Distributed Localization Algorithm Using Hybrid Cuckoo Search with Hill Climbing (CS-HC) Algorithm for Internet of Things

S.P. Kesavan, K. Sivaraj, A. Palanisamy and R. Murugasamy

Abstract--- *Currently, Internet of Things (IoT) influenced applications are significant upon deployed sensors accurately. Anyhow, classical optimization problem is induced along NP-hard class of problems to determine the accurate localization of deployed sensors nodes. Thence this proposal work provides distributed localization algorithm using hybrid Cuckoo search with hill climbing (CS-HC) algorithm. In turn it improvises the mechanism of optimisation solution by validating threshold value for IoT. Computational complexity get reduced by locating deployed sensor nodes via CS-HC algorithm as well as increase lifetime of resource constrained IoT sensor nodes. Simulated results predicts that proposed CS-HC algorithm produces significant performance accurately.*

Keywords--- *Distributed Localization, Computational Complexity, Hybrid Cuckoo Search, Hill Climbing, Internet of Things.*

I. INTRODUCTION

Nowadays, IOT resolves many challenges in emerging applications like acoustic detection military surveillance, inventory tracking, and environmental monitoring. On deploying sensor nodes in IOT, scattering of nodes randomly in area are detected. It seems adhoc on lack of information. Thus prediction of node position accurately is mandatory. Wireless devices in overabundance tells that internet of things (IoT) is required for interconnected world.

Software and electronics embedding sensors and physical objects helps network communication to process in IOT [1][2]. Target tracking, routing, cities, monitoring homes, automation, health monitoring, transportation management and environment are emerging applications of IoT[3]. These tasks get efficient on successful sensor nodes deployment for surrounding monitor, entity collection and transmission accordingly with IOT applications. Sensor nodes are localized accurately for efficient IoT applications in turn segregate sensing information with no locality data from sensed data [4]. Hence, absence of locality data of sensor node are mere useless. Unlike this, sensed data influences success in geographic routing [5], intrusion detection [6], and traffic monitoring [7]. Anyhow, classical optimization problem is induced along NP-hard class of problems to determine the accurate localization of deployed sensors nodes. [8].

S.P. Kesavan, Associate Professor, Department of ECE, Nandha College of Technology, Erode, Tamil Nadu, India. E-mail: kesavan.vlsi@gmail.com
K. Sivaraj, Assistant Professor, Department of ECE, Nandha College of Technology, Erode, Tamil Nadu, India. E-mail: ksivaraj13@gmail.com
A. Palanisamy, Assistant Professor, Department of ECE, Nandha College of Technology, Erode, Tamil Nadu, India. E-mail: apalanisamy03@gmail.com
R. Murugasamy, Associate Professor, Department of ECE, Nandha Engineering College, Erode, Tamilnadu, India. E-mail: murugasamyr@gmail.com

Received: 16 Sept 2019 | Revised: 18 Oct 2019 | Accepted: 15 Nov 2019

Navigation system as Global Positioning System (GPS) supports localization of sensor nodes conventionally [9]. But fails in locating data of sensor nodes on deployment in urban or indoor environment which may block or damage satellite signal [10]. Additionally, size, price, power are consumed high for GPS receivers being dependent of resource constrained. Sensor nodes are noticed to locate in area of interest which is battery oriented. Thence, consuming energy constraint in sensor nodes are required to enhance network lifetime process [11].

Estimation of (X,Y) location for sensor node in IOT is done on communication between nodes with known data as (X_1,Y_1),(X_2,Y_2),(X_3,Y_3) accordingly [12]. The primary phases are ranging as well as estimation in localization process. Received Signal Strength Identification (RSSI) identify distance between sensor nodes which is unknown, Time of Arrival (TOA) of received signal, Time Difference of Arrival (TDOA) of received signal [13] in phase of ranging. Factors of noise influence the results to be inaccurate in ranging phase [14]. Computation of position ranged from information on the first phase of unknown sensor in the estimation phase. These phases are performed via algorithm of mathematical optimization conventionally like a simultaneous equations set and stochastic optimization algorithms for decreasing the localization error. Hence, algorithms of bio-inspired stochastic optimization are focused. Figure 1 explicates IOT sensor nodes localization.

