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WiFi-Tally: Crowd Monitoring and Counting: Review

Anushka Tiwari[1], Arpit Srivastava[2], Deepesh Attri[3], Rajeev Pandey[4]
ABES Engineering College, Ghaziabad, Uttar Pradesh, India

Abstract: WiFiTally is a cutting-edge technology designed for monitoring and counting crowds in public spaces using Wi-Fi signals. Imagine a system that can track and analyze the movement of people in areas like shopping malls, airports, or event venues without invading privacy. WiFiTally achieves this by tapping into the Wi-Fi signals emitted by smartphones and other connected devices carried by individuals.
In simple terms, WiFiTally observes the patterns of Wi-Fi signals within a designated area, providing insights into crowd density and movement. Instead of relying on traditional methods like cameras, this technology prioritizes privacy by using existing Wi-Fi signals that people willingly emit from their devices.
The process involves collecting anonymous data from Wi-Fi signals and transforming it into valuable information about crowd size and flow. It doesn't identify individuals; instead, it focuses on overall trends, helping businesses and event organizers make informed decisions about crowd management. WiFiTally offers a non-intrusive and privacy-friendly solution for understanding and optimizing crowd dynamics. This abstract aims to introduce the concept of WiFiTally crowd monitoring and counting, emphasizing its user-friendly approach and respect for personal privacy in public spaces.

I. INTRODUCTION

The current population of the world is approximately 7.7 billion according to a recent statistical report. Today all regions in the world are connected with some form of transport system; cities in all countries are filled with luxury multi-purpose malls, stadiums, and so on. Where-ever we go all over the world we face one or another problem with the crowd due to increasing population and more modern development in technology. So there is a need for some responsible technology to overcome the problems created by increasing population; like automated systems for finding Tourists flow estimation to provide proper resources to them which in turn attracts many Tourists who will again increase the country's revenue; for actively managing city services for public comfort; Crowd behavior modeling, disaster prevention and crowd control for public safety; some statistical applications like allocation of resources for public events, usage statistics to public transport systems, finding occupancy limit of a building and crowd behavior can help architects and town-planners to design safer buildings and real-time estimation of people in a shopping mall can provide valuable information for managers.
The workflow of the project is as mentioned below:

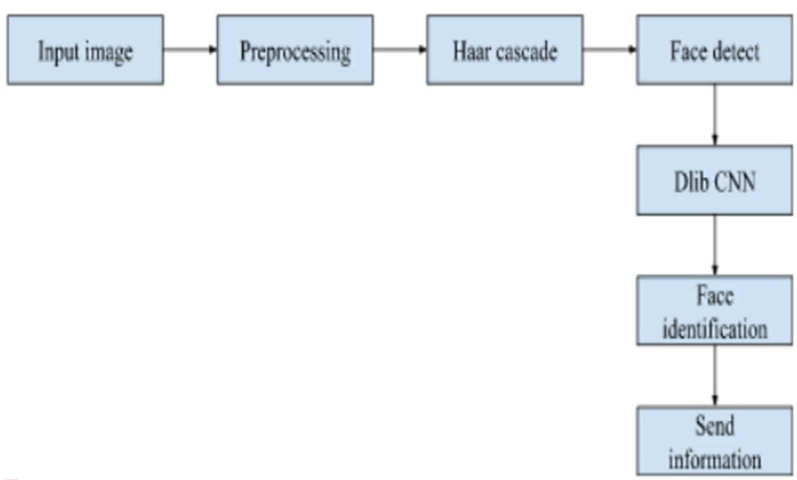

Fig.2 Data Flow Diagram

In the system design in three modules

1) *Live Module:* In this live module, the system will do all things automatically. This means the system will count the people who are entering the building at the correct time and send the information to the head of the department by email. It will also detect people who are entering the building at the wrong time and identify the face and send the information to the head of the department.
2) *Admin Module:* In this manual module, the system will do in manual. This means the system will give choices to users like counting the people, and face detecting. In this module, all processes will be done with the help of the user. The information will be sent when the user clicks the “Q button”. This manual module is for checking the system. Is the system working correctly or not.
3) *Training Module:* In this training module, the system will automatically train itself. When we create one folder for each person with their names the system will start the training and can detect person faces. The folder should be there one person pictures only and pictures should be from different angles.

