

Optimizing Gas Station Location Using Genetic Algorithms

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Abstract— Gas station location is not only based on financial but also environment aspects because it will give negative impact if there are some accidents such as fire, tank leakage, etc. Helping customer in supplying fuels should not sacrifice other needs such as health, food, education, living circumstance, and so on. Therefore we propose the system that can help someone deciding and analyzing the location of gas station, especially when doing proper analysis. By using genetic algorithms our system can find optimum location of gas station after considering other important location that must be far away from it. The distance from important place was counted by normal euclidean after converting road and the river at map into nonlinear equation using interpolation. Population was generated from converting road on the map into equation. The important places that must be far away from gas station are collected and with that equation then give an objective function. Testing result showed the system could find optimum gas stations location at Bekasi regency.

INTRODUCTION

In this paper, we present a genetic algorithms-based system for estimating optimum location of gas stations¹. This system integrated soft computing with Geographic Information System (GIS) in a single Graphical User Interface (GUI) using Matlab programming language.

Transportation is very important for national economic growth. For supporting it, every local government has to ensure the availability of fuels by establishing some gas stations. In the other hand, another aspects such as health, education, environment, and so on must be improved and have the risk of negative impact from gas station location. Fire accident, traffic jam, tank leakage, pollution, flood, etc., are some negative impacts that we can address. Therefore we must ensure the location of gas station having minimum risk if there is an accident to the vital places or regions. The evaluation of gas station location so far is domain of local government. This evaluation called environmental impact assessment (AMDAL)

1. Demonstration of this system can be seen at <http://youtu.be/IFIM0wPcgP8>.

as prerequisite if we want to build a gas station [8].

For many years, GIS is research area that having integration between geography and another discipline, such as statistics, sociology, and also with Information Technology [1,7]. The increasing technology of hardware and software make Information Technology become a main support of GIS application. Some GIS applications also have specific area such as Spatial Decision Support System (SDSS) that help giving decision based on map. GIS need some database manipulation and computation that information technology can solve that kind of problems. .

Description of The System

Bekasi regency has 23 local government that must be ensure to supply fuel. For easiness, we create eleven regions being computed by our system. One region has more than three main roads that must be evaluated by genetic algorithms. We note location that must be far away from gas station and then count it distance from every possible location near the road. The gas station must be build near the main road as instruction of our national oil and gas company, Pertamina, and also for easiness in supplying.

Every region shows a map after the user press the region button. The road having an opportunity as gas station locations have to be converted into equation. This equation than become base of population of our genetic algorithms. When optimization button is pressed, our system count the distance of every important location that must far away from gas station from the sample of population. Then, our system will choose the point having maximum number of total distance.

Geographic Information System

Because our research is looking for an optimum location of gas station, we have to integrate the genetic algorithms with spatial data using GIS. Although there are many application of GIS available in the market today, because it has to integrated with our Matlab application, we must create GIS using Matlab GUI.

Bekasi regency has 127.388 Ha of area, so we breakdown it into 11 region. Each region consists of or more sub regency that must be looked for the optimum location for gas station.

First, we must provide the scraps of bekasi regency map. Each scraps in GIS terminology called raster data has to combine with vector data. We use Joint Photographic Expert Group (JPG) picture format as a raster data because it has benefit in size. Of course, this data could not be processed until we integrate it to vector data. Both raster data and vector data then called layer. We have three layers: raster data, road as vector data, and important location also as vector data.

Second, we provide the vector data using Matlab software. The road has to convert into equation before plotting to GIS and important places have to plot according our local coordinate. We use simple script with Matlab language to

create equation as a representation of the road. For easiness we use linear equation, for example:

```
function y=jklmn(x)
    index=find(x <= 200);
    y(index)=-0.55*(x(index)-50)+350;
    index=find(200 <= x & x <= 430);
    y(index)=(x(index)/x(index))*265;
    index=find(430 <= x & x <= 445);
    y(index)=-6*(x(index)-445)+165;
```

Finally, we insert important places layer that user will be able to modify it. Important places are places that must be far away from gas station location because they have a high risk if there is an accident to gas station. The important places may be hospital, river, plantation, high voltage electrical tower, railroad crossing, school, government institution, and so on. Actually, this data is presented using matrix format that type in writer application such as notepad, ms-word, and so on, but with extension "DAT". Fig 1 shows combination of three layers as composition of our simple GIS. We use iteration to plot that layer.

