Section A-Research paper

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A Bibliometric Survey on Tsetlin

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Abstract: In this paper, Bibliometric survey has been carried out on Tsetlin. Tsetlin- an automaton that has learning capability developed M L Tsetlin in 1960s. Recently, Tsetline machines are developed and used in game theory, and may be used in many more upcoming technologies. Recent studies proved that the classification results obtained using Tseltin machines are competitive compared with Decision tree, Random Forest, Neural Networks, Support Vector Machine, Naïve Bayes Classifier and Logistic regression. When the search is made using key 'Tsetlin' in Scopus database, it shows 372 documents as a result. Scopus database is the most trusted database, so most of the researchers are publishing papers in journals cited by Scopus database. Hence, Scopus database is considered to conduct bibliometric analysis in this paper. The statistical analysis is carried out source wise, year wise, area wise, Country wise, University wise and author wise. Network analysis is also carried out using VOSviewer1.6.16 software. The Source for all tables and figures is www.scopus.com. The data is assessed on 24thJuly, 2021.

Key Words: Automata, Boolean Algebra, Classification, Deep Learning, Game Theory, Lattice Theory, Neural Networks, Support Vector Machine, Tsetlin, Tsetlin Machine.

1. INTRODUCTION

The performance of machine learning algorithms is acceptable for many applications as they are giving better results compared to any other models. Deep learning networks accuracy is even better in some applications. In order to implement these applications, an expert is required to build the system or to develop an algorithm. This process is complex and even expensive. A

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better approach was initiated by M L Tsetlin in the early of 1960 in the form of Tsetlin Automata [1]. Based on biological systems, Tsetlin Automata was developed. It has considerable attraction because these automata is able to acquire the best action even in unknown stochastic environments with low computational complexity and accurate convergence [2, 3]. This automaton learns based on reinforcement learning. The new state i.e result of the automaton depends on present state, present input and past history. That's how the new Tsetlin automaton are another class of Machine Learning algorithm [2, 4-5].

In the year 2018, a novel machine learning paradigm is introduced based on Tsetlin Automata and FSLA (first Finite State Learning Automaton) called Tsetlin Machine (TM) which have good number of properties [6-11]. Arguably, these machines are replacement of Neural Networks. Tsetlin machines are efficient and accurate and works well even in the uncertain environment. These machines are inexpensive compared to neural network and deep neural network.

The following search is carried out on Scopus Database. The number of documents published in Scopus database are 372. The key used to find the documents is:

TITLE-ABS-KEY (tsetlin).

2. LITERATURE SURVEY

The Literature survey presented here are based on Tsetlin Automaton learning, new approached developed to make TA powerful, development of Tsetlin machine and application of Tsetlin machine.

Unified theory of combinational switching networks was presented by Yoeli, M. in 1959 [12], using the help of lattice algebra and linear graph theory. The kinematics of running of the dog on a treadmill are investigated by Shik, M.L. et al., and they also drawn conclusions which may also apply to the general case of control of movement [13]. The design of an asymptotically optimal active automaton in a complex medium is presented by Yerokhin, A.T., in 1970 [14]. The work considered by Yerokhin A T is, the generalization of one of the postulates of the theory of M.L. Tsetlin.

The final distribution and its asymptotic properties for an infinitely increasing number of players in gore game as functions of the memory capacity is presented in [15]. The behavior of the group of automata approaches 1 in which each of the automata, independently of the rest,

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chooses one of the two actions with equal likelihood, without reacting to penalties or rewards that it might receive.

A non-stationary medium is proposed by Takeuchi, et al., as a medium with more complex behavior to analyze the behavior of finite automata. The authors proposed a kind of probabilistic automaton, which includes as special cases all media discussed hitherto, reveals that a systematic discussion of all the individual problems is possible, and gives examples of interaction between automata and a media with certain structures [16]. The probabilistic automaton is introduced by Tsuji, H et al.[17].

Tsuji et al., presented the behavior of automata while expressing the probabilistic properties of nonstationary environments in terms of sequences of uniformly distributed random numbers [18]. Matrix representation for the efficient computation of the U(n), unitary group in the Gelfand-Tsetlin was presented by Downward M J et al. [19]. The validity of Estes' learning theory using the Tsetlin model is presented by Takeuchi, A. [20]. A novel solution to the symplectic group state labeling problem is presented by Gould, M.D., and Kalnins, E.G [21].

Li, X., and Paldus, J. described an algorithm that implement valence bond (VB) method using CAUGA (Clifford algebra unitary group approach) [22]. Akimov, V., and Soutchanski, M. investigated cooperation in a simulated evolution process [23]. Molev, A.I. constructed an analog of the Gelfand-Tsetlin [24]. Brown K S analyzed a class of semigroups called "left-regular bands" [25]. Cheng S J., gave a representation-theoretical interpretation of the Gelfand-Tsetlin pattern for strict partitions [26].

Regenwetter, M., and Tsetlin, I. extended the inference framework of Tsetlin [27]. Guillemin, V.,and Rassart, E. proved signature analogues of the Kostant formula [28]. The results of research in the use of the Bellman-Zadeh approach was presented in[29] and decision making approach is presented in [30].

M. L. Tsetlin introduced GG (Goore Game) in 1973 that has the fascinating property. The concept used in GG is included in various fields like Quality-of-Service (QoS) routing and sensor networks [31-32]. Futorny, V., and Ovsienko, S., provided solution to the extension of commutative subalgebra and showed that it always solvable [33]. Alexandersson, P, gave a combinatorial proof of the skew version of the K-saturation theorem [34]. The explicit formulas for describing the behavior of the automaton that were obtained are suggested a deep analogy with the results of M.L. Tsetlin [35]. Zadunaisky, P., presented a simplified way to construct the

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Gelfand-Tsetlin [36]. Yazidi, A., and Sandnes, F.E., presented an approach for solving the problem using Learning Automata (LA) [37].

