Science Mapping and Visualization Tools Used for Bibliometric and Scientometric Studies: A Comparative Study

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Abstract

In the fastest growing technological world of information and communication technology, scientific research and development, an overwhelming amount of information / data in various formats is generated directly or indirectly. As far as academic and scientific community is concerned, a large number of scholarly articles are being published on daily basis by research scholars and academician across the world. After the introduction of Computer Technology computerized data processing has become common among the researchers, this has been prompted to develop Bibliometric software. Some of them are open source software (Freeware) and others are commercial products. The study comprises to assess the potential value of data analysis of selected open source Bibliometric and Scientometric Packages (Tools).

Keywords: Scientometric, Bibliometrics, Science Mapping and Visualization Tools, Bibexcel, Publish or Perish, Citespace II, CiteNetExplorer, VOSviewer.

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INTRODUCTION

Bibliometrics discovers its theory related to Bibliography of research outlook; it functions as a measurement factor of the information sources and, at long last, it shows up as a technique to be utilized by the scientific method. Henceforth: Bibliometrics contemplates the association of innovative parts from the outlook of the information forecasts. It quantifies logical development by applying statistical techniques to the outputs of researchers. Thus, it builds up the level of improvement of the various disciplines. It performs evaluation about on data utilization dependent on the reports used by researchers. These investigations are completed by utilization of bibliographic references of publications contained in bibliographies and information sources, amid a set timeframe. These bibliographic instruments give enough information about the essential records to take into account significant bibliometric explore. The study relies upon the various software tools used to carry out statistical evaluations (metrics) of various online and offline datasets.

REVIEW OF LITERATURE

Chen, Ibekwe, & Hou [1] has described CiteSpace II as- The provision of a tool-like CiteSpace II enables analysts to perform quantitative and qualitative studies of scientific subject domains more easily. In terms of intellectual contributions, the study shows the potential of a practical tool for improving our understanding of a research field. The study also demonstrates how the experience and findings of the study have led to an understanding of more challenges and more opportunities ahead. By drawing the strengths from multiple disciplines, the research becomes a melting pot to turn otherwise isolated techniques into an integrative environment.

Jacsó [2] describes about the Publish or Perish (PoP) tool and finds that is a quick and exquisite instrument to give the basic output features that Google Scholar does not offer. It is discovered that PoP enables the client to edit the outcome results displayed in a minimal, proficient framework position. It encourages finding the duplication of records and it has

dynamic efficiencies of sorting feature of datasets by eight various metadata elements, It also offers compatibility with exported dataset of Scopus and Web of Science in CSV formats-which are more reliable than the google scholar. The results are explored calculating H-index and other bibliometric indicators of recent outlooks with the Publish or Perish software.

Cobo, López, Herrera-Viedma, & Herrera [3] have identified nine software tools that can be used for Bibliometric analysis: Bibexcel; CiteSpace II; CoPalRed; IN-SPIRE; Leydesdorff's Software; Network Workbench Tool; Science of Science (Sci2) Tool; VantagePoint; VOSViewer. In addition to the tools identified by Cobo et al, this review identified generic database tools and scripts, such as those developed and discussed by Mallig [4] & Neuhaus [5] are available and were also identified as being able to fulfill some of the Bibliometric requirements.

Van Eck & Waltman [6] described in his article that CitNetExplorer is a software tool for visualizing and analyzing citation networks of scientific publications. The tool is freely available at www.citnetexplorer.nl. He first downloaded data from the WoS database on about 26,000 publications that appeared in the 14 journals. He selected these journals either because they are core journals in the fields of bibliometrics, scientometrics, and research evaluation or because they have strong citation relations to core journals in these fields. Then he provided the data on the 26,000 publications as input to CitNetExplorer. CitNetExplorer then constructed the citation network of the 26,000 publications. In addition, CitNetExplorer identified publications (not only journal publications but also for instance books) that did not appear in the 14 journals but that were cited at least ten times in these journals. These publications were also included in the citation network. In this way, a citation network of almost 30,000 publications was obtained.

Reasons to conduct Bibliometric Studies
Applications of bibliometric research identified by Wallace [7] indicated that the use is for developing libraries:

- Improving the bibliographic control of literature.
- Identifying a core documents especially Journals.
- Classifying a literature.
- Tracing the spread of ideas and growth of a literature.
- Improving the efficiency of information handling services.
- Predicting publishing trends and needs.
- Describing patterns of book use by patrons.
- Developing and evaluating library collections.

Aims and Objectives:
The aim of this study was to present a comparative study of five representative science mapping software tools by showing their advantages, drawbacks and most important differences. The software packages selected for the study were:
- Bibexcel[8],
- Publish or Perish[9],
- CiteSpace II[10],
- CiteNetExplorer [11] and
- VOSviewer [12].

1. To compare and evaluate the Bibliometric and Scientometric tools (packages) based on the predefined criteria like: Basic OS system compatibility, Record form compatibility, Menu tabs and features, Bibliometric network relationships, Normalization Measures, Methods of analysis,
2. To make suggestion with respect to which software tool ought to be adequate or efficient for Bibliometric or Science and technology mapping through their rankings.

METHODOLOGY AND SCOPE
Significant areas to study bibliometrics or Scientometric software are to decide the effectiveness, suitability and sufficiency of the software utilized in these practices. The Selected Packages for evaluation are: Bibexcel, Publish or Perish, CiteSpace II, CiteNetExplorer and VOSviewer. To process identical datasets on chosen software packages (i.e. WOS-Institution Oriented: Shivaji University 2010-15) and the data considered for study is till March 2018.

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Analysis and Interpretation

There are various science mapping and visualization tools used for Scientometric and bibliometric analysis but major five software packages were selected for study. The efficiency, appropriateness and adequateness of selected software were studied applying some criteria likewise-Basic OS system compatibility, Record form compatibility, Menu tabs and features, Bibliometric network relationships, Normalization Measures, Methods of analysis, etc.

Although these software tools present different characteristics; for example, some of them are focused only on visualization and others have different pre-processing modules. But for the ranking there is no any universal standard of evaluation hence researcher allotted points to them with respect to various predefined parameters. The ranking of software has been done by allotting points for each parameter.

