SUPPORT VECTOR MACHINE (SVM)RESEARCH IN INDIA: A SCIENTOMETRIC EVALUATION OF INDIA'S PUBLICATIONS OUTPUT DURING 2002-19

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The present study examines "Support Vector Machines" (SVM) research in India based on bibliometric indicators with the aim to describe the status of research in the subject at global, national, institutional, and author level. The data for the study was sourced from Scopus database covering 18-year period 2002-19. The paper identifieskey countries, key subject areas, key SVM applications, key organizations and authors, key journals and highly-cited papers in SVM research. Indiaregistereda high 57.15% growth, and a 384%jump in its 9-year cumulative output. India contributed a 7.46% share to the global output, a 10.96% share as international collaborative papers, and a 6.37% share as sponsored research papers. SVM research by India registered an average of 13.10 citations per paper. China leads the world ranking with a global publication share of 48.60% share in SVM research, followed distantly by USA (9.81%), India (7.46%), etc.

Keywords: Support Vector Machine, Machine Learning, Algorithms, Data Mining, Indian publications, Bibliometrics, Scientometrics

INTRODUCTION

Support Vector Machine (SVM) is a type of algorithm in supervised machine learning domain most used for undertaking classifications tasks. While SVM algorithms can be employed for regression analysis tasks, but in practice they are most used for classification applications, such as classifying binary data into two distinct classes (Pupale, 2019; *What Is Support Vector Machine (SVM) In Machine Learning*, 2021). In addition, there are some other types of algorithms in machine learning such as decision trees, random forest, and K-NN which are employed also for both classification and regression analysis tasks. Allsuch algorithm types, including SVM, however, differ in their fundamental approach to find solution to classification problems. A SVM algorithm, in particular, is based on the basic concept to find the best decision boundary (a line in a graph) that segregates the plotted data points (vectors) into two distinct classes. The decision boundary is also known by other names such as decision plane, hyper plane, and boundary front (Burges, 1998; Campbell et al., 2006). A

SVM algorithm works to find the closest data point (support vector) of the boundary lines from both the classes. SVM further seeks to optimize a hyper planethat creates a maximum margin (the maximum distance) between the support data points (vectors).The term 'support vectors' in SVMrefers to coordinates for individual data point (vectors) in the plotted graph (Vadapalli, 2020). Value of each feature in a data point is the value of the specific coordinate. SVM uses labelled binary data (linearly sseparable data) as its input data and transforms it into required forms of output. But if in case input data type is non-linear, SVM classifies it using Kernel Tricks method (*Kernel Functions-Introduction to SVM Kernel & Examples*, 2017). SVMs are most used when input data size is small and manageable. SVMs have already become a popular tool for real-life applications such as face recognition, handwriting recognition, image processing, medical practice, computer vision, and pattern recognition, machine learning, applied statistics, and artificial intelligence(Sarkar, 2019). The advantages of using SVMs are higher accuracy; they work well on smaller cleaner datasets, and are rated more efficient. Over time, SVMs have become the focus of intense research across machine learning community including research, academia, industry and business. Given such on-going trends, it will be worthwhileif a bibliometric study be undertaken to analyze and evaluate SVM literature as published from India in global context with the aim to discover the status of research in the subject at global, national, institutional, and individual author level.

LITERATURE REVIEW

Till date, just a single research study has appeared in the bibliometric literature which has sought to analyse and evaluate China's publications output on 'Support Vector Machine". (Yu et al., 2020) sourced the data for their study from Web of Science and analyzed China'spublications output in SVM. They identified core countries, organizations, authors, journals, and most cited publications. The study further describes collaboration linkages between China and other countries, and between major research organizations in China using VOSviewer software. The study also identified the changes in the research hotspots overtime in the SVM field.

OBJECTIVES OF THE STUDY

The study seeks to examine India's research in "Support Vector Machine" (SVM) area in machine learning with the objective to understand the status of research in the subject at global, national, institutional, and individual author level based on bibliometric indicators. The study will be based on research publications as indexed in international Scopus database covering the publication period 2002-19. The study, in particular,will profile India's research output byi) publication source and type, (ii) publications annual and cumulative growth, (iii) international collaborative publications as a share of national output, (iv) distribution of publications by broad subject areas, by significant keywords, by research applications, by top organizations and authors, by most productive and most cited

journals and by highly-cited papers in India's output.

METHODOLOGY

For the present study, the publications output by India in "Support Vector Machine" research was searched, identified, retrieved and downloaded from the Scopus database (https://www.scopus.com) covering the period 2002-19. The "Support Vector Machine" as a keywords construct was applied to "TITLE" or "KEY" tags in the search bar and confined the search output to publication period '2002-19' using "date range tag". The search strategy so developed was initially used to discover global output. Subsequentlythe global output was refined by country of research participation (including India) to identify top 10 most productive countries in "Support Vector Machine". The main search strategy yielded a total of 19581 global publications and 1460 publications by India. The global output was further analyzed to identify 10 most productive countries. Using analytical provisions of Scopus database, the Indian publications data was further analyzed for its distribution by broad subjects, collaborating countries, author-wise, organization-wise and journal-wise output, etc. Citations to publications were counted from date of their publication till 1.10.2020.