II. RELATED WORKS

In the paper [1] titled “Ma, Zheng et al, 2013 and Li, Jingwen, et al, 2011 have categorized the crowd counting in the video as two broad categories. Estimating the number of people using • Region of interest (ROI counting) This is a process of estimating the total number of people in some regions at a certain time instance. • Line of interest (LOI counting) This is the method of counting people who cross a detecting line in a certain time duration. A. LOI COUNTING: The LOI counting can be developed using feature tracking techniques:

A. LOI COUNTING: The LOI counting can be developed using feature tracking techniques: • Feature Tracking Counting: Cong, Yang, et al, 2009 highlighted that in this technique the features are either tracked into trajectories and these trajectories are clustered into object tracks or based on extracting and counting crowd blobs from a temporal slice of the video.

In the paper [2] titled” Rabaud, Vincent, et al, 2006 have developed a methodology based on a highly parallelized version of the KLT tracker to process the video into a set of feature trajectories. These will provide a substrate for motion analysis, their unequal lengths and fragmented nature present difficulties for subsequent processing. This will be addressed by a simple means of spatially and temporally conditioning the trajectories. Then they have integrated it with a learned object descriptor to achieve a segmentation of the constituent motions. This framework will face problems while identifying a more complex model (in appearance and motion) of the objects. Antonini, Gianluca,et al, 2006 have introduced an approach that uses the clustering methods for the automatic counting of pedestrians in video sequences. Clustering techniques are applied to the resulting trajectories from the tracking system to reduce the bias between the number of tracks and the real number of targets.

In the paper [4] titled “Park, Hyun Hee, et al, 2006 have introduced a method that involves robust background subtraction uses a mixture of K Gaussian, the block-based decision method, and processing which analyze various actions that can occur with moving people in real-world environments. The accuracy rate is 100% if the number of people is lesser and this rate decreases with the increase in several people. Chen, Chao-Ho, et al, 2008 have exploited for classifying each block according to its motion vector and are collected to form a passenger object for counting. The inherent problems of camera shaking and variation of illumination in the bus can be rectified. If the passenger flow is so crowded that some person may stay on the stair for longer time will be counted twice.

In the paper [6] titled “Sidla, Oliver, et al, 2006 have proposed a system that uses motion to compute ROI and prediction of movements, extracts shape information from the video frames to detect individuals, and applies texture features to recognize people. A search strategy will create trajectories and new pedestrian hypotheses and then filters and combines those into accurate counting events. Computation time of the proposed system is high. Li, Min, et al, 2008 have combined a MID (Mosaic Image Difference) based foreground segmentation algorithm and a HOG (Histograms of Oriented Gradients) based headshoulder detection algorithm to provide an accurate people counts in the observed area. Merad, Djamel, et al, 2010 have implemented a new head detection based on skeleton graph processing which will extract the head of each person crowded with other persons in the same blob.

Then, the head pose estimation was estimated by finding the rigid transformation between the reference system of the model head and the reference system of the camera. This method can be made robust only with an integration of the tracking process

In the paper [7] titled “Dong, Lan, et al, 2007 have created a framework based on background differencing. This novel example-based algorithm which maps the global shape feature by Fourier descriptors to various configurations of humans directly. They have used locally weighted averaging to interpolate for the best possible candidate configuration.

The inherent ambiguity resulting from the lack of depth and layer information in the background difference images is mitigated by the use of dynamic programming that finds the trajectory in state space that best explains the evolution of the projected shapes. This algorithm will work very efficiently only when there is low to moderate number of people in the scene.

In the paper [8] titled "Fehr, Duc, et al, 2009 have proposed a model in which the first step is foreground–segmentation and then the different blobs get projected onto the head and ground planes. Later projections are used to estimate the number of people in a group. The count estimates is combined with tracking information to get a smooth count estimate. This is not desirable in public places like airports or railway stations it is highly likely that there will be people who remain stationary for extended periods.

Many studies [9] have been made in the field of people counters, several focusing on the use case of public transport, like buses and trains. Although fewer, studies have also investigated solutions for other use cases like buildings or detecting people in the case of a fire.

