Implementation of Intelligent Algorithms for Localization of Wireless Sensor Network for Secure Wireless Communication Applications

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Research Article

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Implementation of Intelligent Algorithms for Localization of Wireless Sensor Network for secure wireless communication applications

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***Abstract*—Sensorsareimportantdevicetocollecttheinformation for many applications. The present era is usinginternet of things (IOT) which is basically working on sensors.Theinputsorstatusofthesystemismonitoredusingthesensorsembeddedinthesystemunderconsideration.Thesensors need to be small in size, has to consume less power,more reliable and consistence. Wireless sensor network (WSN)isacollectionofsensorswhichworkstogethertodoaparticular task. This cluster of sensors are called nodes and hasits own power and ability to communicate to other nodes in thecluster. The location of sensors in the cluster is required to beidentified for proper data analysis. When the data is receivedfrom the sensor the location is also mapped with it then onlyproper action can be taken based on signal and location. InWSN few sensor locations are known which are called anchors,fromtheseanchors,thelocationofunknownsensorsareestimated.Inthispaper,intelligentalgorithmsfireflyandflower pollination algorithm (FPA) are used to find the locationof the sensors. The performance of the algorithms is comparedwiththeiraccuracytofindthelocation,andconvergencespeed.**

Keywords*—Wirelesssensornetwork,intelligentalgorithm,fireflyalgorithm,flowerpollinationalgorithm,sensornodelocalization.

I. INTRODUCTION

Smart city, smart home, and many other smart controlsare the intelligent operation of the system, which operatesindependently without human supervision. These intelligentcontrol techniques require monitoring of the environmentandchangeinthestate.Themonitoringispossibleby sensors, and most of the time its wireless. For the smart andbetter control, many inputs at different locations either withsame time or at particular time slot is essential. This formsthe network of wireless sensors [1]. A sensor is a node inWSN, which is tiny and has sensing elements, power backupforitsfunctionality,analogtodigital(ADC)converterrequired to convert the sensed analog quantity into digitalformat as required by the WSN. It also has a small memoryunit, a transmitter, a receiver and a processing unit. Theanchor nodes positions are known and other nodes positionsarenotknownintheWSN.Localizationorfindingthelocation of these unknown nodes depends on terrain, signalstrength,hardwarefunctionsandirregularitiesofWSNspace[2].Thesesensorsmaybewearableandhelpfulforthehumans in need. Patients in need of external support andsufferingfrommemorylossmayusethesesensors.Themonitoring of such sensors from the hospital or in centralcontrol unit requires to find the locations of the sensors. In apredefinedsearchspace,artificialneuralnetwork(ANN)maytrainbasedonthepasthistorytofindthepresentlocationofthesensors.ANNisanintelligentalgorithmand is used to find the locations of the sensors with maximum of6% error [3]. In practical applications, hundreds of sensornodes are deployed to form a WSN and they communicateamong them in wireless medium. Accurate location of thesensor nodes is important to make proper control scheme.GPS is the best method but it is expensive and made thesensor nodes bulky and not suitable for many applications.The location may be in 2 dimensional or 3 dimensions basedontheapplicationsforwhichtheWSNisdesigned[4].Optimization algorithms are widely used for the followingapplicationsinWSNnamelysensorlocalization,energyefficient clustering, optimal coverage and data aggregation.Bio inspired optimization techniques are commonly used tofor this optimization in WSN [5]. Localization is the processof finding the location of the unknown sensor node from thereference of anchor or base station nodes. A cluster consistsof few anchor nodes and many unknown nodes. The processoflocalizationistofindthepositionofunknownnodesbased on the position of anchor nodes [6]. WSN applicationsare extended to healthcare, military, autonomous vehicle andmanymore.MostoftheseapplicationsrequireselflocalizationoftheunknownnodeintheWSN.Itisachallenging task for the WSN of low cost and low powerapplicationascomparedtohighpowerGPS[7].Manyintelligent and bio inspired algorithms are used for the WSNforlocalization,energyefficientclusteringandoptimalcoverage. One among them is the firefly algorithm. It usesthe intelligence of the firefly insects for the optimizationtechnique. The firefly is the insect which emits light on itsstomach. This light is flashing at some frequency based onthe need of the insect [8]. The firefly emits it light and itobserve the light of brightest firefly then the firefly movestowards the brighter one. This makes the faster convergenceof the firefly insect with its groups. The same technique isused in the optimization to get the faster convergence for thelocalization of the unknown nodes [9]. Firefly is a randomsearch which has attraction between the two light emittinginsects,thebrightergivesmoreattractionandfastmovementtowardsthebestresults.Thelessattractionamong the firefly makes premature in convergence and hencecare to be taken for the implementation of this algorithm[10]. Constraint firefly algorithm finds the solution inthespace bounded by the boundary conditions is helpful for thereal time application [11]. Flowering plants survives in theuniverse for many billions of years and its characteristic isusedtodevelopthealgorithmcalledflowerpollinationalgorithm (FPA) [12].The steps involving in the FPA issimple and has only two steps, they are local pollination andglobalpollination.Inglobalpollinationtheinsectsoranimals or birds are involved [13]. The insects' behavior ismodeled with levy flight constant and included in theglobalpollination[14].Theswitchingconstantdecides the pollination of the flower to be local or global pollination.The global pollination pollinates the flowers with the globalflower, and in the local pollination, the global flower is notinvolved in the pollination process [15]. The section 2 givestheproblemformulation,section3explainsthefireflyalgorithm, section 4 explains flower pollination algorithm,section5explainsresultsanddiscussion,andsection6 concludesthepaper.

