A Study of Optimising Sensor placement in Smart Cities based on Circle Packing Problem

A thesis

submitted to the Faculty of Engineering and Technology , Jadavpur University in partial fulfilment of the requirement for the Degree of

Master of Computer Science & Engineering

Submitted By

KOUSTAV MANDAL

Examination Roll Number : M4CSE22018

Registration No: 135929 of 2016-2017

Class Roll Number - 002010502018

Master of Engineering ,

Computer Science & Engineering ,

Jadavpur University,

Kolkata - 700032

Under the Guidance of

Prof. NANDINI MUKHERJEE and Dr. Chintan Kr. Mandal .
Department of Computer Science and Engineering,
Faculty of Engineering & Technology,
Jadavpur University, Kolkata-700032

Declaration of Originality And Compliance of Academic Ethics

I hereby declare that this thesis contains literature survey and original research work done by me as part of my Masters of Engineering in Computer Science and Engineering course in Second Year.

All information in this document has been obtained and presented in accordance with academic rules and ethical conduct.

I also declare that, as required by these rules and conduct ,I have fully cited and referenced all materials and results that are not original to this work.

Signature :

Date :

Name : Koustav Mandal

Examination Roll Number : M4CSE22018

Registration No: 135929 of 2016-2017

Email Id : utpalkumarmandal1967@gmail.com

Mobile : 8420844295

Master of Engineering , PG - II ,

Department of Computer Science and Engineering ,
JADAVPUR UNIVERSITY , Kolkata-700032

To whom it may concern

This is to certify that Koustav Mandal , registration number - 135929 of 2016-17,exam roll number M4CSE22018 , a student of M.E. Second Year department of Computer Science and Engineering , Jadavpur University has done a thesis under our supervision, titled "Optimising Sensor placement in Smart Cities based on Circle Packing Problem" . The thesis is approved for submission towards maximum fulfilments for the requirements of the Degree of Master of Engineering of Computer Science and Engineering , Jadavpur University for the session 2021-2022.

…………………………. ………………………………….

Dr. Chintan Kumar Mandal

Thesis Supervisor
Department of Computer Science
And Engineering
Jadavpur University

Professor Nandini Mukherjee

Thesis Supervisor
Department of Computer Science
And Engineering
Jadavpur University

…………………………..

Prof.Anupam Sinha

Head of Department of Department of Computer Science and Engineering ,
Jadavpur University , Kolkata - 700032 , West Bengal

…………………………….

Prof. Chandan Majumdar

Dean , Faculty of Engineering & Technology,
Jadavpur University , Kolkata - 700032 , West Bengal

FACULTY OF ENGINEERING AND TECHNOLOGY
JADAVPUR UNIVERSITY

Certificate of Approval* (Only in case of thesis is approved)

This is to certify that the thesis entitled by is a bonafide record of work carried out by **Koustav Mandal** in partial fulfilment of the requirements for the award of the degree of **Master of Engineering in Computer Science and Engineering in the Department of Computer Science and Engineering, Jadavpur University** during the period of July 2020 to July 2022. It is understood that by this approval the undersigned do not necessarily endorse or approve any statement made, opinion expressed or conclusion drawn therein but approve the thesis only for the purpose for which it has been submitted.

…………………………………………………………………….

Signature of Examiner 1

Date:

…………………………………………………………………….

Signature of Examiner 2

Date:

…………………………………………………………………….

Signature of Examiner 3

Date:

# Acknowledgement

I would like to start by thanking the holy trinity for helping me deploy all the right resources and for shaping me into a better human being.

I would like to express my deepest gratitude to my advisor, **Dr. Nandini Mukherjee**, Professor of the Department of Computer Science and Engineering, Jadavpur University and **Dr. Chintan Mandal**, Assistant Professor for their admirable guidance, care, patience and for providing me with an excellent atmosphere for doing research.

I would like to thank my seniors without whom this thesis could not be completed as they played a major role in educating me about technical aspects. I would like to specially mention my friends, who helped me for this thesis.

Most importantly none of this would have been possible without the love and support of my family, especially my mother for her constant motivation to complete this Masters of Engineering Degree even after tough family conditions as my father expired in an accident during 12 March,2019 when I was in Third Year of B.E. of Computer Science and Engineering , Jadavpur University. It was one of my dad's wildest dreams to see me passing M.E. in Computer Science and Engineering from the same Jadavpur University. Moreover I would love to also publish a Research Journal Paper on this topic in near future under the utmost guidance of **Dr. Nandini Mukherjee.**This thesis would not have been completed without the inspiration and support of a number of wonderful individuals like my University seniors , batchmates , my B.E. departmental senior Dr. Angan Mitra , (BE-CSE 2016,JU) and many others — my thanks and appreciation to all of them for being part of this journey and making this thesis possible.

……………………………………

KOUSTAV MANDAL

Registration No: 135929 of 2016-2017

Class Roll Number -002010502018

Examination Roll Number M4CSE22018

Master of Engineering , Department of Computer Science & Engineering, Jadavpur University , Kolkata - 32

Table of Contents

Acknowledgement……………………………………………………………….10

Abstract………………………………………………………………………12

Chapter 1. INTRODUCTION………………………………………………...14

CHAPTER 2. LITERATURE SURVEY………………………………………… 24

Chapter 3 METHODOLOGIES………………………………………………….30

CHAPTER 4. RESULTS, CONCLUSION AND FUTURE WORKS…………..34

BIBLIOGRAPHY………………………………………………………………..38

ABSTRACT :

The smart city is an idea of using computerised innovations to improve and upgrade the existence of a city's occupants.

This idea has been the subject of expanding interest throughout recent years. Notwithstanding, most investigations address further developing parts of a city's foundation, for example, data security, protection, correspondence organisations, government, and transportation. Smart urban communities manage basic and day to day issues, including homes and structures, climate, transportation, medical services, energy, training, and assembling . The Internet of Things (IoT) coordinates multiple items, like sensors, cell phones, actuators, houses, and machines, into an organisation to involve their information for constant dynamic sensor sending, is the strategy for setting sensors in an ideal region, is viewed as a difficult issue for specialists and engineers.

Smart cities are enabled by placing sensors at strategic positions, such that they can communicate among themselves. In this proposal, we present an algorithm to place the sensors, represented as circles of various radii inside a rectangular region such that the distance between circles is minimized. The circles can be placed such that they overlap to some extent, touch each other at the boundary or do not touch each other.

Chapter 1. **INTRODUCTION**

USE OF SMART CITIES IN SOCIAL SYSTEMS

The major functionalities of smart homes and civil infrastructure can be realised to a large extent through the analysis of data recorded by wireless sensors. One of the main objectives in a smart home is to efficiently control the devices and applications in a modern home, e.g., electronic devices, home indoor/outdoor security systems, climate control, light controls, room temperature monitoring, appliance use and maintenance/health monitoring, etc.

