

# Biomimicry-based Algorithms and Their Lack of Generalization

BSc Thesis

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University of Bern

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# Expectation



Reality



# Reality

## Security by nature

Division in CS	Category PB	Category BK
CP establish a route to p.	Collaboration	Ecology
se specialized application	Collaboration	Ecology (behavioral)
ecure protocols (HTTPS, Adaptation		Ecology (behavioral)
ecure protocols (HTTPS, Weakening		Ecology (behavioral)
PU architecture and desig	Process optimiza	Genetics
ools that capture screen c	Cloaking	Ecology
hardware scanners / immed	Adaptation	Ecology (behavioral)
eprecation warnings	Process optimiza	Genetics
improved update mechanis	Process optimiza	Genetics
ecuring dataGhosing att	Process optimiza	Ecology
outsourcing/ cuda accelera	Protection	Neurobiology

## Data analysis

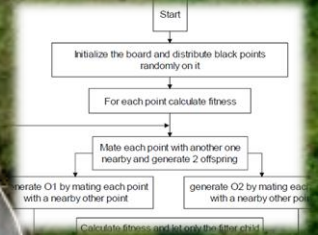


Presentation / Writing



1. Presentation

## Adaptation



## Literature review

Title	Primary Source	Page
Modeling Biology Inspired Reactive Agents Using Kinematics	waset.org/	Journal
Biology-inspired Optimizations of Peer-to-Peer Overlay Networks	K.G. Saur Verlag,	Journal
Biology-inspired self-healing system design	University of Helsinki	Paper
Nature-inspired computing technology and applications	BT Technol J	Paper
Python microframework for building nature-inspired algorithms	The Journal of Open	Paper
Developing pervasive multiagent systems with nature-inspired coordination	Elsevier	Journal
Physarum Optimization: A Biology-Inspired Algorithm for the Steiner Tree Problem in Networks	IEEE	Paper
Nature-inspired techniques for conformance testing of object-oriented software	Elsevier	Journal
Nature-inspired approaches in software faults identification and debugging	Elsevier	Paper
The intelligent water drops algorithm: a nature-inspired swarms-based optimization algorithm	Inderscience Enterpr	Paper
The AntBee Routing Algorithm: A New Agent Based Nature-Inspired Routing Algorithm	Journal of applied Sc	Paper
An Exhaustive Survey on Nature Inspired Optimization Algorithms	International Journa	Paper
A novel metaheuristic algorithm: Dynamic Virtual Bats Algorithm	Elsevier	Journal
EvoToPy: An Opensource Nature-inspired Optimization Framework in Python	SCITEPRESS	Paper
Automated Test Case Generation using Nature Inspired Meta-Heuristics Genetic Algorithm: A Review Paper	IAIEM	Paper
Nature-inspired computation and communication: A formal approach	Elsevier	Paper
A novel nature-inspired algorithm for optimization: Virus colony search	Elsevier	Journal
A comprehensive review of nature inspired routing algorithms for fixed telecommunication networks	Elsevier	Journal

# What biomimicry literature is available?

# What biomimicry literature is available?

*Literature review*

# Process

112 publications and 23 features per publication collected

## Meta

*title | origins | submission target | first author | country | Publication type | university | publication date*

## Computer science

*solution type | stability | reliability | efficiency gain | field | optimization for | optimized group | implementation available*

## Nature

*source model | domain | habitat | lifespan (years) | social | pack size | individual size*

