Article Received: *25 May 2023* ***Revised:*** *12 September 2023* ***Accepted:*** *30 September 2023*

Framework Models for Theme Park Design: Incorporating Transportability Models and Visitor Preferences

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Abstract— Analyzing human movement is crucial for evaluating designs in transportation and urban planning. Our expertise lies in the realm of designing and assessing wireless networks and services tailored for cutting-edge theme park experiences. The effectiveness of specific wireless networks, such as mobile ad hoc networks, is significantly impacted by human mobility. In response to this challenge, we've developed an advanced program known as ParkSim, dedicated to replicating the intricate motion patterns of guests within a theme park environment. ParkSim utilizes an activity-based mobility model, influenced by the diverse activities guests engage in throughout the park. The calibration of this tool is based on GPS data collected from an amusement theme park, ensuring its accuracy and reliability. It has undergone rigorous verification against various performance metrics relevant to wireless ad hoc networks. Our primary goal is to enhance ParkSim further, enabling it to evaluate innovative strategies for equitably distributing visitors across different sections of the theme park. This expansion will provide valuable insights into optimizing wireless network performance and enhancing the overall theme park experience for guests.

Keywords- *Framework models , Theme park design ,Transportability models ,Visitor preferences*.

I. INTRODUCTION

Transportation and civil engineers have long been engaged in the development of techniques to model and simulate pedestrian motion. Understanding pedestrian behaviour is essential in urban planning, particularly when building walking amenities like pavements and subterranean tunnels. Civil engineers must consider pedestrian mobility while constructing constructions such as stadiums, airports, and railway stations. When there are many people in a confined space, groups of pedestrians may gather, and their actions are replicated and recreated to analyse the process of evacuating the area. Furthermore, crowd simulations find use in the film and gaming industries to provide authentic motions for extensive assemblies of characters. Wireless networking research use pedestrian and vehicular mobility models to assess the efficiency of mobile communication networks, but these models are often less complex than those utilised by transportation and civil engineers.This article focuses on the phenomenon of human movement inside entertainment theme parks.

We have successfully included an activity-based mobility model that was built expressly for park visitors into our ParkSim simulator. This model was developed by us. A total of over 600 park visitors' GPS tracks and data collected from theme parks are used to calibrate the model throughout the calibration process. We make it a priority to develop genuine mobility patterns that can be used for the purpose of evaluating the efficiency of the wireless services that are offered to park visitors. It is possible that these services will include individualised location-based services, mobile multiplayer games, park information services, social networking, and the sharing of multimedia with other users. These services might be provided via software installed on visitors' own mobile devices or on specially designed devices. Nevertheless, implementing a wireless infrastructure at a theme park may give rise to challenges that extend beyond the expenses associated with construction and maintenance. The presence of access points and antennae could be noticeable to visitors and disrupt the desired atmosphere of the park. Moreover, the uninterrupted connection offered by fixed wireless technology may not be viable in some regions of the park.

Infrastructure-based communication may be expensive or inaccessible, prompting the adoption of ad hoc mode as a viable alternative for wireless devices to directly connect within their respective ranges. Nevertheless, due to the mobility of devices, ad hoc communication may encounter interruptions when connections between devices materialise and vanish with movement.

Hence, it is essential to assess the efficacy of wireless services using practical mobility models. Furthermore, the mobility model may be used to evaluate tactics for equilibrating the quantity of visitors at various sites inside a theme park. Theme parks may experience congestion during peak periods, resulting in extended waiting times for popular attractions and causing passenger displeasure.

By providing incentives for tourists to relocate to less densely populated regions of the park, congested places may be alleviated. Although there are several pedestrian mobility models and simulation tools available, they are either too simple or fail to accurately represent real-world mobility circumstances. These models are insufficient for analysing the distinct patterns of movement seen at theme parks.Mobility models must be tailored to particular settings to ensure practical use, even if this necessitates limiting their application. Our model is specifically designed to cater to the distinct movement patterns seen at theme parks. However, it may also be customised to suit comparable environments like trade exhibitions, zoos, open-air museums, and festivals.

The extent of intricacy included in the model relies on the desired application, since most existing models only concentrate on micro-mobility (walking behaviour) or macro-mobility (destination choices influenced by activity schedules). Our model encompasses all facets and has sufficient computing efficiency to mimic the motion of large crowds in real-time. Our ParkSim model was calibrated and verified using empirical data obtained from actual theme parks. This process generated artificial mobility trajectories for park guests, which include timestamps and associated locations at defined time intervals.

II. REPRESENTATION OF PARK

To simulate the movement of theme park guests, the first step is to construct a model of the park's spatial arrangement in the simulator. ParkSim uses the OpenStreetMap (OSM) instead of developing its own layout editor for designing a theme park.