(KEY ("SUPPORT VECTOR MACHINE") AND TITLE ("SUPPORT VECTOR MACHINE")) AND PUBYEAR > 2001 AND PUBYEAR < 2020 AND (LIMIT-TO (AFFILCOUNTRY, "India")).

SIGNIFICANCE OF THE STUDY

Since SVM is an important and upcoming area in machine learning and that just a single bibliometric study has been conducted till date with a focus on SVM research in China, it will be worthwhile that a bibliometric study is undertaken to understand the status of SVM research in India in the global context as well as at national, institutional, and individual author level.

ANALYSIS & RESULTS

Publications Analysis

As seen from the Scopus database, the global research output in the area of Support Vector Machine (SVM) accumulated a total of 19581 publications in 18 years during 2002-19. India accumulated a total of 1460 publications during the same period, accounting for a 7.45% global share in the subject. India registered a high annual growth rate of 57.15% compared to 13.17% for the global output. India witnessed a 384% increase in its 9-year cumulative output between 2002-10 and 2011-19. SVM research by India received an average of 13.10 citations per paper (CPP) since publication during 2002-19. The country witnessed a citation rate of 32.66 CPP in 2002-10 but it dropped to 13.10 CPP in 2011-19 (Table 1). In sum, it may be observed that SVM research in India witnessed a rapid growth vis-a-vis the growth in the global research in the subject.

During the study period 2002-19, India contributed a tiny share (6.37%, 93 publications) as output from sponsored research projects funded by more than 50 national and international funding agencies. India witnessed a significant

rise in its sponsored research papers from 19 in 2002-10 to to 74 publications in 2011-19. The sponsored research papers (93) received a total of 4665 citations since their publication in 2002-19, an average of 50.16 citations per paper, a substantially higher citation rate than the country citation rate of 32.66 CPP (Table 1). The leading funding agencies that had sponsored research projects in SVM research by India during 2002-19 were: CSIR and DST (14 papers each), Science & Engineering Board (10), UGC (9 papers), DST, Kerala (6 papers), DBT (5 papers), AICTE and DST, West Bengal (4 papers each), DRDO and MHRD (3 papers each), etc. Of the total output, articles and conference papers contributed the largest publications share (50.55% and 47.26%), followed by book chapters (1.85%), reviews (0.27%) and retracted (0.07%).

Table 1: Support Vector Machine (SVM) Research - Publications and Citations Data, India vs World during 2002-2019

Publication Period	Global	India					
	TP	TP	TC	CPP	%TP	ICP	%ICP
2002	238	2	95	47.50	0.84		
2003	315	3	62	20.67	0.95		
2004	461	11	299	27.18	2.39	2	18.18
2005	778	18	729	40.50	2.31	3	16.67
2006	937	20	1260	63.00	2.13	3	15.00
2007	986	33	1965	59.55	3.35	7	21.21
2008	1152	47	1272	27.06	4.08	7	14.89
2009	1373	51	1495	29.31	3.71	5	9.80
2010	1375	65	987	15.18	4.73	7	10.77
2011	1397	75	1583	21.11	5.37	10	13.33
2012	1349	82	1140	13.90	6.08	7	8.54
2013	1268	71	705	9.93	5.60	7	9.86
2014	1242	104	1504	14.46	8.37	5	4.81
2015	1160	148	2007	13.56	12.76	17	11.49
2016	1283	165	1420	8.61	12.86	21	12.73
2017	1286	144	1105	7.67	11.20	15	10.42
2018	1422	180	893	4.96	12.66	20	11.11
2019	1559	241	611	2.54	15.46	24	9.96
2002-10	7615	250	8164	32.66	3.28	34	13.60
2011-19	11966	1210	10968	9.06	10.11	126	10.41
2002-19	19581	1460	19132	13.10	7.46	160	10.96

TP=Total Papers; TC=Total Citations; CPP=Citations Per Paper; ICP=International Collaborative Papers

International Collaborative Research Output by India

Out of 1460 publications by India, 160 (10.96%) appeared as international collaborative papers, a 13.60% share in 2002-19. In 2002-10 this share was 32.66% but it dropped to 9.06% in 2011-19, a significant fallin collaborative research output share between 2002-10 and 2011-20. As a share of total 160 international collaborative papers in 2002-19, India's collaboration with top 10 countries variedfrom 3.75% to 19.38%. India's collaboration with the USA was the largest (19.38% share of 160 ICP output), followed by South Korea (10.0%), and with eight other countries its collaboration varied between 3.75% and 8.75%. Except for the U.K., Germany and the USA (where ICP share dropped from 4.06% to 27.69%), India witnessed a rise in its collaboration by 1.5% to 11.11% with rest of thecountries between 2002-10 and 2011-19 (Table 2).The 160 international collaborative papers received a total of 3603 citations since their publication in 2002-19, an average of 22.52 CPP.

