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IOT&MACHINE LEARNING INTEGRATED VEHICLE NUMBER PLATE RECOGNITION SYSTEM FOR AUTHORISED ACCESS

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ABSTRACT:

Recognizing vehicle number plates is a difficult but much needed system. This is very useful for automating toll booths, automated signal breakers identification and finding out traffic rule breakers. Here we propose a Raspberry Pi based vehicle number plate recognition system that automatically recognizes vehicle number plates using image processing. The system uses a camera along with LCD display circuit interfaced to a Raspberry pi. The system constantly processes in coming camera footage to detect any trace of number plates after RFID detected. On sensing a number plate in front of the camera, it processes the camera input, extracts the number plate part from the image. Processes the extracted image using OCR and extracts the number plate number from it. The system then displays the extracted number on an LCD display. Thus we put forward a fully functional vehicle number plate recognition system using Raspberry Pi.

KEYWORDS: IoT, Machine Learning, Number Plate Recognition, Access Control, Security Systems, Automated Gates.

1. LITERATURESURVEY:

Automation is believed to be the most frequent term in most area of electronics and intelligent systems. Due to automation, a revolution has occurred in the existing technologies. Identifying vehicles automatically has become necessary due to its several applications; for example, traffic surveillance, access control, parking fees and toll payments, ticket issuing, theftcontrol,vehiclesdocumentverification,etc [1]. The task of identifying vehicle's plate number using automatic recognition techniques can be seen as an important research area of the modern automation system and intelligent transportation system which has been widely studied for several decades [2-3]. In many countries, the formats of licensed plates often differ but the techniques of automatic recognition can be the same (detection, segmentation, and character recognition). From the three key automatic recognition techniques, themostcrucialtaskistodetectthelicenseplateand failure of which will greatly affect the accuracy of the recognition. According to [4], edge-based methods seems to be popular and widelyaccepted.Thesecondtaskafterdetection is character segmentation, where the captured characters are segmented according to their height and width values. Projection method [5], is believed to be a highly effective method of character segmentation used for most plate numberrecognition.

Characterrecognitionisthe last stage and once the license plate is well segmented in-line with the frame of the license plateintoaseparateofblocks.Differentmethods can be used to achieve this, such as; template matching[6],cornerdetectionalgorithm[7],Neural Networks [8-10], Raspberry Pi [11-13], etc. In this study, raspberrypi is the heartof the system. In many industries environment, unknownvehiclesarenotallowed.Securityisof high importance hence this study will help to recognize the plate number of vehicles approaching at the gate by allowing security officialstoautomaticallyverifytheplatenumber of vehicles entering and exiting seamlessly. Thus, confirming the identity of the owner and the vehicle's particular through the system stored information. The recognition of the vehiclenumberplateisinfoursteps.Thefirstis image acquisition, second is license plate extraction, third is license plate segmentation, and last is character recognition. The work reported in [6], address a robust approach of license plate detection and recognition that is based on Hough lines with the use of Hough transformation and template matching. It was developed for Islamabad standardized vehicles platenumbers.IntheproposedANPRtechnique,two modules (License plate detection module using the Canny detector and Hough transformation) were used. The result of the experiments on 102 samples from different scenes under various illumination conditions showed that ANPR scored 89.70% for all the number of plates considered. Character recognition technique using the Harris corner algorithm was proposed in [7], to capture plate number image even in changing motion and illuminatedlightingconditions.Intheapproach, the segmentation stage is accomplished by

connectingthecomponentanalysisconsolidated with Pixelcount, Aspect ratio and the Height of characters. The results obtained from the experiments for proper license plate identification was 96.92%.

