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UNIFIED PAYMENT SYSTEM FOR INDIAN TRANSPORTATION

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Abstract - *In a developing nation like India as cities continue to grow as a result of the influx of people from smaller towns and rural areas, more people will live farther away from the commercial districts and will have to commute to work, putting a pressure on the transportation system and resulting in longer travel times and congestion. The nation's public transit systems, including the toll booths, monorails, metros, and trains, will need to operate more efficiently. Effective, safe, and user-friendly transit payment methods contribute to this. Presently, India distributes monthly-renewable individual bus and suburban local train passes. Furthermore, specific metro cards exist that may be refilled based on customer demand; similarly, our concept will do the same thing but on a larger scale.*

The project's objective is to find out what would happen if passengers on urban transit systems like city buses, ferries, or even ropeways were not required to carry cash. This one smart card is required for all payments; it only needs a tiny deposit, which will be deducted when the card is scanned.

Key Words: ***Smart Card; Transportation; K-Means Clustering; Public Transportation; India; Fare Method Collection.***

1. INTRODUCTION

The vast majority of the current public transportation networks, including as metro lines, suburban trains, and bus links, have been increased in accordance with the assumption that most people dwell at either end of a commercial district. Hence, these routes are frequently complicated and perhaps even challenging to use. Cities and urban transportation networks encounter a number of difficulties, including traffic jams, a lack of parking spaces, unequal access for all people, a lack of last-mile connectivity, dangerous roads, or pollution. According to a July 2018 Forbes India article, India loses $21.3 billion yearly as a result of traffic congestion. Also, there are problems with connectivity. One is the case where there is actually no connectivity to certain areas of the town or metropolis. Together with this, there are other problems including accessibility, regularity, and dependability. People need to travel in this situation, yet there aren't enough public transportation options. Two, where there is connectivity but no one knows how to go around or find their way. This typically occurs when there is a massive inflow of people, especially to metropolitan centres that are dispersed over vast distances. The current transportation systems become insufficient as a result of the significant population growth. Because of this, more and more individuals are turning to the use of private vehicles, and public transit is becoming less and less popular, with only 18.1% of people in Indian cities using it for business related travel.

Transfer nodes must be given a lot of consideration if urban transportation is to be fully utilized. Although study has been done on the significance of transfer nodes for the successful use of urban transportation, efficient research has not been conducted to fully utilize the capabilities of smart cards and their applications.

The project's goal is to investigate what would happen if people didn't need to carry currency when using urban transportation systems like city buses, ferries, or even rope ways. All payments must be made using this one single smart card, which only requires a small deposit from which the fare will be automatically deducted upon scanning.

2. PROBLEM DEFENIATION AND OBJECTIVES

The enormous population expansion mainly in countries like India causes the current transportation networks to become insufficient. As a result, more and more people are choosing to drive privately, and public transportation is becoming less and less common; in Indian cities, only 18.1% of people utilize it for business-related travel.

If urban transportation is to be used to its maximum potential, transfer points must be carefully considered. The importance of transfer nodes for effective urban transportation use has been studied, but effective research has not been done to fully exploit the potential of smart cards and their applications.

The project's objective is to find out what would happen if passengers on urban transit systems like city buses, ferries, or even rope ways were not required to carry cash. This one smart card is required for all payments; it only needs a tiny deposit, which will be deducted when the card is scanned.

The main objectives include:

- To find out what would happen if passengers on urban transit systems like city buses, ferries, or even rope ways were not required to carry cash.
- To modernize the transportation and locomotion industries in India which is coherent with the

industry 4.0 which promotes autonomous decision making with digitized and robot chain processes in the field of transportation industry.

- To promote Digital Payment System towards a cashless India.

3. METHODOLOGY

Firstly, a total of 25 papers were reviewed and based on that the problem definition and objectives were considered also the components of the smart card has been discussed. Based on those discussions a cost benefit analysis has also been conducted and a cost estimation analysis has also been derived. Secondly, we discussed on the programs and the algorithms associated with a smart Transportation Card and type of smart cards used in other countries. Finally, a total of five surveys has been conducted from regions such as Assam and Gujarat prioritizing the assessment on the mode of transportation the public uses and also the potential customers willing to switch to smart cards, based on those surveys from where the datasets were taken a form of vector quantization was conducted in the form of K -means clustering in MS Excel. A 3D model of the smart card was then made in Blender.