Smart Retail and Healthcare: In smart cities, online retail and healthcare can be supported by IoT devices. Remote retail and healthcare can be effectively enabled by visualising sensor data retrieved from smart devices carried by or worn by citizens. Visualisation is particularly important to online shopping, given that customers typically desire to see the items before making any purchases.

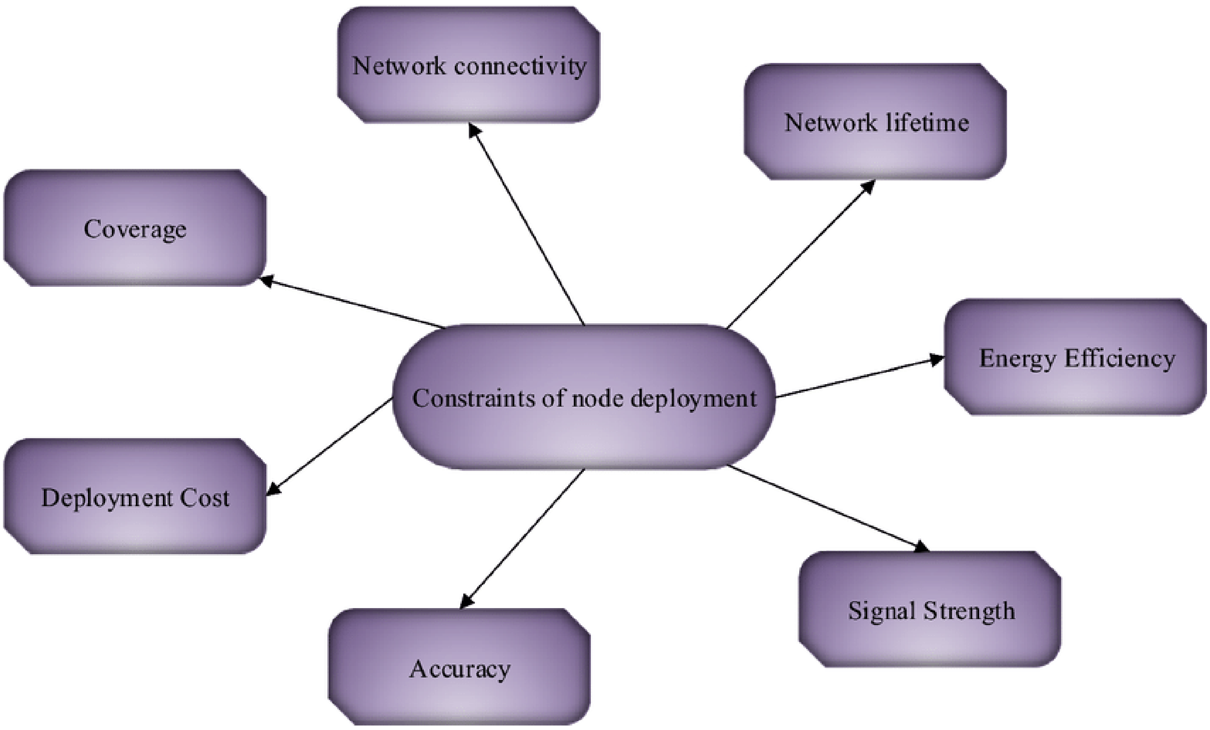


Fig : Basic constraints of Sensor node Deployment

Here, most useful is the plan of the issue of vagrancy. SOCIAL Examinations AND SOCIAL Frameworks Vagrancy and destitution are SC complex issues impacting different sorts of individuals with different necessities. State run organisations all around the planet have made various drives to address vagrancy for different social occasions . For instance, in 2013, the Canadian government arranged Cnd $119 million for new strategies that could somewhat handle vagrancy. The important one among these is Lodging First, which gives down and out individuals, who so need, their own supported, durable housing, as well as individualised maintenance. While current methodology course leans toward developing the openness of Lodging First tasks (to which our computations could consign a person), eventually emergency covers, flashing dwelling and various types of housing (e.g., substance abuse treatment centres), are presumably going to remain an essential piece of available organisations long into what's in store. The splendid city is a thought that means to help the city with passing organisations on to occupants even more capably. The splendid city improvement is mainly founded on information development and headway in government. State run organisations in sagacious metropolitan networks generally based on projects with wide applications like progress in information development, huge data, and electronic movement of information. In any case, less acceptance is given to how advancement and data can handle social issues and help with taking out resolute issues, for instance, vagrancy and poverty.Plan limits like affiliation thickness, association and energy use are considered for empowering the prosperity work.

1.1 Wireless sensor networks

A major problem when designing these networks is deploying sensors such that their area coverage is maximised. Given a number of sensors with heterogeneous sensing ranges, the problem of coverage maximisation is known to be NP-hard. As such, prevailing methods often rely on metaheuristic techniques while employing approximated fitness functions, resulting in modest solution quality and stability. This paper proposes a novel and efficient metaheuristic in the form of a genetic algorithm, which overcomes several weaknesses of existing metaheuristics, along with an exact method for calculating the fitness function for this problem. The proposed genetic algorithm includes a heuristic population initialization procedure, the proposed exact integral area calculation for the fitness function, and a combination of Laplace Crossover and Arithmetic Crossover Method operators. Experiments have been conducted to compare the proposed algorithm with five state-of-the-art methods on a wide range of problem instances. The results show that our algorithm delivers the best performance in terms of solution quality and stability on a majority of the tested instances.

Advancements in wireless technology have had broad impacts over the last few decades, including but not limited to the improvement of the communication range and scalability of wireless networks. Among branches of wireless networks, wireless sensor networks (WSNs) have received significant attention from the academic community due to their wide range of applications, particularly in Internet of Things (IoT) technology. As a result, communication in large scale WSNs has seen significant improvements in recent years, enabling their deployment in regions of complex terrain or hard-to-reach areas.

WSNs usually consist of one or more base stations and a set of sensor nodes tracking changes in environmental factors such as temperature, water salinity and humidity. Each sensor has a known sensing range, within which environmental data is continuously collected. This data is then sent either directly or via temporary nodes to the base station within the limits of the sensor’s communication range .

Information collected by sensors is useful for anticipating and giving warnings about unusual occurrences within the monitoring area. Therefore, WSNs support a variety of applications in environmental studies, healthcare, military, industry, agriculture, and IoT

However, the limited range of sensor nodes is considered to be one of the primary weaknesses of WSNs, resulting in unmonitored areas in the surveillance region. For the sake of greater coverage, there is a tendency to increase the number of sensor nodes, which requires higher infrastructure costs. Practically, sensors with different sensing ranges can be deployed in the same network to adapt to the specific size and shape of the surveillance region and optimise the cost of deployment. Thus, some existing models that assume a fixed sensing range for all sensors may not address the requirements of real life applications.

