|  |  |
| --- | --- |
|  | |
|  | |
| A project report on | |
|  | |
| **“****Social Group Optimization Based Cluster Head Identification In Underwater Acoustic Sensor Networks”** | |
|  | |
| Submitted in partial fulfillment of the requirements for the Degree of | |
|  | |
| B. Tech in Computer Science and Engineering | |
|  | |
| by | |
|  | |
| **Trilok Bhattacharya (1705281)**  **Pratul Patel (1728233)** | |
|  | |
| under the guidance of | |
|  | |
| **Miss Junali Jasmine Jena** | |
|  | |
| School of Computer Engineering | |
| Kalinga Institute of Industrial Technology  Deemed to be University  Bhubaneswar | |
|  | |
| March 2021 | |
|  | |
| **CERTIFICATE**  This is to certify that the project report entitled **“Social Group Optimization Based Cluster Head Identification In Underwater Acoustic Sensor Networks”** submitted by   |  |  | | --- | --- | | **Trilok Bhattacharya**  **Pratul Patel** | **1705281**  **1728233** |   in partial fulfillment of the requirements for the award of the **Degree of Bachelor of Technology** in **Computer Science and Engineering** is a bona fide record of the work carried out under my(our) guidance and supervision at School of Computer Engineering, Kalinga Institute of Industrial Technology, Deemed to be University. | |
| Signature of Supervisor  Miss Junali Jasmine Jena  Associate Professor  KIIT Deemed To Be University |
| ................................................................................................................................................ | |
| **The Project was evaluated by us on 15/11/2020** | |
|  | |

**ACKNOWLEDGEMENTS**

|  |
| --- |
|  |
| We are profoundly grateful to Ms. Junali Jasmine Jena for her expert guidance and constant support throughout, without which the completion of this project would not have been possible. Her continuous encouragement has helped us in completing the project in the provided tie.  We are also grateful to the FIC(Project), the Program Head, and the Dean of the School for the opportunity to present this project, and provide us with all the requirements for the successful completion of the project. |
| **Trilok Bhattacharya - 1705281**  **Pratul Patel - 1728233** |

**ABSTRACT**

|  |
| --- |
| Due to the advancements in ocean monitoring and underwater exploration, it has become increasingly important to incorporate a method of underwater sensor network that would be cost effective and energy efficient, reducing maintenance efforts and increasing longevity. Underwater Sensor Network applications based on acoustic, optical and RF communication are gaining popularity, especially acoustic communication in this area for applications such as offshore oil and gas extraction, military surveillance, mine detection, tsunami, and hurricane forecasts to name a few.  One of the simpler architectural implementations of the sensor network is the 2D – Underwater Sensor Network, where a group of sensor networks are anchored underwater to the surface, with a cluster head nominated for communication within the cluster nodes and the surface buoyant nodes.  There exist certain optimization algorithms that address the problem of optimal cluster head selection to minimize resources consumed and increase the lifespan of the cluster. One such technique that we use in our research is Social Group Optimization (SGO). It is based on the human behavior of learning and solving complex problems. This report uses this SGO technique to choose the cluster head among a set of clusters, in which no of solutions are taken and calculated to yield a robust solution where the sacrifices of time and complexity are minimized. |

TABLE OF CONTENTS

|  |  |  |  |
| --- | --- | --- | --- |
|  | Page No | | |
| Abstract | | : | 1 |
| Table of Contents | | : | 2 |
| List of Figures | | : | 3 |
| List of Tables | | : | 4 |
|  | |  |  |
| CHAPTER 1: INTRODUCTION | | : | 5 |
|  | |  |  |
| CHAPTER 2: BACKGROUND/BASIC CONCEPTS | | : | 6 |
| * 1. PSO-Routing   2. Social Group Optimization      1. Improving Phase      2. Acquiring Phase | | :  :  :  : | 6  7  8  8 |
|  | |  |  |
| CHAPTER 3: PROJECT ANALYSIS/ PROJECT IMPLEMENTATION | | : | 10 |
|  | |  |  |
| CHAPTER 4: RESULTS AND DISCUSSION | | : | 14 |
|  | |  |  |
| CHAPTER 5: CONCLUSION & FURTHER WORK | | : | 15 |
|  |  |  |  |
| REFERENCES |  | : | 18 |