Raw data											CS Domain		
ID	Title	Primary Source	Paper/Works	first Autho	Country	Publication	University	Publiç	Field	Optimization	optimized		
1	Modeling Biology Inspired Reactive Agents Using Xmachines	waset.org/	Journal	George Elefth	United Kingdom	Potential Use	University of Sheffiled	2007	Algorithms	Testing	Testing		
2	BiologyInspired Optimizations of PeertoPeer Overlay Networks	K.G. Saur Verlag,	Journal	Sven Apel	Germany	Potential Use	University of Magdeburg	2005	Optimization	Networks	Networks		
3	Biologyinspired selfhealing system design	University of Helsink	Paper	Teemu Kempa	Finland	New	University of Helsinki	2007	Software archi	-	-		
4	Natureinspired computing technology and applications	BT Technol J	Paper	P Marrow	-	-	-	2000	-	-	-		
5	Python microframework for building natureinspired algorithms	The Journal of Open	Paper	Grega Vrbanc	Maribor	New	University of Maribor	2018	Software archi	-	-		
6	Developing pervasive multiagent systems with natureinspired coordination	Elsevier	Journal	Franco Zambc	Italy	Potential Use	Università di Modena e Re	2014	-	Pervasive compu	-		
7	Physarum Optimization:A BiologyInspired Algorithm for the Steiner Tree Problem in Networks	IEEE	Paper	Liang Liu	China	Potential Use	Beijing University of Posts i	2015	Networks	network design	Networks		
8	Natureinspired techniques for conformance testing of objectoriented software	Elsevier	Journal	A. Bouchachia	Austria	Potential Use	University of Klagenfurt	2009	Optimization	Testing	Testing		
9	Natureinspired approaches in software faults identification and debugging	Elsevier	Paper	Florin Popent	Romania	Potential Use	Academy of Romanian Scie	2016	Optimization	Testing	Testing		
10	The intelligent water drops algorithm: a natureinspired swarmbased optimization algorithm	Inderscience Enterpr	Paper	Hamed ShahH	Iran	New	Shahid Beheshti University	2009	Algorithms	multiple knapsa	knapsack		
11	The AntBee Routing Algorithm: A New Agent Based NatureInspired Routing Algorithm	Journal of applied Sc	Journal	Sh. Rahmatiza	Iran	Improvement	Shahid Beheshti University	2009	Optimization	Routing	Networks		
12	An Exhaustive Survey on Nature Inspired Optimization Algorithms	International Journa	Paper	Manish Dixit	India	Comparison	Madhav Institute of Techno	2015	Algorithms	-	-		
13	A novel metaheuristic algorithm: Dynamic Virtual Bats Algorithm	Elsevier	Journal	Ali Osman Toj	Turkey	New	Epoka University	2016	Optimization	metaheuristic	heuristic		
14	EvoLoPy: An Opensource Natureinspired Optimization Framework in Python	SCITEPRESS	Paper	Hossam Faris	Jordan	Potential Use	The University of Jordan	2016	Optimization	Software archite	Compisitic		
15	Automated Test Case Generation using Nature Inspired Meta Heuristics Genetic Algorithm: A Review Paper	IJAIEEM	Paper	Rizwan Khan	India	Improvement	Jamia Millia Islamia A Cen	2014	Testing	-	-		
16	Natureinspired computation and communication A formal approach	Elsevier	Paper	Phan Cong Vir	Vietnam	Potential Use	Ho Chi Minh City	2015	-	metaheuristic op	heuristic		
17	A novel natureinspired algorithm for optimization Virus colony search	Elsevier	Journal	MuDongLi	China	New	Air Force Engineering Unive	2015	Algorithms	Unconstrained o	general Op		
18	A comprehensive review of nature inspired routing algorithms for fixed telecommunication networks	Elsevier	Journal	Horst F. Wedc	Germany	Potential Use	University of Dortmund	2006	Optimization	Networks	Networks		
19	Galactic Swarm Optimization: A new global optimizationmetaheuristic inspired by galactic motion	Elsevier	Journal	Venkatarama	India	New	VIT University	2015	Optimization	metaheuristic op	heuristic		
20	Electromagnetic field optimization:Aphysicinspiredmetaheuristic optimizationalgorithm	Elsevier	Journal	Hosein Abedi	Malaysia	New	Universiti Teknologi Malay	2015	Optimization	global optimizat	general Op		
21	NatureInspired Coordination Models: Current Status and Future Trends	Hindawi Publishing C	Paper	Andrea Omici	Italy	-	Universit'a di Bologna	2013	-	-	-		
22	Artificial algae algorithm (AAA) for nonlinear global optimization	Elsevier	Journal	Sait Ali Uyua	Turkey	New	Selcuk University	2015	Optimization	metaheuristic op	heuristic		
23	Nature Inspired Preemptive Task Scheduling for Load Balancing in Cloud Datacenter	ICICES	Paper	G.Shobana	India	Potential Use	Kongu EngineeringCollege	2014	Optimization	Loadbalancing	Networks		
24	SPLBA: An Interaction Strategy for Testing Software Product Lines Using the BatInspired Algorithm	ICSECS	Paper	Yazan A. Alsa	Malaysia	Potential Use	Universiti Malaysia Pahang	2015	Optimization	integration	Compisitic		
25	Software Module Clustering Using BioInspired Algorithms	IGI Global.	Paper	Kawal Jeet	India	Potential Use	D. A. V. College, India	2016	Optimization	Software Module	Compisitic		
26	On the Idea of Using NatureInspired Metaphors to Improve Software Testing	IFIP International Fe	Paper	Francisca Emz	Brazil	Potential Use	IVIA	2006	Software testi	Testing	Testing		
27	A comparative study of Artificial Bee Colony algorithm	Elsevier	Journal	Dervis Karabo	Turkey	Comparison	Erciyes University	2009	Optimization	Unconstrained o	general Op		
28	A Hybrid Bat Algorithm	cs.NE	Paper	Iztok Fister Jr.	Maribor	Improvement	University of Maribor,	2013	Optimization	global optimizat	general Op		
29	A Hybrid Least SquareFuzzy Bacterial Foraging Strategy for Harmonic Estimation	IEEE	Paper	S. Mishra	India	Improvement	Indian Institute of Technol	2005	Optimization	Harmonic Estima	general Op		
30	A modified Artificial Bee Colony algorithm for realparameter optimization	Elsevier	Journal	Bahriye Akay	Turkey	Improvement	Erciyes University	2010	Optimization	realparameter of	general Op		
31	A novel clustering approach: Artificial Bee Colony (ABC) algorithm	Elsevier	Journal	Dervis Karabo	Turkey	Potential Use	Erciyes University	2009	Optimization	Clustering	Networks		
32	A Novel Optimization Approach: BacterialGA Foraging	IEEE	Paper	TaiChen Chen	Taiwan	Improvement	National Kaohsiung Univer	2007	Optimization	Unconstrained o	general Op		
33	A Novel Search Algorithm based on Fish School Behaviour	IEEE	Paper	Carmelo J. A. E	Brazil	New	University of Pernambuco	2008	Optimization	Search	Search		
34	A powerful and efficient algorithm for numerical function optimization: artificial bee colony (ABC) algori	Springer	Paper	Dervis Karabo	Turkey	Potential Use	Erciyes University	2007	Optimization	numerical functi	general Op		
35	Accelerated PSO Swarm Search Feature Selection for Data Stream Mining Big Data	IEEE	Journal	Simon Fong	Macau	Potential Use	University of Macau	2016	Optimization,	Search feature se	Search		
36	An Enhanced Fish School Search Algorithm	IEEE	Paper	C. J. A. Bastos	Brazil	Improvement	University of Pernambuco	2013	Optimization	multimodal sear	knapsack		
37	Ant colony optimization for continuous domains	Elsevier	Journal	Krzysztof Soch	Belgium	Potential Use	Universite' Libre de Bruxell	2008	Optimization	continuous optin	general Op		
38	Ant Colony Optimization for Resource Constrained Project Scheduling	IEEE	Paper	Daniel Merkle	Germany	Potential Use	University of Karlsruhe	2002	Optimization	Resource Constr	Scheduling		
39	Ant Colony Optimization: A New MetaHeuristic	IEEE	Paper	Marco Dorigo	Belgium	Potential Use	Universitt Libre de Bruxelles	1999	Optimization	metaheuristic op	heuristic		
40	Bacterial Colony Optimization	Hindawi Publishing C	Journal	Ben Niu	China	Improvement	Shenzhen University	2012	Optimization	metaheuristic op	heuristic		
41	Bat algorithm for constrained optimization tasks	Springer	Journal	Amir Hossein	Iran	Potential Use	Islamic Azad University	2012	Optimization	Constraint opti	general Op		
42	Binary bat algorithm	Springer	Journal	Seyedali Mirj	Australia	Improvement	Griffith University	2013	Optimization	Binary optimizat	general Op		
43	Binary Fish School Search Applied to Feature Selection: Application to ICU Readmissions	IEEE	Paper	João A. G. Sarç	Portugal	Potential Use	Universidade de Lisboa	2014	Optimization,	Feature selectio	Compisitic		
44	Biomimcry of bacterial foraging for distributed optimization and control	IEEE	Journal	Kevin M. Pass	United States	New	The Ohio State University	2002	Optimization	metaheuristic op	heuristic		
45	Cat Swarm Optimization for Clustering	IEEE	Paper	Budi Santosa	Indonesia	Potential Use	Institut Teknologi Sepuluh	2009	Optimization	Clustering	Networks		
46	Chaotic bat algorithm	Elsevier	Journal	Amir H. Gand	United States	Improvement	The University of Akron	2013	Optimization	global optimizat	general Op		