Maslen, D., et al., presented a general diagrammatic approach for computing the Fourier transform of a function on a finite group [38]. Kuruge, D.A., proposed a novel TA coordination scheme with continuous input and output for learning problems [39]. Berge G.T et al., introduced a text categorization approach using Tsetlin Machine [40]. Rahimi Gorji, S et al., introduced the Multigranular Tsetlin Machine (MTM) [41]. Abeyrathna, K.D., et al., introduced Regression Tsetlin Machine (RTM) [42] and applied TM to the field of disease forecasting and pattern classification [43].

Abeyrathna, K.D et al., proposed a novel finite-state learning automaton to replace the TA in TM learning [44]. Saha R et al., proposed TM-based method for Natural Language Processing tasks [45]. Abeyrathna, K.D et al., introduced integer weighted RTM [46]. Rahimi Gorji, S., introduced a novel algorithm that avoids assessing the clauses exhaustively [47]. Darshana Abeyrathna, K et al., introduced the regression Tsetlin machine (RTM) [48].

Wheeldon, A et al., proposed a new AI hardware architecture for IOT [49]. Lei J et al., investigated two architectures implemted in C language[50]. Lavrova, D.S., and Eliseev, N.N., proposed an approach to the detection of cyber-attacks that involves detecting anomalous network traffic using the Tsetlin machine [51]. Abeyrathna, K.D et al., proposed an efficient intrusion detection mechanism based on the TM [52] and addressed limitations of TM [53]. Zhang, X et al., analyzed the convergence of the TM for classification [54]. Bhattarai, B et al., extended TM with a novelty scoring mechanism [55]. Yadav et al., introduced TM based supervised model [56]. Lei J et al., evaluated the performance of KWS using TM [57].

3. RESULTS AND DISCUSSIONS

3.1 Statistical Analysis

There are 372 documents found on the topic of “Tsetlin”. Scopus Database is used for collecting the data of publications. The following Statistical Analysis is carried out on database.

Fig. 1 and table 1 shows the number of documents by source. Advances In Mathematics and Journal Of Mathematical Physics have published 15 documents which is highest under the category of sources. This is followed by Journal Of Algebra and LNCS Including Subseries LN

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In AI And LN In Bioinformatics with 13 documents each. Next to it is Journal Of Algebraic Combinatorics with 9 documents.

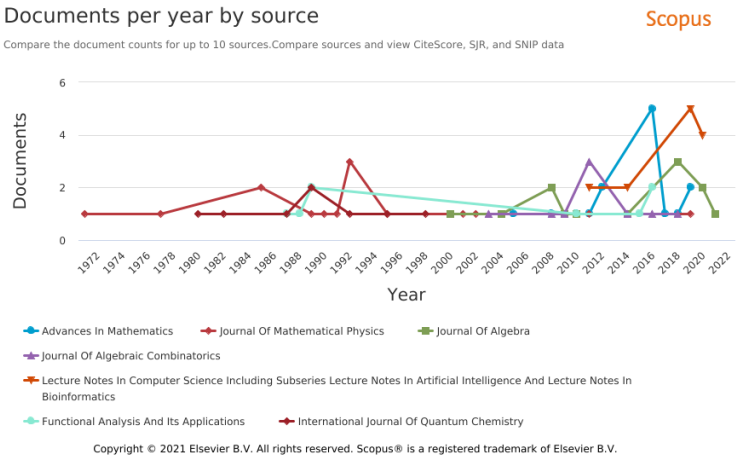

Fig. 1. Documents by Source

Table 1. Number of Documents by Source

SOURCE TITLE	NO. OF DOCUMENTS
Advances In Mathematics	15
Journal Of Mathematical Physics	15
Journal Of Algebra	13
LNCS Including Subseries LN In AI And LN In Bioinformatics	13
Journal Of Algebraic Combinatorics	9
Functional Analysis And Its Applications	8
International Journal Of Quantum Chemistry	8
Communications In Mathematical Physics	6
Journal Of Mathematical Chemistry	6
Mathematics In Science And Engineering	6

Fig. 2 and Table 2 provides the details of year wise publication of documents. The highest number of documents were published in year 2019 with 32 followed by the 2020 with 29. In the year 2021, there are 22 documents published upto 25th July, still there is scope for publishing a greater number of documents. Great research is going on in this area.

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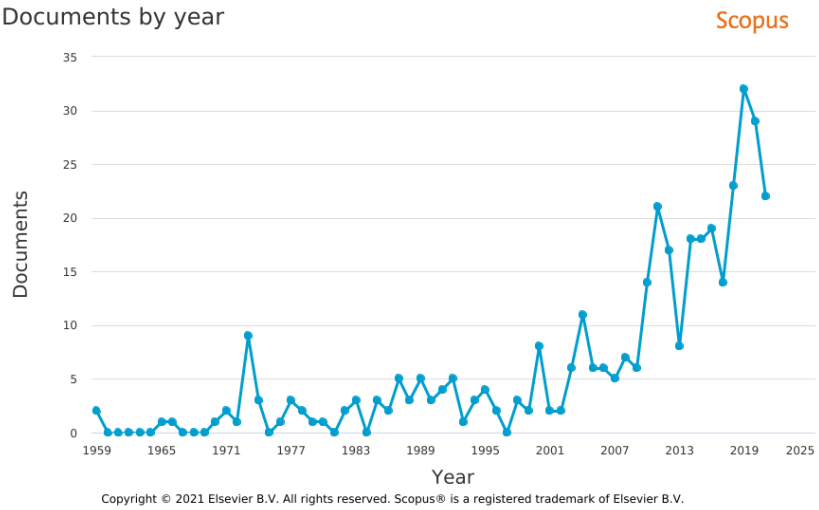

Fig. 2. Documents by year

Table 2. Documents by Year

YEAR	No.of Documents
2021	22
2020	29
2019	32
2018	23
2017	14

Fig. 3 and Table 3 shows the documents published by subject area. Highest percentage of documents published in the 'Mathematics' area equal to 53% and followed by Physics and Astronomy 13.6%.

