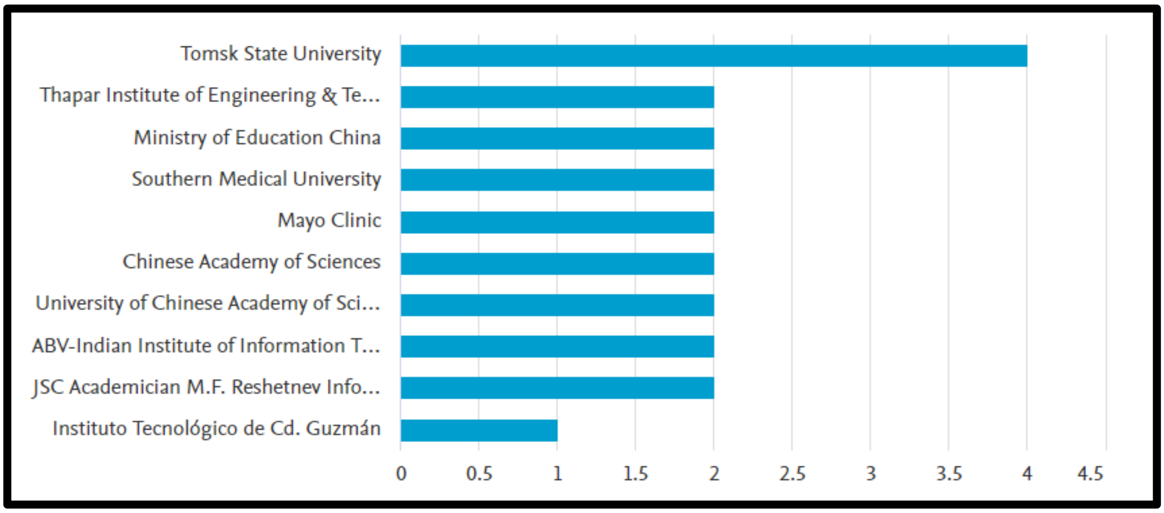

Figure 6. Shows the Documents published by top ten affiliation

3.5 Geographical region analysis

In figure 7 the bar graph shows the documents published by top ten countries/territories.. It shows that the United States published a maximum number of documents which were 11. India and China published 9 documents followed by Canada, Russian Federation with a count of 5. South Korea and Spain published documents with a count of 3. France, Taiwan, Turkey published the minimum number of documents which was 2.

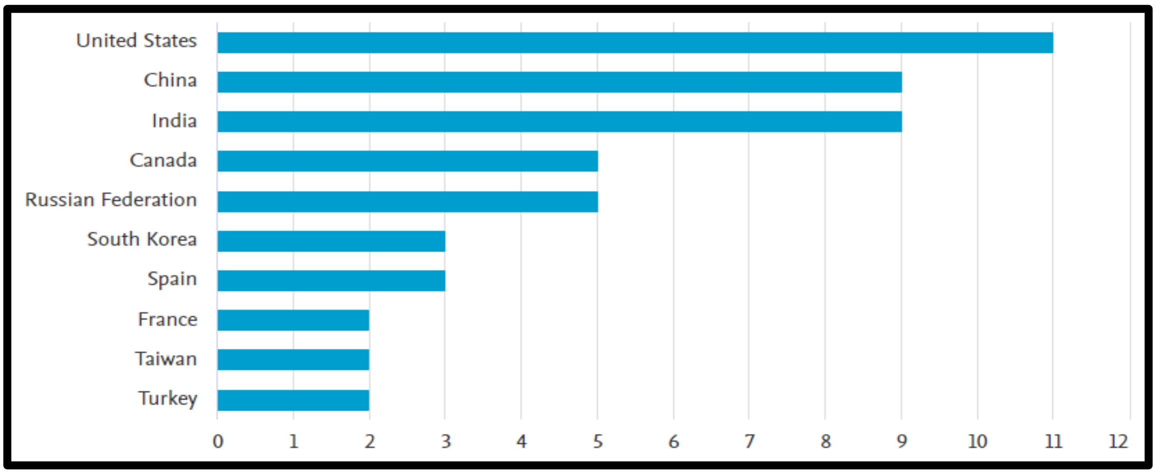

Figure7. Shows the documents published by top 10 countries

Figure 8 depicts the geographical regions of thoughtfulness of the written articles, which was created using the GPS Visualizer method from gpsvisualizer.com.