Researchers have recently approached the problem of maximising area coverage in WSNs with multiple sensing ranges in different ways, e.g. applying particle swarm optimization algorithms and evolutionary algorithms. This improvement led to a great reduction in computational complexity .

To improve the convergence speed, the authors proposed the Democratic Particle Swarm Optimization (DPSO) algorithm which was proven to converge nearly five times faster than IGA while obtaining solutions of similar quality. Improved Cuckoo Search (ICS) and Chaotic Flower Pollination Algorithm (CFPA) were proposed by Binh et al. to achieve even better computational time.

This area coverage varied greatly in different runs and sometimes even exceeded the theoretical upper bound. We assume that the problems leading to this performance instability and unreliability lie within the fitness function calculation procedure. Therefore, in this paper, we propose a novel genetic algorithm called MIGA to overcome the aforementioned weaknesses. In particular, the new contributions of our genetic algorithm are as follows:

- A heuristic algorithm for population initialization.
- A more stable and reliable fitness function whose computed area coverage does not exceed the theoretical upper bound.
- A combination of two different crossover operators.
- A local search using Virtual Force Algorithm (VFA) for further improvement of the final results.

A WSN generally involves a gigantic number of insignificant cost, low-power, multifunctional, energy obliged sensor centre points with limited computational and correspondence limits . In WSNs sensors may be conveyed either for arbitrary reasons or deterministically depending on the application . Sending in a battle zone or perilous locales is generally unpredictable, while a deterministic plan is preferred in pleasant circumstances. Generally a deterministic position requires less sensor centres than the unpredictable shipping of play out a comparable task. Network lifetime is one of the huge limits to overhaul as energy resources in a WSN are confined due to action on battery.

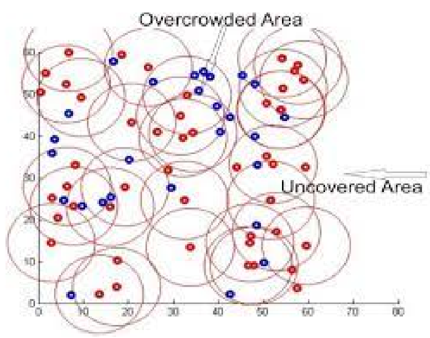


Fig: Circle sensor deployment

1.2 SENSOR DEPLOYMENT AND COVERAGE PROBLEMS

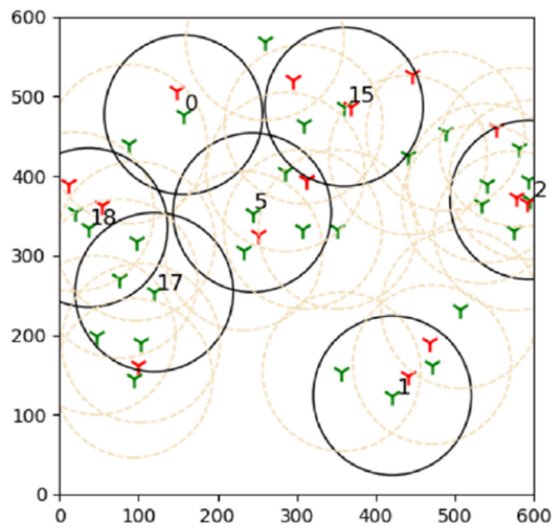


Fig: SENSOR DEPLOYMENT OF WSN

Sensor sending in WSNs is a significant issue that should be tended to. This study proposed a three phase organisation procedure, called ED TDSC, for WSNs in brilliant urban communities. The ED TDSC is an organisation approach reasonable for deciding the areas of sensors and sinks in a detecting region with snags. The main stage includes perusing a setup document including data about the polygons that make up a shrewd city map and the hindrances inside the city. The subsequent stage includes sensor arrangement, containing three stages: irregular area age, Delaunay triangulation creation,and inclusion assessment. The last stage is sink dispersion, in view of the means of bunching AI procedure. Accordingly, the proposed plot beat the irregular and four ordinary organisation techniques as far as the end to end delay and the region inclusion, which are the main exhibition measurements in WSN applications. IoT assumes a critical part in forming the fate of savvy urban communities as a systems administration worldview. Shrewd urban areas and IoT are ready to make another age in metropolitan living, upgrading the security, reasonableness, and solace of residents, and giving a spine to cutting edge organisations and empowering more productive and savvy city administrations and organisations. For future work, the EDTD calculation can measure up to different methodologies, like DVOC, VCOND, CAFT, CPSO, and CPSO EDTD- - Fuzzy. Moreover, the SC can be applied to different urban communities, like Florida City, Cleveland, New York, and Los Angeles City to concentrate on the effect of changing geological sizes on network execution. Furthermore, as of late this organisation technique is additionally been utilising in numerous MiddleEast nations.

1.3 CIRCLE PACKING PROBLEM

Solving maximal covering circle location problem using geneti0c algorithm with local refinement

In this article, we have proposed a GA-based approach for solving the maximal covering location problem. The proposed GA-based approach utilises a local refinement strategy during initial generations to guide the search for potential facility locations. Use of this local refinement strategy improves its overall rate of convergence. The performance of the proposed technique has been demonstrated on several benchmark data sets. Moreover, its performance has been compared with that of existing heuristic approaches and other GA-based approaches and illustrated both numerically and visually. The proposed approach has been found to outperform the existing approaches in most of the cases

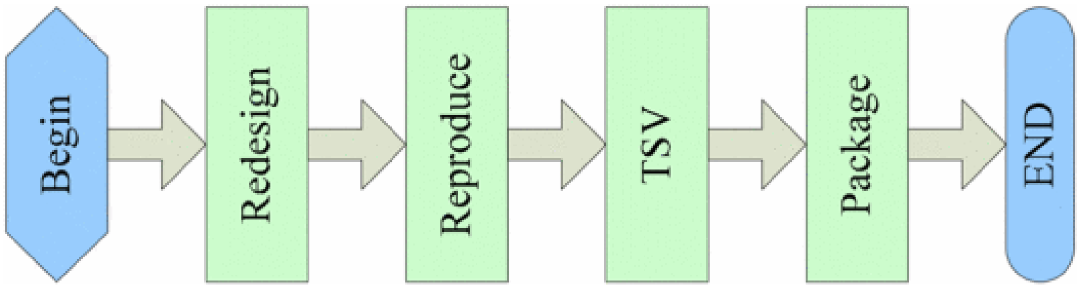


Fig:Solving maximal covering circle location problem using genetic algorithm with local refinement

Parametric Circle Approximation Using Genetic Algorithms

Addressing the parent people to convey bit designs that address best fitted reactions for the issue being taken care of.

Boss benefit of such stochastic improvement is the chance of creating some distance from neighbourhood minima through the change, confirmation and mating tasks. Fundamental prevention is the need of meaning of a fair wellbeing work that reflects how well any piece setup acts in the arrangement space. For pinnacle, we will introduce a system of the essential pieces of a GA.