LIST OF FIGURES

|  |  |  |
| --- | --- | --- |
| **Figure ID** | **Figure Title** | **Page** |

LIST OF TABLES

|  |  |  |
| --- | --- | --- |
| **Table ID** | **Table Title** | **Page** |
|  |  |  |
|  |  |  |
|  |  |  |
|  |  |  |
|  |  |  |

**CHAPTER 1**

**INTRODUCTION**

This report focusses on finding an optimal solution of determining the cluster head (also called as anchor node) from a group of sensor nodes that are deployed underwater for monitoring and exploration purposed.

The member nodes in the network are divided into multiple clusters and an anchor node is nominated from each cluster, which acts as the cluster head. This node is responsible for communication in two dimensions – one, with each member of the cluster, which is the horizontal communication, and second, with the buoyant nodes on the surface, which is the vertical communication.

We try to achieve this by using the Social Group Optimization (SGO) algorithm, which is a population-based optimization technique, inspired by the concept of social behavior of humans toward solving a complex problem, to find the optimal anchor node.

To successfully implement it, we first take a underwater network of sensors, and divide the nodes into clusters by using K-Means clustering. Then we begin analyzing every node from each cluster to find the optimal cluster node according to the suitable energy consumption and distance factor.

This report first presents the overview of the 2D-UWSN (Underwater Sensor Network), and then goes on to explain the SGO algorithm in brief, along with its implementation for this problem, taking the example of a randomized underwater sensor network data, concluding it with the experimentation analytics and future work potential.

**Keywords:** Optimization, Path planning, population-based algorithm, Sensor Network

**CHAPTER 2**

**BACKGROUND**

In this implementation, we will first discuss about the Underwater Sensor Network Architecture on a 2-dimensional plane. Then, we will explore the scope of Social Group Optimization to find the cluster head, or anchor node, on the UWSN architecture.

One cluster head is nominated for each cluster, from a group of clusters that are estimated by using K-Means clustering scheme on a random set of points on a 2D plane resembling a underwater bed of sensors for the purpose of establishing a working model for the algorithm.

**2D – UWSN Architecture [1]**

The 2D-UWSN architecture refers to a network where a group of sensor nodes are deployed under the water, stationary to the surface. Each cluster has a cluster head, and they are anchored to the surface of the waterbed. The member nodes of the cluster gather the underwater data and communicates with the anchor node. The anchor node gathers the information from all the member nodes and relays it to the surface buoyant nodes.

In this method, the communication is carried in two dimensions – (i) each member of the cluster communicates with its anchor node with horizontal communication link while (ii) the anchor node communicates with the surface buoyant node with vertical communication link.

In 2D-UWSN, different communication media can be used, such as acoustic, optical, and RF communication, depending upon the type of application and nature of underwater environment.

For the cluster nodes, the network arrangement can be star, mesh, or ring depending on the application requirement.

The 2D-UWSN can be used for both time-critical and delay tolerant applications.

**Social Group Optimization [2]**

The population-based optimizations motivated commonly from nature locate near optimal solution to optimization problems where every population-based algorithm has the common characteristics of finding out global solution of the problem.

It begins with an initial an initial solution and gradually builds towards a better solution area of search space based on the information of their fitness.

In SGO, each candidate is empowered with some sort of knowledge having a level of capacity for solving the problem. For SGO, the population is considered as the group of persons, where each person acquires knowledge and thereby possesses some level of capacity to solve the problem. The best candidate, corresponding to the best fitness propagates this knowledge among all the candidates which in turn will improve the knowledge level of the entire members of the group.