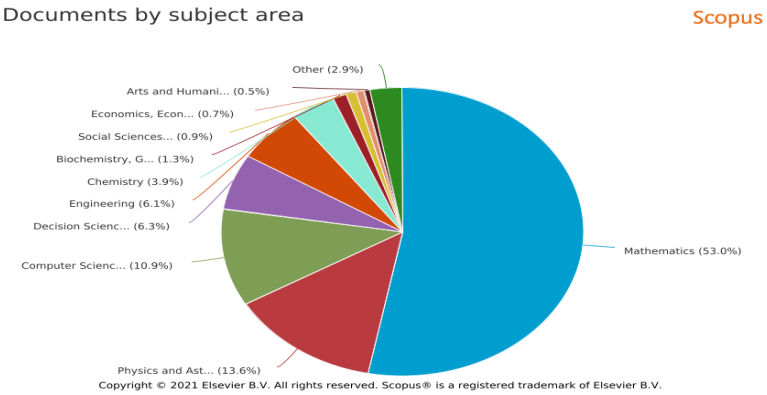

Fig. 3. Documents by Subject Area

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Table 3. Documents by Area

SUBJECT AREA	No. of Documents Published
Mathematics	297
Physics and Astronomy	76
Computer Science	61
Decision Sciences	35
Engineering	34
Chemistry	22
Biochemistry, Genetics and Molecular Biology	7
Social Sciences	5
Economics, Econometrics and Finance	4
Arts and Humanities	3
Materials Science	3
Medicine	3

Fig. 4 Shows the distribution based on type of documents. Majority of the published documents are articles followed by review documents. There are 81.2 % Articles and 15.4% conference documents.

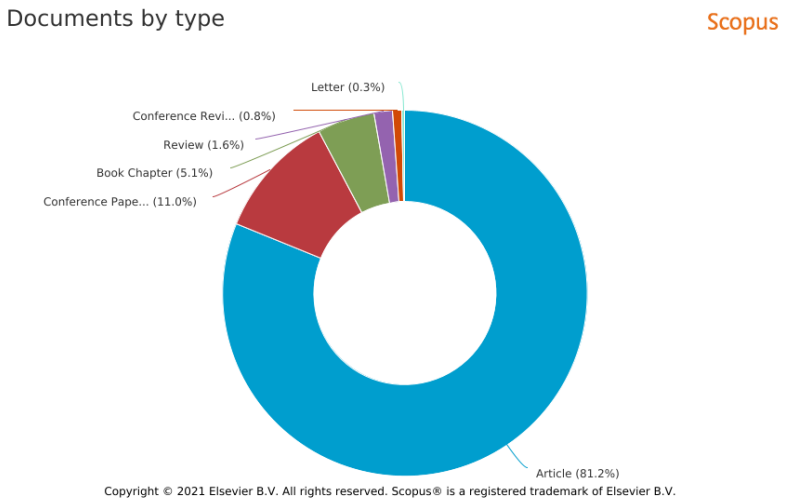

Fig. 4. Distribution based on type of document

Fig. 5 shows documents by country/territory. Table 4 presents documents by country. US has published 108, which is the highest number of documents followed by Russian Federation and Brazil. Russian Federation has published 60 documents and Brazil has published 36 documents.

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Table 4. Documents by Country

Country / Territory	Number of Documents
United States	108
Russian Federation	60
Brazil	36
Norway	27
Canada	22
Australia	18
United Kingdom	18
Germany	16
India	15
Japan	13

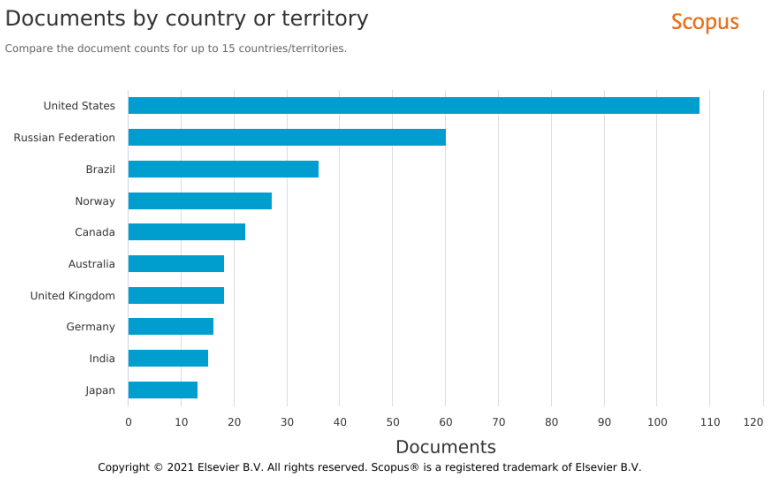

Fig. 5. Documents by Country

Fig. 6 shows documents by author. Table 5 presents the number of documents by author. Granmo, O.C., has published 26 documents on the topic Tsetlin which is highest and followed by Futorny, V. with 22 documents.