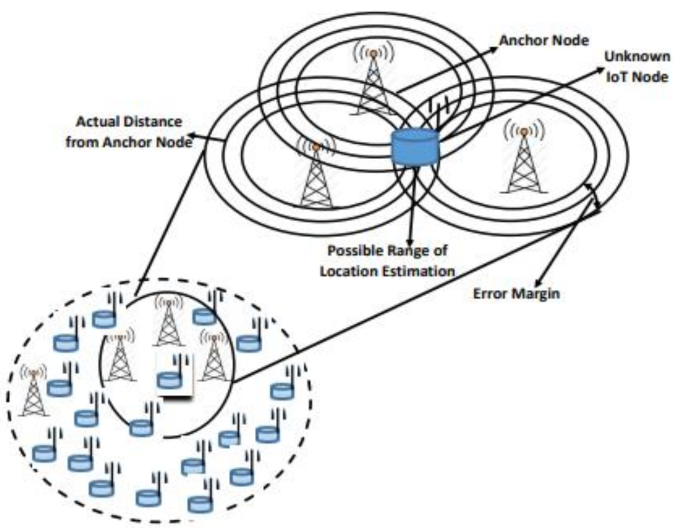

Fig. 1: Illustration of Localization of Sensor Nodes in Internet of Thing

Since earlier days, several methods are being used for localization of nodes accurate as well as maximizes the network lifetime in WSN and reported in the literature [15][16]. Thus bio-inspired PSO are proposed for localization of nodes in [17][18]. But fails in trapping of local minimal optimization problem. So, Cuckoo search with hill climbing (CS-HC) algorithm is employed for validating the threshold values using threshold technique.

II. CUCKOO SEARCH WITH HILL CLIMBING (CS-HC) ALGORITHM

This proposal of cuckoo search algorithm with hill climbing (CS-HC) depending on technique of multiple threshold for objective function by means of selecting CH node. The optimal threshold are focused to choose resulted image.

Cuckoo Search Algorithm

It is a process of Meta-heuristic search CS algorithm that follows protocol as

1. Unique eggs are laid by each cuckoo at specific time and place it in random nest.
2. Execution is carried to determine the qualified nest with qualified egg to next iteration.
3. Fixed number is attained on host obtained and may decide probability of unknown eggs inside nests.

This criteria is considered in a way that host bird nest may built new nest for its purpose in new location or threw outside and use its own nest. This prototype is built in cuckoo search algorithm. Levy flight is performed as (1) on preparing new solutions for ith cuckoo, as

$$x_i^{(t+1)} = x_i^{(t)} + \alpha \oplus \text{Levy} (\qquad (1)$$

Interest scale is related step size. Entry-wise multiplications represent Product. Distribution of step-lengths are measured by Levy flight depending on subsequent probability distribution

$$\text{Levy } u = t^{\wedge}(-\lambda), 1<\lambda\leq 3 \qquad (2)$$

Infinite variance are observed. Random walk procedure is maintained on successful steps of cuckoo basically leading senses power-law step length distribution on crucial tail.

Algorithm: Cuckoo Search

Determine Objective function f(x), x=(x1, x2,…,xd)
Initialize population of n host nests xi (i=1,2,…,d)
While (t<MaxGeneration) or (stop criterion);
Attain cuckoo (say i) randomly and produce novel solution by levy flights
Estimate its quality/ fitness Fi
Select nest between n (say j) arbitrarily
If (Fi > Fj)
Replace j by novel solution
End
Throw away fraction (Pa) of worse nests and construct novel ones at novel locations through levy flights
Maintain finest solutions or nests with quality solutions
Position solutions and acquire current best
End while
Post procedure outcomes and visualization
End

Hill Climbing (HC)

A mathematical optimization technique to the base of Hill Climbing (HC) is used for searching process locally. Neighborhood and current state are being searched by validation. Once goal is attained, stop the execution. Else, iteration is repeated on current state possibly on without new operators remained. Additionally, the primary phases are two for choosing operator on not applying to the current state in producing new state and in sequence second step validate the new state.