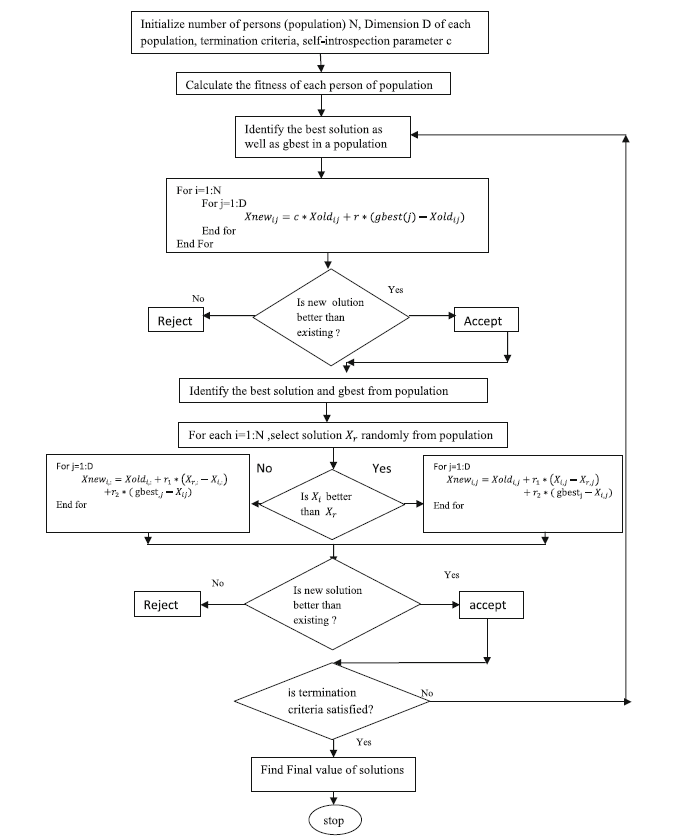
The procedure of SGO is divided into two phases:

**Improving Phase**

In this phase, the knowledge level of each person in the group is enhanced with the influence of the best person in the group, having the highest knowledge and capacity to solve the problem in hand.

**Acquiring Phase**

In this phase, each person enhances their knowledge with the mutual interaction with another person in the group and the best person in the group at that point in time.



Algorithm 1: SGO Algorithm

We try to solve the problem of selecting a cluster head from N number of clusters chosen by applying elbow method on K-Means, on a randomized underwater sensor network data, and make use of the above two algorithms to optimize the solution based on the user’s choice of iteration, steps of which is explained in the next section.