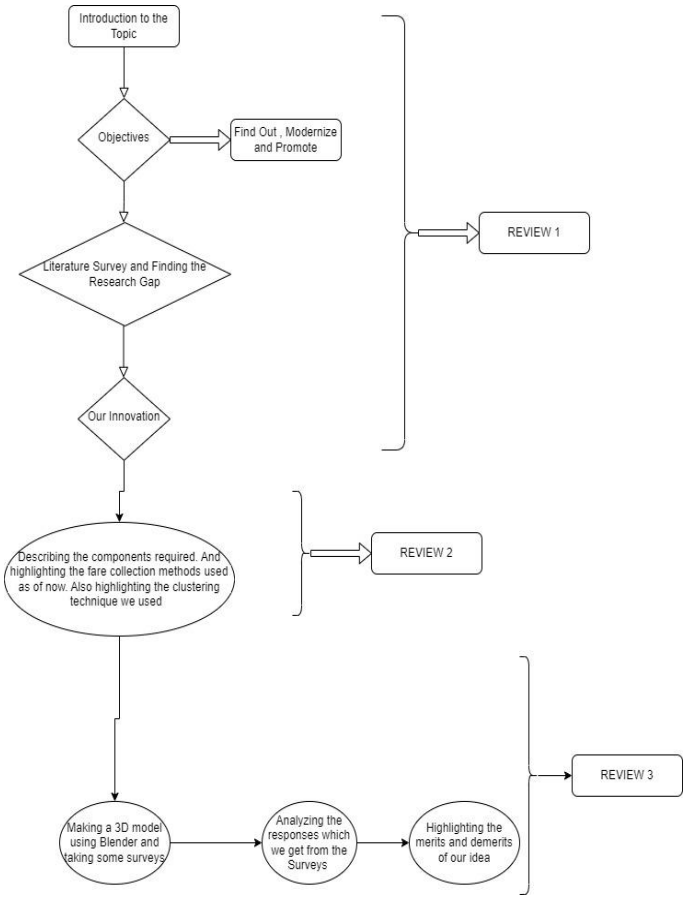

Fig -1: Methodology of the Project

4. COMPONENTS OF THE SMART CARD

The price of making a transportation-related smart card can differ significantly based on a variety of variables, such as the type and complexity of the card, the quantity being manufactured, and the materials and technologies employed. The following are some of the key elements that can impact how much a smart card cost:

- MICROPROCESSOR: The "brain" of the smart card is the microprocessor, which handles data processing, data storage, and external system communication. The type and capabilities of the chip, as well as the manufacturer, might affect the price of the microprocessor.

- CARD SUBSTRATE: A variety of materials, including PVC, PET, and polycarbonate, can be used to create the card substrate, which serves as the card's foundation. The thickness, quality, and requirements for printing and customization can all affect how much the substrate costs.

- CARD FEATURES: The features of the card: Contactless chips, magnetic stripes, and displays are just a few examples of the extra features that smart cards can have. Depending on the nature and complexity of the feature, the quantity of cards being manufactured, and the feature itself, the price of these features can change.

4.1 Microprocessors

Depending on the type and features of the chip as well as the manufacturer, the cost of the microprocessor in a smart card for transportation can change. The following are some broad ranges for the cost of smart card microprocessors:

- Low-end microprocessors: These chips are frequently found in simple smart cards that don't call for highly developed computing power. These chips might cost depending on the manufacturer and volume.

- Mid-range microprocessors: These chips support a larger range of smart card applications and have more advanced processing capabilities than low-end chips. Depending on the volume and manufacturer.

- High-end microprocessors: These chips are utilized in smart cards that need extensive security features or a lot of memory since they have the best processing power. The price of these chips varies based on the manufacturer and volume.

4.2 Card Substrate

A smart transit card's substrate is the substance that serves as the card's basis or base. It usually takes the form of a thin, hard sheet that supports the card's different parts, such as the IC microprocessor, memory, and other parts. The substrate can also be composed of various materials, such as paper or metal, however it is frequently made of plastic, such as PVC (Polyvinyl Chloride) or PET (Polyethylene Terephthalate).