# Observations - Venues

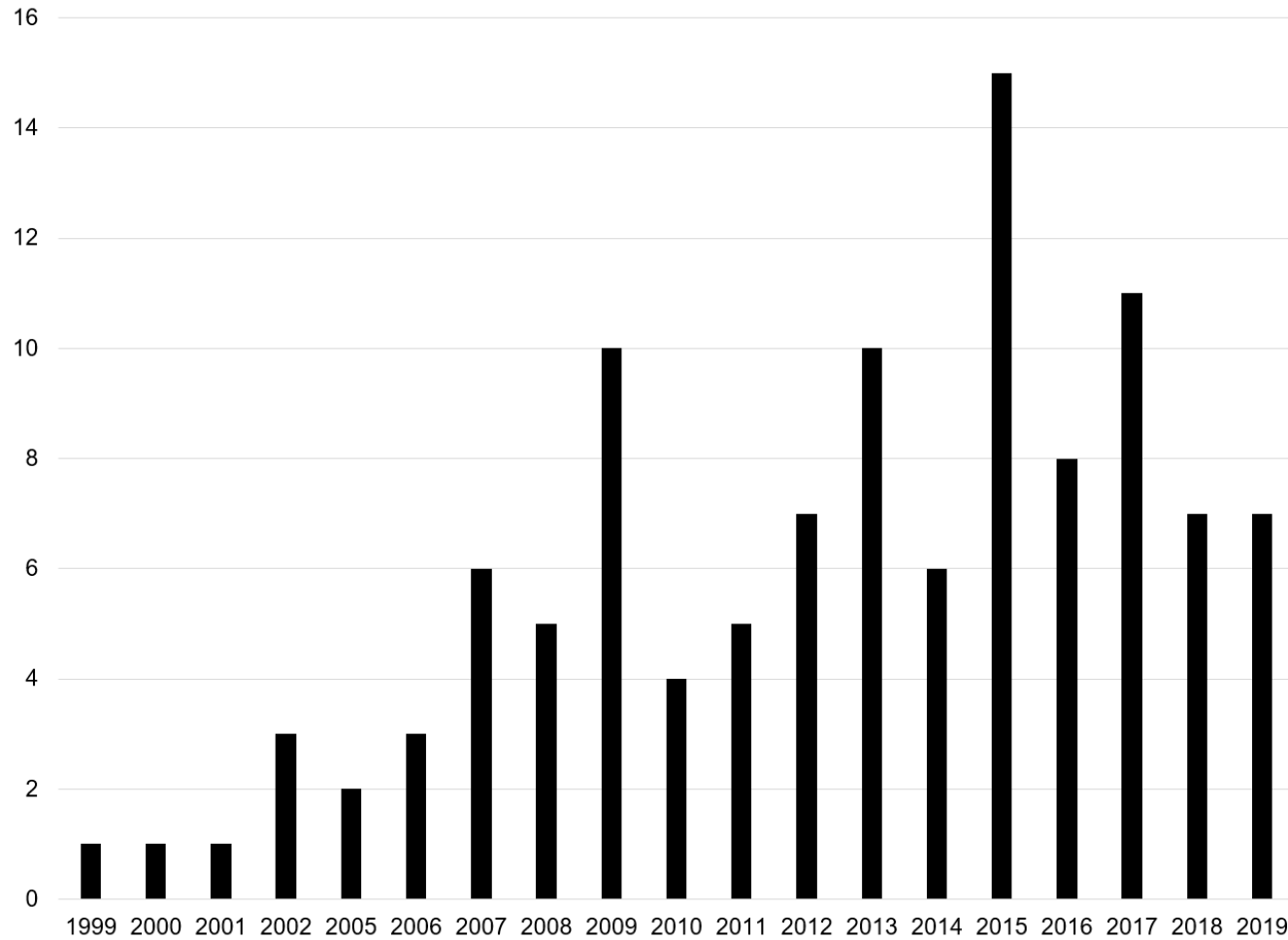
## Submission targets

62%	journals
38%	workshops or conferences

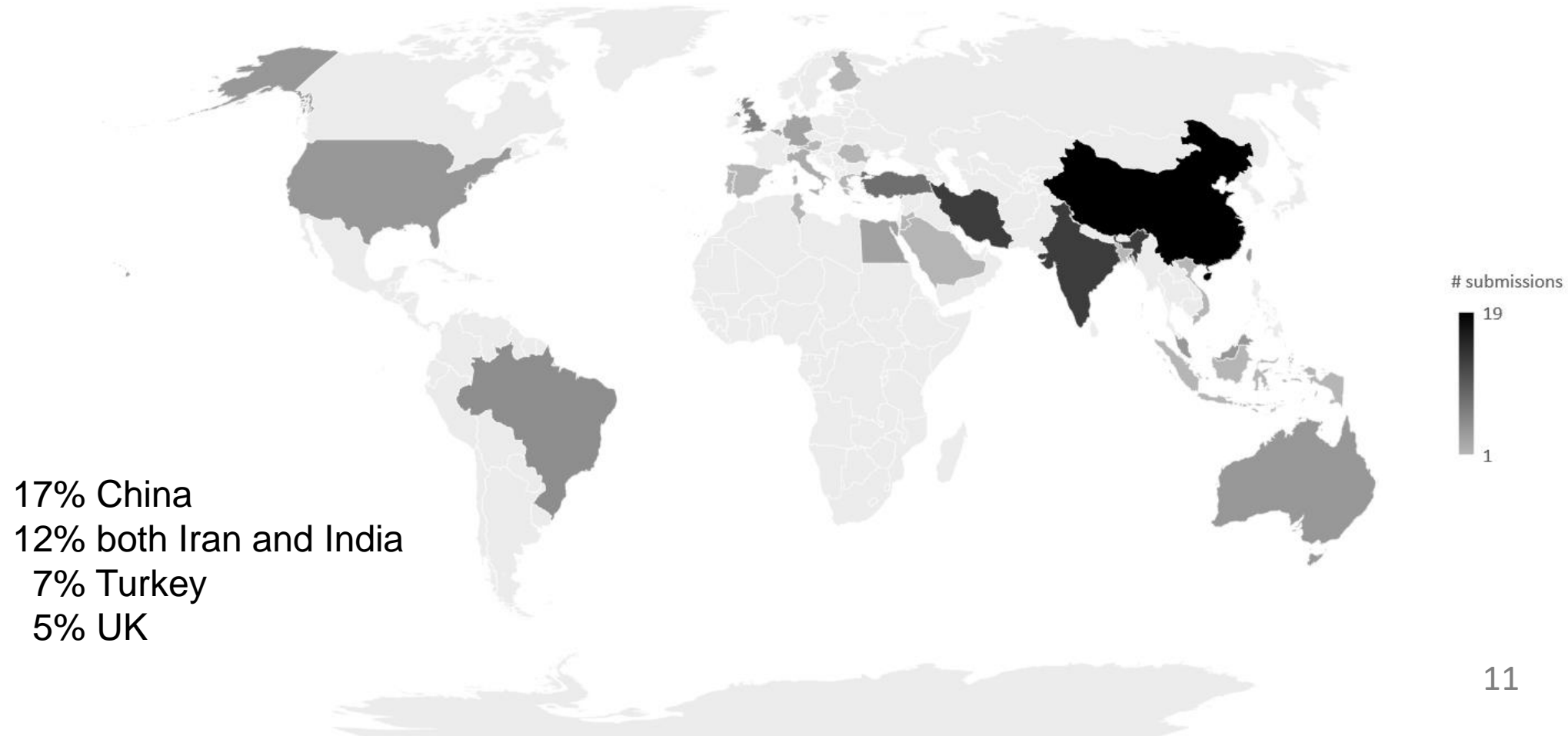
## Publishers

54%	Elsevier
21%	IEEE
8%	Springer
17%	small local or online publisher

# Observations - Publication date



# Observations - Origins

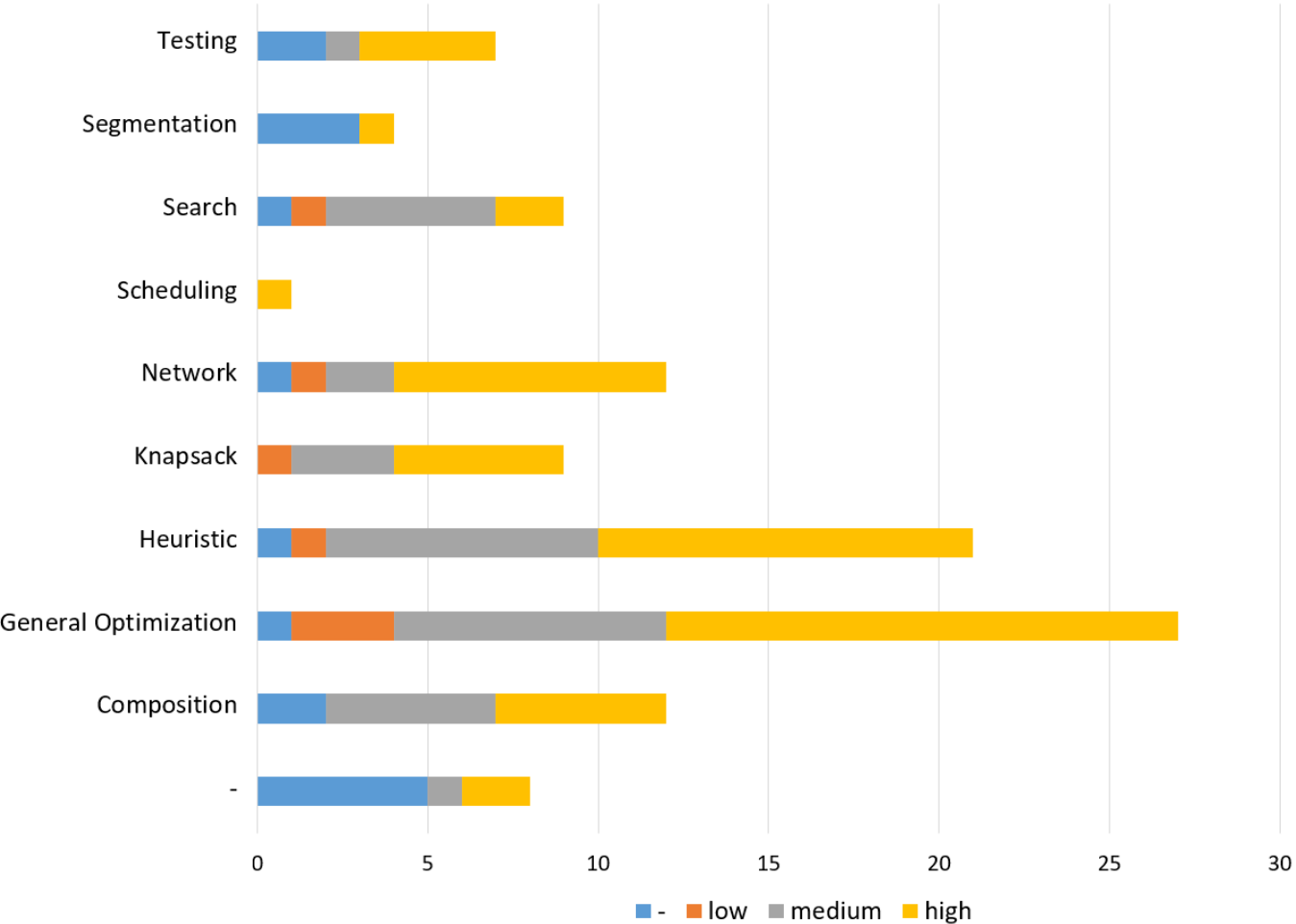


What are characteristics of the proposed algorithms?

What are characteristics of the proposed algorithms?

