

GPS Assistance taximeter suited to the characteristics Of a City

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Abstract— Today almost every one use a taxi, in many countries the rate is agreed upon the service is taken, in many cases the rate is too low or high and the service is not taken, on the other hand taximeters provides good estimated of the service but are too complex to install in a cab and maintain. Today we can get advance of GPS technology to improve and enhance the taximeters while the rate is calculate base on the different features of a city. We propose a novel algorithm to calculate rate using GPS data and base on the different features of a city; we build a prototype and test it with very good results.

Keywords—*gps; taxi; taxímetro*

I. INTRODUCTION

The GPS is a global positioning system consisting of an orbit of 24 satellites, which were originally used for military purposes. Nevertheless, it was opened later for commercial and civilian use, [1], [2], [4] and [6].

Consisting on a constellation of 24 satellites that are located in 6 orbital planes with 60° of separation between each of them [2]. Like any satellite-based system, the timing is very important, that is why they are equipped with 4 atomic clocks: two cesium and two rubidium.

The GPS navigation system consists of 3 basic parts, which are: navigation control center, the terminal and the VHF wireless communication network. Vehicle navigation terminal indicates the current position of the vehicle, its speed, and other information in accordance with the GPS receiver. After processing this information, it is transmitted to the control center [4].

GPS provides 2 service levels which are SPS and PPS [9]. The SPS is the standard obtained with the simple frequency C/A code. The PPS is the precise service based on code P for dual frequency and is only accessible to authorized users. The C/A code is used for civil purposes, L1 and L2 are its frequencies.

The idea of NMEA is to send a data line, which is completely independent [11]. All the lines of the NMEA protocol must begin with the symbol "\$" [7] and [24], followed by the letters GP. The size of each line should not exceed 80 characters of visible text. There are different types of message, and each one of them provides different parameters, which gives information. The most basic are the GGA, RMC the GSA, [18].

It is very common that taximeters use electrical impulses, and that they are connected to the car transmission. The electrical impulses enable the taximeter to measure the distance and time [15].

In this work present a novel taximeter, that consider some parameter of geography and socioeconomically situation from a city.

This work has been developed in a city without any type of taximeter, and it is a priority improve the service of the public transportation system. Another important information is that it has a particular geography, so it is important to take in mind the different conditions of travel and the different costs.

II. BASIC PARAMETERS

The algorithm of a GPS-based taximeter, it is proposed to provide rate according to the distance travelled, also taking into account parameters which are:

- Place
- Time
- Fuel Consumption
- Additional Charge
- Date (holiday).
- Traffic Hour
- Cost of Fuel.

The algorithm to measure distance that has been developed is based on different parameters, one of which is the points that GPS delivers. Hence, the first important thing is to consider the frequency of the point taking.

A. Definition of the frequency of the point taking

To define this, it is necessary to first take measures every 40 seconds, then every second in moderated traffic conditions, at an average speed of 40 Km per hour (maximum rate allowed) [23].

In Figure 1 are the points taken in the first case, the route starts at *a* ends in *b*; and you can clearly see that is not feasible because de reconstructed routes is not real. This is because the time between points is too long.

Fig. 1: Case number 1 taken from points every 40 seconds



In Figure 2, the second case, where the decision is every second it is viable because you can take the points and reconstruct the real distance that the car is traveling. In this case the error is less than 1 m that does not change the measurement considerably.

Fig. 2: Second case, take points every second



In addition, it is important to consider that the maximum speed is 40 Km/h, [29]; this speed may vary depending on the place where the system is deployed. It is important that the space between points will not be so big, for that reason the next formula is enunciate.

$$t = \frac{V_{max}}{11 m} \quad (1)$$

Where:

t: It is the interval to take the points

V_{max} : The maximum permitted speed

The system take a point every 11.11 m approximately when it is configured to take a point every second, as shown in Figure 2. Taking this interval of points, we will have 10 points per block approximately.

B. Division of the city

To achieve an efficient way of pricing the taxi service, try different kinds of methods. First dividing the city by sectors, first urban, semi-urban and rural if they exist, to later divide the urban sector in areas where the fee will change depending on some factors, it is important that that the algorithm does not become too complex division of this sector is as homogeneous as possible.

you can see how would be the first possible division, which is in concentric circles, the central area of this figure represents what would be the Centre of the city, and while go away and exchange areas also would change the base price given per meter. In this type of graph the entire circumference will have the same price level and the size of the circumference will be depending on how many messages are taken per second of all the GPS receiver module delivery. And speed of average vehicles have in the city.

