International Journal for Innovative Engineering and Management Research

A Peer Revieved Open Access International Journal

www.ijiemr.org

IJIEMR Transactions, online available on 12th Sept2017. Link :http://www.ijiemr.org/downloads.php?vol=Volume-6&issue=ISSUE-8

Title: **LEVEL OF SERVICE CRITERIA OF URBAN WALKING ENVIRONMENT IN INDIAN CONTEXT USING CLUSTER ANALYSIS**

Volume 06, Issue 08, Pages: 145– 155.

Paper Authors

BHUKYAKRISHNA,MR.UDAY KRIAN

Ashoka Institute Of Engineering & Technology.

USE THIS BARCODE TO ACCESS YOUR ONLINE PAPER

International Journal for Innovative Engineering and Management Research
A Peer Revieved Open Access International Journal
www.ijiemr.org

LEVEL OF SERVICE CRITERIA OF URBAN WALKING ENVIRONMENT IN INDIAN CONTEXT USING CLUSTER ANALYSIS

BHUKYAKRISHNA, MR. UDAY KRIAN

Civil Department (Highway Engineering),Ashoka Institute Of Engineering & Technology

Asst.Prof, Civil Department(Highway Engineering),Ashoka Institute Of Engineering & Technology

ABSTRACT

Pedestrians form the largest single road user group and also are the most vulnerable road users. Pedestrians' movements are not restricted to lanes or specific routes however they are restricted by the physical boundaries around them such as the presence of walkways or pedestrian ways. To know how well roadways accommodate pedestrian travel or how they are pedestrian friendly it becomes necessary to assess the walking conditions. It would also help evaluating and prioritizing the needs of existing roadways for sidewalk construction. Estimation of Pedestrian Level of Service (PLOS) is the most common approach to assess the quality of operations of pedestrian facilities. The focus of this study is to identify and access the suitable methodology to evaluate PLOS for off-street pedestrian facilities in Indian context. Defining the level of service criteria for urban off-streets pedestrian facilities are basically classification problems. Cluster analysis is found to be the most suitable technique for solving these classification problems. Cluster analysis groups object based on the information found in the data describing their relationships. *K*-means, Hierarchical Agglomerative Clustering (HAC), Fuzzy *c*-means (FCM), Self Organizing MAP (SOM) in Artificial Neural Network (ANN), Affinity Propagation (AP) and Genetic Algorithm Fuzzy (GA Fuzzy) clustering are the six methods are those employed to define PLOS criteria in this study. Four parameters such as pedestrian space, flow rate, speed and volume to capacity (v/c) ratio are considered to classify PLOS categories of off-street pedestrian facilities. And from the analysis six LOS categories i.e. A, B, C, D, E and F which are having different ranges of the four parameters are defined. From the study it found that pedestrian faces a good level of service of "A", "B" and "C"are more often than at poor levels of service of "D", "E" and "F". From all the six clustering methods *K*-means is found to be the most suitable one to classify PLOS in Indian context. The PLOS ranges defined in this study are significantly different from that mentioned in HCM (2010) because of highly heterogeneous traffic flow on main carriageway, poor enforcement of traffic laws, varying road geometry,

unauthorizedvendors' activities, unwanted obstructions from utilities, and illegal parking in off-street facilities etc.

Key words: Pedestrian Level of service, Pedestrian Facilities, video data collection, averagepedestrian space, flow rate, speed, volume to capacity ratio, clustering technique

