# Taximeter Design Based on Digital Image Processing Approach

M. J. Assadifard, M. Javanmard, and M. H. Moazzam

***Abstract*—In this paper, a taximeter is offered that`s connected to 4 small digital cameras front of passengers. It firstly can recognize passengers by face detection techniques, based on digital image processing. There are some unique geometrical segments and signs in the face of each person that the system can detect each person by analysis the pictures. In addition, skin color is the other useful item to recognize people in the few count of persons.**

**On the other hand, this taximeter obtains amount of car movement by satellite map. Instead of regular odometers, it defines the origin location, the path and the location of destination in unilateral satellite communication. According to the city map, each path or street is a side of a weighted graph that beginning and end point of them are two vertices of this graph. If we assume the origin and destination of movement as two vertices, we may reach the actual traveled distance by Dijkstra Algorithm.**

***Index Terms*—Dijkstra algorithm, face detection, satellite map, skin color recognition, taximeter.**

## I. Introduction

In most societies, accurate qualifying the taxi fares is a hard problem for drivers and passengers. Insufficiency of taxi stations, not specified price of taxi lines, getting on between stations and not calculated movement amount, cause difference in the prices.

Hence taxi management organizations force the taxi drivers to use taximeter system that can decrease the problem. It has 4 buttons as count of 4 passengers. To use the system, driver pushes the button shortly thereafter a passenger gets on the taxi and taximeter calculates the fare. Finally when he wants to get off, system calculates the price exactly and shows it.

But the current system has some problems cause the drivers don`t use it. First it needs manually order. The driver should push the button by hand and sometimes he forgets that. The other problem happens when a passenger changes his location after other passenger gets on or gets off the taxi, then he becomes confused for reading price. On the other hand, when a driver decided to ride in indirect and longer paths (for example to stay away from busy roads), it calculate more price.

But, in the offered system, entry or exit of passengers, is recognized automatically by 4 digital cameras and in each moment, taxi fares are shown bottom of passenger`s image. Calculation the real navigated path by satellite map reader, avoids accounting extra amount. Finally in addition to possibility cash payment, passengers could to pay by credit ticket card and it solves problem of coin payment.

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## II. Face Recognition by Form Geometry

The first historical solution for face detection, is based on face geometry. 37 important points are surveyed in the pictures, but analysis some points are easier. These points creates several segments on the face those are useful to recognize it. Some of those are in Fig. 1 [1].

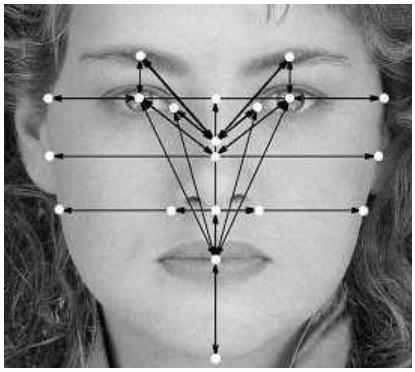

Fig. 1. Analytical segments in face geometry [1].

But, heads are not always smooth opposite of taxi cameras and maybe distance of head and camera changes. If we suppose focal distance of camera lens is '*F*' and distance between real object and lens is '*p*' and distance between virtual picture and lens is '*q*', according to optical physics formulas:

$$\frac{1}{F}=\frac{1}{p}+\frac{1}{q} \tag{2}$$

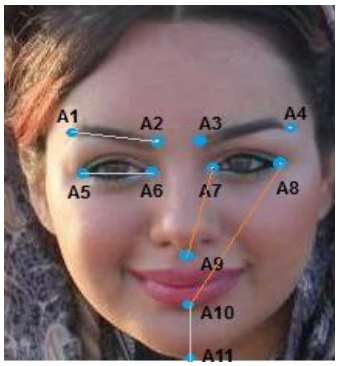


Fig. 2. 11 useful points in face geometry.

Thereupon, it results to change image sizes of segments.

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Another problem is that some passengers wear sun glasses and ornaments and cause more problems for us. So, According to Fig. 2, we choose 11 important points on the face of person. Some values such as eyebrows length, are not unique and are not constant for persons too, but it doesn`t change in a travel for them.

To study image of 70 persons (35 women and 35 men) between 20 to 40 years old, size of $A1A2$ and $A3A4$ were different by a good approximation and segments $A5A6$, $A6A7$, $A7A8$ and $A10A11$ and values $\frac{A5\,A6}{A6\,A7}$ and similarly $\frac{A7\,A8}{A6\,A7}$, was completely different for all people.

Given the situation of head, system probably receives the side view image. As a result, values $\frac{A7\,A9}{A8\,A10}$ and similarly $\frac{A6\,A9}{A5A10}$ and size of $A10A11$, are more helpful (according to Fig. 3).