The second way is proposed in figure 3 too. Where each circumference is divided into zones, this makes the method more specific, but at the same time this brings one greater complexity, since to make it as similar as possible to the figure, the streets in the city should be square which unfortunately is not. And also should bear in mind the azimuth angle of the path that the taxi driver is taking.

Fig 3: Division into zones concentrically and in each level



The last form that has been proposed for the calculation of the rates, as shown in Figure 4, is the divide the city by districts and in turn each one in urbanizations. This would be simpler if all districts were square or at least have regular form, but this is not real unfortunately as shown in Figure 5, which is a graph taken from Google Earth, with an example, of the form for a district. This heterogeneous forms makes impossible to develop this three proposals.

Fig. 4: Division by districts and urbanizations

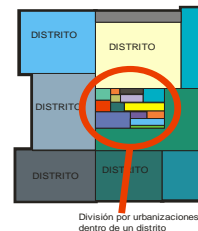


Fig. 5: Map of the city with an example of a district



At last the algorithm of division chosen is to divide the city into squares of 1 Km per side, this algorithm has been chosen to simplify the programming, without reducing the system's efficiency. The division can be seen in Figure 7, several of the squares divide a single district, and can be differentiated by percentages that will be multiplied by the rate base. The dividing lines of the quadrants must be parallel to the meridians and the parallels so that the algorithm works properly.

Fig. 6: City divided in squares of 1 Km per side



III. ALGORITHM

For the calculation of distance, it is important to explain in advance the logic that will be used, taking in mind that every measured point will have its own latitude and longitude. Knowing that the longitude is parallel to the Equator and the latitude is transversal to it. In the worst case, wherever you go a triangle will be drawn. Otherwise, either the longitude or the latitude will increase.

Taking into account that we will use a point every second, these triangles will be small, as shown in Figure 7, using the Pythagorean theorem we can get the distance value. For this the formula we will use for the worst case will be:

$$Distance = \sqrt{(FPlat - IPlat)^2 + (FPlon - IPlon)^2} \quad (2)$$

Where:

FPlat= Final point in latitude

IPlat=Punto Inicial en latitud

FPlon= Final point in longitude

IPlon= Initial point in longitude

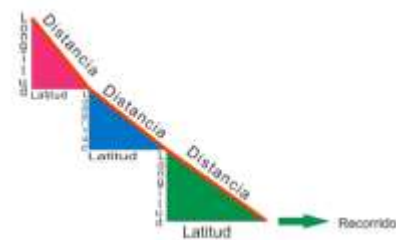
To make this possible, it is necessary to convert the longitude and latitude, which are currently in degrees, minutes and seconds; to meters. Taking in consideration that all meridians have an approximate length of 20003,916 km that go from - 90 to 90 degrees, i.e. 180°: The approximations of geographical coordinates to meters can be found in table 1.

TABLE 1: APPROACH GEOGRAPHIC COORDINATES TO METERS

Coordenadas Geográficas	Metros
1°	111000 m
1'	18350 m
1''	30.83 m

The three values that were converted to meters are then added. The same procedure is done for length. After this process, formula 2 can be used. The distances obtained will be accumulated and will become the total distance of the route.

Fig 7: Method to measure distance



For the calculation of the fare, in addition to the distance travelled, it is fundamental to know the actual quadrant of the taxi. This will give a percentage that is multiplied to the rate base, which is given by every 20 meters.

The rate base will be differentiated for each company according to their expenses, being able to determine their rate base for the day. This will be entered in an encrypted way by means of the keyboard's system. For the implementation of the prototype, was calculated a rate base through the different pricing tables that exist in the city, thus, obtaining the rate base of 0.008 as proof.

The percentages of each quadrants was calculated based at empirical study, using the comparative analysis. That was made with the different tables of prices found at the city. Each company provides a percentage to the different areas of the city, this values depends. So this table also need to be differentiated for companies. For the implementation of the prototype the division of the city is shown in table 2 and table 3. The percentages of each quadrants is shown at table 4.

TABLE 2: LATITUDE DIVISION IN 1 KM.