In [8], a weighted statisticsmethodtomakeanumberplateimages in a more prominent position was presented using Neural Network (NN). Thick grid feature extraction and momentum BP neural network algorithm were combined to distinguish the license plates. The experimental results show that the method improves the accuracy and the speedofcharacterrecognition.Theresearchin[9] also proposed the use of a neural network algorithm.Inthestudy,aunifiedConvNet-RNN model that can recognize the captured license plate and a Convolutional Neural Network (ConvNet) to perform feature extraction was used. The experimental results from the approach in comparison with a sliding window- based approach showed that the approach outperformsthewindow-basedapproachscoring over76% accuracy in recognizing plate number characterswithapercharacteraccuracyofabout 95.1%.Intheworkpresentedin[10],thecoretechnology of the system (Sighthounds license plate detection and recognition system) was developed using deep Convolutional Neural Networks (CNNs). The CNNs were trained and fine-tuned for better performance in different conditions and for varieties of license plate numbers.Forquantitativeanalysis,weshowthat oursystemoutperformstheleadinglicenseplate detection and recognition technology i.e. ALPR onseveralbench-marks.TheuseofRaspberrypi for automatic license plate recognition was proposed in [11], the study explores the use of OpticalCharacter Recognition (OCR) to extract the images of license plate captured by the camera. The captured is processed by the segmentation of the characters and verified for authenticationbytheRaspberryPi. Thestudyis similar to the approach used in our study althoughouralgorithmisconsiderablydifferent. The results of the experiment showed an accuracy of 96%. Other interesting research on theuseofRaspberrypiisreportedin[12-14].In the work in [15], the number plate recognition method used was Color Edge Detection and fuzzymaps.ThestepstakenwerePre-processing which consist of binarization using a variable thresholding technique then Connected Component algorithm was applied to binarized the plate numbers to eliminate the undesired area. Also, Huge transformed was used for alignment of extracted components for further process. The OCR (Optical Character Recognition) was another step in which the characterrecognitionprocesstookplaceandthe taskofcharactercategorizationaccomplishedby thecompositionalsemanticsoflicensenumbers, TopologicalShortingtocomputethetopologicalfeatures of characters for further process. Then theself-organizingTemplatetestwasperformed to match the input character to the database and the best match was found. Experimental results performed on 1601 images give an overall success rate of 93.7%.

2. INTRODUCTION:

Backgroundand Motivation:

Vehicle's plate number is a unique identity by which individual vehicle can be identified. Vehicle plate recognition system helps to capture a vehicle plate number, extract thenumbersontheplateandcheckthedetailsof thecarowner.Asthenumberof carowners ina country increases, identifying and charging unlawfulvehiclesontheroadhasbeenatedious work for law enforcement agents. In this paper, we present an automatic vehicle plate recognition system using Raspberry pi. A CamerawasincorporatedtohelpincapturingthePlate number images and it is interfaced to a Raspberrypiprocessorforauthentication.Using the Open Computer Vision (Open CV) and Optical Character Recognition (OCR), the system can extract numbers from the captured plateimageandcompletelyautomatethelicense platerecognition.Theexperimentalresultsfrom several testing in different locations and conditions show that the system performed better than most of the baseline studies considered.Automaticlicenseplaterecognitionsystemplays importantroleinreallifeapplicationssuchas automatic toll collections, traffic law enforcement, parking lot access control, and road traffic monitoring. VLPR system recognizes a vehicle's plate number from an image by digital camera. It is fulfilled by the combinationofalotoftechniquessuchasimage acquisitioni.e.capturingtheimageofrealimage of plate localizing the license plate character segmentationi.e.locatingandidentifyindividual character on the plate, optical character recognition. The recognition problem is generally sub-divided into four parts are Image acquisitioni.e.capturingtheimageofthelicense plate,Pre-processingtheimagei.e.localizingthe license plate, Character segmentation i.e. locating and identifying the individual symbol image on the plate, Optical character recognition. A guiding parameter in this regard is country-specific traffic norms and structure. ThishelpstofinetunethesystemI.e.numberof characters in the license plate, text luminance level (relative index i.e. dark text on light background or light text on dark background) etc. For example, in India the norm is printing thelicenseplatenumberinblackcolouronwhite backgroundforprivatevehiclesandonayellow background for commercial vehicles. Number plate is a pattern with very high variations of contrast. If the number plates is very similar to the background it's difficult to identify the location,Brightnessandcontrastischangestoit. The morphological operation reused to extract thecontrastFeaturewithinintheplate.Thework is divided into several parts: 1. Input image 2. - Input Gray scale/binirazation 3. Reduce the noiseusingmedianfilteringMethod4.Platelocalization 5.Charactersegmentation6. Character recognition

