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Angular Based Cheetah Chase Algorithm For Shortest Path Optimization (ABCCA Algorithm)

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Abstract: A shortest-path algorithm finds a path containing the minimal cost between two vertices in a graph. A surfeit of shortest-path algorithms is studied in the literature that span across multiple disciplines. This paper presents a novel approach of modified Cheetah Chase Algorithm as Angular Based Cheetah Chase Algorithm (ABCCA) which is framed by angular based cheetah movements to reach the sink from the given position as source through graph theoretical approach along with shortest path optimization. Angular based movement derives from layered structure spanning tree through hunting process of Cheetah to its prey.
Keyword: Angular based movement, Cheetah Chase Algorithm, Shortest Path Optimization.

I. INTRODUCTION:

The shortest-path problem is one of the well-studied topics in computer science, specifically in graph theory. An optimal shortest-path is one with the minimum length criteria from a source to a destination. There has been a surge of research in shortest-path algorithms due to the problem's numerous and diverse applications. These applications include network routing protocols, route planning, traffic control, path finding in social networks, computer games, and transportation systems, to count a few. [1]

There are various graph types that shortest-path algorithms consider. A general graph is a mathematical object consisting of vertices and edges. A spatial graph contains vertices where their positions are not interpreted as locations in space. On the other hand, a spatial graph contains vertices that have locations through the edge's end-points. A planar graph is plotted in two dimensions with no edges crossing and with continuous edges that need not be straight.[1]

There are also various settings in which a shortest-path can be identified. For example, the graph can be static, where the vertices and the edges do not change over time. In contrast, a graph can be dynamic, where vertices and edges can be introduced, updated or deleted over time. The graph contains either directed or undirected edges. The weights over the edges can either be negative or non-negative weights. The values can be real or integer numbers. This relies on the type of problem being issued. [1]

Most short algorithms fall into two broad categories. The first category is the one-source shortest path (SSSP) with the aim of finding the shortest paths from a single-source vertex to all other vertices. The second category is All-Pairs Shortest Path (APSP), with the aim of finding the shortest paths in a graph between all pairs of vertices. The shortest path calculation can generate either accurate or approximate solutions.

The selection of the algorithm to use depends on the graph features and the application required. For example, the objective of approximate shortest path algorithms is to provide quick answers even in the presence of a large input graph. Hierarchical algorithms divide the shortest path into a linear problem of complexity. This can lead to improved computational performance by orders of magnitude. [1]

II. CHEETAH CHASE ALGORITHM (CCA):

The Cheetah is a giant and energetic civet that was once found all through Asia, Africa and certain places of Europe. Cheetahs are one of Africa's most energetic predators and are most famous for their monstrous speed when in a chase. Equipped for achieving speeds of more than 60mph for minimum span of time, Cheetah is the speediest land vertebrate on the earth [12]. The Cheetah is one of a kind among Africa's civets principally on the grounds that they are most dynamic amid the day, which keeps away from rivalry for nourishment from other substantial predators like Lions and Hyenas that chase amid the cooler night. The Cheetah has outstanding visual perception thus chases utilizing sight by first stalking its prey from between 10 to 30 meters away, and after that pursuing it when the time is correct. The light and thin body of the cheetah influences it to appropriate to short, dangerous blasts of speed, hasty acceleration, and a capability to execute extraordinary alters in course while moving at speed. These behaviours represent unique features of the cheetah's capability to capture fast moving prey. [4]

Cheetahs can start from 0 miles for per hour to 65 miles per hour in only 3.5 seconds. Cheetahs can achieve a best speed anyplace in the middle of 60 and 70 miles per hour, varies on the size of cheetah. But, the fascinating thing is that cheetahs can just run that quick for 20 to 30 seconds. Along these lines, they can't maintain that speed for long circumstances. What is the reason they can't run that quick for long? All things considered, in light of the fact that keeping up that speed for any more extended than 20-30 seconds could have an exceptionally negative impact on their organs, and the cheetah could experience the ill effects of extraordinary over-effort and over-warming.[5]
Elliot et al., (1977) gave an applied model to prey securing by earthly carnivores depicting four noteworthy components; look, stalk, assault, and stifle. Of these, the assault is the most power-requesting (Williams et al., 2014), ordinarily including complex fast moves, supported by obviously entangled behavioural alternatives for the both predators and prey. [3]
The speediest land vertebrate, the cheetah, can fasten from a standing start to 95 km/h in only three seconds, which compares to an acceleration of 8.8 m/s2. Cheetahs can just keep up their quickest pace (111 km/h) for roughly 400 m before their body overheats and their muscles start to tire and create lactic corrosive from fatigue.