Most Productive Countries in the World

A total of 104 countries participated in the global "Support Vector Machine" research during 2002-19. The distribution of publications output by country of participation in SVM research is highly skewed. Out of a total 104 countries, 61 contributed 1-10 papers each, 28 countries 11-50 papers each, 15 countries 51-100 papers each, 24 countries 101-692 papers each and 3 countries contributed 1460-9516 papers each. The bulk of the global output,a84.59% share in SVM research, came from 10 most productive countries alone. China leads in global ranking with a high publication share of 48.60% of global output, followed distantly by the USA (9.81%), India (7.46%), Taiwan (3.53%), Japan, Iran, U.K., South Korea, Germany and Australia (from 2.35% to 2.83%) during the period. During the period

Table 2: Support Vector Machine Global Research - Most Productive Countries during 2002-2019

Sl. No.	Name of the Country	Number of Papers			Share of Papers		
		2002-10	2011-19	2002-19	2002-10	2011-19	2002-19
1	China	3910	5606	9516	51.35	46.85	48.60
2	USA	905	1015	1920	11.88	8.48	9.81
3	India	250	1210	1460	3.28	10.11	7.46
4	Taiwan	331	361	692	4.35	3.02	3.53
5	Japan	251	303	554	3.30	2.53	2.83
6	Iran	96	428	524	1.26	3.58	2.68
7	U.K.	214	287	501	2.81	2.40	2.56
8	South Korea	210	295	505	2.76	2.47	2.58
9	Germany	191	241	432	2.51	2.01	2.21
10	Australia	169	291	460	2.22	2.43	2.35
Total of 10 countries		6527	10037	16564	85.71	83.88	84.59
World		7615	11966	19581	100.0	100.0	100.0

between 2002-10 and 2011-19,India, Iran and Australia witnessed a rise in their global publication share by 0.21% to 6.83%. For other 7 countries it dropped by 0.29% to 4.50% during the same period (Table 2).

Collaborative Linkages of Top 10 Most Productive Countries

All of the top 10 most productive countries had one to one collaborative linkages in SVM research. The top three countries, namely China, the USA and the U.K.ccollaboratedwithina network of 10nodes and each registered (596, 580 and 219) collaborative linkages respectively. Figure 1 provides a visual view of the collaborative network chart of top 10 countries which occur in three clusters (blue, green, and red). The thickness of links between the countries and also the distance between them represents the degree of their research collaboration. The bigger the diameter of a network node and its font size, the bigger its weight in research collaboration. The network visualization chart was created using Biblioshiny tool. The last three countries Taiwan, Iran and India in the top 10 countries list collaborated with 8-9 nodes and created 287, 95 and 101collaborative linkages respectively. Among the list of country-country collaboration, USA-China registered the highest number of collaborative linkages (349), followed by China-U.K. (108), China-Australia (84 linkages), China-Japan (71 linkages), etc.

