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AUTOMATIC OPTIMIZATION OF THE ROUTE ON THE SCREEN OF THE CAR DRIVER

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ABSTRACT

The main goal of this work is to optimize the search time for gas stations, which is depending on the condition of the tank car, road congestion and the number of gas stations along the road to the car. This is done through the development of a fuzzy control system of decision-making and program optimization calculation time to the nearest gas station from the car.

Keywords: electric vehicle, optimization, energy efficiency, vehicle modeling.

1. INTRODUCTION

We always seek to reach the final goal through the shortest way; the task of finding the optimal path to the final goal of a driver without consideration of the car on the road is a meaningless task, also the exclusion of technical problems of car is a meaningless task.

There are many of problems that may arise such as the process of moving vehicle can be do not insufficient fuel in the tank with the time of delivery of cargo or passengers, traffic congestion, the existence of several gas stations without the possibility of determining what is the optimal way to the nearest etc.

To solve this problem, you can apply the theory of optimal control in the traditional theory, but this approach is not applicable in this case because of a priori uncertainty of the calculation time and the load of the road, the value of which may be inaccurate and / or approximate but not accurate.

In this case, the design of the control scheme, it is proposed to apply the theory allows to take the relevant decisions, this is the theory of fuzzy control

Fuzzy control is used to construct models of humansô reasoning and their use in fuzzy systems to improve quality control while reducing resource and energy consumption, provide better stability when exposed to all sorts of system perturbations.

Roadmap

When we need to describe a path and a road map to move the car to the specific goal, it is necessary to develop a plan to move it, with indicating the number of intersections, stop signs and gas stations, taking into account traffic jams and perform simulation [1-4].

To set up the model for path and road map to move the car run in MATLAB, since partition roadmap for individual intersections, it is necessary:

- To indicate the roadmap, suppose they have bounds [-6 - 6] (Figure-1);
- Split into sectors roadmap (junctions), we assume that there are six sectors and are arranged symmetrically;

where: xi, yi path describing the location of intersections and major roads.

As can be seen from (Figure-1) that coordinate trajectory consists of three intersections, three major roads and highways.

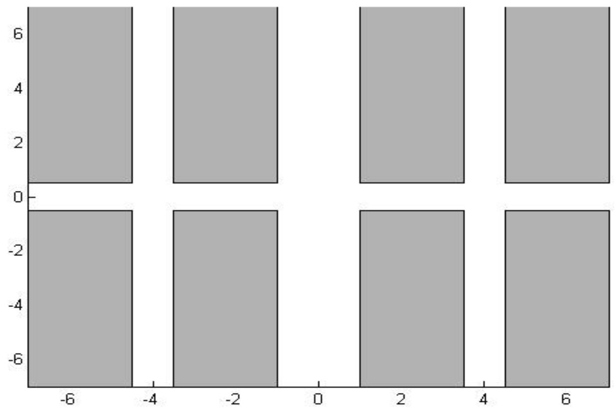

Figure-1. Border road map.

- For continue modeling process point out stop signs, signs on roads and location of fuel tanks.

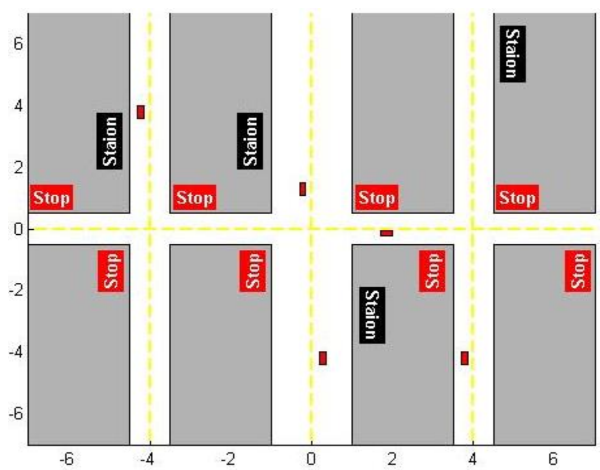

Figure-2. Full roadmap with delay elements.

