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A Comparitive study on TSP

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1 Abstract

Traveling salesmen problem is the most important and familiar problem in order to get the optimal and shortest path to reach at the goal point. To achieve this objective multiple approaches has been developed. In this paper we are comparing different approaches from the collection of many algorithm and approach to present that all of these are providing best results of optimization.But these approaches having best and optimal results.

2 Introduction

Traveling salesman problem(TSP) is the most famous, important and abstracted problem to find the shortest path from a set of nodes locations.This problem is consider as the foundation problem in different fields not either in computer science.This problem focus on route finding algorithm and optimal path planning for vehicle or salesmen with the minimum traveling cost. For this purpose of robots route finding most recently new research approach Stochastic TSP and Orienteering for dynamic system[1].This approach work on randomly distributed set of locations. In which approach deals with the impact of length on the tours for optimization selection of shortest tour. Because generally in optimal solution finding needs to the computational time given O(n!) where n number of cities.In TSP with the set of few number of location cities determining through linear programming. But in case of complex data set of locations computation can be extremely time intensive . For such purpose finding new framework also used in MTSP problem with maximum entropy principal base approach[2].This approach find the shortest route of a salesman from set of routes.In which consider the many constraints also like total distance covered is minimized.For single salesman use heuristic approach with always their starting and ending points are same.This concept presents to a low efficient resources algorithm like deterministic annealing, combinational and resource allocation problem.Selective TSP deals with the single vehicle or sometimes many of them salesman involved. But when more then one vehicle involved then its called routing problem with the profit and minimum travel cost.To solving of this problem purposes a new algorithmic approach Genetic algorithm developed[3].This consider orienteering problem which used in practical sences.This presented mathematical model for the some subsequent details. Which uses in determining convergence to optimal solution. Genetic algorithm is basically a search technique for computing of exact or approximated optimal solution.This transforms population in natural way of occurring genetic operations such as crossover and mutation.Examples of NP-hard are Classical Search Maps, Simulated Annealing and Artificial neural network.Now GELS GA algorithm approach is design to solving the mTSP with the sufficient and realistic results. TSP in which searching of possible optimized combinations.From complex set of nodes at computational step leds towards more expensive and unrealistic results.So far that purpose of work to find shortest approaches for other GA and ACO heuristic approaches.Hybrid

Ant Colony Optimization approach design to solve the difficult problems.And underperformance of the capability for finding optimal solution through Euclidean Equations[6].With the help of this equation by change of the root equation through ACO algorithm.It can includes the new results as compared to the other equations results which has basic goal of developing.

3 THEROEMS REPRESENTATION IN FIGURE

Theorem 1 (Bounds on TSP_Π). *Let Π be a set of constraints, and f be a probability distribution over $\mathcal{X}$, satisfying the assumptions given in Section II-C. Then, if $X_1, X_2, \ldots, X_n \in \mathcal{X}$ are identically and independently distributed according to f,*

$$\mathrm{TSP}_\Pi(X_1, X_2, \ldots, X_n) = \Theta(n^{(\gamma-1)/\gamma})$$

with very high probability.

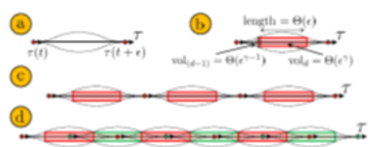
Theorem 2 (Bounds on ORNT_Π). *Let Π be a set of constraints, and f be a probability distribution over $\mathcal{X}$, satisfying the assumptions given in Section II-C, and let $\lambda > 0$. Then, if $X_1, X_2, \ldots, X_n \in \mathcal{X}$ are identically and independently distributed according to f,*

$$\mathrm{ORNT}_\Pi(X_1, X_2, \ldots, X_n; \lambda) = \Theta(\lambda n^{1/\gamma})$$

with very high probability.

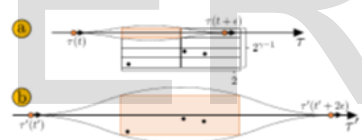
To solve the length of set of n distributed number of cities through which can be obtain the best result of Orienteering with the high probability.These algorithm are simple and provide the approximate optimal soultions for them.In the first theorem special peremater is used to define the length of tour.But in the second theorem is represent the Orienteering of TSP. With the use of these algorithms having the optimal results got.