Figure 8. Geographical locations of study

3.6 Analysis based on subject area

Figure 9 depicts classification based on subject area. Maximum amount of publication was issued in the area of medicine which was 20.02% and minimum amount of documents was issued in the field of Decision Science. The number of documents published was 1.1% followed by others with a count of 1.1%. While in the field of Computer science and Engineering the number of documents published was 18.1% and followed by Physics and Astrology with a count of 14.9%. In the field of Biochemistry the number of documents published was 10.6%. While in the field of Material Science the number of documents published was 6.4%. In mathematics the number of documents published was 5.3% followed by earth and planets with a count of 2.1%.

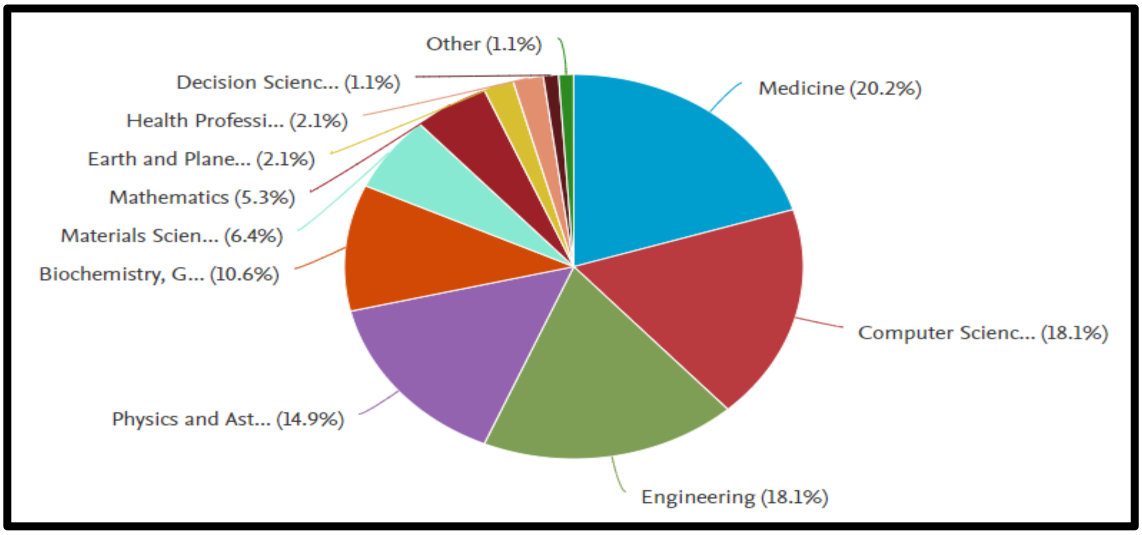

Figure 9. Demonstrated the Documents issued by subject area

3.6 Analysis based on funding sponsor

In figure 10 the bar graph shows the documents by the funding sponsor. The National Natural Science Foundation published the maximum number of papers which was 4. The National Institutes and U.S. Department of Health and Human published 3 papers which was followed by the Ministry of Science, ICT and future and National Research Foundation of Korea with a count of 2. While the minimum number of papers was published by Atlantic Canada Opportunities Agency, China Scholarship Council, Dalhousie University, European synchronization Radiation and Georgia Research Council which was 1.