1.0 Introduction

GeneralCities play a vital role in generating economic growth and prosperity. Keeping with the global trend economic growth has ushered India to go under tremendous urbanization in last century which become more significant after the independence. The sustainable development of cities largely depends upon their physical, social and institutional infrastructure. In this context, the importance of transport infrastructure is paramount. To facilitate this, what is required is a sound urban transport policy. The urban population in India has increased significantly from 62 million in 1951 to 285 million in 2001 and is estimated to grow to around 540 million by the year 2021. In terms of percentage of total population, the urban population has gone up from 17% in 1951 to 29% in 2001 and is expected to increase up to around 37% by the year 2021. Consequently, the number and size of cities have also increased considerably. Urban areas in India, which includes wide ranges of mega cities, cities, towns are not all that lucky in terms of intra & inter city transportation. Transport in this context has been a victim of ignorance, neglect and confusion all these at once. In 2002, 58.8 million vehicles were plying on Indian roads. According to statistics provided by the Ministry of Road Transport & Highways, Government of India, the annual rate of growth of motor vehicle population in India has been about 10 percent during the last decade. The basic thing is that transportation is the most important factor for developing urbanization and a significant proportion of every modal trip is made by walking. Therefore the needs of the pedestrian, like the needs of motor vehicles, should be considered in the design of the urbanenvironment and transportation facilities. Efforts should be directed toward the safe, accessible, and convenient mobility for pedestrians. Walking provides mobility to a large percentage of people in many cities, especially the poor who often do not have other alternatives. It is also essential in supporting public transport facilities, improving the overall livability of cities, providing accessibility within built areas, and providing an alternative to private vehicles for short-distance trips.Indian cities have traditionally been cities of walkers, and many urban dwellers rely on walking, cycling and public transport for their daily travel. However, with the exponential increase in motorization, limited attention has been paid to pedestrian and public transport facilities. A change in focus is required which will allow people, not vehicles, to reclaim the urban environment. Growing motorization has also lead to a dramatic increase in the number of pedestrian fatalities and accidents, and high levels of air pollution—particularly exposing pedestrians who walk to work or access public transport to reach their destinations. There are few initiatives to promote the improvement of walking in Indian cities. The few civil society organizations and nongovernment organizations working in this area can play key roles in promoting improvements on workability and pedestrian facilities in their cities.India being a developing country the traffic especially in urban street is very much heterogeneous consisting various kind of vehicles having different operational characteristics. There is a pressing need to overhaul the existing pedestrian guidelines or develop appropriate guidelines for Asian cities; particularly for Indian cities. The available guidelines are often ambiguous or inequitable and rarely enforced in cities. Traffic experts still rely on speed as the basis of performance measurement in urban areas, as found in the United States HighwayCapacity Manual (HCM). This antiquated view emphasizes the improvement of speed rather than planning for streets that promote accessibility for all users.At present no proper methodology is available to evaluate Pedestrian Level of Service (PLOS) provided by urban streets in India. It is important to develop suitable methodologies for level of service analysis of urban streets. Defining PLOS criteria is a module of level of service analysis procedure for urban streets. These methodologies affect the planning, design, and operational aspects of transportation projects as well as the allocation of limited financial resources among competing transportation projects. This envisages the importance of suitable methods that should be adopted while defining pedestrian level of service criteria of urban streets in the context of cities in India. As pedestrian level of service is not well defined for highly heterogeneous traffic flow condition on urban corridors in India, an attempt has been made in this regard to define pedestrian level of service criteria in this study.Level of Service (LOS) concept germinated from the concept of “practical capacity” presented in the 1950 HCM. In the 1965 HCM, LOS was stated as “qualitative measure of the effect of numerous factors, which include speed and travel time, traffic interruptions, freedom to maneuver, safety, driving comfort and convenience, and operating cost.” In the 1985 HCM the statement of 1965 HCM was clarified by incorporating two significant factors i.e. “Qualitative major of operational factors” and “Perception of motorist and passengers” however “OperationCost” was dropped. In 1965 and 1985 HCM the LOS was described by the six classes from “A” to “F” defined, based on the combination of travel time and the ratio of traffic flow rate to the capacity, because travel time was recognized as a dominant factor of the service quality.