Hence CH is selected on new state against current one for improvising solution.

1: i = initial solution

2: While f(s) ≤f (i) s€ Neighbours (i) do

3: Generates an s€ Neighbours (i);

4: If fitness (s) > fitness (i) then

5: Replace s with the i;

6: End If

Cluster head is chosen for its beneficial on adjustment. Customization and adjustable algorithm are selected. For instance, discrete domains and communication are focused.

Proposed Cuckoo Search Algorithm with Hill Climbing Algorithm for localization process

The proposed CS-HC algorithms are collaborative combinations of the techniques. Techniques of CS and HC are incorporated to propose a new algorithm. behavior of brood parasitic are determined by CSA in some cuckoo species with combined nature of Levy flight randomly with new power law of step length distribution inclusive of a heavy tail. A few birds behavior influences some birds and fruit flies discovery. A bright exploration is utilized on Levy flight for better result. Hence, a balance between local nearby exploitation and global wide exploration are balanced by CSA of significant met heuristic swarm-based algorithm towards space search problem. But, fails in convergence which is poor and slow. To resolve these issues, proposed algorithm comes along incorporation of CSA and HC and achieve bright explore as to optimize the benchmark function.

III. PROPOSED DISTRIBUTED IOT SENSOR NODE LOCALIZATION PROCESS BASED ON HYBRID CUCKOO SEARCH WITH HILL CLIMBING (CS-HC) ALGORITHM

The primary focus is to validate N coordinates which is unknown depending on 2D stationary anchor nodes M for accurate localization of sensor node in IoT accurately For instance, d = 2 based on CS-HC algorithm procedural flow. The following steps are as to proceed distributed localization process of the IoT sensor nodes.

1. 2-D sensor nodes are deployed randomly for determining M anchor nodes and N unknown IoT sensor nodes along R being the sensor communication range.
2. Coordinates are located by the anchor nodes as well as being transmitted its location of coordinate information in regular mode.
3. Sensor node which is unknown of ith IoT is focused on localization of three or more anchor nodes which is in the communication range. Else its not possible to localise. In implementation simple, hardware complexity as well as low cost are attained. RSSI based ranging approach is implemented for validating distance of neighbouring nodes. additional energy consumption is not required for measuring RSSI signal that benefit sensor nodes of resource constrained IoT. a zero-mean Gaussian distribution with variance σ^2 is followed for RSSI based distance estimation

Received: 16 Sept 2019 | Revised: 18 Oct 2019 | Accepted: 15 Nov 2019

approaches that ranging error. (x_n, y_n) and (x_m, y_m) location nodes or coordinates are measured with its distance by dnm and Euclidean distance defines mth anchor node on location coordinate for distance d_{nm} as

$$d_{nm} = \sqrt{(x_n - x_m)^2 + (y_n - y_m)^2} \quad (3)$$

Surroundings in network as of ranging error influence actual distance d_{nm} is usually different from the measured distance$\hat{d}_{nm}$ as $\hat{d}_{nm} = d_{nm} + p_n$ Gaussian noise Pn .

4. Cost/objective function are defined. The nodes of anchoring and unknown senor are determined its distance by mean of square of ranging/localization error by cost/objective function $f(x_n, y_n)$ from

$$f(x_n, y_n) = \frac{1}{M}\sum_{m=1}^{M}\sqrt{(x_n - x_m)^2 + (y_n - y_m)^2 - \hat{d}_{nm})^2} \quad (4)$$

on $M \geq 3$ as communication range of anchor nodes along n th unknown sensor node are estimated along coordinates (x_n, y_n) via deploying CS-HC algorithm for minimal cost/objective function $f(x_n, y_n)$.