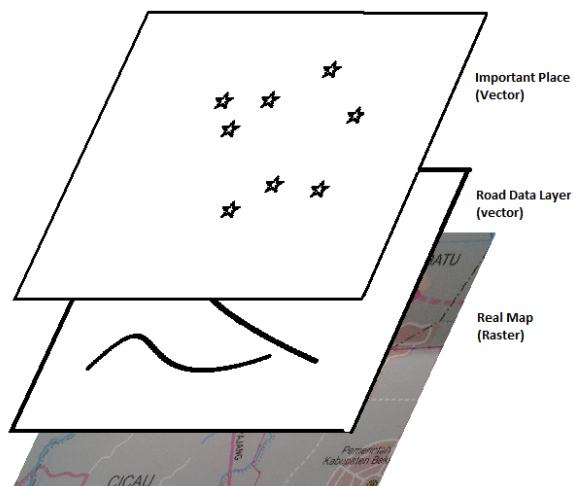


Fig. 1. Layer Composition of our Proposed GIS.

The iteration was used because if a user adds an important place the script can plot without recreating of our script. Figure 2 shows the tool for inserting important place as constraints of gas location. We iterated it using this simple script:

```
load datajih.dat
i=size(datajih);
```

```

i=i(1,1);
for j=1:i;
plot(datajih(j,1),datajih(j,2),'marker','*')
end

```

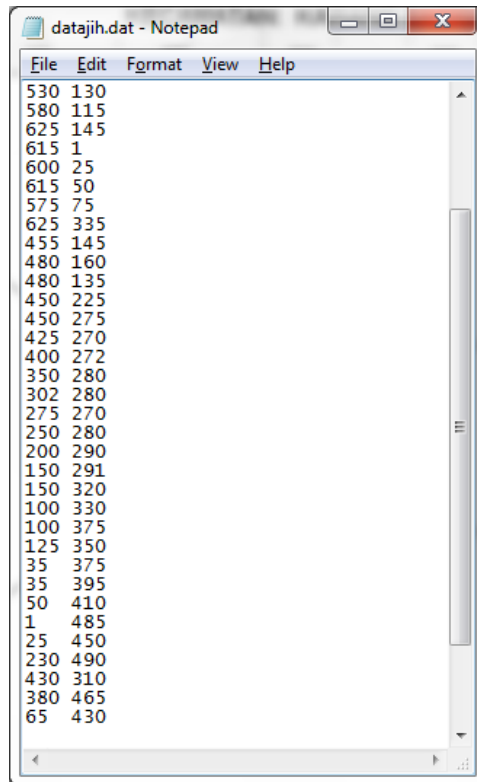


Fig. 2. Inserting Coordinate of Important Places

There is one problem when creating GIS in Matlab. The problem is different rule of coordinate system. The image showing in Matlab has ordinate axis the same as Cartesians but the ordinate is in opposite way (negative). Also the image showing does not have zero point. Therefore we must state the coordinate in our GUI in order user can understand it. Fig 3 shows the local coordinate of our GIS that different with Cartesians standard.

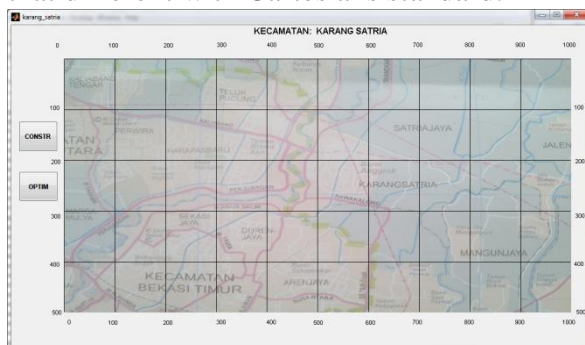


Fig. 3. Creating a Local Coordinate

Genetic Algorithms (GAs)

GAs are algorithms that trying to mimic the biology genetic. This kind of algorithm was introduced by John Holland and his students [2,3,4]. It has a robust characteristic and can solve the problem when there are so many local optimum points that conventional algorithms could not find the answer. The terminologies also similar to biological genetic such as chromosome, mutation, gen, population, and so on.