The selection of the substrate material can be influenced by a variety of elements, including the card's physical requirements, intended application, and cost of the substrate material. For instance, a card that needs to be thrown away and is used infrequently would be more suited with a paper substrate than one that is more durable and resistant to wear. The substrate might also need to adhere to certain norms or specifications, such as being impervious to fraud or manipulation.

4.3 Card Features

Various features can be included in smart transit cards, depending on the requirements and objectives of the project. Smart transit cards frequently have the following features as standard inclusions:

- MICROPROCESSOR: The microprocessor, sometimes known as the "brain" of the smart card, manages data storage, processing, and communication with external systems. A typical integrated circuit (IC) that may be configured to carry out a range of functions is the microprocessor.
- CONTACTLESS CHIP: Using radio frequency (RF) technology, a contactless chip enables the card to interface with external systems. Smart transit cards frequently use contactless chips to support tap-and-go payments and access control.
- MAGNETIC STRIPE: Information on the card is kept on a magnetic stripe, a sort of data storage medium. Smart transit cards frequently use magnetic stripes to store data like the balance or ticket information.

In general, the characteristics of a smart transit card will rely on the particular specifications of the project and the card's objectives. A large range of functionality may be present on some cards to enable a wide range of applications and use cases, while others may have a minimal feature set.

5. IMPORTANCE OF SMART CARD FOR THE FUTURE OF INDIAN TRANSPORTATION AND THE SOFTWARES INVLOVED

- Convenience: Compared to more conventional ways of fare payment, such cash or ticket vending machines, smart cards may be more user-friendly. They don't require users to carry cash or stand in line to buy tickets, and they may be simply reloaded with value or used to buy tickets.
- Efficiency: By minimizing the need for ticketing and cash handling activities, smart cards can also help the transportation system run more smoothly. Operators can save time and money while also getting a better overall user experience if they do this.
- Data gathering: A lot of data produced by smart cards can be used to guide transportation planning and decision-making. Transportation engineers can use this data to increase the effectiveness and efficiency of the transportation system by using it to better understand user usage patterns and preferences.
- Integration: To give users a more seamless and practical experience, smart cards can be combined with other technologies, such as contactless payment systems or real-time tracking systems. When it comes to multi-modal transportation systems, where consumers would have to switch between various forms of transportation, this can be very crucial.

Overall, smart cards may be a crucial instrument for India's transportation engineering, enhancing users' accessibility, effectiveness, and system integration.

For smart card systems in Indian transit, the following examples of fare collection, ticketing, and payment processing software might be used:

- Many Indian transit networks employ Trivec Aviacom, a comprehensive platform for processing payments and smart card tickets. It has features including real-time tracking, contactless payment, and online and mobile ticketing.
- Indian transportation systems employ the fare collection and ticketing software platform known as Trapeze FareMaster. It has functions including fare estimation, ticket sales, and revenue management.
- The Nextfare ticketing platform, which is utilized by numerous transit systems in India, is one of the fare collection and ticketing software solutions offered by Cubic Transportation Systems.

- Trimax IT Infrastructure and Services: This business provides a selection of smart card ticketing and payment processing solutions, such as the Trimax E-Ticketing System, which is utilized by several Indian transportation systems.

These are only a handful of the several software options that can be used for fare collection, ticketing, and payment processing in the Indian transportation system. There are numerous further alternatives, and the particular software used will depend on the demands and objectives of the transportation system.

5.1 Current Fare Method Collection for Indian Transportation

Cash: To collect fares, many Indian transit systems, including buses and railroads, still use cash. While some consumers may find this handy, managing it can be time-consuming and expensive for operators.

Ticket Vending Machines: Machines that sell tickets have been installed in some Indian transportation systems, enabling customers to pay with cash or a debit or credit card. These terminals, which can be found at stations or other places, let you to buy tickets for one or more trips.

Smart cards: As a form of fare collecting, many transit networks in India have adopted smart cards. These cards can be used to pay for rides by tapping them on readers at the beginning and conclusion of trips. They can also be filled with money or used to buy tickets. As users do not need to carry cash or stand in line to buy tickets, smart cards can be more practical and effective than cash or ticket vending machines.

Overall, the way that fares are collected in the Indian transportation system might change based on the system and the region. Some systems might combine various techniques, but others might only use one.