4 Problem representation of TSP upper Bound

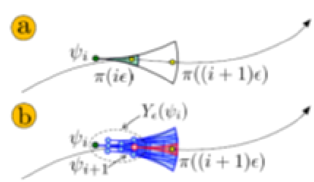


This figure represents the soultion of optimal shortest length of tour by using the first theorem which auotomatically proofs the Orienteering and collects all the distributed n number of cities for sub length of tour.Which explain clearly in below figure.

5 SOLUTIONS OF THEOREM



figuer:2 represents the cel merging process for different number of cities path finding



figuer:3 illsutrates the initial point to move to words the goal point achiving Multiple Traveling Salesmen and Related Problems A Maximum-Entropy Principle based Approach[2].This resreach paper based on two algorithm for solving the multiple traveling salesman problem One

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algorithm is MEP and second algorithm Close enough multiple traveling salesman problem.These are basically heuristic approaches with te help of them optimal soultion for TSP can be found easily at run time.The CEMTSP equation is given that

6 CEMTSP EQUATION Figure

$$F = -\frac{1}{\beta}\sum_{i=1}^{n}\log\left(\sum_{j=1}^{n} e^{-\beta d_{CE}(x_i, y_j, \rho_i)}\right) + \theta\sum_{j=1}^{n} d(y_j, y_{j+1}).$$

Taking derivative of the free-energy term and setting it to 0, we obtain the update equation for each facility given by

$$y_j = \frac{\sum_{i=1}^{n} p(j|i)(x_i + \rho_i \operatorname{sgn}(y_j - x_i)) + \theta(y_{j+1} + y_{j-1})}{2\theta + \sum_{i=1}^{n} p(j|i)},$$

where, the association probability distribution is now given by $p(j|i) = \left(\frac{e^{-\beta d_{CE}(x_i, y_j, \rho_i)}}{\sum_{k=1}^{n} e^{-\beta d_{CE}(x_i, y_k, \rho_i)}}\right)$ and $\operatorname{sgn}(\cdot)$ is a vector-valued *signum* function.

with the help of this equation find the distance of minimum cities at runtime.But its difficult to find the soultion manually for complex data sets even to difficult to implement it on runtime.This can be explain clearly in the figure

7 RUNTIME SOLUTION AND LENGTH OF TOUR BETWEEN CITIES

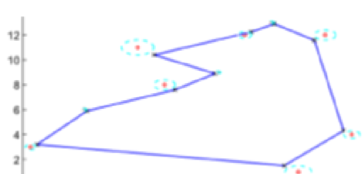


figure:4 from[2] Returning CESTP total length=14.57, Run time=6.82s

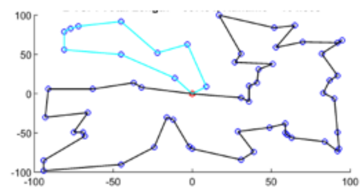


figure:5 from[2] 2-TSP total length=637.34 , Run time=104.82

The MEP approach is purposed to solve the problem of SA and DA algorithms which having the solution for 59 number of cities optimal at run time but not compatible for the large datasets at run time so that it can make the comparison between them to get the sufficient and relaible results.

$$\min_{y_j \in \Omega, 1 \le j \le K} \sum_{i=1}^{n} \left\{ \min_{y_j, 1 \le j \le K} d(x_i, y_j) \right\}, \qquad (1)$$

where $d(x_i, y_j) \in \mathbb{R}_+$ denotes the distance between the i^{th} city location x_i and j^{th} facility location y_j, and $\Omega \subset$

In the MEP follows this equation to get the relaiable results.And the comparison of SA and DA demonstrated in the graph notation.

8 comparison of SA and DA respresentation

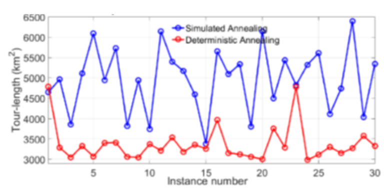
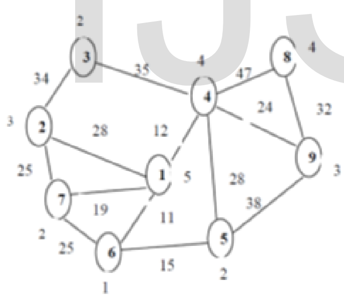