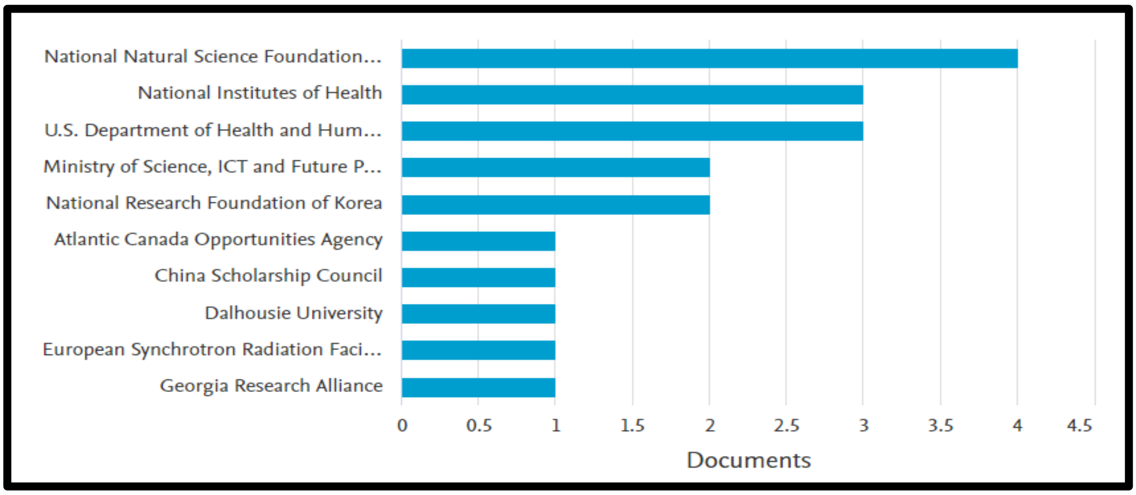

Figure 10. Shows the Documents by funding sponsor

3.7 Analysis based on the year of publication as well as the title of the study

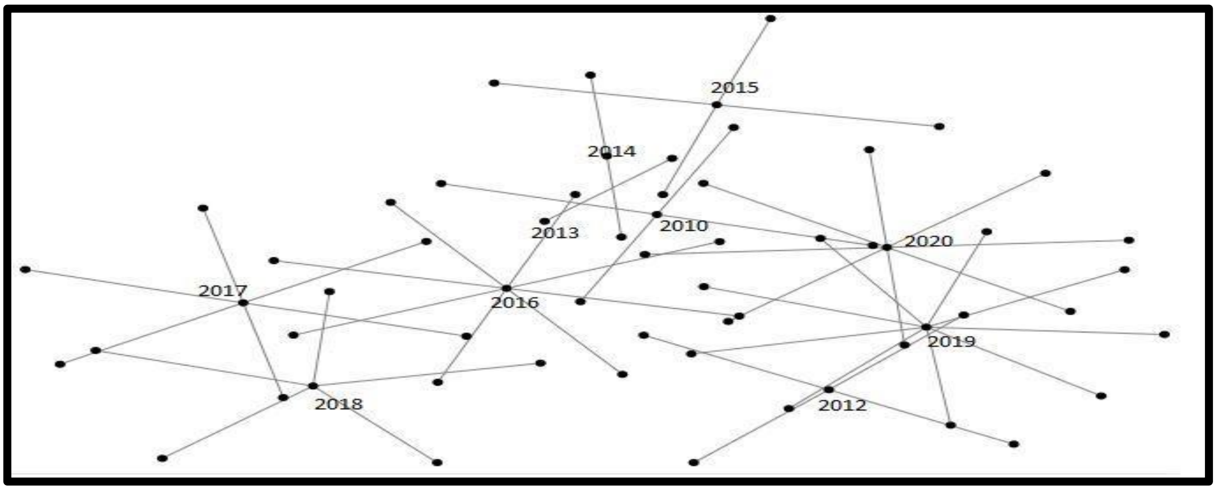

Figure 11. Shows the Cluster of publication year and article title

Figure 11 depicts a cluster of issuing years and the number of articles written in each year, created using the NodeXL method.