Pseudo Code: Hybrid CS_HC

Start

Define Objective function f(x), $x=(x_1, x_2,\ldots,x_d)$

Initial a population of n host nests x_i (i=1,2,…,d)

Define the cuckoo search parameters P_a

Begin CS

Evaluate its quality/ fitness F_i

Get a cuckoo (say i) randomly and generate a new solution by levy flights

Choose a nest among n (say j) randomly

If ($F_i > F_j$)

Replace j by the new solution

End

Then

Calculate the neighbouring nest

Find the maximum of neighbouring nest

If (Larger than the current one)

Local minimum is found

If not again calculate the neighbouring nest

If the local minimum is larger than the current local minimum

Abandon a fraction (P_a) of worse nests and build new ones at new locations via levy flights

Keep the best solutions or nests with quality solutions

Rank the solutions and find the current best based on the max iteration

End while

Final best population of nests

End begin CS

Therefore, CS-HC initiates search by base CS algorithm with many iterations. So, better HC is obtained to resolve the slow convergence from basic algorithm of cuckoo search. So cluster head algorithm initiates arbitrary solution to get qualified solution that by incremental of each step. On modifying solution, incremental modification is required till the new solution is obtained. In turn it give back CSA algorithm on examining probability fraction P_α.

5. At the end of each CS-HC algorithm iteration, an unknown node that gets localized will act as an additional anchors for other unknown sensor nodes in the next iteration.

6. Step 2 to Step 4 are executed repeatedly until all the unknown IoT sensor nodes have been localized or the termination conditions have been reached.

7. Calculating the average localization error EALE. If (X_n, Y_n) is the actual unknown sensor node location and (x_n, y_n) is the computed location through CS-HCalgorithm then the EALE can be given as:

$$EALE = \frac{\sum_{n=1}^{N} \sqrt{(X_n - x_n)^2 + (Y_n - y_n)^2}}{N} \quad (5)$$

It should be noted that the main objective of the localization algorithm is to reduce EALE to have a better localization performance.

IV. Experimental Results

Experimental results of proposed algorithm in domain of IoT from distributed CS-HC localization along BPSO and modified BPSO are implemented against PSO in MATLAB R2016b. Table 1 depicts the simulated results. An pc with Intel Core i7-6500 2.5 GHz CPU running in Microsoft Windows 7 enterprise edition SP1 64-bit operating system implements the algorithm of proposed CS-HC and existing approaches. In addition, anchor nodes are deployed identically in CS-HC and several algorithms.

Table 1: Simulation Parameters

Parameter	Value
Sensor Field Size	$100 \times 100\ m^2$
Anchor Nodes, M	10
Unknown Nodes, N	50
Transmission Range, R	25 m
Noise Percentage, P_n	2
Maximum Iteration, t_{max}	150
Inertia Weight ω	0.7

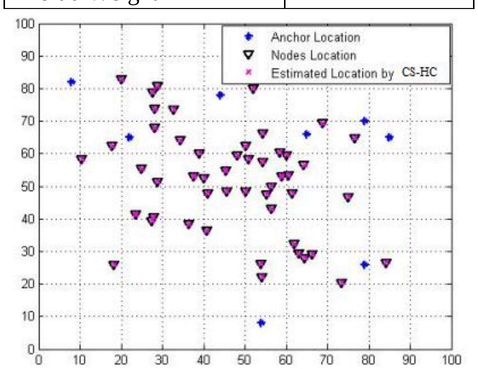

Fig. 2: Localization Using Social Learning based proposed CS-HC

Received: 16 Sept 2019 | Revised: 18 Oct 2019 | Accepted: 15 Nov 2019

Table 2: Comparison of Localization Error

Algorithm	Average Localization Error	95% CI Lower range	95% CI Upper range
Modified BPSO	0.2494	0.1684	0.3089
BPSO	0.2494	0.1684	0.3098
PSO	0.0710	0.0674	0.0806
SL-PSO	0.0024	0.0014	0.0040
Proposed CS-HC	0.0018	0.0010	0.0032

Accuracy of localization as well as rate of convergence are computed by proposed CS-HC localization algorithm and PSO and tabulated in Table 2 and figure 3.