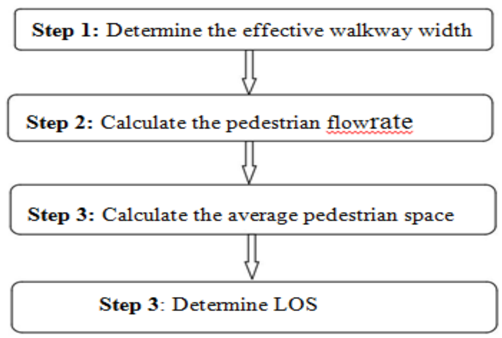
2.0 Pedestrian Level of Service Concepts Introduction

The measures used to determine LOS for transportation system elements are called service measures. The HCM defines six levels of service, ranging from A to F, for each service measure, or for the output from a mathematical model based on multiple performance measures. LOS A represents

International Journal for Innovative Engineering and Management Research
A Peer Revieved Open Access International Journal
www.ijiemr.org

the best operating conditions from the traveler's perspective and LOS F the worst. For cost, environmental impact, and other reasons, roadways are not typically designed to provide LOS A conditions during peak periods, but rather some lower LOS that reflects a balance between individual travelers' desires and society's desires and financial resources. Nevertheless, during low-volume periods of the day, a system element may operate at LOS.

The LOS criteria for pedestrian flow are based on subjective measures, which can be imprecise. However, it is possible to define ranges of space per pedestrian, flow rates, and speeds, which can be used to develop quality-of-flow criteria. Speed is an important LOS criterion because it can be observed and measured easily, and because it is a descriptor of the service pedestrians perceive. There are other significant indicators of service levels. For example, a pedestrian's streams ability to cross a pedestrian stream is impaired at space values less than 3.5 m^2/pedestrian (p). Above that level, the probability of stopping or breaking the, normal walking gait is reduced to zero. Below 1.5 m^2/p, virtually every crossing movement encounters a conflict. Similarly, the ability to pass slower pedestrians is unimpaired above 3.5 m^2/p, but becomes progressively more difficult as space allocations drop to 1.8 m^2/p, the point at which passing becomes virtually impossible. Another LOS indicator is the ability to maintain flow in the minor direction when opposed by a major pedestrian flow. For pedestrian streams of roughly equal flow in each direction, there is little reduction in the capacity of the walkway compared with one-way flow, because the directional streams tend to separate and occupy a proportional share of the walkway.Photographic studies show that pedestrian movement on sidewalks is affected by other pedestrians, even when space is more than 4 m^2/p .At 6 m^2/p, pedestrians have been observed walking in a checkerboard pattern, rather than directly behind or alongside each other.



LOS methodology for off-street walkways in HCM 2010

3.0 REVIEW OF LITERATURE

Kim et. al. (2006) suggested that street performers have a negative impact on pedestrian LOS as they create congestion, limit access, and interfere with pedestrian flows. Although street performers have freedom of expression rights, there are serious questions about their rights to the use of public property. Muraleetharan and Hagiwara(2007) focused on examining the influence of overall LOS of sidewalks and crosswalks on pedestrian route choice behavior and attributes affecting overall LOS of sidewalks and crosswalks were defined and weighted by relative importance through the stated preference survey. Jianhonget. al. (2008) analyzed the pedestrian flow characteristics on basis of one-way passageways, two-way passageways, descending stairways, and ascending stairways in Shanghai metro stations and revealed that consistent rules for traffic flow, density, and speed could be applied to both pedestrian flows and vehicle flows from the view of macroscopic statistics. Schneider et. al. (2009) demonstrated how pedestrian volumes can be routinely integrated into transportation safety and planning projects and how data from automated counters can be used to extrapolate total weekly pedestrian intersection crossing counts from manual counts. Smith (2009) suggested that perceptions as well as objective assessment of the environment are significant in different ways in predicting walking behavior. Marshall and Garrick (2012) suggest that all three of the fundamental measures of a street network-street connectivity, street network density, and street patterns are highly significant and associated with influencing the choice to drive, walk, bike, or take transit. Ullman and Trout (2009) established preliminary message design guidelines for the development of audio messages to assist visually impaired pedestrians with navigation in work zones and theauthors have noted that the visually impaired pedestrians strongly desire accurate and credible guidance information when they experience unexpected path conditions. Aultman-Hall et al. (2009) suggested that season and weather have an effect on levels of pedestrian volume in downtown Montpelier, Vermont. Precipitation reduces the average hourly volume level by approximately 13% and the winter months reduce it by 16% and also it was noted that at best a combination of weather variables accounts for 30% of the variance measured in hourly volumes.

