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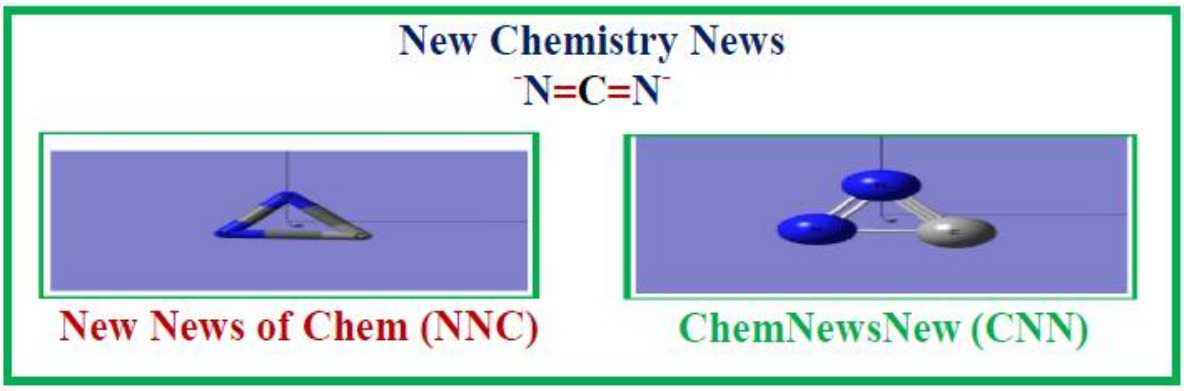


Evolution of Mimics of Algorithms of Nature (E-man)

11. Physics/Chemistry/MathsInspired Optimization (Mathematical) Methods (Mpc.iOM)

Information Source	ACS.org ; sciencedirect.com
K. Somasekhara Rao, **Dept. of Chemistry,** **Acharya Nagarjuna Univ.,** **Dr. M.R.Appa Rao Campus,** **Nuzvid-521 201, India**	**R. Sambasiva Rao,** **School of Chemistry,** **Andhra University,** **Visakhapatnam 530 003, India**

Nature Inspired(mathematical)Algorithms (NiMa)

Universe ….

Science Eye

Experimental

- Physics
- Chemistry
- Biology

Theoretical

- Mathematics

Material world

- Boson
- Atom
- Macro-molecule

- Life
- Non-life

Energy

Fact-base

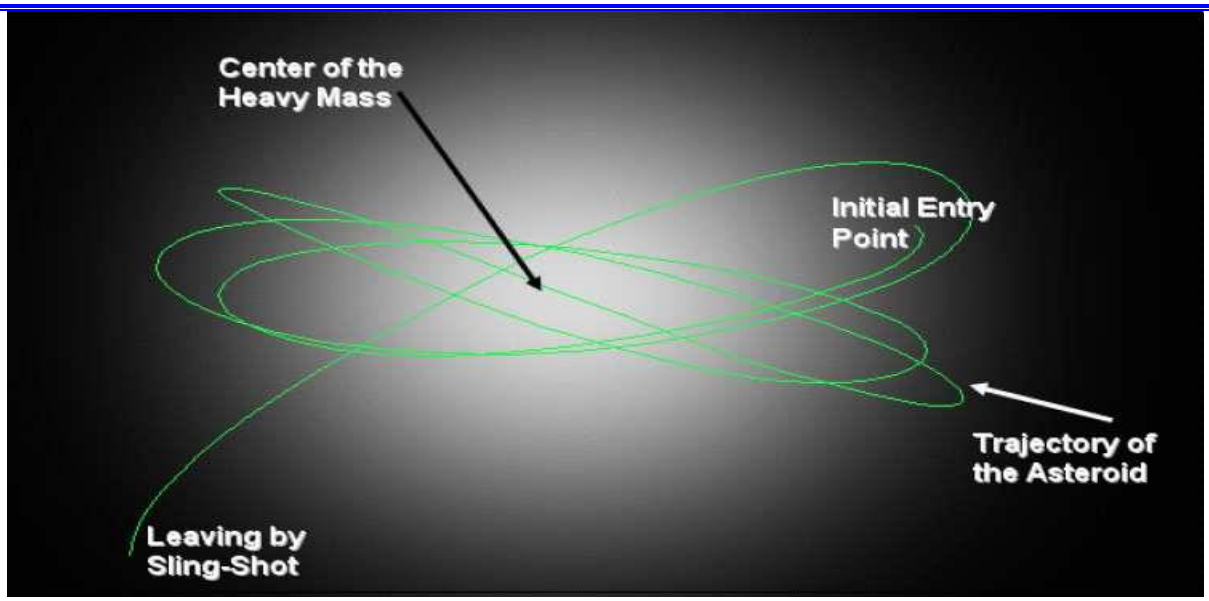
- Universe today is outcome of evolution of energy in time (13.7 billion years) and space
- Life and non-life systems nature made
- Man is an evolved intelligent Lifeform in animal kingdom
- Science is man-made by observing Universe and making use of tools of nature (including his brain/mind/consciousness)

11a. Physics Inspired Optimization (Mathematical) Methods (Phys. iOM)

[[[[[[[[[[[[[[~~~~~~~~~~~~~~~~~~~~Small-World

world	Small-World Optimization Algorithm for Function Optimization	Title
	ICNC 2006, Part II, LNCS 4222, (2006) 264 – 273.	Journal
	Haifeng Du, Xiaodong Wu, and Jian Zhuang	Author(s)

[[[[[[[[[[[[[[~~~~~~~~~~~~~~~~~~~~Gravitation



Simulation of effect of gravitational field

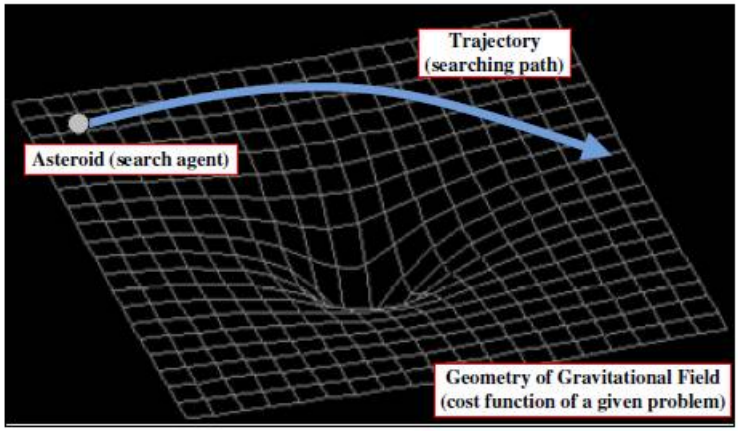


Illustration of an asteroid missing the location of local gravitysource

.

a)	A local-gravitation-based method for the detection of outliers and boundary points Knowledge-Based Systems, 192 (2020) 105331. doi.org/10.1016/j.knosys.2019.105331 Jiang Xie, Zhongyang Xiong, Qizhu Dai, Xiaoxia Wang, Yufang Zhang
b)	Improving Gravitational Search Algorithm Performance with Artificial Bee Colony Algorithm for Constrained Numerical Optimization The Journal of MacroTrends in Applied Science, (2016), 55-67. Hasan Ali AKYÜREK, ÖmerKaan BAYKAN, Barış KOÇER
c)	A Memetic Chaotic Gravitational Search Algorithm for unconstrained global optimization problems Applied Soft Computing Journal, 79 (2019) 14–29. doi.org/10.1016/j.asoc.2019.03.011 Ricardo García-Ródenas, Luis Jiménez Linares, Julio Alberto López-Gómez

d)	Gravitational Search Algorithm for Optimal Economic Dispatch Procedia Technology, 6 (2012) 411 – 419. doi: 10.1016/j.protcy.2012.10.049 R.K.Swain, N.C.Sahu, P.K.Hota
e)	Sequential Hybrid Particle Swarm Optimization and Gravitational Search Algorithm with Dependent Random Coefficients Mathematical Problems in Engineering (2020). https://doi.org/10.1155/2020/1957812 Shanhe Jiang, Chaolong Zhang and Shijun Chen

f)	A Novel Optimization Algorithm: Space Gravitational Optimization IEEE International Conference on Systems, Man and Cybernetics Waikoloa, Hawaii (2005), 2323-2328. Ying-Tung Hsiao, Cheng-Long Chuang, Joe-Air Jiang and Cheng-ChihChien
g)	Disruption: A new operator in gravitational search algorithm Scientia Iranica D (2011) 18 (3), 539–548. doi:10.1016/j.scient.2011.04.003 S. Sarafrazi, H. Nezamabadi-pour, S. Saryazdi
h)	A novel hybrid particle swarm optimization and gravitational search algorithm for multi-objective optimization of text mining Applied Soft Computing Journal, 2020. doi.org/10.1016/j.asoc.2020.106189 Mohamed Atef Mosa
i)	Optimized gravitational-based data clustering algorithm Engineering Applications of Artificial Intelligence, 73 (2018) 126–148. doi.org/10.1016/j.engappai.2018.05.004 Mohammed Alswaitti, Mohamad Khairi Ishak, Nor Ashidi Mat Isa
j)	An evolutionary gravitational search-based feature selection Information Sciences, 497 (2019) 219–239. doi.org/10.1016/j.ins.2019.05.038 Mohammad Taradeh, MajdiMafarj, Ali Asghar Heidari, Hossam Faris, Ibrahim Aljarah, SeyedaliMirjalili, Hamido Fujita
k)	Manifold Learning for Efficient Gravitational Search Algorithm Information Sciences, 2020. doi.org/10.1016/j.ins.2019.12.047 Chen Giladi, AvishaiSintov
l)	SCGSA: A Sine Chaotic Gravitational Search Algorithm for Continuous Optimization Problems Expert Systems With Applications, 2020. doi.org/10.1016/j.eswa.2019.113118 Jianhua Jiang, Ran Jiang, Xianqiu Meng, Keqin Li