6. COST BENEFIT ANALYSIS OF THE SMART CARD

Implementing a smart card system for India's transport network: A cost-benefit analysis

Assumptions:

5 million riders per year

20 INR is the average fee per trip.

Total yearly income of INR 100 million

Installing a smart card system will cost INR 20 million.

Smart card system's yearly running expense is INR 5 million.

Smart card technology generates a 5% increase in annual revenue.

Smart cards' annual cost reductions are 2%.

Benefits: Gain in annual revenue brought on by the smart card system: 5% of yearly sales equals INR 5 million.

Savings per year brought on by the smart card system: 2% of yearly sales equals INR 2 million.

Net advantages Gain in annual income of 5 million INR yearly financial savings of INR 2 million

Benefits of INR 7 million each year.

Repayment period:

The annual benefit / the implementation cost of the smart card system will determine how long it takes to recover its costs.

Payback term equals INR 20,000,000 / INR 7,000,000, or 2.85 years.

According to this estimate, deploying a smart card system would have a payback period of 2.85 years and a net yearly benefit of INR 7 million. The cost-benefit analysis can offer a useful framework for assessing the viability and possible impact of a smart card system in the transportation industry, albeit these numbers can vary depending on the unique context and assumptions utilized.

6.1 COST ESTIMATION OF SMART CARD IMPLEMENTATION

Cost analysis of a smart card system for a 10,000-passenger daily average and 50 vehicles in India's medium-sized bus transportation network

Costs of Hardware: Assuming a smart card reader will cost roughly INR 5,000 and that 50 readers will be needed; the total cost of hardware will be INR 2,50,000.

Software Costs: Assuming there are 50 buses in the network and fare collection software costs about INR 10,000 per bus, the total cost of software would be INR 5,00,000.

Costs of Implementation: Assuming that the whole cost of implementation, which includes staff training, hardware and software installation, and integration, will be roughly INR 10,00,000.

Operational Costs: It is assumed that the smart card system's yearly operating costs, which include staffing costs, maintenance, repairs, and replacements of both hardware and software, are roughly INR 5,00,000.

Revenue Loss: If passengers abandon the system or switch to another means of transportation during the transition period, there will be a 10% revenue loss, which will result in a loss of income of about INR 5,00,000.

Gain in revenue: Assuming a 10% increase in ridership and a 5% decrease in the price of paper tickets, handling cash, and fraud, the gain in revenue would be about INR 20,00,000.

According to these projections, the smart card system would cost about INR 18,50,000 to build and run for the first year, with an estimated net income gain of INR 15,00,000. The cost-benefit analysis would need to be updated on a regular basis in light of actual usage patterns, maintenance expenses, and other elements that might influence the system's performance.

7. SURVEY, ANALYSIS AND DISCUSSIONS

Our research and other studies have shown that technology-enhanced mode integration, including fare and ticketing, can impact both the journey experience and a person's willingness to use public transportation. Primary info was used as the data source. A total of about 500 samples were gathered from different regions of India, and our research was based on those results.

Questionnaires are the survey tool used to gather data. Using internet platforms like Google, this was disseminated to individuals located throughout India. Electronic records of the responses were also made. The online material was retrieved and put into a format that allowed for cleaning. Analyses were conducted using Microsoft Excel. People who resided in India's main cities provided the responses.

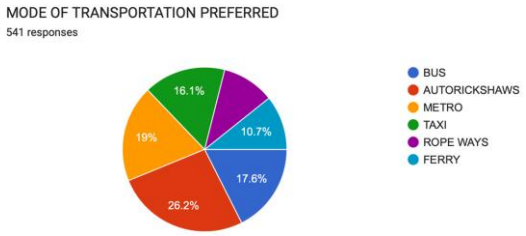

Fig -2: Mode of Transportation Preferred

In accordance with Figure 2, out of the entire population, 26.2% of commuters have access to auto rickshaws, and another 19% have access to metro services. It is also important to keep in mind that 16.1% of the people can choose to use taxis, while 17.6% can choose to commute to work by bus, and another 10.7% and 10.4% can choose to use ropeways or ferries, respectively.