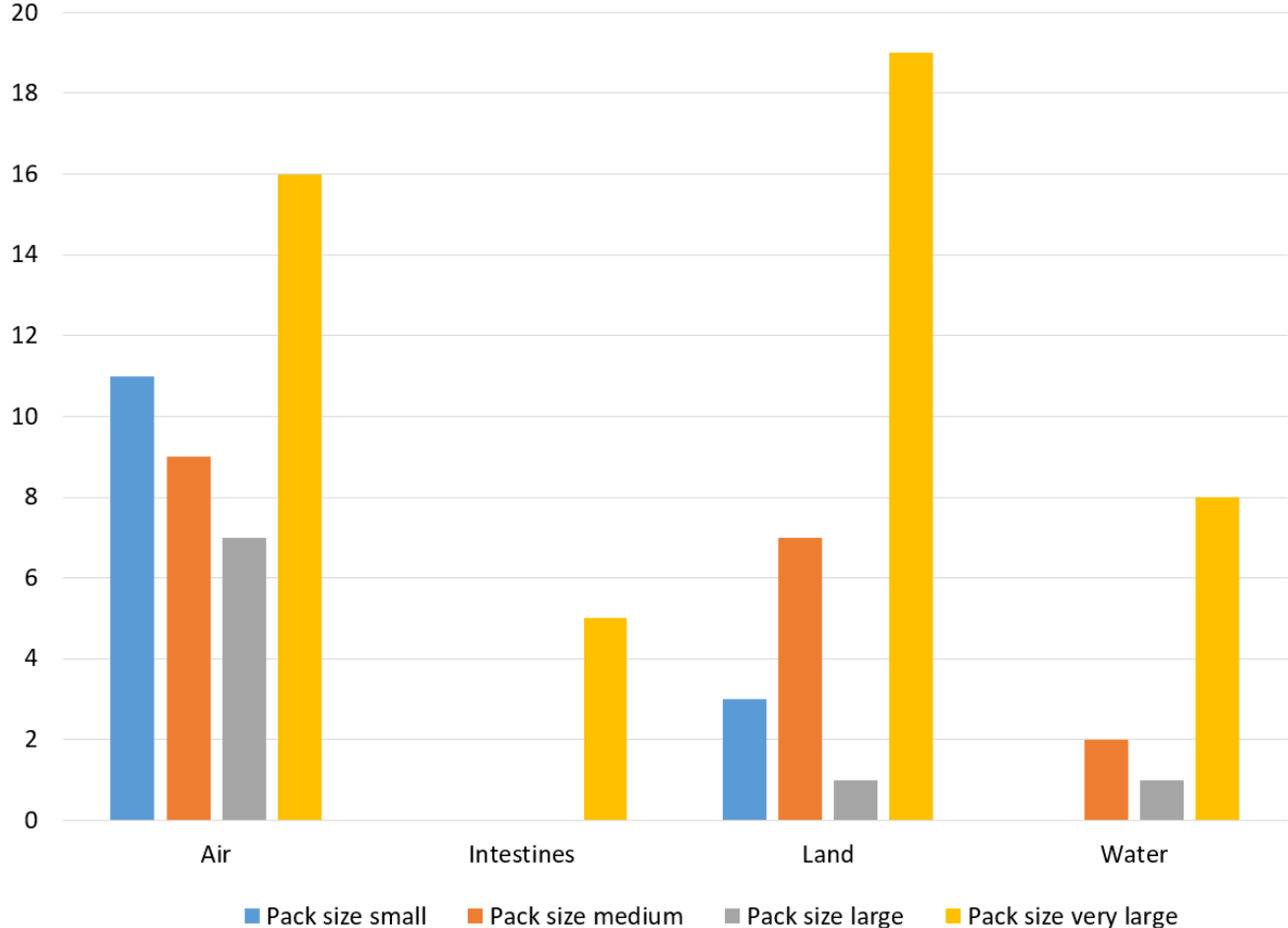
*Data analysis*

# Findings - Efficiency gain

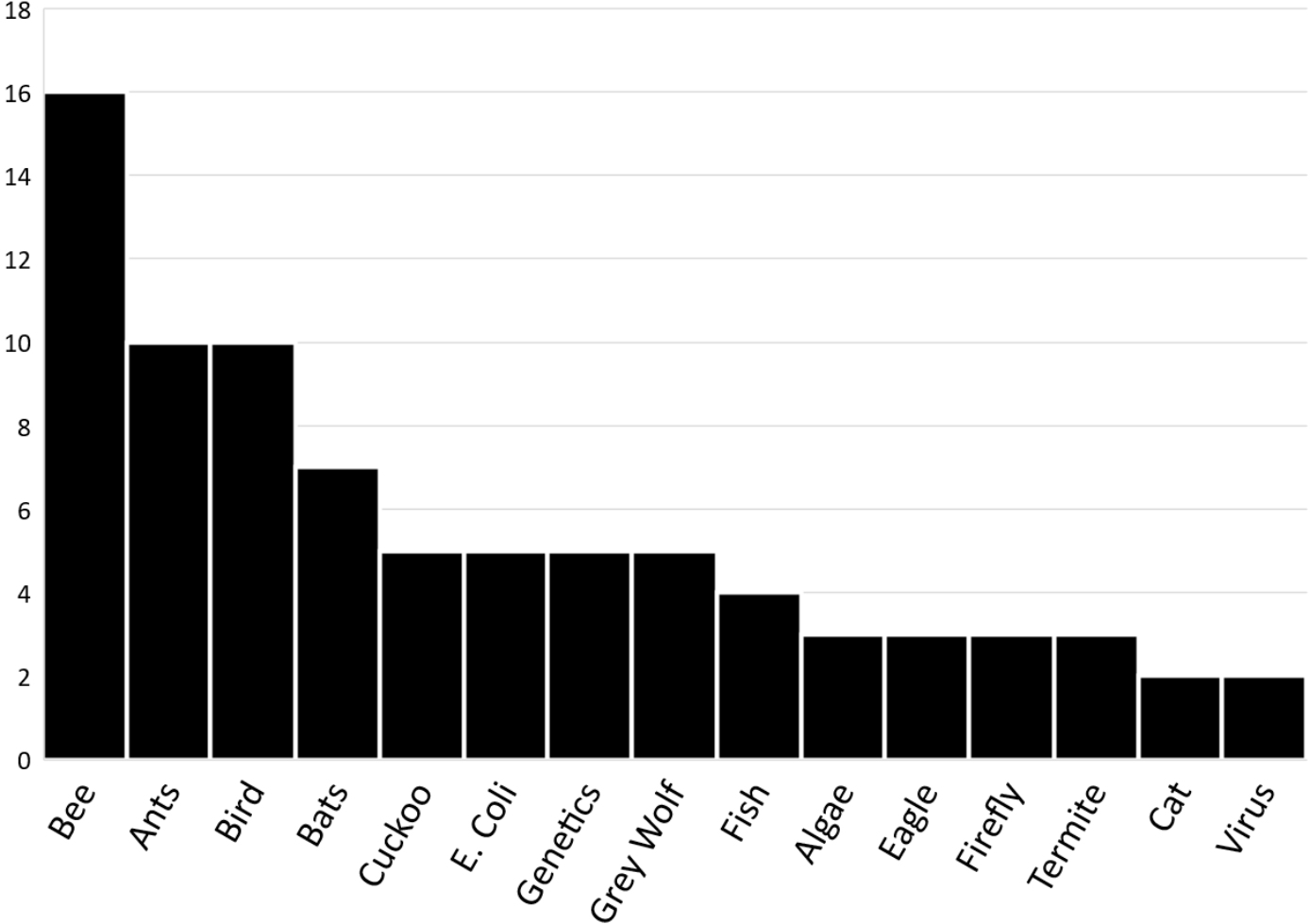


# Findings - Habitat and pack size

Pack size	# Individuals
small	1 to 10
medium	10 to 25
large	25 to 100
very large	> 100

