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Tracking without Backtracking (TBT) – An efficient two way searching technique for guidance through ocean

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Abstract : Here a Two way routing technique been proposed, where the concept of backtracking is omitted. This efficiently works on digitized map. The methodology is optimal and complete. The technique been successfully implemented for searching efficient path way through ocean. Various parameters like visibility, depth, air flow, water current etc. been considered and regression analysis been performed. Upon entering the source and destination points on a digitized map, on the basis of these parameters, best path is suggested.

IndexTerms **- Two way routing, optimal, complete, digitized map, parameters, backtracking.**

I. Introduction

Till this twenty first century ocean is the main medium of transport, not only for cargo ships, but also for the passenger ships. However, each month a number of ship wrecks occurs till date and most of them occurs due to selection of wrong or unsafe path. In this paper the goal node searching technique Tracking without Back-Tracking (TBT), is proposed and applied for finding the less hazardous route in the ocean for sailing through, but the methodology could be applied for any other such applications, like roadways also, only by changing the influencing factors. Here the basic intention is not to find only an optimal, but at the same time the safest route as well, between two Points – namely, SOURCE and DESTINATION. There present many connected cross-points through which a number of routes exist between Source and Destination. Thus the entire problem could be viewed as a graph (weighted) traversal problem, between two given end-points. For determination of the weight of the edges, not only its length (i.e. distance between its two end points), but also various influencing parameters (values are determined from various case studies or previous history) are considered. In this chapter different existing popular goal finding approaches, such as Generate – And – Test , Simple Hill – Climbing, Steepest – Ascent Hill Climbing , Russel's Bi-Directional Search etc. are considered for being applied in the same application area of finding the shortest-cum-safest route. Discussions been made on the problems observed in each case and illustrations been made on how the proposed TBT method could be helpful to overcome some of those demerits. While finding the optimal and safest route, equal importance has given to the distance (has to traverse for reaching destination) and safety measures.

The organization of the chapter is as follows. Section II discusses on the technique behind finding the optimal and safest route. Section III focuses on implementation and results. Section IV compares the proposed Track without- Backtrack Method with several other popular goal node searching methods and finally concluding remarks are there in section V.

II. Methodology

While searching for the safest route, at first it is needed to find the factors influencing the safety of the route. These factors vary from application to application (i.e. factors will be changed while considering routing through road-ways instead of considering routing through ocean). As here, safest route for sailing through ocean is under consideration; among a lot of influencing factors five have found to play very important role. These are —

- Depth of water
- Air flow
- Water current
- Visibility
- Presence (possibility) of iceberg/storm

It is the discretion of the implementer that how much weightage should be given for choosing shortest path and how much to safety measures. For the present purpose, without compensating with any one among them equal weightage has given to both. Presently the measure has carried out in a 100 point scale, among which 50 is emerging from distance and remaining 50 from safety measures.

For each route-let (i.e. part of the route, existing between one junction or cross-point to another. During graph representation, it is simply the edge between two nodes) the values of the influencing factors may be fed by the user or be achieved from satellite images. While fixing up the relative weightage of different influencing factors, which one should be prioritize over which, is on the basis of historical data/case studies. For the present purpose, depth of water has given 20 points weightage, where as next threes (Air flow, Water current and Visibility) have given 10 points each. Presence of iceberg/storm has a Boolean result. Thus each of the five factors has been adjusted to a 10 point scale, so that sum of these five is scaled in 50. Lesser is the value, cheaper is the route. The way of fixing out the above mentioned five influencing factors been discussed in the following portion.

• Depth of Water

While selecting a smooth route for sailing through ocean, the choice is very much affected by the depth of water. Sailing reports tells that route having depth more than 50 mt. is the best choice (to make it cheapest, 0 point has been offered), whereas route with depth 12 mt. is a moderate choice and hence awarded 10 point. The routes with depth less than 12 mt. are being sidetracked by giving point 20 in the 20 point scale, to make them costlier. Route with depth 25 mt. is also a quite good choice (thus given point 5 in the 20 point scale). These data enable to obtain table 1.