Table 2 shows the basic OS System-compatibility and requirements of Java Runtime Environment has been identified by the researcher and allotted points according to their compatibility JRE bases. For the compatibility of OS 2 positive points are given and for requirement of Java JRE 2 points are deducted.

Table 3 shows Record form compatibility (Database format) These software tools are prepared with specified record form assembling purposes so researcher explored the record form compatibility of each software that various sources(i.e. WoS, PubMed, etc) provides various record forms (i.e. WoS Plaintext, RIS Format, etc) to be exported for further use. Some of these software needs to pre-processing of data before its use for analysis, export of databases through specified format is required for accurate & adequate analysis results. Each Database format compatibility hold 2 points.

Table 1: General information: Selected Science mapping & Visualization tools.

Software tool	Last version	Year	Developed by
Bibexcel	v1.0.0(08-04-2018)	2018	University of Umeå (Sweden)
Publish or Perish	v6.28.6197(29-03-2018)	2018	Anne-Wil Harzing
CiteSpace	v5.2.R2(26-03-2018)	2018	Chaomei Chen
Cite Net Explore	v1.0.0(10-03-2014)	2014	Leiden University
VOSviewer	v1.6.7(16-02-2018)	2018	Leiden University

Table 2: Basic OS Systems-Compatibility.

Software Tool	OS System-Compatibility			Java Runtime Environment(JRE)	Points Gained
	Windows	Linux	Mac OS		
Bibexcel	✔	✔	X	X	06
Publish or Perish	✔	✔	✔	X	08
CiteSpace	✔	✔	✔	✔	04
CiteNetExplore	✔	✔	✔	✔	04
VOSviewer	✔	✔	✔	✔	04

Table 3: Record form compatibility of tools.

Sr No	Bibexcel	Publish or Perish	CiteSpace	Cite Net Viewer	VOSviewer
1.	WOS plain text	Web of Science	Web of Science	Web of Science	Web of Science
2.	WOS tabbed format	Microsoft Academic	Scopus	CiteNetExplorer: Saved databases (Requires Publication & Citation File)	Scopus
3.	RIS format(Diva, Procite)	Google Scholar	Crossref*		Pubmed
4.	Scopus RIS format	Scopus	Pubmed		RIS format
5.	Medline format	Google Profile	ADS		Crossref* JSUN
6.	Winspires/Silver platter format	Crossref	arXiv		Crossref* API
7.	EI compendex format	External Data Export	CMKI		
8.	Endnote show-all style		CSSCI 2.0		
9.			Derwent		
			NSF		
			Proquest		
Points	16	14	22	04	12

Bibexcel

Bibexcel [13] is a bibliometric tool developed at the University of Umeå (Sweden). This tool was specifically developed to manage the bibliometric data and build maps, which can be read by software such as Excel, SPSS, UCINET and Pajek Bibexcel is freely accessible for academic non-profit use. Bibexcel can read data retrieved from different bibliographic sources, such as ISI, Web of Science (WoS), Scopus, and the Procite export format.

Publish or Perish

Publish or Perish [9] is a tool developed by Anne-Wil Harzing can explores and analyzes citation counts of research output. It uses a various data sources such as Google Scholar and Microsoft Academic Search to retrieve the raw citations, also can handle exported csv forms of databases such as Scopus and web of science then for analyzing and establishing the following types of metrics:

- Total count of papers and citations count.
- Average citations per research output, citations count per author, research output per author, and citations count per year.
- h-index, g-index and related indicators.
- The average annual cumulative in the individual h-index.
- An analysis of the number of authorship pattern (per paper).

The results can available on-display and can also be copied to the clipboard (for pasting into word & other applications) or saved to a various output forms (for further reference or analysis). Publish or Perish provides a described help file with searching techniques and much more information about the citation metrics and other indicators.
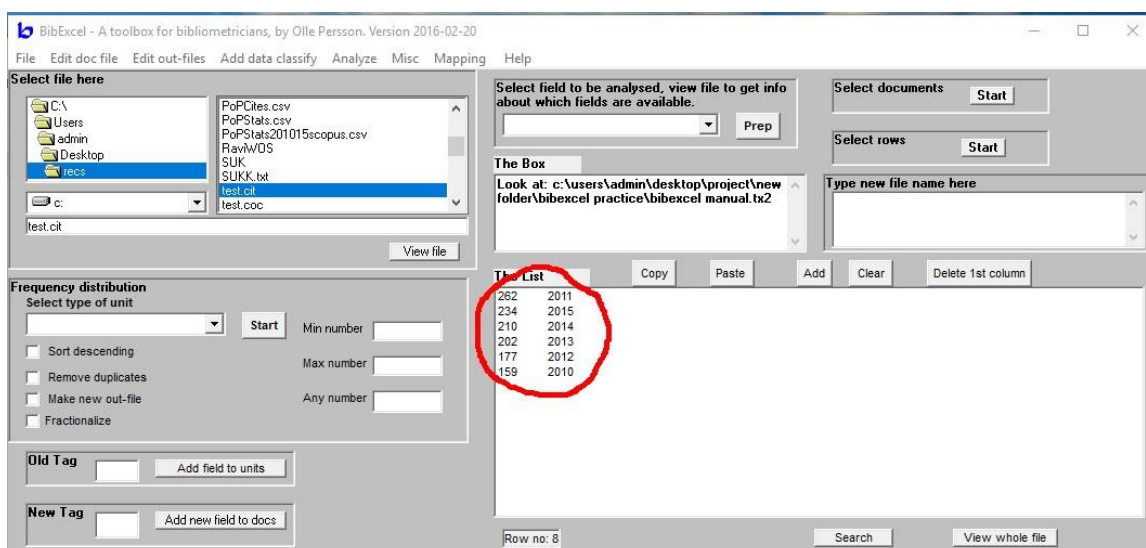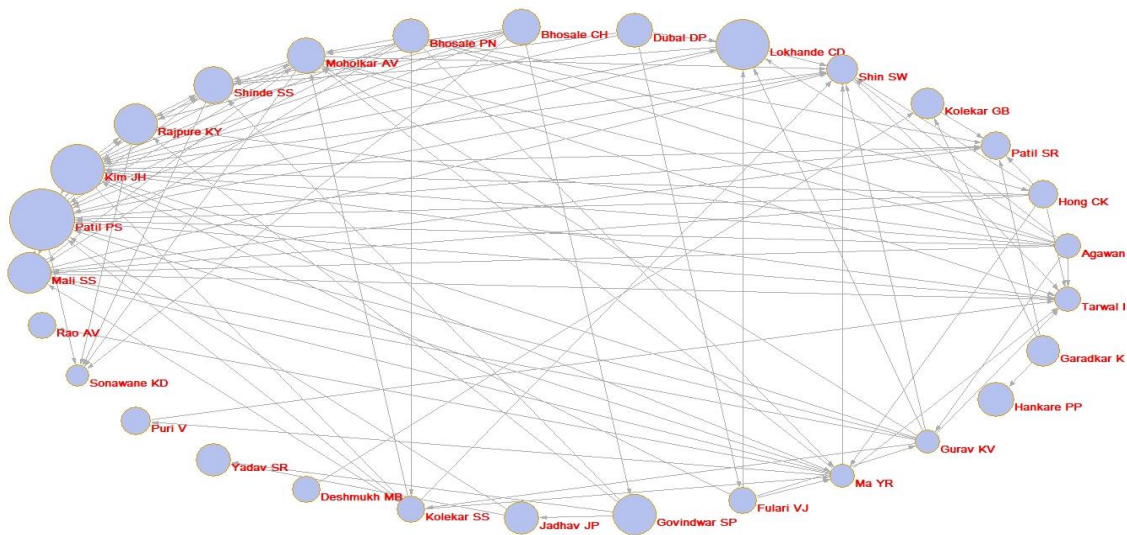