Crosswalk

Golani et al. (2007) developed a model which includes all the elements affecting the crossing time of a pedestrian platoon: start-up time, walking speed and pedestrian headways (lag) as a function of the size of the dominant platoon, and the opposite platoon separately and the proposed model was calibrated according to data extracted from a video survey of crosswalks in three major metropolitan areas in Israel. Montufar et al. (2007) found that in all cases the normal walking speed is lower than the crossing walking speed. It also found that younger pedestrians walk faster than older pedestrians, regardless of season and gender, and females walk slower than males regardless of season and age. Furthermore, both younger and older pedestrians have a greater normal walking speed in summer than in winter but lower crossing speed in winter than in summer. Mitman et al. (2008) stated that crosswalks at uncontrolled intersections are numerous and widespread. Although engineering countermeasures offer significant potential for reducing pedestrian crash risk, not every intersection is in need of an engineering treatment. Lu and Noyce (2009) provided a quantitative comparison among several existing options for signalizing midblock crosswalk (MBC) at varied geometries.Schroeder and Rouphail (2010) demonstrated the application of a framework on the basis of pedestrian and driver behavioral parameters to develop a mixed priority delay model for pedestrian crossings at single-lane roundabouts. “Mixed priority” refers to crosswalk operations where drivers sometimes yield to create crossing opportunities, but where pedestrians sometimes have to rely on their judgment of gaps in traffic to cross the street. Ma et al. (2011) on the basis of detailed modeling of key operational characteristics, such as pedestrian delays and the area of the central refuge island, presented a multi-objective optimization model and its solutionalgorithm for optimal control of a two-stage midblock crosswalk that consists of different traffic modes (i.e., walking and driving). Ren et al. (2011) shown that most of the pedestrians evaluated walk normally when they cross the street. More than 80% of pedestrians completely use the crosswalks. However, only 73.6% cross the street during the green time. The total pedestrian compliance rate is 62.8%. Hagiwara et al. (2012) investigated the communication capability of a dedicated short-range communications (DSRC) system (5.8GHz) between right-turning vehicles and pedestrians in the crosswalk.

Cluster Analysis

4.1 Introduction This chapter presents the details of algorithms used in defining off-street Pedestrian level of service criteria of urban areas. Six cluster analysis methods are used for this purpose. From Highway capacity manual it is clear that it is quite convenient to derive off-street pedestrian LOS by using video data.

Methods of Cluster Analysis

K-means Clustering

K-means is one the simplest algorithms that can solve the well-known clustering problem. Toperform*k*-means cluster analysis on a data set; the following steps are followed:

Step 1: Placing *K* points into the space represented by the objects that are being clustered. Thesepoints represent initial group centroids

Step 2: Assigning each object to the group whose centroid is closest to the object.

Step 3: Recalculating the positions of the *K* centroids after assigning all objects

Step 4: Repeating Steps 2 and 3 until the centroids no longer move. This produces a separation ofthe objects into groups.

