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Research Article

Real-time Street Parking Availability Estimation

[1]B. Raju, [2]Rathod Maheshwar, [3]A. Likitha, [4]A. Varshini, [5]A. Shivani, [6]M. Akhila, [7]V. Shashank

[1,7]B. Raju Assistant Professor in Dept. of CSE (AI&ML)

[2]Rathod Maheshwar Assistant Professor in Dept. of CSE (AI&ML), Vignana Bharathi Institute of Technology , HYD, India,

[3,4,5,6] Btech Student, Dept. of CSE (AI&ML),

[1,3,4,5,6,7]Vignan's Institute of Management and Technology for Women, HYD, India

[1]rajub@gmail.com [2] ratkitsw@gmail.com [3]likithaavvaru@gmail.com [4]achivarshini0@gmail.com [5]adumekalashivani@gmail.com [6]malaakhila2003@gmail.com, [7]shashankreddyvoorelli.1@gmail.com

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ABSTRACT

The rapid growth of cities in India initiated rapid growths of motor vehicles that resulted in unacceptable traffic congestions and a high rate of illegal parking incidents. The rapid growth of cities in India initiated rapid growths of motor vehicles that resulted in unacceptable traffic congestions and a high rate of illegal parking incidents. The conditions require immediate application of modern traffic management systems combined with parking systems. An autonomous parking space monitoring system builds its base using OpenCV and Python integration for the management of parking complexes. The system process video or image inputs from parking areas IHigh-end image preprocessing algorithms with adaptive thresholding techniques combined with contour analysis are employed to automatically transform parking space detection into autonomous processes for tracking available spots and providing visual tallies of empty spaces. The scalable technology system demonstrated improved operational efficiency with autonomous surveillance monitoring since it works well at scale. The system acts as part of smart city infrastructure to provide users with improved experience while enhancing space efficiency. The system is a key advancement towards city transport systems using data and smart functions.

Keywords: Smart Parking System, Computer Vision, Real-Time Monitoring, OpenCV, Parking Space, Urban Traffic Management.

I. INTRODUCTION:

Climate change not only affects the environment but also leads to various severe effects on carbon footprints. The rapid increase in Indian automobile ownership created additional challenges for transportation infrastructure that led to severe traffic congestion and unauthorized parking incidents throughout the country. The affected urban mobility requires immediate implementation of efficient intelligent parking management systems because of these developing problems. An innovative solution to tackle this problem arrives through the combination of Python and OpenCV with computer vision techniques in the Smart Parking System project. The system tackles the main challenge by implementing self-automatic space availability recognition cabilities. Live video or image feed inspection by this system reveals valuable data about parking spot availability that updates dynamically and in real time. Real-time space monitoring occurs thanks to the system\'s thorough breakdown of parking regions of interest (ROIs) in combination with advanced video frame processing and effective visual indicators systems. The system adopts a scalable architecture which makes its deployment possible in various parking facilities and supports integration into smart city networks. This solution produces enhanced operational efficiency which reduces urban parking matter.

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II. II. LITERATURE SURVEY:

1. Alex Net Architecture Modification for Video CCTV Car Parking Availability Detection:

Chastine Fatichah and Evan Tanuwijaya (2020) [1]. The method suggested uses Lite Alex Net as a substitute for Alex Net in the detection of vacant parking spaces in CCTV video content. The method suggested uses Lite Alex Net as a substitute for Alex Net in the detection of vacant parking spaces in CCTV video content. The system uses Lite Alex Net as a parameter-light classifier and YOLO V3 to identify marked available parking spaces. It is shown to have drawbacks when there is poor night or rainy weather that limits its working area.

2. Better Canny Based Image Edge Detection Algorithm Kewen Liu, K. Xiao, and H. Xiong devised an enhanced edge detection technique developed during 2017 [2] that incorporated adaptive median filtering and improved Gaussian blurring and adaptive thresholding to improve classical Canny edge detection [2]. With such improvements noise sensitivity was reduced to a minimum and automatic threshold setting was removed hence giving better and consistent edge detection outcomes. With such improvements noise sensitivity was reduced to a minimum and automatic threshold setting was removed hence giving better and consistent edge detection outcomes. forState-KewenLiu detection techniques exhibit robust performance in real-time systems and medical diagnosis as well as intelligent surveillance since they provide automated edge detection by virtue of their noise-immune mechanisms.