Goudhaman et al., (2018) gave an optimal algorithm aiming to find better solution for the SPP between the start and end positions with dynamic allocation of nodes between the start and destination nodes. The properties of the present model empower us to sort out a meta-heuristic in accordance with Cheetah Chase Algorithm to illuminate the most limited way outline. The Cheetah Chase Algorithm is developed by the process of Cheetah hunting and chasing of Cheetah to capture its prey with the parameters of high speed, velocity and greater accelerations. The pseudo code for the cheetah chase algorithm is given below. [3]

```
Step 1: Initialization of the parameters like speed, velocity, acceleration, time and distance.
Step 2: Initialize total time, tc and total distance travelled dc.
Step 3: While (t < Tmax), // Multiple numbers of iterations based on number of Cheetah's.
Step 4: At start node measure the parameters like speed (sc), velocity (vc ) and acceleration (ac).
// Start of the chase Cheetah can accelerate to top speed for first few seconds.
Step 5: Move on to next node and update parameters.
Step 6: If prey captured by Cheetah
            Step 6.1:  Estimate the total time, tc = tc1 + tc2.,
   Where tc1 is time to get the cheetah to accelerate to top speed.
        tc2 is that travel certain distance at top speed
            Step 6.2: Estimate the total distance dc = dc1 + dc2
            Where dc1 and dc2 are the distances went in times tc1 and tc2 respectively.
            Step 6.3: Estimate distance the prey can go in time tc, dp = dp1 + dp2,
            Step 6.4: Estimate the maximum distance travelled by prey dmax= dc – dp.
      Else
        Repeat step 4.
Step 8: End while.
Step 9: Select the best possible shortest path node details with other parameters Speed (sc), Velocity (vc ) and Acceleration (ac)..
Step 10: Post-process and Visualization.
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Figure 1: The pseudo code of the Cheetah Chase Algorithm [3]

III. TAXONOMY OF ANGULAR BASED APPROACH:

The Proposed novel approach of angular based network is shown in below block diagram. For a given network to find the optimized shortest path four different steps involved,
Step 1: From the source node first network is framed by connecting all the relevant nodes.
Step 2: From the network spanning tree is constructed with the possible nodes.
Step 3: From the spanning tree nodes, constructed a formal structured tree.
Step 4: From the structured tree, angular degrees are fixed up with each of the path constructed.

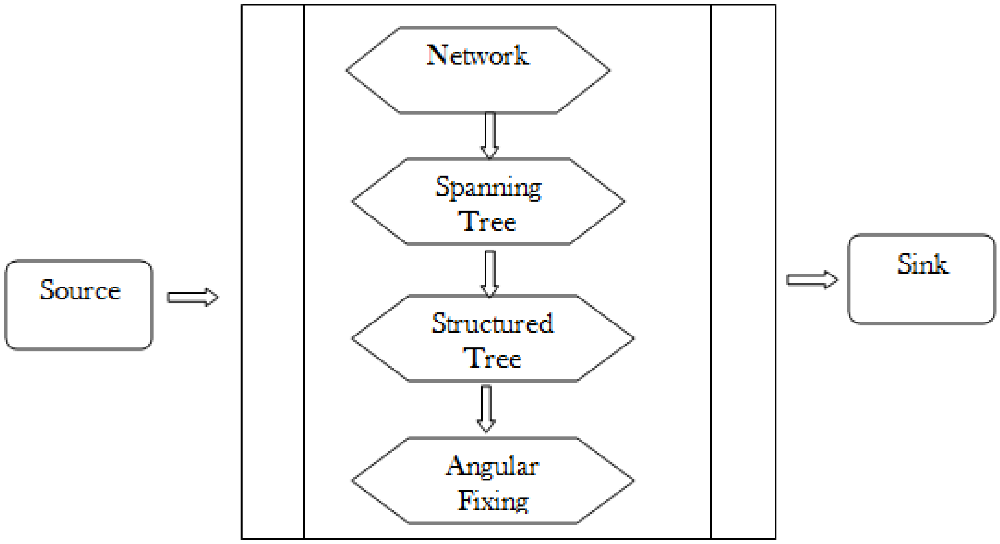

Figure 2: Taxonomy of Angular Based Approach

IV. ANGULAR BASED SPANNING TREE LAYERED STRUCTURE ALGORITHM:

Step 1: (S0, S1, S2, S3, θ_1, θ_2, θ_3)

At Source S0, there are three possible ways to pass through S1, S2, S3 with the angle of θ_1, θ_2, θ_3. respectively. Here it is noticed that vertices S1 and S3 are degree 1, so called pendent vertices. So the paths S0 - S1 and S0 - S3 will not be considered for further process, since vertices S1 and S3 are lies in starting level itself and not Lnth level. (ie level L2 < L9). The path S0 – S2 will be considered for the next iteration.