The steps mentioned above are expressed mathematically as flows after choosing the number of clusters $1 < c < N$ and initializing random cluster centers from the data set, the following steps were followed

Study Area and Data Collection

Introduction

In this chapter details of study area, map preparation and data collection are described. The study area for this research work is taken as Bhubaneswar and Rourkela City of Odisha state, India. The required data of the study area are obtained using video data cameras. Type and timing of data collection, data smoothing and data compilation are also discussed in detail. Observations ofthe characteristics and walking speeds of pedestrians were collected on sidewalks. A survey was used to build a pedestrian database, to aid in understanding the relationship between pedestrian characteristics. Using a digital video camera, the data recorded sidewalks at various locations in 15-minute segments. The video clips were then used to observe pedestrian walking behavior, including pedestrian interactions with street furniture or with other pedestrians. Pedestrians were counted and their walking speeds and relevant characteristics were recorded at different sidewalk locations. These data were used to build a pedestrian database, which is the core data source for this study. The survey data helped in finding out how pedestrian characteristics are affecting, and are affected by, the sidewalk environment.

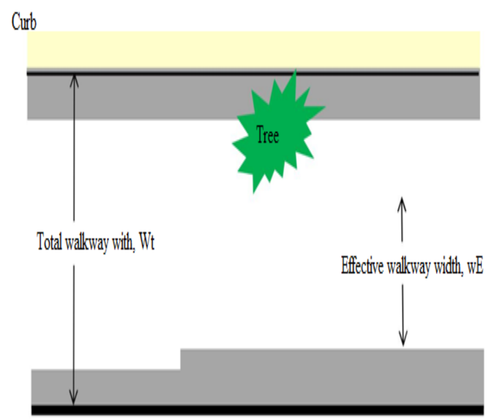
Study Corridors and Data Collection

Map preparation

A detailed roadway map is prepared from Google map which helps in the inventory study records of off-street pedestrian facility before capturing video of the road segments.

Data collection

From extensive literature survey it was found that the measure aspects for the survey are effective walkway width, pedestrian speed and hourly volume of pedestrian. Effective walkway width is the portion of a walkway that can be used effectively by pedestrians. Various types of obstructions and linear features, discussed below, reduce the walkway area that could be effectively used by pedestrians. It is calculated manually by following HCM 2010 procedure. Linear features such as the street curb, the low wall, and the building face each have associated shy distances. The shy distance is the buffer that pedestrians give themselves to avoid accidentally stepping off the curb, brushing against a building face, or getting too close to other pedestrians standing under awnings or window shopping. Fixed objects, such as the tree, have effective widths associated with them. The fixed object effective width includes the object's physical width, any functionally unusable space, and the buffer given the object by pedestrians. Effective walkway width is shown in Figure 5.3.



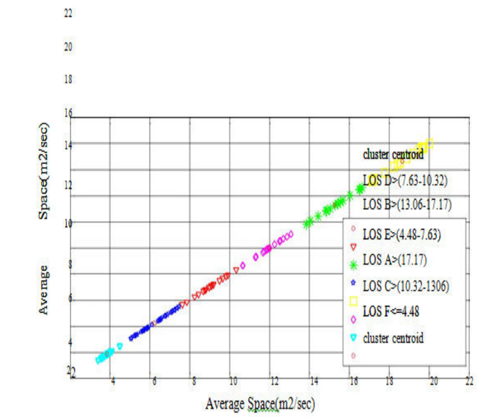
Typical diagram of Walkway Width

6.0 Result and Analysis for Defining PLOS

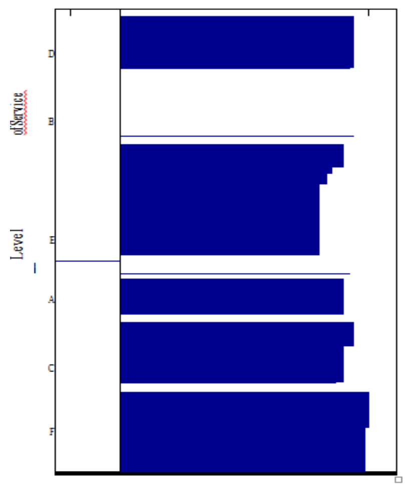
Criteria of Urban Off-street Facilities

All the parameters like average pedestrian space, flow rate, speed and volume to capacity ratio are calculated for each segment. Six advanced cluster analysis techniques (*K*-Means, FCM, HAC, SOM, AP and GA Fuzzy) are applied on these parameters. By the application of clustering methods all these four parameters gives different ranges of PLOS categories. Six PLOS categories that is "A" to "F" are defined on the basis of this classification in Indian context