Table 1: Depth of Water

x(mt.)	70	60	50	25	12	11	10
y(scale)	0	0	0	5	10	20	20

The relationship between x and y from the data presented in table 1 has buttoned up using the Regression Analysis [30] strategy. The intended work is fit a parabolic curve or polynomial function of degree m in this data. Here 5th degree polynomial curve fitting for Regression Analysis has been considered, which is of the form:

$$y = c_0+c_1.x+c_2.x^2+c_3.x^3+c_4.x^4+c_5.x^5$$

The next step is to calculate the unknowns i.e., c_0 , c_1 , . . . , c_5 of the equation. To accomplish this task, Gauss Elimination method is used. The final values of the unknowns are listed below in table 2.

Table 2: values of the unknown variables used in equation for table 1

Co-efficients	Values
c_0	47.7784331324361
c_1	-4.0045389395348
c_2	0.12416784919141
c_3	-0.00140244183634885
c_4	-6.74518773914788E-07
c_5	7.23394231515351E-08

The polynomial (equation) obtained for the parameter depth of water has depicted as follows.

$$y = 47.7784331324361+(-4.0045389395348).x+ 0.12416784919141).x^2+(-0.00140244183634885).x^3+ -6.74518773914788E-07).x^4+(7.23394231515351E-08).x^5$$

The graphical nature of the polynomial is shown in figure 1, which reveals the fact that depth more than 50 mt. is the best choice.

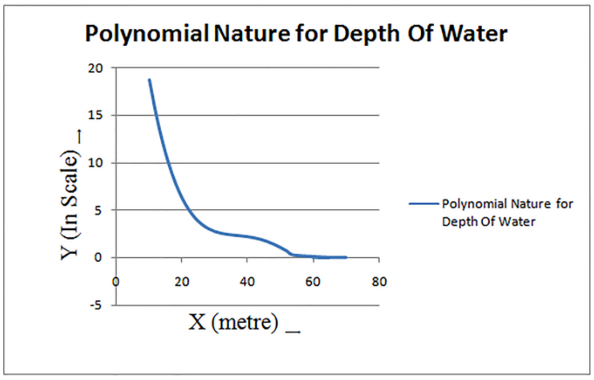

Fig. 1: Polynomial for Depth of Water

• **Air Flow**

Air flow has a crucial role during determination of sailing path through ocean. It has become obvious from the reports that route with air flow 89 KM/H or more (in any direction, positive or negative) should be avoided (thus given point 10 in the 10 point scale, to make it costlier). Routes with air flow 45 KM/H in positive direction is the best choice (so given 0 point to make it cheapest). However routes with very minimal air flow is a moderate choice (given point 5 in the 10 point scale) and routes with air flow 45 KM/H in negative direction makes the situation worsen (thus given point 7 in the 10 point scale). This results in table 3.

Table 3: Air Flow

x(KM/hr)	89	45	0	-45	-89
y(scale)	10	0	5	7	10

Using the same procedure of Regression Analysis, the set of values of the unknowns is obtained and shown in table 4.

Table 4: values of the unknown variables used in equation 1 for table 3

Co-efficients	Values
c_0	4.99994410760793
c_1	-0.104490894607928
c_2	-0.00121189124100473
c_3	0.0000131916319554311
c_4	2.3268915510016E-07
c_5	-9.76631790679625E-17

The polynomial obtained for the parameter air flow has depicted in equation 4 .

y = 4.99994410760793+(−0.104490894607928).x+ (−0.00121189124100473).x2+(0.0000131916319554311).x3+ (2.3268915510016E−07).x4+(−9.76631790679625E−17).x5

The graphical nature of the polynomial is as shown in figure 2, which reveals that the air flow ≈ 45 km/Hour in positive direction is the best choice.