1.4 GENETIC ALGORITHM

A Genetic Algorithm based multi-objective methodology was implemented for a self-organising wireless sensor network.

Movements have been finished to manage such issues. GA is one of the most astounding heuristics for taking care of streamlining issues that depend upon common choice, the correspondence that drives regular new development. The GA over and over changes an all inclusive community of individual plans. At each step, the natural calculation picks people haphazardly from the consistent individuals to be guards and uses them to convey the youngsters for what the future holds. Over moderate ages, everybody "advances" towards an ideal approach.

GAs can be applied to manage an assortment of progress that are not legitimate for standard streamlining calculations, reviewing issues for which the goal work is broken, non-differentiable, stochastic, or fundamentally nonlinear. Two or three specialists have truly executed GAs in a sensor network plan that incited the improvement of a few other GA-based application-express frameworks in WSN plan, for the most part by the improvement of a solitary prosperity work. In any case, these procedures either cover bound network attributes or neglect to facilitate two or three utilise express necessities into the execution degree of the heuristic.

The calculation mainly tracks down the utilitarian techniques for the middle focuses to meet the application of unequivocal necessities nearby minimization of energy use by the affiliation. Much more unequivocally, network arrangement is examined like powerful sensors' situation, social occasion and correspondence degree of sensors, while execution assessment merges, along with openness and energy-related qualities, two or three use express properties like consistency and spatial thickness of distinguishing focuses. Thus, the execution of the proposed strategy accomplishes an ideal plan plot, which chooses the activity mode for every sensor.

Genetic estimations

Genetic computations are a pseudo-unpredictable improvement system that duplicates ordinary advancement to find the plan of the issue being handled. The block diagram of the Straightforward Hereditary Calculation (SGA) is shown in Figure 1. As portrayed by this layout, to use a SGA, we truly need to instate a general population of newcomer plans. Each potential plan is tended to as a computational individual where the innate material is encoded as to a great extent bits. We name a computational chromosome to such a progression of pieces. There is also an encoding and unravelling limit that lets us go the two distinct ways from the game plan space to the chromosome space. Each computational individual is surveyed to find the best game plans among the general population. We need to describe the indicated health work to give out a health worth to each reasonable plan. The health regard encodes the data we have about the qualities of the best game plan and endeavours to compensate for potential courses of action that best fit these components. Best game plans are kept and they are offered the distinction of mating to create another general population that will be inspected in much the same way, until an ending condition is fulfilled. Genetic heads like mating and change work directly on the piece string

Encoding part

The encoding plan used in a GA has the limit of tending to in a unique manner each plan in the issue search space by using one or a couple of computational chromosomes.

We sort out by computational chromosome an associated series of pictures, where the pictures are investigated by a particular letter set. Most often used depictions are arranged in an equal letter set. That is, every potential plan is tended to as a progression of pieces. We can use twofold strings to encode promising new kids on the block in basically any improvement issue with extraordinary results. Various upgrade issues require including authentic exactness values as the PC execution data type. We can use entire number depictions to chip away at computational treatment of the information. Regardless, we use an arranging ability to disentangle the entire number record of the contender into a certified worth.

Populace instatement

GA works on basic people searching for best fitted individuals. Each individual connects with a potential game plan of the improvement issue. We can use any derived strategy to populate the GA. Such instrumentation plans could exploit concluded data on the specific issue to be settled. Eventually, and as a means of giving assortment to the GA people, this step is done by randomly picking different individuals from the chase space.

Wellness evaluation

We need to evaluate how well every new kid on the block plan performs. To do this, we use a limit f(x) that is redesigned when x expects the value that deals with the issue. In this work, we need to encode all the data about the issue being tended to. For each conceivable game plan, this limit returns a health score used to rank likely game plans. In this step, the piece string tending to the game plan (similarly called the genotype) is decoded to get the components connected with such a piece string (moreover called the total). These limits are used by the health ability to calculate the wellbeing score. Health work multifaceted design can move depending upon the issue being settled. The wellbeing score is by and large the method for closing which individuals remain being significant for the GA people.

Determination instrument

The assurance part lets us set up bit by bit processes for getting by in the formative framework. One of the most direct bit by bit processes for getting by to be considered is the best fitted perseverance. In this method, individuals which have the better health score are kept to participate with its genetic code to the accompanying pattern of the GA people. We truly need to describe the quantity of parent individuals who will be decided to mate among them to create one more person for the GA, and how much will all of them add to the promising age of the GA.

Change manager

The change director is an unpredictable disturbance overseer used to change and possibly sort the genetic material of the computational chromosomes. The use of such a head is wanted to stay aware of the general population assortment and to avoid the unfavourable blend of the computation in a close by. The chairman is tended to by a change probability regard. This value is related to the ease of an unpredictable change in each piece in the genotype. Including little characteristics for this likelihood is recommended.

We have presented a computation that approximates circles by using a GA-based approach. Similarly, we have presented a short diagram of GA-based systems and we have advised the most effective way to address a model affirmation issue to include GA for handling it. To know, we settle a circle surmise task.

We have executed two quantitative tests to survey the introduction of the proposed system. We have in like manner played out a close to home abstract test over hand-drawn pictures. In this way, we have found in one hand, a high precision computation execution on circles spoiled by Gaussian commotion. On the other hand, sinusoidal disturbances are better seen expecting the adequacy of the annoyance is little concerning the circle. For another case, our estimation will endeavour to fit a circle to one of the changed corners of the disturbed circle. We have moreover shown the outcome of different emotional tests on human data. The results are adequately encouraging to consider this as a design block for graphical sketch affirmation.

We are making at this point various modules to see more numerical shapes that can be conveyed in parametric terms. We are making modules to see circles, quadrilaterals and polygons generally.

Genetic Calculation (GA) is one of the most great heuristics for dealing with progress that relies upon customary assurance, the cycle that drives normal turn of events. The GA at least a time or two changes a general population of individual plans. At each step, the innate computation picks individuals capriciously from the continuous people to be watchmen and uses them to convey the young people for what's in store. Over moderate ages, the general population "propels" towards an optimal plan. GAs can be applied to deal with an arrangement of improvement gives that are not suitable for standard smoothing out computations, recollecting issues for which the objective work is fitful, non-differentiable, stochastic, or significantly nonlinear

PROBLEM STATEMENT - Here we have to place the circles in a rectangular area so that we get the minimal distance between the placement of circles.

Constraints - The circles can partially overlap among themselves but the circles cannot be placed as concentric circles.