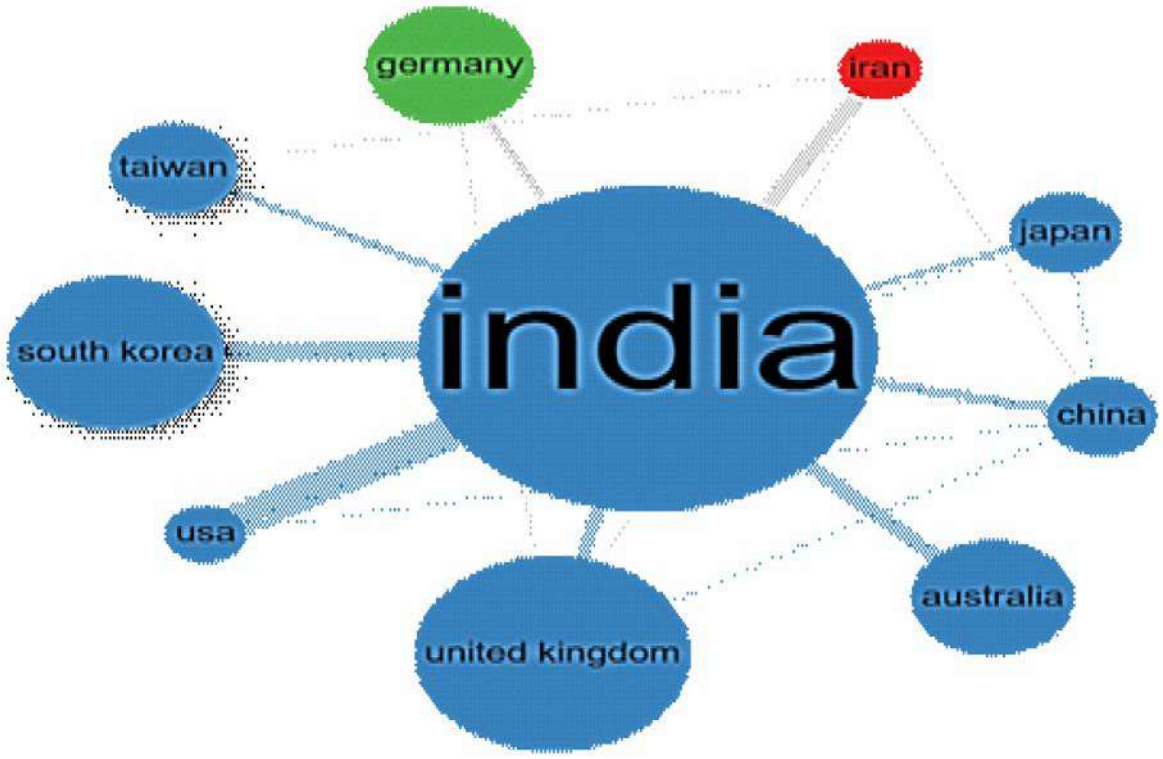

Figure 1. Collaboration network among Countries

Subject-Wise Distribution of Global Research Output

The Scopus database classified the global SVM research output under 10 broad disciplines (Table 5). The SVM research share was the largest in Computer Science and Engineering accounting for a 65.0% and 44.52% global share respectively, followed by Mathematics (15.89%) and other 7 broad subject areas registered a 3.90% to 7.33% share during 2002-19. Based on evaluation of SVM research on activity index measure, it was observed that specialization level increased in Computer Science (from 89.23 to 102.23), Engineering (from 96.14 to 100.80), Physics & Astronomy (from 65.50 to 107.13), and Medicine (from 47.53 to 110.84) during 2002-10 to 2011-19. On the other hand, specialization level dropped in Earth & Planetary Science, Biochemistry, Genetics & Molecular Biology, Environmental science and Materials science during the same period. Earth & Planetary Science registered the highest citation impact per paper of 24.0, Physics & Astronomy registered the least citations per paper (8.13) (Table 3).

Types of Kernels used with SVM Algorithms

SVM algorithms use a set of mathematical functions that are defined as kernel. A Kernel'sfunction is to take data as input and transform it into the required form. "Kernels"transforms a non-linear decision surface to a linear equation. The most preferred types of kernels areWavelet(with 105 papers), followed by Gaussian RBF (88 papers), Quadratic (28 papers), Gaussian (22 papers), Polynomial kernel (19 papers), Linear and Gradient Descent (!0 papers each) and Cauchy (2 papers), etc.

Significant Keywords

A set of 26 keywords (assumed to be significant) has been identified from SVM research publications by India. The co-occurrence of these keywords offer a secondary support to

Table 3: Subject-Wise Breakup of India's Publicationson Support Vector Machines Research during 2002-2019

Sl. No.	Subject*	Number of Papers (TP)			Activity Index		TC	CPP	%TP
		2002-10	2011-19	2002-19	2002-10	2011-19	2002-19		
1	Computer Science	145	804	949	89.23	102.23	11427	12.04	65.00
2	Engineering	107	543	650	96.14	100.80	7200	11.08	44.52
3	Mathematics	40	192	232	100.69	99.86	3130	13.49	15.89
4	Physics & Astronomy	12	95	107	65.50	107.13	870	8.13	7.33
5	Energy	21	81	102	120.24	95.82	1897	18.60	6.99
6	Medicine	7	79	86	47.53	110.84	918	10.67	5.89
7	Earth & Planetary Science	22	54	76	169.05	85.73	1825	24.01	5.21
8	Biochemistry, Genetics & Molecular Biology	19	55	74	149.95	89.68	1439	19.45	5.07
9	Environment Science	12	57	69	101.57	99.68	1599	23.17	4.73
10	Materials Science	10	47	57	102.46	99.49	759	13.32	3.90
Global Output		250	1210	1460			19132	13.10	
TP=Total Publications; TC=Total Citations; CPP=Citations Per Paper									

identify key research trends in the SVM area. These keywords are listed in the decreasing order of the frequency of their occurrence in the literature published during 2002-19 (Table 4). Using VOSviewer software, a network chart of keywords co-occurrences reveals that keywords occur in four clusters (Red cluster 1 (12 items), Green cluster 2 (6 items), blue cluster (5 items) and yellow cluster 4 (3 items) respectively). The chart shows the relationship between the one topic and another. The more often a keyword appears, the greater the size of the letters and circles (Figure 2).