[[[[[[[[[[[[[~~~~~~~~~~ Quantum gravity ……

a)	An introduction to quantum gravity Giampiero Esposito arXiv,2011

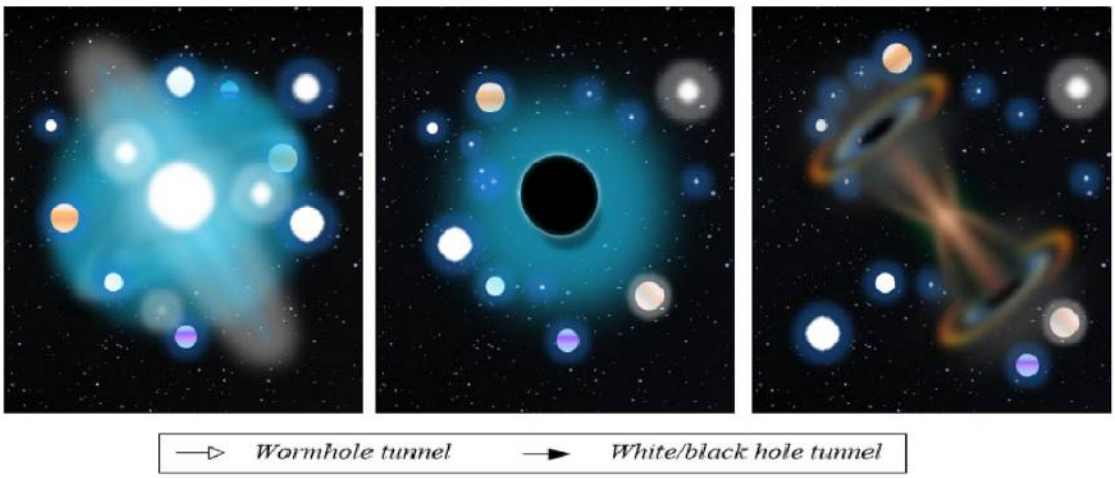
[[[[[[[[[[[[[~~~~~~~~~~~~~~~~~~Galaxy …..

a)	Principal components analysis by the galaxy-based search algorithm: A novel metaheuristic for continuous optimisation	Title
	Int. J. Computational Science and Engineering, (2011), Vol. 6, Nos. 1/2, DOI: 10.1504/IJCSE.2011.041221	Journal
	Hamed Shah-Hosseini	Author(s)

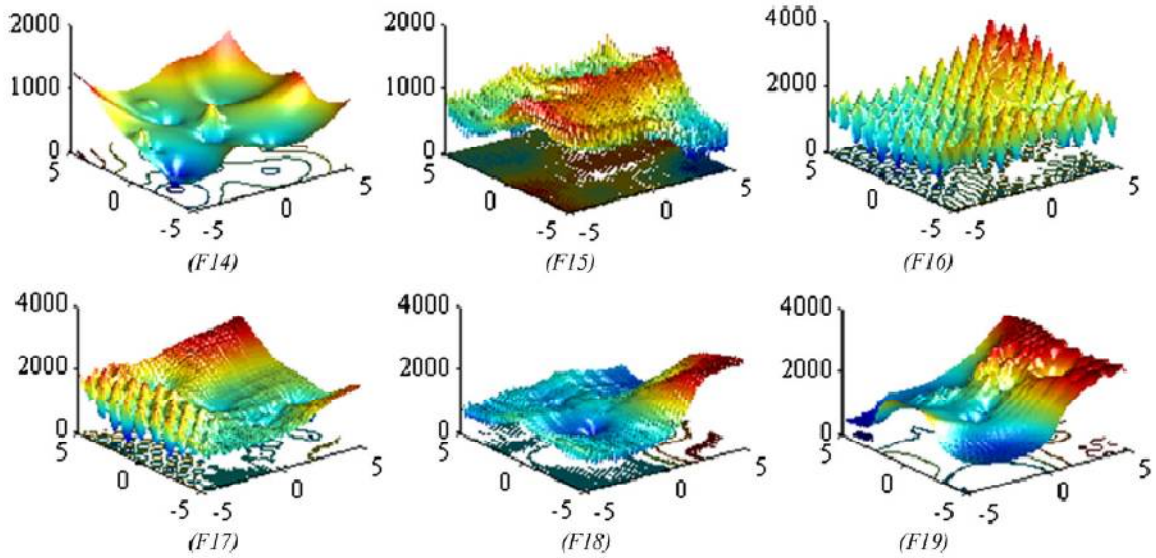
[[[[[[[[[[[[[~~~~~~~~~~~~~~~~~~Supernova

a)	Supernova Optimizer: A Novel Natural Inspired Meta-Heuristic	Title
	Modern Applied Science; Vol. 12, No. 1; (2018), https://doi.org/10.5539/mas.v12n1p32	Journal
	Amjad A. Hudaib& Hussam N. Fakhouri	Author(s)

[[[[[[[[[[[[[~~~~~~~~~~~~~~~~~~Multi-verse



Multi-verse

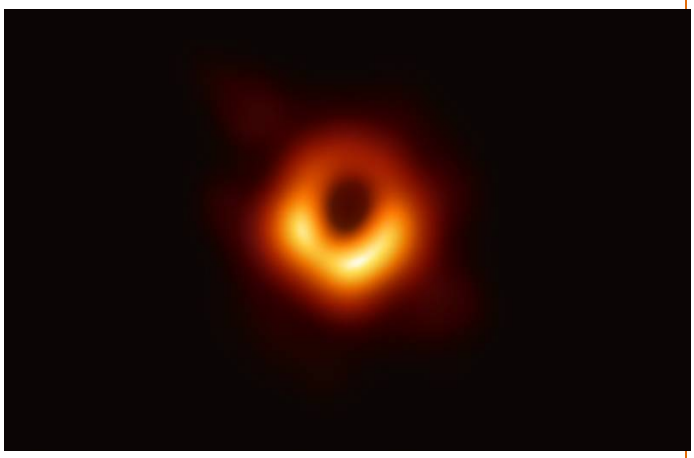


Mathematical functions solved with Multi-verse optimization

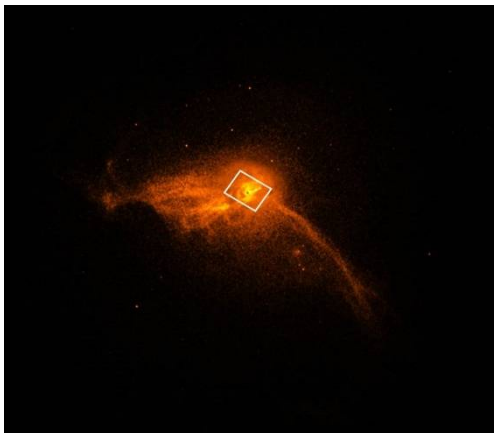
a)	A hybrid multi-verse optimization for the fuzzy flexible job-shop scheduling problem Computers & Industrial Engineering doi.org/10.1016/j.cie.2018.11.046 Jian Lin, Lei Zhu, Zhou-Jing Wang
b)	Multi-Verse Optimizer: a nature-inspired algorithm for global optimization Neural Comput&Applic, (2015). DOI 10.1007/s00521-015-1870-7 SeyedaliMirjalili, Seyed Mohammad Mirjalili, AbdolrezaHatamlou

[[[[[[[[[[[[[[[~~~~~~~~~~~~~~~~~~~Black hole

Inspired by	☞ Black hole devouring other stars
	☞ The BH is an area in the space with high gravitational force ☞ It sucks anything viz. starsor even light when they get too close to it ☞ Black holes were referred to as frozen stars, dark stars, or collapsed stars
	! Some scientists belief: mini-black holes were created at the same time as the universe ! They are of size of an atom yet with mass of a large mountain



A black hole and its shadow



- Black hole cannot be seen
- hot disk of material that encircles it shines bright
- Black hole appears to cast a shadow.

a)	Short-term scheduling of thermal power systems using hybrid gradient based modified teaching–learning optimizer with black hole algorithm Electric Power Systems Research, 108 (2014) 16– 34. doi.org/10.1016/j.epsr.2013.10.012 RasoulAzizipanah-Abarghooeea, Taher Niknama, FarhadBavafaa, Mohsen Zarea
b)	Black hole: A new heuristic optimization approach for data clustering Information Sciences, 222 (2013) 175–184. doi.org/10.1016/j.ins.2012.08.023 AbdolrezaHatamlou
c)	Binary black hole algorithm for feature selection and classification on biological data Applied Soft Computing, 56 (2017) 94–106. doi.org/10.1016/j.asoc.2017.03.002 Elnaz Pashaei, Nizamettin Aydin

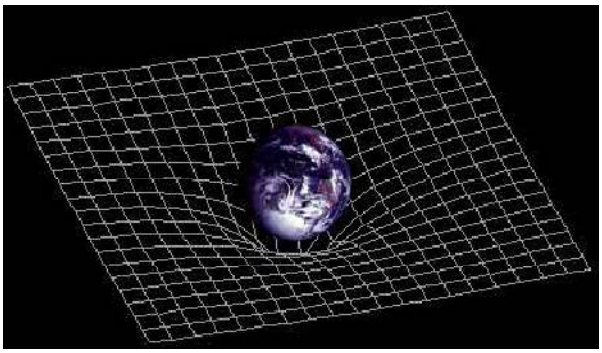
d)	How novel is the ‘‘novel’’ black hole optimization approach? Information Sciences, 267 (2014) 191–200. doi.org/10.1016/j.ins.2014.01.026 Adam P. Piotrowski, Jaroslaw J. Napiorkowski, Pawel M. Rowinski
e)	Optimal Design of Electromagnetic Devices Using a Black-Hole-Based Optimization Technique IEEE TRANSACTIONS ON MAGNETICS, VOL. 49, NO. 12 (2013). Houssem R. E. H. Bouchekara

f)	AMOBH: Adaptive Multiobjective Black Hole Algorithm Computational Intelligence and Neuroscience, Volume 2017. https://doi.org/10.1155/2017/6153951 Chong Wu, Tao Wu, Kaiyuan Fu, Yuan Zhu, Yongbo Li, Wangyong He, and Shengwen Tang

g)	3-D Terrain Node Coverage of Wireless Sensor Network Using Enhanced Black Hole Algorithm Sensors, (2020) 20, 2411. doi:10.3390/s20082411 Jeng-Shyang Pan, Qing-Wei Chai, Shu-Chuan Chu, and Ning Wu
h)	Modified Black Hole Algorithm with Genetic Operators International Journal of Computational Intelligence Systems, Vol. 9, No. 4 (2016) 652-665. doi.org/10.1080/18756891.2016.1204114 Saber Yaghoobi & Hamed Mojallali

i)	Enriched black hole algorithm for diminution of real power loss International Journal of Research – Granthaalayah, 5(9), 186-194. https://doi.org/10.5281/zenodo.1002636 Dr.K.Lenin
j)	AMOBH: Adaptive Multi objective Black Hole Algorithm Computational Intelligence and Neuroscience, Volume 2017, Article ID 6153951. https://doi.org/10.1155/2017/6153951 Chong Wu, Tao Wu, Kaiyuan Fu, Yuan Zhu, Yongbo Li, Wangyong He, and Shengwen Tang
k)	Optimal power flow using black-hole-based optimization approach Applied Soft Computing, (2014). doi.org/10.1016/j.asoc.2014.08.056 H.R.E.H. Bouchekara

[[[[[[[[[[[[[[~~~~~~~~~~~~~~~~~~~~Curved Space



☞ **Illustration of a curved space-time.**

- **The distortion at the centerof the plot is created by the mass of the earth**
- **geometricalgradient of curved space-time represents the gravitational**
- **field formed by the earth.**