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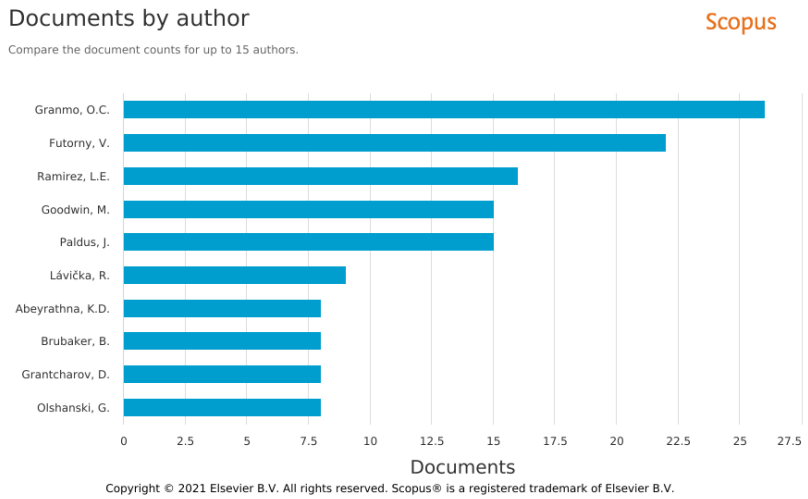

Fig. 6. Documents by author

Table. 5 Number of Documents by author

AUTHOR NAME	**Number of Documents**
Granmo, O.C.	26
Futorny, V.	22
Ramirez, L.E.	16
Goodwin, M.	15
Paldus, J.	15
Lávička, R.	9
Abeyrathna, K.D.	8
Brubaker, B.	8
Grantcharov, D.	8
Olshanski, G.	8
Borodin, A.	7
Gould, M.D.	7
Jiao, L.	6

Fig. 7 shows documents by author's affiliation. Table 6 presents documents by author's affiliation. Massachusetts Institute of Technology has published 34 documents which is highest followed by Universidade de Sao Paulo - USP with 30 documents.

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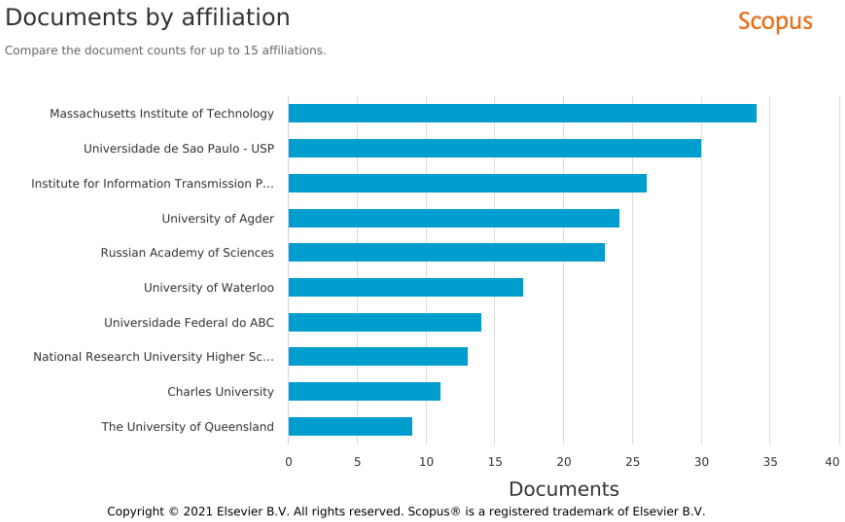

Fig. 7. Documents by affiliation

Table 6. Documents by affiliation

AFFILIATION	**No. of Documents**
Massachusetts Institute of Technology	34
Universidade de Sao Paulo - USP	30

Fig. 8 shows the documents by funding agency. National Science Foundation has sponsored 37 documents which is highest in the category of funding agencies.

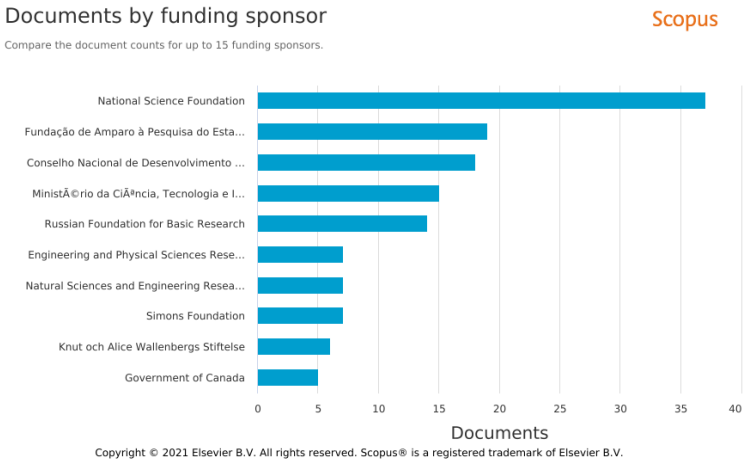

Fig. 8. Documents by Funding agency

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3. 2 Network Analysis

3.2.1 Co-authorship Analysis in terms of

i. Author

The documents with more than 25 authors are ignored. Five documents per author is considered as threshold.