3. Smart Real-Time Parking Monitoring and Control System Presenting 2023 research proposing an AI-driven dynamic slot allocation system with motion sensors and license plate recognition (LPR) to optimize parking space management were A.O. Elfaki, Wassim Massoudi, Anas Bushnag, Shakour Abuzneid, and T. Alhmiedat [3]. Through its automatic recognition of incoming vehicles utilizing LPR technology and assignment of available slots in real time, the system raises the overall efficacy of smart parking systems. By allowing the movement and identification of vehicles, motion sensors assist with enhancing the effectiveness of slot tracking. A significant drawback of the system is its falling accuracy in LPR with decreasing light levels, which may jeopardize vehicle recognition precision, especially in low-visibility conditions or during nighttime.

4. Research into an Improved Adaptive Median Filter Algorithm Weibo Yu, Yanhui Ma, Liming Zheng, and Keping Liu, in their 2016 research, discussed the application of Adaptive Median Filtering (AMF) in eliminating salt-and-pepper noise from grayscale images. By changing the window size according to the local image features and noise density, the adaptive scheme effectively filters out noise without blurring the edges, unlike conventional median filters. The scheme widens the filtering window dynamically in heavily corrupted regions to locate appropriate median values. The research observes that AMF performs poorly in the presence of excessive noise such that it becomes harder to differentiate between noise and image features. The research observes that AMF performs poorly in the presence of excessive noise such that it becomes harder to differentiate between noise and image features. Nevertheless, it performs perfectly when eliminating low to moderate levels of noise

III. METHODOLOGY

1. Spatial Detection using YOLO V3

The YOLO V3 object detection model served to detect parking zones within surveillance videos. Application of YOLO V3 framework enabled detection performance along with real-time speed capabilities. Training the YOLO V3 model involved supervised learning from video recordings of parking lots during which annotations concerning occupancy (occupied/vacant) were added to bounding boxes. Training the YOLO V3 model involved supervised learning from video recordings of parking lots during which annotations concerning occupancy (occupied/vacant) were added to bounding boxes. The spatial detection outputs became segmented inputs before being sent to

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classification.

2. **Image Enhancement via Edge Detection and Noise Filtering***

The algorithm implemented a refined version of the Canny Edge Detection method. The method applied adaptive median filtering together with Gaussian blurring for reducing image noise and enhancing edge detection which improved parking space boundary clarity. The method applied adaptive median filtering together with Gaussian blurring for reducing image noise and enhancing edge detection which improved parking space boundary clarity. A dedicated threshold optimization procedure occurred per test condition to achieve the most accurate detection of edges. A modified adaptive median filter functioned as part of a solution to combat environmental noise sources like rain and night conditions.

A modified adaptive median filter functioned as part of a solution to combat environmental noise sources like rain and night conditions. The method-maintained edge definition yet it lowered random noise and impulse interference in input images because of which detection became more dependable during shifting lighting and weather conditions.

3. **Classification using Lite AlexNet A**

trained lightweight edition of the convolutional neural network AlexNet completed the duty of parking space availability categorization. The designers created this model to reach maximum computational efficiency so it became suitable for deployment at the edge. The classifier received spatially divided YOLO V3 output sections after enhancement processing as its input. Measurement of the classification system relied on accuracy alongside processing time and memory usage evaluation.

4. **IoT-Based Real-Time Monitoring**

System For integrating the detection system within real-world smart parking solutions, the project adopted an IoT-based control architecture. The system comprised: Embedded parking space sensors served as edge devices to verify detection outcomes while sending occupancy data from parking spaces. The system stored and analyzed real-time data obtained from combination of visual detection systems and IoT sensors through a single cloud-based data platform. The system stored and analyzed real-time data obtained from combination of visual detection systems and IoT sensors through a single cloud-based data platform. The system features an application interface with intuitive attributes to deliver real-time parking availability details to end-users.