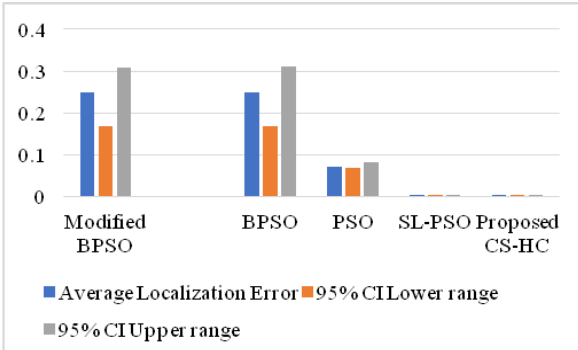

Figure 3: Comparison of Localization Error

Time taken for computing proposed algorithm against prevailing method SL-PSO, PSO, BPSO and Modified BPSO are tabulated in Table 3 and depicts that proposed method took low time consumption with better quality.

Table 3: Comparison of Computation Time

Algorithm	Computation Time (s)
Modified BPSO	66.657
BPSO	100.436
PSO	139.343
SL-PSO	63.638
Proposed CS-HC	60.012

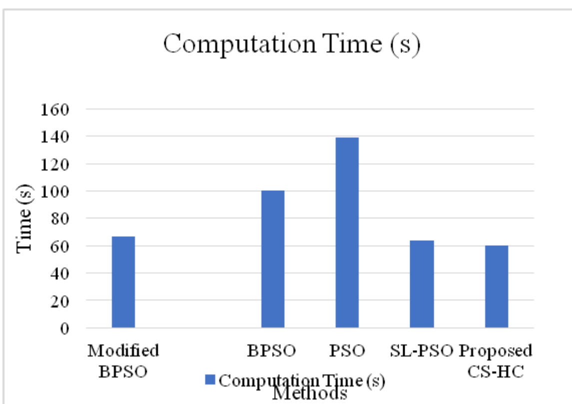

Figure 4: Comparison of Computation Time

Received: 16 Sept 2019 | Revised: 18 Oct 2019 | Accepted: 15 Nov 2019

Time taken for computing proposed algorithm against prevailing method SL-PSO, PSO, BPSO and Modified BPSO are figured in figure 4 and depicts that proposed method took low time consumption with better quality.

V. Conclusion

Several years, WSN uses a range of small network area to big one becomes crucial. But it fails in achieving efficient energy utilisation and life time of network. Hence, sensor nodes is used for localization of nodes. WSN uses nodes deployment randomly in this proposed research. The geographical location of deployed nodes are known utilising the known information sensed node. Target node is determined for known localised node along reduced error in localization. Similar way, GPS are deviced with sensed nodes on deployment seems high cost effective. Hence, it is too resolved by implementing without GPS by detecting target node locations. The indicated node used for this technique is defined as anchor node. The target nodes are detected and located by mobile anchor node around the network area. Thence, this proposed research of a innovative algorithm of distributed localization along CS-HC is used for IoT. Experimental results depicts that proposed CS-HC attains better quality of network life time and reduces energy consumption with constrained resource and sensor nodes with operating battery in IoT.

References

[1] C.-W. Tsai, C.-F. Lai, and A. V. Vasilakos, "Future internet of things: open issues and challenges," *Wireless Networks,* vol. 20, no. 8, pp. 2201– 2217, 2014.

[2] S. Hasan and E. Curry, "Thingsonomy: Tackling variety in internet of things events," *IEEE Internet Computing,* vol. 19, no. 2, pp. 10–18, 2015.

[3] X. Li, R. Lu, X. Liang, X. Shen, J. Chen, and X. Lin, "Smart community: an internet of things application." *IEEE Communications Magazine,* vol. 49, no. 11, pp. 68–75, 2011.

[4] Z. Chen, F. Xia, T. Huang, F. Bu, and H. Wang, "A localization method for the internet of things," *The Journal of Supercomputing,* vol. 63, no. 3, pp. 657–674, 2013.

