

A Brief Analysis of Gravitational Search Algorithm (GSA) Publication from 2009 to May 2013

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Abstract—Gravitational Search Algorithm was introduced in year 2009. Since its introduction, the academic community shows a great interest on this algorithm. This can be seen by the high number of publications with a short span of time. This paper analyses the publication trend of Gravitational Search Algorithm since its introduction until May 2013. The objective of this paper is to give exposure to reader the publication trend in the area of Gravitational Search Algorithm.

Keywords— gravitational search algorithm, bilbometric analysis, publication trend, computational intelligence.

I. INTRODUCTION

SINCE the introduction in 2009 by Esmat Rashide [1], Gravitational Search Algorithm (GSA) gains large popularity from researcher around the world. The statistical analysis is not something new where B. Hamadicharef [207] in year 2011 wrote a paper presenting the bilbometric analysis of the Partricle Swarm Optimization (PSO) research from 2000 to 2010. This paper has used similar approach done by [207] in analysing the GSA publications. Scopus and Google Scholar had been used as the database for extracting the infromation required.

This analysis is to illustrate current state of GSA study from its research literature, indentifying the most imminent researchers, their collaborations, their country of origin, citation and reference distribution patterns, and finally study keywords related to this research field to get insight into applications, hot topics and trends in GSA research.

Even though GSA algorithms are established in the year 2009 but until now it's deliberately developed and mostly utilized by Asian countries. By doing this research, the total papers published by countries can be identified which enables

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to draw a conclusion. It's also a great opportunity to discover the potential and growth of GSA algorithm in future.

II. PUBLICATION

A. Total Paper Published

The growth of the GSA research literature from 2009 to 2012 is shown in Figure 1. Its characteristic was fitted with a "polynomial of order 2" curve with ($R^2 = 0.996$). It's a "best fit" curve because it is a unique function of 2nd order polynomial that makes R^2 as close to being equal to 1 as possible. Fig. 1 clearly illustrate that total paper published grows rapidly year by year due to acknowledgement of GSA algorithm among the researchers has been increased.

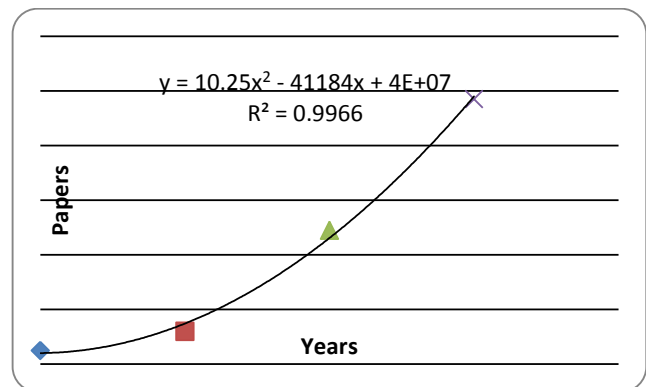


Fig. 1 Growth of the GSA research literature from 2009 to 2012

B. Authorship

According to [208], the word authorship defines as "the person who originated or gave existence to anything and determines full responsibility on what was created". Table I shows the name of authors and co-authors as well as country of origin with their total of published papers. According to the figure, Hossein Nezamabadi-Pour leading at first place for publishing 23 papers, Radu-Codrut David who published 12 papers currently at second place while Radu-Emil Precup at third place for publishing 11 papers.

C. Authorship Distribution

Authorship distribution shows number of authors involved in a published paper. Fig. 2 demonstrates the authorship distribution of the GSA articles. From the figure, majority published papers were produced by 3 authors and followed by 2 authors and 4 authors.