II. PROBLEMFORMULATION

The unknown sensor node location is estimated using theknown location of anchor node. Minimum of three anchornodes are required to identify the correct location of thesensor node. The distance between the sensor node and theanchorsarecalculatedand basedonthis,thelocationisfixed. The root mean square error is estimated for the sensornode from all the anchor nodes. When the root mean squareerroris zero,thenthecorrectlocationisarrivedforthesensor node.

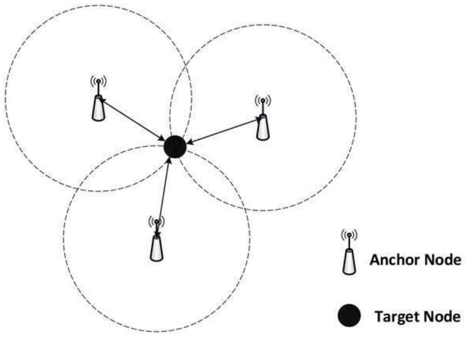

Fig.1.Threeanchornodestolocatethesensornode

$$D_i = \sqrt{(x_{est}-x_a)^2 + (y_{est}-y_a)^2} \tag{1}$$

Thedistancebetweenunknownsensornodeandtheanchoriscalculatedusingtheequation(1).X_{est}andY_{est}aretheestimatedX,Y directionsdistancebetweenanchorandunknownsensornode.X_a and$Y_a$aretheactualdistanceoftheunknownsensornodefromthe anchornode.Themeansquareerrordistanceistheobjectivefunctionofthelocalization problemandgivenintheequation(2).

$$f(d) = \left[\sqrt{(x_{est}-x_a)^2 + (y_{est}-y_a)^2} - D_i\right]^2 \tag{2}$$

Theequation(2)isthefunctionofdistanceandit calculates the square root of the distance error. When thiserror is zero then the actual position of the unknown sensornodelocationisarrived.