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As can be seen from (Figure-2) delay elements are appear on the map like «Stop» sign, distance to the nearest gas station «Station» or sudden appearance of gridlock. And the roads are unloading items randomly «Start» signs and approximate distance to the target and taking into account the situation on the road will have the picture shown in Figure-3.

These elements are the basic input parameters automatic route optimization system of the vehicle, where the output parameter is the distance to the final goal, but the result of the work - calculation of the optimal time depending on the initial.

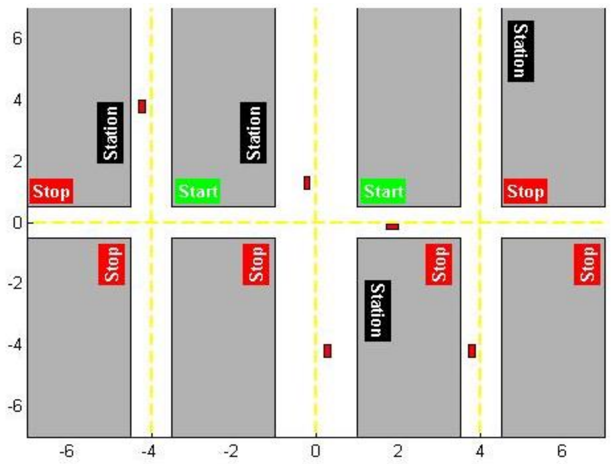

Figure-3. Full roadmap with elements of unloading.

2. PROBLEM STATEMENT AND PRELIMINARIES

2.1. Determination of the control method

There are a lot of methods to control, therefor in choosing a method of control is the success of the system, it is necessary to take into account all the requirements for the project management. As is known to control strictly nonlinear [1], based on what was selected fuzzy control theory.

It is known that there is a plurality of fuzzy control systems or decision-making, such as Mamdani [5, 6], Sugeno [6-8], Takagi [9], Takagi - Sugeno [9, 10], Takagi - Sugeno - Kang [9, 10].

To solve the problem of automatically optimizes of the route of the car, no need to use sophisticated algorithms such as TSC [10], but cannot be used as a simple algorithm as an algorithm Mamdani [7], for many reasons, one of which is the requirement for output parameter fuzzy inference algorithm, here we have linear process not just the decision making. Therefor in this article we will focus on the choice of algorithm Sugeno [10].

2.2. Sugeno fuzzy inference algorithm for optimizing the route of the vehicle

It is needed to work in specific road map for simplicity that use the one show in (Figure-3) that moves upon it a car to be adjusted on the basis of fuzzy logic algorithm using Sugeno fuzzy inference.

The Sugeno fuzzy inference has four inputs and one output. We define the module inputs Sugeno like the following:

- Start-Stop state for the route (ST);
- Coefficient of congestion along the selected route (KP);
- The proportion of fuel to the final goal of the route (TK);
- The number of gas stations, taking into accounts all possible paths to the final goal (AP).

Output parameters of the algorithm:

- The optimal path to the final goal, depending on the ratio of the amount of fuel in the car and for the number of petrol stations (OP).

Define the levels of factors and parameter (possible values) is shown in Table-1.

Table-1. The levels of factors and parameters.

Variable	Fuzzy value	numeric value
ST	Small Average High	[1-3] [2-5] [4-8]
KP	Low Average High	[0-0.25] [0.2-0.5] [0.4-0.75]
TK	Low Average High	[0-0.33] [0.2-0.66] [0.5-1]
AP	Small Average High	[1-3] [2-4] [3-5]

Fuzzy decision algorithm Sugeno decision-making system is shown in Figure-4.