(The picture of the earth was captured fromthe website of National Space Science Data Center, NASA.)

a)	Curved Space Optimization: A Random Search based on General Relativity Theory Xiv 2012 Aug 10 Fereydoun Farrahi Moghaddam; Reza Farrahi Moghaddam and Mohamed Cheriet
b)	Integrated Radiation Optimization: Inspired by the Gravitational Radiation in the Curvature of Space-time Cheng-Long Chuang, and Joe-Air Jiang

[[[[[[[[[[[[[[~~~~~~~~~~~~~~~~~~~~Quantum world

a)	A Quantum-Inspired Evolutionary Algorithm Using Gaussian Distribution-Based Quantization Arab J Sci Eng, (2017). DOI 10.1007/s13369-017-2641-9 Sreenivas Sremath Tirumala
b)	Florin Leon Real-Valued Quantum-Inspired Evolutionary Algorithm for Multi-Issue Multi-Lateral Negotiation Proceedings of 2012 IEEE 8th International Conference on Intelligent Computer Communication and Processing (ICCP 2012), 41-48.
c)	The Improvement of Quantum Genetic Algorithm and Its Application on Function Optimization Mathematical Problems in Engineering, Volume 2013, Article ID 730749. http://dx.doi.org/10.1155/2013/730749 Huaixiao Wang, Jianyong Liu, Jun Zhi, and Chengqun Fu
d)	Optimizing quantum optimization algorithms via faster quantum gradient computation SIAM, (2019). AndrásGilyén Srinivasan Arunachalam Nathan Wiebe
e)	Quantum Gravity Edited by Rodrigo Sobreiro, Published by InTech, JanezaTrdine 9, 51000 Rijeka, Croatia

[[[[[[[[[[[[[[~~~~~~~~~~~~~~~~~~~~Superposition

a)	Enhanced superposition determination for weighted superposition attraction algorithm Soft Computing https://doi.org/10.1007/s00500-020-04853-4 Adil Baykasoglu, SenerAkpinar
b)	Weighted Superposition Attraction (WSA): A swarm intelligence algorithm for optimization problems – Part 2: Constrained optimization Applied Soft Computing, (2015). Adil Baykasoglu, SenerAkpinar

[[[[[[[[[[[[[[~~~~~~~~~~~~~~~~~~~~Electric Field

a)	AEFA: Artificial electric field algorithm for global optimization Swarm and Evolutionary Computation, 48 (2019) 93–108. doi.org/10.1016/j.swevo.2019.03.013 Anita, Anupam Yadav
b)	Artificial Electric Field Algorithm for Engineering Optimization Problems Expert Systems With Applications, (2020). doi.org/10.1016/j.eswa.2020.113308 Anita, Anupam Yadav, Nitin Kumar

[[[[[[[[[[[[[[~~~~~~~~~~~~~~~~~~~~Electrio-magnetic Field

a)	An Electromagnetism-like Mechanism for Global Optimization Journal of Global Optimization, 25: (2003), 263–282. S. ILKER BIRBIL and SHU-CHERNG FANG

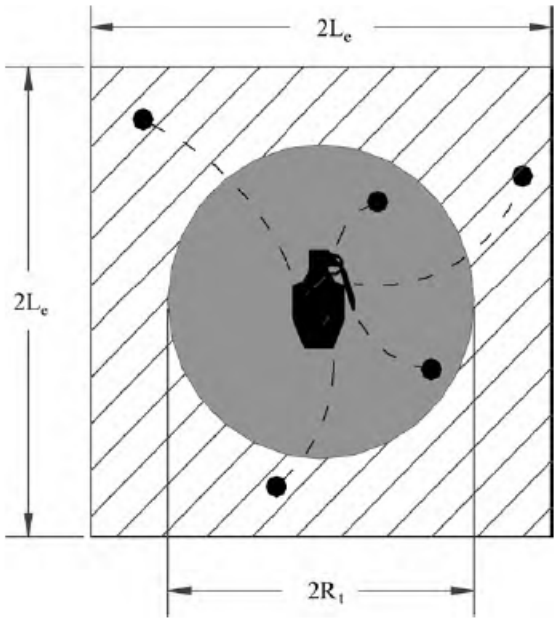
b)	An Improved Electromagnetic Field Optimization for the Global Optimization Problems Computational Intelligence and Neuroscience, Volume 2019, Article ID 6759106. https://doi.org/10.1155/2019/6759106 AlkinYurtkuran
c)	Circle detection using electro-magnetism optimization Information Sciences, 182 (2012) 40–55. doi:10.1016/j.ins.2010.12.024 Erik Cuevas, Diego Oliva, Daniel Zaldivar, Marco Pérez-Cisneros, Humberto Sossa

[[[[[[[[[[[[[[~~~~~~~~~~~~~~~~~~Equilibrium

a)	Equilibrium optimizer: A novel optimization algorithm Knowledge-Based Systems, 191 (2020) 105190. doi.org/10.1016/j.knosys.2019.105190 Afshin Faramarzi, Mohammad Heidarinejad, Brent Stephens, SeyedaliMirjalili

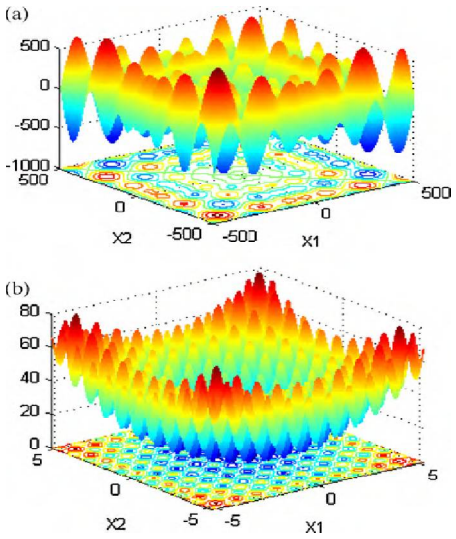
[[[[[[[[[[[[[[~~~~~~~~~~~~~~~~~~Grenade Explosion

Grenade expl



Range of explosion and territory radius in the two-D space

Surface plot and contour lines



(a) Schwefel function

(b) Rastrigin function

a)	Grenade Explosion Method-A novel tool for optimization of multimodal functions Applied Soft Computing, 10 (2010) 1132–1140. doi:10.1016/j.asoc.2009.11.032 Ali Ahrari, Ali A. Atai
b)	Chaotic Grenade Explosion algorithms for global numerical optimization Advanced Materials Research, 602-604 (2013) 1787-1792. doi:10.4028/www.scientific.net/AMR.602-604.1787 YANG Shi-da,YIYa-lin, LU Yan-ping

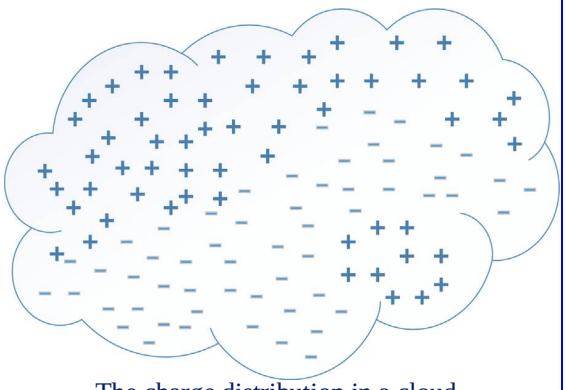
c)	Application of Grenade Explosion Method Optimization for Plate-Fin Type Heat Exchanger (PFHE) IOSR Journal of Mechanical and Civil Engineering (IOSR-JMCE) 12-15. DOI: 10.9790/1684-17010031215 R. D. Rakhade, N. V. Patil, M. P. Panchbhai
d)	Grenade Explosion Method for Maximum Weight Clique Problem M. Parashar et al. (Eds.): IC3 2012, CCIS 306, (2012) 20–27. Manohar Pallantla and Alok Singh

e)	Two Improved Artificial Bee Colony Algorithms Inspired by Grenade Explosion Method D.S. Huang et al. (Eds.): ICIC 2013, CCIS 375, (2013) 100–105. Chaoqun Zhang, Jianguo Zheng and Yongquan Zhou

[[[[[[[[[[[[[[~~~~~~~~~~~~~~~~~~~~Lightning Flash

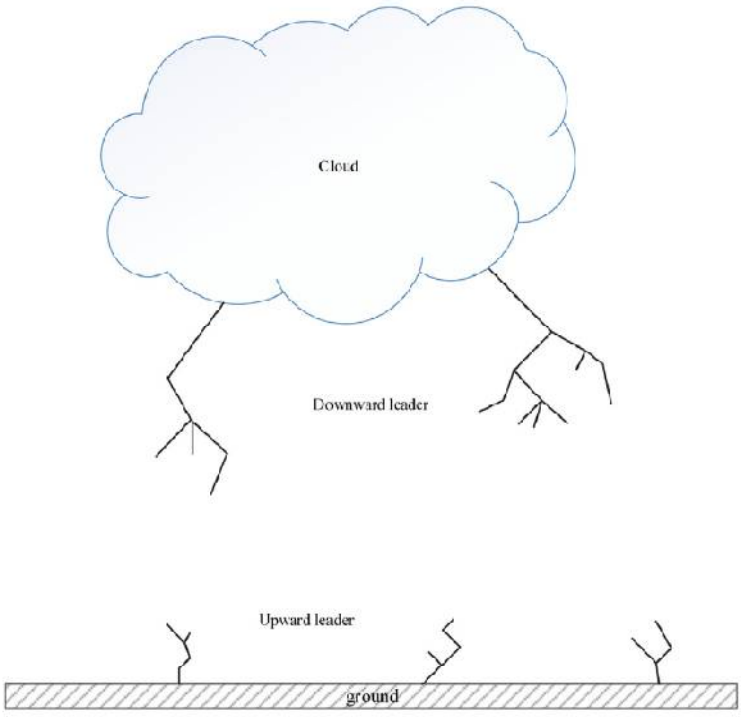
inspired by	☞ Lightning attachment procedure inspired by the attachment procedure of lightning in nature

Step leaders descending from a storm cloud



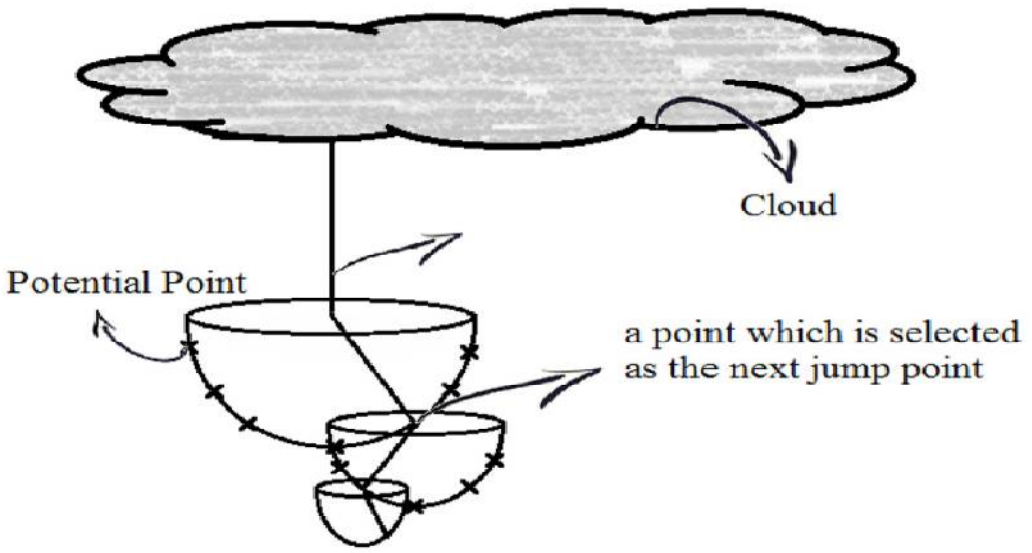
The charge distribution in a cloud

Different starting points of lightning from the cloud.