ALOGORITHMS USED:

1 Grayscale Conversion

Step 1: Input: Color image 1_color

Step 2: For each pixel (x, y) in the image:

- Calculate the grayscale intensity I _gray(x,y) using the formula
- Igray(x,y) = 0.2989 * Ired(x,y) + 0.5870 * Igreen (x,y)+0.1140 * Iblue(x, y)

Step 3: Output Grayscale image I_gray

2 Gaussian Blurring

Step 1: Input Grayscale image I_gray, Gaussian kernel K (of size n x n)

Step 2 : For each pixel (x, y) in the image

Compute the blurred pixel value by applying the Kernal:

I_blurred(x, y) = Σ I gray(x +I, y + j).K(i, j)

$I=-k$ $j=-k$

Where k is half the size of the kernel

Step 3 : Output Blurred image I_blurred

3 Adaptive Thresholding

Step 1 : Input: Grayscale image I_gray , block size B, constant C

Step 2 : For each block B(x, y) of size B x B in the image

•Calculate the local mean of the block:

$$T(x, y) = \frac{1}{B^2}\sum_{i=B/2}^{B/2}\sum_{j=-B/2}^{B/2} \mathbf{I\ gray\ (x + I, y + j)}$$

• Apply the thresholding rule:

$$Ibinary\ (x, y) = \{255\ if\ Igray\ x, y > T\ x, y - C$$

Step 3 : Output: Binary image I_binary

4 Median Blurring

Step 1: Input: Grayscale image gray, kernel size k

Step 2: For each pixel (x, y) in the image:

•Extract a_k x_k window around the pixel (x, y)

•Replace the pixel value with the median value from the window

Step 3: Output: Median blurred image I_median _blurred

5 Dilation (Morphological Operation)

Step 1: Input: Binary image I_binary, structuring element SE (of size n x in)

Step 2: For each pixel (x, y) in the image Check if at least one pixel in the neighbourhood (defined by SE) is 1, and set the center pixel (x, y) to 1 if so

Step 3: Output: Dilated image I_dilated

6 Non-zero Pixel Counting

Step 1: Input Binary image I_ binary

Step 2: Iterate over all pixels (x, y) in the image

Count the pixels where I_binary(x, y)! = 0

Step 3: Output: Count of non-zero pixels

IV. RESULTS:

The Smart Parking System project demonstrates an effective, intelligent, and real-time approach to managing street parking through a well-integrated combination of user interface, real-time monitoring, and data processing. The system features a user-friendly login interface, which allows users to access a fully functional dashboard displaying multiple parking areas such as Area 1, Area 2, and Area 3. This dashboard serves as a central hub where users can conveniently view the current availability of parking spots in each designated area. This dashboard serves as a central hub where users can conveniently view the current availability of parking spots in each designated area. Upon selecting a specific area, the system successfully fetches live data and provides visual feedback occupancy, ensuring accurate and up-to-date information for the users. Upon selecting a specific area, the system successfully fetches live data and provides visual feedback occupancy, ensuring accurate