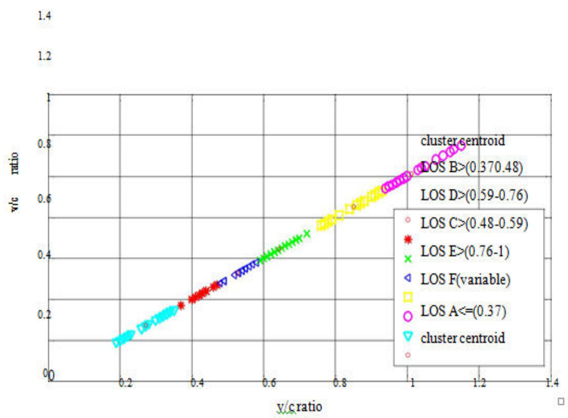
International Journal for Innovative Engineering and Management Research
A Peer Revieved Open Access International Journal
www.ijiemr.org



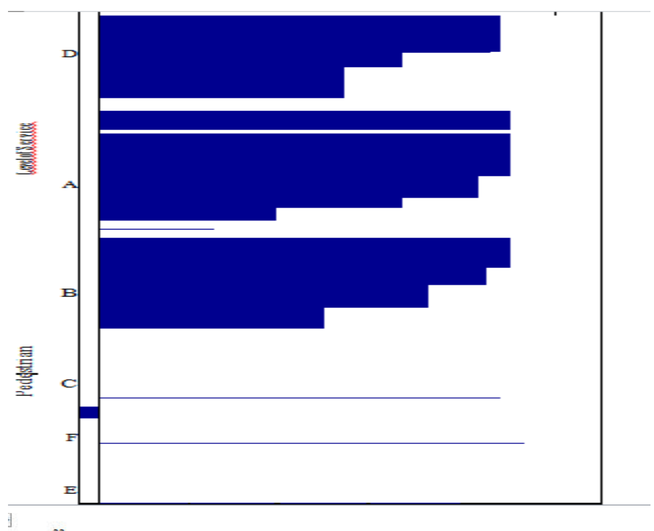
(A)Average Pedestrian Space of PLOS Categories