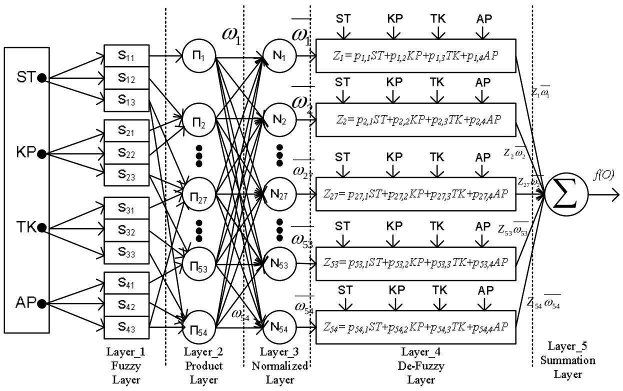

Figure-4. Fuzzy decision algorithm Sugeno management system roadmap.

Sugeno FIS was proposed to develop a systematic approach to generate fuzzy rules from a given input-output data. The Sugeno FIS architecture used in this paper for

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the choice the optimal way to the final goal of a vehicle is shown in Figure-3. The rule base for Sugeno FIS is given by:

- if (ST is S_{11}) and (KP is S_{21}) and (TK is S_{31}) and (AP is S_{41}) then Z1 = r_1 (ST, KP, TK, AP);
- if (ST is S_{12}) and (KP is S_{21}) and (TK is S_{31}) and (AP is S_{41}) then Z1 = r_1 (ST, KP, TK, AP);
- if (ST is S_{13}) and (KP is S_{21}) and (TK is S_{31}) and (AP is S_{41}) then Z1 = r_1 (ST, KP, TK, AP);
- if (ST is S_{11}) and (KP is S_{22}) and (TK is S_{31}) and (AP is S_{41}) then Z1 = r_1 (ST, KP, TK, AP);
- if (ST is S_{12}) and (KP is S_{23}) and (TK is S_{31}) and (AP is S_{41}) then Z1 = r_1 (ST, KP, TK, AP);
- if (ST is S_{13}) and (KP is S_{24}) and (TK is S_{31}) and (AP is S_{41}) then Z1 = r_1 (ST, KP, TK, AP);

with

$Z_k = r_k$ (ST, KP, TK, AP) $k = 1,...,38$

where: S_{ij}, Z_k, and r_k represent the *jth* membership functions of the *ith* input, the output of the k_{th} rule, and the *kth* output membership functions, respectively.

As shown in Figure-4, the Sugeno FIS structure consists of ýve layers: fuzzy layer, product layer, normalized layer, de-fuzzy layer, and summation layer. The operating mechanism of the layers for Sugeno FIS can be described as follows:

Layer-1:

In this layer, the crisp input values are converted to the fuzzy values by the input membership functions. In this paper, the following generalized bell for the inputs is used:

Generalized bell membership functions for (i=1é 4), (j=1, 2, 3), (x = ST or x = KP or x = TK or x = AP):

$$S_{ij}(x) = Gbell(x; a_{ij}; b_{ij}; c_{ij}) = \frac{1}{1 + \left| \frac{x - c_{ij}}{a_{ij}} \right|^{2b_{ij}}}$$

where a_{ij}, b_{ij} and c_{ij}, are the premise parameters that characterize the shapes of the input membership functions.

Layer-2:

In this layer, the weighting factor of each rule is computed. The weighting factor of each rule, which is expressed as ω_k, is determined by evaluating the membership expressions in the antecedent of the rule. This is accomplished by ýrst converting the input values to fuzzy membership values by using the input membership functions in the layer_1 and then applying the «and» operator to these membership values. The «and» operator corresponds to the multiplication of input membership values. Hence, the weighting factors of the rules are computed as follows:

$\omega_1 = S_{11}$ (ST) S_{21} (KP) S_{31} (TK) S_{41} (AP)
$\omega_2 = S_{12}$ (ST) S_{21} (KP) S_{31} (TK) S_{41} (AP)
$\omega_3 = S_{13}$ (ST) S_{21} (KP) S_{31} (TK) S_{41} (AP)
$\omega_4 = S_{11}$ (ST) S_{22} (KP) S_{31} (TK) S_{41} (AP)
.
.
.
$\omega_{37} = S_{137}$ (ST) S_{237} (KP) S_{31} (TK) S_{41} (AP)
$\omega_{38} = S_{138}$ (ST) S_{232} (KP) S_{31} (TK) S_{41} (AP)

Layer-3:

The normalized weighting factor of each rule, $\overline{\omega}_k$ is computed by using

$$\overline{\omega}_k = \frac{\omega_k}{\sum_{i=1}^{36} \omega_i} \qquad k = 1,...,36$$

Layer-4:

In this layer, the output rules can be written as:

$$\overline{\omega}_k S_k = \overline{\omega}_k r_k(SP, KP, TK, AP)$$
$$= \overline{\omega}_k (p_{k1}SP + p_{k2}KP + p_{k3}TK + p_{k4}AP)$$

$k = 1,...,38$

where p_k are the consequent parameters that characterize the shapes of the output membership functions. Here, the types of the output membership functions (r_k) are linear.

Layer-5:

Each rule is weighted by own normalized weighting factor and the output of the FIS is calculated by summing of all rule outputs:

$$f(O) = \sum_{i=1}^{36} \overline{\omega}_k Z_k = \frac{\sum_{i=1}^{36} \omega_k Z_k}{\sum_{i=1}^{36} \omega_k}$$

The Sugeno FIS used in this paper contains a total of 304 ýtting parameters, of which 34 (3×3+3×4+2×2+3×3=34) are the premise parameters and 270 (5×54=270) are the consequent parameters.

2.3.. The block diagram of Sugeno fuzzy control algorithm for roadmap

Based on the developed Sugeno fuzzy algorithm we are going to create a block diagram of the system management of roadmap Figure-5.

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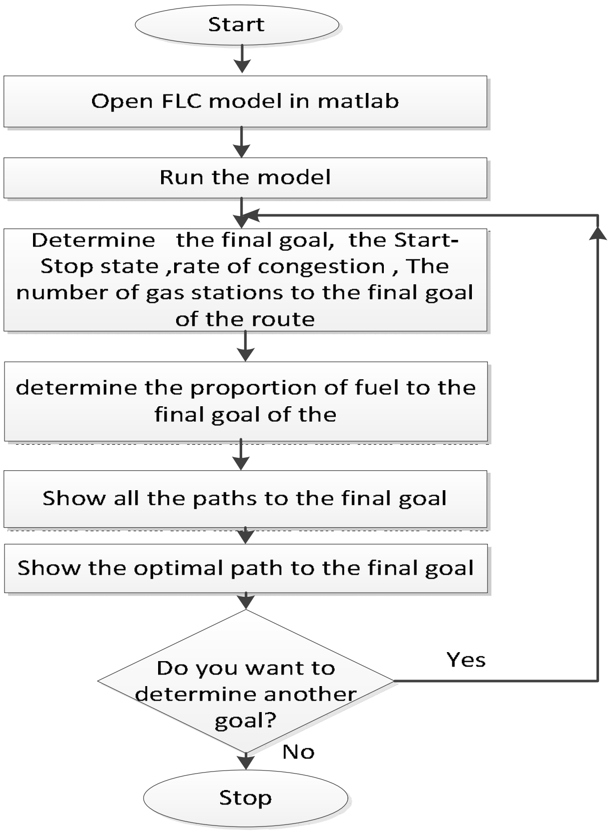

Figure-5. the block diagram of fuzzy control for roadmap.

Initially, the model needs some information to run and show all available paths to reach to the goal, therefore some data were obtained from satellite like the number of gas station through the road to the final goal, traffic state, proportion of congestion of road, determine the proportion of fuel, which is need to reach to goal. Then, when the tank of car needs to fuel to continue the road the model of Sugeno fuzzy control can determine all the paths from source to destination cross to gas stations and then it shows the best path to full the tank of car and reach to destination.

