# Biometric Bus Ticketing System In Mauritius

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**Abstract:** In the recent years, the number of people using the public bus to commute to work or to other locations of Mauritius has drastically increased. Mauritians prefer to utilize public transit rather than using their own vehicles due to the increase of petrol prices. They find it more frugal to utilize public transport rather than private vehicles due to parking and commuting cost. Since there is an issue with the traditional ticketing system, this study proposes a public transport ticketing system with face recognition. The system allow users to register themselves as passenger and enable them to utilize the services. Before proceeding with the development of the biometric system, the people of Mauritius were surveyed and changes were made accordingly to the functionalities of the system to increase its efficiency amongst the users. Final system testing were conducted with potential users at Mauritius and the acceptance level of this system is encouraging.

**Keyword** : Principle Component Analysis, Independent Component Analysis, Gaussian distribution, Eigen points, Karhunen-Loeve Transform

## 1.0 INTRODUCTION

With the increase in the economy of Mauritius, the country is currently developing smart cities with most of the services being automated such as booking services for apartments, entry to houses or other depository financial institution transactions. However the problem is that the country is still using traditional methods of ticketing for public transportation. It happens that conductors and passengers do not have enough fare change for ticketing. In a day to day basis, there is a traffic jam in the cities of Mauritius especially during peak hours. Even those who own a car prefer to use public transport to go to their offices because it is more economical and also it will reduce traffic in the towns [1]. The traditional ticketing system works in the way that the bus will stop and pick passengers at every bus-stop and conductor will collect cash and do tickets [2]. According to statistics, during the peak hours of the morning, more than 200 vehicles enter Port-Louis each passing minute. The number is about 8000 vehicles passing the side of the roundabout Caudan. In total, more than 25,000 vehicles enter the city every morning between 7:00 and 9:00 then between 7 and 17 hours about 70,000 vehicles pass through Port-Louis[3]. After analyzing this problem context, Biometric Bus Ticketing System (BBTS) will be an important solution that can solve this issue. The objective of this system is to implement a Biometric platform for passengers to register to the system and scan their face upon boarding to further send the ticket fare to the account. It is web application where passengers can register themselves to the service. For first time users, they register with their basic details and their passport photo uploaded to the system. The system will break the image and saves all the biometric details to a cloud storage. Upon boarding to the bus, there will be a camera that will scan the passenger face and validate the face of the passenger by checking the biometric details in the system whether this passenger is a registered user.


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If the user exists in the system, the fare detail will be updated to passenger's personal portal. Admin of the system shall be able to manage the passenger's details and maintain the face machine. BBTS can greatly help in the technological advancement of the country and for smart cities.

## 2.0 SIMILAR SYSTEM

There is currently no system that does ticketing using face recognition services. However, there are universities use facial recognition for registration and entry access to campus for example University of Science and Technology Beijing, China.

### 2.1 Detection Phase and Algorithm

Face recognition is divided into 3 main phases named face detection, feature extraction and facial expression identification. Face detection is a procedure by which the face region of any human being is extracted from the whole body surface. According to Mrs. Sunita Roy, the first step towards a good detection is the localization of the face, where the system try to identify where the face is present in either a picture or a real-time image [4]. The face is located with the help of some mathematical algorithms and calculations [5]. This step is extremely important as it demands to differentiate between the face and the repose of the situation of the body. In the second step which is normalization, all the alignments of facial features are checked and ensured that they are all in the correct location and properly arranged [6]. The third step involves in extracting eyes, nose, mouth, eye distance, face structure and ears. The last step is verification of anticipated parts of face is carried out [4]. It involves verification of relation between features upon insertion to database. There are many face detection algorithms used to locate faces in an image. Appearance based method used in this field. In this technique, the templates learn from the examples of images that are supplied as test images. This is done via algorithms of machine learning, statistical analysis and other mathematical functions. There are appearance methods that work with network probability. Normally feature vectors and images are random variables with a percentage of belonging to a certain face from the database. Eigen points method is the most used by most technologies. It involves a lot of statistical and mathematical methods. Service and

Kirby used Principle Component Analysis for their method to represent images of human faces [7] [8]. Their aim was to refer a face as a coordinate system [9].

### 2.2 Feature Extraction

After facial detection, the next step is facial feature extraction. This step uses facial spatial features of the nose, eyes and mouth. After detection of face region, different features of the face are extracted and verified for recognition purposes [10]. There are four types of extraction that can be used such as generic methods, feature template-based methods, color "segmentation-based" process and "appearance-based" methodology. Appearance based method uses the linear and statistical method to represent face using vectors. Principle Component Analysis (PCA) and Independent Component Analysis (ICA) are used to decrease the number of dimensions of spatial feature and information loss of features in the face [11]. PCA uses the statistics of second-order in the data and it is a special type of ICA works using "Gaussian source models." As claimed by Bruce, Kyungim, Marian and Beveridge, Gaussian distribution can be obtained from natural signals of speech and linear combinations [11]. For feature extraction, Appearance-based method has been chosen as the most performer out of many other algorithms [10].