Screenshot 1: *Bibexcel: Year-wise Productivity Analysis (Shivaji University 2010-2015)*
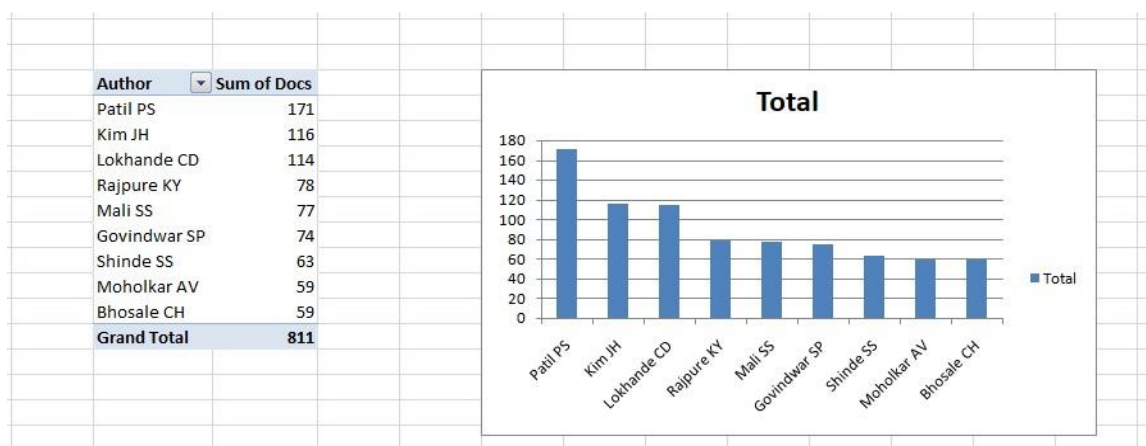
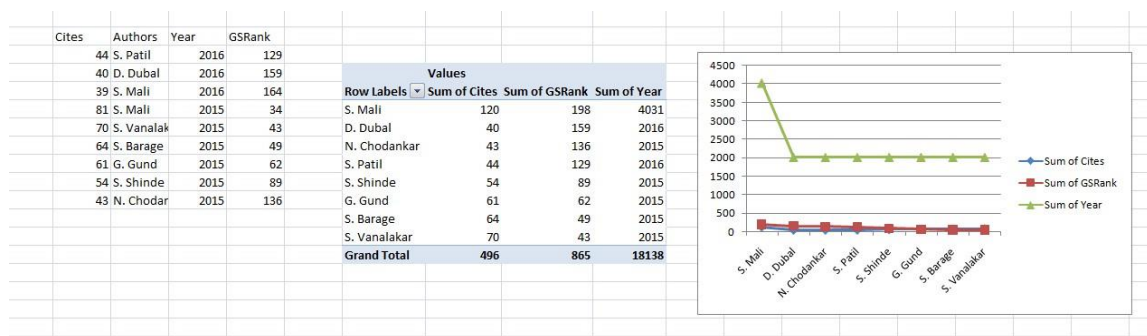***Screenshot 2:*** *Bibexcel: Year wise Productivity Analysis (Excel)*

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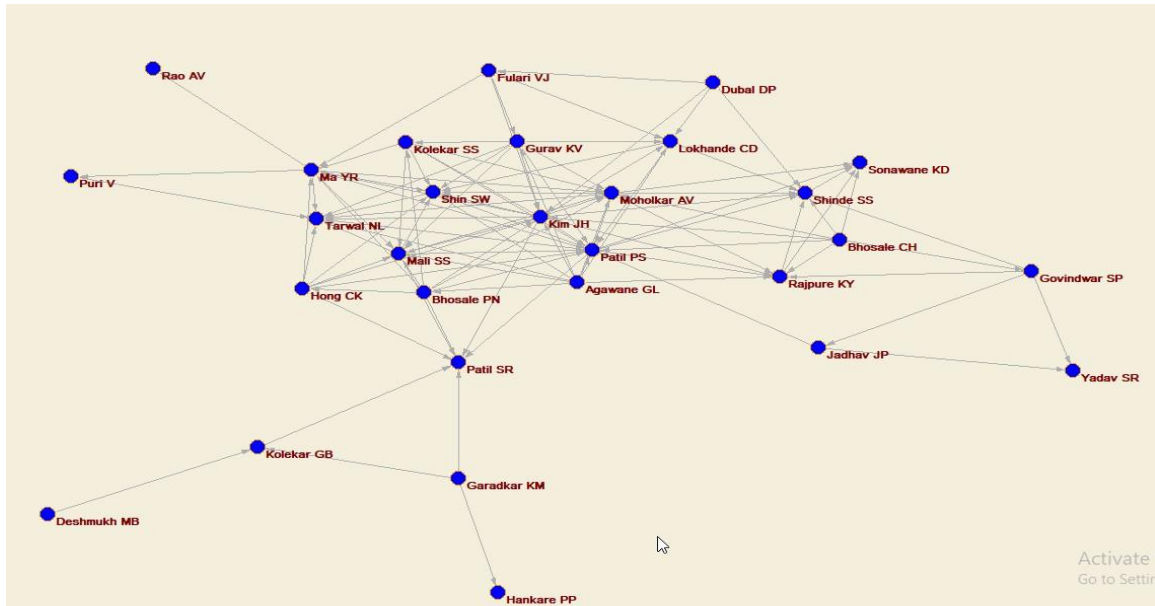
Screenshot 3: *Pajek Visualization (Exported from Bibexcel)*