Table 4: Support Vector Machines Research - Significant Keywords in Indian Publications, 2002-2019

Sl. No.	Name of the Keyword	Frequency	Sl. No.	Name of the Keyword	Frequency
1	Support Vector Machine (SVM)	1403	14	Learning Algorithms	83
2	Classification of Information	302	15	Optimization	79
3	Vectors	302	16	Radial Basis Function (RBF) Networks	76
4	Feature Extraction	198	17	Image Processing	72
5	Artificial Intelligence	150	18	Pattern Recognition	66
6	Learning Systems	150	19	Prediction	66
7	Algorithms	139	20	Image Segmentation	65
8	Neural Networks	133	21	Artificial Neural Networks	64
9	Machine Learning	106	22	Signal Processing	64
10	Forecasting	106	23	Speech Recognition	55
11	Image Retrieval	100	24	Wavelet Transforms	55
12	SVM Classifiers	93	25	Face Recognition	49
13	Data Mining	84	26	Diseases	48

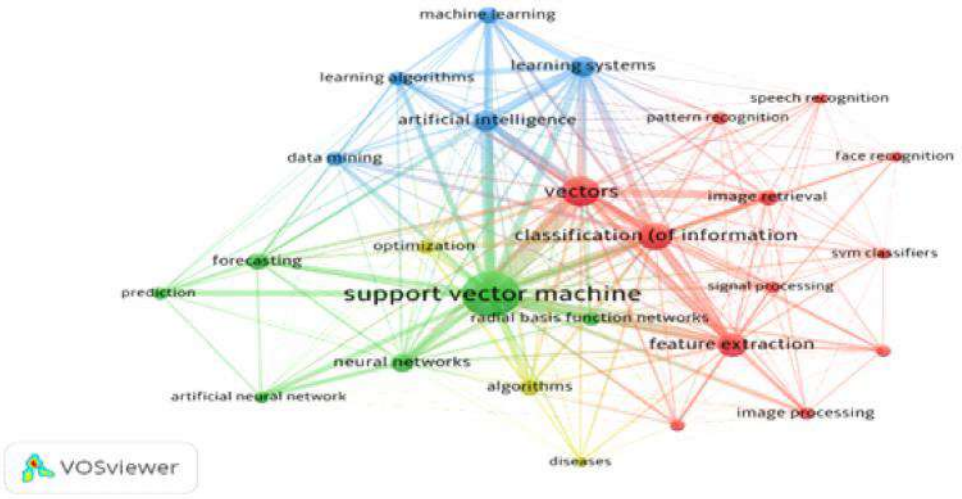

Figure 2. Keyword co-occurrence network of SVM publications in India

Applications of SVM Algorithm

SVM algorithms have been used in 24 different applications in India. "Classification" applications account for the highest share in total publications (24.11%), followed by image classification (15.55%), forecasting (7.19%), signal analysis & processing (7.19%), pattern classification & recognition (5.82%), medical Disease diagnosis & imaging (5.68%), optimization (5.48%), Fault classification, detection and diagnosis,Prediction and Speech recognition, analysis & communication (from 4.45% to 4.73%), Facial & Expression recognition, Cancer/Tumor detection, Electro cephalogram (EEG), Clustering Algorithms and Gene Classification (from 2.19% to 3.56%), ECG Beat Classification, Text classification & processing, Risk assessment, Rule Extraction, Reliability Analysis, Fingerprint & Palm Classification, Drug Design, RIS Recognition and Product Classification (from 0.21% to 1.92%) during 2002-19.

Top 30 Most Productive Organizations

A total of 290 organizations participated in SVM research by India during 2002-19. The distribution research by organizational productivity is much skewed. Out of 290 organizations, 209 published 1-5 papers each, 46 published 6-10 papers each, 24 published 11-20 papers each and 11 published 21-53 papers each. The productivity of top 30 most productive Indian organizations varied from 12 to 53 publications per organization; together they accounted for a 46.58% (680) share of country output, and a 61.19% (11707) share of total citations during 2002-19. A scientometric profile of top 10 most productive and 10 most cited organizations is presented in Table 5.Eleven of the 30 organizations registered their productivity above the group-of-30 average (22.67): VIT – Vellore (53 papers), IISc-Bangalore and IIT-New Delhi (46 papers each), Jadavpur University, Kolkata (45 papers), Anna University, Chennai (43 papers), IIT-Madras (35 papers), Amrita Vishwa Vidyapeetham (30 papers), IIT-Roorkee (27 papers), NIT-Kurukshetra (25 papers), NIT-Rourkela (24 papers) and IIT-Guwahati (23 papers);

- Nine of top 30 organizations registered their citations per paper and relative citation index above the group-of-30 average (17.22 and 1.31): IIT - New Delhi (50.37 and 3.85), IISc –Bangalore (42.48 and 3.24), ISI-Kolkata (39.75 and 3.03), Amrita School of Engineering, Coimbatore (31.6 and 2.41), IIT-Roorkee (28.59 and 2.18), NIT-Karnataka (24.08 and 1.84), NIT-Kurukshetra (22.0 and 1.68), NIT-Rourkela (20.71 and 1.58) and Jadavpur University, Kolkata (17.62 and 1.35).

