A GIS-Assisted Optimal Lashio Route Finding Approach Based on A* Algorithm

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Abstract

GIS technology integrates common database operations such as query and statistical analysis with the unique visualization and geographic analysis benefits offered by maps. Geographical Information System (GIS) provides strong decision support for a user in searching optimal route, finding the nearest facility and determining the service. This system is intended to present Optimal Route Finding system for Lashio. In this system, A searching algorithm is used to find the optimal route for interesting places in Lashio map in a short time. The goal of this system is to explore different design issue associated with map based itinerary planning tools. This technique can be implemented to easily know the interesting places in Lashio.*

Keywords: GIS, Raster method, Spatial Model, A* Search Algorithm

1. Introduction

Geographical Information System (GIS) incorporates an elaborate way of capturing, analyzing and visualizing geo-relevant phenomena. GIS is used to digitally reproduce and analyze the feature present on the earth surface and the events that take place on it. It is designed to work with data reference by spatial/geographical coordinate [1].

GIS and Spatial Decision Support System (SDSS) are being used to generate alternatives to aid-decision maker in their deliberation [5]. GIS and SDSS typically lack formal mechanisms to help decision maker explore the solution space of other problem and there by challenge in their assumption about number of range of optimum available. These systems propose the use of A* search algorithm to generate arrange of optimum available. A* employs a heuristic function and is both complete and optimal. This means that A* will always find a path if a path exists and report failure if a path does not exist and the path that A* returns will be optimal in terms of the heuristics function. The structure of the A* algorithm is used to find the shortest path between the start and goal [4].

The advantage of using GIS is that it allows the user to select an origin and destination on a map, easing the tasks of inputting information to the searching process. In addition, the mapping feature of the GIS can provide a user-specific-map, showing the route(s) in longitude/ latitude map of Lashio.

This system provides users the option of selecting their origin or destination on the map of Lashio, manually entering an address or selecting a land map from pull-down menu. The routing algorithm then finds the optimum path and output is presented to the user both in text and mark on the map. It provides an interactive point and click map feature.

2. Geographical Information System (GIS)

Geographic Information System could be understood in two parts “Geography and Information system”. Firstly, “Geography”- it is study of relationship between man & environment and key tool to study this spatial relationship is map. Secondly, “Information system”- it is a continuous chain of data collection, storage of data, analysis of data, and use the derived information in some decision-making.

Geographic information (GI) is “information which can be related to a location (defined in terms of a point, area or volume) on the Earth, particularly information on natural phenomena, cultural and human resources [6]”. The positional data can be a specific set of spatial coordinates, or can cover less precise locations or areas, such as addresses, postal codes or administrative boundaries, regions or even whole countries. Most GI also includes a time dimension, since the world is not a static place. Geographical Information Systems (GIS) can be exchanged, used, modified and combined with other spatial and non-spatial data in an unlimited number of ways [3].

GIS technology integrates common database operations such as query and statistical analysis with the unique visualization and geographic analysis benefits offered by maps. These abilities distinguish GIS from other information systems and make it valuable to a wide range of public and private enterprises for explaining events, predicting outcomes, and planning strategies [3].

The spatial data used in the GIS can be categorized into three groups: those required for routing functionality, those complimenting an intermodal transportation network, and those landmarks that might aid in the use of the program.

2.1 Raster Model

Two types of spatial data structures, vector and raster, are commonly used to store and represent geographic information. In this paper, raster data structure is used.

In a raster representation, a matrix or rectangular array of cells is used to represent geographic information. Where image data are stored in a raster representation, cells are termed picture elements, or pixels. Where other spatial data are stored as a raster representation, the cells are termed grid cells. In either case, the grid is organized into rows and columns that are referenced to a common origin. Each pixel is assigned a value representing a geographic phenomenon such as elevation, land use, or population density. The raster structure is also used in image data such as scanned maps and aerial photographs, or satellite imagery. In the case of image data, cell values typically represent reflectance or brightness as opposed to geographic entities [3].