After that, the model asks the driver if wants to determine another destination, if a driver need to reach to another place, then must determine the place on the map, the model takes required data to determine the best path.

3. AN EXAMPLE AND SIMULATION RESULTS

Based on above model, the simulation is done. In this simulation Sugeno fuzzy control algorithm works to determine the optimal path for the blue car from the source A to the goal B (Figure-6).

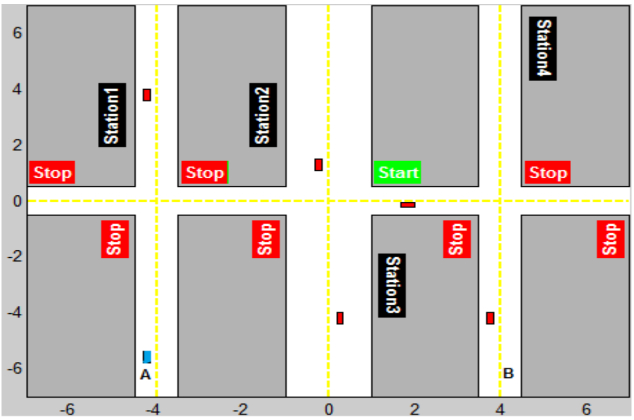

Figure-6. Roadmap with source and destination.

Firstly, the car needs to go to gas station to continue the road to final goal. The program depended on the inputs value and shows all paths the nearest stations to car like in (Figure-7.) There are three paths to reach to goal.

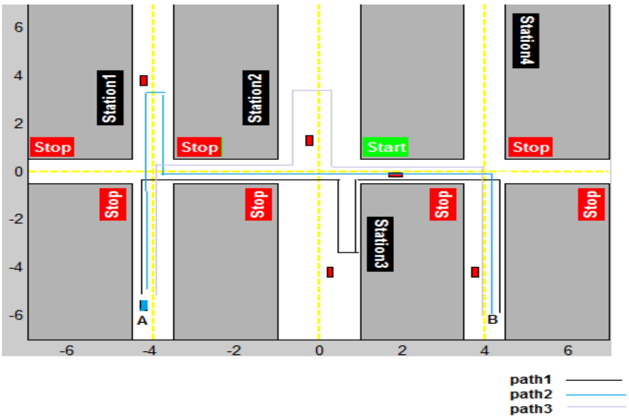

Figure-7. All the paths to reach destination.

Then the program shows the best path in terms of the nearest one to the car, through this path the car arrives to the goal quickly, so the best path to the blue car shows like in (Figure-8).

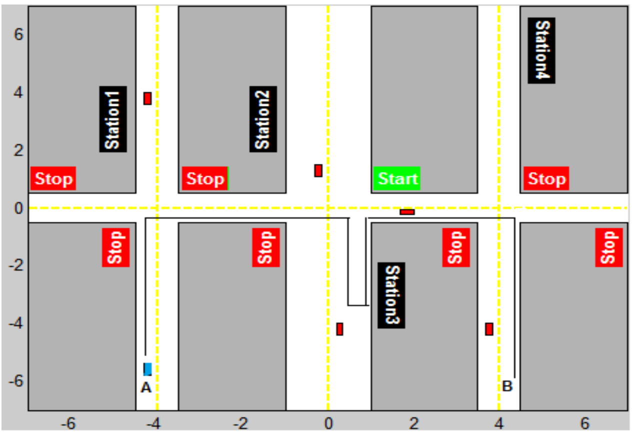

Figure-8. The best paths to reach destination.

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We also apply this program with new information such as new source, destination and another road as (Figure-9).