**CHAPTER 4**

**LITERATURE REVIEW**

|  |  |  |  |
| --- | --- | --- | --- |
| **Citation** | **Abstract** | **Introduction** | **Conclusion** |
| **Krishnaswamy, V., Manvi**  Wireless Pers Commun 108, 1529–1546 (2019). https://doi.org/10.1007/s11277-019-06483-y  *S.S. Fuzzy and PSO Based Clustering Scheme in Underwater Acoustic Sensor Networks Using Energy and Distance Parameters.* | Pocuses on proposing a novel method for cluster selection using Fuzzy Clustering and Particle Swarm Optimization.  The process is divided into multiple steps and can be broken down into the following –  Cluster formation using Fuzzy Clustering algorithm, Finding the number of clusters, Fitness function of the cluster is analyzed and Cluster head nodes are determined | The research done by the authors of this paper provide valuable information about the domain in question, with the extensive study on the parameters in question form the base of our study in implementing Social Group Optimization for cluster head selection.  The energy consumption model of the cluster nodes to depend on the following two factors –   1. Sensing, receiving, and processing data. 2. Forwarding the aggregated data to the base stations. | The proposed algorithm, when compared with algorithms such as LEACH and KBPSO, show a significant decrease in death rate of the nodes thereby prolonging the lifespan of the cluster network. |
| Nagireddy, V., Parwekar, P. & Mishra, T.K.  *Velocity adaptation based PSO for localization in wireless sensor networks.* | The work done by the authors of this research paper focus on the localization problem of determining the exact location of cluster nodes in a particular area by taking the location of cluster heads as reference. Position information of sensor node in an area is useful for routing techniques and some application specific tasks. | The paper proposed by the authors present an objective function for localization with a modified PSO with respect to velocity. Here, PSO is applied to mitigate the localization problem. | The proposed method aims to reduce the localization error in locating a particular sensor which helps in identifying the location of randomly deployed sensors. |
| **Al‐Baz, A, El‐Sayed, A.**  Int J Commun Syst. 2018; 31:e3407. https://doi.org/10.1002/dac.3407  *A new algorithm for cluster head selection in LEACH protocol for wireless sensor networks* | The work of these authors, in this paper, focuses on a hierarchical routing protocol which is depending on LEACH protocol to enhance its performance and increase the lifetime of the wireless sensor network. The paper proposes an enhanced algorithm, known as Node Ranked – LEACH which increases the total lifetime based on node rank algorithm. | Node rank depends on both, path cost and number of links between nodes, to select the anchor node. This enhancement reflects the real weight of specific nodes to success, and it can represent as the anchor node. | The novel method discussed in this paper enhances the performance of LEACH protocol by distributing the energy load among the sensor nodes when electing the anchor node. The proposed algorithm overcomes the random process selection, which leads to unexpected failures for some anchor nodes as in the other LEACH versions. |
| **Kaur, Sunpreet & Bhardwaj, Vinay. (2016).**  International Journal of Computer Applications. 145. 43-47. 10.5120/ijca2016910606.  *Energy Efficient K-Means Clustering Technique for Underwater Wireless Sensor Network* | In this paper, the authors have suggested the use of multi-hop communication in underwater acoustic networks. They have developed the novel Multi-Hop K-Means clustering technique to increase the performance in energy constrained network. |  | The novel algorithm proposed by the authors has three phases –   1. Cluster formation 2. Cluster head selection 3. Data transmission phase   In cluster formation phase, they have used K-Means Clustering method to form clusters.  In the cluster head phase, clusters area is selected randomly according to distance.  In data transmission phase, data is transmitting to base station. In this phase, the concept of two gateway nodes is added to facilitate transmission.  Most of the algorithms present deal with sensor nodes dispersed in 2D plane. This paper has extended few 2D geometrical topologies to 3D. |
| Hassan, Ali & Md Shah, Wahidah & Othman, Mohd Fairuz Iskandar & Hassan, Hayder. (2020).  International Journal of Electrical and Computer Engineering (IJECE). 10. 1515. 10.11591/ijece.v10i2.pp1515-1523.  Evaluate the performance of K-Means and the fuzzy C-Means algorithms to formation balanced clusters in wireless sensor networks | This recent paper discusses the efficiency of the two main algorithms for cluster formation – Fuzzy C-means (FCM) and K-Means (KM) in terms of balanced cluster formation. | Due to the random manner of node distribution, on certain occasion, forces the algorithms to form unbalanced clusters. The authors have investigated the performance of KM and FCM and which of them has better ability to construct balanced clusters to enable to choose the appropriate algorithm for sensor network formation.  The authors have simulated several scenarios based on three measured parameters, which are –   1. variation between cluster size 2. standard deviation for MSE for intra-distances 3. the ratio between minimum cluster size and maximum cluster size in the network.   The evaluation was based on six scenarios, with each scenario having 50 different observation of nodes and the nodes in each observation have been divided into five clusters. | Based on the result, FCM has better performance than KM to formation of a balanced cluster’s size based on the parameters with the random distribution manner. When the number of nodes distributed is increasing along with the increase in the monitoring area, the performance of FCM is still relatively stable compared to KM, where the performance of KM decreases.  Although FCM is superior to KM, it still suffers from the effect of the random nodes deployment condition where sometimes, it forms imbalanced clusters. |