Collaboration linkages among top 20 organizations

Except for six, all of the organizations in the top 30 list have had at least one to one collaboration.The top three organizations Anna University, Chennai, Madras Institute of Technology, Varanasi and Indian Institute of Technology, New Delhicollaboration with 2-4 countries nodes each and created with largest collaborative linkages (20, 15 and 14) respectively. Figure 3 depicts network relationship of top 30 organizations created using Biblioshiny tool. The sizeof the node in the network chart depends upon the number of its

Table 5: Top 10 Most Productive and Most Impactful Organizations in Support Vector Machine Research 2002-2019

Sl. No.	Name of the Organization	TP	TC	CPP	HI	ICP	ICP (%)	RCI
Top 10 Most Productive Organizations								
1	Vellore Institute of Technology (VIT), Vellore	53	570	10.75	14	19	35.85	0.82
2	Indian Institute of Science (IISc)-Bangalore	46	1954	42.48	17	5	10.87	3.24
3	Indian Institute of Technology (IIT), New Delhi	46	2317	50.37	18	10	21.74	3.85
4	Jadavpur University, Kolkata	45	793	17.62	13	7	15.56	1.35
5	Anna University, Chennai	43	207	4.81	7	2	4.65	0.37
6	Indian Institute of Technology (IIT),Madras	35	302	8.63	10	3	8.57	0.66
7	Amrita Vishwa Vidyapeetham	30	512	17.07	9	0	0.00	1.30
8	Indian Institute of Technology (IIT), Roorkee	27	772	28.59	14	8	29.63	2.18
9	National Institute of Technology (NIT), Kurukshetra	25	550	22.00	12	4	16.00	1.68
10	National Institute of Technology INIT), Rourkela	24	497	20.71	10	5	20.83	1.58
Top 10 Most Impactful Organizations								
1	Indian Institute of Technology (IIT), New Delhi	46	2317	50.37	18	10	21.74	3.85
2	Indian Institute of Science (IISc)-Bangalore	46	1954	42.48	17	5	10.87	3.24
3	Indian Statistical Institute (ISI), Kolkata	12	477	39.75	7	2	16.67	3.03
4	Amrita School of Engineering, Coimbatore	15	474	31.6	6	0	0	2.41
5	Indian Institute of Technology (IIT), Roorkee	27	772	28.59	14	8	29.63	2.18
6	National Institute of Technology (NIT), Karnataka	13	313	24.08	6	3	23.08	1.84
7	National Institute of Technology (NIT), Kurukshetra	25	550	22	12	4	16	1.68
8	National Institute of Technology INIT), Rourkela	24	497	20.71	10	5	20.83	1.58
9	Jadavpur University, Kolkata	45	793	17.62	13	7	15.56	1.35
10	Amrita Vishwa Vidyapeetham	30	512	17.07	9	0	0	1.3

TP=Total Publications; TC=Total Citations; CPP=Citations Per Paper; ICP=International Collaborative Papers; RCI=Relative Citation Index

publications. The various colors in the visualization networks represent 19 co-operation clusters. The largest clusters(in blue) includesNIT Kurukshetra, South Asian University New Delhi, Bannari Amman Institute of Technology, IIT Roorkee and IIT New Delhi respective organizations. The second largest cluster (in purple) includes VIT Vellore, Anna University Chennai and IISc. Bangalore were the leading organizations.