III. FIREFLYALGORITHM

Itisanatureinspiredoptimizationalgorithm.Theintelligence of firefly insect is observed and this algorithm isdevelopedbyXin-SheYang[8].Theseinsectsliveassocial group.Thisswarmofinsectsmovesfromoneplaceto anotherinsearchoffood.Thebionatureoftheseinsects emitslightat itsstomachcalledflashinglights.Theflashing frequencyisdifferentforeachinsect.Moreinsectswillemerge where there is more source of food. From this, onecanunderstandthatmorebrightnessindicatestheavailability ofmoreinsectsandmorefoodavailableforthem.Afirefly which is away from the swarm has to observe the brightnessof the light and it has to move towards the brighter spot togetfood andtoget matting partner.Figure2 showsthefireflymovingtowardsthebrighterfireflyinthegroup.

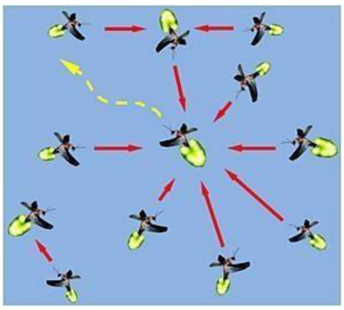

Fig.2.Fireflymovestowardsthebrighterfirfly

Forthedevelopment ofthe intelligentalgorithm, fewidealizations are added into the algorithm. They are, fireflymoves towards the brighter firefly irrespective of the sex oftheinsects.Theattractivenessbetweenthefireflydependsonthe brightness of the emitted light intensity and inverselyproportional to the distance between them. Distance is thedestructive factor of attractiveness. When a firefly finds nobrighter firefly, then it moves randomly to explore the bettersolutionfortheconsideredproblem.Thebrightnessiscalculated using the objective function of the problem. Forthemaximizationproblem,brighterindicatesthebetterresult. Forminimizationproblem,theobjective functionisinversely considered asthefitnessfunction ofthe firefly.

A.Attractiveness

A firefly moves towards the brighter firefly based on theattractivenessamongthem.Thecalculationofthisattractivenessisgivenintheequation(3).

$$\beta(x) = \beta_0 e^{-\gamma . x^m} \tag{3}$$

In the above equation (3), β is the attractiveness, β_0 is theinitial attractiveness, x is the distance between the fireflies, γisabsorptioncoefficientand$m$isthedimensionofthesolutionspace.Mostoftheproblemuses2dimensionalspacesasasearchspaceandconsidered inthispaper.

B.Distance

Thedistancebetweenthefirefliesunderconsiderationfor themovementisgivenintheequation(4)

$$x = \| x_i - x_j \| \tag{4}$$

Thedistanceisthenorm2distancesbetweenthetwo fireflies'$x_i$andx_j.

C.Movement

Thefireflyupdatesitspositionofmovingtowardsthebrighterfireflyusing theequation(5).

$$F_i^{p+1} = F_i^p + \beta(x)\times x + a\times(r-0.5) \tag{5}$$

In the above equation (5), $F_i$is the firefly position to beupdated, p is the iteration count, β(x) is the attractiveness, $x$isthedistance,$a$isthe randomizingparameter,$r$istherandomnumber.

D.Algorithm

The firefly algorithm for the localization of the unknownsensor nodesisgivenbelow.

Step 1:Initial population of firefly which contributes to thepositioninthelocationspacearecreated.

Step2:Setiterationcount=1.

Step3:Localizationerrorisconsideredasthefitnessforthe

firefly.

Step4:Attractivenessbetweentheconsideredfireflyandbrighterfireflyiscalculated.

Step5:Distancebetweenfirefliesiscalculated.

Step6:Thefireflymovestowardthebrighterfirefly.Step

7:Step-4to6isrepeatedforallthefireflies.

Step8:Incrementtheiterationcountandcheckforthemaximumvalue.

Step 9: If the iteration count is less than maximum thenjumptostep3elsestoptheiterationandprinttheresults.