The arithmetic of GAs is easy and simple. The difficulty is only when creating a target function that must be solved for the optimum. This target function is called objective function. If we miss the target function, although our GAs done well, the result may be do not represent the actual condition. The stage of GAs procedures are: creating the population, evaluating the objective function, selection using appropriate methods, and choosing the best chromosome [2]. Figure 4 shows flowchart of our propose system.

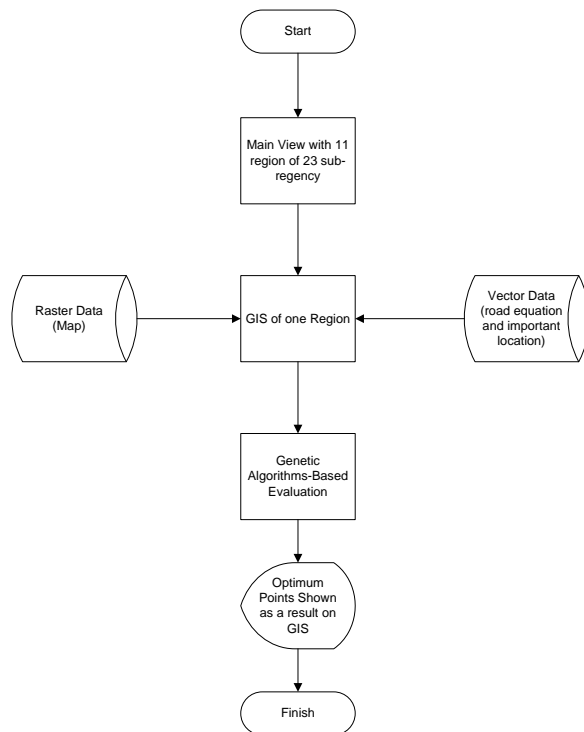


Fig. 5. Flowchart of Our Proposed System

Normal Euclidean

Normal euclidean is a method to count the distance one point to others. In our system, it used to count the distance from gas station location candidate to important places. The total distance of normal Euclidean is consider to be the

optimum location of gas station.

Figure 5 shows normal euclidean distance to other important points. After counting the distance, then add to other distance normal Euclidean from other points.

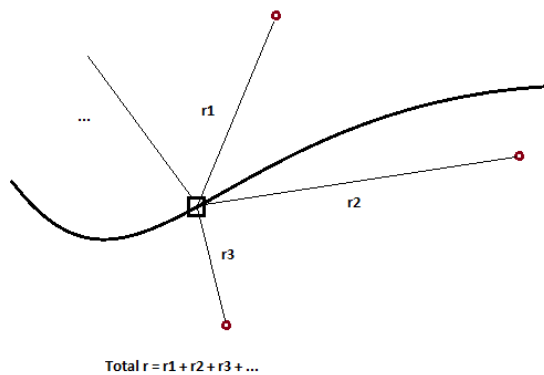


Fig. 5. Counting the Normal Euclidean Distance

The distance of two points can be counted by using this equation [6].

$$r = \sqrt{(x_2 - x_1)^2 + (y_2 - y_1)^2} \quad (1)$$

In Matlab we used this equation using a function “norm()”. It will apply to objective function of our GAs. This is one example of objective function using normal Euclidean.

```
function f=targetjklmn(x)
load datajih.dat
constrain=size(datajih);
i=constrain(1,1);
x(2)=jklmn(x(1))
fold=0;
for j=1:i;
p=[x(1) x(2)];
row=datajih(j,:);
f=1/(norm(p-datajih(j,:)))
f=f+fold
fold=f;
end
save p.mat
```

The default of GAs in Matlab is about finding the minimum. Therefore we have to inverse the objective function in order to find maximum.

Experimental Results

We have tried to optimize the gas station location at sub-regency at Karang Satria. First, we collected the important places that must be far away from the gas station. The important places are: river, local hospitals, schools, high voltage electric tower, railroad crossing, flood risk areas, government places, and plantation areas. The main view of our system can be seen at figure 6.