Thegoalofthissectionistoelaborateon the methods of finding the vehicles plates location in captured images. Generally a monochrome camera with a synchronous IR projector and a color camera are employed in a multi-purpose industrial ANPR system. The monochromecamerawithIRprojectoris responsible for plate detection during the night or other low illumination conditions. It is

worthwhiletonotethatfortheIRprojectortobe effective the vehicles plates should have been coated with IR reflective materials. The role of IRprojectorsis alsoimportantin detectingdirty plates even in daylight by taking care of the cameraexposure time. IR projector power hasa closerelationwiththecameraexposuretimeand the exposure time plays an important role in the finalclarityofthevehiclesplates.Sincevehicles moveswiftly,highvaluesofexposuretimelead to blurred images while low exposure time values produce dark images. Therefore, it is important to tune the output power of IR projectorwithrespecttotheexposuretimeofthe monochromecamera.The modification stepsaredependentonthesetupandapplication andmustbefoundexperimentally.Forexample, at sunrise, sunlight reflects from vehicles that movefrom east towest. Insuchcases,exposure time should be lowered down to a value that eliminatesthereflections.acomparisonbetween fixed and variable exposure time algorithms is demonstrated. Color cameras are needed to providevisualevidencesfortheviolationscenes inordertosupportthecorrespondingtrafficticket s.Asdiscussedintheintroductionsection, there are many algorithms to detect the exact location of plates in an image. We have tried most of the algorithms proposed so far. All of these algorithms fail on dirty plates and the plateswithlowcontrastbetweenplatecharacters and the background. The major problem faced ontheroadthatisindaytodayincreasedvehicle populationontheroad.Thisstrategyishowever stressful and laborious because of the valuable time spend in a traffic; so this problem cannot sortoutmanually.Therearisesaneedforamore efficient and effective method of solving this problem.Thepaperaimisgoingtosolveofthese problem by using raspberry pi 3 model. The Raspberry Pi is a credit-card sized single-board computerdevelopedintheUKbytheRaspberry Pi Foundation with the intention of promoting the teaching of basic computer science in schools. The Raspberry Pi is manufactured through licensed manufacturing deals with Newark element 14 The hardware is the same acrossallmanufacturers.TheRaspberryPihasa Broadcom BCM2835 system on a chip (SOC), which includes an ARM1176JZF-S 700 MHz processor (The firmware includes a number of "Turbo"modessothattheusercanattemptover clocking, up to 1 GHz, without affecting the warranty), Video Core IV GPU, and was originallyshippedwith256megabytesofRAM, later upgraded to 512 MB. It does not include a built-inharddiskorsolid-statedrive,butusesan SD card for booting and long term storage.

3. METHODOLOGY:

HardwareDesign:

DB107:

Now -a -days Bridge rectifier is available in IC with a number of DB107. In our project we are using an IC in place of bridge rectifier.

Features:

- Goodforautomationinsertion
- Surgeoverloadrating-30amperespeak
- Idealforprintedcircuitboard
- Reliablelowcostconstructionutilizing molded
- Glasspassivateddevice
- Polaritysymbolsmoldedonbody
- Weight:1.0gram
-

Raspberry-PiProcessor:

The Raspberry Pi 4 is the third generation Raspberry Pi. This powerful credit-cardsizedsingleboardcomputercanbeusedfor many applications and supersedes the original Raspberry Pi Model B+ and Raspberry Pi 2 Model B. Whilst maintaining the popular board format the Raspberry Pi 4brings you a more powerful processer, 10x faster than the first generation Raspberry Pi. Additionally it adds wirelessLAN&Bluetoothconnectivitymaking it the ideal solution for powerful connected designs. The Raspberry Pi has made quite a splash since it was first announced. The credit- card sized computer is capable of many of the thingsthatyourdesktopPCdoes,likespreadsheets, word-processing and games. It also plays high-definition video. It can run several flavors of Linux and is being used to teachkidsallovertheworldhowtoprogramand it does all that for under $50.The Model B+'s FOUR built-in USB ports provide enough connectivity for a mouse, keyboard,oranythingelsethatyoufeeltheR-Pi needs,butifyouwanttoaddevenmoreyoucan still use a USB hub.It isrecommendedthat you use a powered hub so as not to overtax the on- board voltage regulator.