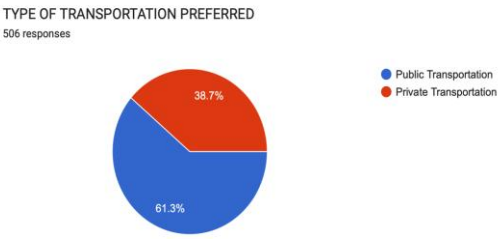

Fig-3: Type of Transportation Preferred

Figure 3, shows that, in accordance with our answers, public transportation is used by 61.3% of the population while private transportation is used by 38.7% of the population.

Another survey was conducted on the case whether or if people faced any difficulties regarding the mode of payment in Public Transportation.

Fig -4: Hindrances faced during Payments

According to Figure 4, 44.3% of people do not face any problem while paying the fare, around 37.9% of people sometimes face the issue and around 17.3% face this issue almost regularly mainly because of using certain methods of payment such as UPI.

A questionnaire with potential reasons why people might not choose public transportation was prepared as part of another survey we did on this topic. The objective behind this survey is to find a suitable spot where we can boost the current standards of Indian Transportation.

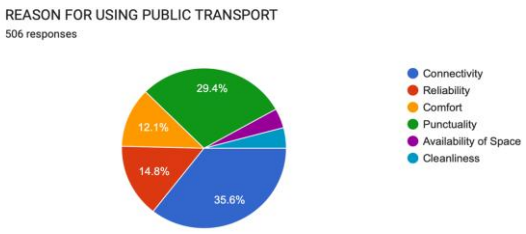

Fig -5: Reasons for Using Public Transportation

This raises the question of connectivity and reliability. Those surveyed indicated that they would use public transit if the problems with connectivity, timeliness, and dependability were resolved.

Our respondents claim that they do not choose smart cards or passes because, in the opinion of 31.6% of the general population, they are only suitable for one form of transportation. A single smart card cannot be used for all transit methods. We must either purchase new tickets or use alternative passes in our transfer nodes, and if a pass expires, passengers must either renew it at that time or go without a ticket for that day. Mumbai Suburban Railways has a very high prevalence of this practice. One of the reasons people don't use public transport is due to this.

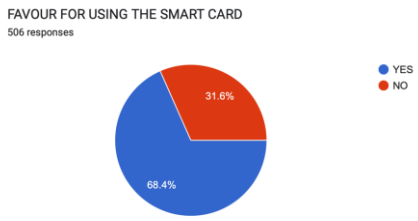

Fig -6: Favor for Using the Smart Card

According to our survey results, the majority of people want a single smart pass that combines bus, metro, and local train services. The integration of auto rickshaws and taxis with buses, the metro, and local trains into a single smart card is the next significant reaction.

7.1 Current Use of Smart Card in Transportation Industry in a Global Scale

Smart card systems are used in many nations throughout the world for transit and other purposes. Countries that are well-known for using smart cards include:

Japan: The Suica card, one of the world's most sophisticated smart card systems, is used extensively in Japan. It can be used to pay for rides on buses, trains, and subways as well as to make purchases at vending machines and convenience stores.

South Korea: T-Money cards, which are widely used in South Korea's public transportation system and for other purposes including paying for things at convenience stores, parking spaces and even public lockers, have been put into place.

Hong Kong: Hong Kong has adopted the Octopus card system, which is used to make purchases at shops, vending machines, and parking lots as well as to pay fares on buses, subways, and ferries.

Singapore: The EZ-Link card system was put into place in Singapore, and it is used to pay for fares on buses, subways, and light rail transit, as well as in shops, vending machines, and parking lots.

United Kingdom: The Oyster card system has been deployed in London and is used to pay fares for buses, subways, and trains as well as to make purchases at shops, vending machines, and parking lots.

Globally, smart cards are used extensively in the transportation sector, and their use is growing quickly in many nations, including India. In the transportation sector, smart cards are now used for:

- Smart cards are frequently employed for contactless fare collection on public transport systems like buses, trains and metros. Without using cash or paper tickets, passengers can load money onto the smart card and touch the card on the scanner to pay for their trip. This increases passenger convenience, lowers the possibility of fraud and revenue leakage, and boosts transportation providers' operational effectiveness.