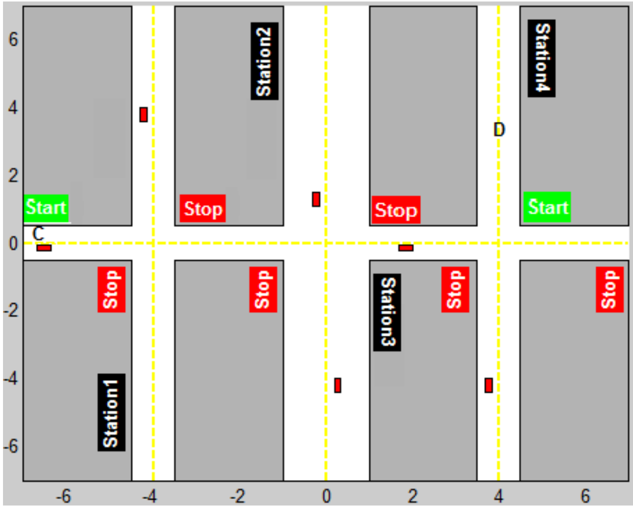

Figure-9. New roadmap with source and destination.

From (Figure-9), the car wants to move from source C to destination D, it needs to fuel from station to continue, the program shows are three paths from C to D, through these paths the car can takes fuel and arrive to the final goal as can see in (Figure-10).

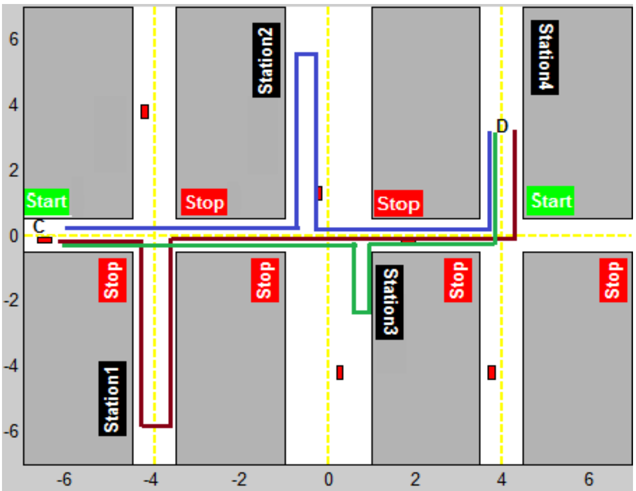

Figure-10. All the paths from source C to destination D.

After that the program appears to a driver of a car the best path to reach final goal D from source C and save the time like in (Figure-11).

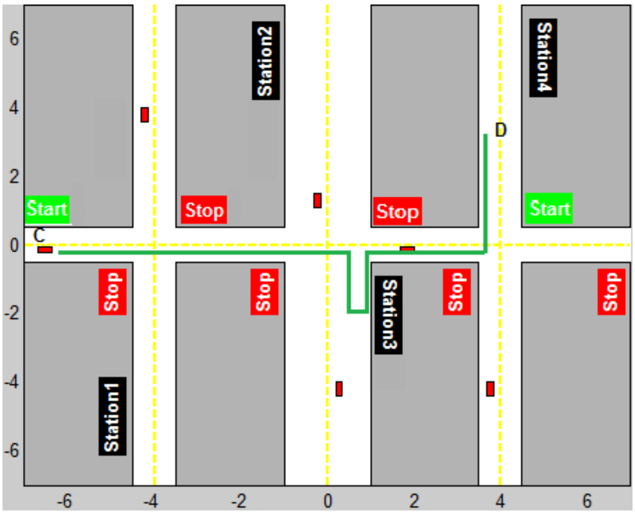

Figure-11. The best paths to reach destination D.

Finally, we give final example to prove the efficient of the program in many roads, so here we suppose that the driver wants to move from source E to final goal F like in (Figure-12).