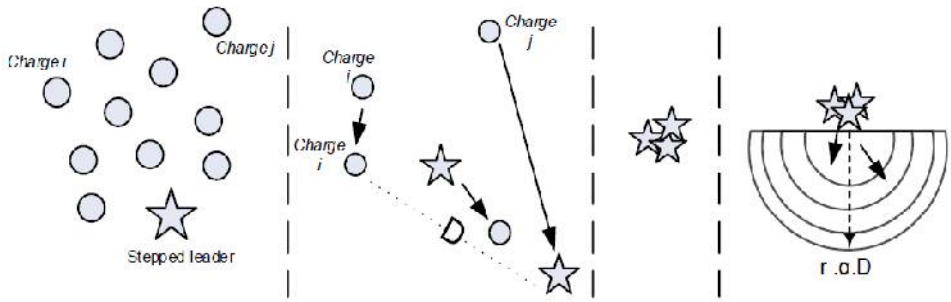
upward leader formation and propagation through downward leader.

.



The procedure of stepwise movement of downward lightning leader.

Fading branches in high speed camera photographs of lightning.



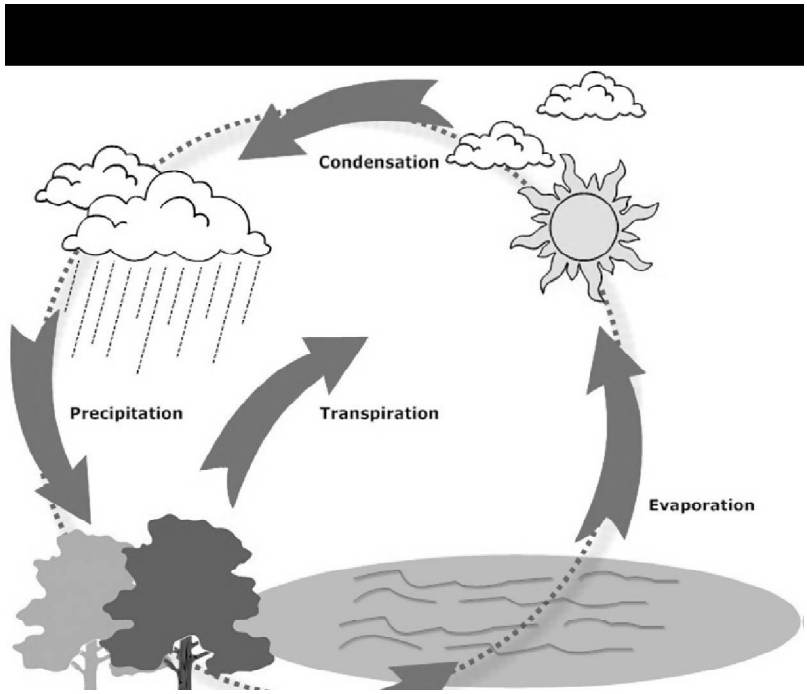
Lightning Flash Algorithm; from initial charge population to jumping stage.

a)	An effective Lightning Flash Algorithm solution to large scale non-convex economic dispatch with valve-point and multiple fuel options on generation units Energy, 129 (2017) 1-15. doi.org/10.1016/j.energy.2017.04.081 Mostafa Kheshti, Xiaoning Kang, ZhaohongBie, Zaibin Jiao, Xiuli Wang
b)	Lightning search algorithm Applied Soft Computing, (2015). doi.org/10.1016/j.asoc.2015.07.028 Hussain Shareef, Ahmad Asrul Ibrahim, Ammar Hussein
c)	An Enhanced Lightning Attachment Procedure Optimization with Quasi-Opposition-Based Learning and Dimensional Search Strategies Computational Intelligence and Neuroscience, 2019, Article ID 1589303. https://doi.org/10.1155/2019/1589303 Tongyi Zheng and Weili Luo

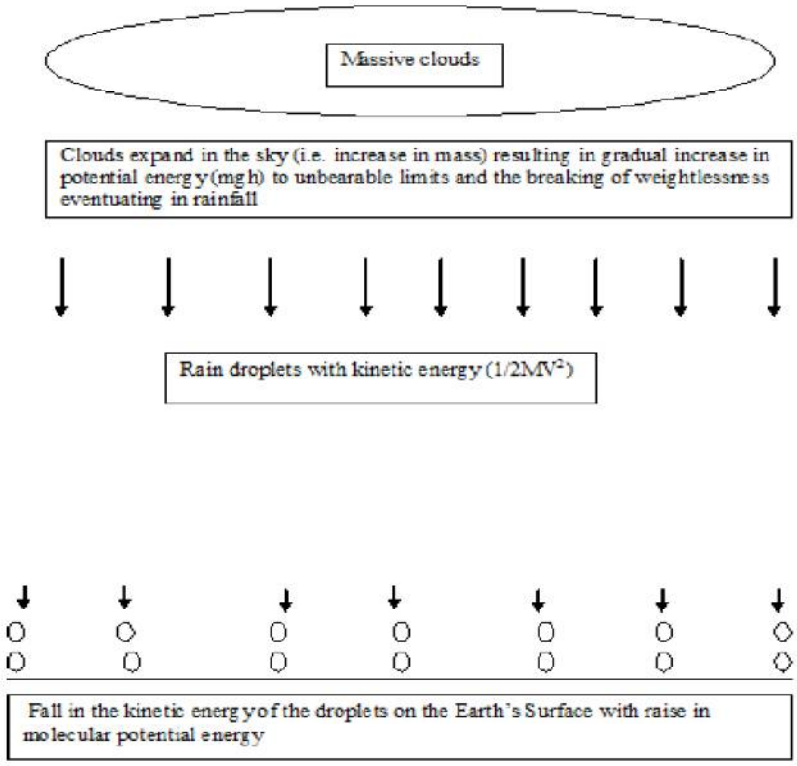
[[[[[[[[[[[[[[~~~~~~~~~~~~~~~~~~~~Water

a)	An approach to continuous optimization by the Intelligent Water Drops algorithm Procedia - Social and Behavioral Sciences, 32 (2012) 224 – 229. doi:10.1016/j.sbspro.2012.01.033 Hamed Shah-Hosseini
b)	Artificial showering algorithm: a new meta-heuristic for unconstrained optimizationSci.Int.(Lahore), 27(6), (2015) 4939-4942. Ali J., M.Saeed, N. A. Chaudhry, M. Luqman, M.F.Tabassum
c)	A binary water wave optimization for feature selection International Journal of Approximate Reasoning, 120 (2020) 74–91. doi.org/10.1016/j.ijar.2020.01.012 AbdelmonemM.Ibrahim, M.A.Tawhid, Rabab K.Ward
d)	Water cycle algorithm for solving constrained multi-objective optimization problems Applied Soft Computing, 27 (2015) 279–298. doi.org/10.1016/j.asoc.2014.10.042 Ali Sadollah, HadiEskandar, JoongHoon Kim
e)	An efficient chaotic water cycle algorithm for optimization tasks Neural Comput&Applic DOI 10.1007/s00521-015-2037-2 Ali Asghar Heidari, Rahim Ali Abbaspour, Ahmad RezaeeJordehi
f)	Water cycle algorithm – A novel metaheuristic optimization method for solving constrained engineering optimization problems Computers and Structures, 110–111 (2012) 151–166. doi.org/10.1016/j.compstruc.2012.07.010 HadiEskandar, Ali Sadollah, ArdeshirBahreininejа, Mohd Hamdi

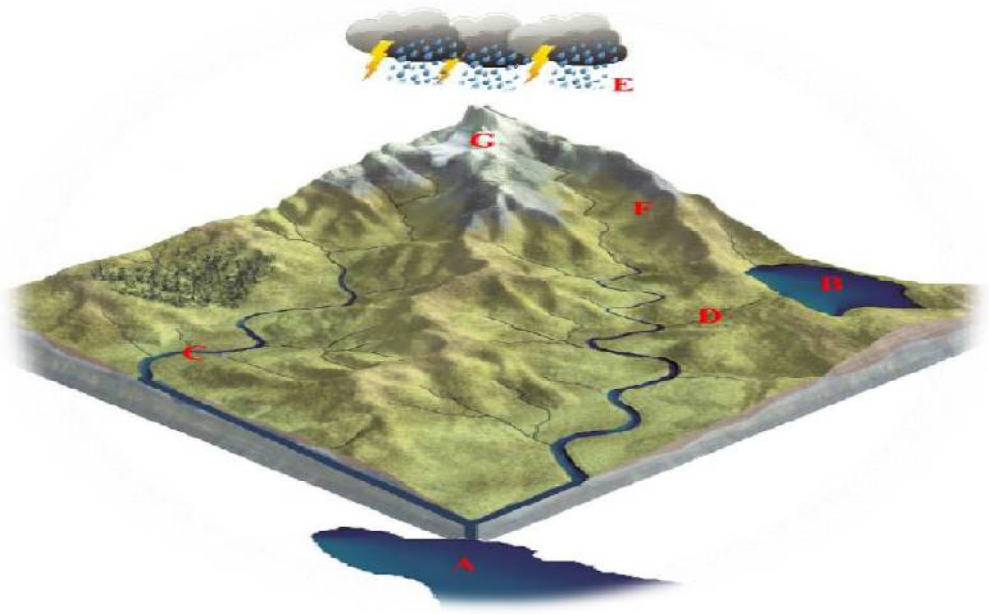
g)	Water cycle algorithm: A detailed standard code Software X doi.org/10.1016/j.softx.2016.03.00 Ali Sadollah, HadiEskandar, Ho Min Lee, Do GuenYoo, JoongHoon Kim
h)	A Comprehensive Evaluation: Water Cycle Algorithm and Its Applications Springer Nature Singapore Pte Ltd. 2018, J.Qiao et al. (Eds.): BIC-TA 2018, CCIS 952, (2018), pp. 360–376. https://doi.org/10.1007/978-981-13-2829-9_33 Rana Muhammad SohailJafar, Shuang Geng (&), Wasim Ahmad, Safdar Hussain, and Hong Wang
i)	Water cycle algorithm for solving multi-objective optimization problems Soft Comput DOI 10.1007/s00500-014-1424-4 Ali Sadollah, HadiEskandar, ArdeshirBahreininejad, JoongHoon Kim
j)	A novel and effective optimization algorithm for global optimization and its engineering applications: Turbulent Flow of Water-based Optimization (TFWO) Engineering Applications of Artificial Intelligence, 92 (2020) 103666. doi.org/10.1016/j.engappai.2020.103666 MojtabaGhasemi, IrajFarajiDavoudkhani, Ebrahim Akbari, AbolfazlRahimnejad, SahandGhavidel, Li Li



Simplified diagram of the hydrologic cycle (water cycle).