Table 7. Co-authorship Analysis in terms of Authors

Selected	Author	Documents	Citations	Total link strength
☑	goodwin m.	6	7	6
☑	granmo o.-c.	11	24	6
☑	futorny v.	9	14	5
☑	ramirez l.e.	6	17	5
☑	li x.	5	140	4
☑	paldus j.	13	470	4
☑	gould m.d.	7	43	0
☑	molev a.i.	5	45	0

Eight authors out of two hundred and twenty six authors met the criteria. Goodwin M and Granmo O -c have total link strength of 6 which is the highest in the co-authorship analysis. Paldus J has 4 links with 470 citations for 13 documents as shown in table 7.

ii. Organizations:

Out of 179 organization 6 met the thresholds value minimum 3 documents per organization as shown in the table 8. Only two organizations have link strength of 4 and other have no link strength.

Table 8: Co-authorship analysis in terms of Organizations

Selected	Organization	Documents	Citations	Total link strength
☑	instituto de matemática e estatístic...	6	29	4
☑	universidade federal do abc, santo ...	5	17	4
☑	centre for artificial intelligence rese...	3	4	0
☑	department of applied mathematic...	3	7	0
☑	department of applied mathematic...	5	194	0
☑	department of mathematics, univer...	3	16	0

iii. Country

Nine countries met the threshold out of 33 countries when the threshold of minimum 5 documents by a country is considered. Brazil is found to have the highest link strength of 7 as

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shown in table 9. This is followed by China with link strength of 6. Fig. 9 shows the network of co-authorship in terms of country.

Table 9. Co-authorship in terms of Country

Selected	Country	Documents	Citations	Total link strength
☑	brazil	18	65	7
☑	china	6	91	6
☑	united states	25	371	5
☑	canada	16	488	4
☑	norway	13	25	3
☑	united kingdom	5	38	3
☑	australia	12	76	2
☑	japan	8	14	0
☑	russian federation	22	269	0

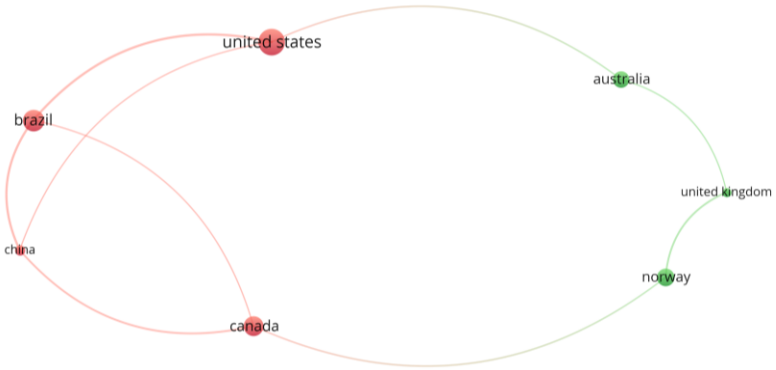

Fig. 9 Co-authorship in terms of Country

3.2.2. Network Analysis of Co-occurrences in terms of

i. All keywords

Out of 538 keywords, 13 keywords met the threshold value 4. The keyword “formal logic” and “propositional logic” are having 15 link strengths with 7 times occurrence in various documents as shown in figure 10. The keyword “Tsetlin machine” having 7 link strengths with 4 as shown in Table 10.

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Table 10. Co-occurrence analysis in terms of all keywords

Selected	Keyword	Occurrences	Total link strength
☑	formal logic	7	15
☑	propositional logic	7	15
☑	learning algorithms	4	7
☑	learning automata	4	7
☑	learning systems	5	7
☑	tsetlin machine	4	7
☑	automata theory	14	6
☑	gelfand-tsetlin modules	4	2
☑	tableaux realization	4	2
☑	article	5	0
☑	computational methods	4	0
☑	gelfand-tsetlin pattern	4	0
☑	gelfand-tsetlin patterns	4	0

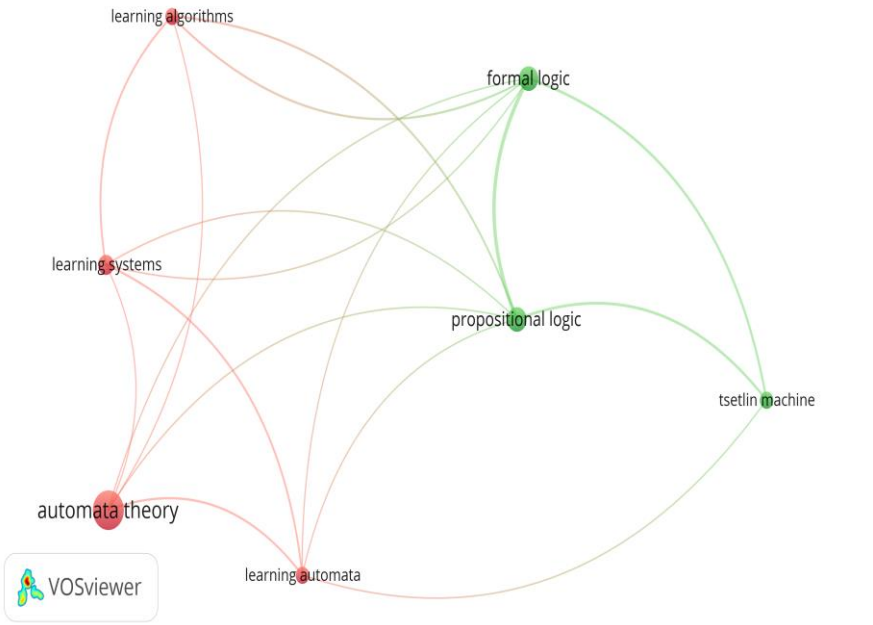

Fig. 10 Co-occurrence Analysis in Terms of All Keywords

ii. Author keywords

Out of 216 keywords by the authors, 11 keywords met the threshold value 3 per author. Three keywords have total link strength 6 as shown in table 11.