Chapter 2. LITERATURE SURVEY

Developmental calculation manages the circle serious issue

In this paper, we propose a developmental calculation based answer for the circle serious issue, called ECPP. These approaches depend upon two fixed parts: shock based and Delaunay triangulation based. We consolidate these help heuristics with GA, ES, DE, and PSO (yet GA and DE are addressed in this paper). The arrangement space of the circle serious issue is colossal and increments quickly with the issue size, i.e., how many circles to be scattered. Since these serious issues are NP-finished, heuristic solicitation techniques are utilised. The strength of developmental calculations lies in the capacity to look through gigantic and complex arrangement spaces in a purposeful and convincing manner. Developmental pursuit strategies are not reliant upon a specific issue plan and award the client to incorporate various methods for the encoding of the genotype. The presentation of the pursuit cycle is unequivocally connected with the portrayal of the circle's serious issue. The specific part of our unprecedented assessment made for the circle's serious issue is their two-stage approach. ECPP is used to look at and control the arrangement space, and a resulting methodology is used to assess the plans. The genotype should be fixed to look at the quality and reachability of the crushing course of action: the complete as a matter of fact. The technique on the game plan as opposed to an encoded information structure raises different issues, like move past.

Covering blueprints are invalid plans and should be settled by pardoning, amending, or immediately persevering through them. Dismissal consumes huge calculation time and may accomplish less thick designs for fundamentally unequal radii, since the humblest change ready or turn could incite invalid game plans, which will not ever from here onward add to the pursuit cycle; after the help correspondence is applied to an opportunity strategy, it accomplishes a critical game-plan. Reviewing invalid plans has every one of the reserves of being a predominant choice, since routinely minor repositioning is fundamental to get a veritable blueprint.

The certification of an invalid setup requires a discipline term in the assessment work, as alluded to in the blueprints introduced in the organisation. The discipline verbalization should be carefully organised, changing between plan compaction additionally, and moving past age. Discipline limits are a less able manual for the pursuit than a help assessment that stays away from conveying hindrance excusing plans. Precisely when the pursuit cycle works on an encoding, the crushing guidelines applied by the disentangling calculation ensure that all plans considered in the pursuit coordinated effort are huge. There has been a lot of hypothesis on whether this is significant concerning the transmission of unequivocal setup to the future and the going with state close by, freely. We have not had the decision to track down a respectable response to this issue in the synthesis. The different arrangement approaches have not been separated from one another. Since a lot of their show emphatically relies on radii and the number of circles related concerning the significance of the goal work, it isn't adequate to censure their show simply considering benchmarks accomplished.

This features the need for reviewing thickness for the general assessment of the courses of action introduced in this paper. The mathematical outcomes show the way that all strategies can find satisfactory plans and their introductions will be particularly close to tolerating the Delaunay triangulation fix. We can likewise see that differential improvement performs better standing out from the accompanying three metaheuristics when a shock based fix is applied and acquired assessments perform better when a Delaunay triangulation-based fix is applied. Our revelations surely show that ES and PSO give the most beyond preposterous dreadfully unpleasant consequences of the four metaheuristics with the two fix instruments on the vast majority of the issue cases. GA and DE came by additional created results, utilising both of the help parts. Once in a while, the revolution based fix gives us further created results than the DT-based fix. This happens especially considering the way that the approach of the most well known strategy isn't shaped by trios of circles redirection to one another. At any rate, overall terms, the presentation of DT-based fix is better, unequivocally given that this help cycle controls the circles to be deviation with unquestionably two unmistakable circles. Sensibly, a flavour assessment moulded with the two fix instrument could give us further created results than those got with every heuristic openly, unequivocally in the event that we apply the shock based fix followed by the DT-based fix.

At last, the last arrangement of assessments shows the way that ECPP can oversee issue cases with circles of various sizes, as genuinely concerning the unit circle models. This outcome was average, since the game-plan was organised with no size related essential. ECPP was separated and the outcomes flowed at MathRec. Those results address the cutting edge in managing that particular issue occasion, and no single calculation offers the best reaction for all issue sizes. Broadly more, not all people gave manages any results in regards to all issueSM

Noteworthy assessment approaches occasions. If all else fails, calculations are best at a particular arrangement or at most at a degree of them. Also, none of the game-plans introduced in the MathRec challenge depended after pivotal assessment; to the creators' information, ECPP is the head undertaking to deal with CPP utilising metaheuristics of this sort. Future work will zero in on the pressing of polygons on square shapes and strips. Up to this point, we have not found any historic calculation based answer for the CPP that had been actually appropriated;

An Improved Artificial Fish Swarm Algorithm and Its Application to Packing and Layout Problems

Conceptual: Pressing and format issues have a place with NP-Complete issues hypothetically and they happen widely in many designing fields by and by. Fake fish swarm calculation (AFSA) is a recently proposed promising multitude insightful enhancement calculation.

Consequently we endeavour to apply this unique shrewd estimation to dealing with squeezing and configuration issues. Be that as it may, there really exist a couple of deformations of this estimation itself, for instance, low association rate and exactness, inopportune as well as lamentable limit of changing misleading and examination. To overcome them, a predominant equivalent flexible hybrid phoney fish swarm computation (PAHAFSA) is proposed. This computation isolates the whole people into two subpopulations (social events) with a comparable size, and different flexible frameworks are applied to the two get-togethers independently to make one get-together revolve around overall request while the other on neighbouring pursuit. The two subpopulations create independently and individual developments are coordinated every time to achieve information correspondence, increase the general population assortment and further foster mix speed of proposed estimation.

Exactly when the information on the delivery load up doesn't change for a particular times, the crossbreed procedure considering imitated reinforcing system will be familiar with help the computation escape from neighbourhood optima and accelerate blend rate. An occurrence of squeezing and arrangement issues shows that PAHAFSA is conceivable and effective.

Unique Counterfeit Fish Multitude Calculation

Expecting in a D-layered search space, there exist a general population with N fake fishes. The state of a fake fish can be tended to by vector

D x , x , , X 1 2 ,

where xi (i=1,2,… ,D) is the I-th smoothing out factor. The

food gathering of the fake fish position is imparted

as Y=f (X), in which Y is the health work regard. The

distance between two phoney fishes is depicted as

dij Xi X j . Visual is known as the visual degree of a fake fish, Step is the best moving step, the undertaking number in preying conduct is Trynum, and ¡ is amassing factor. By virtue of getting overall most outrageous worth, the approaches to acting of interesting AFSA can be depicted as follows.

Moving Repetitive Sensors in Haphazardly

Sent Remote Sensor Organisations

—In a Remote Sensor Organisation (WSN), issues like overabundance centre points and replicated data coming about in light of conveying centres inside each other's distinguishing district are at this point very challenging for unpredictable association procedure. This paper looks at the issue of recognizing and moving tedious centres in a WSN where sensors are following events. Introductory, a planned bipartite association, which contains two kinds of vertices - centre points and perceived events, and edges getting centre points along with events, is created from rough material data to recognize overabundance centre points. Then, these overabundance centre points are either moved or set into rest mode using a circle squeezing procedure to update incorporation while restricting energy use during relocation. Generation results exhibit the way that the proposed computation can perceive generally 10% monotonous centres while separating 98% events unequivocally. Our proposed dreary centre ID computation has runtime multifaceted nature of O(U) + O(E), where U is the amount of sensors and E is irrefutably the quantity of edges, the computation is in like manner prepared to augment efficiency in back-end data dealing with by diminishing around 20% duplicate data. Results similarly showed that, our abundance centre relocation strategy further creates incorporation and energy viability of the association.