Latitude	Grades	Minutes	Seconds	Meters
16°	19	17.82	35695.5906	
16°	19	50.91	36715.7553	
...				
16°	28	12.04	52165.5932	
16°	28	45.13	53185.7579	

TABLE 3: LONGITUDE DIVISION IN 1KM

Longitude				
Grades	minutes	seconds	Meters	
71	27	55.06	51642.0998	
71	29	34.48	54707.2184	
...				
71	36	47.23	68048.9009	
71	37	20.37	69070.6071	

IV. TEST/CASES

This section will be an example of follow-up to a possible route for a taxi, and how the rate calculated. It is shown in table 5, in this example, the basic rate taken is 0.008 soles, for every 20 meters. The chosen route begins at the plaza de Armas to the Calle Fernandez Davila.

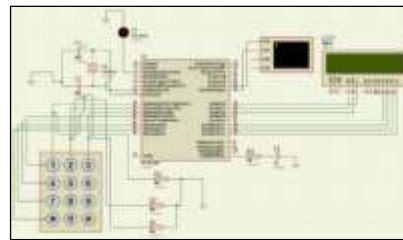
In this table you can see that the total at the end of the tour fare, has a reasonable according to the distance of travel cost, since this example consists of a short route where the percentage by area is the same, the final price is a price low.

V. IMPLEMENTATION

A. Design

Diagram schematic fact software Proteus you can see in Figure 12, this figure shows that to simulate GPS input which not is located inside the devices, owning this software; has been used a virtual terminal, which is connected to the port of the microcontroller PIC 18F4550 serial. [24].

Figure 8: Taximeter's Schematic



If the service is during in an hour or zone of traffic, the taximeter sends a high number of frames, if these are more than 20 each 20 meters, the rate increases in 30% of the rate base every 20 meters that the car is in the same state. This amount is determined by the average expenditure which the driver uses to move normally, without a situation of high traffic.

Another situation that also adds a percentage to the rate base is the day. If the service is being on Sunday or in holidays the basic rates increase in 50% more. Besides if the service is taken in hour from 10:00 pm to 4:00 am, the basic rate add a 10% more.

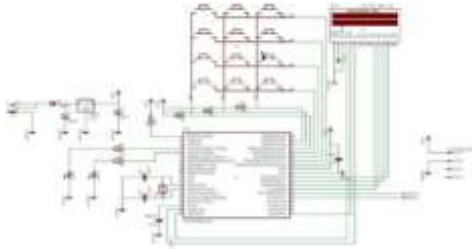
The line ZDA is used to know the date. This line will be taken into account only at the beginning of the service.

And finally to know if the service is providing to high hours of the night, used the line called GLL, where gives the current time in UTC format data.

TABLE 4: PERCENTAGE FOR EACH QUADRANT

Longitude	51642.099	52663.806	53685.5122	54707.2184	55728.9246	56750.6308	57795.7678	58817.474	59840.1051
Latitude									
35695.5906	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01
36715.7553	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.05
37735.92	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.05
38756.0847	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.05
39776.2494	0.01	0.01	0.01	0.01	0.03	0.03	0.4	0.001	0.03
40986.9435	0.01	0.01	0.01	0.01	0.03	0.03	0.4	0.4	0.4
42007.1082	0.3	0.3	0.3	0.3	0.3	0.04	0.4	0.4	0.4
43027.2729	0.3	0.3	0.3	0.3	0.3	0.3	0.4	0.4	0.1
44016.2993	0.01	0.02	0.3	0.09	0.09	0.09	0.09	0.4	0.1
45046.0213	0.01	0.02	0.3	0.04	0.05	0.05	0.06	0.4	0.1
46017.7829	0.01	0.02	0.3	0.04	0.04	0.04	0.05	0.06	0.4
47064.7697	0.01	0.01	0.01	0.01	0.01	0.02	0.03	0.4	0.05
48084.9344	0.01	0.01	0.01	0.01	0.01	0.02	0.03	0.4	0.05
49105.0991	0.01	0.01	0.01	0.01	0.01	0.02	0.03	0.4	0.05
50125.2638	0.01	0.01	0.01	0.01	0.01	0.02	0.03	0.4	0.05
51145.4285	0.01	0.01	0.01	0.01	0.01	0.02	0.03	0.4	0.08

Figure 9: Taximeter schematic in Eagle Software



Design of the prototype, for convenience in Eagle schematic diagram was implemented. The design was generated for PCB.