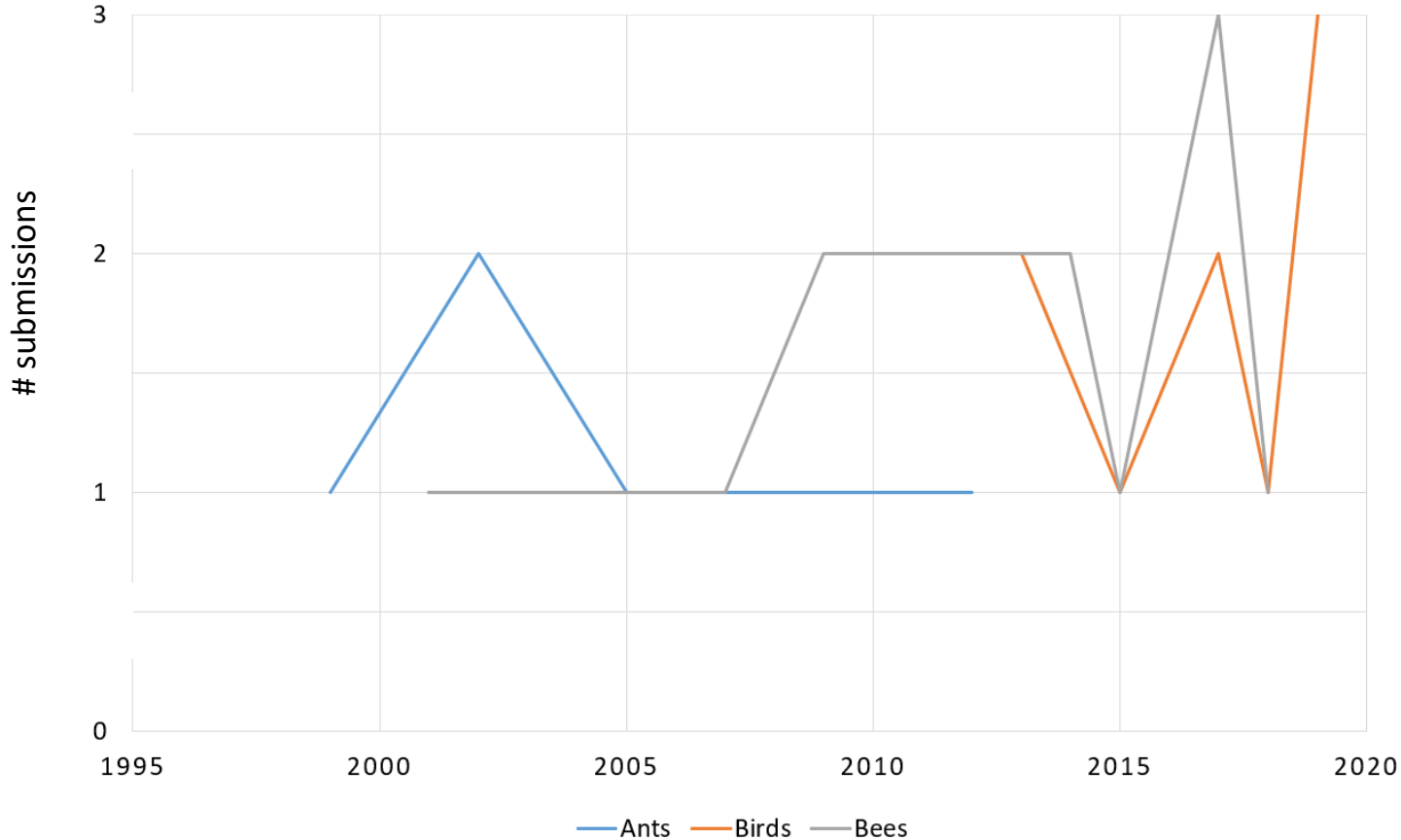


# Finding - Source models



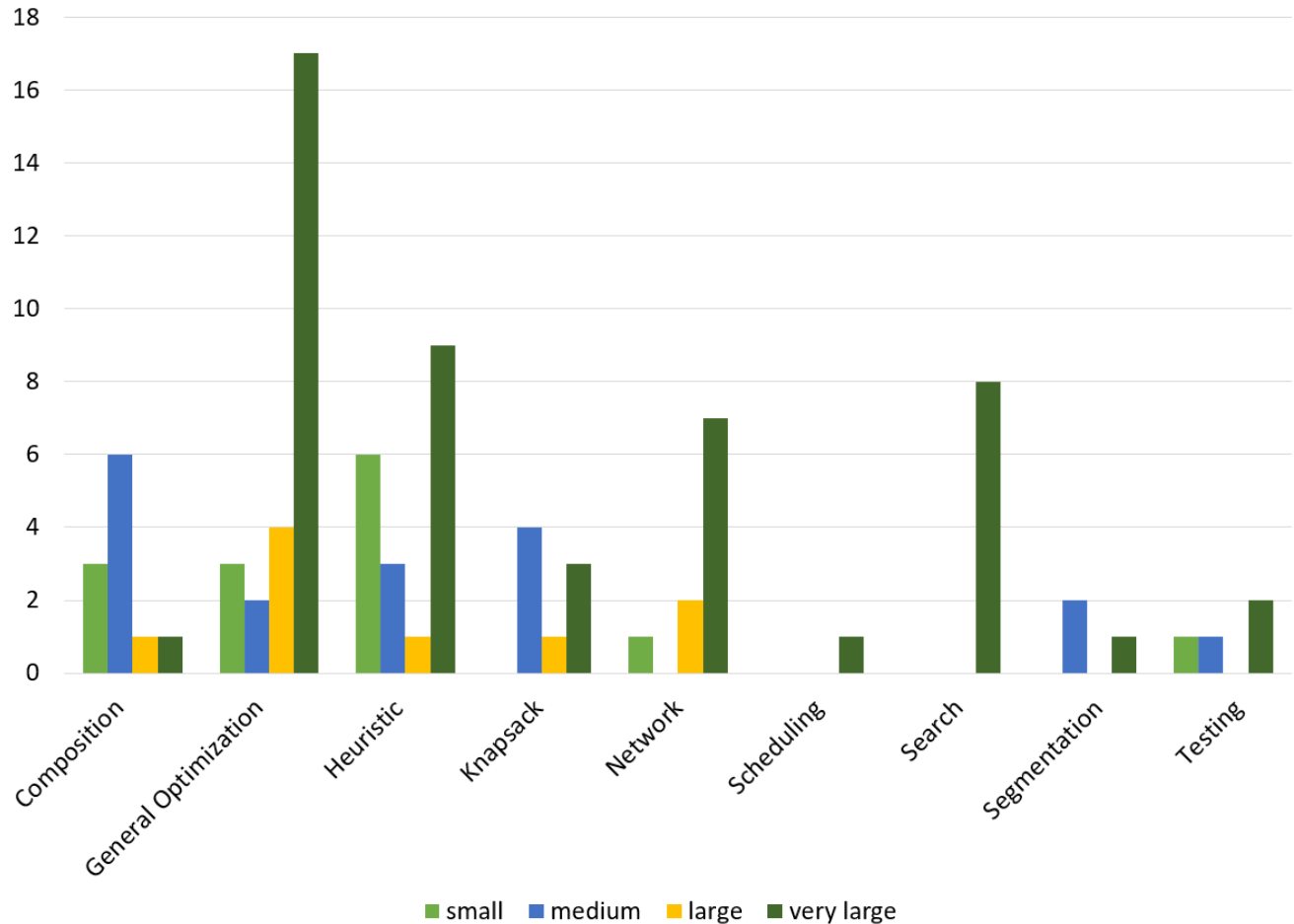


# Finding - Top 3 models



# Finding - Pack size and CS fields

Pack size	# Individuals
small	1 to 10
medium	10 to 25
large	25 to 100
very large	> 100



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Can we generalize a specialized algorithm, and what are the gains?

Can we generalize a specialized algorithm, and what are the gains?

*Adaptation*



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Contents lists available at ScienceDirect

# Applied Soft Computing Journal

journal homepage: [www.elsevier.com/locate/asoc](http://www.elsevier.com/locate/asoc)

## Cost optimized Hybrid Genetic-Gravitational Search Algorithm for load scheduling in Cloud Computing

Divya Chaudhary\*, Bijendra Kumar

Department of Computer Engineering, Netaji Subhas Institute of Technology, Dwarka, New Delhi, India

### H I G H L I G H T S

- This paper proposes Cost optimized Hybrid Genetic-Gravitational Search Algorithm (HG-GSA) for load scheduling in cloud computing.
- It uses a hybrid genetic crossover approach (based on two point and uniform crossover).
- The updated force is calculated based on Gravitational constant using the pbest (particle best) and gbest (global best) values.
- The HG-GSA reduces the Total Cost of Computation considerably than existing algorithms.
- The results are computed on a large set of values and compared with the existing algorithm results using CloudSim simulator.

### A R T I C L E I N F O

#### Article history:

Received 21 June 2017  
 Received in revised form 13 June 2019  
 Accepted 12 July 2019  
 Available online 15 July 2019

#### Keywords:

Cloud computing  
 Load scheduling  
 Gravitational Search Algorithm  
 Swarm intelligence  
 Genetic algorithm

### A B S T R A C T

In cloud computing, cost optimization is a prime concern for load scheduling. The swarm based meta-heuristics are prominently used for load scheduling in distributed computing environment. The conventional load scheduling approaches require a lot of resources and strategies which are non-adaptive and static in the computation, thereby increasing the response time, waiting time and the total cost of computation. The swarm intelligence-based load scheduling is adaptive, intelligent, collective, random, decentralized, self-collective, stochastic and is based on biologically inspired mechanisms than the other conventional mechanisms. The genetic algorithm schedules the particles based on mutation and crossover techniques. The force and acceleration acting on the particle