[5] S. Cirani, L. Davoli, G. Ferrari, R. Leone, P. Medagliani, M. Picone, ´ and L. Veltri, "A scalable and self-configuring architecture for service discovery in the internet of things," *IEEE Internet of Things Journal,* vol. 1, no. 5, pp. 508–521, 2014.

[6] S. Raza, L. Wallgren, and T. Voigt, "Svelte: Real-time intrusion detection in the internet of things," *Ad hoc networks,* vol. 11, no. 8, pp. 2661– 2674, 2013.

[7] L. Zhou and H.-C. Chao, "Multimedia traffic security architecture for the internet of things," *IEEE Network,* vol. 25, no. 3, pp. 35–40, 2011.

[8] S. Sivakumar and R. Venkatesan, "Meta-heuristic approaches for minimizing error in localization of wireless sensor networks," *Applied Soft Computing,* vol. 36, pp. 506–518, 2015.

[9] J. Hightower and G. Borriello, "A survey and taxonomy of location systems for ubiquitous computing," *IEEE computer,* vol. 34, no. 8, pp. 57–66, 2001.

[10] N. Bulusu, J. Heidemann, and D. Estrin, "Gps-less low-cost outdoor localization for very small devices," *IEEE personal communications,* vol. 7, no. 5, pp. 28–34, 2000.

[11] D. Miorandi, S. Sicari, F. De Pellegrini, and I. Chlamtac, "Internet of things: Vision, applications and research challenges," *Ad Hoc Networks,* vol. 10, no. 7, pp. 1497–1516, 2012.

[12] S. Pandey and S. Varma, "A range based localization system in multihop wireless sensor networks: A distributed cooperative approach," *Wireless Personal Communications,* vol. 86, no. 2, pp. 615–634, 2016.

[13] M. Aziz, M.-H. Tayarani-N, and M. R. Meybodi, "A two-objective memetic approach for the node localization problem in wireless sensor networks," *Genetic Programming and Evolvable Machines,* vol. 17, no. 4, pp. 321–358, 2016.

[14] M. X. Cheng and W. B. Wu, "A model-free localization method for sensor networks with sparse anchors," *in Communications (ICC), 2016 IEEE International Conference on. IEEE,* 2016, pp. 1–7.

[15] A. Pal, "Localization algorithms in wireless sensor networks: Current approaches and future challenges," *Network protocols and algorithms,* vol. 2, no. 1, pp. 45–73, 2010.

[16] G. Mao, B. Fidan, and B. D. Anderson, "Wireless sensor network localization techniques," *Computer networks,* vol. 51, no. 10, pp. 2529– 2553, 2007.