| Satapathy, Suresh & Naik, Anima. (2016)  Complex & Intelligent Systems. 2. 10.1007/s40747-016-0022-8.  Social group optimization (SGO): a new population evolutionary optimization technique | In this paper, the authors have determined the cost and physical constraints in the engineering applied problems obligate finding the best results that global optimization algorithms cannot realize. For accurate and faster optimization, switching between known multiple local/global solutions is necessary. | The current work proposed a social group optimization (SGO) for solving multimodal functions as well as data clustering problems. For solving global optimization problems, the SGO inspired by the social behaviour of human toward solving a complex problem was applied. The SGO is a population-based optimization algorithm using solution population to reach global solution. The simulation results compared its performance with eight particle swarm optimizer variants. The results demonstrated good performance of the SGO.  This consists of two phases which is improving and acquiring phase. In this paper, the performance of SGO is compared with many classical population-based optimization techniques as well as their advanced variants using some basic benchmark functions and 25 test functions proposed in the CEC2005 special session on real-parameter optimization. Performance comparisons are made with state-of-the-art optimization techniques like GA, PSO, DE, ABC and its variants and the recently developed TLBO. Different variants of the popular evolutionary optimization techniques are also taken into consideration for comparing them with SGO. | The experimental results show that the proposed social group optimization outperforms all investigated optimization techniques in computational costs and also provides optimal solutions for most of the considered functions. One of the best things in this algorithm is that it is easier to understand and to implement in comparison to other algorithms and their variants. |
| K. A. Abdul Nazeer, M. P. Sebastian  Improving the Accuracy and Efficiency of the k-means Clustering Algorithm | Conventional database querying methods are inadequate to extract useful information from huge data banks. Cluster analysis is one of the major data analysis methods and the k-means clustering algorithm is widely used for many practical applications. But these are quite expensive and quality depends on selection of centroids. This paper proposes a method for making the algorithm more effective and efficient, so as to get better clustering with reduced complexity. | According to these paper, the major drawback of the k-means algorithm is about selecting of initial centroids which produces different clusters. But final cluster quality in algorithm depends on the selection of initial centroids. Two phases includes in original k means algorithm: first for determining initial centroids and second for assigning data points to the nearest clusters and then recalculating the clustering mean. But this enhanced clustering method uses both the phases of the original k-means algorithm. This algorithm combines a systematic method for finding initial centroids and an efficient way for assigning data points to clusters. But still there is a limitation in this enhanced algorithm that is the value of k, the number of desired clusters, is still required to be given as an input, regardless of the distribution of the data points. |  |
| Soumi Ghosh, Sanjay Kumar Dubey  Comparative Analysis of K-Means and Fuzzy C-Means Algorithms | proposed a comparative discussion of two clustering algorithms namely centroid based K-Means and representative object based Fuzzy C-Means clustering algorithms.  This discussion is on the basis of performance evaluation of the efficiency of clustering output by applying these algorithms. |  | The result of this comparative study is that FCM produces closer result to the K-means but still computation time is more than k-means due to involvement of the fuzzy measure calculations |
| M Sakthi, AS Thanamani  An Enhanced K Means Clustering using Improved Hopfield Artificial Neural Network and Genetic Algorithm | proposed that due to the increment in the amount of data across the world, analysis of the data turns out to be very difficult task. To understand and learn the data, classify those data into remarkable collection. So, there is a need of data mining techniques. |  |  |
| R. Amutha  Different Data Mining Techniques and Clustering Algorithms | proposed that when two or more algorithms of same category of clustering technique is used then best results will be acquired. | Two k-means algorithms:   * Parallel k/h-Means Clustering for Large Data Sets * A Novel K-Means Based Clustering Algorithm for High Dimensional Data Sets.   Parallel k-Means algorithm is designed to deal with very large data sets. | Novel K-Means Based Clustering provides the advantages of using both HC and K-Means. Using these two algorithms, space and similarity between the data sets present each nodes is extended |