- Smart cards are used to offer integrated mobility solutions, allowing users to use a single card for a variety of forms of transport, including buses, trains, taxis and ferries. As a result, there is easier connectivity between various forms of transit, fewer tickets are required, and the passenger experience is improved.

- Smart cards are used to deliver personalized services, including loyalty programmers, savings, and rewards for regular travelers. This supports sustainable transportation methods, increases passenger participation, and incentivizes the usage of public transportation.

- Data analytics: The use of smart cards generates enormous amounts of data, which can be examined to gain knowledge about traveler behavior, demand for transportation, and resource allocation. This makes it possible for transport companies to streamline their processes, raise the standard of their services, and cut expenses.

- Smart cards are used to regulate access to restricted locations including parking lots, toll highways, and areas reserved for employees. This improves security and lowers the possibility of unauthorized access.

In general, smart cards are being utilized more and more in the transportation sector for a variety of purposes, including contactless fare collection, integrated mobility solutions, personalized services, data analytics, and access control. Smart cards have the potential to revolutionize the transport sector and improve passenger experience, safety, and sustainability with further innovation and acceptance.

8. K-MEANS CLUSTERING FOR THE SMART CARD

K-means clustering is a popular unsupervised machine learning technique that can be utilized to analyze data related to smart card usage in the Indian transportation system. Here are some ways in which K-means clustering can be helpful:

- Segmentation of Smart Card Usage Patterns: K-means clustering can group smart card usage data based on usage patterns, such as frequency, duration, and fare amount. This can help in identifying different segments of passengers with similar usage behaviors, such as daily commuters, occasional travelers, or tourists. Understanding the usage patterns of different passenger segments can assist transportation authorities and operators in tailoring their services and fare policies accordingly.

- K-means clustering can be used to analyze smart card transaction data on fares to find anomalies in fares and improve fares structures. K-means clustering can be used to find the best fare brackets that strike a compromise between revenue generation and passenger affordability by grouping fare data according to journey distance, time of day, day of the week, and other relevant parameters.

- K-means clustering can be used to find abnormalities or outliers in smart card data that might point to fraud, like card cloning or misuse. K-means clustering can assist in highlighting suspected fraud situations for further examination by grouping typical usage patterns and identifying data points that drastically depart from the clusters.

- Demand Prediction: Historical smart card data analysis using K-means clustering can be utilized to spot patterns and trends in passenger demand. K-means clustering can estimate passenger demand for various transportation services by grouping data based on time of day, day of the week, and other pertinent characteristics. This can help with capacity planning, resource allocation, and operational decision-making.

K-means clustering can, in general, be a useful tool for analyzing smart card data in the Indian transportation system, enabling data-driven, decision-making and optimization of transportation services for increased effectiveness and passenger experience.

Trip ID	Distance (km)	Travel Time (min)	Fare (USD)
1	5	12	6
2	12	25	10
3	8	15	8
4	10	22	11
5	6	10	5
6	14	30	14
7	7	15	7
8	3	5	3
9	2	3	2
10	16	35	16
11	9	20	9
12	11	23	12
13	4	7	4
14	13	28	13
15	6	10	5
16	5	11	5
17	17	40	17
18	8	16	8
19	12	27	12
20	6	12	6

center 1	5.454545455	10.54545455	5.363636364
center 2	12.66666667	27.77777778	12.66666667

1si iteration	1	2	Clusters
1	6	23	1
2	18	5	2
3	2	15	1
4	14	3	2
5	8	25	1
6	29	12	2
7	0	17	1
8	18	35	1
9	22	39	1
10	38	21	2
11	9	8	2
12	17	0	2
13	14	31	1
14	25	8	2
15	8	25	1
16	8	25	1
17	45	28	2
18	3	14	1
19	22	5	2
20	5	22	1

2nd iteration	1	2	Clusters
1	2.545454545	30.11111111	1
2	25.63636364	6.111111111	2
3	9.636363636	22.11111111	1
4	21.63636364	10.11111111	2
5	1.454545455	32.11111111	1
6	36.63636364	4.888888889	2
7	7.636363636	24.11111111	1
8	10.36363636	42.11111111	1
9	14.36363636	46.11111111	1
10	45.63636364	13.88888889	2
11	16.63636364	15.11111111	2
12	24.63636364	7.111111111	2
13	6.363636364	38.11111111	1
14	32.63636364	0.888888889	2
15	1.454545455	32.11111111	1
16	1.272727273	32.11111111	1
17	52.63636364	20.88888889	2
18	10.63636364	21.11111111	1
19	29.63636364	2.111111111	2
20	2.636363636	29.11111111	1