List Terms — Remote Sensor Organisation, bipartite association sensor plan

We centre around the issue of excess focus accomplished by irregular affiliation strategy in a WSN. Copy information made because of covering in sensors' distinguishing thought has moreover been tended to. We propose a calculation which use network hypothesis to foster an arranged bipartite affiliation

from sensors' course and unpleasant material information to track down drawn-out focuses. Through diversion results we showed that the proposed calculation truly perceives repetitive focus and takes out copy information to progress quickly back-end managing. Here WSN is considered to sort out areas of rectangular space by GA.

Dull focuses could choose to move or go into rest mode considering encompassing affiliation conditions. Furthermore, we showed the way that including excess focuses in a convincing manner can remarkably moreover cultivate association thought. Later on, we ought to relax our reaction to use rest strategies for repetitive focus proficiently and develop affiliation hypotheses to set up models to concentrate regarding deterministic arrangement models.

Chapter 3. METHODOLOGY

Here the number of circles can change population size so just by changing the variations of circle results will differ as we need to get the minimal distance. We can vary circles and population with alternate sizes. IF to change the number of rounds we have to change the number of rounds like 500 if done with 550 ,there will be 50 extra rounds. That's how the round will be iterated.

The above problem statement is solved by an evolutionary algorithm preferably Genetic Algorithm.
And the variables to change population_size circle.

3.1 Pseudocode

WSN are placed by the sensor networks so that every coverage area can be chosen as circles. Now, we have to place and take the circle with more combinations such that one combination of all circles are considered as genes. The circles are placed in a rectangular area so that we get the minimal distance between the placement of circles. So to get the minimal distance of circles we need best fitness values. The notations are already mentioned. Population sorting with graphs is done for 3 cases - random, GP and Fibonnaci. Here we have to first find the procedure distance computer (c1, c2) by distance formulae. Every circle is represented by x,y,r. Then comes the procedure fitness score to get proper summation of chromosome sets. Then comes the procedure of mutation where both displacement of x,y occurs during movement of circle C1 and C2 . Then to check the variable radial property we have to check all the possible pairs . Now we have to compute the distance between circles to check if circles are overlapping or not. Now we have a procedure to validate the Boundary conditions. Also the size of the population are tunable parameters.

Now, comes the minimisation of radius via random , gp and fibonacci in a rectangular graph. Then comes the procedure of crossover mutation where we have 2 parents Parent 1 and Parent 2 along with circles C1 and C2. So, to initialise 2 empty networks to store the new configuration. Then occurs the swap of half of the chromosomes.
Now for each 2 circles have to check if the circles are not overlapping and are within the boundary. Then if validated evaluate the fitness score and then add to the population set . Now comes the main procedure where there are n number of rounds with Cs^m as mutated set of chromosome and Cs^c as crossover set of

chromosomes .After CS gets sorted by fitness score and with best configuration its get plotted in graph for three cases randomly , Geometric Progression and Fibonnaci series.

MEANING OF ALL SYMBOLS AND ARRAYS BEFORE PSEUDOCODE -

NOTATIONS -

- n^Circ - number of circles in chromosome
- n^Pop - no. of chromosomes in population
- n^Rounds - no. of iterations for algorithm
- CS^m - mutated population
- CS^c - crossover population
- CS - set of all chromosomes/ population
- C1 - circle network 1 (a chromosome)
- C2 - circle network 2 (a chromosome)
- C - centre of the circle

The Pseudocode is broken down as procedures and is as follows:

PROCEDURE DISTANCE COMPUTE (C1 , C2)

```
D = sqrt {(c1[0] - c2[0] )*(c1[0] - c2[0] + (c1[1]-c2[1])*(c1) -  (c2)}
            // comment - every circle represented as (x,y,r) //
Return D
```

PROCEDURE FITNESS SCORE CHROMOSOME SET (ChS)

```
 For i = 1 TO n^C / N ^  C  = no.of chromosomes
        Sum = 0
        For Ci to 1 to N^circ  :
                forCj to 1 to N ^ circ :
                        If Ci == Cj : skip
                        Sum = sum + Distance compute(Ci , Cj)
        Chs [i][-1] = sum
Return Chs
```

PROCEDURE move centreY(C) / C:Circle/

```
Y1 radius = c[1],c[2]
If (y - radius)< 0
        Y =   y + Radius
If (y + radius) >limitY:
```

```
        Y = y - radius
Else
        N = random. int(1, 7 )
        Y = y + (-1 ^ n) *0.5*radius
Return y
```

PROCEDURE MOVE CENTRE X(C):

```
X , radius = C[0],,C[2]
If (x- radius)<0 :
        X = x + radius
if( y + radius)>limit x:
        X = x - radius
Return x
```

Procedure Mutate (C1 , C2):

```
FOR I IN 1 TO N^circle:
        C1[I].X =MOVE CENTER X (C1)
        C1[I].Y =MOVE CENTER Y (C1)   //circle1 centre moves//  { x , y
        displacement}

        C2[I].X = MOVE CENTREX(C2)
        C2[I].Y = MOVE CENTRE Y (C2)  //circle2 centre moves//
Return C1,C2
```

PROCEDURE VALIDATE RADIAL PROPERTY (C) :

```
Invalid flag = false
For i from1 to n^C:
        For j in (i+1,n^C):                                   //{all possible pairs}//
                circle dist  = distance compute  (c[i],c[j])
                If circle dist <c[i].radius                   //compute distance between
                circles//
                        Or
                Circledist <c[j].radius:
                        Invalid = true      //check that circles are not overlapping//
                        break
Return invalid flag
```

PROCEDURE VALIDATE BOUNDARY CONDITIONS (C)

```
Valid flag = true
For i=1 to  n^ C  :
```

```
        If c[i.]x ϵ [0 , X-MAX] Or c[i].Y ϵ (O , Y-max)
        Valid flag = false
Return valid flag



Procedure initial random pop (n^pop)      /n^pop =size .of population/
Cs ← {}
For i = 1 to  n^pop :
        Network c = []
        For j = 1 to n^circle
                r = random (1, n ^circ+1)
                X = random(r+1 , xmax-r-1 )          /radius minimization/
                Y  = random(r+1  , y-max-1)
                Network ← Network U (x,y,r)

        #fibonacci ,  gp series//
                If type = random:
                        Radius = (1,n^circ+1)

                If type = fibonacci
                        Radius = Phi^n - (-Phi)^n /sqrt 5   (discrete)   //fibonacci
                If type = gp:
                        R = bc^n
        If validate Boundary condition (network) And validate radial property(Network)
                CS  ← CS U network

Return CS
```