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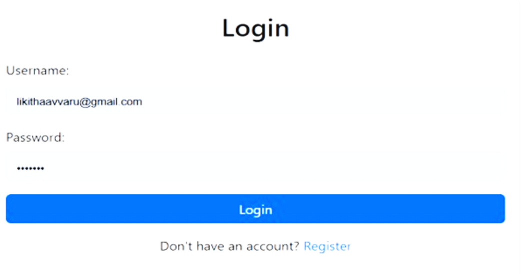
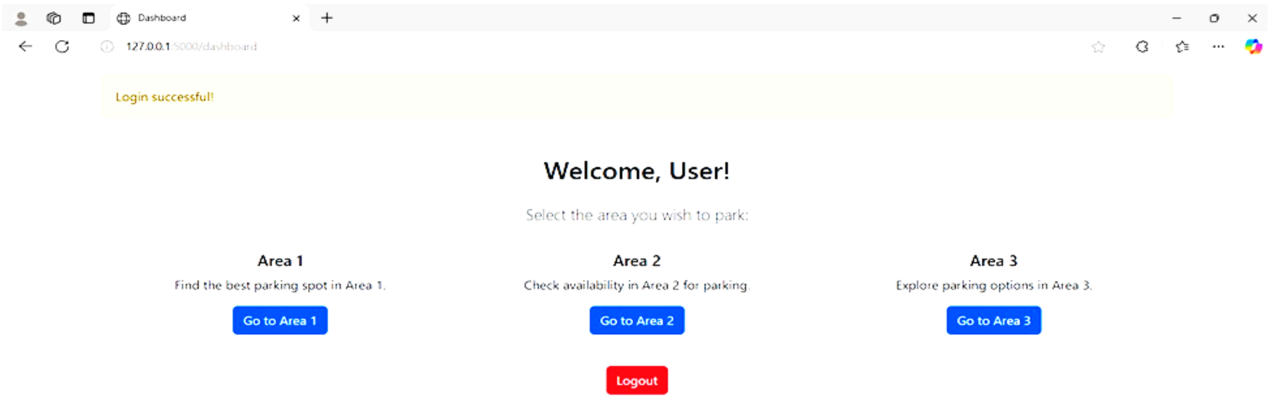
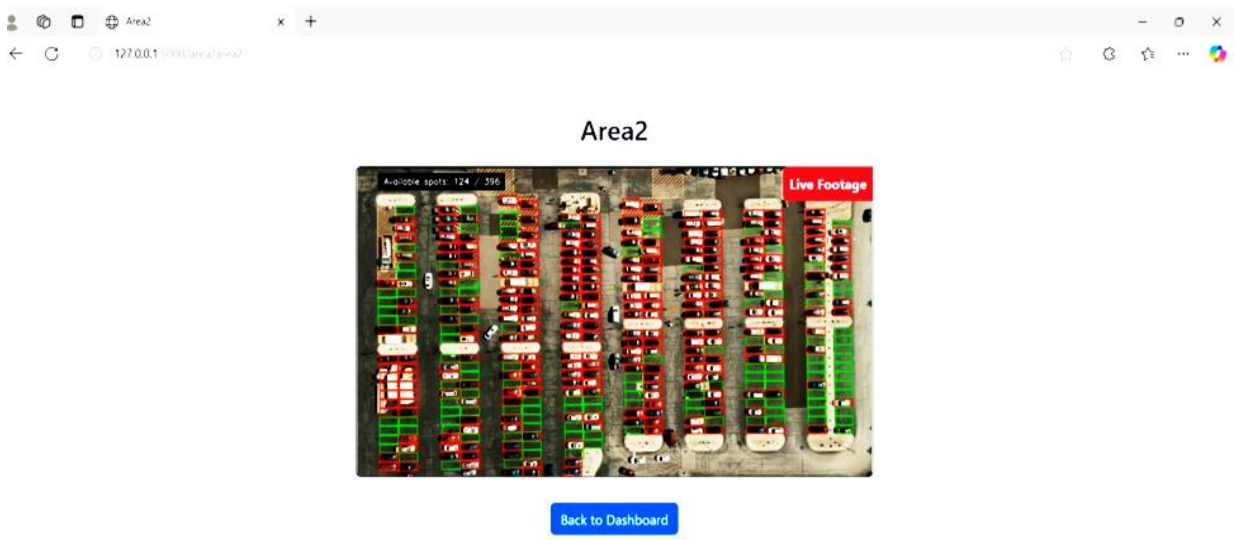
and up-to-date information for the users.