K=2 single linkage		1	2	Clusters
	1	2.54545455	30.1111111	1
	2	25.6363636	6.11111111	2
	3	9.63636364	22.1111111	1
	4	21.6363636	10.1111111	2
	5	1.45454545	32.1111111	1
	6	36.6363636	4.88888889	2
	7	7.63636364	24.1111111	1
	8	10.3636364	42.1111111	1
	9	14.3636364	46.1111111	1
	10	45.6363636	13.8888889	2
	11	16.6363636	15.1111111	2
	12	24.6363636	7.11111111	2
	13	6.36363636	38.1111111	1
	14	32.6363636	0.88888889	2
	15	1.45454545	32.1111111	1
	16	1.27272727	32.1111111	1
	17	52.6363636	20.8888889	2
	18	10.6363636	21.1111111	1
	19	29.6363636	2.11111111	2
	20	2.63636364	29.1111111	1

cluster 1	1,3,5,7,8,9,11,13,15,16,17,18
cluster 2	2,4,6,10,12,14,19,20

Fig -7: K-Means Clustering for Segmentation

9. 3D-MODEL OF THE SMART CARD

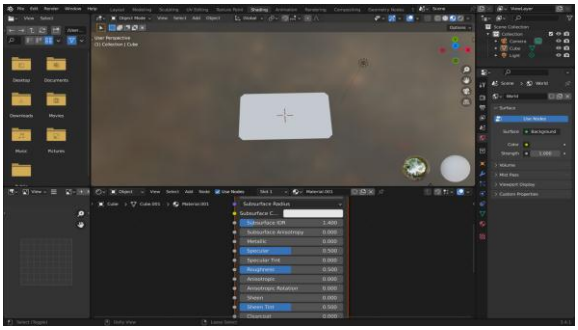

Fig -8: 3D Model of the Smart Card

Using Blender, we created a 3D model of a smart card by importing a plane image of the card, using the Extrude tool to give the plane depth and give the card a 3D shape, modelling the chip, magnetic stripe and card numbers, applying materials to the model, setting up lighting and camera angles to render the model, and exporting the rendered model as a.png or.jpeg file. In conclusion, creating this smart credit card in Blender was a rewarding and difficult project that called for a solid command of 3D modelling, texturing, and rendering. We are glad to present our design, we will try to update it in the foreseeable future also.

10. CONCLUSIONS AND DISCUSSIONS

The research was conducted entirely from the bottom up. It emphasizes the value of transfer hubs over end-to-end connectivity. We learned what travelers want and how to improve their services. We learned the fundamental reason why people choose our smart cards from further discussion. First, smart cards may be more practical for users than more conventional means of paying for transportation, including cash or ticket vending machines. They don't require users to carry cash or stand in line to buy tickets, and they may be simply reloaded with value or used to buy tickets. By minimizing the need for ticketing and cash-handling procedures, smart cards can also increase the effectiveness of the transportation system. Operators can save time and money while also getting a better overall user experience if they do this.

But there were also some demerits to the smart card. Firstly, a smart card system's implementation can be costly because it calls for the acquisition or manufacture of the cards themselves as well as the required hardware and software. Users may pay more in fares or other fees as a result of this expense. Utilizing a smart card in the Indian transportation system could provide problems with cost, inclusivity, dependency, and security. When considering whether to install a smart card system in the transportation system, it is crucial to carefully weigh these factors.

Only a few locations in India have smart card research going on. The information on public transportation and routes is provided by the already-available apps like Google Maps and m-indicator, but not its availability or position. This research addresses the disconnect between smartcards and the currently available apps. Data from smart cards can be used to plan the network of public transportation's general sustainability. One card for all public transportation options is heavily emphasized. According to the research, fare collection should take place at the time of embarkation rather than alighting. It also highlights the benefits and drawbacks of smartcards. Finally, this paper clarifies the different problems with data sharing and the kinds of information that people are willing to share. This sheds light on how individuals view data security and how crucial it is.

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