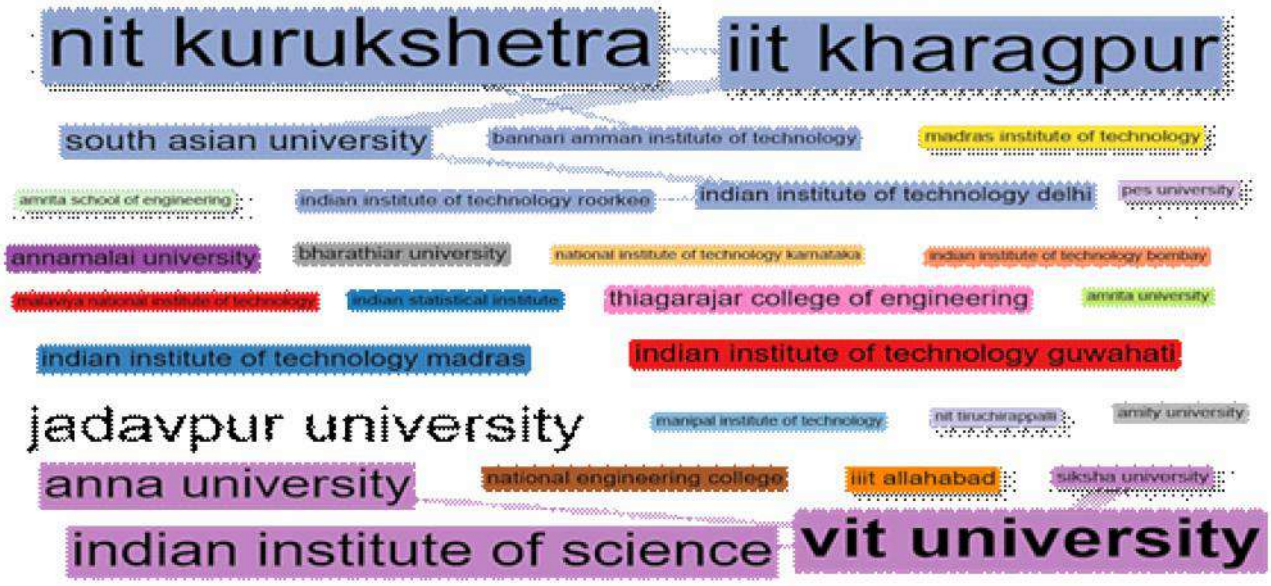

Figure 3. Organizations Collaboration network of SVM publications in India

Top 30 Most Productive Authors

A total of 378 authors participated in SVM research by India during 2002-19. Of these, 336 authors published 1-5 papers each, 29 authors 6-10 papers each and 13 authors 11.37 papers each. The research productivity of top 30 most productive authors varied from 7 to 37 publications per author. Together they accounted for a 22.60% (330) share in the total output by India and a 48.80% (9337) share in total citations during 2002-19. A detailed scientometric profile of top 10 most productive and most cited authors is presented in Table 6.

• Nineof top 30 authors registered their productivity above the group-of-30 average 11.0: P. Samui (37 papers), R. Tiwari (19 papers), S. Chandra (17 papers), R. Khemchandani and M. Pal (14 papers each), V.K. Jayaraman and K.P.Soman (13 papers each), A. Agarwal and A.D. Dileep (12 papers each);

• Eight of top 30 authors registered their citation per paper and relative citation index above the group-of-30 average (28.29 and 2.16): Jayadeva (145.0 and 11.07), K.I. Ramachandran (91.14 and 6.96), R. Khemchandani (85.71 and6.54), V. Sugumaran (85.38 and 6.52), S. Chandra (70.24 and 5.36), H.P. Khincha (38.0 and 2.9), I. Prakash (36.5 and 2.79) and D. Thukaramkandan (35.09 and 2.68).

Table 6: Top 10 Most Productive and Most Impactful Authors inVector Support MachinesResearch by India 2002-2019

Sl. No.	Name of the Author	Affiliation of the Author	TP	TC	CPP	HI	ICP	ICP (%)	RCI
Top 10 Most Productive Authors									
1	P. Samui	VIT-Vellore	37	662	17.89	14	15	40.54	1.37
2	R. Tiwari	IIT – Guwhati	19	249	13.11	10	0	0.00	1.00
3	S. Chandra	IIT-New Delhi	17	1194	70.24	10	0	0.00	5.36
4	R. Khemchandani	IIT – New Delhi	14	1200	85.71	10	0	0.00	6.54
5	M. Pal	NIT – Kurukshetra	14	394	28.14	8	1	7.14	2.15
6	V.K. Jayaraman	NCL-Pune	13	209	16.08	7	0	0.00	1.23
7	K.P.Soman	Amrita Vishwa Vidhyalaya	13	182	14.00	7	0	0.00	1.07
8	A. Agarwal	IIIT-Allahabad	12	185	15.42	6	0	0.00	1.18
9	A.D. Dileep	IIT-Madras	12	120	10.00	6	0	0.00	0.76
10	D. Gupta	NIT-Arunachal Pradesh	11	55	5.00	5	4	36.36	0.38
Top 10 Most Impactful Authors									
1	Jayadeva	IIT-New Delhi	7	1015	145.00	5	2	28.57	11.07
2	K.I.Ramachandran	Amrita Vishwa Vidyapeeth	7	638	91.14	5	0	0	6.96
3	R. Khemchandani	IIT – New Delhi	14	1200	85.71	10	0	0	6.54
4	V.Sugumaran	Amrita Vishwa Vidyapeetham	8	683	85.38	7	0	0	6.52
5	S. Chandra	IIT-New Delhi	17	1194	70.24	10	0	0	5.36
6	H.P.Khincha	IISc-Bangalore	10	380	38.00	5	0	0	2.9
7	I. Prakash	University of Transport Technology	8	292	36.5	8	8	100	2.79
8	D. Thukaramkandan	IISc-Bangalore	11	386	35.09	5	0	0	2.68
9	M. Pal	NIT – Kurukshetra	14	394	28.14	8	1	7.14	2.15
10	B.D.Kulkarni	NCL-Pune	8	193	24.13	6	0	0	1.84
TP=Total Publications; TC=Total Citations; CPP=Citations Per Paper; ICP=International Collaborative Papers; RCI=Relative Citation Index									

Collaborative linkages of top 30 authors

Except for eight, all of the other22 authors in top 30 list have had at least one to one collaborative linkages. The top three S. Chandra, R. Khemchandani and R. Tiwariwith largest collaborative linkages (22, 18 and 14) have collaborated with 2-4 other authors. Figure 4 portrays top 30 authors in the co-authorship visualization network chart created by using Biblioshiny tool. Most productive authorssuch as Chandra S., Khemchandani R., Rastogi R., and Sharma S. are in cluster 1, followed by Bordoloi D.J., Gangsar P. And Tiwari R. in cluster 2 respectively.