The small number of people (4 persons), simplifies the matter for us and we don't need to consider a large population.

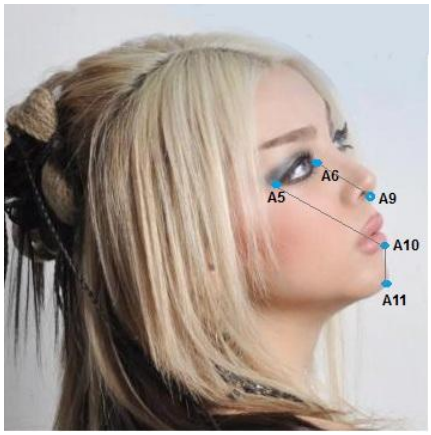


Fig. 3. Using the analyzable segments of face, from the side view.

## III. Face Recognition Based on Skin Color

One of problems we involved that, is wearing sun glasses and other things cover a part of face that contains analyzable points or maybe passenger speaks by cell phone or the head has inappropriate situation on snapshot moment. So, in some pictures such as Fig. 4, (covered by scarf and glasses) we use analysis of face skin color. Skin color and it's brightness includes a wide range that distinguishes people for large number of persons [3].

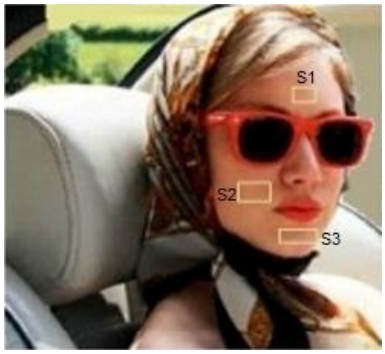


Fig. 4. The sections of color processing for covered face by sunglasses and scarf.

In this processing we should note to use sections of face have uniform color and less likely to beetle.

### A. HSI Color Space

While color processing in *RGB* mode is the most commonly used for color describing, but this method has negative aspects. First, it completely depends on luminance effects. On the other hands, skin color is a function of amount of red, green or blue and we don`t want to be involved it`s measurement. We avoid detecting which color is for face skin and which one is not. So, we use analytical algorithm HSI that only use face skin color range to recognize.

If $0.05 < H < 0.07$, then the section is a part of skin, otherwise the selected pixels are parts of unhelpful objects [4].

### B. YCbCr Color Space

YCbCr color space, divides image to luminosity component and chrominance components. The important advantage of using this color space is that influence of luminosity can be removed during the image processing.

In processing of reference image, we understand values of Y, Cb and Cr is different for skin and non skin colors. After experimenting with various thresholds, the best values for skin pixel detection, are according to below [4]:

$$135 < Y < 145$$
$$100 < Cb < 110$$
$$140 < Cr < 150$$

Finally, by two above solutions, we can recognize passengers in different conditions of face and appearance.

## IV. Finding Real Traveled Path

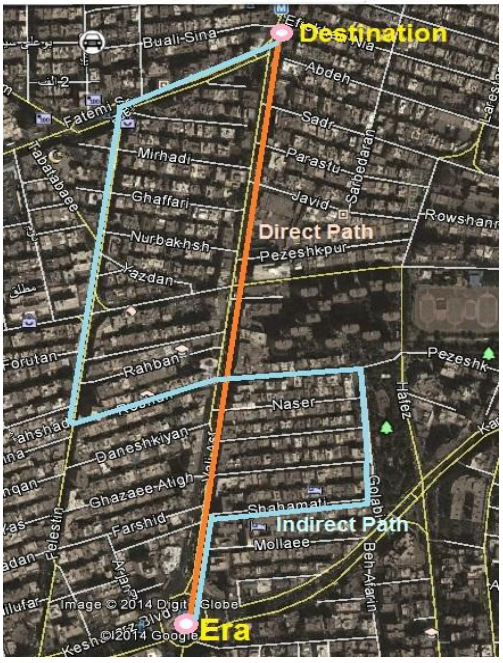


Fig. 5. The direct and indirect path from origin to destination.

Sometimes taxi drivers exchange the regular streets with shortcut paths (such as Fig. 5). For example when they envisage heavy traffic at streets and to avoid it, they do. But

we don`t want to calculate extra fares and should specify the shortest way as the real traveled path.

To specify this path, we use a satellite map reader system. In this map, every intersections, squares, origin and destination points are spotted as vertices of a graph. Every streets and alleys conduced this vertices are edge of this graph. We suppose that`s a weighted graph and the weight of each edge is the street length.