Raster data type consists of rows and columns of cells, with each cell storing a single value. Raster data can be images (raster images) with each pixel (or cell) containing a color value. Additional values recorded for each cell may be a discrete value, such as land use, a continuous value, such as temperature, or a null value if no data is available. While a raster cell stores a single value, it can be extended by using raster bands to represent RGB (red, green, blue) colors, color maps (a mapping between a thematic code and RGB value), or an extended attribute table with one row for each unique cell value. The resolution of the raster data set is its cell width in ground units [3].

3. A* Searching Algorithm

In this paper we propose the structure of the A* algorithm. The objective is to find the shortest path between the start and goal and the minimum number of squares we need to transverse in order to reach goal from start. The A* algorithm to enable to find an optimal path from its starting position to any goal location specified by a human operator for a given environment [2]. Inputs to our system should include:

- start and goal positions;
- dimension of the workspace (i.e. number of cells _ number of cells);
- map file of the workspace; and
- output the optimal path as a list of waypoints [4].

3.1 Properties of A* Searching Algorithm

The cost of the optimal solution path is C*. A* expands all nodes with f(n)<C*. A* might expand some of nodes with f(n)=C* on the "goal contour". A* will expand no nodes with f(n)>C*, which are pruned. Pruning means eliminating possibilities from consideration without examination.

A* is optimally efficient for any given heuristic function, h(n). That is, no other optimal algorithm is guaranteed to expand fewer nodes than A*. An algorithm might miss the optimal solution if it does not expand all nodes with f(n)<C* [4].

Algorithm 1 A* algorithm [4]

```
function A*(start, goal)
var closed = the empty set
var q = make queue (path (start))
while q is not empty do
    var p = remove _rst (q)
    var x = the last node of p
    if x in closed then
        continue
    end if
    if  x = goal then
        return p
    end if
    add x to closed
    foreach y in successors(x) do
        enqueue(q, p, y)
    end foreach
   return failure
end while
```

In this system, there are 30 nodes (interesting places) in Lashio.

3.2 Path Scoring

A heuristic function is considered the following equation:

$$f(n) = g(n) + h(n)$$

where n denotes the current cell, g(n) gives the distance to move from the start position, start, to the current cell n, and h(n) is the heuristic function which gives an estimate of the distance to move from the current cell n to the goal position, goal. In the path planning community, h(n) is often chosen to be the Euclidean distance between the current cell and the goal cell, i.e. he straight line distance between a current position and the goal position disregarding all obstacles in the environment. As such h(n)is generally chosen as a lower bound on the actual cost. Thus, given g(n) and h(n), the function f(n) is a conservative estimate of the distance of the shortest path from start to goal through the current cell n. The path is then generated by repeatedly going through our open list and choosing the cell with the lowest distance f(n) [4].

3.3 Finding Route from Yan_Aung_Myin Pagoda to Mansu Pagoda by using A*

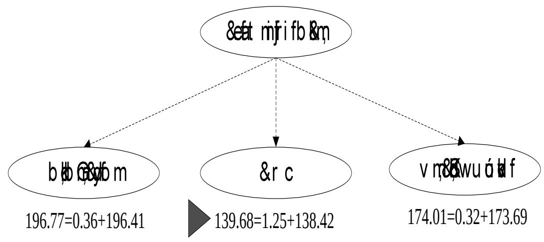
The following figures show the implementation of A* search. Source node is defined by Yan_Aung_Myin Pagoda and destination node is Mansu Pagoda. In A* search, the nodes expand closest to the goal. F(n)=g(n)+h(n). g(n) is the distance to reach the node and h(n) is the estimated distance to the goal from n. f(n) is estimated total distance of path through n to the goal.