| N Singh, D Singh  Performance Evaluation of K-Means and Heirarichal Clustering in Terms of Accuracy and Running Time | proposed the comparative analysis of one partition clustering algorithm (k means) and one hierarchical clustering algorithm (agglomerative).On the basis of accuracy and running time the performance of k-means and hierarchical clustering algorithm is calculated using WEKA tools. |  | This work results that accuracy of k-means is higher than the hierarchical clustering for iris dataset which have real attributes and accuracy of hierarchal clustering is higher than the k-means for diabetes dataset which have integer, real attribute. So for large datasets k means algorithm is good. |
| Shi Na, Liu Xumin, Guan Yong  Research on K-means Clustering Algorithm: An Improved K-means Clustering Algorithm | Proposed the analysis of shortcomings of the standard k-means algorithm. As k-means algorithm has to calculate the distance between each data object and all cluster centers in each iteration. This repetitive process affects the efficiency of clustering algorithm. |  |  |
| Cui, Xiaoli, and Zhu, Pingfei and Yang, Xin and Li, Keqiu and Ji, Changqing  Optimized big data K-means clustering using MapReduce | Variety is an important feature in big data so using sampling techniques is questionable when applied to huge data sets in maintaining the quality of clustering | proposed optimized big data K-Means using Map-Reduce in which they claimed to counter the iteration dependence of Map-Reduce jobs. They used a sequence of three Map-Reduce (MR) jobs. | in their approach sampling technique is used in the first M-R job and in the final M-R Job the data set is mapped to centroids using the Voronoi diagram. |
| Yan, W.Brahmakshatriya, U.Xue, Y.Glider  p - PIC:Parallel power iteration clustering for big data |  | According to this report an MPI based spectral clustering algorithm, which uses POSIX threads at individual node. However, MPI itself does not address the problem of node failure and the programmer has to explicitly take care about the data partitioning and distribution among the nodes. The memory is shared which is bottleneck in some cases. |  |
| Mitsuo GEN, Yasuhiro Tsujimura, Erika Kubota  Solving Job-Shop Scheduling Problems by Genetic Algorithm | In this paper, a new method for solving JSP using Genetic Algorithm (GA) and demonstrate its efficiency by the standard benchmark of job-shop scheduling problems |  | In this paper, a new approach is proposed for solving Job-shop Scheduling Problem (JSP). As the hardest combinational problems and its resolution with conventional method, as branch-and-bound method, it spent a computational time relatively.  In this paper, some modifications have been performed with a Genetic Algorithm (GA) in order to solve JSP effectively as to demonstrate that choosing suitable representation of individuals, genetic operators and parameters of evolutional system are an important step to get better results. |
| O Etiler, B Toklu , M Atak and JWilson  A genetic algorithm for flow shop scheduling problems | In this paper we develop a genetic algorithm-based heuristic for the flow shop scheduling problem with makespan as the criterion. The performance of the algorithm is compared with the established NEH algorithm. Computational experience indicates that genetic algorithms can be good techniques for flowshop scheduling problems. |  | In this paper, a new GA-based heuristic is developed for solving the flow shop scheduling problems which is easily implementable and performs quite effectively. steps include:   1. protect the best schedule which has the minimum makespan, at each generation 2. transfer this schedule to the next population with no change as it enables to choose the higher crossover and mutation probability pc = 1 (crossover probability) and pm = 0.05 (mutation probability).   Here 0.05 is used in heuristic instead of 0.01 in order to achieve good results. According to the computational results, the GA-based heuristic success rate is 76% and 78%. This means our heuristic is quite effective for flow shop scheduling problems. Also, the GA-based heuristic can be easily extended to solve flow shop problems with other criteria, such as total flow time, maximum tardiness, total tardiness, etc. |
| N Bouhmala, A Viken, JB Lonnum  Enhanced Genetic Algorithm with K-Means for the Clustering Problem |  |  |  |
| R Maghsoudi, AG Delavar  Representing the New Model for Improving K-Means Clustering Algorithm based on Genetic Algorithm |  |  |  |
| S Rana, S Jasola, R Kumar  A hybrid sequential approach for data clustering using K-Means and particle swarm optimization algorithm | Proposed a new Hybrid Sequential clustering approach. They have used PSO and K-Means algorithm in sequence for data clustering. This approach was proposed to overcome the drawbacks of both algorithms as well as improves clustering and avoids being stagnated. |  | Four kinds of data sets have been tested in order to obtain comparative results. For comparison purpose, different algorithms such as PSO, K-Means, Hybrid K-Means PSO, and Hybrid K-Means + Genetic Algorithm were considered. The proposed algorithm generates more accurate and robust clustering results. |
| BA Attea  A fuzzy multi-objective particle swarm optimization for effective data clustering |  |  |  |