Now, we can find the optimum path between origin and destination by Dijkstra Algorithm (Fig. 6). Dijkstra Algorithm can obtain the most cost-effective way between two vertices in a weighted graph [5].

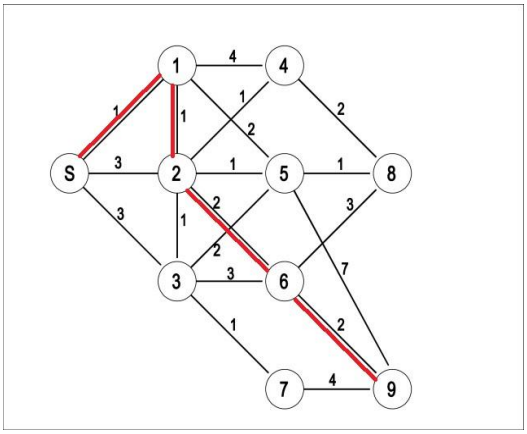


Fig. 6. The found optimum path from S to 9 by Dijkstra Algorithm.

Each street may be one-way or two-way road (Fig. 7). So, the map of a city is a directed graph that we spot a no-entry road as an edge by weight -∞.

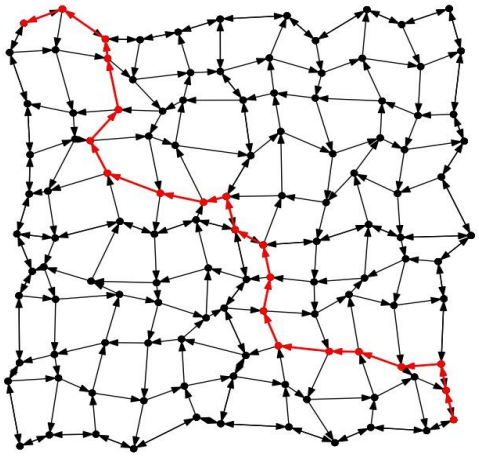

Fig. 7. The found optimal path in the city map by Dijkstra Algorithm.

## V. Designing System and Activity Stream

This system consists of several parts. According to Fig. 8, there is a small camera, one calculation button and a credit ticket-card, in the below car roof and front of each passenger. All of them are connected to the central part.

One LED lamp on the front camera set, lights until passenger looks it thereupon locates his face front the camera vividly. Image of passenger is sent to central system on this moment and leaving time. The passenger sees his calculated fare when he pushes the corresponding button or when he opens the car door and if he puts his ticket-card near his sensor, the amount of fare will be paid from him to the driver credit account.


Fig. 8. The parts of taximeter system, includes 4 cameras, 4 calculation buttons, 4 ticket-card sensors and one central system.

The central system is a box by 4 separated LCD displayers which show initial image, traveled path and the fare for each person. When the car door becomes closed, cameras receive the pictures automatically and send them to central system and image of each one (if there) is shown in his LCD. So, according to Fig. 9, this system has a calculation button too. Meanwhile if the driver puts the passenger`s credit card on his own image, fare will be cashed.


Fig. 9.The central system of taximeter, Includes 4 image and calculation displayers, 4 Credit ticket sensors and one calculation button.

This system retrieves fare calculation program by an USB port. For example formula for year 2014 is as follow:

"Entrance fare for each person is 1$ and it's extra fare is free until 500 meters. Then it increases 20 cents for each 300 meters."

The activity stream of this system is according to follow:

1) On shutting the car doors, images of passengers are processed and displayed on LCD screen.
2) This place is origin of travel for the person who recognized as a new passenger.
3) For each 300 meters along the way, the traveled path and updated amount of fare are shown on the screen.
4) When any key is pushed, real path, amount and new images will be located on the screens.
5) When you open a door, this point of street is spotted as vertices of graph and system calculates the length of optimal traveled path. Then it displays distance, amount and the last image on LCD screen.

6) Before the passenger gets off the car, can pay the fare with cash and can pay it by electronic card.
7) When you close the doors, image of persons in the car will be processed again.
8) For privacy of individuals, system removes images of passengers who leaved the taxi.

## IV. Conclusion

Although some image processing methods don`t have generality to use for face recognition, but we can use them for small count of people such as passengers of a taxi.

Face geometry and skin color processing are not completely accurate and fault less ways for huge number of persons, but we optimized them to be helpful for less than 70 persons.

This optimization caused to remove the lapse due varying distance between objects and camera.

On the other hands, we removed a long range of color spectrum by analysis of YCbCr Color Space that we know it`s not skin color. Deleting excess pixel colors, causes system works very fast and measurement of geometrical ratios causes it works more efficiently.

At last, this solution could be developed for a lot of fields used instead of human vision.

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