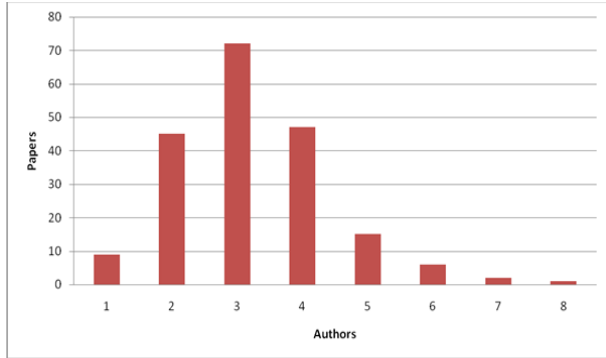


Fig. 2 Authorship distributions of the GSA articles

TABLE I
LIST OF AUTHORS AND CO-AUTHORS WHO PUBLISHED 6 OR MORE ARTICLES

No	Name	Country	Number of Papers
1	Hossein Nezamabadi-Pour	Iran	23[1,17,21,23,28,41,42,43,45,46,58,67,73,77,91,103,105,106,136,146,163,190,206]
2	Radu-Codrut David	Romania	11[48,99,102,112,129,130,132,135,162,169,184]
3	Radu-Emil Precup	Romania	11[48,99,102,112,129,130,132,135,162,169,184,]
4	Esmat Rashedi	Iran	11[1,22,43,45,46,73,91,106,110,146,206]
5	Serhat Duman	Turkey	10 [62,71,79,90,122,150,166,167,168,192,]
6	Nuran Yorukeren	Turkey	9[62,71,79,122,150,166,167,168,192,]
7	Emil M. Petriu	Romania	8 [48,102,112,129,130,132,162,184]
8	Stefan Preitl	Romania	8 [48,102,112,129,130,132,162,184]
9	Miguel A. Vega-Rodríguez	Spain	8[18,29,68,83,100,152,155,157]
10	Hussain Shareef	Malaysia	7[39,65,121,137,170,180,185,]
11	Saeid Saryazdi	Iran	6
12	Jianzhong Zhou	China	6
13	S.P.Ghoshal	India	6
14	Mircea-Bogdan Rad Ac	Romania	6
15	Ugur Guvenc	Turkey	6
16	Ali Ghasemia	Iran	5
17	Behnam Barzegar	Iran	5
18	Mohammad Khajezadeh	Iran	5
19	Yusuf Sonmez	Turkey	5

D. Citations

Table II shows total GSA papers and total counts of papers that have been cited in another paper. Top three most cited papers owned by same researchers and also GSA introduction papers.

TABLE II
TOTAL NUMBERS OF CITATION FOR PUBLISHED PAPERS WITH 6 OR MORE CITATIONS

No	Papers	No of Citations
1	GSA: A Gravitational Search Algorithm	333
2	BGSA: binary gravitational search algorithm	79
3	Filter modeling using gravitational search algorithm	62
4	Parameters identification of hydraulic turbine governing system using improved gravitational search algorithm	37
5	Gravitational Search Algorithm for Economic Dispatch with Valve-Point Effects	26
6	Comparative Performance Of Gravitational Search Algorithm And Modified Particle Swarm Optimization Algorithm For Synthesis Of Thinned Scanned Concentric Ring Array Antenna	24
7	Disruption: a new operator in gravitational search algorithm	21
8	A Multi-Objective Gravitational Search Algorithm	20
9	Optimal power flow using gravitational search algorithm	19
10	Advances of Soft Computing Methods in Edge Detection	17
11	A novel opposition-based gravitational search algorithm for combined economic and emission dispatch problems of power systems	16
12	A novel hybrid K-harmonic means and gravitational search algorithm approach for clustering	15
13	A Hybrid Neural Network and Gravitational Search Algorithm (HNNGSA) Method to Solve well known Wessinger's Equation	13
14	A prototype classifier based on gravitational search algorithm	13
15	A Combined Approach for Clustering on K-Means and Gravitational Search Algorithm	12
16	Evolutionary optimization-based tuning of low-cost fuzzy controllers for servo systems	12
17	Forecasting future oil demand in Iran using GSA (Gravitational Search Algorithm)	11
18	Facing the Classification of Binary Problems with a GSA-SVM Hybrid System	10
19	Gravitational search algorithm-based tuning of fuzzy control systems with a reduced parametric sensitivity	10
18	Facing the Classification of Binary Problems with a GSA-SVM Hybrid System	10
19	Gravitational search algorithm-based tuning of fuzzy control systems with a reduced parametric sensitivity	10
20	Probabilistic energy and operation management of a microgrid containing wind/photovoltaic/fuel cell generation and energy storage devices based on point estimate method and self-adaptive gravitational search algorithm	10
21	Non-dominated Sorting Gravitational Search Algorithm	9
22	An Approach for Web Services Composition Based on QoS and Gravitational Search Algorithm	8