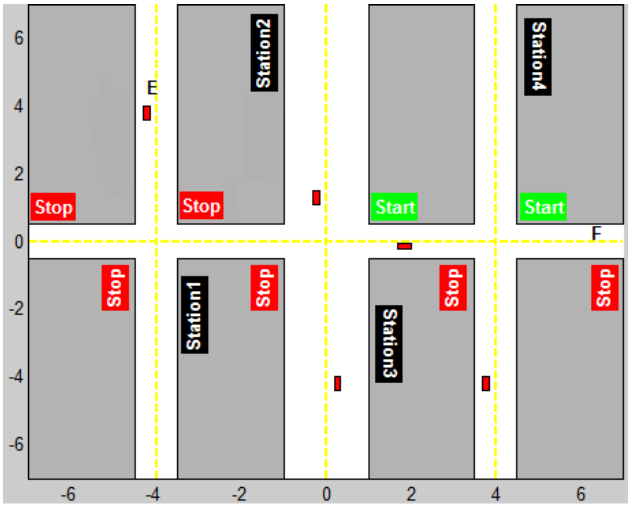

Figure-12. roadmap with source E and destination F.

The program gives the driver many choices of available paths to go to his final goal F from source E and here there are three choices (Figure-13).

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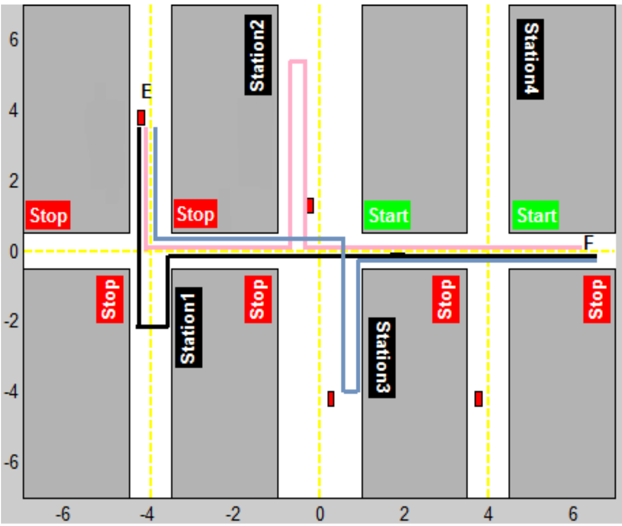

Figure-13. All the paths from source E to destination F.

The program here also gives the driver the optimal path to arrive to destination F (Figure-14).

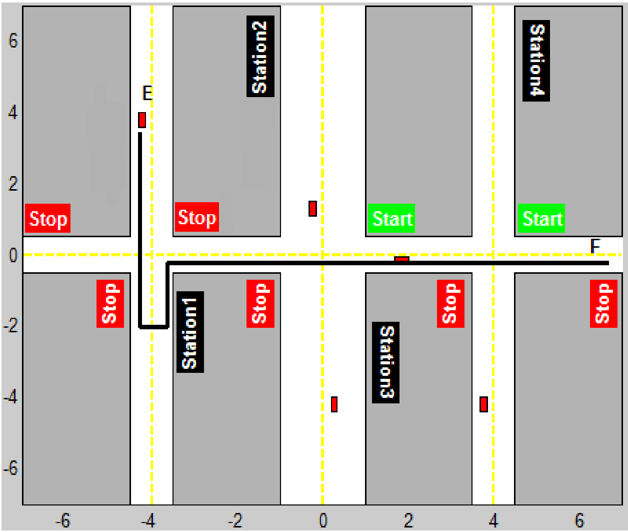

Figure-14. The best paths to reach destination F.

From the three examples above, the Table-1 represents the coordinate of the optimal path for each example.

Table-2. The coordinates of optimal path in examples.

Source	Destination	Angles/s	Goal/s
A	B	9, 177/16	20, 9/90
C	D	10, 464/18	26, 669/107
E	F	10, 597/21	23, 033/100

4. DISCUSSIONS

In this study, the results show that using the Sugeno fuzzy logic control is the optimal way to find the best path to car in terms of saving the time and simplicity of theory. Meanwhile, it gives the driver all possible paths to arrive to destination.

The theory of Sugeno considered one of the best theories to solve this problem without any complexity.

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