Screenshot 4: *Pajek visualization co-authorship (Exported from Bibexcel)*

Screenshot 5: *PoP: Metrics data*

Cites	Authors	Year	GSRank
44	S. Patil	2016	129
40	D. Dubal	2016	159
39	S. Mali	2016	164
81	S. Mali	2015	34
70	S. Vanalak	2015	43
64	S. Barage	2015	49
61	G. Gund	2015	62
54	S. Shinde	2015	89
43	N. Chodar	2015	136

	Values		
Row Labels	Sum of Cites	Sum of GSRank	Sum of Year
S. Mali	120	198	4031
D. Dubal	40	159	2016
N. Chodankar	43	136	2015
S. Patil	44	129	2016
S. Shinde	54	89	2015
G. Gund	61	62	2015
S. Barage	64	49	2015
S. Vanalakar	70	43	2015
Grand Total	**496**	**865**	**18138**

Screenshot 5: PoP to Excel analysis (Top 10 authors GSrank and Citation freq.)
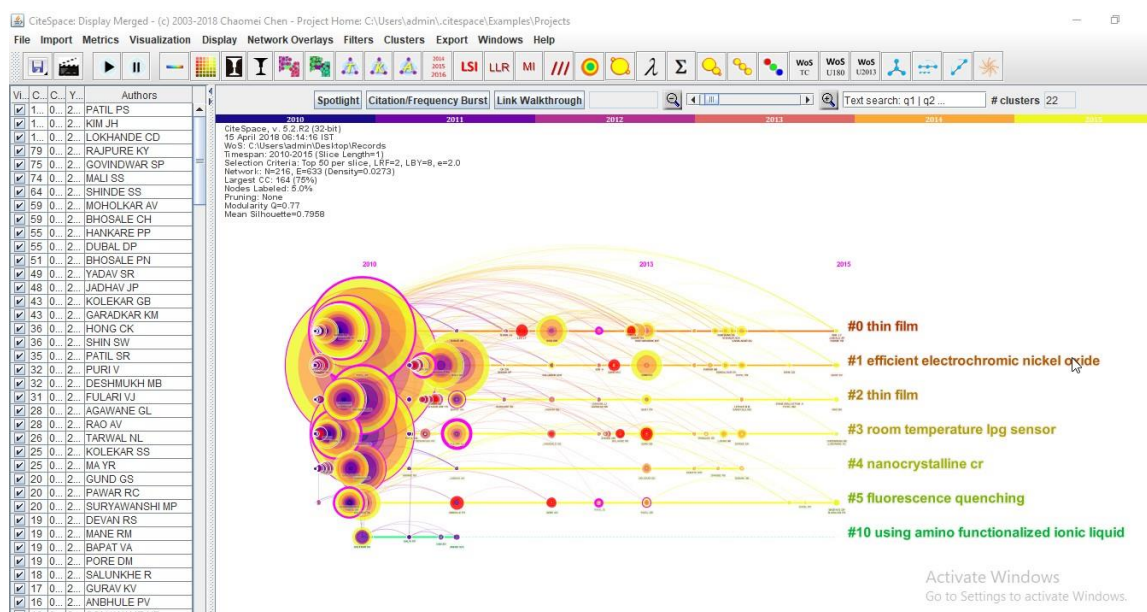
Screenshot 6: Citespace Output Timeline View (Key term based-Shivaji University 2010-2015)

CiteSpace

CiteSpace [6] was developed at Drexel University (USA) and it can be freely downloaded. It is a software tool developed to detect, analyze, and visualize patterns and trends in scientific literature. Its primary goal is to facilitate the analysis of emerging trends in a knowledge domain. CiteSpace can read different formats of bibliographic sources, such as WoS, PubMed, arXiv, and SAO/NASA Astrophysics Data System (ADS). Furthermore, CiteSpace is able to read grants data such as NSF Awards and patent data from Derwent Innovations Index.

CiteNetExplorer

CiteNetExplorer [11] is a software tool for visualizing and analyzing citation networks of scientific publications. It was developed by Nees Jan van Eck and Ludo Waltman at Leiden University's Centre for Science and Technology Studies (CWTS).The tool allows citation networks to be imported directly from the Web of Science database. Citation networks can be explored interactively, for instance by drilling down into a network and by identifying clusters of closely related publications.

VOSviewer

VOSviewer [14] is a software package especially developed for building and representing bibliometric networks, giving graphical representation of such network maps. It is easiest way to represent large maps with zoom-in facility, labelled algorithms, and density visualizations are used for representing the information.

The software tool developed at Centre for Science and Technology Studies, Leiden University and it is freely available to the

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bibliometric research community. Although VOSviewer can be used to construct and visualize bibliometric maps of any kind of co-occurrence data, the software tool does not allow any co-occurrence matrix from the bibliometric data to be extracted and built. To do this, an external process is needed. Furthermore, the software tool has no pre-processing modules to prepare the data for later analysis.

Table 4 shows the Menu Tabs and Features to considered science mapping software tools. Although all these software tools are developed by various individuals or institutions they have their specific features and attributes to analyze the prepared or raw databases/records. These features help for pre-processing and normalization of databases for analyses in particular way with their normalization standards.