Specify the park layout using the OpenStreetMap 2011 format. Therefore, any OpenStreetMap editor may be used. Utilising OSM offers the benefit of pre-existing comprehensive mapping of significant portions of theme parks, as seen in Figure 1. The OSM maps use XML format, which facilitates parsing by the simulator. Parks consist of two distinct sorts of zones: walking areas and activity areas. Visitors use the walking areas to go between the activity areas. Prior to parsing the park map in the simulator, it is necessary to establish the boundaries of these regions in the OSM map editor.

Figure 1 .Theme park layout

2.1 Walking Areas

The simulator starts the process by generating a depiction of the theme park's spatial arrangement. ParkSim uses the OpenStreetMap (OSM) standard to define the park layout, rather than developing its own layout editor. This is beneficial since a significant portion of the theme park has already been meticulously mapped in OSM, as seen in Figure 1. The park is segregated into two distinct categories: pedestrian zones and recreational zones. Walking places are categorised into two distinct types: pathways and plazas. The OSM map editor is used to precisely define the boundaries of these locations.

In OSM maps, walkways are shown as a sequence of waypoints. Within ParkSim, every sequence of waypoints is divided into segments consisting of just two consecutive waypoints. The segments are calculated as rectangles with a height equal to the distance between the waypoints, and a width determined by the width of the walkway, as seen in Figure 2 (left).

Plazas, however, are shown as polygons with a variable number of edges. The plaza is connected to the bordering walkways by connection points situated at the margins of the polygon, as seen in Figure 2 (on the right side). Guests use the

International Journal on Recent and Innovation Trends in Computing and Communication
ISSN: 2321-8169 Volume: 11 Issue: 9
***Article Received:** 25 May 2023 **Revised:** 12 September 2023 **Accepted:** 30 September 2023*

most direct route when transitioning between two connecting points, under the assumption that the route lies inside the polygon. Nevertheless, if the shortest route extends beyond a concave polygon, the plaza may be divided into many smaller convex plazas to circumvent this problem.

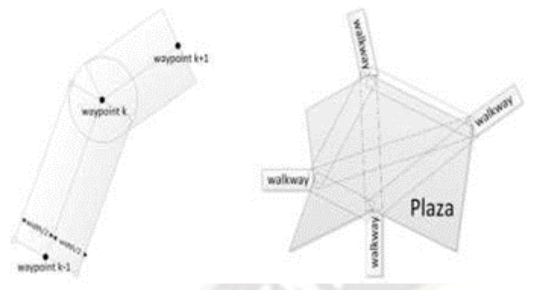

Figure 2 .Geometric representations of a walkway Geometric and adjoining walkways

III. MOBILITY MODEL

Visitors to the park arrive at the gate based on a distribution of arrival rates that fluctuate depending on the time of day. The park has the flexibility to modify the amount of arrivals according to its choice, usually increasing them during weekends and holidays. Upon entering the park, guests' movement is simulated by the ParkSim simulator at two distinct levels. Macro mobility refers to the decision-making process of individuals in selecting activity areas and prioritising among various activities. On the other hand, micro mobility refers to the actual movements of individuals inside and between activity areas, including their ability to navigate walking spaces and wait lines without colliding with other visitors. The length of time a tourist spends in the park is determined by an empirical distribution of visit durations. After concluding their stay, people go towards the exit.

3.1 Macro Mobility

A park visitor may be in one of three states: ambulating, exploring, or waiting in queue. At first, they are walking and reach the entrance of the park. Afterwards, they choose one of the authorised activity areas as a potential starting point, usually situated close to the entrance. The visitor navigates through the walking areas to reach the starting destination by following the quickest route available.

Upon reaching the location, the visitor is presented with three alternatives:
Users may enter the activity area if there is available space, and their status will change to "visiting." If the destination is a ride, their status will change to "queuing" when they join the line. Alternatively, users can opt to visit the area at a later time and continue walking towards the next destination, without any change in their status.

During the guest's visit to the park, their emotional state may fluctuate as they transition between strolling areas, activity areas, and queuing lines.Upon entering an activity area, guests choose a visit length at random from a distribution that is unique to that location. The length of visits for rides and activities is pre-established. Within the confines of an activity area, the visitor adheres to a distinctive micro-mobility framework specific to that particular location.

After finishing their tour, the visitor chooses their next activity area by referring to an activity matrix. The matrix has probabilities that indicate the likelihood of tourists visiting other attractions and rides in the park, depending on their most recent visited attraction or ride. The probability are calculated based on GPS traces of individuals who visit the park.

Presently, the activity matrix fails to distinguish between visitors of varying ages or genders. Visits to restaurants and event areas are determined by customers' hunger levels and the park's event calendar, rather than the activity matrix. Upon selecting their next location, the guest's status transitions to "walking". Figure 3 displays the state transition diagram.