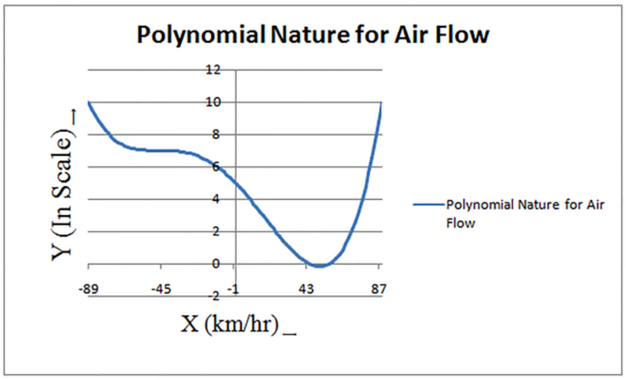

Fig. 2: Polynomial for Air Flow

• **Water Current**

Water current also plays a crucial role in ocean route selection. Path with current less than 0.4 m/s or more than 2.5 m/s should be avoided. Hence given 10 points (in a 10 point scale), for making it costlier. Paths with current 1.3 m/s is best choice and awarded with 0 point to make it cheapest. Finally path with current 0.85 m/s or 1.9 m/s is a moderate choice, adorned with point 5 in 10 point scale. Using these data table 5 is reached.

Table 5: Water Current

x(Mt./s)	0.4	0.85	1.3	1.9	2.5
y(scale)	10	5	0	5	10

Using the procedure of Regression Analysis, the values of the unknowns are obtained and depicted in table 6.

Table 6: values of the unknown variables used in equation 1 for table 5

Co-efficients	Values
c_0	3.14324
c_1	40.77444
c_2	-71.75304
c_3	31.7
c_4	0.63035
c_5	-1.70556

The polynomial obtained for the parameter water current has shown in equation 5.

y = 3.14324+(40.77444).x+(−71.75304).x2+(31.7).x3+ (0.63035).x4+(−1.70556).x5

The graphical nature of the polynomial is shown in figure 3, which reflects the fact that water current ≈ 1 .3 mt. / s is the best choice.

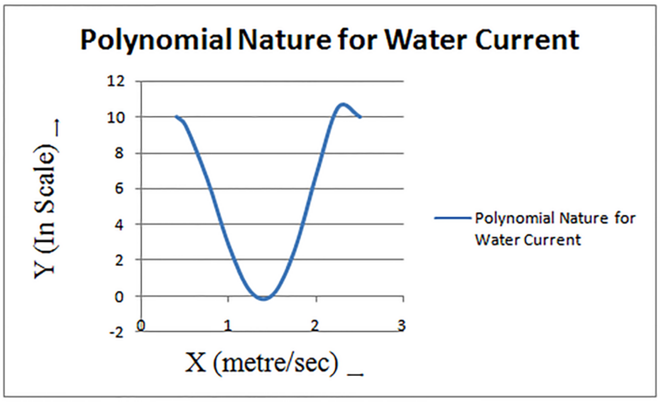

Fig. 3: Polynomial for Water Current

• **Visibility**

During choosing a route through ocean, one also must consider the factor visibility. When the visibility is very low due to heavy fog or alike, that route should be avoided for sidetracking mishaps, hence given point 10 in a 10 point scale to make the route costlier. When visibility is near about 5 KM, makes the route a moderate one choice; thus given weightage point 5 and finally visibility 10 KM or more makes the route a best choice, that's why weightage point 0 is associated with this route to make it cheapest. Table 11.7 illustrates the fact.

Table 7: Visibility

x(KM)	10	5	0
y(scale)	0	5	10

Without losing its generality, this data could be fit to a Linear Equation of the form y = ax+b

Putting the values from table 7, three simultaneous equations are obtained—

$$0 = a\times10+b \qquad (a)$$
$$5 = a\times5+b \qquad (b)$$
$$10 = a\times0+b \qquad (c)$$

From Equation c, value of b is obtained as; b = 10.
Putting this value of b (i.e. b = 10) in equation a, it is found that
0 = a×10+10
or, −10 = a×10
or, a = (−1)
Thus finally the Linear Equation takes the form
y = (−1)x + 10

The graphical nature of the polynomial is shown in figure 4 and reflects the fact that visibility 10 km or more is the best choice and the path become poor for selection with decrement of the visibility value.