Break of cloud's weightlessnes

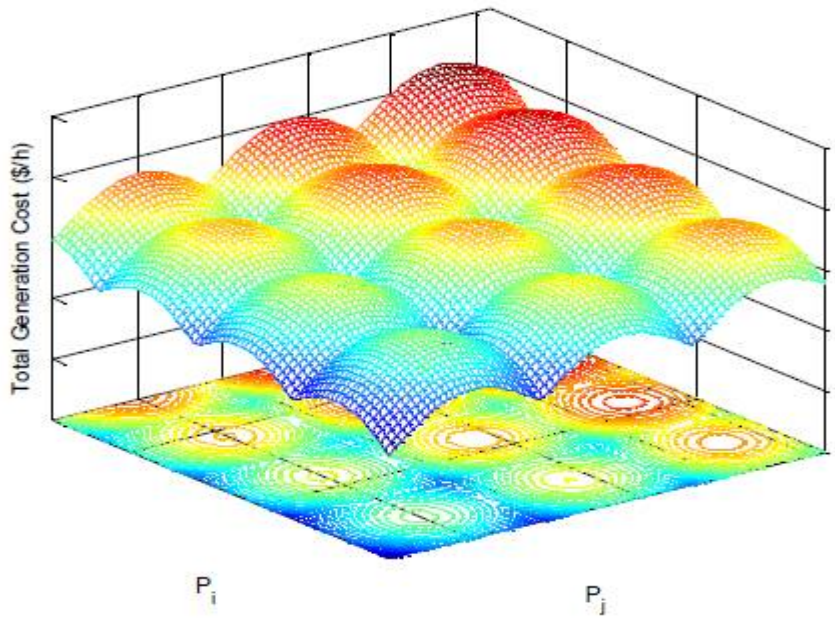


A: Sea (global optimum), B: Lake (local optimum), C: River, D: Tributary, E: Rain-fall, F: Valley, G: Melting snow

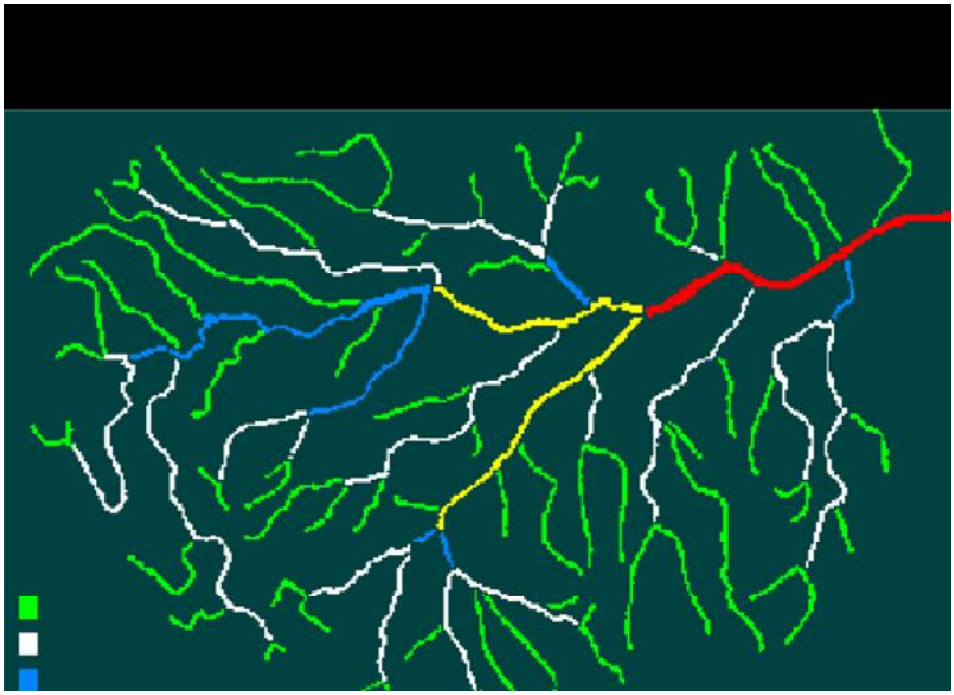
k)	Hydrological Cycle Algorithm for Continuous Optimization Problems Journal of Optimization (2017), Article ID 3828420, https://doi.org/10.1155/2017/3828420 Ahmad Wedyan, Jacqueline Whalley, and Ajit Narayanan

[[[[[[[[[[[[[[~~~~~~~~~~~~~~~~~~~~ Rainfall

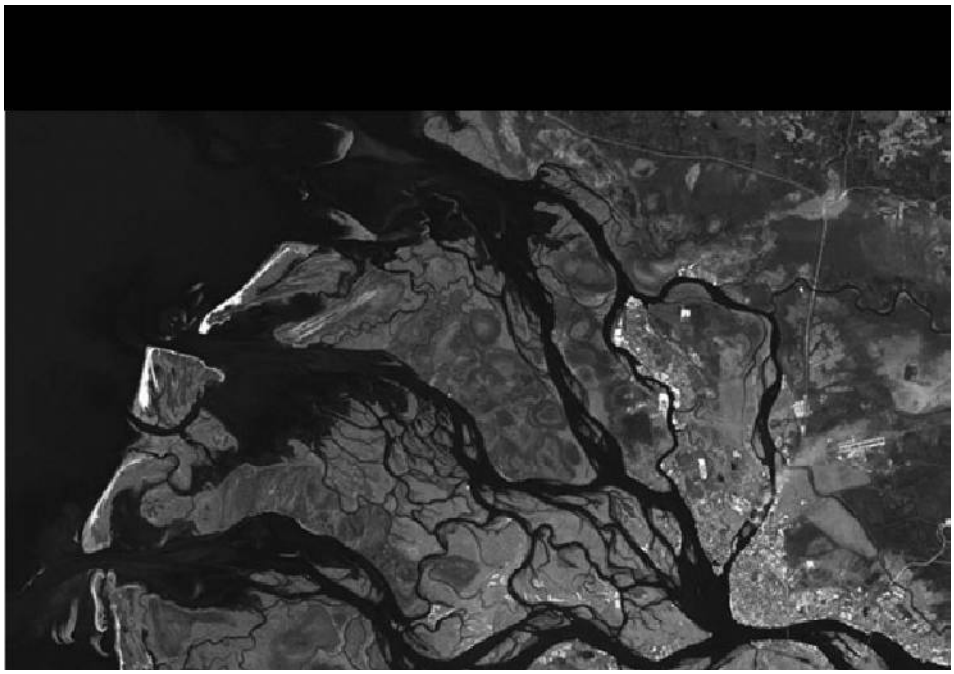
a)	Rain-fall optimization algorithm: a population based algorithm for solving constrained optimization problems Journal of Computational Science http://dx.doi.org/10.1016/j.jocs.2016.12.010 S.Hr.AghayKaboli, J.Selvaraj, N.A.Rahim,
b)	Rain-fall optimization algorithm: a population based algorithm for solving constrained optimization problems Journal of Computational Science, (2016). http://dx.doi.org/10.1016/j.jocs.2016.12.010 S.Hr.AghayKaboli, J.Selvaraj, N.A.Rahim
c)	Physics of RainfallAmajama Joseph, Review Journal of Scientific and Engineering Research, (2016), 3(1):51-54.



Non-convex generation cost function for two power units
Rainwater



Schematic diagram of how streams flow to rivers and also rivers flow to sea.



Arkhangelsk city on the Dvina River
(adopted from NASA, Image Source:
http://asterweb.jpl.nasa.gov/gallery-detail.asp?name=Arkhangelsk

[[[[[[[[[[[[[[~~~~~~~~~~~~~~~~~~~~~ Tsunami

a)	Optimal Location of Sensors for Early Detection of Tsunami Waves International Conference on Computational Science, ICCS 2020: Computational Science – ICCS 2020 pp 562-575. Angelie R. Ferrolino, Jose Ernie C. Lope, and Renier G. Mendoza

[[[[[[[[[[[[[[~~~~~~~~~~~~~~~~~~~~~Music

a)	Economic load dispatch problems with valve-point loading using natural updated harmony search	Title
	Neural Comput&Applic (2016), DOI 10.1007/s00521-016-2611-2	Journal
	Mohammed Azmi Al-Betar, Mohammed A. Awadallah, Ahamad Tajudin Khader, AsajuLa'aro Bolaji, Ammar Almomani	Author(s)

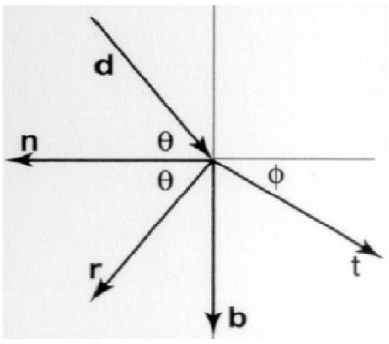
b)	An Adaptive Harmony Search Approach for Gene Selection and Classification oh High Dimensional Medical Data Journal of King Saud University-Computer and Information Sciences, (2018). doi: https://doi.org/10.1016/j.jksuci.2018.02.013 Rasmita Dash
c)	Two-Level Multidimensional Enhanced Melody Search Algorithm for Dynamic Planning of MV Open-Loop Distribution Networks Chapter 11, Classical and Recent Aspects of Power System Optimization. https://doi.org/10.1016/B978-0-12-812441-3.00011-2 Mohammad Kiani-Moghaddam, MojtabaShivaie and Philip D. Weinsier
d)	Performance evaluation of an improved harmony search algorithm for Numerical optimization: Melody Search(MS) Engineering Applications of Artificial Intelligence, 26 (2013)1301–1321. doi.org/10.1016/j.engappai.2012.08.005 S.M. Ashrafin, A.B.Dariane
e)	Developing Self-adaptive Melody Search Algorithm for Optimal Operation of Multi-reservoir Systems J. Hydraul. Struct., 2017; 3(1):35-48. DOI: 10.22055/jhs.2017.13282 Seyed Mohammad Ashrafi, Seyedeh Fatemeh Ashrafi, SaberMoazami
f)	Music Based Metaheuristic Methods for Constrained Optimization IEEE 2018. ElifVarol Altay, Bilal Alatas

g)	an optimization algorithm inspired by musical composition in constrained optimization problems TeorıayAplicaciones, 2013 20(2) : 183–202 Revista de Matematica
h)	An optimization algorithm inspired by musical composition ArtifIntell Rev, (2014) 41:301–315. DOI 10.1007/s10462-011-9309-8 Roman Anselmo Mora-Gutiérrez, Javier Ramírez-Rodríguez, Eric Alfredo Rincón-García