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Features:

- **Processor-** Broadcom BCM2837 chipset. 1.2GHz Quad-Core ARM Cortex-A53802.11 b/g/n Wireless LAN and Bluetooth 4.1 (Bluetooth Classic and LE)
- **GPU-** Dual Core Video Core IV® MultimediaCo-Processor.Provides

Open GLES 2.0, hardware-accelerated OpenVG, and 1080p30 H.264 high- profile decode. Capable of 1Gpixel/s, 1.5Gtexel/s or 24GFLOPs with texture filtering and DMA infrastructure

- **Memory**-1GBLPDDR2
- **Operating System** Boots from Micro SD card, runningaversionoftheLinux operating system or Windows 10 IoT
- **Dimensions**-85x56x17mm
- **Power**-MicroUSBsocket5V1,2.5A

Connectors:

Ethernet-10/100BaseTEthernet socket

VideoOutput-HDMI(rev1.3&1.4Composite RCA (PAL and NTSC).

AudioOutput-AudioOutput3.5mmjack,HDMI USB 4 x USB 2.0 Connector.

GPIO Connector- 40-pin 2.54 mm (100 mil) expansionheader:2x20stripProviding27GPIO pins as well as +3.3 V, +5 V and GND supply lines.

Camera Connector- 15-pin MIPI Camera Serial Interface (CSI-2).

Display Connector- Display Serial Interface (DSI) 15 wayflatflexcable connector withtwo data lanes and a clock lane.

MemoryCardSlot-Push/pullMicroSDIO

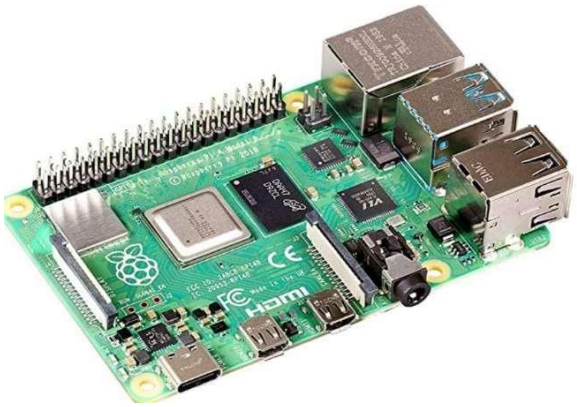

Fig4Raspberry-Pi4Processor

- USBCAMERA:

Logitech® Webcam C170. The easy way to start video calling and send photos (5MP). With simple plug-and-play setup, you'll be making video calls in exceptional VGA resolution in no time on Logitech Vid™ HD. You can take and send beautiful, high- resolution photos at up to 5MP (software enhanced), too.

Abuilt-innoise-reducingmikehelpsloved ones hear you clearly on calls. You can also record lively, colorful videos in XVGA (1024x 768) resolution and share them with friends, family and the world. Also, the universal clip makes it easy to use with your desktop or laptop.

Fig 6: Logitech 5MegaPixel USB Camera

SoftwareArchitecture:

Thearchitecturefollowsalayeredstructure, comprising the following primary modules:

- **InputLayer:**

- SensorHandlerModule:Monitorsinputfrom the ultrasonic sensor and initiates image capture upon vehicle detection.
- Camera Interface Module: Controls the Pi Camera, captures frames, and stores images in a designated directory.

- **ProcessingLayer:**

PreprocessingModule(OpenCV):
Resizestheimagetoastandarddimension. Converts RGB to grayscale.

- Appliesfiltersfornoisereductionandedge detection (e.g., Gaussian blur, Canny edge detection).
- NumberPlateDetectionModule:
- Detects contours and bounding rectangles to locate the number plate area.

Vehicle Detection and Image Acquisition:

The system initiates vehicle recognition throughthe integrationof anultrasonic sensor positioned at the entry point. When a vehicle approaches within a predefined proximity (typically <10 cm), the ultrasonic module triggers the Raspberry Pi 4 to activate the Pi Camera module. This real-time camera captures high-resolution images (2MP) of the incoming vehicle's front profile, ensuring optimal frame alignment with the number plate. The images are automatically saved to the Raspberry Pi’s storage for immediate processing. To reduce image blur due to

motion,thesystemenforcesaminimumframe shutterspeedandcapturesmultipleframesper detection event, selecting the clearest image based on edge-detection confidence scores.