*Table 4: Features and attributes of selected Science mapping software tools.*

| Bibexcel	Publish or Perish	CiteSpace	CiteNetexplorer	VOSviewer
File	File	File	Open	File
Edit Doc File	Data Sources	Projects	Citation network	Items
Edit Out File	Edit	Data	Publications	Analysis
Add data classify	Query	Network	Save	Network Visualization
Analyse	Tools	Visualization	Screenshots	Overlay visualization
Misc	Help	Geographical	Options	Density Visualization
Mapping		Overlay Maps	Back	Map
Help		Analytics	Forward	Info
		Text Preferences	Full Network	Normalization
		Help	Clear Selection	Clustering
		Resources	Drill Down	
			Expand	
			Groups	
			Analysis	
			Help	
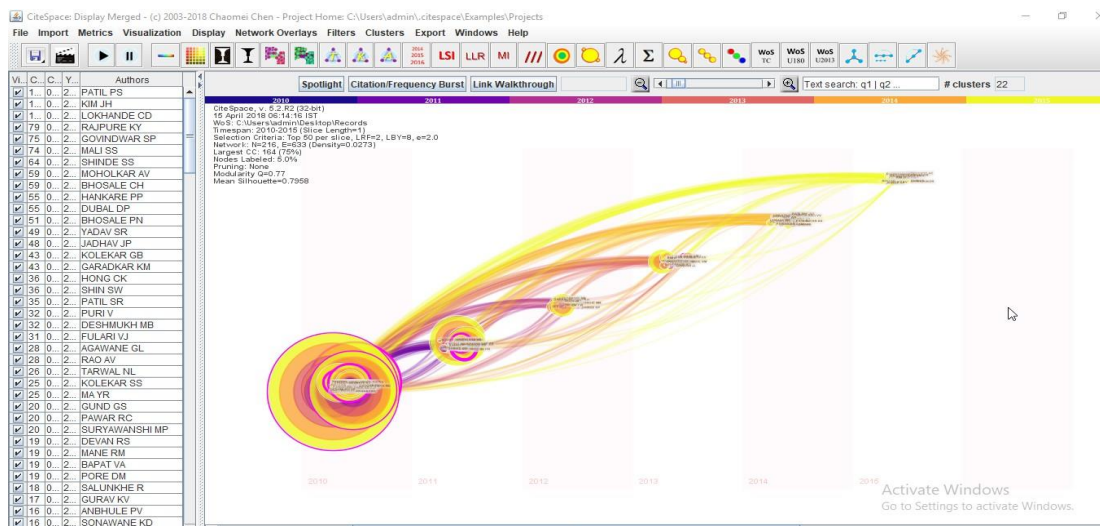
Screenshot 7: *Citespace Output Time zone View (AU productivity based- Shivaji University 2010-2015)*
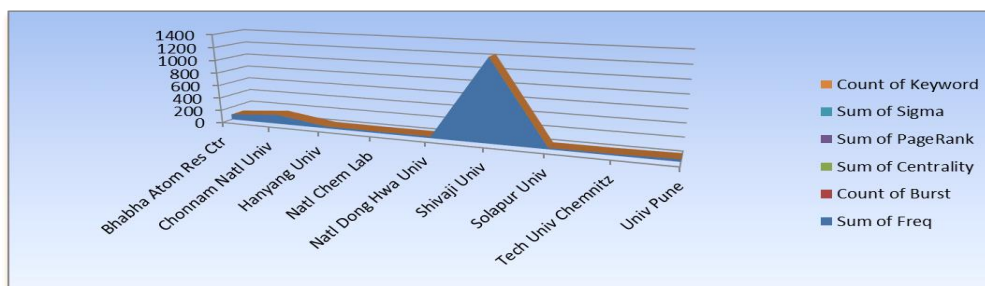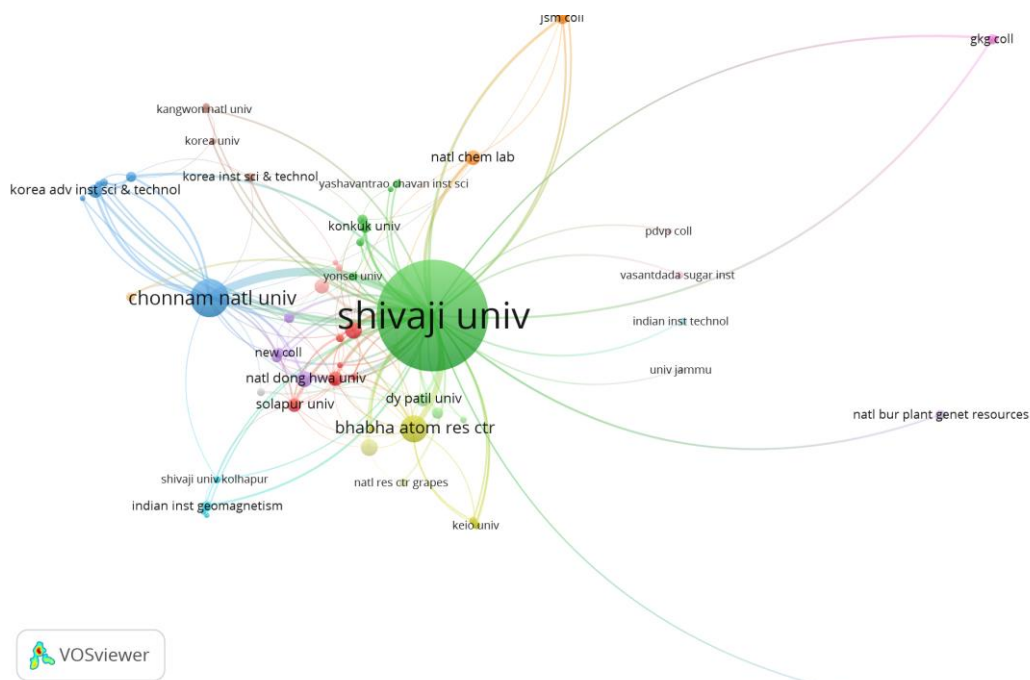