[17] A. Gopakumar and L. Jacob, “Localization in wireless sensor networks using particle swarm optimization,” in Wireless, Mobile and Multimedia Networks, 2008. *IET International Conference on. IET*, 2008, pp. 227– 230.
[18] R. V. Kulkarni and G. K. Venayagamoorthy, “Particle swarm optimization in wireless-sensor networks: A brief survey,” *IEEE Transactions on Systems, Man, and Cybernetics, Part C (Applications and Reviews),* vol. 41, no. 2, pp. 262–267, 2011.
[19] Nandagopal S., Arunachalam V.P., Karthik S."A novel approach for inter-transaction association rule mining, *Journal of Applied Sciences Research* VOL, 8, Issue 7, 2012.
[20] Kannan R., Selvambikai M., Jeena Rajathy I., Ananthi S. Rasayan, A study on structural analysis of electroplated Nano crystalline nickel based thin films, *Journal of Chemistry,* Vol 10, issue 4, 2017.
[21] Arunvivek G.K., Maheswaran G., Senthil Kumar S., Senthilkumar M., Bragadeeswaran T. Experimental study on influence of recycled fresh concrete waste coarse aggregate on properties of concrete. *International Journal of Applied Engineering Research*, Vol 10, issue 11, 2015
[22] Krishna S.K., Sathya M. Usage of nanoparticle as adsorbent in adsorption process. *A review International Journal of Applied Chemistry*, vol 11, Issue 2, 2015.
[23] Sudha S., Manimegalai B., Thirumoorthy P. A study on routing approach for in-network aggregation in wireless sensor networks, *International Conference on Computer Communication and Informatics: Ushering in Technologies of Tomorrow, Today, ICCCI* 2014.
[24] Satheesh A., Jeyageetha V. Improving power system stability with facts controller using certain intelligent techniques, *International Journal of Applied Engineering Research,* Vol 9, no 23, 2014.
[25] Ashok V., Kumar N, Determination of blood glucose concentration by using wavelet transform and neural networks, *Iranian Journal of Medical Sciences*, Vol 38, Issue 1, 2013.
[26] Somasundaram K., Saritha S., Ramesh K, Enhancement of network lifetime by improving the leach protocol for large scale WSN, *Indian Journal of Science and Technology,* Vol 9, Issue 16, 2016.
[27] Jayavel S., Arumugam S., Singh B., Pandey P., Giri A., Sharma A. Use of Artificial Intelligence in automation of sequential steps of software development / production, *Journal of Theoretical and Applied Information Technology,* Vol 57, Issue 3, 2013.
[28] Ramesh Kumar K.A., Balamurugan K., Gnanaraj D., Ilangovan S, Investigations on the effect of flyash on the SiC reinforced aluminium metal matrix composites, *Advanced Composites Letters,* Vol 23, Issue 3, 2014.
[29] Suresh V.M., Karthikeswaran D., Sudha V.M., Murali Chandraseker D, Web server load balancing using SSL back-end forwarding method. *IEEE-International Conference on Advances in Engineering, Science and Management, ICAESM-2012*, 2012.
[30] Karthikeswaran D., Sudha V.M., Suresh V.M., Javed Sultan A, A pattern based framework for privacy preservation through association rule mining, *IEEE-International Conference on Advances in Engineering, Science and Management, ICAESM-2012*, 2012.
[31] Senthil J., Arumugam S., Shah P, Real time automatic code generation using generative programming paradigm, *European Journal of Scientific Research*, vol. 78, issue 4, 2012.
[32] Vijayakumar J., Arumugam S, Certain investigations on foot rot disease for betelvine plants using digital imaging technique, *Proceedings - 2013 International Conference on Emerging Trends in Communication, Control, Signal Processing and Computing Applications, IEEE-C2SPCA*", 2013.
[33] Vijayakumar J., Arumugam S. Odium piperis fungus identification for piper betel plants using digital image processing, *Journal of Theoretical and Applied Information Technology*, vol 60, issue 2, 2014.
[34] Manchula A., Arumugam S, Face and fingerprint biometric fusion: Multimodal feature template matching algorithm, *International Journal of Applied Engineering Research,* vol 9, issue 22, 2014.
[35] Ramesh Kumar K.A., Balamurugan K., Arungalai Vendan S., Bensam Raj J, Investigations on thermal properties, stress and deformation of Al/SiC metal matrix composite based on finite element method. Carbon - Science and Technology, Vol 6, Issue 3, 2014.
[36] Kanchana A., Arumugam S, Palm print texture recognition using connected-section morphological segmentation, *Asian Journal of Information Technology* Vol 6, Issue 3, 2014.
[37] Padmapriya R., Thangavelu P, Characterization of nearly open sets using fuzzy sets, *Global Journal of Pure and Applied Mathematics,* vol 11, issue 1, 2015.
[38] P.B. Narandiran, T. Bragadeeswaran, M. Kamalakannan, V. Aravind, Manufacture of Flyash Brick Using Steel Slag and Tapioca Powder. *Jour of Adv Research in Dynamical & Control Systems*, Vol. 10, No. 12, 2018, 527-532
[39] R. Girimurugan*, N. Senniangiri, K. Adithya, B. Velliyangiri, Mechanical Behaviour of Coconut Shell Powder Granule Reinforced Epoxy Resin Matrix Bio Composites, J*our of Adv Research in Dynamical & Control Systems,* Vol. 10, No. 12, 2018, 533-541.