Marcus Thornemo Larsson and David Mozart Andraws [10], together with TietoEvry, studied different techniques already in use and compared different options based on low cost, accuracy, and the ability to be used in real-time. The different options of using WiFi-sniffing, Light Detection and Ranging (LIDAR), infrared (IR), Object Detection, and pressure pad/sensors for the use of an Automatic Passenger Counter (APC) were compared. A Raspberry Pi 4 was chosen as the microcontroller, and object detection as the method to satisfy these requirements. A prototype was developed and then tested.

this study, a goal of an accuracy of 90 % was set, and this goal was met for pre-recorded video, but live video got 66.7 % accuracy [11].

Zheng et al. developed an algorithm to detect passengers entering and exiting trains within a train station. A camera was placed to film from above. To detect passengers' heads, a network was developed called CircleDet. This network used a circle to show a detected person instead of a bounding box. The algorithm was seen to be effective and worked well on edge devices. The authors were able to get an accuracy of 97.1 % on their dataset with this solution [12].

Hsu et al .[13] used deep learning to develop a method that could be used on a bus to estimate the number of people on it. Instead of cameras by the door to count people entering and exiting the bus, one camera was put in the front and one in the back to count the number of people within the whole bus. To render a more accurate system this choice would then be incorporated with an algorithm were passengers were counted by the door.

III. PROPOSED WORK

1) *Enhancing Accuracy and Precision:* Investigate methods to improve the accuracy and precision of crowd counting through advanced signal processing techniques. This could include refining algorithms for signal collection and data preprocessing.
2) *Real-time Crowd Dynamics Analysis:* Explore the development of real-time analytics for instant crowd dynamics insights. This could involve optimizing algorithms for faster processing and more efficient movement tracking.
3) *Integration with Other Technologies:* Investigate opportunities to integrate WiFiTally with other technologies, such as surveillance cameras or IoT devices, to enhance overall crowd monitoring capabilities.
4) *Privacy-Preserving Techniques:* Develop and assess privacy-preserving techniques to further ensure the anonymity of individuals contributing to Wi-Fi signal data, addressing potential concerns related to data security and privacy.
5) *Scalability for Large Venues:* Explore strategies to scale the WiFiTally system for deployment in larger venues, optimizing performance while maintaining accurate crowd counts in expansive spaces.
6) *User-friendly Interfaces:* Design intuitive user interfaces and visualization tools to make WiFiTally more accessible for businesses and event organizers, allowing them to easily interpret and act upon the gathered insights.
7) *Machine Learning Integration:* Investigate the integration of machine learning algorithms to continuously improve crowd counting accuracy based on evolving patterns and behaviors.
8) *Benchmarking and Comparative Analysis:* Conduct benchmarking studies to compare WiFiTally with other crowd monitoring technologies, evaluating its strengths and weaknesses in various scenarios.
9) *Feedback Mechanism Implementation:* Develop mechanisms for gathering feedback from users to continually refine and enhance the WiFiTally system based on real-world usage experiences.

IV. FUTURE SCOPE

1) *Integration with Smart Cities:* Explore how WiFiTally can contribute to the development of smart cities by providing valuable data for urban planning, traffic management, and optimizing public spaces.

2) *Health and Safety Applications:* Investigate the use of WiFiTally for monitoring and managing crowd density in public spaces to ensure compliance with health and safety regulations, especially in post-pandemic scenarios.
3) *Event Planning and Security:* Enhance WiFiTally for event planning and security, offering real-time insights to organizers for crowd management, security resource allocation, and emergency response planning.
4) *Retail Analytics:* Extend the application of WiFiTally to retail environments for optimizing store layouts, analyzing customer behavior, and improving the overall shopping experience.
5) *Public Transport Efficiency:* Explore how WiFiTally can contribute to optimizing public transport by monitoring crowd density at stations, bus stops, and transit hubs, helping to improve service efficiency.
6) *Machine Learning Enhancements:* Integrate advanced machine learning algorithms to continuously improve crowd counting accuracy, adapt to changing patterns, and enhance the overall reliability of the system.
7) *Edge Computing Implementation:* Investigate the feasibility of implementing edge computing solutions to process WiFi signal data closer to the source, reducing latency and allowing for faster real-time analytics.
8) *Global Collaboration for Standardization:* Collaborate with industry stakeholders, researchers, and policymakers to establish standards for crowd-monitoring technologies, ensuring interoperability and ethical use of such systems.
9) *Privacy-Aware Innovations:* Develop and implement additional privacy-preserving techniques to address evolving concerns related to data security and individual privacy in public spaces.