Table 1. Heuristics Straight-Line Distance to Mansu Pagoda

Position	Lat , Long	h*sld*
ရန်အောင် မြင်ဘုရား	22’50’N 97’56’E	180.2
ဘိုးဘွားရိပ်သာ	16’22’N 97’23’E	196.41
ဂေါက်ကွင်း	22’50’N 97’53’E	351.03
ဘူတာ	22’53’N 97’51’E	259.94
ရွှေလီရိပ်သာ	22’53’N 97’59’E	167.94
ရမခ	22’51’N 98’1’E	138.42
အားကစားကွင်း	22’51’N 98’13’E	65.63
ရှမ်းစာပေ	22’50’N 98’13’E	28.38
မန်ဆူဘုရား	22’49’N 98’ 13’E	0
ရန်အောင် မြင်ဘုရား	22’50’N 97’56’E	180.2
ဘိုးဘွားရိပ်သာ	16’22’N 97’23’E	196.41
ဂေါက်ကွင်း	22’50’N 97’53’E	351.03
လေယာဉ်ကွင်း	22’55’N 98’7’E	162.96
နတလ	22’56’N 98’14’E	197.02
လားရှိုးတက္ကသိုလ်	22’49’N 97’56’E	173.69
သာသနာ ၂၅၀၀	22’49’N 98’5’E	95.47
လားရှိုးမိုတယ်	22’46’N 97’59’E	183.42
မြို့တော် ခန်းမ	22’46’N 98’2’E	152.52
သီတာအေး ရုပ်ရှင်	22’46’N 98’4’E	128.72
မန်ဆူကားကွင်း	22’49’N 98’11’E	40.49

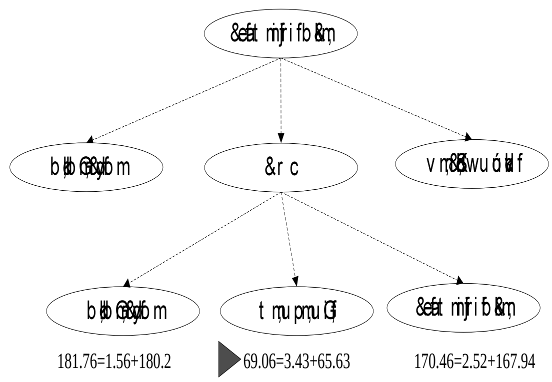
Table 1 is Heuristics Straight-Line distance table from Mansu Pagoda to other waypoints. A* algorithm replace this values as h(n) into the equation.

(a) The initial state



In this initial state, start expands from the source node as shown in Figure. f(n) of Yan_Aung_Myin Pagoda is 180.2, g(n) is 0 and h(n) is 180.2. After the initial state, must choose minimum distance waypoints. Yan_Aung_Myin Pagoda to Lashio University is 174.01 nautical miles. Yan_Aung_Myin Pagoda to Ya_Ma_Kha is 139.68 nautical miles. Yan_Aung_Myin Pagoda to Old peoples home is 196.77 nautical miles. In all waypoints Ya_Ma_Kha is minimum distance. So algorithm expands from Ya_Ma_Kha to the other nodes as shown in Figure.

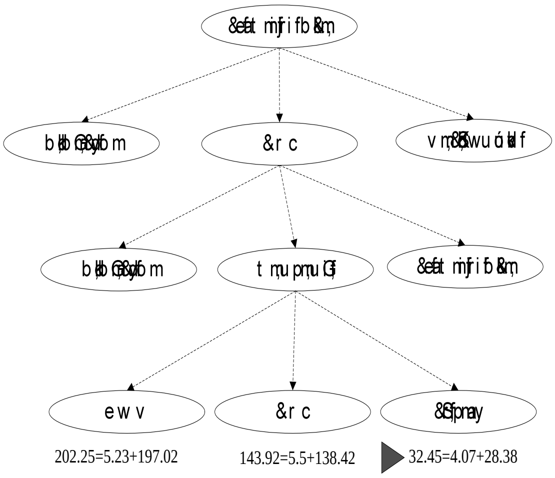
(b) After expanding Ya_Ma_Kha (22’51’N 98’1’E)