No	Papers	No of Citations
23	Gravitational Search Algorithm for Post-Outage Bus Voltage Magnitude Calculations	8
24	T-S Fuzzy Model Identification With a Gravitational Search-Based Hyperplane Clustering Algorithm	8
25	A new intelligence solution for power system economic load dispatch	7
26	Gravitational search algorithm for coordinated design of PSS and TCSC as damping controller	7
27	Parameters identification of chaotic system by chaotic gravitational search algorithm	7
28	New Insights on Nontechnical Losses Characterization Through Evolutionary-Based Feature Selection	7
29	A New Hybrid PSO-GSA Algorithm for Function Optimization	6
30	Application of gravitational search algorithm on data clustering	6
31	Application of Gravitational Search Algorithm for Optimal Reactive Power Dispatch Problem	6
32	Multi-objective economic emission load dispatch solution using gravitational search algorithm and considering wind power penetration	6
33	Feature Selection Through Gravitational Search Algorithm	6

III. PUBLISHED PAPERS REFERENCES

A. Distribution of References

The distribution of the number of references is shown in Fig. 3. From 2012 to May 2013, the yearly average number of references per article grew from 14.7 to 26.4. Articles with large number of references is “Advances of Soft Computing Methods in Edge Detection” (148 references) and “Gravitational search algorithm–optimized neural misuse detector with selected features by fuzzy grids–based association rules mining” (120 references).

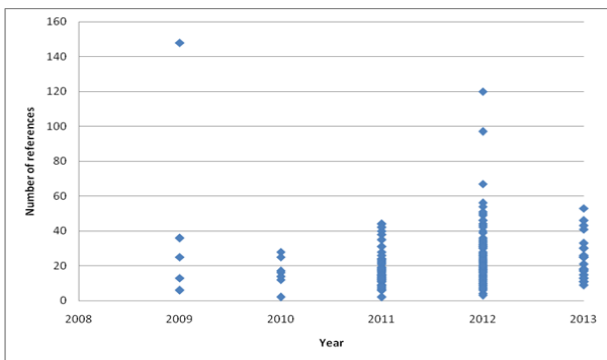


Fig. 3 Distribution of the references in GSA articles

B. Type of Academic Contribution

Published paper can be categorized into 3 types which are Improvement, Application, and others. An application paper shows the steps on how to applied GSA algorithm to a certain problem which can be in any field. Improvement means to

make a minor modification to original GSA algorithm to cater a projected problem. Others type's papers are papers that excluded from both mentioned categories. Papers that use GSA as comparison or case-study can be classified in others category.

C. Country of Origins

There are total of 18 countries contributing to the GSA literature. According to the Fig. 4, top 10 countries from highest to lowest publishing as following: Iran (57, 28.75%), India (33, 16.67%), China (23, 11.62%), Malaysia (19, 9.60%), Turkey (18, 9.09%), Spain (7, 3.54%), Iran collaborating with Malaysia (6, 3.03%), Romania(6, 3.03%), Canada collaborating Romania (4, 2.02%) and Brazil(3, 1.52%). This concludes that Iran has published the most numbers of papers followed by India and China.