3.8 Analysis based on the main authors, keywords and the top most journals

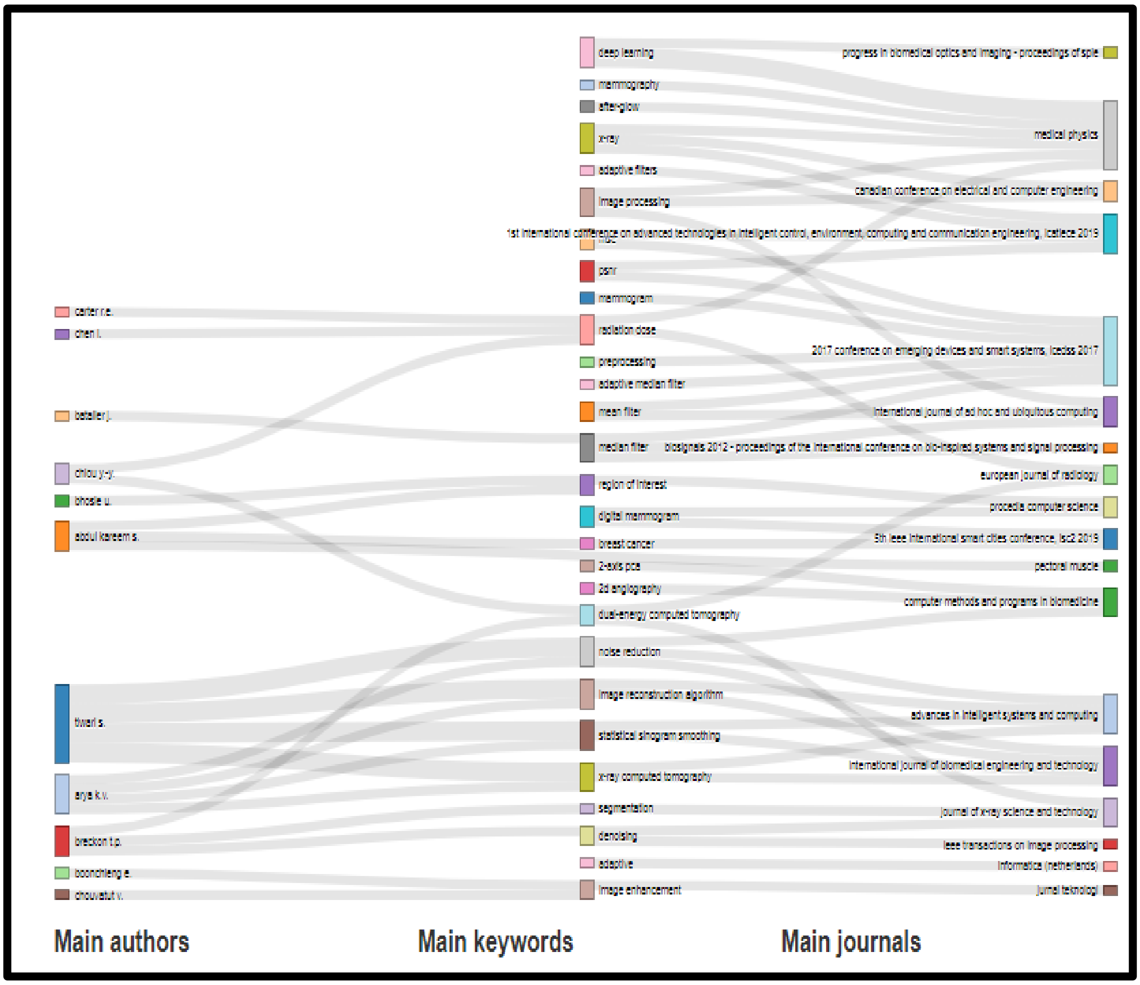

Figure 12. Shows how main authors, keywords and important journal linked together

From the figure12 we can explore the connection between the main authors, keywords and the top most journals. By using the Science scape tool we are able to plot this. It is open source software available for different types of visualization for researchers. Size depicts here the relation or repetition of corresponding keyword or author or journal. Large size represents more number of times the keyword or journal or author is repeated.

3.9. Analysis relying on the relationship between the author and co-publication, author and keywords, title of source and keywords appear in same paper

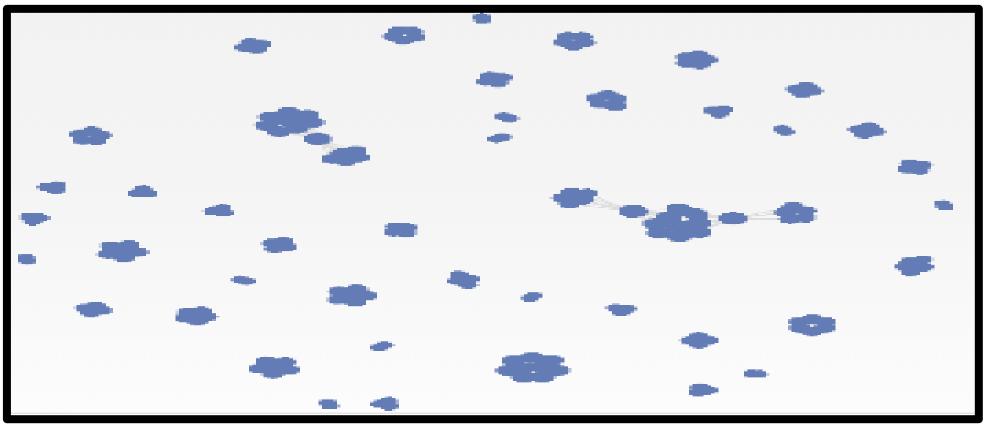

Figure 13. Shows the authors connected by co-publication

From figure13 we can depict the connection between the authors and how they are connected by co-publication. By using Science scape we are able to build this network.