### 2.3 Face Recognition Algorithm (Statistical Method)

PCA is the most used statistical methods for recognition of face which operates by performing a reduction in dimensions through extraction of multi-dimensional data of principal components. It is a mathematical procedure where a linear combination is formed out of original dimensions having highest variability. The n-the component is the highest variability linear combination which is orthogonal to the n-the principle component. The greatest variance of data projection depends on the first coordinate. The n-the coordinates will lead the way to the n-the maximum variance - the n-the principal component. As for the mean x, it is obtained from the extraction of the data, so that PCA is equal to "Karhunen-Loeve Transform (KLT)". $X_{nxm}$ is a matrix of data whereby $x_1$, ..., $x_m$ are vectors of image and n being the pixels per image. KLT basis is therefore derived by solving Eigenvalue problem:

$$\boldsymbol{C_x = \Phi \Lambda \Phi^T}$$

Mathematically, the Eigen - face method finds the principal components for face distribution from the covariance matrix of the set of face images. The number of possible Eigen-faces is same as that of facial images in training set [12]. The steps and formula for calculation of eigen-faces are listed below.

1. I will denote the image:

Image I: (N x N) pixels

The image matrix I of (N x N) pixels of size is converted to the image vector Γ of size (P x 1) where P = (N x N). So, the image matrix is retrieved by adding each column to each other.

2. Γ will be denoting the training set:

Training Set: Γ = [Γ1 Γ2 ... Γ M],

The image vectors forming the training set and the size are (P x M) whereby M being the number of training images.

3. Mean face is calculated by the equation:

$$\text{Mean Face: } \boldsymbol{\Psi = \frac{1}{M} \sum_{i=1}^{i=M} \Gamma\, i}$$

This formula shows the image vectors being averaged and are trained at each point of pixel and the size is P x 1.

$$\text{Mean subtracted Image: } \boldsymbol{\Phi = \Gamma - \Psi}$$

The equation above shows the difference between mean image and training image.

$$\text{Difference Matrix: } \boldsymbol{A = [\Phi 1 \Phi 2 \ldots \Phi m]}$$

The size is (P x M) which is the matrix of all mean subtracted image training vectors.

$$\text{Covariance Matrix: } \boldsymbol{X = A\,.\,A^T = \frac{1}{M} \sum_{i=1}^{M} \phi_i\, \phi_i T}$$

This formula shows a covariance matrix for training image vectors (P x P).

### 2.4 Programming language and Storage

The front end of the Biometric Bus Ticketing system (BBTS) developed using a bootstrap framework with HTML5, CSS3 and jQuery libraries. This is to ensure the final deliverable is a responsive web application. Moreover HTML5 can easily be configured with the backend codes which PHP and curl with Amazon Recognition. The Amazon Web Services (AWS) Recognition are an AI suite that has been imported by using their API. It provides facial analysis, facial comparison, facial recognition and emotion analysis [13]. PHP is a programming language used to configure all the connections to the cloud database and to maintain a connection with the Recognition API of Amazon to scan faces and extract all their biometric details [18]. Furthermore PHP facilitates the use of Amazon API and the Clockwork SMS library. As for storage of data, Index Cloud storage of AWS and MySQL are used to store the Biometric details of passengers and to validate their face. As for IDE, Brackets and Atom were used. Brackets is a modern open source text editor that supports web design and backend scripts codes. It is easier to code for PHP with its light weight application and the focus on visual tools and preprocessor supports. It has an inline editor which lets developer to open a window into the code to allow modifying code parallel to changes in design [14]. Secondly, Atom which is a PHP and web design software has been used. It has a Teletype feature which allow codes sharing between programmers for seeking help.

## 3.0 RESEARCH MODEL

In order to come up with a good research, the authors conducted preliminary reading on the transportation system in Mauritius and the technologies shall be used for the upcoming smart cities. From this, the problem statement was then made clear and deeper research were conducted. Moreover, primary data gathering as also conducted where questionnaire involving current system and future specifications were distributed to a sample of 50 people. The aim for this process was to obtain feedbacks to enhance the implementation of the system. After collection of responses, they were further categorized and analyzed graphically with charts. This process resulted in a positive response that resulted in developing Biometric Bus Ticketing System web application.

## 4.0 METHODOLOGY

Rapid Application development (RAD) is an agile project management strategy used in software development. James Martin claimed that RAD is a lifecycle that is used

for rapid development of applications that gives high quality product in a minimum amount of time [15]. RAD can be divided into four main phases namely Requirement planning, User Design, Rapid construction and Cutover. Requirement planning is the stage where all the scopes of the project are discussed and finalized between client and development team. The goals, expectations and current issue and solution are all put on a paper and discussed by the team. The second phase is a user design where quick prototype will be implemented and clients can interact with the prototype and ask for changes wherever clients feel that the outputs are lacking of features or functionalities [19]. Phase three consist of converting the prototype into a working model whereby heavy coding and testing will be conducted. Then phase four is the final phase where the system launching after implementation [20]. This includes data conversion, testing and changeover to the new system. Bugs are also fixed at this stage.