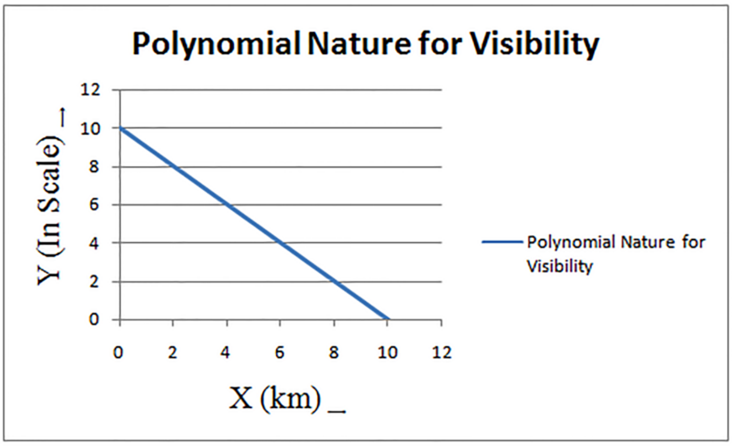

Fig. 4: Polynomial for Visibility

• **Possibility of presence of Sea Storm or Iceberg**

Keeping mind the famous incident of "TITANIC", any route with possibility of presence of iceberg or sea storm is strongly being avoided. Thus here, if no such possibility is there weightage 0 point is awarded and for such possibility, a very high sentinel value 99 is awarded, so that the route becomes so much costly, such that it would not come onto crease even its distance factor is low. In other words, the path with such risks are strongly avoided even they are very short. Thus table 8 is readily being achieved.

Table 8: Possibility of presence of sea storm or iceberg

x (Is There any such Possibility?)	0	1
y(scale)	0	99

This procedure of finding optimal cum safest route through ocean, takes as input the Raster Map of any sea/ ocean. It may be any scanned image/ satellite image, which is not needed to digitize anyhow, making it less time consumed process. The reference cross points are marked by simply clicking onto them and parametric values like depth of water, air flow, water current, visibility etc. are directly fed for each of this route-let. For the present method, user-friendly GUI is there for accommodating these values. Upon entering the Starting and Destination point of the journey, the technique invoke Tracking without Back-Tracking (TBT) goal searching method and displays the safest cum shortest route by "RED" line.

III. Implementation and Results

The results of enactment, design of GUI and all the required operations have been done using Net Beans IDE 8.0.2 (Java) , which is based on flat-file systems without using databases, hence have increased its portability. The work begins with selection of a map (may be a scanned image or likewise) from any location of the computer. The start-up screen and the buttons for loading or adding new map are shown in the figures 5 and 6 respectively.