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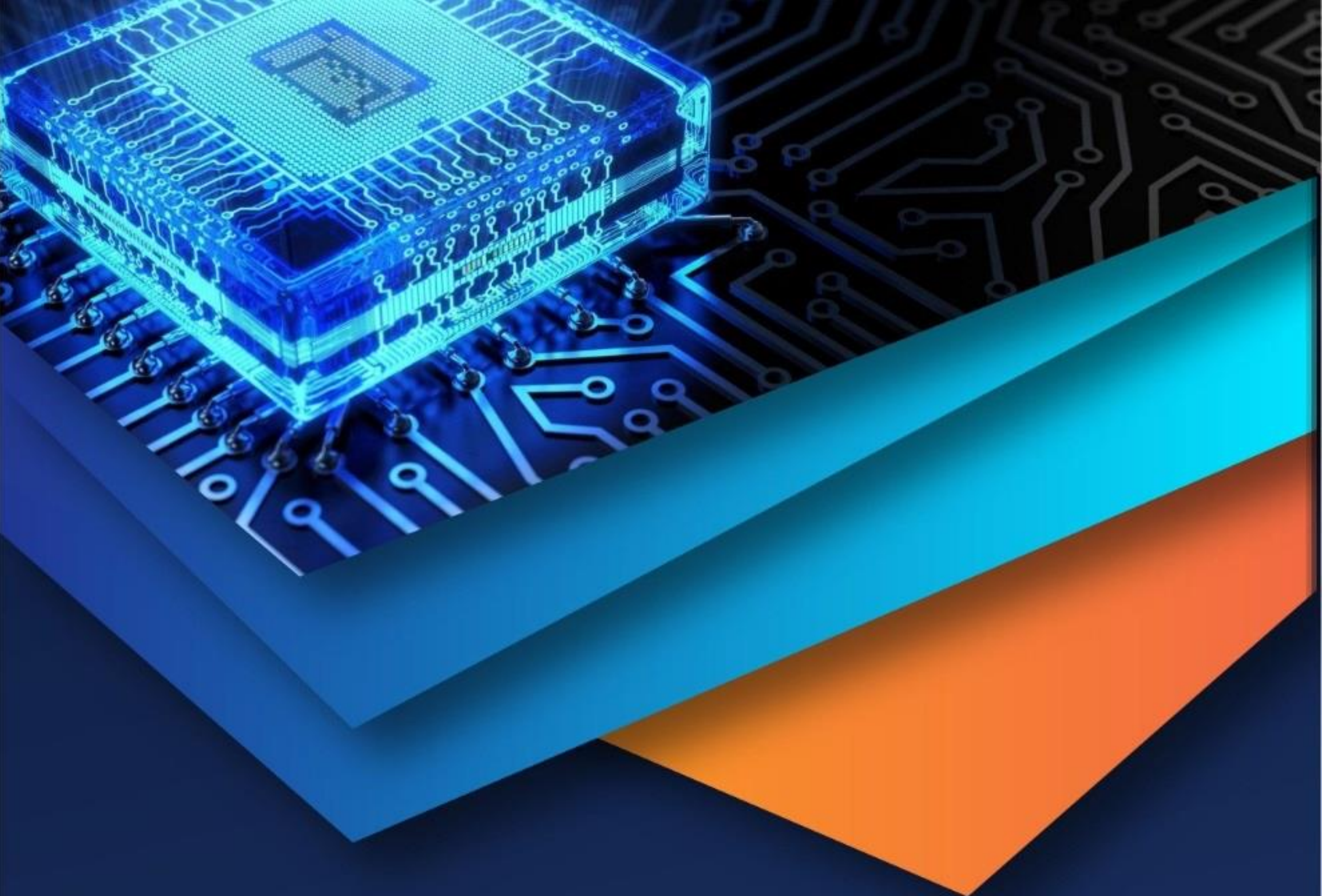

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