## 5.0 SYSTEM DESIGN

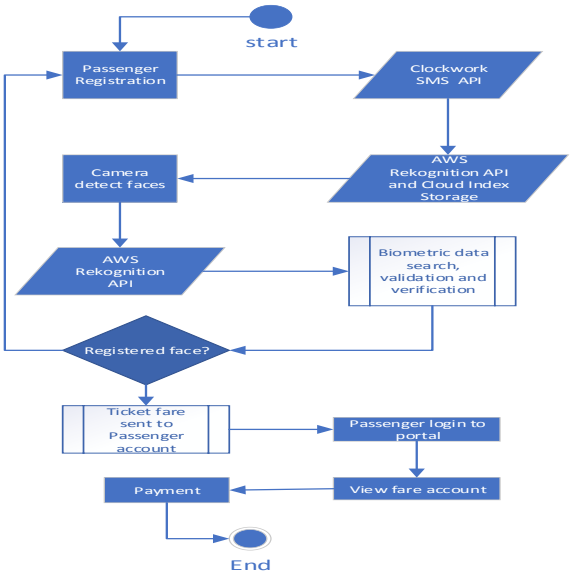


***Figure 1** – system design*

Figure 1 above illustrates the architectural design of BBTS processes from registration, login to the facial recognition. First, the passenger registers to BBTS and receives a confirmation SMS via phone. During boarding, the camera in the bus scans and verifies passenger's face. If the passenger has registered before, the ticket fare goes to the passenger's personal portal. The passenger can use the personal portal to make payment for their ticket fares on monthly basis. Admin have control over all the passenger details, maintenance of face machine and registering and updating drivers. They can generate reports of sales and view all the ticket sales.

## 6.0 IMPLEMENTATION AND TESTING

Figure 2 below shows the sign-up page that allows passengers to input their personal details to register to BBTS web application. Here the user is required to upload his/her face photo.

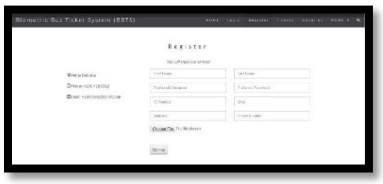

***Figure 2** –Sign Up*

Figure 3 below shows the map that passenger can use to navigate and see where the bus stop are in the country with a live bus tracker. This feature will be enhanced in the future by integrating Google Map and Waze into it so that drivers can use to drive.

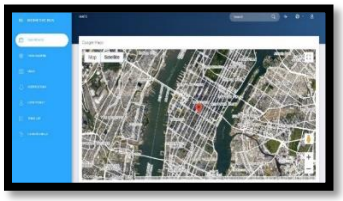

***Figure 3** - Admin Bus Tracker*

Figure 4 below shows the face machine which is installed in the bus. It start to scan and verify the passenger's face once someone enter into the bus. The scanned face is saved into the local server and the face id is searched from the Amazon Index Cloud collection database. If the user is valid, then the ticket fare, source, destination and passenger details will be sent to the payment database and an instant invoice is displayed. However if the passenger is unknown, none of the details are saved and a warning is displayed.

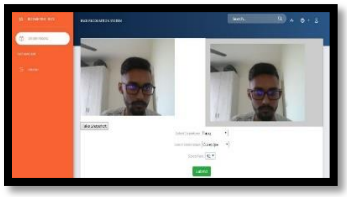

***Figure 4** –Face Machine*

Unit testing has been conducted to validate each single feature of BBTS to make sure all features are functioning properly. This is to ensure to meet all the requirements that were set from beginning of this study. Unit testing helps to debug and break codes for refining [16]. Before developing BBTS, surveys were conducted with 50 users to know their feedbacks about the system features. User Acceptance Testing (UAT) is the final phase in the development of a software testing process [17]. Rates and feedbacks are given at this stage. Recommendation from UAT are justified by updating the system.

## 7.0 CONCLUSION

In this paper, a Biometric Bus Ticketing system (BBTS) has been designed and developed to help passengers that are travelling using public buses in Mauritius. The aim of this project is to enhance the current transportation system in the country and make it more advanced and technological so that it can easily adapt to the new upcoming smart cities. Before development, surveys have been conducted and feedbacks have been used to modify the system

functionalities and make it more appropriate for users. BBTS helps users to register to the service using their face photo. Upon boarding, the camera in the bus scan the passenger's face and if they are valid based database record, the ticket fare are sent to their monthly invoice that they can check from their online portal. Future enhancements for BBTS would be to incorporate a live bus tracker for passengers and the map will be converted to a Google Map with directions for drivers.

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