figure:6from[2] A new approach based a genetic algorithm for the Selective Travelling Salesman Problem[3].this resreah paper based on the genetic algorithm approach which has been concernd about to solve the shortest path problem and focused on that using minimized cost and total profit maximized.In which approach follows the population of genration and optimized combination of cities between the length of shortest path tour.The algorithm code is such that

$$\text{Maximum} \sum_i pi \sum_j xij$$

9 Graph representation of a Network of cities

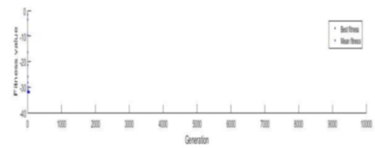


And the population gain and profit caculated by this algorithm

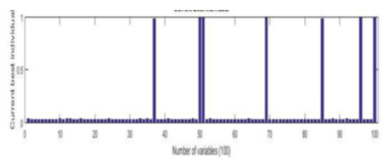
```
begin
I = {v1}, n:=m :=1 ;
        begin
        find vi and vj such that
        pi /cir=max{pk /ckr} and pj/cjs=max{pk/ckr} ;
        if (pi /cir > pj/cjs ) then add  vi to I before r and set r:= i
        else add  vj to I after s and set s:=j
        end
        close the current path by  adding arc ( vn,vm )
        end
end
```

With the help of this algorithm gets the best result of maximum cost ratio between gain and cost for using the same piece of code.

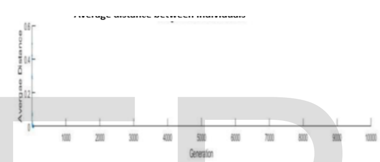
10 Results of initial Population



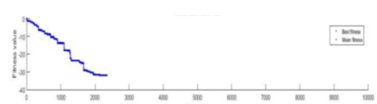
Current Best Individual



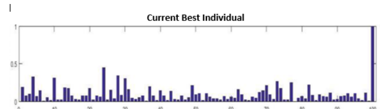
Average distance between Individuals



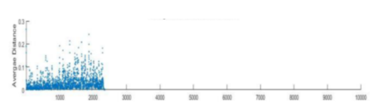
11 Results without Considering Initial Population



Current Best Individual



12 Average Distance between Individual



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13 GELS-GA

Hybrid Metaheuristic Algorithm for Solving Multiple Travelling Salesman Problem[4].This paper has inculded new heuristic algorithm approach which is the type of NP complete problem solving.It is simple and efficient then two other algorithm approachs in which includes ACO and GA.Through this algorithm easily find the optimal solution for mTSP with the help of this equation

$$F(x) = \sum_{i=1}^{m}\sum_{j=2}^{n}\sqrt{(x_1 - x_j)^2 + (y_1 - y_j)^2} + \sum_{i=1}^{m}\sum_{j=2}^{n}\text{cost}(c_1, c_j)$$

GELS has provides the best solution as comparied to ACO and GA at the distance cover between multiple number of cities at minium cost.This minimized ratio of calculations represent in this figure Proposed method of algorithm representation

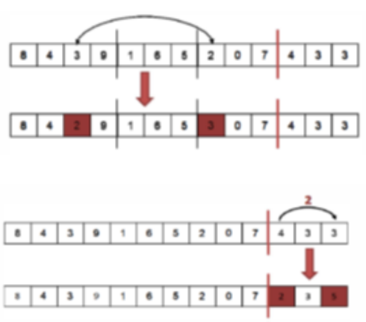


figure:10 [4] Explain the first part about proposed method for transfer mutation but the second part at left side describes about the salesman of mutation for proposed method

14 Comparison table of ACO and GELS-GA

Table: 1[4] Comprison show the result of Minimized Total Distance covered by different algorithms

Problem				ACO in [22]		SW+AS_elite in [23]		GELS-GA		%Improvement of the GELS-GA over	
Name	n	m	l	Avg.	Time (s)	Avg.	Time (s)	Avg.	Time (s)	ACO[21]	SW+Aselite[23]
pr76	76	5	20	180690	51	157562	19	132784	5	26.51	15.73
Pr152	152	5	40	136341	128	128004	41	105205	8	22.84	17.81
Pr226	226	5	50	170877	143	168156	62	152135	9	10.97	9.53
Pr299	299	5	70	83845	288	82195	65	76554	11	8.7	6.86
Pr439	439	5	100	165035	563	162657	95	146523	16	11.22	9.92
Pr1002	1002	5	220	387205	2620	381654	186	354341	27	8.49	7.16
									Minimum	8.49	6.86
									Mean	14.79	11.17
									Maximum	26.51	17.81