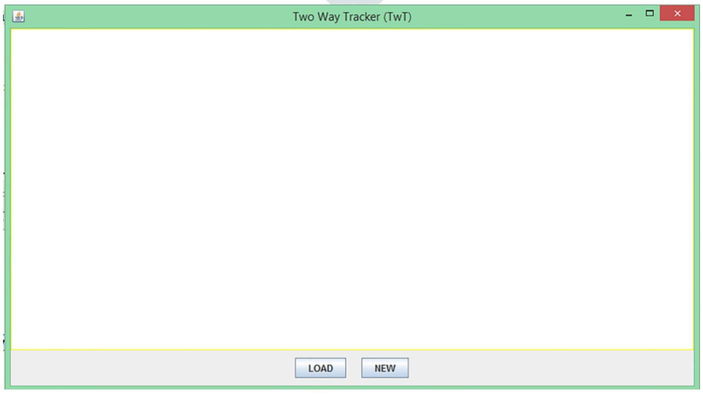

Fig. 5: Start-up Window

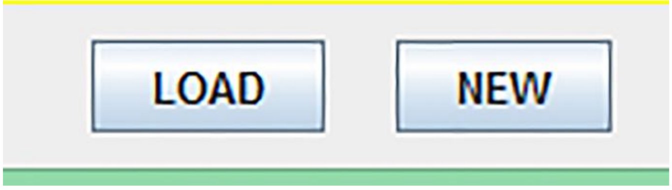

Fig. 6: Loading New Map

Figure 7 is showing the way of selecting a saved map from any location of the system.

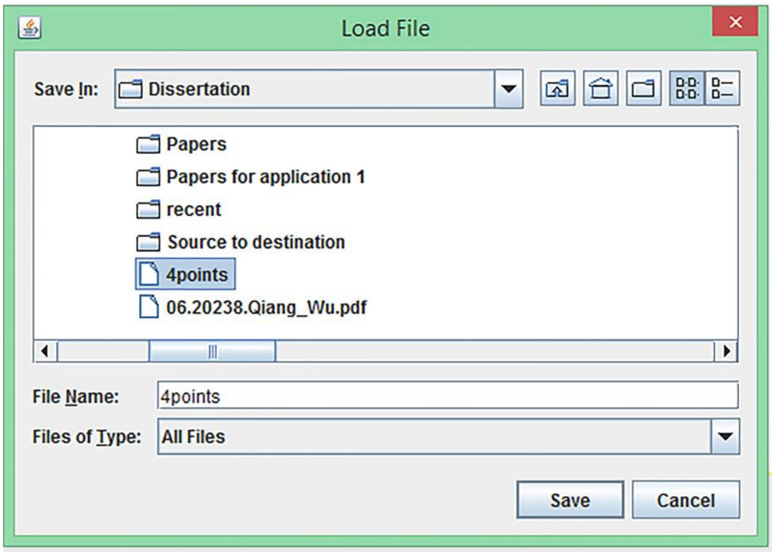

Fig. 7: Selecting New Map

By clicking "DRAW POINTS" button, the reference cross-cross points are being marked (Fig. 8).

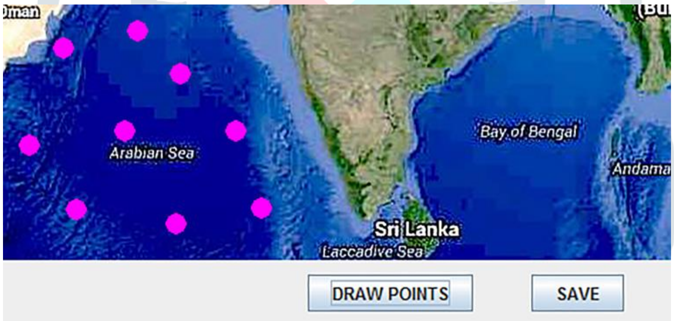

Fig. 8: Digitizing Reference Cross-Points

Next, the values of the influencing factors for the route-lets are entered by clicking onto the "SET PARAMETER" (Fig. 9) button, after which the information being fed is saved by clicking "SAVE" button (Fig. 10).