IV. FLOWERPOLLINATIONALGORITHM

It is a nature inspired algorithm. The flowering plantsgeneration and survival are implemented in this algorithm.This algorithm has two simple steps, one is self-pollinationand another one is cross or global pollination. Floweringplants are aimed to produce the seeds of the plant to extendits generation. To produce the seeds the pollen is transferredto ovary of the flower. About 10 percent of flower does notneedhelpfromtheinsects.Honeybeeisoneoftheimportantinsectwhichhelpstheflowerstoproduceseeds.

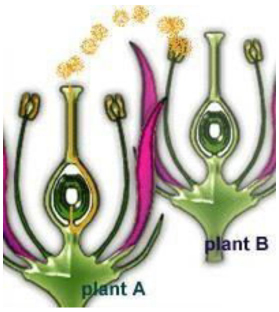

Fig.3.Globalpollinationoftheflower–A

Transfer of pollen from one plant's flower to anotherplant's flower is called global pollination and shown in thefigure 3. The pollen of plant - B is transferred to plant – A'sflower ovary. This process needs the help of wind or insectsoranimalorbirds.Thetwo-pollinationprocessisgivenbelow.

A.Localpollination

The pollen of the flower in the same plant is transferredtotheovaryoftheflowers.Thisprocessiscalledlocalpollination and the mathematical equation for the process isgivenintheequation(6).

$$F_i^{p+1}=F_i^p+\varepsilon(F_j^p-F_k^p) \tag{6}$$

Intheaboveequation(6),Fistheflower,i–istheflowerundergoing for the pollination, j and k are the flowers of thesameplant,εisscalingfactorand*p*istheiterationcount.

B.Globalpollination

Thepollenfromtheflowerofplant-Bistransferredtotheplant-Aflowerbymeansofinsectsoranyotherbioticnature.Thisprocessisgiven intheequation(7).

$$F_i^{p+1}=F_i^p+L(F_G^p-F_i^p) \tag{7}$$

Intheaboveequation(7),Fistheflower, *i*–istheflowerunder going for the pollination, subscript *G* is the globalflowerhavingbestresultsinit,and*p*istheiterationcount.

C.Algorithm

The flower pollination algorithm for the localization oftheunknown sensornodesisgivenbelow

Step1:Initialpopulationofflowerwhichconsistsofpositionofthesensornodesarecreated.

Step 2: Localization error is considered as the fitness of theflowers.

Step 3: Set iteration count =

1.Step4:Setflowercount=1.

Step 5: For every flower, generate a random number, if therandom number is less than the switching constant thenexecutestep7.

Step6:Fortheflower-*i*localpollinationisdoneusingequation(6). Afterpollinationgotostep8.

Step 7: For the flower-*i*global pollination is done usingequation(7).

Step 8: Increment flower count, and if it is less than numberofflowerpopulationthengotostep5.

Step9:Incrementiterationcount,andifitislessthanmaximum numberthengo tostep4.Elseprinttheresults.

V. RESULTSANDDISCUSSION

Fortheimplementationofthefireflyandflowerpollination algorithm a test case consisting of 40 nodes areconsidered.Inthis40sensornodes,8sensornodesareconsidered as anchor nodes and those locations are known.Restofthe32sensornodeslocationsareunknown,theintelligent algorithm has to estimate the correct location ofthese 32 sensor nodes [1]. The boundary of 0 to 100 units isconsidered for the search space for the 40 sensor nodes. The40 nodes locations are randomly generated by the MATLABsoftware. Among them 8 anchor nodes are identified andfixed to estimate the location of other 32 sensor nodes. Thesearchspaceistwodimensional.Thelocationisx,ypositionin thesearchspaceof(0,0)to(100,100)units.Theunknown sensor nodes locations are estimated one by one.Themaximumnumberofiterationsistakenas100iterations.Ifthelocationofthesensornodeisnotidentifiedthen the best near location is considered. Then next sensornode locationissearchedinthesolutionspace.Samestepsare used toidentifyallthe32unknownsensornodes.Theresultsoftheintelligentalgorithmsare givenbelow.