D. Distribution of Types Covering Total Published Papers

Fig. 5 is pie chart that shows percentage of distribution of types of papers for papers published from 2009 to May 2013. Application types are leading with 35% followed by improvement and the last is others. Application types are very famous because researchers in different field try this new algorithm to suit and solve their problem which are documented and tested as well as published.

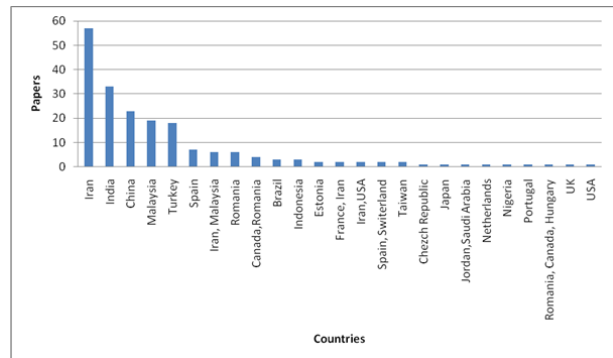


Fig. 4 Countries of origin of the GSA articles researchers

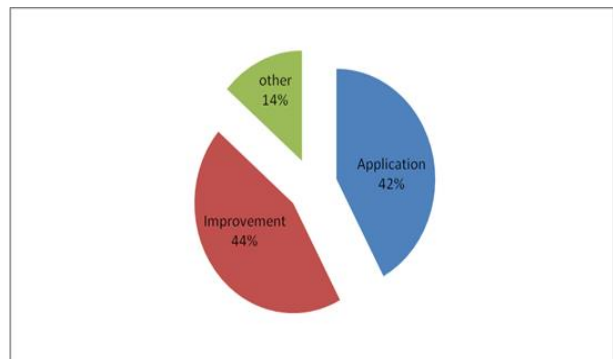


Fig. 5 Types of papers published from 2009 to May 2013

E. Distribution of Types According to Years

Fig. 6 shows types of papers published from 2009 until May 2013 which segregated by years. This figure portray that

Improvements lead in year 2012 followed by application in the same year. 2012 will be the third year after GSA are introduced so the trend shows researcher moving from application to improvement after well verse with this GSA algorithms. Full understandings of GSA algorithm enable the researchers to fine tune original GSA algorithms to solve a specific problem which published as Improvement paper.

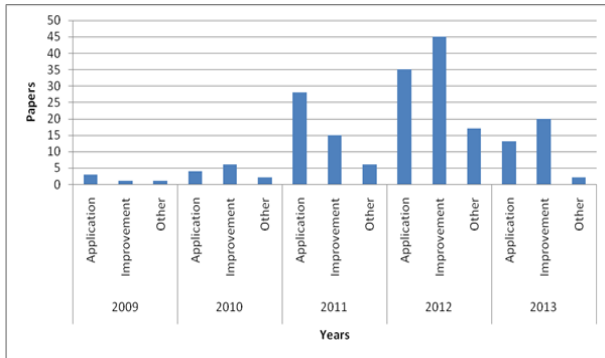


Fig. 6 Types of papers published segregated by years



Fig. 7 TagCloud of GSA literatures

F. Keywords

In Fig. 7, the keywords from papers in year 2009 until May 2013 has been extracted and illustrated as Tagcloud for better visibility using the tools in tagxedo.com. [15] A closer look at the keywords can provide insights into research trends within GSA research and helps to identify specific small research topic of interest. The most outstanding words in this Tagcloud are Gravitational, Search, Algorithms, GSA, optimization and Heuristics that shows the name of projected algorithm. Others are Network, Fuzzy, Power, and Systems are the leading fields used to apply the GSA algorithms.

IV. CONCLUSION

This paper presented a brief analysis of the statistical information of the publication of GSA from its introduction until May 2013. It can be clearly seen in the finding that there is a great interest of the scientific community on the algorithm.

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