[[[[[[[[[[[[[[~~~~~~~~~~~~~~~~~~~~ Radial movement

a)	Scenario-based wind speed estimation using a new hybrid metaheuristic model: Particle swarm optimization and *radial movement optimization* *Measurement and Control, 1–16, (2019*). DOI: 10.1177/0020294019842597 AlperKerem and Ali Saygin
b)	Improved radial movement optimization to determine the critical failure surface for slope stability analysis Environmental Earth Sciences (2018) 77:564. https://doi.org/10.1007/s12665-018-7742-6 LiangxingJin, Qixuan Feng
c)	Radial movement optimization (RMO) technique for solving unit commitment problem in power systems Journal of Electrical Systems and Information Technology, (JESIT), 167 (2010). http://dx.doi.org/10.1016/j.jesit.2017.05.003 Vanithasri M., Balamurugan R., Lakshminarasimman L.,
d)	Modified radial movement optimization (MRMO) technique for estimating the parameters of fuel cost function in thermal power plants Engineering Science and Technology, an International Journal, (2016). doi.org/10.1016/j.jestch.2016.07.012 M. Vanithasri, R. Balamurugan, L. Lakshminarasimman
e)	A new simple, fast and efficient algorithm for global optimization over continuous search-space problems: Radial Movement Optimization Applied Mathematics and Computation, 248 (2014) 287–300. doi.org/10.1016/j.amc.2014.09.102 RasoulRahmani, Rubiyah Yusof

[[[[[[[[[[[[[[~~~~~~~~~~~~~~~~~~Ray



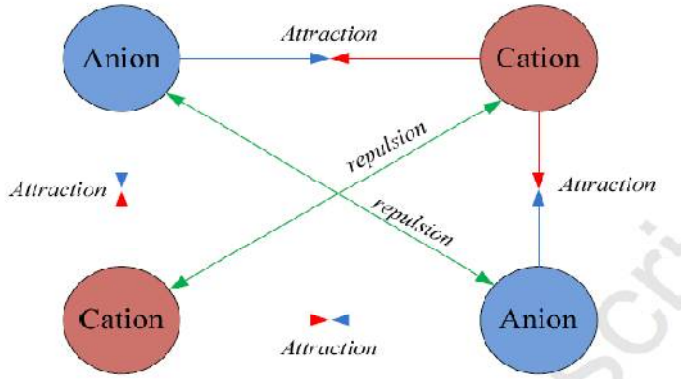
Incident and refracted rays and their specifications.
Ray opt

a)	A new meta-heuristic method: Ray Optimization Computers and Structures, 112-113 (2012) 283–294. doi.org/10.1016/j.compstruc.2012.09.003 AKaveh, M. Khayatazad

11b. Chemistry Inspired Optimization (Mathematical) Methods (Chem iOM)

[[[[[[[[[[[[[[~~~~~~~~~~~~~~~~~~Ions Motion

Forces in Ions motion



Conceptual models and anion, cation, attraction force, and repulsion force

a)	Ions Motion Algorithm for Solving Optimization Problems Applied Soft Computing Journal, (2015). http://dx.doi.org/10.1016/j.asoc.2015.03.035 B. Javidy, A. Hatamlou, S. Mirjalili
b)	An Experimental Study of Ion Motion Optimization for Constraint Economic Load Dispatch Problem 2018 1st IEEE International Conference on Power Energy, Environment & Intelligent Control (PEEIC2018). Mohit Kumar, J.S. Dhillon

[[[[[[[[[[[[[[~~~~~~~~~~~~~~~~~~Chemical Reaction

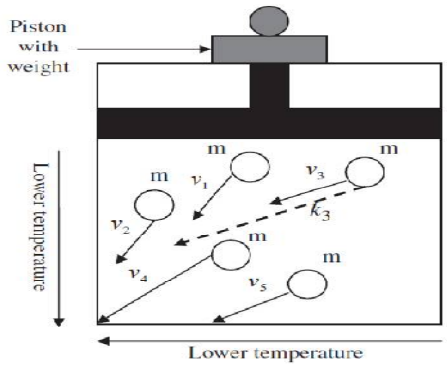
a)	ACROA: Artificial Chemical Reaction Optimization Algorithm for global optimization Expert Systems with Applications, 38 (2011) 13170–13180. doi:10.1016/j.eswa.2011.04.126 Bilal Alatas
b)	Nature-Inspired Chemical Engineering: A New Design Methodology for Sustainability Chapter 2, Sustainable Nanoscale Engineering. https://doi.org/10.1016/B978-0-12-814681-1.00002-3 Panagiotis Trogadas, Marc-Olivier Coppens
c)	Neutrosophic rule-based prediction system for toxicity effects assessment of bio transformed hepatic drugs Expert Systems With Applications, 121 (2019) 142–157. doi.org/10.1016/j.eswa.2018.12.014 Sameh H. Basha, Alaa Tharwat, Areeg Abdalla, Aboul Ella Hassanien
d)	New trends for design towards sustainability in chemical engineering: Green engineering Chemical Engineering Journal, 133 (2007) 7–30. doi:10.1016/j.cej.2007.02.028 J. Garca-Serna, L. Perez-Barrigon, M.J. Cocero

Physical Chemistry
Chemical Physics

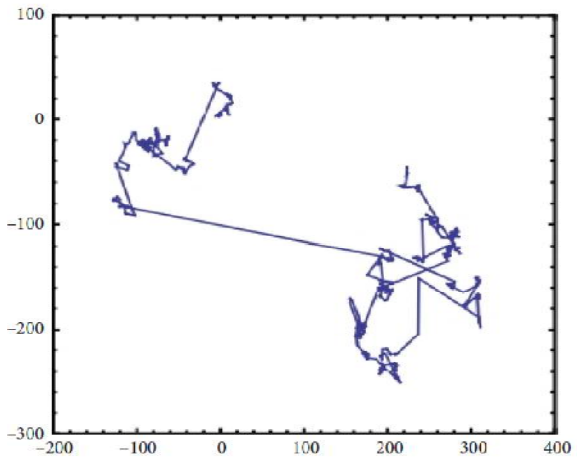
[[[[[[[[[[[[[[~~~~~~~~~~~~~~~~~~Gas solubility

a)	An efficient henry gas solubility optimization for feature selection	Title
	Expert Systems With Applications, 152 (2020) 113364, https://doi.org/10.1016/j.eswa.2020.113364	Journal
	Nabil Neggaz, Essam H. Houssein, Kashif Hussain	Author(s)

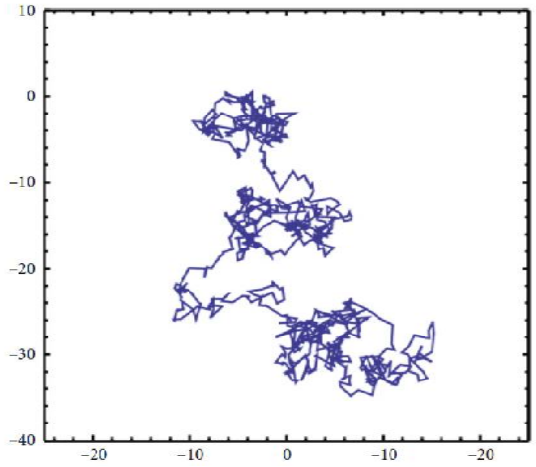
[[[[[[[[[[[[[[~~~~~~~~~~~~~~~~~~Gas movement …..



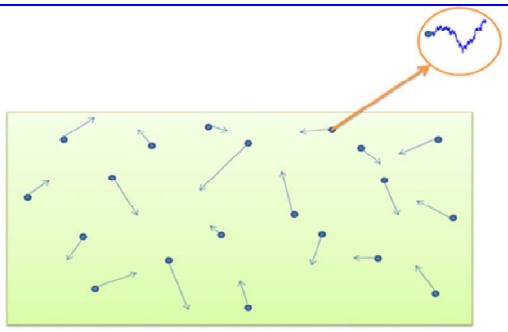
Under constant pressure, the kinetic energy of gas molecules decreases by decreasing velocity



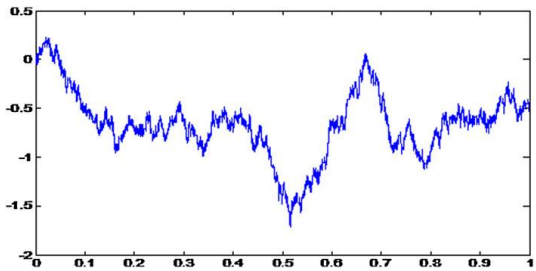
Simulation of the first 1000 steps of Levy Flight Mechanism



Simulation: First 1000 steps of Brownian motion



Turbulent rotational motion and Gases Brownian Motion



Turbulent rotational motion

a)	Gases Brownian Motion Optimization: an Algorithm for Optimization (GBMO) Applied Soft Computing, 13 (2013) 2932–2946. doi.org/10.1016/j.asoc.2012.03.068 MarjanAbdechiria, Mohammad Reza Meybodib, Helena Bahramia
b)	A Modified Dragonfly Optimization Algorithm for Single- and Multi objective Problems Using Brownian Motion Computational Intelligence and Neuroscience, Volume 2019, Article ID 6871298. https://doi.org/10.1155/2019/6871298 ÇigdemInanAc andHakanGulcan
c)	Pareto-based allocations of multi-type flexible AC transmission system devices for optimal reactive power dispatch using Kinetic Gas Molecule Optimization algorithm Measurement and Control, 2020, Vol. 53(1-2) 239–249. DOI: 10.1177/0020294019866857 Pradeep Panthagani1 and R Srinivasa Rao
d)	KGMO: A swarm optimization algorithm based on the kinetic energy of gas molecules Information Sciences, (2014). doi.org/10.1016/j.ins.2014.02.026 Sara Moein, RajasvaranLogeswaran .
e)	Physics inspired algorithms for (co)homology computations of three-dimensional combinatorial manifolds with boundary Computer Physics Communications, 184 (2013) 2257–2266. doi.org/10.1016/j.cpc.2013.05.006 PawełDłotko, Ruben Specogna