A. Fireflyalgorithm

Fortysensornodesarecreatedinthesolutionboundedbythe (0, 0) and (100, 100) units of the two-dimensional searchspaces. Eight anchor nodes are considered and rest of the 32unknownsensornodesaretobelocatedinthesolutionspace.

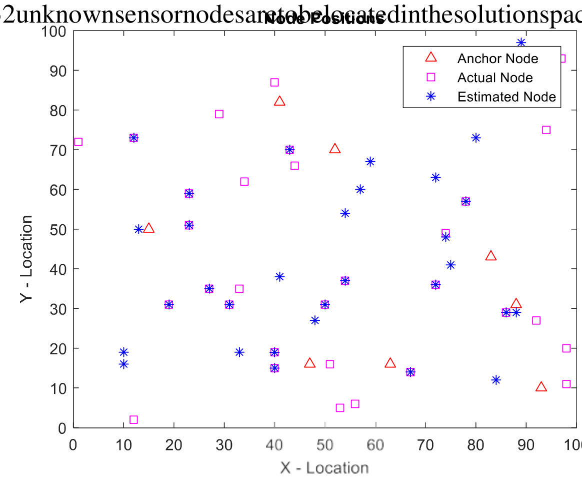

Fig.4.Fireflyalgorithmlocalization

Inthefigure4,trianglesareanchornodesusedtofindthelocation of other unknown nodes. The pink colour squareboxesaretheactuallocationofthe sensornodes.Bluecolourstars are the estimated location of the algorithm. From thefigure it is evident that 15 nodes location are not identifiedand17nodesareidentifiedcorrectly.

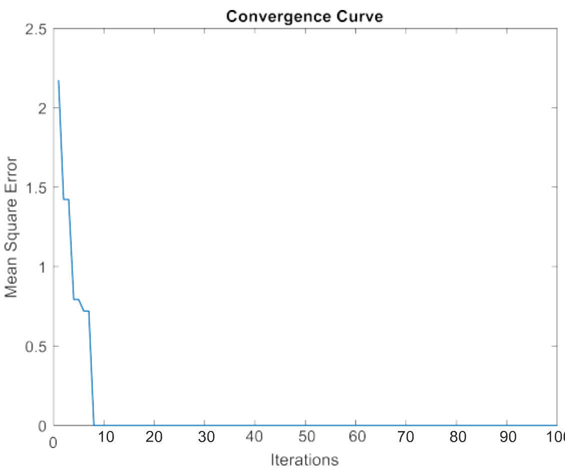

Fig.5.Fireflyalgorithmconvergencecurve

Figure 5 shows the convergence curve for one of theidentifiedsensornodes.Thelocationisestimatedcorrectlyataround8thiterationofthealgorithm.

B. Flowerpollination algorithm

Same localization system is considered for the flowerpollination algorithm for the comparison. In this algorithmalso 40 nodes are created in the solution space of (0, 0) and(100, 100) two dimensional space. Figure 6 shows 40 nodesin the solution space. In that 8 anchor nodes are given as redtriangle. Based on this position, rest of 32 sensor nodes areestimated. Actual node locations are shown as square boxandestimatednodesareshownasbluecolourstars.

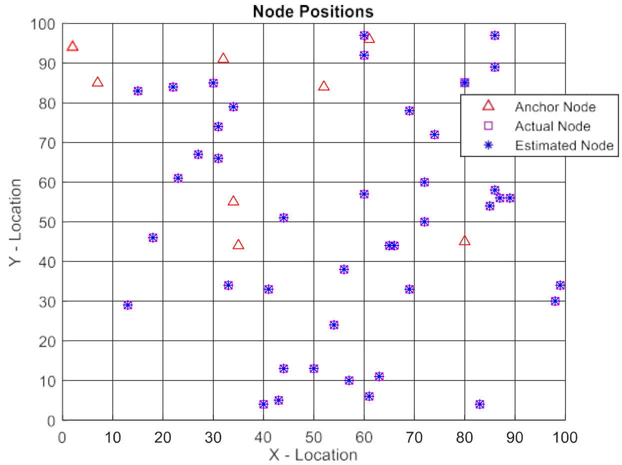

Fig.6.Flowerpollinationalgorithmlocalization

From thefigure 6, all the unknown sensor nodes areidentified.