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Table 11. Co-occurrence analysis in terms of Author keywords

Selected	Keyword	Occurrences	Total link strength
☑	many-electron correlation problem	3	6
☑	uga generator matrix elements (mes)	3	6
☑	unitary group approach (uga)	3	6
☑	gel'fand-tsetlin basis	3	3
☑	generalized fourier transform	3	3
☑	gelfand-tsetlin modules	4	2
☑	tableaux realization	4	2
☑	learning automata	3	1
☑	tsetlin machine	4	1
☑	gelfand-tsetlin pattern	4	0
☑	gelfand-tsetlin patterns	3	0

iii. Index Keywords

The minimum threshold of 3 per author is considered. Out of 348 index keywords only 17 met the threshold. Fig 11 shows the Co-occurrence Analysis in Terms of Index Keywords.

Table 12. Co-occurrence in terms of Index Keywords

Selected	Keyword	Occurrences	Total link strength
☑	formal logic	7	18
☑	propositional logic	7	18
☑	learning algorithms	4	12
☑	learning systems	5	11
☑	automata theory	14	10
☑	computer circuits	3	10
☑	artificial intelligence	3	8
☑	intelligent computing	3	8
☑	article	5	6
☑	learning automata	3	5
☑	problem solving	3	5
☑	animal	3	4
☑	physiology	3	4
☑	stochastic systems	3	4
☑	computational methods	4	3
☑	functions	3	2
☑	combinatorial mathematics	3	0

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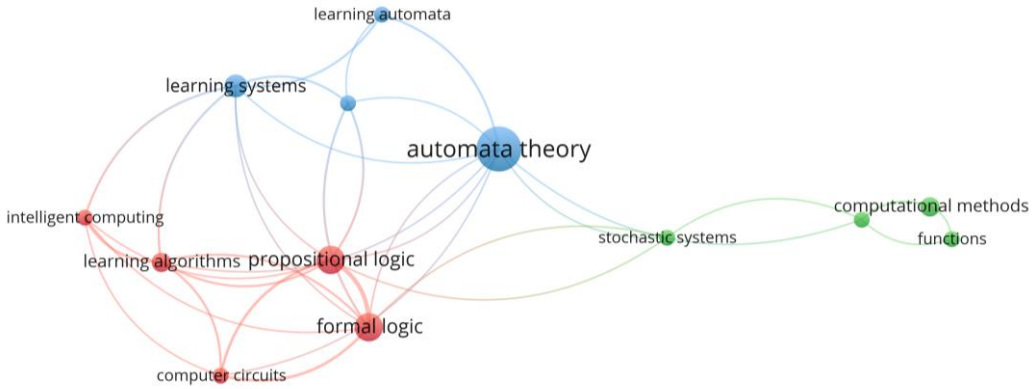

Fig. 11 Co-occurrence in Terms of Index Keywords

3.2.3. Network Analysis of Citations

i. Citation Analysis of Documents

Out of total of 164 documents, 66 documents met the threshold value 4. Document authored by Paldus J (1985) has the citations 71 while the link strength is 8 which is the highest. Table 13 and Fig. 12 presents these details.

Table 13. Citation Analysis of Documents

Selected	Document	Citations	Links
☑	paldus j. (1985)	71	8
☑	paldus j. (1987)	49	6
☑	li x. (1993)	13	6
☑	downward m.j. (1977)	33	5
☑	li x. (1989a)	67	5
☑	li x. (1990)	15	5
☑	li x. (1992)	31	5
☑	li x. (1989b)	14	4
☑	wormer p.e.s. (1980)	21	3
☑	born g. (1982)	25	2
☑	gromov n.a. (1991)	7	2
☑	payne p.w. (1982)	15	1
☑	gao m.j. (1987)	9	1
☑	gould m.d. (1989)	5	1
☑	gromov n.a. (1992a)	5	1
☑	gromov n.a. (1992b)	13	1
☑	jeziorski b. (1995)	73	1
☑	fill j.a. (1996)	43	1
☑	maslen d.k. (1998)	18	1
☑	bidigare p. (1999)	76	1

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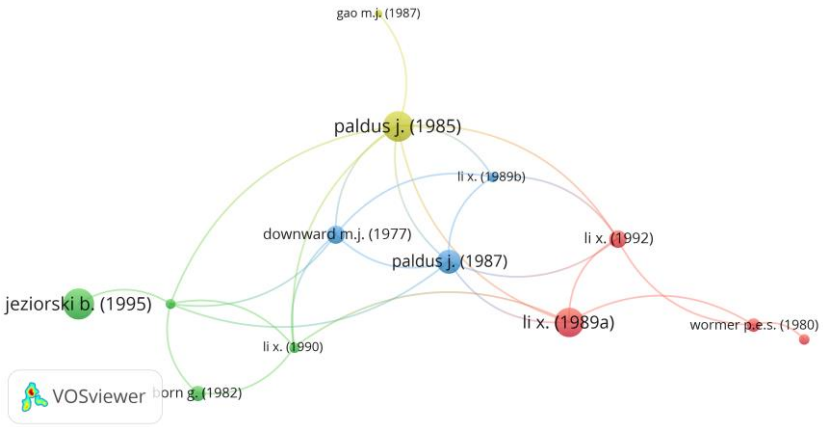

Fig. 12 Network Analysis of Citations (In terms of Documents)

ii. Citation Analysis of Sources

In this network analysis, threshold of 3 citations per source is considered. Out of the 93 sources only 14 met the threshold. The Journal of Chemical Physics has got maximum link strength of 8 with citations 269 as shown in table 14.