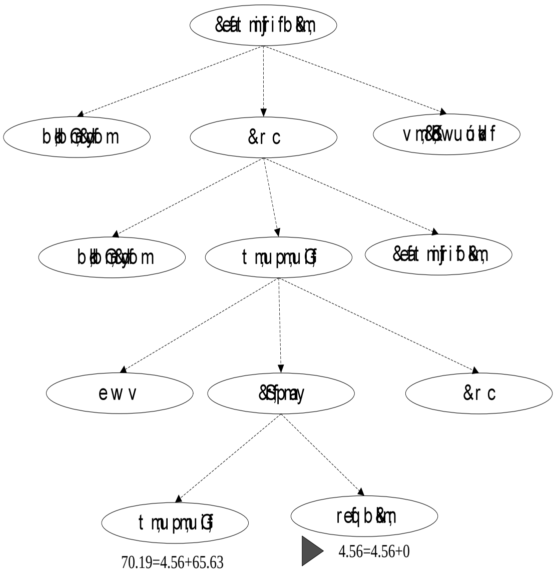
After expanding Ya_Ma_Kha, A* algorithm get from Ya_Ma_Kha to Namuta Road is 363 nautical miles. Ya_Ma_Kha to Yang_Aung_Myin is 182.2 nautical miles. Ya_Ma_Kha to Stadium is 69.06 nautical miles. Ya_Ma_Kha to Shweli Guest is 764 nautical miles. In all waypoints Stadium is minimum distance. So algorithm expands from Ya_Ma_Kha to the other nodes. After expanding Stadium, A* algorithm get Shan Sarpay is minimum distance.

After expanding Shan Sarpay, A* algorithm reach Mansu Pagoda as shown in Figure.

(c) After expanding Stadium (22’51’N 98’13’E)



(d) After expanding Shan Sar Pay (22’50’N 98’13’E)



4. System Design

There are two main phases in this system. They are Administrator level, which is performed to create Lashio map and add/modify route for users and then administrator calculates distance between two points, and the user level, which is performed to search the shortest path by using A* algorithm and the user can view shortest route from source to destination and the information of selected location.

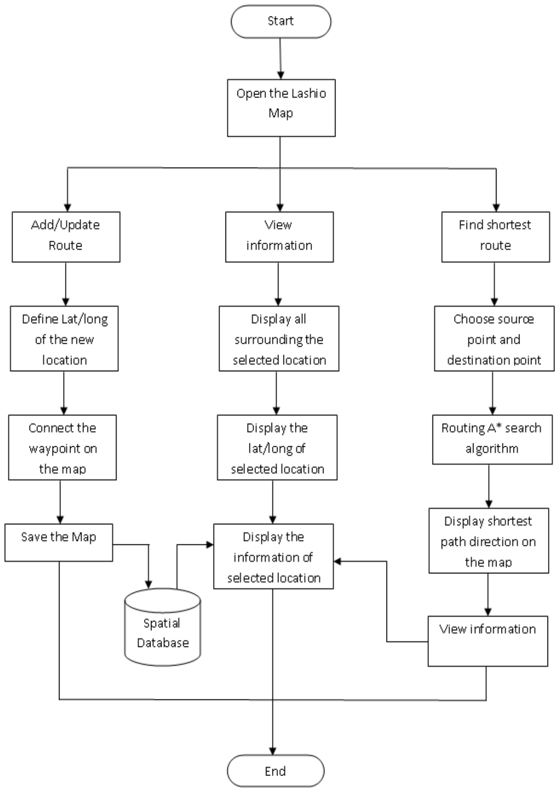


Figure 1. System design

5. Implementation

The user must choose source point and destination point in the system. And then, its searching is starting. In A* search, if the expanded tree node is arrival waypoint, the system will display the result of the goal. If the result is not goal, compute h_{SLD} value of all child nodes. And select the minimum h_{SLD} child node and compare with the target node. If the comparison node is null, call recursively A* search with minimum h_{SLD} child node as root and root as comparison node. If not, select minimum h_{SLD} child node of comparison node. Then the system compares two minimum h_{SLD} nodes. After that, the system calls recursively A* with minimum h_{SLD} child node as root and the other with comparison node. If the system meets its goal, compute minimize distance and running hours.

Figure 3 is View the Shortest Path and Information Form. The distance between nodes is marked by miles. Source point defined by Yan Aung Myin Pagoda and destination point Mansu Pagoda.