Comparison Show the results for Minimized travelled distance an Time by Salesman

Problem		Enhanced GA [24]				GELS-GA				%Improvement of the GELS-GA over
Name	m	Best	Avg.	Worst	Time (s)	Best	Avg.	Worst	Time (s)	Enhanced GA
mTSP-51	3	447.42	448.5	449.62	7.10	252	254.5	257	5	43.25
	5	476.11	478.41	482.41	8.78	259	263.5	268	4	44.92
	10	583.57	587.39	589.86	11.20	324	328	332	9	44.15
mTSP-100-II	3	22366.57	22466.41	22611.24	17.27	17800	18035	18270	12	19.72
	5	23895.38	24040.57	24095.96	20.18	20532	20589	20646	14	14.35
	10	27675.42	28033.53	28216.64	26.52	24354	24803.5	25253	17	11.52
	20	39993.83	40274.58	40582.55	34.89	35142	35969	36796	23	10.69
mTSP-150-II	3	39179.41	39361.04	39557.43	28.04	37600	37933.5	38267	25	3.62
	5	40437.18	40663.31	40803.15	34.02	38132	38336.5	38541	28	5.72
	10	44088.29	44546.77	44782.05	44.32	41213	41739	42265	32	6.30
	20	55959.70	56417.86	56572.87	57.13	51393	51443	51493	36	8.81
	30	71605.25	71808.99	71923.98	67.47	66474	66824.5	67175	44	6.94
									Minimum	3.62
									Mean	18.33
									Maximum	44.92

All of the calculations show that how much improvement has been discoverd through GELS method of algorithm.These results are optimal and even mostly accepted in high complex data set. Estimation of Cost Rate Percentage for Travelling Salesman Problem Using Hybridized ACO Algorithm[5].ACO algorithm purposed to solve the shortest path and cover all data set at minimum cost.For such purpose inculdes equations rahter thn their algorithms like hamming and Euclidean distance standard equation in ACO.

15 ALGORITHM FOR ACO

```
Procedure ACO_MetaHeuristic
    while(not_termination)
        generateSolutions()
        daemonActions()
        pheromoneUpdate()
    end while
end procedure
```

Here are presented three equations with their results and formula.

16 REPRESENTATION OF EQUATIONS

Eucliden equation

$$Dist_{Euclidean}((x, y), (a, b)) = \sqrt{(x - a)^2 + (y - b)^2} \quad (3)$$

Chebyshev equation

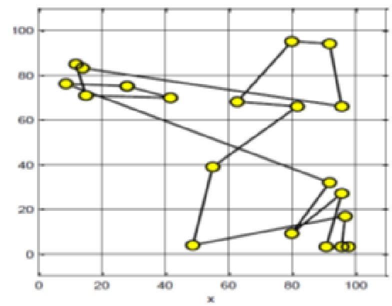
$$Dist_{Chebyshev}(p, q) = max_i(|p_i - q_i|)$$

Hamming equation

$$Dist_{Hamming}(i, j) = pdist2(p, q, 'hamming');$$

with the help of these three equations easily make comparison for ACO algorithm.They are not dependent on each other every equation has its own parallel data set of execution.

17 TSP tour graph for visited node with equations



18 COST ESTIMATION ANALYSIS RESULTS OF EQUATIONS

So the graph representation of the equations discrbes about the different cases of equations with compare the other equations. Table:3 [5] Comparative study of Euclidean,Hamming and Chebyshev Distance equation[5]

S No.	Euclidean distance		Hamming distance		Chebyshev Distance	
	Best cost	Worst cost	Best cost	Worst cost	Best cost	Worst cost
Case 1:	410.55	622.51	20	20	278	368
Case 2:	462.85	703.12	20	20	280	486
Case 3:	428.37	428.37	20	20	244	356
Case 4:	14.70	683.18	20	20	300	404
Case 5:	685.18	423.37	20	20	276	354
Case 6:	371.53	524.03	20	20	212	240

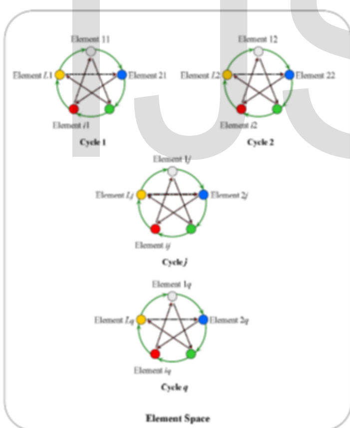
In this table of comparison clearly shows that best results of three equation with the distance formula and also express the worest cost .Five-elements Cycle Optimization Algorithm for The Travelling Salesman Problem[6].This algorithm approach has been develop to solve the multiple Travelling salesman problem and find the optimal solution for them.The five cycle model has been focused on generation and restriction of the worlds elements.But the FECO has been focused on the optimization of TSP.