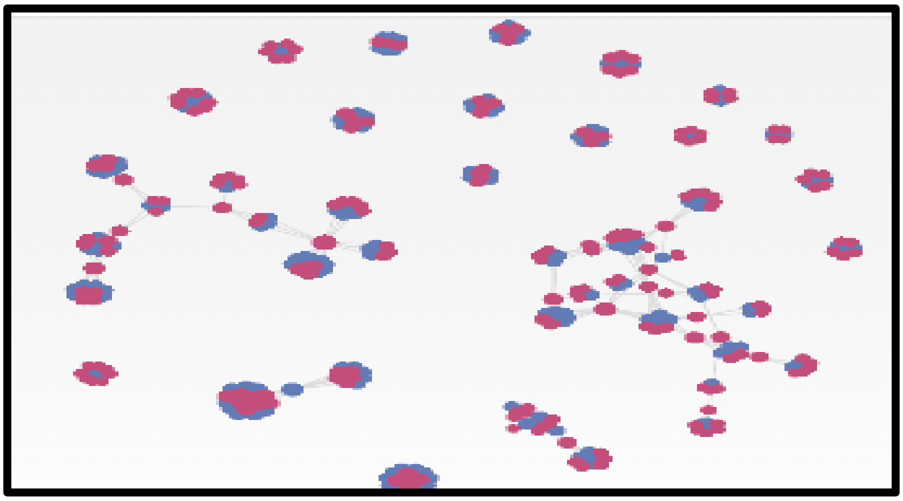

Figure 14. Shows the connection between the authors as well as keywords appearing in same paper

Figure 14 demonstrated the relation between the authors and the keywords as well appearing in the same paper. Pink colour depicts the keywords here while the blue color represents the author. Figure15 shows the connection among the title of the source as well as the keywords which appear in the same paper. Pink color represents the source title and blue color shows the keywords co-appear in the same paper. We use an open-source software which is Science scape to visualize the relation.

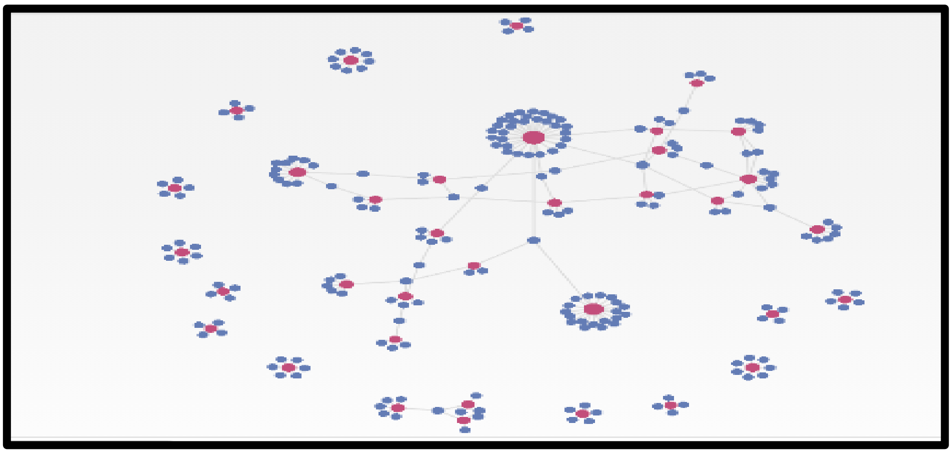

Figure15. Depicts the relationship between title of source and keywords co-appear in the same paper

3.10. Analysis based on the co-occurrence of all keywords and Bibliographic coupling of documents and between the words of highly cited paper

Figure16 shows the co-relation among all keywords. By using the VOS Visualization tool we are able to visualize the co-occurrence between the keywords. Size of the circle represents the amount of times the keyword used. Figure 17 shows the bibliographic coupling of documents. It shows 7 clusters and 52 links.