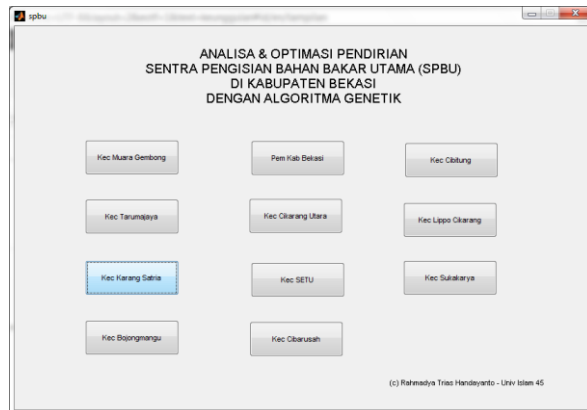


Fig. 6. Main View

Our GAs immediately runs when we press "OPTIM" button. A graphic appeared showing the running of objective function evaluation and best individual result. After for about one minute or two, our system shows the optimum location that far enough from the important places. Figure 7 Shows after our system find the optimum location of gas station at this region. The red lines are equation converted from raster image (map).

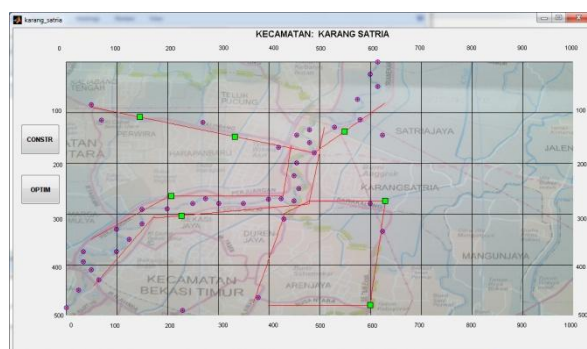


Fig. 7. Optimization Result

The user can see the graph of evaluation process. After fitness value reaching the minimum, the system will stop the calculation and give the best individual as the result. The result shown in Figure 7 as green square points, mean the optimum location of gas station that in general far away from other important location, shown in red circle points. Every result does not mean only one gas station. It may

be happen that two gas station stay in opposite location for solving pick condition at load factor [5]. Figure 8 shows the graph of GAs when evaluate the objective function.

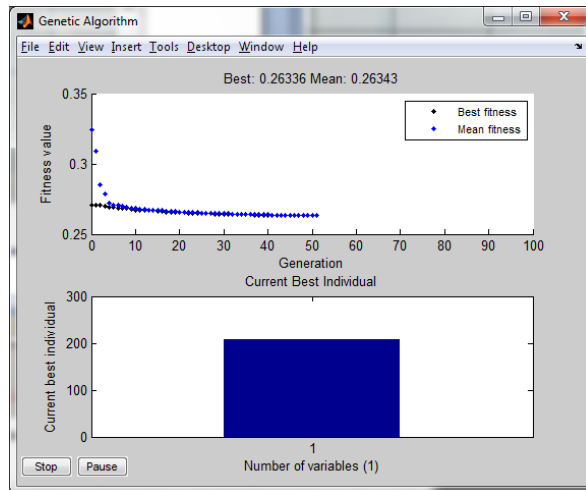


Fig. 8. Evaluation of Objective Function Graph

Improving Efficiency of Computation

Memory is an important stuff in a microcomputer such as a notebook or a gadget. GAs need a lot of resources when doing its job. Many generations need enough processor and Random Access Memory (RAM).

Pertamina, as a national gas company who supplies the gas to every gas station, needs easy access to them from storehouse (Depo) Pertamina Cikampek. The location of gas stations near the road is a must. Therefore we can use this situation as a basis to improve the computation. By using the road as a source of population we reduce the coordinate from two coordinates (x and y) to one coordinate (only x-axis), so we only need one variable for GAs computation.

Comparison to Other Systems

There are many implementations of GAs in other areas. The outstanding implementation is the Travelling Salesmen Problem (TSP), which gives an optimum route of sales with minimum distance and cost [2,3,4].

In Supply Chain Management (SCM) GAs show good results as well as in warehousing of goods in limited space. Both are related to economic benefits [3].

In education, some research has been done for example in scheduling. The limitations of teacher, room, and time can be solved and give the best schedule [9].

Our system integrates the geographic information system with genetic algorithms. Every user can easily look at the result by seeing the map at our GIS. Finally, by using vector data in GIS, users can manipulate data for important locations because there will be many changes in every area in the future.

Conclusions and Future Research

Experimental results show that our system can give the optimum location of gas station that far enough to the important places. This optimum location will differ if there are some changes of the city. The establishment of road, people migration, etc. will slide the position of its optimum location.

The optimization of location is important task of city government, and not only for gas station location. This research can expand to another optimization. Future research must be done for deeper analyzes such as geology, hydrology, pollution, and so on

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