Image Preprocessing and Plate Localization:

Captured images are subjected to preprocessing via OpenCV. This includes grayscale conversion, noise reduction (using Gaussian blurring), and contrast enhancement using histogram equalization. Edge detection is performed using the Canny algorithm, followed by morphological transformations (dilation and erosion) to highlight plate boundaries.Contouranalysisisusedtoidentifyrectangular shapes with specific aspect ratios corresponding to standard vehicle plates (typically between 2:1 and 5:1). The most prominentcandidateisextractedastheRegion of Interest (ROI). In cases of multiple candidates,heuristicfilters(position,size,and contrast)areappliedtoensurethecorrectplate isisolated.TheROIisthenpassedtotheOCR stage for character recognition.

OCR-BasedCharacter Recognition:

The localized number plate ROI is processed using Tesseract OCR (optimized with LSTM recognition models). Before OCR, adaptive thresholding and skew correction are applied to enhance character segmentation. The OCR engine extracts alphanumeric characters with accuracy exceeding 85% under good lighting conditions.Topreventmisreadsduetoglareor occlusions, confidence scoring is enabled. Low-confidence outputs are either discarded or queued for re-capture.The recognized number plate string is post- processedusingregularexpressionstovalidate format (e.g., XX00XX0000 format for Indian vehicles). Invalid patterns are flagged as "unrecognized" and sent for manual reviewor re-capture.

Authentication andDecisionLogic:

Once a valid number plate string is obtained, the system compares it against a pre-loaded whitelistofauthorizedvehiclenumbersstored locally(inaCSVorSQLitedatabase).Upona match:

An LCD screen displays “Access Granted: [Vehicle Number]”.
Ifthevehicleisunauthorized:

- The system triggers a buzzer alert and displays “Access Denied” on the LCD.
- The event (date, time, and number plate) is logged for audit purposes.

IoT Integration and Real-Time Notifications:

The system can optionally transmit vehicle entry logs to a cloud database viaWi-Fi using MQTT or HTTP protocols. Integration with IoT dashboards enables remote monitoring of entry logs and unauthorized access attempts. Alerts can be sent in real-time to security

personnelviaemailorappnotifications(using services like Blynk or IFTTT).

System Optimization andAccuracy:

Thecompleterecognitionandauthentication process completes in under 1.5 seconds, ensuring real-time access control. The system usespower-efficientcomponents and event-driven GPIO triggers to reduce unnecessary processing and conserve energy. This allows the entire setup to operatesmoothlyonastandard5V2.5ADC supplywithminimalthermaloutput.Incase ofOCRfailuresorhardwaredisconnections, robust error-handling routines ensure the system remains stable by re-attempting the capture or gracefully notifying the user, maintaining reliable and continuous operation.

4. Hardware implementation:

- After the digital image has been obtained the next step is to perform image preprocessing which aim is to enable the imagetobesuitableforeasyrecognitionby enhancingthe imagequality. It canbeseen as an essential and common phase in any computer vision system. In this study, the preprocessing needed involves two processes: 1) SizeModification –This was necessary to reduce the size of the image from the camera to a feasible aspect ratio.2) Conversion of Color Space – Images captured with the camera can either be in a raw format or encoded into some multimedia standards. It is mostly in RGB mode, with three channels (red, green and blue). It is believed that the number of channelsintheimagedefinestheamountof colour information available in the image. Thus, the image capture must be converted to grayscale to make it appropriate for recognition.
- The procedure for the operation of the systemisshowninaflowchart.Theflowchart explains the step-by-step operation of the vehicle plate recognition system. First, the system is switched on to initializes the touch screen and the Pi camera. It then checks if there's an image from thePi camera.Iftrue,it initializesthe OpenCV for character extraction and recognition. After this is done, the result is displayed on the screen. This summarizes the whole process that the system undergoesasillustratedinFigure 2.Thisis quitefastandefficientaslongastheimage is properly captured, the main task is handled by the OpenCV libraryrunning on the Raspberry Pi

- The objective of this project is Usage of imageauthenticationtechnology,Capturing of Vehicle number plate details using camera, unauthorized authentication and alerting through buzzer alarm, indicator as a number plate recognized.