<u>PROCEDURE CROSSOVER (CS)</u>

```
For I = 1  to n^pop / 2   //p1 &p2//
        for j =  n^pop / 2 +1 to n^pop

        P1[ ] = CS[I]             /PARENT1//
        P2[ ] = CS[j            //parent 2//

        C1 =[ ]
        C2 = [ ]   //INITIALISE 2 empty networks to store new configuration//

        For k = 1 to n^circ/2 :
                C1'- C1 + P1[K]   /Parent1 , centre//
                C2 -  C2 + P2[K]    //PARENT 2//
```

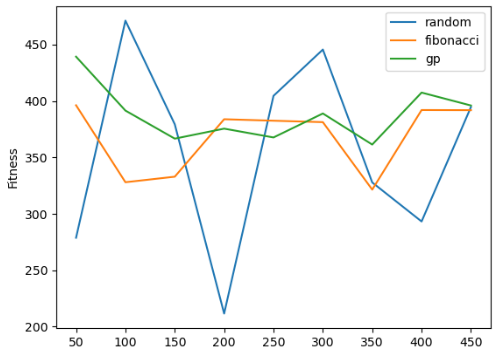
```
For k = n^circ/2 to n^circ

        C1 – C1 + P2[K]          //Swap the last half of chromosome//
        C2 – C2 + P1[K]

If validate rapid property(C1)
And validate boundary condition(C1)
C1 [SCORE) = FITNESS SCORE (C1)
CS — CS U {C1}                          //FOR EACH of circles check if not
over
If variable radial propertycondition  (C2 )          #lap& are in boundary,if
validated #evaluate fitness score, then add to population set//
&
Validate boundary condition  (C2)
        C2.SCORE = FITNESS SCORE  (C2)
        C2.SCORE = FITNESS SCORE  (C2)
        CS — CS U{C2}
```

MAIN PROCEDURE

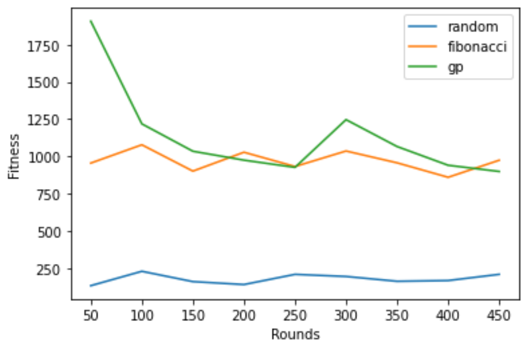
```
CS Int Rand Pop { (type - random / fibonacci  , gp)
   N pop / no.of chromosomes
        Ncirc  // no.of circles
        n^round}

Best config,=. {}
For round = 1 to n ^rounds :
        CS^m  – mutate(CS)  //  mutated set of chromes
        CS^c   —-n crossover( CS)  //crossover ser of chromosomes
        CS  —- CS U CS^m U CS^C
        Sort CS by fitness score   (reverse order)
        Cs  – CS[  1 : N ^pop ]    //SELECT BY n pop  // select n ^pop chromosomes//
        If CS[0].score (best config)
                Best config = CS[0]

Return best config
```

Chapter 4. RESULTS

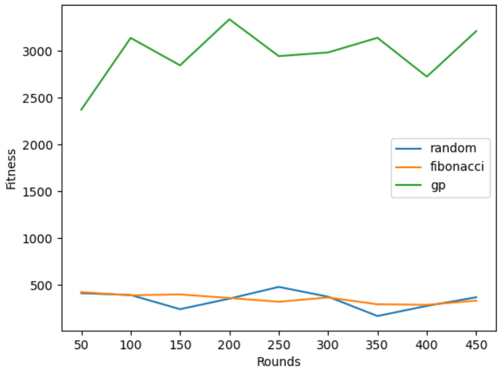
We perform experiments on the system to understand the dynamics of the sensor configuration space. First we vary the radius fixing the population at 60, number of networks = 8 and increase the number of rounds from 50 to 450. To understand the effect of the radius in the genetic optimization, in case A we find that keeping the radius between 4, 13 for all the three modes of initialization, the random initialization achieves a potentially lower intra-circle distance. In the second study B, we observe the effect of radius enlargement by multiplying the fibonacci and geometric progression radii with a factor of 2. We observe there is not much difference between fibonacci initialization against geometric methods. However we note that the fitness value has jumped by 4 times. In case C, the radius of the geometric series is multiplied by a factor of 6 in comparison to the fibonacci and random as per case A. Here we observe that the fitness score is 5 times higher for the geometric series while both the random and geometric achieve similar performance. That the fitness score increases with radius is explainable since larger the circle, more distance is required to make sure neighbouring circles or sensor networks do not overlap.



CASE A



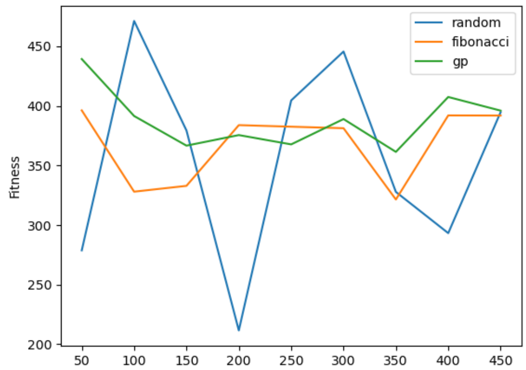
CASE B



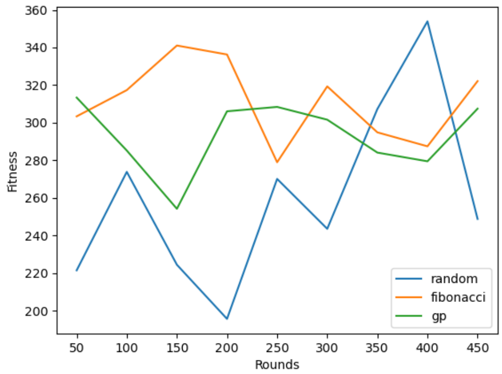
CASE C

Fig. FITNESS SCORE VARIATION AGAINST VARIABLE RADIUS

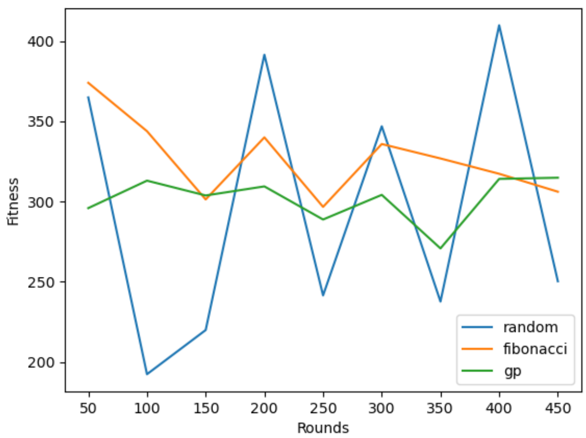
Next we observe the influence on increasing the population size keeping the rest of the parameters unchanged. We investigate in 3 cases, where cases A,B and C represent the population size of 50, 100 and 150 respectively. We observe that random diameter initialization yields the lowest score of around 200 for all three cases-. On increasing the number of chromosomes, we see that geometric progression performs better than fibonacci for case B and C.