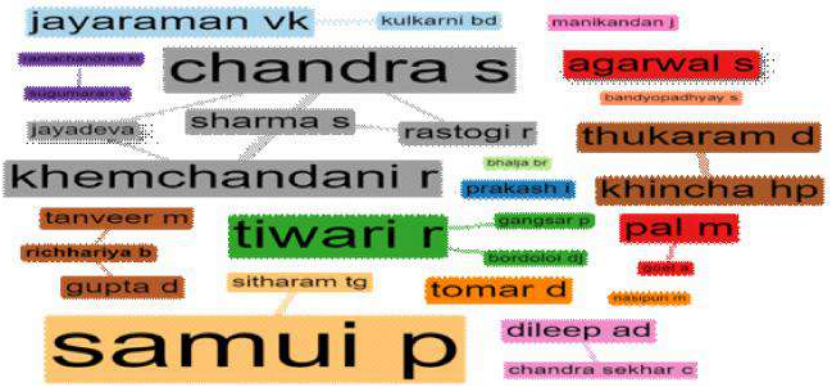

Figure 4. Collaboration network among authors in SVM publications in India

Medium of Research Communication

A 50.82% (742) share SVM research by India during 2002-19 appeared in journals, 38.08% (556) in conference proceedings, 10.34% (151) in book series, 0.62% (9) as books and 0.14% (2) in trade journals during 2002-19. A total of 220 journals reported 738 articles. The distribution of articles in journals is skewed. Of 220 journals, 209 published 1-5 papers each, 5 published 6-10 papers each, and 6 published 11-27 papers each 2002-19.The top 30 most productive journals accounted for a 33.60% share of "Support Vector Machine" research output in journals. In 2002-10 this share was 15.15%, which increased to 37.62% in 2011-2019.

The top 8 most productive journals in SVM research are i) International Journal of Applied Engineering Research (27 papers), ii) Journal of Advanced Research in Dynamical & Control Systems (16 papers), iii) International Journal of Recent Technology & Engineering (14 papers), iv) Applied Soft Computing Journal (13 papers),v) Measurement Journal of the International Measurement Federation (13 papers), vi) International Journal of Innovative Technology & Exploring Engineering (12 papers), vii) Expert Systems & Applications (10 papers) and viii) Applied Intelligence (8 papers). The top 8 most cited journals are i) IEEE Transactions on Power Delivery (131.8), ii) Expert Systems & Applications (104.1), iii) Information Sciences (74.0), iv) Neurocomputing (60.38), v) International Journal of Remote Sensing (52.0), vi) Applied Soft Computing Journal (47.38), vii) Environmental Earth Science (40.8) and viii) International Journal of Electric Power & Energy Systems (39.0)

SUMMARY AND CONCLUSION

The paper has analysed and evaluated "Support Vector Machine" (SVM) research by India in global context with the aim to describe status of research in the subject at global, national, institutional, and individual author level. The publications data for the study covering the period 2002-19 was sourced from Scopus database. The study reveals that India accounts for a 7.45% global share in SVM research. Despite its small global share, India ranks third most productive country in the world. In the global list of top 10 productive countries, China leads the list with a 48% global share, followed distantly by the USA 9.81% share. Out of top 10 most productive countries, nine are just distant cousins to China in SVM research. Their cumulative share is nearly 46% compared to 48.60% by China alone. This highlights that the contribution of Chine in the global SVM research has been big and dominating. India registered a rapid 57.14% growth, four times the global growth rate (13.17%) in the subject. India witnessed a surge in its 9-year output by 384% in 2011-19 over its 9-year output in 2002-10. India registered a significantly high citations rate of 30.66 CPP for its SVM research output in 2002-10, and it is far above country average rate of 13.10 citations per paper in 2002-19.

The study finds that all of the top 30 institutes in SVM research in India belong to higher education sector. None of them is either from research, industry, or business sector. This drives home the point that by far the academia alone has been the driver of SVM research in India. Secondly, none of the institutes from the top 30 list belong to private academic sector. Only the institutes supported and funded by the government

agencies in the state and centre dominate SVM research space in India. Thirdly, classification and image processing are the most popular applications of SVM research vis-a-vis other applications as 47% share of the national output accounts for such applications alone. India's share of international collaborative papers (ICP) was merely 10.96%, it reveals the fact that the country did not give much importance to international collaboration in SVM research. India's share of output through sponsored research was merely 6.3%. It appears that SVM research is still not a priority area for sponsored research in the country. In addition, the study has identified the key academic institutes, key countries, key authors, key journals, and key subject areas in SVM research. The study concludes that India's position in SVM research vis-a-vis China is weak. India has a potential to contribute significantly to SVM research, but a great deal of planning and funding is required at a policy level to enable and catalyse academia, research, industry, and business sectors for to play a bigger role in SVM research in the country.

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