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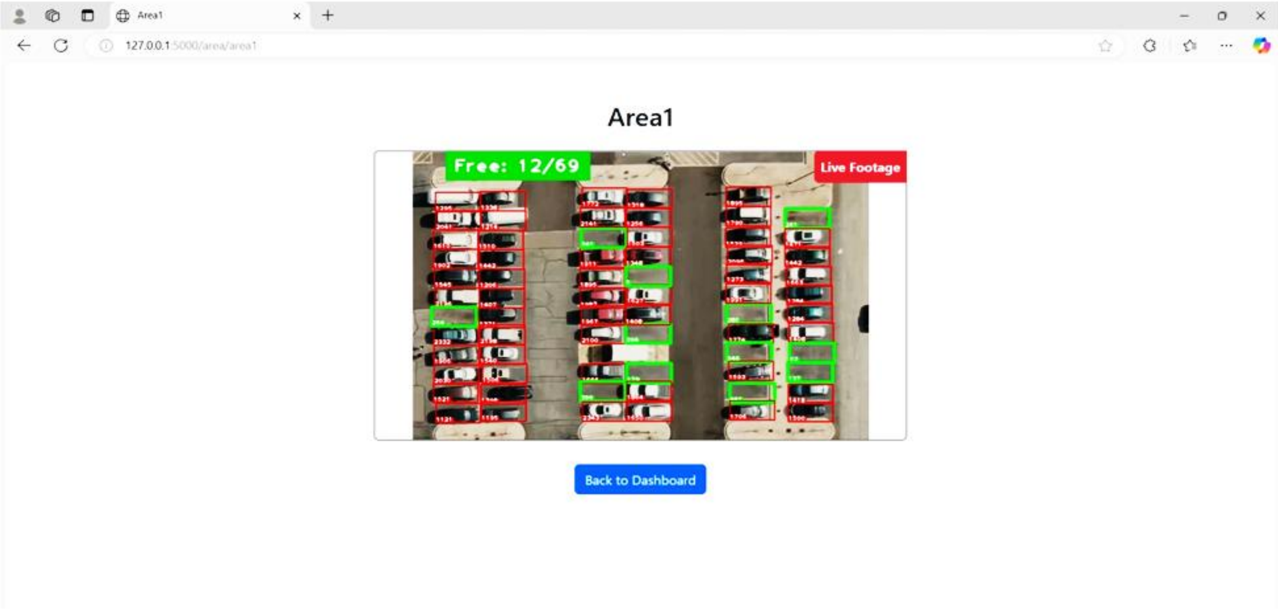

V. COMPARATIVE ANALYSIS:

Criteria	**Traditional Image Processing**	**Deep Learning (YOLOv5)**
Detection Method	Uses thresholding, dilation, and contour detection on predefined ROIs	Uses CNN-based object detection to localize and classify vehicles
Accuracy	Moderate; sensitive to lighting and shadows	High; robust under diverse conditions including occlusions
Real-Time Performance	Very fast on standard CPU hardware	Requires GPU for real-time performance
Implementation Complexity	Simple; no training required; easy to debug	Complex; requires model training and dataset preparation

Scalability	Low; manual ROI definition for each camera	High; model generalizes across different layouts and angles
Hardware Requirements	Low; suitable for edge devices	Medium to high; benefits from GPU acceleration
Maintenance	Easy to update or modify manually	Model retraining may be required for new environments
Best Use Case	Small-scale or static environments with fixed camera views	Large-scale, dynamic, or complex environments

VI. CONCLUSION:

SMART PARKING SYSTEM is designed to overcome the difficulties experienced during parking in urban areas. With immediate monitoring, there are fewer delays caused by full parking spaces and drivers don't have to waste their time searching for empty parking. Smart parking helps communities by using all the available parking and decreasing traffic that results in when cars are searching for a place to park. This solution created through the initiative is simple to use in parking systems and proves that computer vision works in real applications. Based on the test, the system leads to easier parking and more convenient access to cities. It aids in addressing problems with parking in today's cities.

VII. FUTURE SCOPE:

Using AI to anticipate parking patterns, predictive parking analytics utilizes machine learning to analyze regular parking usage and forecast space availability during peak hours, helping drivers plan ahead and save time and resources. Sustainability is enhanced through solar-powered sensors that support environmental goals and system longevity. Smart pricing models based on usage patterns encourage efficient space utilization while discouraging overuse during peak times, boosting profitability. The integration of GPS and public transport tools via the company's app, such as the "My Bus" feature, promotes smarter travel decisions. To ensure system security, advanced encryption and tamper-proof hardware are implemented. A user-friendly interface with multilingual support ensures accessibility for a diverse user base, enhancing the overall experience. Additionally, Augmented Reality (AR) helps drivers identify available parking spots in real-time by visually guiding them within the lot, improving navigation and convenience.

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