helps in the finding the velocity and position of the next particle. The best position of the particles is assigned to cloudlets to be executed on the virtual machines in the cloud. The paper proposes a new load scheduling technique, Hybrid Genetic-Gravitational Search Algorithm (HG-GSA) for reducing the total cost of computation. The total computational cost includes cost of execution and transfer. It works on hybrid crossover technique based gravitational search algorithm for searching the best position of the particle in the search space. The best position of the particle is used calculating the force. The

DOI:

<https://doi.org/10.1016/j.asoc.2019.105627>





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## Cost optimized Hybrid Genetic-Gravitational Search Algorithm for load scheduling in Cloud Computing

Divya Chaudhary\*, Bijendra Kumar

Department of Computer Engineering, Netaji Subhas Institute of Technology, Dwarka, New Delhi, India

### HIGHLIGHTS

- This paper proposes Cost optimized Hybrid Genetic-Gravitational Search Algorithm (HG-GSA) for load scheduling in cloud computing.
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### ABSTRACT

In cloud computing, cost optimization is a prime concern for load scheduling. The swarm based meta-heuristics are prominently used for load scheduling in distributed computing environment. The conventional load scheduling approaches require a lot of resources and strategies which are non-adaptive and static in the computation, thereby increasing the response time, waiting time and the total cost of computation. The swarm intelligence-based load scheduling is adaptive, intelligent, collective, random, decentralized, self-collective, stochastic and is based on biologically inspired mechanisms than the other conventional mechanisms. The genetic algorithm schedules the particles based on mutation and crossover techniques. The force and acceleration acting on the particle helps in the finding the velocity and position of the next particle. The best position of the particles is assigned to cloudlets to be executed on the virtual machines in the cloud. The paper proposes a new load scheduling technique, Hybrid Genetic-Gravitational Search Algorithm (HG-GSA) for reducing the total cost of computation. The total computational cost includes cost of execution and transfer. It works on hybrid crossover technique based gravitational search algorithm for searching the best position of the particle in the search space. The best position of the particle is used calculating the force. The

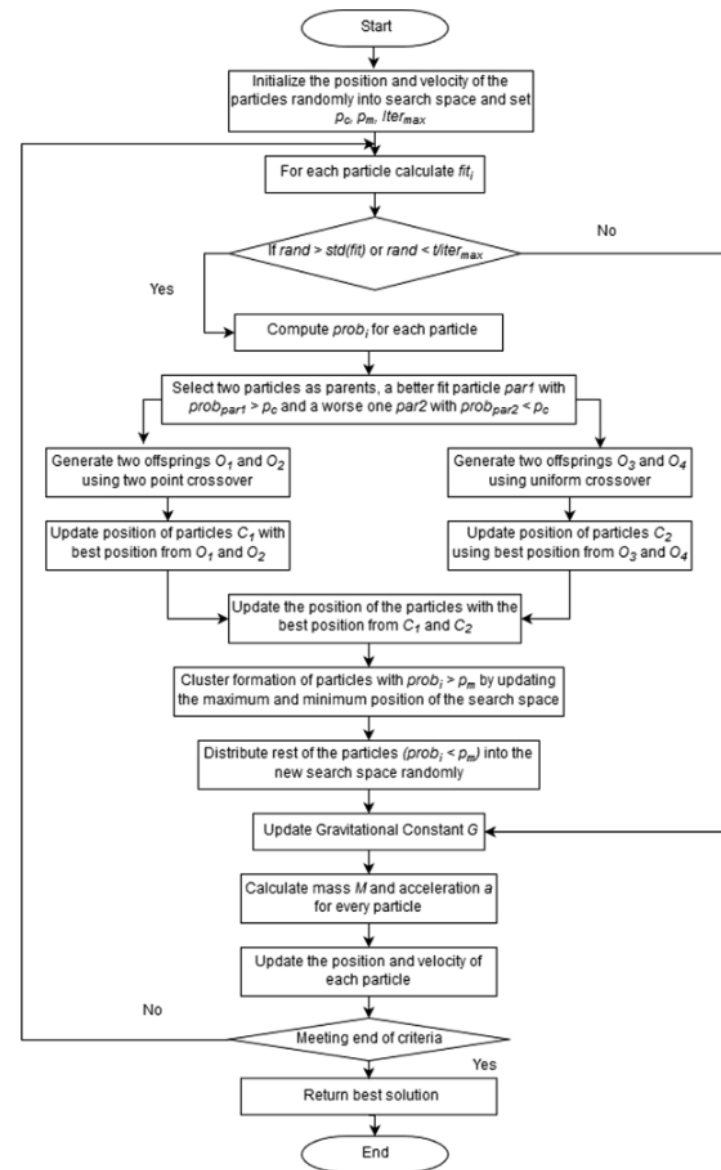
DOI:

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# Their algorithm

## Hybrid genetic algorithm with gravity support

„Uses a genetic algorithm followed by a gravitational one.“



# Our generic adaptation

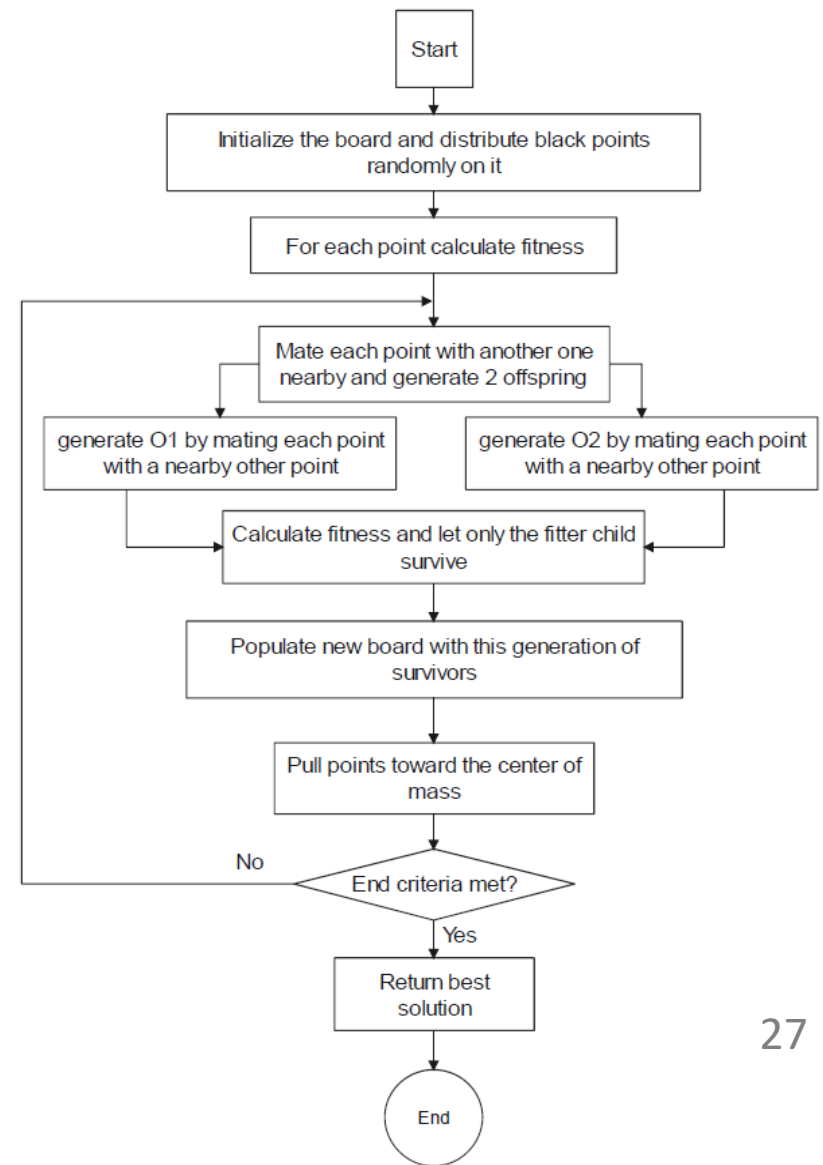
Clustering of pixels on a canvas

Can be adjusted to cluster other structures

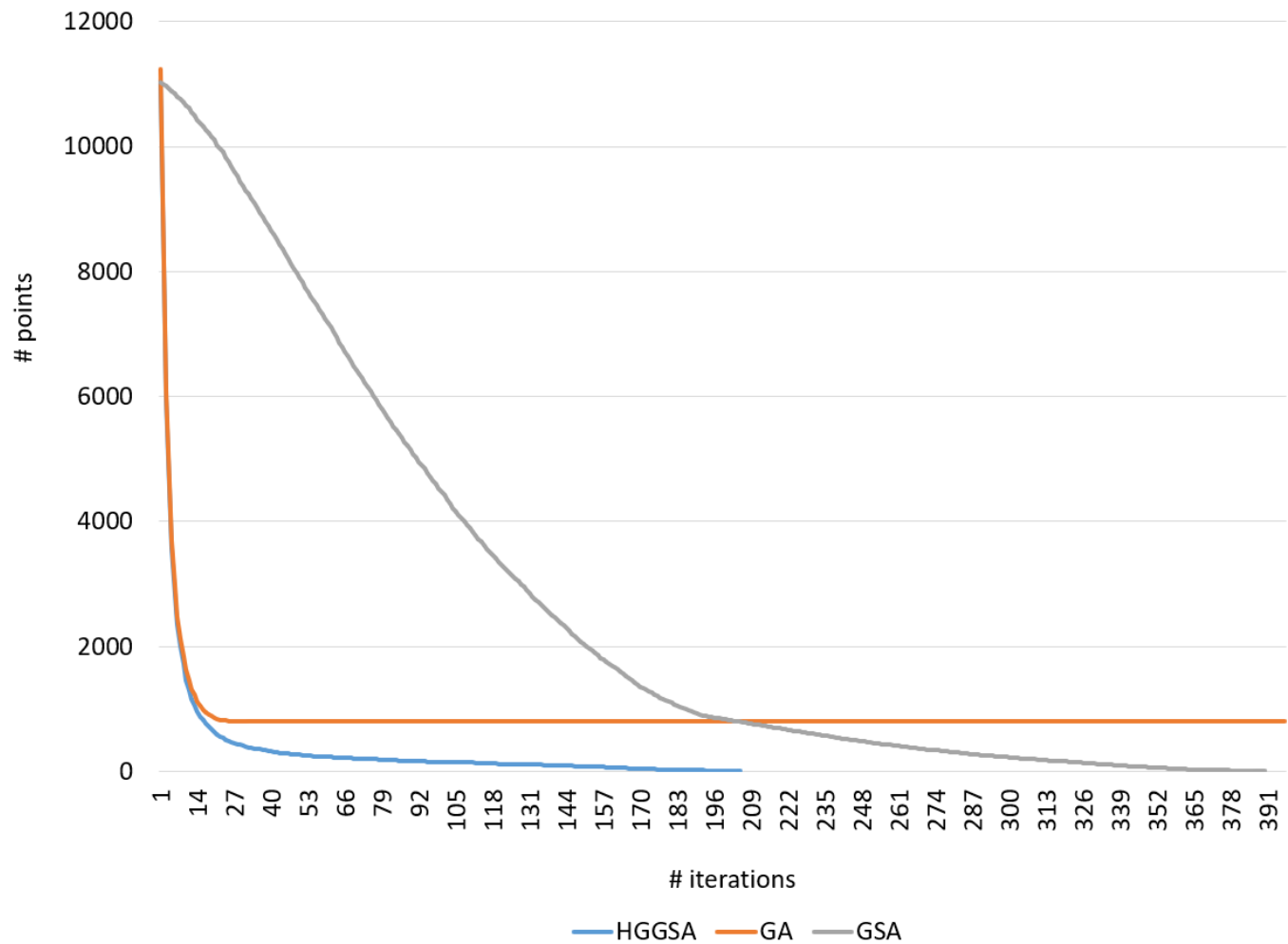
Granularity of solution can be set

Program flow and code available

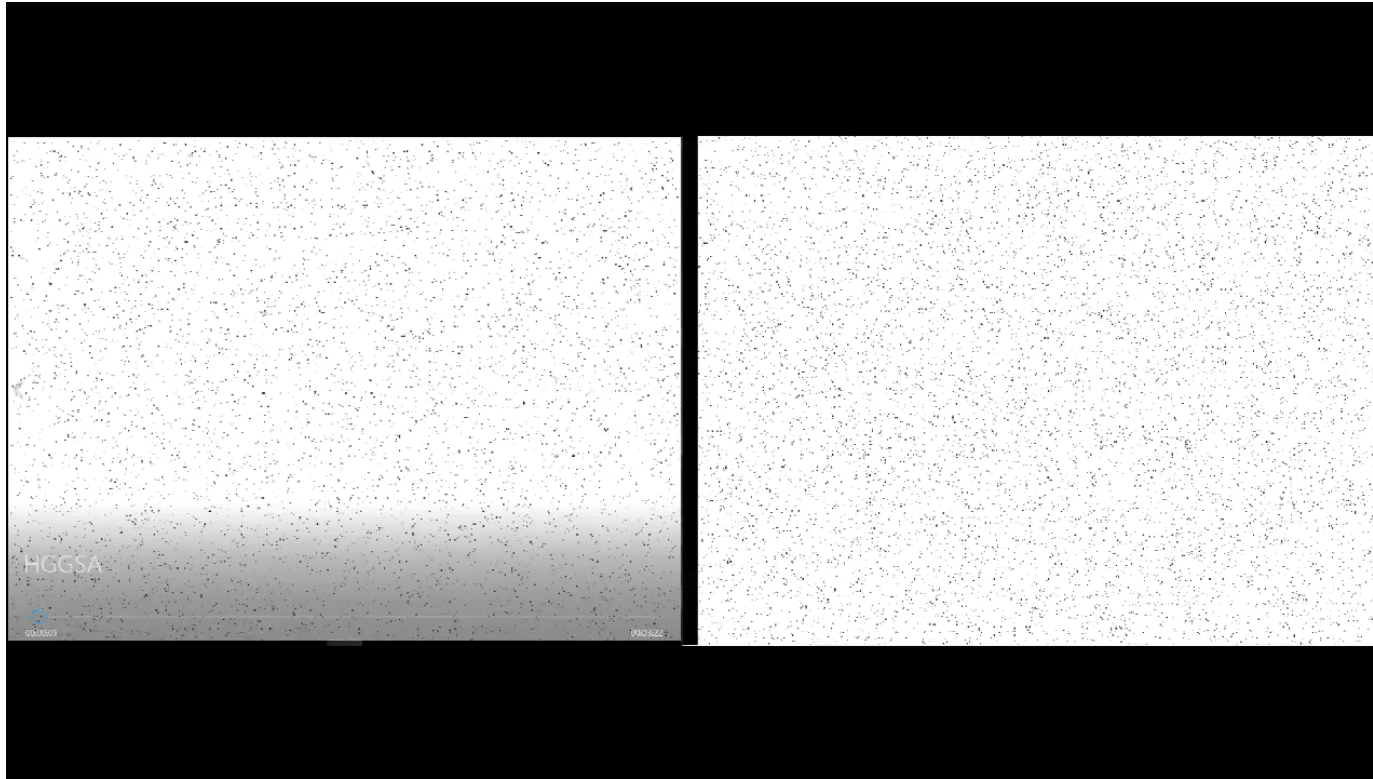
Could be used as a template for other applications



# Comparison



# Convergence



HGGSA algorithm

GA algorithm

Test Setup	
Board size	800x600 pixels
#Points	20'000
Gravity constant	2
Center of mass	(400, 300)

# Conclusion

*This field is small but still alive.*

*Air and land habits are more explored than water and intestines.*

*Generalization is lacking.*

*Specialized algorithms can be easily adapted to different scenarios.*

# Future Work

***There is a lot of “void” ...***

*Many different models solve the same problem.*

*15 million different species exist on earth.*

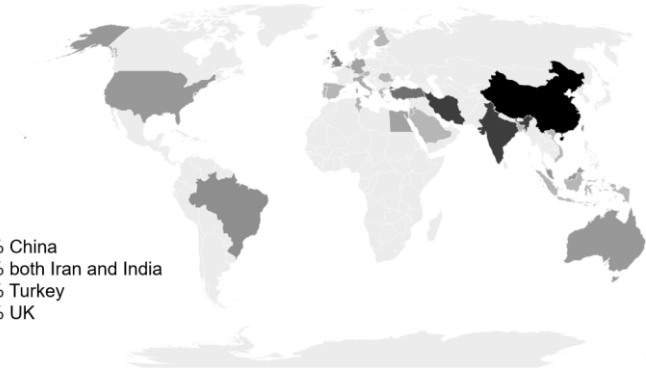
***Combinations and adaptations are worth being explored ...***

*Research indicates large gains.*

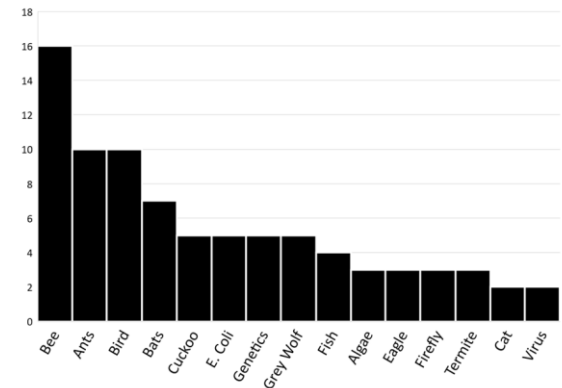
# Summary

ID	Title	Primary Source	Page
1	Modelling Biology Inspired Reactive Agents Using Xmachines	waset.org/	Jou
2	BiologyInspired Optimizations of PeertoPeer Overlay Networks	K.G. Saur Verlag,	Jou