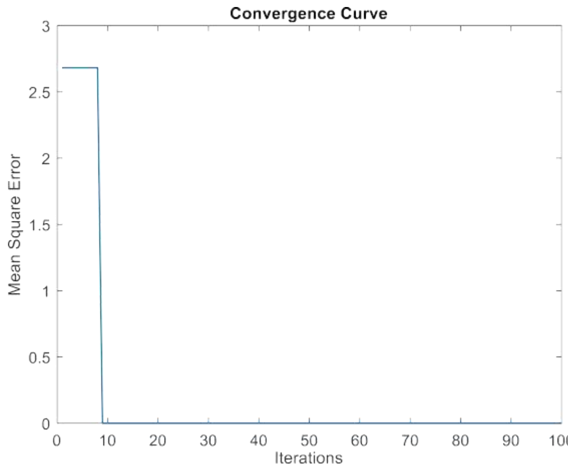

Fig.7.Flowerpollinationalgorithmconvergencecurve

Figure7showstheconvergencecurveoftheflowerpollination algorithm. The nodes are identified and one of itsnode convergence is shown in the above figure. The node isidentifiedafterabout9iterations.

Boththealgorithms,fireflyandflowerpollinationalgorithms are used to identify the location of the unknownsensornodes.Fireflyalgorithmisunabletofindallthenodesin the solution space. In flower pollination all the unknownsensor nodes are identified and shown in the figure 6. TableI,comparestwoalgorithmsconsidered,fromthiswecometoknowthatflowerpollinationalgorithmgivesbetterlocalization.

TABLEI. COMPARISONOF ALGORITHMS

Parameters	FireflyAlgorithm	Flower PollinationAlgorithm
TotalNodes	40	40
Anchornodes	8	8
UnknownsensorNodes	32	32
IdentifiedNodes	15	32
Valuesofconstants	β_0=1,γ =0.96,	ε = 0.3,

VI. CONCLUSION

Wireless sensor networks are common and are increasingtheir use day by day. Due to cost efficiency and miniaturesize,GPSisnotincludedinthesesensornodes.Thelocalization of these sensor nodes is important to take validandbettermonitoringandcontrolofthesystem.Natureinspired algorithms firefly algorithm and flower pollinationalgorithm are used to identify the location of the unknownsensor nodes. For this, a case study with 40 sensor nodes areconsidered. To identify unknown sensor nodes, anchor nodesare used. The intelligent algorithm finds the location of thesensornodes.Inthecomparisonstudy,flowerpollinationalgorithm performs better and identifies all the nodes in thesolutionspace.

Thisinvestigationfindsitsapplicationinoptimizingmechanicalengineeringdesignsuchasdesignofsprings,pressurevessels,speedreducers,robotics.Wirelesssessornetworks on the whole finds its application in the mechanicalengineeringstreammainlyinthesecurityaspectintheenvironmentalsensing,instructuralhealthandEquipmentmonitoring in the aspect of condition monitoring and in theevaluation and improvementin processautomation.

Declarations

1. **Funding**

Not Applicable

2. **Conflicts of interest/Competing interests**

There is no conflict of interest from all the authors in the manuscript.

3. ***Availability of data and material**

Not Applicable

4. ***Code availability** (software application or custom code)

Not Applicable

5. ***Authors' contributions**

T Ashok – Overall concepts, literature survey, Working and ideology, Results development

R Prabhakaran – Supervising, Proof editing

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