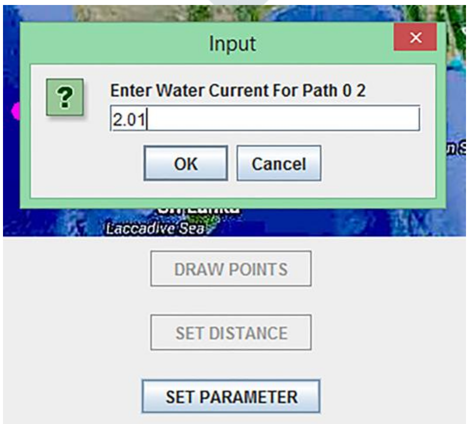

Fig. 9: Setting Parameters

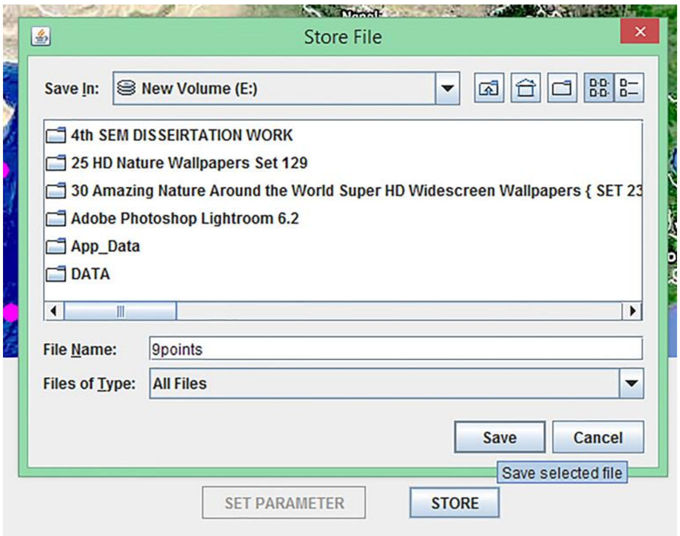

Fig. 10: Saving Data

Among the fed digitized points, any two can be selected as source and the destination points, which is being fed by clicking “SELECT SOURCE” (Fig. 11) and “SELECT DESTINATION” (Fig. 12) buttons respectively.