Step 2: (S2, S4, S5, θ_4, θ_5)

Here the Source will be S2, there are two possible ways to pass through S4, and S5, with the angle of θ_4, θ_5. Here it is noticed that vertex S4 is degree 1, so called pendent vertex. So the path S2 – S4 will not be considered for further process, since vertices S4 is lies in second level and not Lnth level. (ie level L4 < L9). The path S2 – S5 will be considered for the next iteration.

Step 3: (S5, S6, θ_6)

Here the Source will be S5, there is only one possible way to pass through S6, with the angle of θ_6. Here it is noticed that the path S5 – S6 will be considered for further process for the next iteration.

Step 4: (S6, S7, θ_7)

Here the Source will be S6, there is only one possible way to pass through S7, with the angle of θ_7. Here it is noticed that the path S6 – S7 will be considered for further process for the next iteration.

Step 5: (S7, S8, θ_8)

Here the Source will be S7, there is only one possible way to pass through S8, with the angle of θ_8. Here it is noticed that the path S7 – S8 will be considered for further process for the next iteration.

Step 6: (S8, S9, θ_9)

Here the Source will be S8, there is only one possible way to pass through S9, with the angle of θ_9. Here it is noticed that the path S8 – S9 will be considered for further process for the next iteration.

Step 7: (Sink S9,)

Here the Source will be S8, there are no further vertices to pass through and this vertex will be considered as Sink node. Also this is the last level (nth) Level L9. So vertex S9 is considered as Sink.