[[[[[[[[[[[[[[~~~~~~~~~~~~~~~~~~~~Central force…..

a)	Central force optimization: a new Metaheuristic with applications in applied Electromagnetics Progress In Electromagnetics Research, PIER 77, (2007), 425–491. R. A. Formato
b)	Colliding bodies optimization: A novel meta-heuristic method Computers and Structures, 139 (2014) 18–27. doi.org/10.1016/j.compstruc.2014.04.005 A. Kaveh, V.R. Mahdavi

[[[[[[[[[[[[[[~~~~~~~~~~~~~~~~~~~~Entropy …..

a)	A Hybrid With Cross-Entropy Method and Sequential Quadratic Programming to Solve Economic Load Dispatch Problem IEEE Systems Journal DOI: 10.1109/JSYST.2013.2297471 M. S. P. Subathra, S. Easter Selvan, T. Aruldoss Albert Victoire, A. Hepzibah Christinal, and Umberto Amato

11c. Mathematics Inspired Optimization (Mathematical) Methods (Maths. iOM)

a)	Lipschitzian Optimization Without the Lipschitz Constant	Title
	JOURNAL OF OPTIMIZATION THEORY AND APPLICATION: Vol. 79, No. 1, (1993)	Journal
	D. R. JONES, C. D. PERRTTUNEN AND B. E. STUCKMAN	Author(s)
b)	Recent Nature-Inspired Algorithms for Medical Image Segmentation Based on Tsallis Statistics	Title
	Communications in Nonlinear Science and Numerical Simulation (2020), doi: https://doi.org/10.1016/j.cnsns.2020.105256	Journal
	G.A. Wachs-Lopes, R.M. Santos, N.T. Saito, P.S. Rodrigues	Author(s)
c)	Kriging Empirical Mode Decomposition via Support Vector Machine Learning Technique for Autonomous Operation Diagnosing of CHP in Microgrid	Title
	Applied Thermal Engineering (2018), https://doi.org/10.1016/j.applthermaleng.2018.09.028	Journal
	Zehui Shao, Karzan Wakil, MuhammetUsak, Mohammad Amin Heidari, Bo Wang, Rolando Simoes	Author(s)
d)	Good Lattice Swarm Algorithm for Constrained Engineering Design Optimization	Title
	IEEE (2007)	Journal
	ShoubaoSu, Jiwen Wang, Wangkang Fan, Xibing Yin	Author(s)
e)	Fibonacci indicator algorithm: A novel tool for complex optimization problems Engineering Applications of Artificial Intelligence, 74 (2018) 1–9. doi.org/10.1016/j.engappai.2018.04.012 A.Etminaniesfahani, A. Ghanbarzadeh, Z. Marashi	

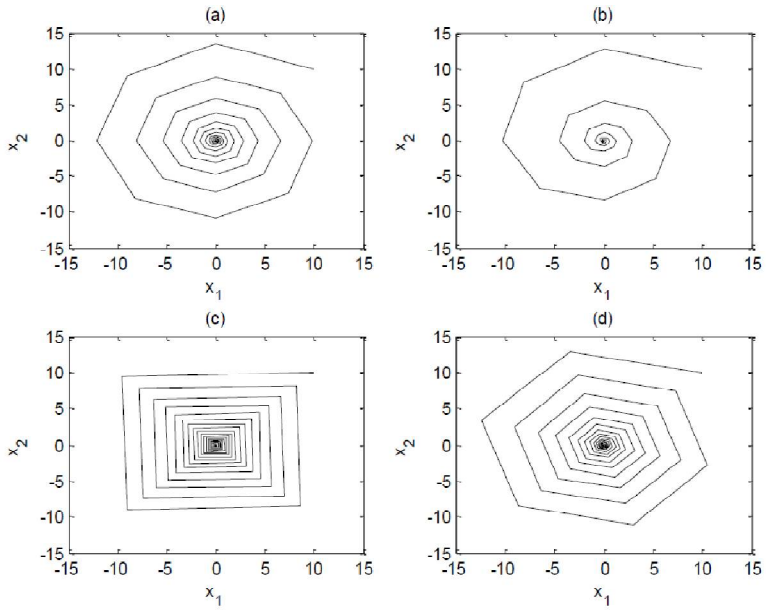
[[[[[[[[[[[[[[~~~~~~~~~~~~~~~~~~~~Derivative free

a)	Multi-objective optimization of inter-story isolated buildings using metaheuristic and derivative-free algorithms Soil Dynamics and Earthquake Engineering, 132 (2020) 106058.doi.org/10.1016/j.soildyn.2020.106058 Konstantinos Skandalos, Hamid Afshari, Warren Hare, Solomon Tesfamariam
b)	A Population-Based Optimization Method Using Newton Fractal Complexity, 2019, Article ID 5379301. https://doi.org/10.1155/2019/5379301 SoyeongJeong and Pilwon Kim

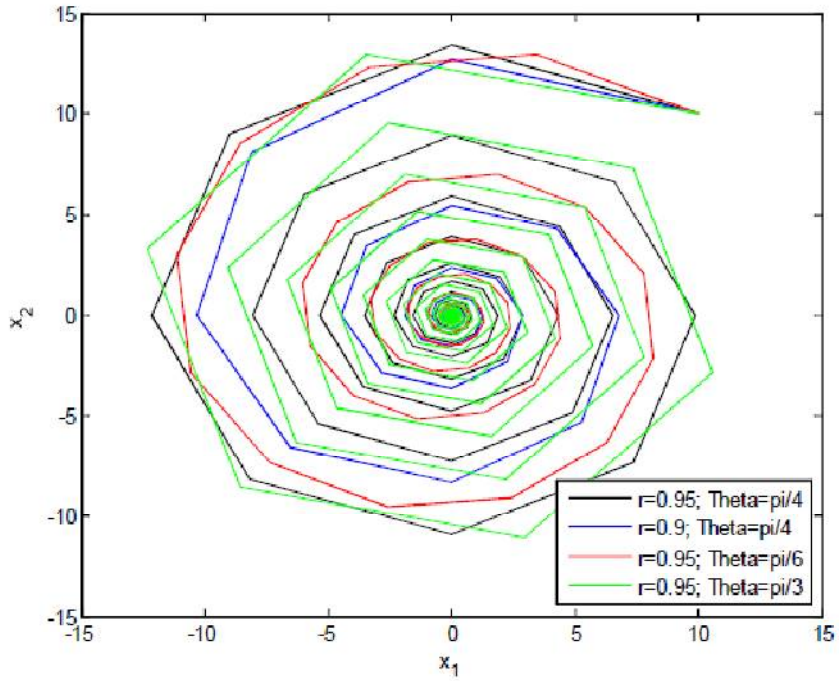
[[[[[[[[[[[[[[~~~~~~~~~~~~~~~~~~Fuzzy

a)	An Integrated Fuzzy Group Decision Support Framework for Performance Assessment of Advanced Manufacturing Technologies: An Eclectic Comparison J. Inst. Eng. India Ser. C (2020). https://doi.org/10.1007/s40032-020-00558-7 SurajitNath, Bijan Sarkar
b)	Efficient algorithms based on the k-means and Chaotic League Championship Algorithm for numeric, categorical, and mixed-type data clustering Expert Systems With Applications, 90 (2017) 146–167. doi.org/10.1016/j.eswa.2017.08.004 TanachapongWangchamhan, SirapatChiewchanwattana, KhamronSunat
c)	An innovative hybrid system for wind speed forecasting based on fuzzy pre-processing scheme and multi-objective optimization Energy, 174 (2019) 1219-1237. doi.org/10.1016/j.energy.2019.02.194 Chen Li, Zhijie Zhu, Hufang Yang, Ranran Li

[[[[[[[[[[[[[[~~~~~~~~~~~~~~~~~~Spiral



Graphical representation of spiral form with different spiral angel/radius parameters.
(a : Θ=0.95, r=π/4), (b : Θ=0.90, r=π/4), (c : Θ=0.95, r=π/2), (d : Θ=0.95, r=π/3).
Spiral



a)	Adaptive Spiral Optimization Algorithm for Benchmark Problems BilecikŞeyhEdebaliÜniversitesi Fen BilimleriDergisi, Cilt: 3, Sayı:1, 2016 Uğur YÜZGEÇ, Tufan İNAÇ
b)	Model of deposit and loan of a bank using spiral optimization algorithm J. Indones. Math. Soc. Vol. 25, No. 3 (2019), pp. 292-301. MochFandiAnsori, KuntjoroAdjiSidarto, and NovrianaSumarti
c)	Computing Complex Roots of Systems of Nonlinear Equations Using Spiral Optimization Algorithm with Clustering Springer Nature Singapore Pte Ltd. 2018, R. Alfred et al. (Eds.): ICCST 2017, LNEE 488, (2018), pp. 390–398. https://doi.org/10.1007/978-981-10-8276-4_37 KuntjoroAdjiSidarto and Adhe Kania

[[[[[[[[[[[[[[~~~~~~~~~~~~~~~~~~~~Sine-Cosine

a)	A novel hybrid forecasting system of wind speed based on a newly developed multi-objective sine cosine algorithm Energy Conversion and Management, 163 (2018) 134–150. doi.org/10.1016/j.enconman.2018.02.012 Jianzhou Wang, Wendong Yang, Pei Du, Tong Niu
b)	Improved sine cosine algorithm with crossover scheme for global optimization Knowledge-Based Systems, (2018). https://doi.org/10.1016/j.knosys.2018.12.008 S. Gupta and K. Deep
c)	Advanced Orthogonal Learning-Driven Multi-Swarm Sine Cosine Optimization: Framework and Case Studies Expert Systems With Applications (2019). https://doi.org/10.1016/j.eswa.2019.113113 Hao Chen, Ali Asghar Heidari, Xuehua Zhao, Lejun Zhang, Huiling Chen
d)	Crisscross optimization algorithm for large-scale dynamic economic dispatch problem with valve-point effects Energy, 93 (2015) 2175-2190, http://dx.doi.org/10.1016/j.energy.2015.10.112 Anbo Meng, Hanwu Hu, Hao Yin, Xiangang Peng, Zhuangzhi Guo