CASE A (50 chromosomes)



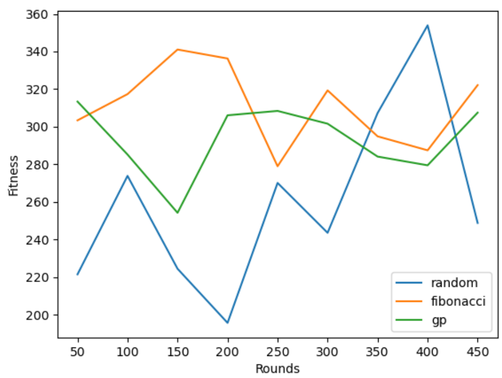
CASE B(100 chromosomes)



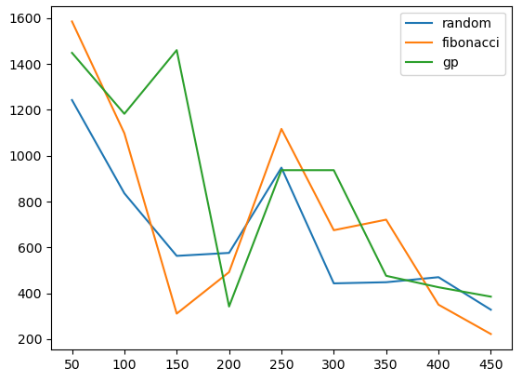
CASE C (150 chromosomes)

Fig. FITNESS SCORE VARIATION AGAINST POPULATION SIZE

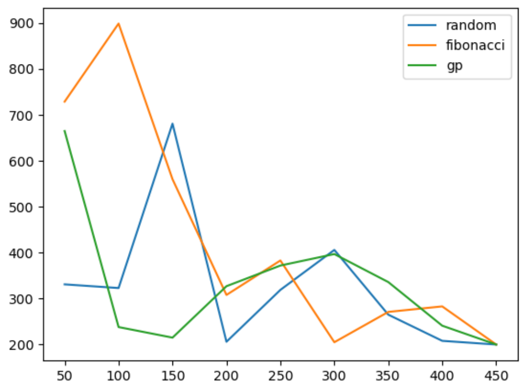
Next we observe the influence on increasing the number of circles size keeping the diameters comparable against a constant population. We investigate in 3 cases, where cases A,B and C represent the number of circles as 8, 16 and 32 respectively, keeping the population size as 100. We observe that as the number of circles increases, the fitness score becomes higher, which is intuitive since the count of pairwise distance increases. However the average circle distance value is lower for CASE C, followed by cases B and A.



CASE A: (8 circles)



CASE B: (16 circles)



CASE C (32 circles)

Fig. FITNESS SCORE VARIATION AGAINST VARIABLE CIRCLE COUNT

Chapter 4: CONCLUSION

Wireless sensor network configurations are deeply related to delivering smart applications across a city. The work investigates the question on how to distribute sensors covering a spatial area? The methodology utilises evolutionary computing techniques for exploring the space of sensor configurations under the constraint of identifying non overlapping radial surfaces. Radius initialization method embeds radius with commonly known mathematical properties.

We investigated the space of sensor configuration by varying three tunable parameters namely radius, population size and number of networks per chromosome. We observe the following behaviour of the system,

a) During radius initialization, extending a radius by a factor of k, does not imply the fitness score will be k times rather the experiments found the multiplying element is less than k.

b) Improvement towards the fitness function can be observed by increasing the number of chromosomes, which shall imply that more and more of the sensor configuration space is explored in order to achieve sub-optimality.

c) The average distance between circles decreases inversely with the increasing number of circle networks embedded in a chromosome, which shall imply that the circles are spread out more and more to cover up the entire area of space.

FUTURE WORK

Research works to recommend that the inclusion in WSNs has a significant impact in assessing the nature of such frameworks. Be that as it may, the improvement targets as far as inclusion shift contingent upon various uses of remote sensor organisations. In light of reviews on this point, the inclusion issues in WSNs can be isolated into three classes relating to at least one explicit use of WSNs, specifically, region inclusion, target inclusion, and obstruction.

The possibilities of extending the research lies in modelling the area coverage penalty which shall imply the case where there is no available Wireless Sensor Network within the vicinity. A second alternative can be modifying the radius while mutation or crossover, which is restricted to only displacing circle-centers in this version of the work.

BIBLIOGRAPHY

1. An Improved Artificial Fish Swarm Algorithm and Its Application to Packing and Layout Problems Guangqiang Li , Yawei Yang , Tinglu Zhao , Peixiang Peng, Yiran Zhou , Ying Hu , Chen Guo 1. School of Information Science and Technology, Dalian Maritime University, Dalian 116026, China 2. School of Software and Applied Technology, Zhengzhou University, Zhengzhou 450001, China E-mail: lgq@dlmu.edu.cn, yyw3816@126.com, tlzhao2013@163.com, peng94326@126.com, zyr82@sina.com, huying@dlmu.edu.cn, guoc@dlmu.edu.cn

3.Parametric Circle Approximation Using Genetic Algorithms Chapter · November 2008
4.Relocating Redundant Sensors in Randomly Deployed Wireless Sensor Networks Sakil Chowdhury, Student Member, IEEE, and Abderrahim Benslimane, Senior Member, IEEE

5.Solving maximal covering location problem using genetic algorithm with local refinement Soumen Atta · Priya Ranjan Sinha Mahapatra · Anirban Mukhopadhyay

6.Relocating Redundant Sensors in Randomly Deployed Wireless Sensor Networks Sakil Chowdhury, Student Member, IEEE, and Abderrahim Benslimane, Senior Member, IEEE

7,A Review of the Application of Meta-Heuristic Algorithms to 2D Strip Packing Problems E. HOPPER and B. C. H. TURTON Cardiff University, School of Engineering, PO Box 689, Cardiff CF24 3TF, UK E-mail: HopperE@gmx.net

8. EDTD-SC: An IoT Sensor Deployment Strategy for Smart Cities
by Ibtihal Alablani [1,2] andMohammed Alenazi [1,*]

[1] Department of Computer Engineering, CCIS, King Saud University, Riyadh 11451, Saudi Arabia , Department of Information Technology, Technical College, Technical and Vocational Training Corporation, Riyadh 11451, Saudi Arabia