Screenshot 8: *Citespace Output Co-Institution Collaboration (Shivaji University 2010-2015)*
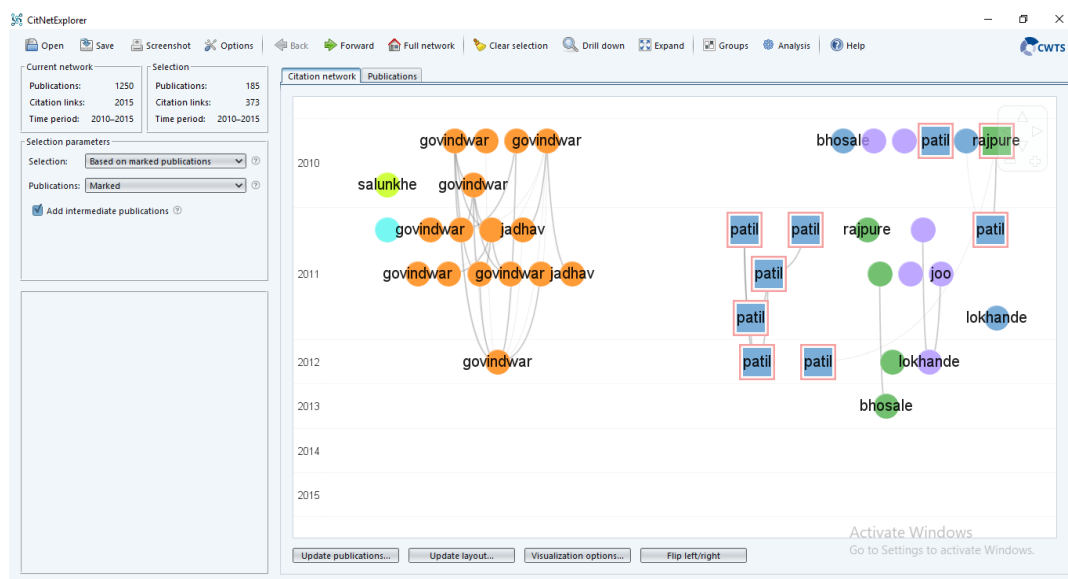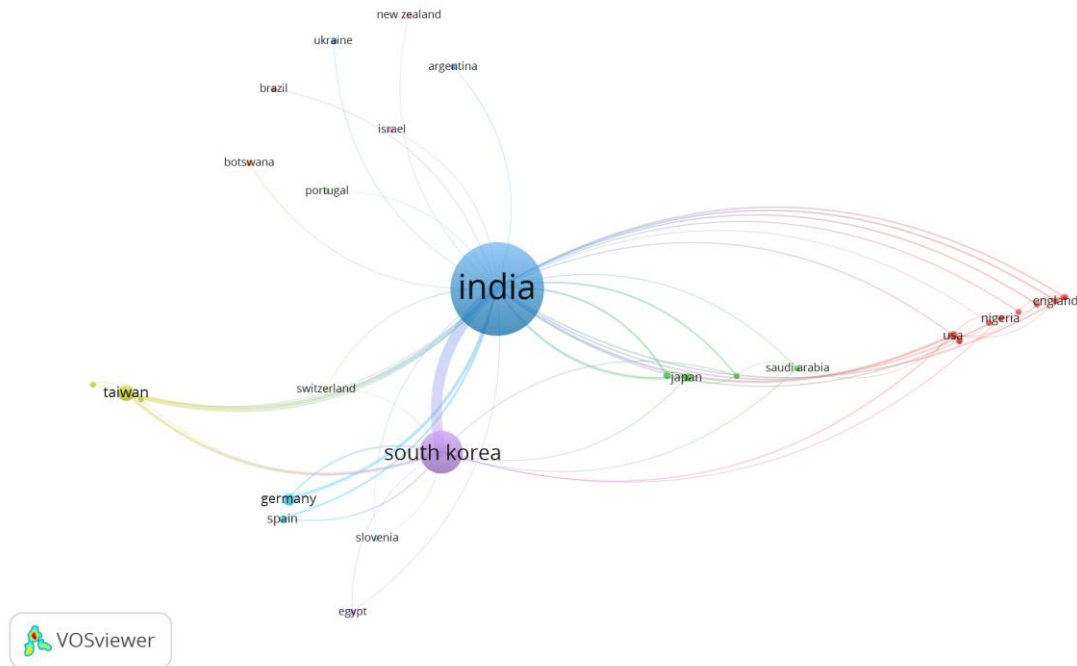
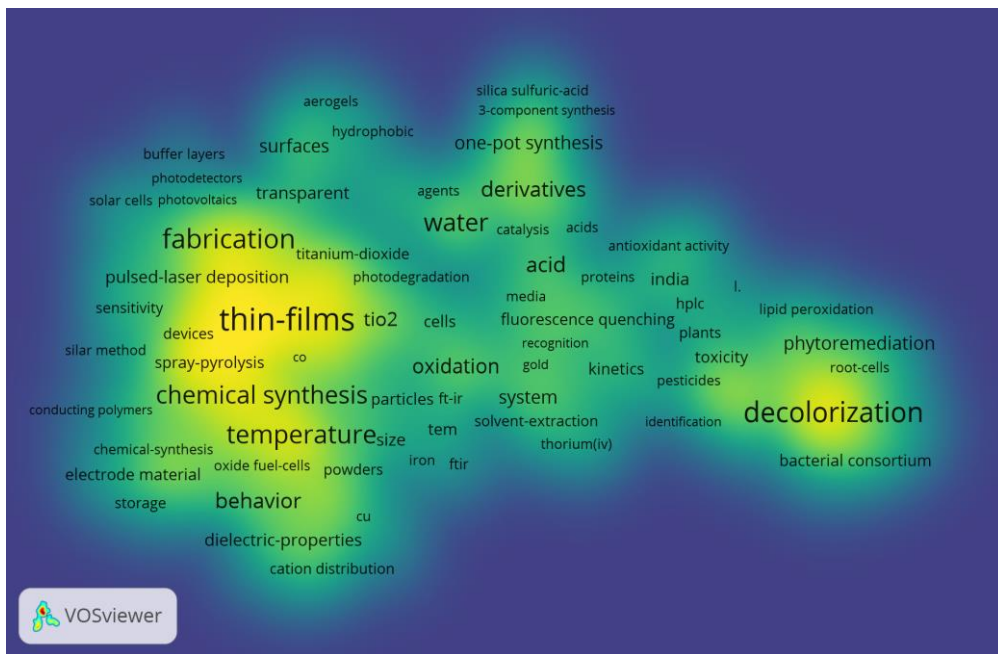**Screenshot 9:** *CiteNetExplorer Output (Co-Authorship Pattern- Shivaji University 2010-2015)*
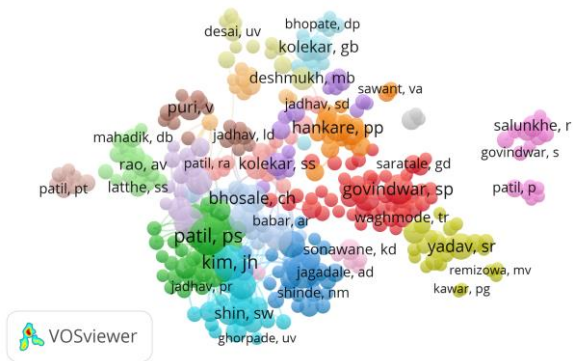
Screenshot 10: *VOSviewer Output Author Productivity (Shivaji University 2010-2015)*