Illustration of golden ratio in nature

[[[[[[[[[~~~~~~~~~~~~Neural Networks-

a)	Training Multi-Layer Perceptron using Opposition based Learning Spiral Optimization Algorithm International Conference on Advanced Technologies, Computer Engineering and Science (ICATCES'18), (2018), Safranbolu, Turkey U. Yüzgeç, C.Karakuzu	
b)	Three Dimensional Pulse Coupled Neural Network Based on Hybrid Optimization Algorithm for Oil Pollution Image Segmentation Remote Sens. (2019), 11, 1046.1-25. doi:10.3390/rs11091046 Heming Jia, Zhikai Xing and Wenlong Song	
c)	A novel artificial intelligent model for predicting air overpressure using brain inspired emotional neural network	Title
	International Journal of Mining Science and Technology (2020), https://doi.org/10.1016/j.ijmst.2020.05.020	Journal
	Victor Amoako Temeng, Yao YevenyoZiggah, Clement Kweku Arthur	Author(s)
d)	Optimization of dynamic behavior of thin-walled laminated cylindrical shells by genetic algorithms and deep neural networks supported by modal shape identification	Title
	Advances in Engineering Software 147 (2020) 102830,	Journal
	Bartosz Miller, Leonard Ziemiański	Author(s)
e)	Nature-inspired algorithms for feed-forward neural network classifiers: A survey of one decade of research	Title
	Ain Shams Engineering Journal (2020), https://doi.org/10.1016/j.asej.2020.01.007	Journal
	Ashraf Mohamed Hemeida, SomaiaAwad Hassan, Al-Attar Ali Mohamed, Salem Alkhalaf, Mountasser Mohamed Mahmoud, Tomonobu Senjyu, Ayman Bahaa El-Din	Author(s)

	Nature-inspired algorithms for feed-forward neural network classifiers: A survey of one decade of research	Title
	Ain Shams Engineering Journal (2020), https://doi.org/10.1016/j.asej.2020.01.007	Journal
	Ashraf Mohamed Hemeida, SomaiaAwad Hassan, Al-Attar Ali Mohamed, Salem Alkhalaf, Mountasser Mohamed Mahmoud, Tomonobu Senjyu, Ayman Bahaa El-Din	Author(s)
g)	Short-term load forecast of electrical power system by radial basis function neural network and new stochastic search algorithm	Title
	Int. Trans. Electr. Energ. Syst. (2015), DOI: 10.1002/etep.2160	Journal
	OveisAbedinia and NimaAmjady	Author(s)
h)	Solar energy forecasting based on hybrid neural network and improved metaheuristic algorithm	Title
	Computational Intelligence. (2017);1–20, DOI: 10.1111/coin.12145	Journal
	OveisAbediniaNimaAmjadyNoradinGhadimi	Author(s)

[[[[[[[[~~~~~~~~~~~~Biogeography-

a)	A full migration BBO algorithm with enhanced population quality bounds for multimodal biomedical image registration Applied Soft Computing Journal, (2020). https://doi.org/10.1016/j.asoc.2020.106335 Y. Chen, F. He, H. Li

[[[[[[[[~~~~~~~~~~~~ Metaheuristics-

a)	Physics Based Metaheuristic Algorithms for Global Optimization American Journal of Information Science and Computer Engineering, (2015), 94-106. Umit Can, Bilal Alatas
b)	New Optimization Algorithms in Physics WILEY-VCH Verlag GmbH & Co. KGaA, Weinheim, 2004. Alexander K. Hartmann and Heiko Rieger
c)	Physics-Inspired Optimization Algorithms: A Survey Journal of Optimization, (2013), Article ID 438152. http://dx.doi.org/10.1155/2013/438152 Anupam Biswas, K. K.Mishra, Shailesh Tiwari, and A. K. Misra
d)	Probability theory for analyzingnature-inspired algorithms Ch 6 Xing-Shi Hea, Qin-Wei Fana, Xin-She Yangb
e)	tri-level r-interdiction median model for a facility location problem under imminent attackComputers & Industrial Engineering (2017). doi: https://doi.org/10.1016/j.cie.2017.10.003 Akbari-Jafarabadi, M., Tavakkoli-Moghaddam, R., Mahmoodjanloo, M., Rahimi, Y., A
f)	Jaya: A simple and new optimization algorithm for solving constrained and unconstrained optimization problems International Journal of Industrial Engineering Computations, 7 (2016) 19–34. doi: 10.5267/j.ijiec.2015.8.004 R. Venkata Rao
g)	Yin-Yang-pair Optimization: A novel light weight optimization algorithm Engineering Applications of Artificial Intelligence, 54 (2016) 62–79 doi.org/10.1016/j.engappai.2016.04.004 Varun Punnathanam, PrakashKotecha

h)	Self-adaptive many-objective meta-heuristic based on decomposition for many-objective conceptual design of a fixed wing unmanned aerial vehicle Aerospace Science and Technology, 100 (2020) 105783. doi.org/10.1016/j.ast.2020.105783 PakinChampasaka, NateePanaganta, NantiwatPholdeea, SujinBureerata, AliRizaYildiz
i)	2018 IEEE International Autumn Meeting on Power, Electronics and Computing (ROPEC 2018). Ixtapa, Mexico A New Improvement Scheme Of Spiral Algorithm (Performance Test) David Matajira-Rueda, Jorge M. Cruz-Duarte, Arturo Garcia-Perez, J. Gabriel Avina-Cervantes, Carlos Rodrigo Correa-Cely
j)	Internal volumetric heat generation and heat capacity prediction during a material electromagnetic treatment process using hybrid algorithms IngenieríaeInvestigación, vol. 38, no. 1, (2018), pp. 74-82. DOI: 10.15446/ing.investig.v38n1.64225 García, Edgar; Amaya, Iván; Correa, Rodrigo

k)	2017 IEEE International Autumn Meeting on Power, Electronics and Computing (ROPEC 2017). Ixtapa, Mexico Primary Study on the Stochastic Spiral Optimization Algorithm Jorge M. Cru z-Duarte, Ignacio Martin-Diaz, J. U. Munoz-Minjares, Luis A. Sanchez-Galindo, Juan G. Avina-Cervantes, and Arturo Garcia-Perez, C. Rodrigo Correa-Cely
l)	Flow Regime Algorithm (FRA): a physics-based meta-heuristics algorithm Knowledge and Information Systems, (2018). https://doi.org/10.1007/s10115-018-1253-3 Mojtaba Tahani· Narek Babayan
m)	A comprehensive review on identification of the geomaterial constitutive model using the computational intelligence method Advanced Engineering Informatics, 38 (2018) 420–440. doi.org/10.1016/j.aei.2018.08.021 Wei Gao

[[[[[[[[[[[[[[~~~~~~~~~~~~~~~~~~~~Miscellaneous …..

a)	Hysteretic Optimization	Title
	Phys. Rev. Lett. 89, 150201, (2002) DOI:10.1103/PhysRevLett.89.150201	Journal
	G. Zarand F. Pazmandi, K. F. Pal, and G. T. Zimanyi	Author(s)
b)	Hysteretic optimization for the Sherrington–Kirkpatrick spin glass	Title
	Physica A 367 (2006) 261–268 , doi:10.1016/j.physa.2005.11.013	Journal
	Karoly F. Pal	Author(s)
c)	Emerging Physics-based CI Algorithms	Title

	Innovative Computational Intelligence: A Rough Guide to 134 Clever Algorithms, Intelligent Systems Reference Library 62, DOI: 10.1007/978-3-319-03404-1_24,	Journal
	B. Xing and W.J. Gao	Author(s)

d)	Wind Driven Optimization (WDO): A Novel Nature-Inspired Optimization Algorithm and its Application to Electromagnetics	Title
	2010 IEEE Antennas and Propagation Society International Symposium DOI: 10.1109/APS.2010.5562213	Journal
	Zikri Bayraktar, MugeKomurcu and Douglas H. Werner	Author(s)

e)	Water cycle, mine blast and improved mine blast algorithms for discrete sizing optimization of truss structures Computers and Structures, 149 (2015) 1–16. Ali Sadollah, HadiEskandar, ArdeshirBahreininejad, JoongHoon Kim

f)	Detection of heart disorders using an advanced intelligent swarm algorithm, Intelligent Automation & Soft Computing, (2016). DOI: 10.1080/10798587.2016.1219453 Sara Moein, RajasvaranLogeswaran& Mohammad Faizal bin Ahmad Fauzi

g)	A new hybrid approach for feature selection and Support Vector Machine model selection based on Self-Adaptive Cohort Intelligence Expert Systems With Applications, (2017). DOI: 10.1016/j.eswa.2017.06.030 Mohammed Aladeemy, Salih Tutun, and Mohammad T. Khasawneh

h)	Constrained Optimization using Triple Spaces Cultured Genetic Algorithm IEEE, Comput Soc., DOI 10.1109/ICNC.2008.336 Wanwan Tang, Yanda Li

i)	Bflybots: A Novel Robotic-Swarm in Pursuit of Dynamic Signal Sources	Title
	Procedia Computer Science 133 (2018) 553–560, doi: 10.1016/j.procs.2018.07.083	Journal
	Madhusudhana Rao Bhattiprolu, Chakravarhi Jada, Ashok Urlana, Pavan Baswani, NavyasriPentakota, Rama Lakshmi Bonagiri, Naveen Boddeda	Author(s)
j)	Constraint handling in genetic algorithms using a gradient-based repair method	Title
	Computers & Operations Research 33 (2006) 2263–2281, doi:10.1016/j.cor.2005.02.002	Journal
	PiyaChootinan, Anthony Chen	Author(s)
k)	Benign and malignant breast cancer segmentation using optimized region growing technique	Title
	Future Computing and Informatics Journal, 3 (2018) 348-358, https://doi.org/10.1016/j.fcij.2018.10.005	Journal
	S. Punitha, A. Amuthan, K. Suresh Joseph	Author(s)

l)	Molecular descriptor subset selection in theoretical peptide quantitative structure retention relationships model development using nature-inspired optimization algorithms	Title
	Anal. Chem., (2015), DOI: 10.1021/acs.analchem.5b02349	Journal
	PetarZuvela, J. Jay Liu, Katarzyna Macur, Tomasz Bączek	Author(s)

[[[[[[[[[[[[[[~~~~~~~~~~~~~~~~~~~~Reincarnation …..

a)	A new optimizing algorithm using reincarnation concept	Title
	CINTI 2010 • 11th IEEE International Symposium on Computational Intelligence and Informatics • 18–20 November, (2010).	Journal
	Anurag Sharma	Author(s)

Nature Inspired(Ni) Mathematical Algorithms (Ma)

Information Source	ACS.org ; sciencedirect.com
K. Somasekhara Rao, Dept. of Chemistry, Acharya Nagarjuna Univ., Dr. M.R.Appa Rao Campus, Nuzvid-521 201, India	R. Sambasiva Rao, School of Chemistry, Andhra University, Visakhapatnam 530 003, India