19 Algorithm for FECO

$$F_{ij}(k) = ln\left[m_{(i-1)j}(k)/m_{ij}(k)\right] - ln\left[m_{(i-2)j}(k)/m_{ij}(k)\right] - ln\left[m_{ij}(k)/m_{(i+1)j}(k)\right] - ln\left[m_{ij}(k)/m_{(i+2)j}(k)\right] \quad (6)$$

After constructing Element Space, FECO can be established to solve TSP. To illustrate clearly, the corresponding relationship among FECM, FECO and TSP is shown in Table I.

20 STRUCTURE OF FECO ELEMENTS SPACE



21 Results for the Optimization comparison of FECO and TSP

Table 4[6]: Optimal results for FECO for 25 TSP instances

Instance	Optimal solution	Best	Worst	Average	D_{avg}(%)	StdDev
burma4	30.8785	30.8785	30.8785	30.8785	0.0000	0.0000
ulysses22	75.3097	75.3097	75.3097	75.3097	0.0000	0.0000
oliver30	423.7406	423.7406	423.7406	423.7406	0.0000	0.0000
eil51	426	428.9816	432.4802	430.5293	1.0632	1.1319
berlin52	7542	7544.3659	7544.3659	7544.3659	0.0314	0.0000
st70	675	677.1096	680.7691	678.1811	0.4713	1.1813
eil76	538	550.4968	557.6628	554.4552	3.0586	1.8229
rat99	1211	1231.8302	1253.5871	1242.6645	2.6147	5.3081
eil101	629	648.4409	658.3476	654.4567	4.0472	2.8841
lin105	14379	14382.9959	14574.9744	14495.4254	0.8097	49.9580
bier127	118282	119509.1745	121484.3358	120593.4775	1.9542	466.0055
ch130	6110	6139.2903	6242.8451	6197.4842	1.4318	22.5804
ch150	6528	6613.4078	6713.1174	6667.1782	2.1320	30.7199
kroA150	26524	26619.1354	27137.2144	27003.7594	1.8088	116.6051
kroB150	26130	26280.1849	26583.6199	26440.2415	1.1873	78.0602
u159	42080	42162.7497	43073.9730	42735.9693	1.5589	259.1648
kroA200	29368	29886.8324	30233.8275	30072.4627	2.3987	93.2910
kroB200	29437	30025.8271	30451.4723	30253.6153	2.7741	109.0839
pr226	80369	80506.7330	80883.7667	80702.3345	0.4148	105.9283
pr264	49135	50439.1466	51382.6923	51057.2608	3.9122	205.6976
pr299	48191	49691.1400	50359.6443	50018.4782	3.7922	181.0639
lin318	42029	43523.8914	44204.2300	43943.4961	4.5552	179.6415
rd400	15281	15989.9321	16244.2942	16127.0661	5.5367	63.1528
pcb442	50778	54373.7330	55109.3559	54740.4516	7.8035	177.8897
rat575	6773	7306.9662	7361.2969	7340.5975	8.3803	12.5739