**CHAPTER 4**

**PROJECT ANALYSIS/ PROJECT IMPLEMENTATION**

The method has two basic steps:

**Step-1: Selecting Clusters**

Clusters are isolated from the dataset by using K-Means clustering scheme, by selecting the value of N, optimal number of clusters, using elbow method.

# Generate some random data

N = 50

data = np.vstack(((np.random.randn(N - 25, 2) \* 0.5 + np.array([1, 0])),

                  (np.random.randn(N - 15, 2) \* 0.5 + np.array([1, 0])),

                  (np.random.randn(10, 2) \* 0.5 + np.array([1, 0]))))

The above code was used to generate a random set of 50 sensor nodes. The plane is assumed to be the underwater surface bed. The surface is assumed to be smooth without any geographical formations that would elevate the position of the sensors. It is also assumed that the sensors are stationary and do not change their locations with changing ocean currents or any natural phenomenon.

The below picture represents the dataset on a 2-dimensional plane.

Chart, scatter chart

Description automatically generated

Figure 1. Dataset

In the above dataset, K-Means clustering was applied to find out the clusters, from which cluster head would be nominated using SGO algorithm. For the use of elbow method, we have taken the upper bound to be [√N], where N is the number of nodes in consideration, and [x] represent the greatest integer less than or equal to x.

As discussed, the elbow method is used to find out the optimal number of clusters, K, by making use of a parameter known as WCSS, which stands for Within Cluster Sum of Squares. This number should be low. Here is the formula representation for WCSS -

A picture containing text

Description automatically generated

Figure 2. WCSS Formula

The resulting graph for WCSS vs number of clusters, for K = 1 to √N is showcased below:

Chart, line chart

Description automatically generated

Figure 3. Elbow Method

In our random dataset, the value of K is taken as 4, and the cluster is calculated. The clusters obtained is showcased in the Result section of this report.

From the clusters obtained from the above method, we proceed to find out the cluster head using SGO Algorithm.

**Step 2. Applying SGO Algorithm to find out identify anchor node.**

To be done.

**Step-2.1. : Enumerating the problem and initialization of the parameters**

The number of iterations were taken as an input from the user.

The population size was initialized with the number of nodes (N), along with the number of dimensions, (D) which is the same as the number of nodes.

The calculation of the next potential destination was performed by multiplying the population value for a node(candidate) with the total number of possible next nodes, which gave us the respective next hop.

(This calculation is for representation purposes only. Actual values would vary as per the candidate solution)

The fitness value for each candidate solution was calculated as the cumulative sum of the formulated value between two nodes in the path from the source to the destination. The following formula was used:

*fitness = alpha \* cost + (1-alpha) \* time*

**Step-2.2. : Improving Phase**

In this phase, the gbest (population with the lowest value of fitness) from the population and the fitness value was found out.

The information was propagated among all the candidates, i.e., the new values for a candidate were formulated by using the formula:

*for i in 0 to N-1:*

*for j in 0 to N-1:*

*Xnew(i, j) = c \* Xold(i, j) + r \* ( gbestj – Xold(i, j) )*

*end for*

*end for*

Here, c is the self-introspection factor, set to 0.2.

r is a random number between 0 and 1.

If the new solution has a better fitness than the previous solution, it is retained, else the initial solution is retained.

**Step-2.3. : Acquiring Phase**

As explained in the SGO algorithm, a candidate in the social group randomly interacts with another candidate to propagate knowledge.

Here, for each candidate in the population, we select a random candidate and share knowledge with each other using the following formula:

*if Xi if better than Xr:*

*for j in 0 to N-1:*

*Xnew(i, j) = Xold(i, j) + r1 \* ( Xold(i, j) – X(r, j) ) + r2 \* ( gbestj – Xold(i, j) )*

*end for*

*else*

*if Xr if better than Xi:*

*for j in 0 to N-1:*

*Xnew(i, j) = Xold(i, j) + r1 \* ( X(r, j) – Xold(i, j)) + r2 \* ( gbestj – Xold(i, j) )*

*end for*

Here, r1 and r2 are random numbers.

If the new solution is better than the initial solution, it is retained, else the initial solution is retained.

**Step-2.4. : Termination Criteria**

The iterations are stopped if the termination criteria are satisfied, the best path of the final solution is displayed along with the fitness value of the best solution (gbest).