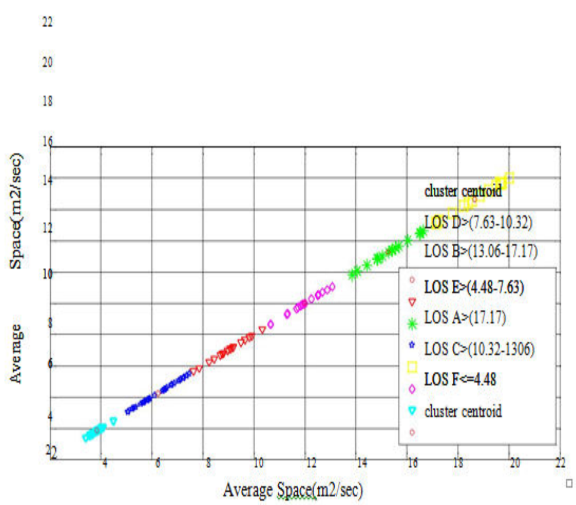


A: Silhouettes Plot for PLOS Categories of Average space

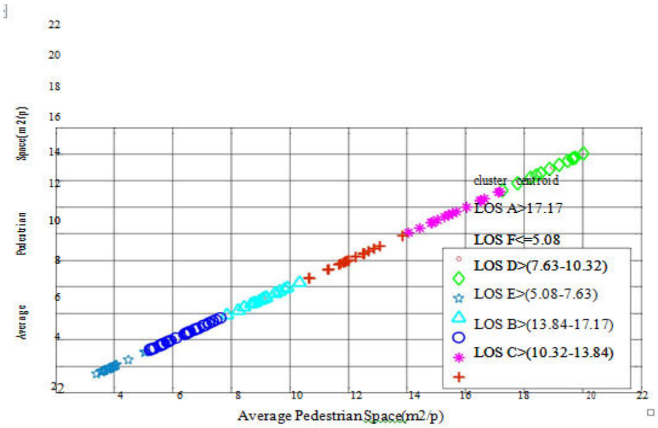


(C) Average Travel Speed of PLOS Categories

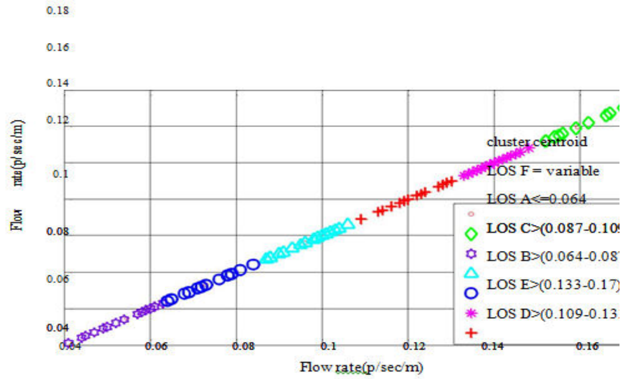




(D) v/c ratio of PLOS categories



(A)Average Pedestrian Space of PLOS Categories



(B) Flow rate of PLOS Categories

7.0 Summary, Conclusions and Future Scope

In this study, existing pedestrian level of service analysis method is discussed and its theoretical underpinnings and performance are appraised. The discussion is restricted only to approaches that have been successfully applied to assess pedestrian level of service (PLOS). The review undertaken illustrates that, over the years, PLOS methods have been developed in a variety of ways however the analysis of the methods discussed suggests the need for substantial improvements in analysis procedures. In Indian context no suitable methodology is developed to access the pedestrian level of service (PLOS). Various models available are suitable for homogenous traffic flow condition as seen in developed countries. From the available source it is found that HCM (2010) methodology for the prediction of PLOS can be used for Indian context after due modifications. Hence the PLOS methodology developed in HCM (2010) is adopted in this study. The majority of these methods and models have been developed by combining models that have been applied to other choice contexts and, as a result, are not suited to universal applications. Currently available methodologies of assessing service levels forpedestrians are unable to analyze the entire spectrum of the walking experience. About study area and video data collection from off-street pedestrian facilities from different segments are described briefly. Literature on six clustering methods such as k-means, FCM, HAC, SOM, AP and GA fuzzy clustering with their advantages, disadvantages and applicability on the kind of classification problems have been elaborated. On the basis of these six cluster analysis six level of service criteria that is from “A” to “F” are defined for pedestrian LOS for off-street pedestrianfacility in Indian context. By taking four parameters (average pedestrian space, flow rate, speed and volume to capacity (v/c) ratio), the classification of PLOS is defined. All the six cluster analysis was applied on each parameter and different ranges of different level of service are found. As the six clusters method gives different level of service values, the most suitable lustering algorithm which is appropriate for Indian condition is elected by using silhouette index.