Screenshot 11: *VOSviewer output Co-Authorship (Institution Base- Shivaji University 2010-2015)*

Screenshot 12: *VOSviewer output Co-Authorship (Country)*

Screenshot 13: *VOSviewer output Co-Occurrence (Density Visualization- Shivaji University 2010-2015*

Table 5: *Bibliometric networks.*

Software Tool	Bibliographic Coupling			Co-author			Co-citation			Co-Word	Points Gained
	Author	Document	Journal	Author	Country	Institution	Author	Document	Journal		
	(ABCA)	(DBCA)	(JBCA)	(ACAA)	(CCAA)	(ICAA)	(ACA)	(DCA)	(JCA)		
Bibexcel	✔	✔	✔	✔	✔	✔	✔	✔	✔	✔	20
POP	✔	✔	✔	X	X	X	✔	✔	X	X	10
CiteSpace	✔	✔	✔	✔	✔	✔	✔	✔	✔	X	18
CiteNetExplore	X	X	X	X	X	X	✔	✔	X	X	4
VOSviewer	✔	✔	X	✔	✔	✔	✔	✔	X	✔	16

Table 5 shows Bibliometric relations between the units of analysis: - Although there are no software tools able to build all of the different varieties of bibliometric networks, An essential thought in the utilization of some science mapping software tools is whether they are able to establish different relationships between the units of analysis, that is, if they are able to extract different Bibliometric networks. Each Bibliometric network unit holds 2 points in table.

Table 6 shows Normalization Measures used by software for the processing of data: Once the Bibliometric networks have been built, a normalization process can be carried out using different similarity measures Two of the analyzed software tools (Bibexcel & CiteSpace) use Salton's Cosine as a similarity

measure. Other software tool CiteNetExplorer Tool allows the users to define their own measures. PoP uses Hirch's Index [15], Eggh's Index & Zhang's Index [16] as normalization. VOSviewer is based on Association strength, Fractionalization and Linlog modularity.

Table 7 shows methods of analysis- Only CiteSpace use the four kinds of analysis. Only CiteSpace Tool has geocoding capabilities. CiteSpace uses Google and Yahoo!'s geo-coder over the institutional data available. Bibexcel only creates network. PoP have network and temporal capabilities. CiteNetExplorer have Network and Temporal analysis properties. VOSviewer shows Burst-detection with Network. Each method gets 2 points accordingly.

Table 6: Normalization measures.

Software Tool	Measure
Bibexcel	Salton's Cosine, Jaccard's Index, or theVladutz and Cook measures
Publish or Perish	Hirch'sIndex,Eggh's Index and Zhang's Index
CiteSpace	Salton's Cosine, Dice or Jaccard Strength
CiteNetViewer	User defined/No normalization
VOSviewer	Association Strength, Fractionalization and Linlog Modularity

Table 7: Methods of Analysis.

Software tool	Burst detection	Network	Temporal	Geospatial	Points Gained
Bibexcel	X	✔	X	X	02
Publish or Perish	X	✔	✔	X	04
CiteSpace	✔	✔	✔	✔	08
CiteNetExplorer	X	✔	✔	X	04
VOSViewer	✔	✔	X	X	04

Table 8: Ranking of selected software tools

Software	OS Compatibility	Record Format Compatibility	Bibliometric Network	Methods of Analyses	Total Points
Bibexcel	6	16	20	2	44
Publish or Perish	8	14	10	4	36
CiteSpace	4	22	18	8	52
CiteNetExplorer	4	4	4	4	16
VOSviewer	4	12	16	4	36

Table 9: Analysis of grading of selected science mapping software tools

Sr. No.	Software	Excellent	Very Good	Good	Average	Poor
1	CiteSpace	✔	X	X	X	X
2	Bibexcel	X	✔	X	X	X
3	Publish or Perish	X	X	✔	X	X
4	VOSviewer	X	X	✔	X	X
5	CiteNetExplorer	X	X	X	X	✔

(Gradings Based On Points:50-58 → Excellent, 40-50 → Very Good, 30-40 → Good, 20-30 → Average, Below 10→ Poor)

Other Aspects

In this subsection, Researcher compared the software tools according to other aspects such as documentation/help, etc Publish or Perish Tool has a great user guide where the tools are explained in detail. Furthermore, the user guide explains important aspects of science mapping; these are the only tool that explains these issues. CiteNetExplorer has a good user guide and online help, and its website provides a large amount of video-tutorials. CiteSpace has a great tutorials and online help. VOSViewer has a good manual with video tutorial. CiteSpace has a big wiki-where important issues are described.

FINDINGS AND CONCLUSION
Findings

The pre-processing capabilities of Bibexcel are one of its main strengths. It incorporates a high quantity of import filters that allows us to load data from almost all the bibliographical sources. Moreover, the database reduction and carriage return to filter the errors within records, helps the pre-processing task, especially the de-duplicating process. Publish or Perish & Citespace allows us to export a .csv file, so other software tools can read this data to perform their own science mapping analysis over the pre-processed data. POP has a good de-duplicating process too, but it is focused only on one kind of unit, the Authors. CiteNetViewer Tool has a good network reduction process.

The various data formats that can be accessed by particular software tool. Some of these software needs pre-processing of data before its use for analysis, export of databases through specified format is required for accurate & adequate analysis results.

WoS databases are compatible to all of the software tools.

Medline/Pubmed records can be assembled and analyzed through Bibexcel, Citespace and VOSviewer tools. POP and VOSviewer are compatible with crossref records. Citespace can export external saved data forms with Publication & Citation files. Bibexcel also supports other data forms such as winspires/Silverplatter, EI Compendex,

Endnote style. PoP have feature to access database of Microsoft Academic, Google scholar, and it also have external database export system. AOS,arXiv, CMKI, CSSCI 2.0, derwent, MSF and proquest records are compatible with Citespace tool. Crossref JSUM and API records can be used with VOSviewer to prepare visualizations.