4.1 Angular Positions:

Every node's angular position is determined by drawing a horizontal line as layers on the vertices and the angle θ_i measured from it (clockwise direction). Angular positions are determined by the sides of quadrangular diagram. These horizontal lines represented as layers L1, L2, L3, L4, L5, L6, L7 on corresponding spanning tree layered structure in data structure.

4.2 Graphical Representation of Algorithm:

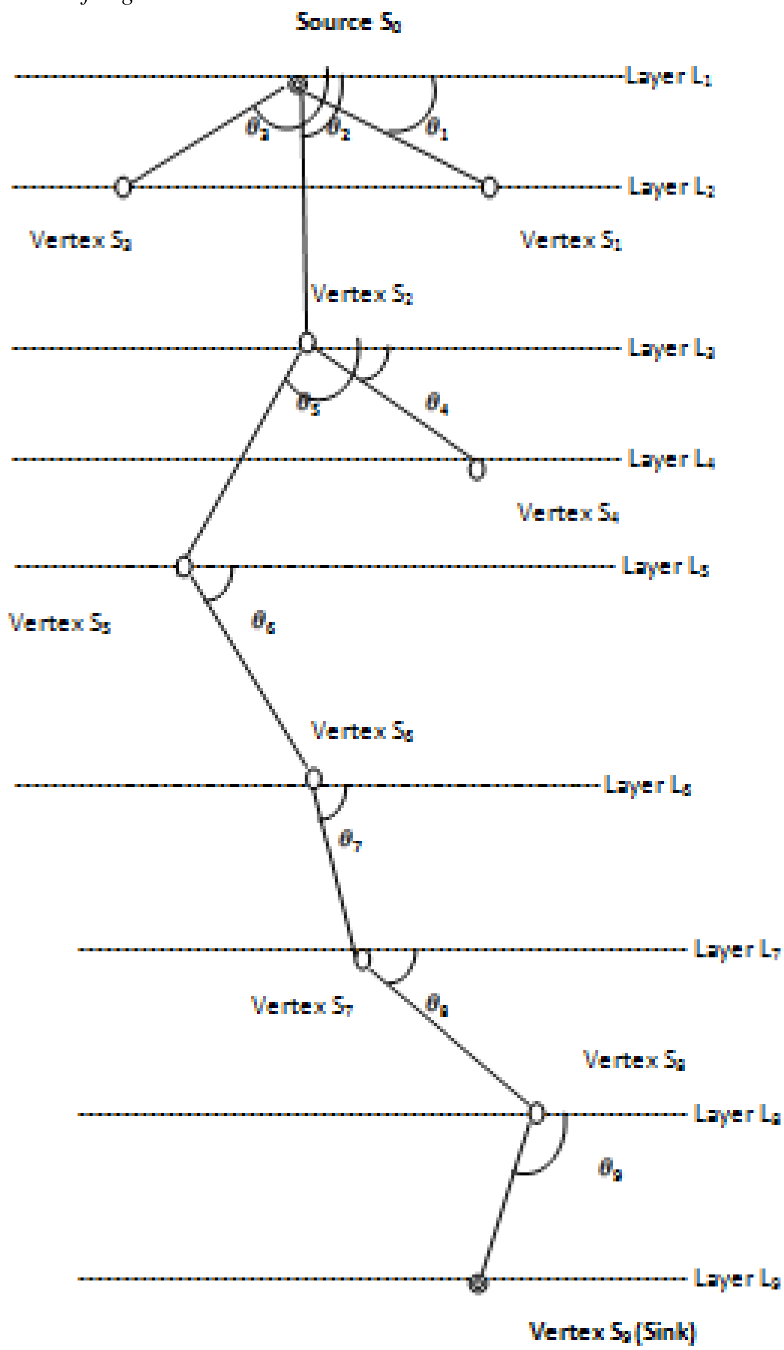

Figure 3: Angular Based Spanning Tree Layered Structure

4.3 Angular based Cheetah Movement – Graphical Representation:

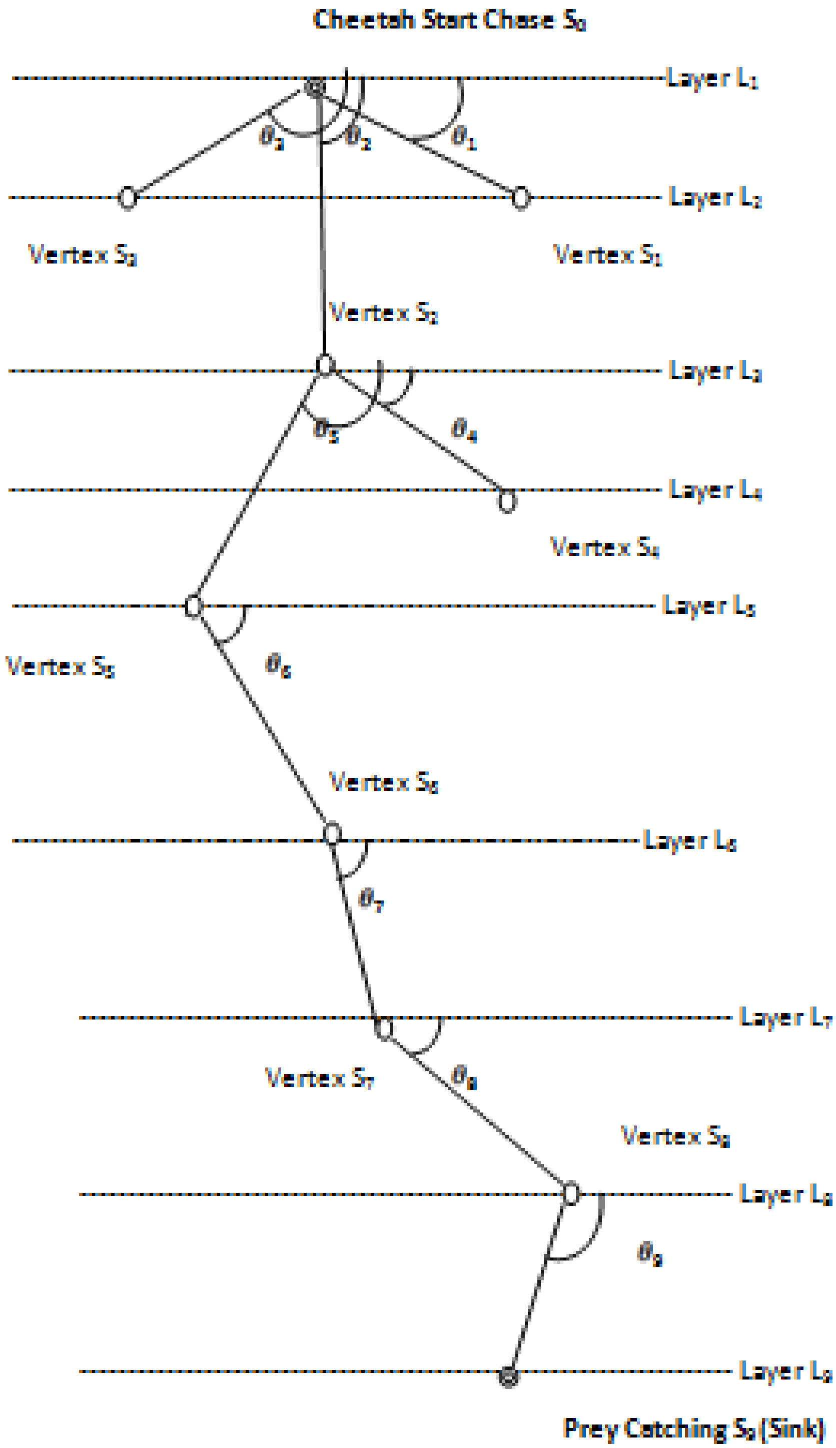

Figure 4: Cheetah Chase to its Prey

4.4 Assumptions:

Cheetah can chase and catch its next level prey through various route depends upon the respective land level.

V. EXPERIMENTS AND DISCUSSION

The proposed Angular Based modified Cheetah Chase Algorithm (ABCCA)approach with its application to the shortest path search are carried out on three different networks with random and varying topologies through computer simulations that using MATLAB 9 on an Intel Core i7 processor (4.2 GHz clock). Test results are also compared with regular CCA approach. [2]

The Angular based modified Cheetah Chase Algorithm parameters are initialized as follows:
To obtain the results for various network topologies, networks with 20–100 nodes are randomly generated. It means that they have random topologies and random branch weights. A comparison between the quality of the solution of the CCA search and the ABCCA search in terms of route failure ratio is shown in Fig. 5. It illustrates clearly that the quality of the investigated solution with the ABCCA is higher than that of the CCA based search. For example, in case that network has 60 nodes (population size is equal to the number of nodes), the route failure ratio for the CCA is about 0.0360 (97% route optimality) with a population size of 20, and 0.02227 for the ABCCA (98.5 % route optimality).

Number of Nodes	Route failure ratio	
	CCA	ABCCA
20	3.19E-02	1.50E-02
30	3.28E-02	1.83E-02
40	3.39E-02	2.02E-02
50	3.50E-02	2.17E-02
60	3.65E-02	2.21E-02
70	3.73E-02	2.33E-02
80	3.77E-02	2.37E-02
90	3.83E-02	2.40E-02
100	3.92E-02	2.45E-02

Table 1: Comparison of route failure between the CCA and the ABCCA algorithms with 20 – 100 nodes

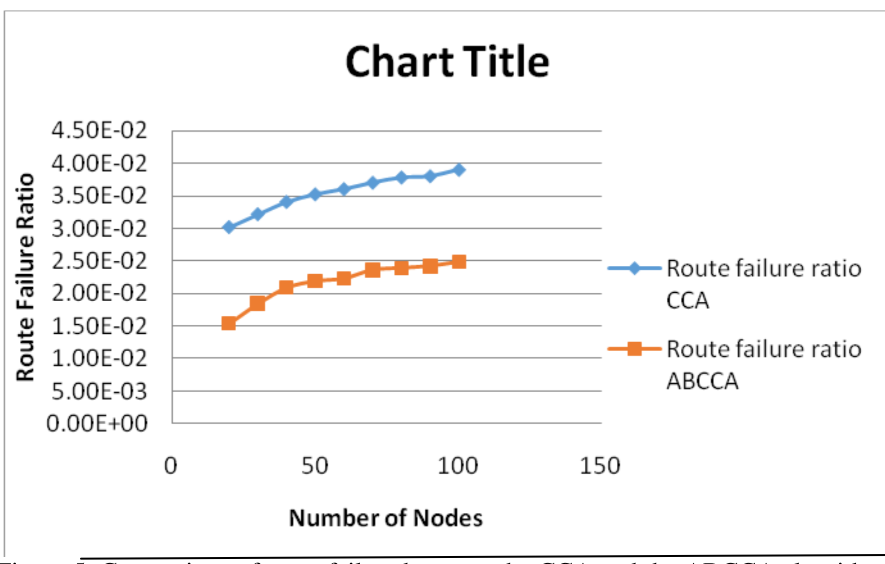

Figure 5: Comparison of route failure between the CCA and the ABCCA algorithms

Figure 6 compares the average changeover CPU time that is consumed to achieve the results. Note that the population size in the CCA is fixed to 20. It is obvious that the average time required for CCA is less than those obtained with the ABCCA. For networks with higher number of nodes, the CCA algorithm has the better time performance with respect to the ABCCA. As is obvious for a network with node numbers more than 50, the CCA time dramatically increased.