3	Biologyinspired selfhealing system design	University of Helsinki	Paq
4	Natureinspired computing technology and applications	BT Technol J	Paq
5	Python microframework for building natureinspired algorithms	The Journal of Open	Paq
6	Developing pervasive multiagent systems with natureinspired coordination	Elsevier	Jou
7	Physarum Optimization:A BiologyInspired Algorithm for the Steiner Tree Problem in Networks	IEEE	Paq
8	Natureinspired techniques for conformance testing of objectoriented software	Elsevier	Jou
9	Natureinspired approaches in software faults identification and debugging	Elsevier	Paq
10	The intelligent water drops algorithm: a natureinspired swarmbased optimization algorithm	Inderscience Enterpr	Paq
11	The AntBee Routing Algorithm: A New Agent Based NatureInspired Routing Algorithm	Journal of applied Sc	Jou
12	An Exhaustive Survey on Nature Inspired Optimization Algorithms	International Journal	Paq
13	A novel metaheuristic algorithm: Dynamic Virtual Bats Algorithm	Elsevier	Jou
14	EvoLoPy: An Opensource Natureinspired Optimization Framework in Python	SCITEPRESS	Paq
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21	Natureinspired Coordination Models: Current Status and Future Trends	Hindawi Publishing C	Paq
22	Artificial bee algorithm (ABC) for nonlinear global optimization	Elsevier	Jou

## Observations - Origins



## Finding - Source models



## Animation