The software tools allow us to generate various kinds of bibliometric networks, but as it were shown in Table No 5: **Bibliometric networks,** there is no single software tool able to extract all of them. Although there are no software tools able to build all of the different varieties of bibliometric networks, Bibexcel, CiteSpace, and VOSviewer are the software tools able to build the majority of them. By contrast, CiteNetExplorer is not able to build many of them; it is focused only on visualizing bibliometric maps. Publish or Perish is focused only on two kinds of Bibliometric networks. CiteNetExplorer can construct the maps using field of the dataset, its way of representing the documents, by using the vector space model, makes it difficult to generate the maps using other fields such as the bibliographic coupling. Bibexcel and Publish or Perish cannot focus on visualization of the maps.

Concluding Remarks

We should point out that this study does not incorporate all of the science mapping software tools used around the world. This is because researchers usually use their own adhoc software tools and algorithms, perhaps motivated by the lack of flexibility of available software tools. These software tools present different characteristics; for example, some of them are focused only on visualization and others have different pre-processing modules.

The software tools have different analysis methods (although some of them are common), which allow the analyst to discover different knowledge. Finally, because the visualizations are different in each one, different views of the field can be generated and these help to interpret and analyze the results. This cooperation among tools gives a positive synergy, which allows us to extract the knowledge hidden behind the data.

The concluding remarks can be given as among these five software tools:

CiteSpace could be considered as best one because it has capability to prepare the most of networks along with the visualizations. Bibexcel gets second position because of its lack of visualization capabilities. It also does not support Temporal and Geospatial methods of analysis. Publish or Perish and VOSviewer are third ranking- PoP enables us to export databases directly through web and VOSviewer can represent data in great visualized form that can illustrate the network easily. CiteNetExplorer remains last at ranking because of lacking in methods of analysis and Bibliometric Networks it can prepare only two types of networks (i.e. co-citation and co-authorship pattern).

Consequently, we think that a complete science mapping analysis of a particular field should be made using a variety of these software tools together for all the important knowledge forecasting and different perspectives (intellectual, social, or conceptual).

REFERENCES

1. Chen C, Ibekwe-San Juan F, Hou J. The structure and dynamics of co-citation clusters: A multiple-perspective co-citation analysis. *Journal of the American Society for information Science and Technology*. 2010;61(7):1386–1409, Available from: https://onlinelibrary.wiley.com/doi/abs/10.1002/asi.21309

2. Jacsó P. Calculating the h-index and other bibliometric and Scientometric indicators from Google Scholar with the Publish or Perish software. *Online Information Review*. 2009 Nov 27-33(6):1189–200., Available from: http://www.emeraldinsight.com/doi/10.1108/14684520911011070

3. Cobo MJ, López-Herrera AG, Herrera-Viedma E, Herrera F. Science mapping software tools: Review, analysis, and cooperative study among tools. *Journal of the American Society for Information Science and Technology*. 2011 Jul 62(7):1382–402, Available from: http://doi.wiley.com/10.1002/asi.21525

4. Mallig N. A relational database for bibliometric analysis. *Journal of Informetrics*. 2010 Oct;4(4):564–80, Available from: https://www.sciencedirect.com/science/article/abs/pii/S1751157710000611

5. Neuhaus C, Litscher A, Daniel H-D. Using scripts to streamline citation analysis on STN International. *Scientometrics*. 2007 Apr 1;71(1):145–50, Available from: https://akademiai.com/doi/abs/10.1007/s11192-007-1656-5

6. Van Eck NJ, Waltman L. Visualizing Bibliometric Networks. In: Ding Y, Rousseau R, Wolfram D, editors. *Measuring Scholarly Impact*. Cham: Springer International Publishing; 2014 p.285–320. Available from: http://link.springer.com/10.1007/978-3-319-10377-8_13

7. Wallace DP. The relationship between journal productivity and obsolescence. *Journal of the American Society for Information Science*. 1986 May 1 37(3):136–45, Available from: https://onlinelibrary.wiley.com/doi/abs/10.1002/%28SICI%291097-4571%28198605%2937%3A3%3C136%3A%3AAID-ASI4%3E3.0.CO%3B2-R

8. Persson O. How to use Bibexcel for various types of bibliometric analysis. *International Society for Scientometrics and Informetrics*. 2009; p 9–24, Available from: https://homepage.univie.ac.at/juan.gorraiz/bibexcel/

9. Harzing AW. Publish or Perish. 2007; Available from: https://harzing.com/resources/publish-or-perish

10. Chen C. CiteSpace II: Detecting and visualizing emerging trends and transient patterns in scientific literature. *Journal of the American Society for Information Science and Technology*. 2006;57(3):359-377. Available from: https://onlinelibrary.wiley.com/doi/abs/10.1002/asi.20317

11. 11.Van Eck NJ, Waltman L. CitNetExplorer: A new software tool for analyzing and visualizing citation networks. *Journal of Informetrics*. 2014 Oct 1 8(4):802–23, Available from: http://www.sciencedirect.com/science/article/pii/S1751157714000662

12. Van Eck NJ, Waltman L. Vosviewer: A Computer Program for Bibliometric Mapping. Rochester, NY: *Social Science*

STM JOURNALS

Research Network; 2009 Nov. Report No.: ID 1346848, Available from: https://papers.ssrn.com/abstract=1346848

13. Bibexcel- Umeå University, Sweden 2011. Available from: http://www.soc.umu.se/english/research/bibexcel/

14. 14. Van Eck NJ, Waltman L. Text mining and visualization using VOSviewer. *arXiv*:11092058 [cs]. 2011 Sep 9; Available from: http://arxiv.org/abs/1109.2058

15. Braun T, Glänzel W, Schubert A. A Hirsch-type index for journals. *Scientometrics*. 2006;69(1):169–173, Available from: https://link.springer.com/article/10.1007/s11192-006-0147-4

16. Shtovba S, Shtovba O. SH-INDEX – A NEW FRACTIONAL MODIFICATION OF HIRSCH-INDEX. Scientific Works of Vinnytsia National Technical University. 2011 Jan 1; Available from: https://works.vntu.edu.ua/index.php/works/article/view/292

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