7.2 Conclusion

Over the years, PLOS methods have been developed in a variety of ways for different walking environments and it has been suggested for substantial improvements in the analysis procedures. Six clustering methods such as *k*-means, HAC, FCM, SOM, AP and GA Fuzzy are used to define PLOS criteria. Different LOS values based

International Journal for Innovative Engineering and Management Research
A Peer Revieved Open Access International Journal
www.ijiemr.org

on pedestrian space, flow rate, speed of pedestrian and volume to capacity (v/c) ratio are defined from each clustering analysis method which gives numeric ranges for LOS categories. From this study it is observed that pedestrian data collection using video cameras is a very simple and accurate procedure. Also, by using silhouette index it is found *K*-Means clustering is most suitable in Indian context and highly efficient in terms of time saving and provides a very accurate solution to this kind of classification problem. By using cluster analysis ranges of parameters for six pedestrian level of service categories i.e. A, B, C, D, E and F are defined for off-street walking facility in Indian context; where LOS "A" represents the best operating conditions and LOS "F" the worst.

Future Scope

These are some limitations in this study and opportunities lie in future studies to eliminate these limitation.This study is conducted for the city of Bhubaneswar and Rourkela of Odisha state, India. Similar studies can be carried out in other cities of India, as it is having significant diversities among pedestrians and their characteristics.

For this research only off-street pedestrian facility is used for data collection purpose. All though off-street pedestrian facility has significance presence in urban pedestrian facility of India but to get complete picture of pedestrian movements further studies can be executed using more pedestrian facilities like cross walk, stair way, platoon flow, queuing area etc.In defining PLOS criteria user perception should be given due consideration. Along with quantitative analysis qualitative analysis from stated preference survey needed to be given due consideration.

References

- Aultman-Hall,L., Lane,D., Lambert,R.R.,(2009), Assessing Impact of Weather and Season on Pedestrian Traffic Volumes. *Transportation Research Board*, Washington, D.C. pp. 35–43.
- Bian, Y., Ma,J., Rong, J., Wang, W., Lu. J.(2009), Pedestrians' Level of Service at Signalized Intersections in China. *Transportation Research Board*, Washington, D.C.pp. 83–89
- Cetiner, B,G., Sari,M., Borat, O. A neural network based traffic-flow model, *Mathematical andComputational Applications,* 2010 Vol. 15, No. 2, p. 269-278.
- Chakroborthy, P.and Kikuchi, S. (1990). "Application of fuzzy set theory to the analysis of capacity and level of service of highways." In the proceedings of *First International Symposiumon Uncertainty Modeling and Analysis*, IEEE Computer Press, College Park, Maryland, 146-150.
- Chen, X., Shao, C., Hao, Y.(2008), Influence of Pedestrian Traffic on Capacity of Right-Turning Movements at Signalized Intersections. *Transportation Research Board,Washington*, D.C.,pp.114–124. pp. 114–124
- Chen, X., Ye, J., Jian, N.(2010), Relationships and Characteristics of

- Pedestrian Traffic Flow in Confined Passageways. *Transportation*

- *Research Board*, Washington, D.C. pp. 32–40.
- Cheol, O., and Stephen, G. R. (2002). "Real-time inductive-signature-based level of service for signalized intersections." *Transportation Research Record,* 1802, Transportation Research Board, Washington, D.C., 97–104.
- Dandan, T., Wei, W., Jian, L., Yang, B.(2007) , Research on Methods of Assessing Pedestrian Level of Service for Sidewalk. *Science Direct*, Vol. 7(5), pp.74-79.

- Galiza,R.J., Ferreira, L.(2012), Developing Standard Pedestrian Equivalent (SPE) Factors: A PCE Approach for Dealing with Pedestrian Diversity. *Transportation Research Board*, Washington, D.C.
- Golani,A., Damti, H.(2007), Model for Estimating Crossing Times at High Occupancy Crosswalks. *Transportation Research Board*, Washington, D.C
- Hagiwara, T., Hamaoka, H., Hamaguchi, M., Nakabayashi, S., Munehiro, K., Sakakima, R.(2012), Data Transmission Capability of Pedestrian-Vehicle Dedicated Short-Range Communications (DSRC) system between Right-turning Vehicles and Pedestrians at Intersection. *Transportation Research Board*, Washington, D.C.