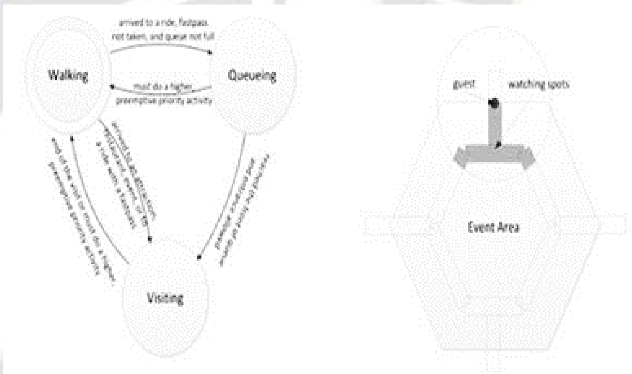

Figure 3 .Three states: walking, queuing, or visiting.

3.2 Model Validation

It is expected that park visitors own portable radio equipment, and two devices are regarded to be in touch if they are within a 50-meter range of each other. The validation of the model primarily examines contact-related parameters, including inter-contact intervals, contact durations, neighbour count, and mean square displacement. These measurements are crucial for assessing the efficiency of data forwarding algorithms in wireless ad hoc networks. The statistical distributions of these parameters are computed by using both GPS traces and synthetic tracks created by the ParkSim simulator. The findings are compared to ascertain if the model effectively captures pertinent mobility features for assessing wireless ad hoc networks. It is important to acknowledge that, despite favourable validation findings, the model may not accurately represent all aspects of park movement.

3.3 Mean Square Displacement

Displacement refers to the quantification of the distance a visitor has travelled from their initial location during a certain timeframe. Consider P(t) as the visitor's location at time t in a Cartesian coordinate system. The mean square displacement (MSD) at time t is calculated by summing the squared Euclidean distances between the positions of the visitor at time $t+\tau$ and time τ, where τ ranges from zero to T-t. Here, T represents the length of the visitor's mobility track. The mean square displacement (MSD) grows with time t, following a power law relationship where MSD(t) is proportional to t raised to the power of γ.

The exponent γ represents the rate at which diffusion occurs. In the case of Brownian motion, the value of γ is equal to 1, and the mean square displacement (MSD) exhibits a linear growth pattern over time. When the value of γ is more than 1, the mobility exhibits superdiffusion. For instance, in the case of a visitor travelling in a straight line, the mean square displacement (MSD) increases according to the square of time (t^2).

Visitors with more diffusion capabilities have a wider coverage area in comparison to those with lesser diffusion, and come across a greater number of visitors equipped with equipment that may function as data relays. The rate of diffusion significantly affects the efficiency of data forwarding techniques. To investigate the diffusive behaviour of park visitors, we computed the mean squared displacement (MSD) using data from both GPS tracks and ParkSim tracks. The curve's slope, almost equal to 1, suggests that visitors' movement has superdiffusive characteristics during a time span of few tens of minutes.

Due to the fact that guests navigate within a limited area and ultimately return to the park entrance upon completing their stay, the MSD is unable to...

exhibit unlimited growth. The rate of change of the mean squared displacement (MSD) drops below unity after roughly one hour. During brief time periods, the Mean Squared Displacement (MSD) in the ParkSim tracks exhibits a somewhat greater magnitude in comparison to the GPS tracks. This discrepancy may be attributed to the following factors:

GPS unavailability.

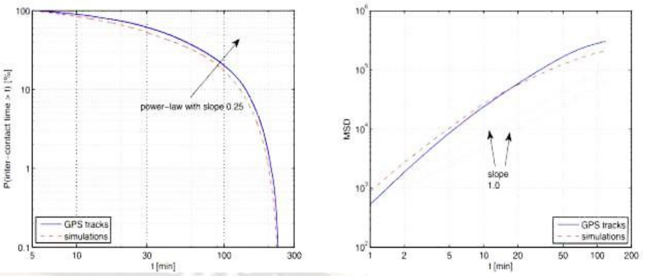

Figure 4 .CCDF of inter-contact times aggregated and Mean square displacement averaged

4. Conclusions

This paper introduces a framework for modelling the movement of pedestrians in theme parks. The concept is implemented in a tool named ParkSim, which will be made publically accessible as a component of the Jemula802 network simulation toolkit. The model is derived from actual data gathered from theme parks and comprises a macro-mobility model created from visitor activities, as well as a basic micro-mobility model for real-time simulation of visitors. The appropriateness of ParkSim for analysing wireless ad hoc networks is confirmed by validating the synthetic mobility traces it generates against real-world GPS tracks. ParkSim may also be used to examine the impacts of novel crowd balancing strategies on patterns of mobility.

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