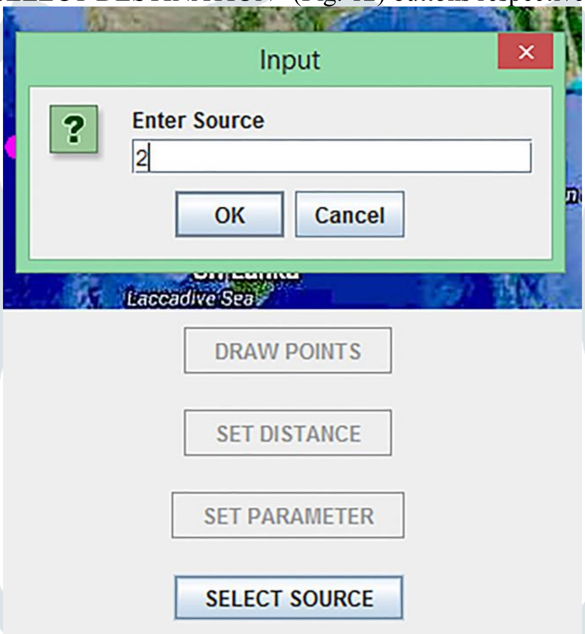

Fig. 11: Selecting Source

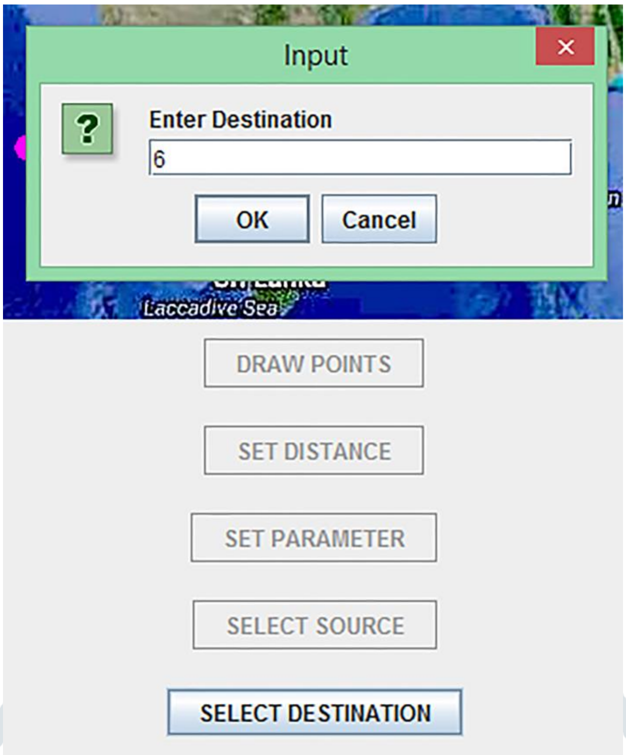

Fig. 12: Selecting Destination

At the final step, by clicking onto the "GENERATE PATH" button, the suggested optimal cum safest path from source to destination is displayed graphically by a red line (Fig. 13 and 14).

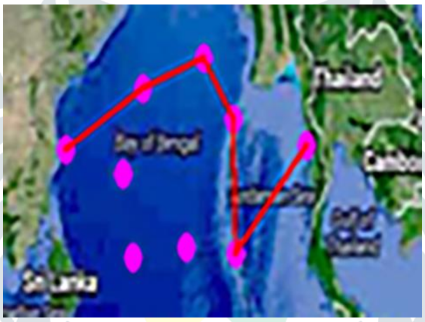

Fig. 13: Optimal Safest Path — Case Study 1

Fig. 14: Optimal Safest path — Case Study 2

Figures 13 and 14 depicts the fact that in different season, due to change in various influencing factors, the path between a pair of Source and Destination may also change.

IV. COMPARISONS

The output produced by the goal searching algorithm can be considered as Boolean, either Success (able to find the Goal node) or Failure (unable to find the Goal node). Some algorithms might get stuck in an infinite loop and never return an output. For comparing different Graph-based-Goal-Searching Algorithms, the useful matrices are Completeness, Optimality and Time Complexity. Table 15 reflects a concise comparison among various Graph-based-Goal-Searching Algorithms, with proposed TBT method.

Table 15: Comparison among various Graph-based-Goal-Searching Algorithms

Algorithm	Time Complexity	Optimal	Complete
Breadth First Search	$O(n^m)$	Yes	Yes
Depth First Search	$O(n^m)$	No	No
Simple Hill Climbing	$O(n^m)$	No	No
Steepest Ascent Hill Climbing	$O(n^m)$	No	No
Best-First Search	$O(n^m)$	Yes	No
Bi-Directional Search	$O(n^{m/2})$	Yes	Yes
Proposed Algorithm (TBT)	$O(n^{m/2})$	Yes	Yes

Where, m = depth of solution within search tree
n = branching factor of search tree

V. CONCLUSIONS

The proposed technique is a kind of goal searching methodology in a weighted graph, where the optimal and low cost (from the present application perspective it has been termed as safest) route between source and destination has found. So this technique could be applied in a number of challenging fields in GIS. Presently one such application area, finding shortest as well as safest route through ocean has outlined.

Till this twenty first century ocean is the main medium of transport of goods for many countries and multinational companies depends very much on cargo ships. In addition to the cargo ships the passenger liners are playing an important role for traveling throughout the world. Frequently it is being heard that many ships loss connectivity with radar, sink due to storm and face many other disasters just due to choose wrong route for traveling. The devastating incident of Titanic, a British passenger liner, is still alive in everybody's mind; which sank in the North Atlantic Ocean in the early morning of 15 April 1912 after colliding with an iceberg during its maiden voyage from Southampton, UK, to New York City, US. This heart touching incident results the premature deaths of more than 1,500 passengers and crew members.

The proposed work is in a way to stretch its helping hand for minimizing these heart breaking incidents. It foretells the captain about the safest route for propelling. The graphical outcome makes it very much understandable to anybody.

This technique cannot only be applied for the avoidance of road accidents and plane crashes due to selection of wrong route or decrepit road for traveling, by simply changing the influencing factors; but could play as a guide while traveling one place to another by side tracking deteriorated or clumsy roads.

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