Table 4[6] Comparison results and Statistical Results for 6 Algorithms

Instance	Optimal solution	GA		ACO		MGACACO		MMA		HMMA		FECO
		D_{avg}(%)		D_{avg}(%)		D_{avg}(%)		D_{avg}(%)		D_{avg}(%)		D_{avg}(%)
eil51	426	9.7254	(+)	2.7676	(+)	0.2840	(-)	16.1408	(+)	5.6502	(+)	1.0632
berlin52	7542	1.7418	(+)	0.8065	(+)	0.0314	(-)	2.1224	(+)	0.0313	(-)	0.0314
eil76	538	5.9219	(+)	5.9229	(+)	0.4279	(-)	12.8643	(+)	3.7268	(+)	3.0586
rat99	1211	10.2659	(+)	6.8803	(+)	1.0619	(-)	9.4228	(+)	7.6614	(+)	2.6147
eil101	629	13.6345	(+)	10.2499	(+)	0.9030	(-)	17.0906	(+)	11.7790	(+)	4.0472
lin105	14379	1.2205	(+)	0.5932	(-)	0.1050	(-)	3.0883	(+)	1.2899	(+)	0.8097
ch130	6110	1.4627	(~)	1.0092	(-)	0.2278	(-)	4.7740	(+)	3.3864	(+)	1.4318
kroA150	26524	1.6114	(-)	0.5112	(-)	0.0505	(-)	5.6699	(+)	4.9855	(+)	1.8088
u159	42080	2.1084	(+)	1.0074	(-)	0.7925	(-)	7.7996	(+)	4.8567	(+)	1.5589
kroA200	29368	2.1030	(-)	0.5237	(-)	0.2271	(-)	8.0633	(+)	6.9385	(+)	2.3987
pr226	80369	10.7431	(+)	0.5630	(+)	0.4023	(~)	9.3740	(+)	5.5640	(+)	0.4148
pr299	48191	1.4530	(-)	0.6161	(-)	0.2542	(-)	11.7209	(+)	10.6337	(+)	3.7922
lin318	42029	2.2430	(-)	1.3260	(-)	0.8073	(-)	13.0791	(+)	10.7535	(+)	4.5552
pcb442	50778	1.8360	(-)	1.0239	(-)	0.8238	(-)	14.3889	(+)	9.6344	(+)	7.8035
rat575	6773	4.7480	(-)	3.3508	(-)	1.8935	(-)	15.7921	(+)	14.3604	(+)	8.3803
p-value		4.3858E-01		4.3858E-01		1.8281E-04		1.0751E-04		7.8911E-04		

ALGORITHM TO SOLVE TRAVEL SALESMAN PROBLEM EFFICENTLY[7].This research paper has been design to solve the problem with efficently an optimaly solutions.In this paper discuss the many previous techniques uses as TSP solution finding but focus on the new purposed method of optimal and efficent results are Pick near Point(PNP).

22 Algorithm for PNP

```
Algorithm 1 Algorithm PNP
Input: C                                  // XY coordinates of cities.
Output: Path                                         // Set of edges
Require: d_Mat        // Distance Matrix calculate using Eq. 1
Require: S_d          // Specific Distance calculate using Eq. 2
  Path   // Maximum cost rectangle by use of corner edges
  while iterate == True do
    Cities = C − Path
    nearPoints = nearPoints(Cities, Path, S_d)
    for all nearPoints do
      for all Path do
        Dist   // minimum distance from path to point
        if minDist > Dist then
          minDist = Dist
        else
          minDist = minDist
        end if
      end for
    end for
  end while

  function nearPoints(Cities,Path,S_d)
    for all Path do
      for all Cities do
        Distance    // Min distance from nearest point
        if Distance < S_d then
          nearPoint = City
        end if
      end for
    end for
  end function
```

This algorithm of PNP express the large

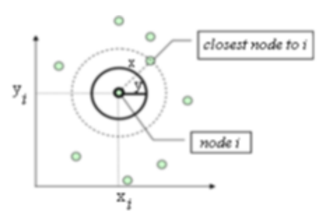
8

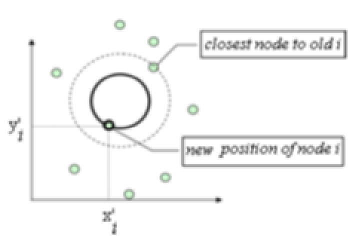
data set instances for TSP with efficently results getting.With the help of such algorithm easly can b find the solution for 100 number of cities with minimum distance travelled very effiecntly.But this is also an approximate algorithm as compare to the another algorithms but not consider as exact. Adaptability of a Discrete PSO Algorithm applied to the Traveling Salesman Problem with Fuzzy Data[8].In this paper describes about the behaviour of optimal soultions by using Partical swarm Optimization implements on TSP uncertain enviornment.It is going too follow that uncertain or fuzzy data by disceret PSO equation[8].

$$x(t+1) = x(t) + v(t+1)$$

$$v_{ij}(t+1) = c_1 v(t) \oplus c_2 (x_{Best}(t) - x(t)) \oplus c_3(t)(x_{GBest}(t) - x(t))$$

23 Initial map and its fuzzied map graphical representation





fuzzie form figure:13[8] In this diagram[8] has been explain about the fuzzines of data set through PSo algorithm finding their behaviour.Which can be clearly explain that how much different after them.