Number of Nodes	Changeover CPU Time	
	CCA	ABCCA
20	2.08E-02	2.11E-02
30	2.25E-02	2.28E-02
40	2.37E-02	2.43E-02
50	2.53E-02	2.55E-02
60	2.77E-02	3.08E-02
70	2.95E-02	3.45E-02
80	3.15E-02	3.67E-02
90	3.28E-02	3.85E-02
100	3.43E-02	4.21E-02

Table 2: Comparison of Changeover CPU time utilization between the CCA and the ABCCA algorithms with 20 – 100 nodes

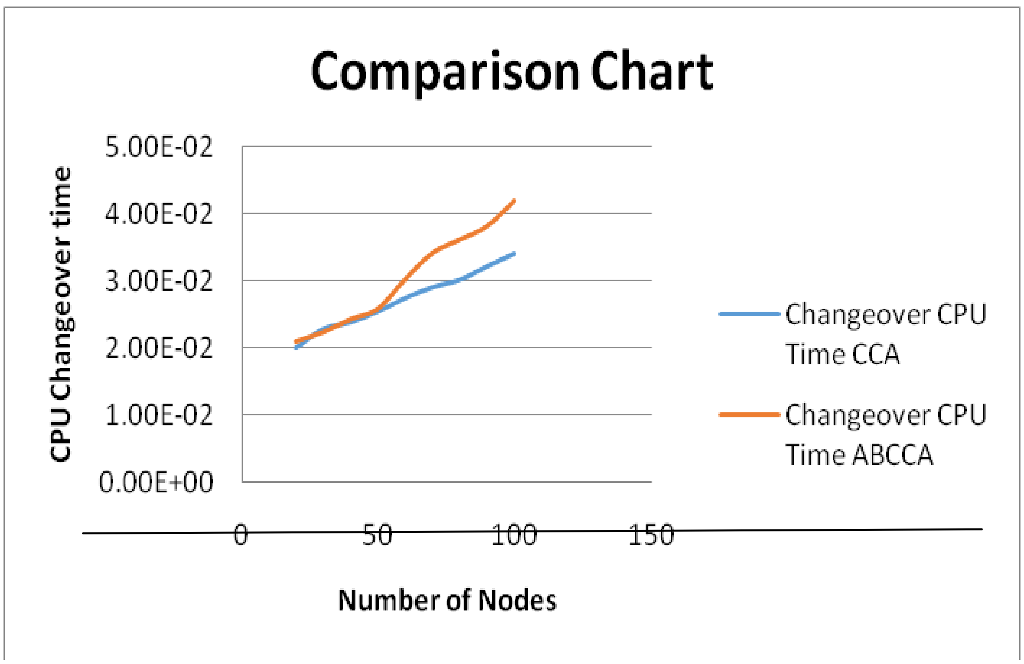

Figure 6: Comparison of Changeover CPU time utilization between the CCA and the ABCCA algorithms

VI. CONCLUSION

In this study, a novel optimization algorithm that is called Angular Based modified Cheetah Chase Algorithm (ABCCA) is introduced. ABCCA is framed by angular based cheetah movements to reach the sink from the given position as source through graph theoretical approach along with shortest path optimization. Angular based movement derives from layered structure spanning tree through hunting process of Cheetah to its prey. In order to evaluate performance of the introduced algorithm, we have tested it on a set of various standard benchmark functions. The results obtained by ABCCA in most cases provide superior results in fast convergence and global optimal achievement and in all cases are comparable with other metaheuristic. The investigated results are presented in realizing the ABCCA for the purpose of solving the SPP. The results are highly encouraging with respect to much superior performance, exhibited by the proposed ABCCA based search.

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VII. REFERENCES

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