B. Construction

Figure 10: Taximeter with GPS assistance prototype



In this figure you can see the prototype consists mainly of an LCD, a GPS receiver, a microcontroller 18F4550 and a numeric keypad.

VI. FUTURE WORKS

Rate base which is used to calculate a service rate as well as other values base for the various factors included in the calculation, should be updated from time to time, some alternatives is to apply for the driver that you enter these values but using some sort of encryption or other methods.

Or send them through any system, so that it is completely transparent to end users as the driver and the passenger. As a solution for this it is proposed to use a GPRS terminal to send and receive data, and update automatically.

Using this method, there will a large amount of data, which opens the door to many more utilities and applications to improve and extend the functionality of the taximeter.

TABLE 5: FOLLOW ROUTE

Origen (Nombre)	Origen (Coordenadas geográficas)	Destino (Nombre)	Destino (Coordenadas geográficas)	Distancia	Noche (30%)	Domingo (50%)	Precio	Porcentaje por zona	Precio anterior	Precio total
Plaza de Armas	Latitud: 16°23'55.32"S Longitud: 71°32'10.91"O	Calle Alfonso Ugarte	Latitud: 16°23'47.18"S Longitud: 71°32'7.44"O	271.54 metros	No	No	0.082	Centro (10%)	0	0.082
Calle Alfonso Ugarte	Latitud: 16°23'47.18"S Longitud: 71°32'7.44"O	Calle Santa Marta	Latitud: 16°23'52.76"S Longitud: 71°31'51.78"O	495.46 metros	No	No	0,149238	Centro (10%)	0.081	0.231238
Calle Santa Marta	Latitud: 16°23'52.76"S Longitud: 71°31'51.78"O	Calle Santa Rosa	Latitud: 16°23'51.68"S Longitud: 71°31'50.83"O	43.40	No	No	0,01362	Centro (10%)	0.231238	0.244858
Calle Santa Rosa	Latitud: 16°23'51.68"S Longitud: 71°31'50.83"O	Calle San Pedro	Latitud: 16°23'53.16"S Longitud: 71°31'49.34"O	63.73	No	No	0,019719	Centro (10%)	0.244858	0.264577
Calle San Pedro	Latitud: 16°23'53.16"S Longitud: 71°31'49.34"O	Av. La Paz	Latitud: 16°23'59.28"S Longitud: 71°31'44.40"O	237.79	No	No	0,071937	Centro (10%)	0.264577	0.336514
Av. La Paz	Latitud: 16°23'59.28"S Longitud: 71°31'44.40"O	Av. Goyeneche	Latitud: 16°24'3.46"S Longitud: 71°31'39.03"O	205.2	No	No	0,06216	Centro (10%)	0.336514	0.3986
Av. Goyeneche	Latitud: 16°24'3.46"S Longitud: 71°31'39.03"O	Calle Fernández Dávila	Latitud: 16°23'55.86"S Longitud: 71°31'29.65"O	361.74	No	No	0,109122	Centro (10%)	0.3986	0.5077

VII. CONCLUSIONS

This work has managed to provide a means of charging, the system urban transportation taxis, which provide an optimum shape of collection where the driver and the user feel satisfied.

GPS technology provides a fully external to this system and not manipulated by the driver, providing some kind of security to the system, since the data may not be altered by external media.

In addition, the developed algorithm, provides rates differentiated according to socioeconomic areas to travel, is given on the taxi route. What regulates the cost in such a way that there is a method that is more fair and equitable for the user, making more accessible to the public in general.

Calculate the taxi fare is not a simple matter must consider different factors and each of them must be customized for each city, have demonstrated that it is possible to have an algorithm that can consider these factors and calculate a rate. The use of GPS provides data that is essential to replace the odometers, on the other hand must implement an algorithm that can consider this type of information to generate an odometer type GPS.

The use of GPS also facilitates using a fully external to automobile technology, since this avoids manipulation of users, which would avoid that measurement is inaccurate and attempt to deceive any user.

To prevent the loss of signal in urban canyons repeaters, could be installed in such a way that there is signal 99% of travel. This would have to be implemented by the company that traded the finished prototype.

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