24 Comparison of Fuzzied data with other algorithms

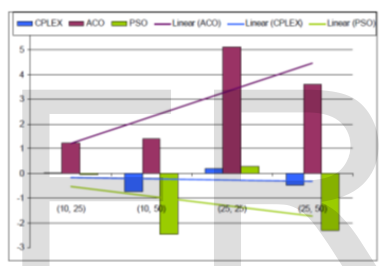


figure:14[8] In which graph discribes about the other algorithm at the level of percentage error as compare to the PSO algorithm.That having the Path Planning and Following using Genetic Algorithms to Solve the Multi-Travel Salesman Problem in Dynamic Senario[9].In this paper having the algorithm about path planning of many number of cities distributed randomly.Here we are going to generate the best path for robouts through this algorithm for dynamic set of problems.With the help of Genetic algorithm easily find the MTSP best solutions efficently.In this paper used algorithm has concept about the chromosomes and population.With the help of this concept easily can be found the solution of poblems with best and optimal results.

25 Process of Genetic Algorithm

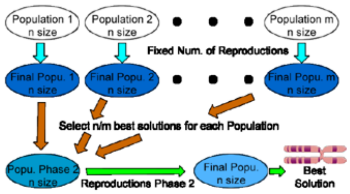


figure:15[9] genetic algorithm process flow representation In which the figure[9] explain about the population how to reproduse through the chomosome and how much increase the numbe of population. Now after to clearly define the genetic algorithm how to solve the MTSP here are discuss about the path palnning for robots.In which focused on this agent has been move through the shortest and optimal path for particular scenarios.

26 Path Planning Repesentation

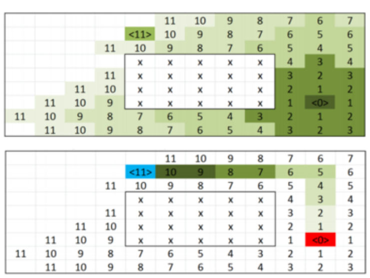


figure:16[9] In this figure express about to find the shortest path for robots agent has been visited each place with the minimum distance.This can be held through with the algorithm to achive it. So with the help of this algorithm we can achive best results for path planning through Ga algorithm approach.

27 Results of GA

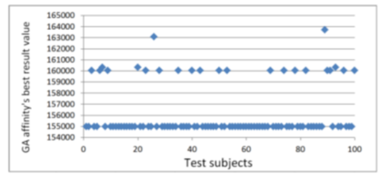


figure :17(a)

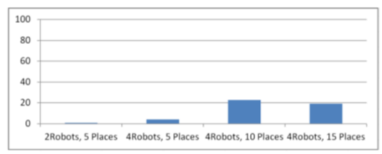


figure:17(b) IN which figure:17[9] a explain about the dispertion of best results though the algorithm of GA but the second part for Figure:17(b) define about the percentage error of GA with respect to best results.

28 Comparison

The Stochastic Traveling Saleman TSP in which has to cover the trajectory length of shortest path for n number of distriuted cities.Those trajectory having the high probabilities for orienteering Problem for these problems which are different then the other approaches.This advantage is one of unique then others. Maximum Entropy Principle based Approach for MTSP in the paper focus on the run time marginal increase for simulated annealing algorithm.For the solution of mTSP using CETSP that is computational challange for it.So with this proofes the best comparison results provide in the SA and DA algorithm which is best working of it. A new approach of GA for Selective TSP algorithm is the heuristic approach following though the help of this easily can be achived the optimal combination of cities.That is the best feature of it rather then others. GELS-GA hueristic approach for MTSP this approach has been different then the Maximum Entropy Principle that also used to solve multiple problems.This is the best as comapried to ACO and GA algorithm also. Path Planning an following for MTSP it can be focused on the best path finding for robots agents with the minimum cost at total travel distance covered each place.This is the advantage of ACO algorithm for path planning which has been unique to others. Harmony search algorithm for TSP in which having the algorithm for the solving the optimal problem results the traveling salesman according to artifical Intelligenc field.Which is the uniques of this algoithm form other that can be covered only in this paper.

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