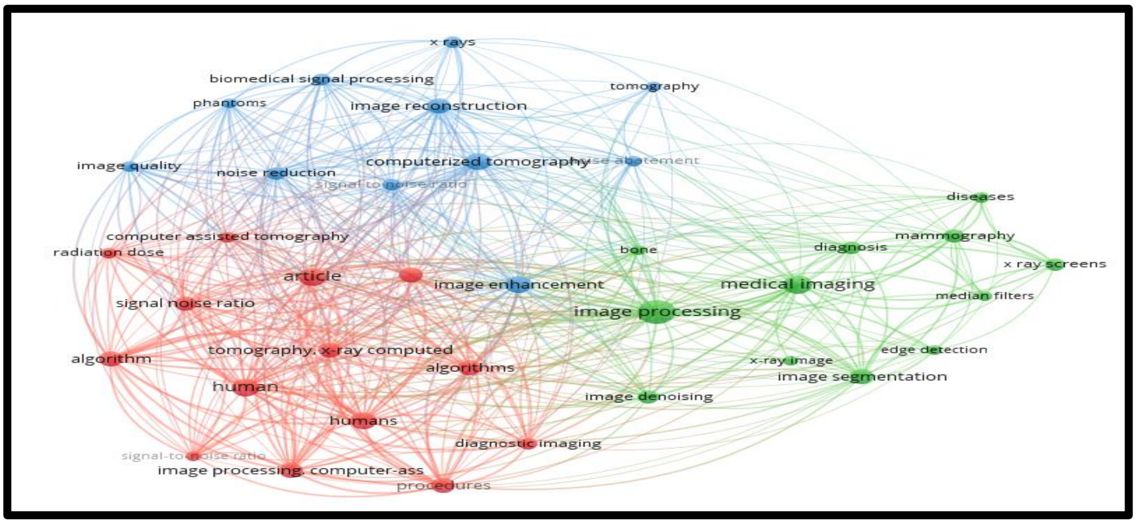

Figure16. Shows the correlation among all keywords

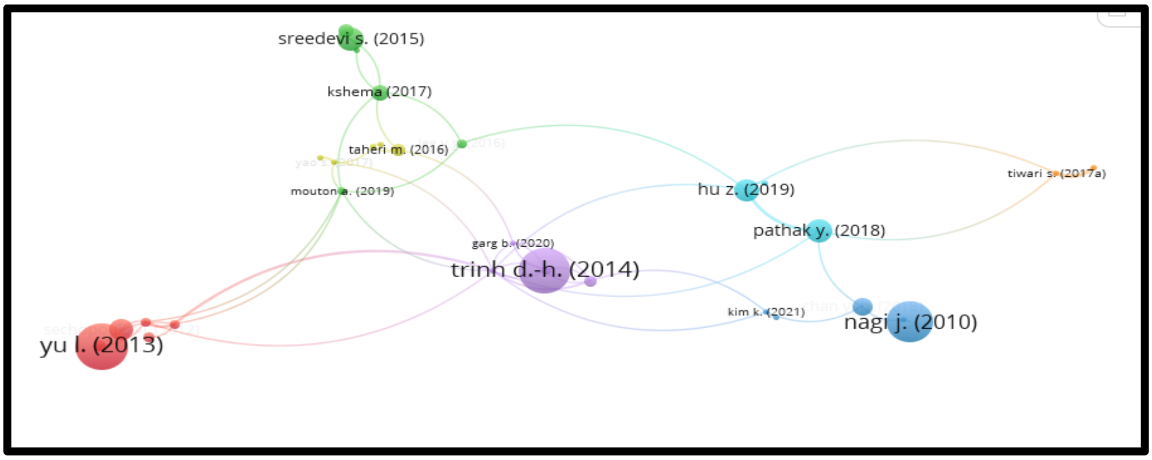

Figure17. Shows the Bibliographic coupling of documents

Figure18. Shows the relation between the words highly cited paper

4. Future Scope

In Noise Reduction and Contrast Enhancement for Small-Dose X-ray Images in Wavelet Domain Area discuss the technique of reduced distortion while maintaining the fine pattern of x-ray images, which was verified. Here the author will analyze a large number of small dose pictures processed with this methodology in the future to validate the method's validity. With the advancement in technology, future research will focus on improving Association rules that use a genetic algorithm, as well as diagnosing mammogram images effectively.

5. Conclusion

The bibliometric analysis is being conducted to determine the significance of study that has been done in the domain of removing the noise from the x-ray image and its future prospect. The survey essentially presents information on the number of publications in different domains, territories, topics, and publications each year. We conducted an analysis of the past ten years in this paper. Clearly, based on the count of publications every year, there is already a vast amount of space for advancement in the domain of x-ray image denoising. The writers also went into detail about keywords, explaining how they relate to one another. However, this review paper also serves as a reference for prospective scholars who choose to look up the academic work of different authors based on their number of publications or citations. Furthermore, the bibliometric review showed that India is second in the field of eliminating noise from x-ray pictures, followed by Canada. Essentially, the bibliometric survey will help current and upcoming researchers identify research gaps in the field of eliminating noise from x-ray images.

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