Table 14. Citation Analysis of Sources

Selected	Source	Documents	Citations	Total link strength
☑	the journal of chemical physics	4	269	8
☑	international journal of quantum c...	8	234	6
☑	journal of mathematical chemistry	5	35	6
☑	journal of mathematical physics	12	79	1
☑	journal of physics a: mathematical ...	3	20	1
☑	2020 ieee symposium series on co...	3	2	0
☑	biophysics	3	43	0
☑	functional analysis and its applicati...	5	33	0
☑	information sciences	4	2	0
☑	journal of algebra	5	13	0
☑	journal of theoretical probability	3	130	0
☑	lecture notes in computer science (...	4	1	0
☑	letters in mathematical physics	3	80	0
☑	mathematics in science and engine...	6	0	0

ii. Citation analysis by Authors

five citations per author is considered as threshold. A total of 8 authors met the threshold amongst the total of 226 authors. Liu Y has maximum link strength of 18 with other authors only for 19 documents with 4378citations as shown in table 15.

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Table 15. Citation analysis by Authors

Selected	Author	Documents	Citations	Total link strength
☑	li x.	5	140	18
☑	paldus j.	13	470	18
☑	futorny v.	9	14	0
☑	goodwin m.	6	7	0
☑	gould m.d.	7	43	0
☑	granmo o.-c.	11	24	0
☑	molev a.i.	5	45	0
☑	ramirez l.e.	6	17	0

v. Citation analysis by country

Out of a total of 33 countries present in the database of the current search, 9 met the threshold criteria. Analysis has a threshold of minimum of 5 documents with minimum 0 citations. Canada has 11 highest link strength with 488 citations as shown in table 16. Next to Canada, United States and china with 4 link strength.

Table 16. Citation analysis by country

Selected	Country	Documents	Citations	Total link strength
☑	canada	16	488	11
☑	china	6	91	4
☑	united kingdom	5	38	4
☑	united states	25	371	3
☑	australia	12	76	1
☑	brazil	18	65	1
☑	japan	8	14	0
☑	norway	13	25	0
☑	russian federation	22	269	0

3.2.4. Network Analysis of Bibliographic Coupling

i. Bibliographic Coupling of Documents

Total strength of bibliographic coupling links with other documents is calculated. Out of 164 documents 66 documents met the criteria. Documents with minimum 5 citations are considered. Li x., (1990) has got highest link strength of 236. Table 17 and Fig 16 provide these details.

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Table 17. Bibliographic Coupling of Documents

Selected	Document	Citations	Total link strength
☑	li x. (1990)	15	236
☑	li x. (1993)	13	182
☑	paldus j. (1985)	71	178
☑	li x. (1989b)	14	158
☑	li x. (1989a)	67	151
☑	paldus j. (1987)	49	149
☑	li x. (1992)	31	106
☑	wormer p.e.s. (1980)	21	100
☑	jeziorski b. (1995)	73	88
☑	payne p.w. (1982)	15	87
☑	gao m.j. (1987)	9	81
☑	gould m.d. (1989)	5	79
☑	lucht m.w. (1995)	6	65
☑	paldus j. (1974)	167	59
☑	born g. (1982)	25	52
☑	burton p.j. (1996)	5	52
☑	gromov n.a. (1991)	7	34
☑	gould m.d. (1992)	12	33
☑	gromov n.a. (1992a)	5	31

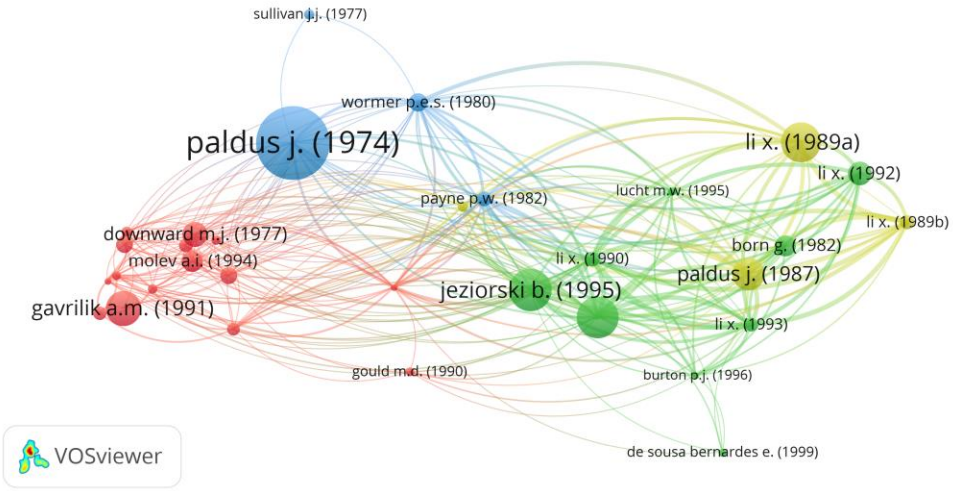

Fig. 13. Bibliographic coupling of Documents

ii. Bibliographic coupling of Sources

In this analysis, 6 sources met the threshold amongst a total of 93 sources. Threshold considered here is 5 documents per source. International Journal of Quantum Chemistry has highest bibliographic coupling strength of 231 with other sources with 8 documents as shown in table 18. Fig 17 shows the Bibliographic coupling by Sources.