**CHAPTER 4**

**RESULTS & DISCUSSIONS**

We obtain K clusters from out random dataset, which is considered to nominate nodes to identify the cluster head using SGO Algorithm.

In our example dataset, the value of K is taken as 4. The clusters obtained by applying K-Means with the value of K as 4 is –

Chart, scatter chart

Description automatically generated

Figure 4. Clusters obtained from K-Means, with K=4

**CHAPTER 5**

**CONCLUSION AND FUTURE WORK**

**5.1 Conclusion**

The implementation of the SGO algorithm to solve the path planning problem provides an optimized solution for the NP-Hard problem of path planning.

It is time effective, since the user can select the number of iterations. In a system with high computation power, it can give a highly optimized solution by running numerous numbers of iterations in minimal amount of time.

**5.2 Future Work**

The algorithm can be applied on a real-life dataset with complex paths and nodes.

The fitness function can also be optimized and chosen in such a way that the best solution is achieved in minimum number of iterations. Comparison of different fitness function using real life dataset can be marked as a future work.

The real-life data can be extracted from an existing API, the scope of which will be discussed in the future work.

**REFERENCES**

1. Murad, Mohsin & Sheikh, Adil & Manzoor, Muhammad Asif & Felemban, Emad & Qaisar, Saad. (2014). A Survey on Current Underwater Acoustic Sensor Network Applications. International Journal of Computer Theory and Engineering. 7. 51-56. 10.7763/IJCTE.2015.V7.929.
2. Satapathy, S., & Naik, A. (2016). Social group optimization (SGO): a new population evolutionary optimization technique. Complex & Intelligent Systems, 2(3), 173–203.
3. Krishnaswamy, V., Manvi, S.S. Fuzzy and PSO Based Clustering Scheme in Underwater Acoustic Sensor Networks Using Energy and Distance Parameters. Wireless Pers Commun 108, 1529–1546 (2019). <https://doi.org/10.1007/s11277-019-06483-y>
4. Nagireddy, V., Parwekar, P. & Mishra, T.K. Velocity adaptation based PSO for localization in wireless sensor networks. *Evol. Intel.* (2018). <https://doi.org/10.1007/s12065-018-0170-4>
5. Al‐Baz, A, El‐Sayed, A. A new algorithm for cluster head selection in LEACH protocol for wireless sensor networks. *Int J Commun Syst*. 2018; 31:e3407. <https://doi.org/10.1002/dac.3407>
6. Kaur, Sunpreet & Bhardwaj, Vinay. (2016). Energy Efficient K-Means Clustering Technique for Underwater Wireless Sensor Network. International Journal of Computer Applications. 145. 43-47. 10.5120/ijca2016910606.
7. Hassan, Ali & Md Shah, Wahidah & Othman, Mohd Fairuz Iskandar & Hassan, Hayder. (2020). Evaluate the performance of K-Means and the fuzzy C-Means algorithms to formation balanced clusters in wireless sensor networks. International Journal of Electrical and Computer Engineering (IJECE). 10. 1515. 10.11591/ijece.v10i2.pp1515-1523.

**“Social Group Optimization Based Cluster Head Identification In Underwater Acoustic Sensor Networks”**

TRILOK BHATTACHARYA

1705281

**Abstract:** We focus on finding an optimized solution for the cluster head selection in 2D Underwater Sensor Network. The cluster formation is achieved using K-Means clustering and the cluster head is selected using SGO Algorithm. The Social Group Optimization (SGO) is a population-based optimization technique, inspired by the concept of social behavior of humans toward solving a complex problem.

**Individual contribution and findings:**

* Code writing of the proposed algorithm implementation.
* Result consistency check.
* Used Python 3.9 to code the algorithm.
* Literature review of the related works – In reference : 2, 3, 4, 5

**Individual contribution to project report preparation:**

* Project Report formatting and proofreading.
* Attachment of results to the project report.

**Individual contribution for project presentation and demonstration:**

* Prepared the project presentation.
* Formatting and proofreading.

Full Signature of Supervisor: Full signature of the student:

……………………………. Trilok Bhattacharya