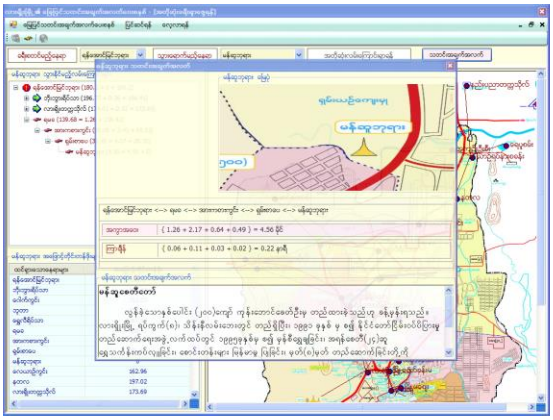


Figure 2. View the Shortest Path and Information Form

After searching the shortest path, if the user can view information of interesting place, the system will be displayed about the information and picture of the interesting places and distance mile and running hour of source to destination place as shown in Figure 3.

Figure 3 represent, if the user selects the point in the map, the system also displayed about the current position of latitude and longitude value, information of interesting place around the current position and picture of interesting place as shown in Figure 3.

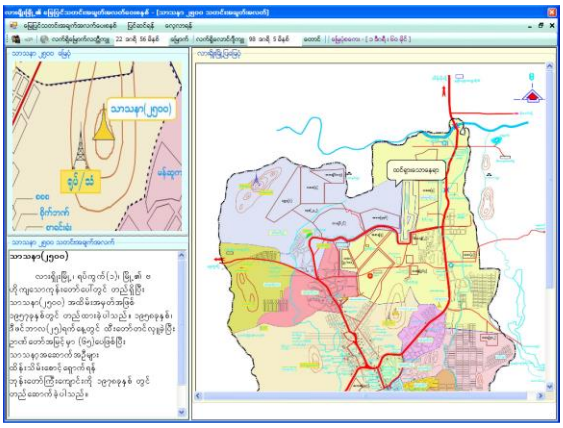


Figure 3. Information of the Interesting Place Form

The administrator can set the location of the interesting places on the existing Lashio map by using the one left click. Then the administrator can type the interesting place's name in the interesting place name input box as shown in Figure 4. Then the interesting places settled on the existing Lashio map, the system allowed the administrator to connect the interesting places each other by the administrator desire. If the administrator can choose the waypoint's name in the waypoint name input box, this waypoint marks with waypoint name or marks current latitude and longitude as shown in Figure 4. And then the system atomically calculates distance and running hours. After adding the interesting place completely, the administrator can see the preview of the chart. Then, the chart can be confirmed from the confirm button, and saved the chart in current interesting place location by the use of save button.

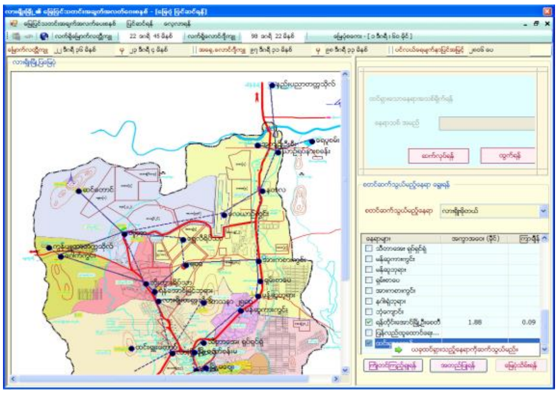


Figure 4. Add/Update Lashio Map Form

6. Conclusion

The goal of this system is to explore different design issues associated with map-based itinerary-planning tools. In this way, a prototype is demonstrated to use and modify existing GIS tools and software to create map-based optimal route finding system for Lashio. In this system, A* search algorithm is used to find the optimal route. This search algorithm is both complete and optimal because A* search algorithm can search optimal route and other possible way from source to destination. So A* algorithm is very suitable for this system. Implementation of the system in the major interesting places would be of great help to the travelers and tourists.

7. Reference

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