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Table 18. Bibliographic coupling of Sources

Selected	Source	Doc...	Cit...	Tot... lin
☑	international journal of quantum chemistry	8	234	231
☑	journal of mathematical chemistry	5	35	224
☑	journal of mathematical physics	12	79	111
☑	functional analysis and its applications	5	33	26
☑	journal of algebra	5	13	0
☑	mathematics in science and engineering	6	0	0

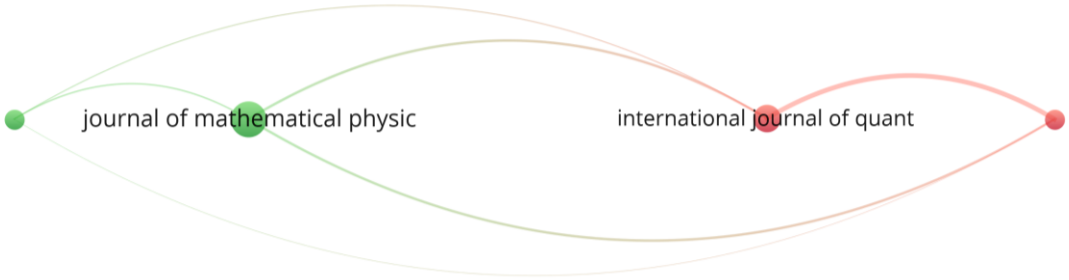

Fig. 14 Bibliographic coupling by Sources

iii. Bibliographic coupling of Authors

Five documents per author considered as threshold value. Out of total 226 authors, 8 authors met the threshold. Paldus J has maximum bibliographic coupling strength of 1089 with 13 documents and 470 citations as shown in table 18.

Table 19. Bibliographic coupling of Authors

Selected	Author	Documents	Citations	Total link strength
☑	paldus j.	13	470	1089
☑	li x.	5	140	1006
☑	gould m.d.	7	43	284
☑	molev a.i.	5	45	17
☑	futorny v.	9	14	3
☑	ramirez l.e.	6	17	3
☑	goodwin m.	6	7	0
☑	granmo o.-c.	11	24	0

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iv. Bibliographic coupling of Organization

Considering, 2 documents per organization as a minimum threshold value. Out of total 179 organization, 17 organizations met the threshold criteria. Two organization have maximum bibliographic coupling strength of 429 as shown in table 20. Fig 15 shows the Bibliographic coupling by Organizations.

Table 20. Bibliographic coupling of Organization

Selected	Organization	Documents	Citations	Total link strength
☑	department of applied mathematic...	2	28	429
☑	department of chemistry and guelp...	2	28	429
☑	department of applied mathematic...	5	194	322
☑	department of mathematics, univer...	2	17	65
☑	department of mathematics, dartm...	2	10	62
☑	susquehanna partners gp, 401 city l...	2	10	62
☑	department of mathematics, univer...	3	16	57
☑	instituto de matemática e estatístic...	6	29	3
☑	universidade federal do abc, santo ...	5	17	3
☑	centre for artificial intelligence rese...	3	4	0
☑	department of applied mathematic...	3	7	0
☑	department of mathematics, tokyo ...	2	0	0
☑	department of mathematics, univer...	2	8	0
☑	faculty of engineering science, osa...	2	2	0
☑	instituto de matemática e estatístic...	2	1	0
☑	technion, israel institute of technol...	2	0	0
☑	university of agder (uia), centre for ...	2	2	0

Fig. 15 Bibliographic coupling by Organizations

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v. Bibliographic coupling of Countries

Considering, 2 documents per Country as a minimum threshold value, out of total 33 Counties, 18 Countries met the threshold criteria. Canada has maximum bibliographic coupling strength of 780 with 16 documents as shown in table 21. Fig 16 shows the network analysis.

Table 21. Bibliographic coupling of Countries

Selected	Country	Documents	Citations	Total link strength
☑	canada	16	488	780
☑	australia	12	76	299
☑	china	6	91	240
☑	netherlands	2	39	210
☑	india	2	76	205
☑	united states	25	371	191
☑	russian federation	22	269	66
☑	japan	8	14	58
☑	united kingdom	5	38	24
☑	brazil	18	65	18
☑	ukraine	2	3	15
☑	norway	13	25	2
☑	israel	4	0	0
☑	italy	3	18	0
☑	mexico	3	4	0
☑	singapore	2	17	0
☑	sweden	2	2	0
☑	taiwan	2	2	0

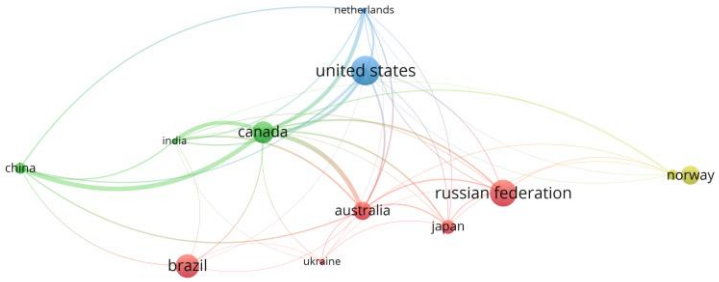

Fig. 16. Bibliographic coupling by Organizations

4. Conclusions

Bibliometric survey has been carried out on "Tsetlin" without specifying year range. There are 372 documents found on this topic. The analysis shows that TM is used in various application like classification, regression and in place of Machine learning algorithm. Extensive

network analysis, Co-occurrence analysis and Citation Analysis is carried out in this paper. Bibliographic coupling in terms of Documents and Authors is also carried out.

The number of documents published in Scopus database are 372 only but from last five years onwards documents published are increasing order. Granmo, O.C., has published 26 documents on the topic Tsetlin which is highest and followed by Futorny, V. with 22 documents. Canada has 11 highest link strengths with 488 citations. Finally, we conclude that there is a tremendous scope is there for Tsetlin machine in near future.

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