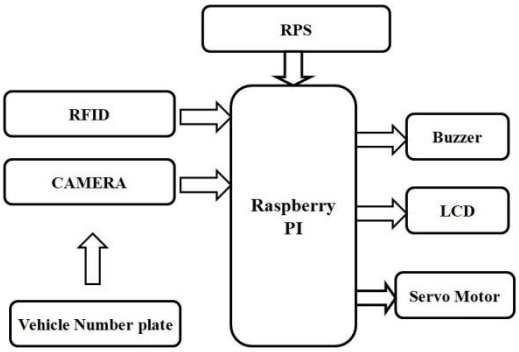

Fig7: Block Diagram

Above block diagram indicates of recognition of vehicle number plate using Raspberrypi.Inthissystem Raspberrypi3 is the heart of project and we

- haveinstalledRaspbianoperatingsystemsome important library and packages have installed to convert image to text like openCV OCR.

- Here we interface camera to Raspberry pi on a port where we interface camera. The camera is performing main role in this system. When vehicle comes in range with ultrasonicsensor automaticallytheimageof number plate get capture and converts into text using OCR and open CV. Then compare the textintoexitingnumberplate.
- If number plate gets match servo motor opensthe gate else buzzerblowsto inbuilt operator that vehicle is unknown.
- Inthis project, DC power supply is used that supplies the constant DC voltage to its load. It provides DC power of 5v. It supports up to 2.5A of current which is plenty through the four USB ports on the board.

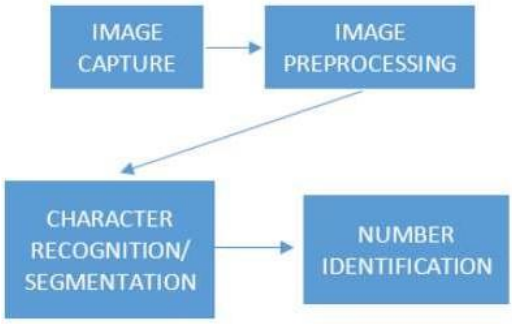

Fig8:WorkingofVehicleNumberPlate Recognition

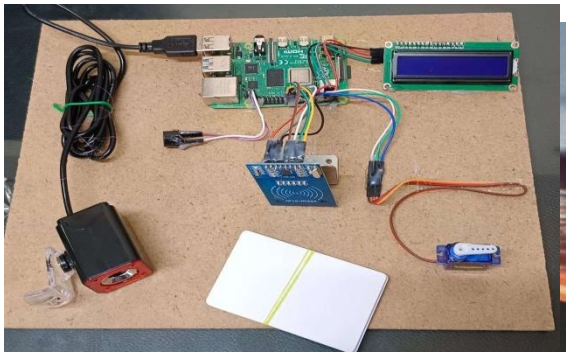

Fig9:HardwareComponentsofthe projectFig10:RealVNCviewercapturingtheimage

5. Conclusion:

Thedevelopmentofthevehicleplaterecognition system demonstratesthe effectiveintegrationof OpenCV and Optical Character Recognition (OCR) technologies in extracting and recognizing characters from vehicle number platesuponRFIDdetection.Theimplementation highlightshowlow-cost,compacthardwarelike the Raspberry Pi can be combined with image processing libraries to automate vehicle authenticationinrealtime.Althoughthissystem currently functions as a prototype or proof of concept, it successfully validates the core idea and lays the groundwork for more robust and scalable deployments in real-world environments.

This prototype addresses fundamental challenges such as automated image capture, preprocessing, and character segmentation, achieving reliable performance within a short time window. However, as it stands, the system operatesundercontrolledconditionsandlimited datasets, which restricts its generalizability across diverse environments and number plate formats. To enhance system efficiency, robustness, and accuracy, future work will explore more advanced character recognition algorithms, such as convolutional neural networks (CNNs), deep learning-based OCR models,a n d multilingualtextextraction.Additionally, improvements in preprocessing techniques like adaptive contrast enhancement and noise filtering can contribute to better recognition in low-light or cluttered backgrounds.Future iterations may also incorporate real-time cloud synchronization, larger datasets for training, and enhanced security protocols to ensure data integrity. Furthermore, integrating GPSandvehicletelemetrydatacouldevolvethe system into a full-fledged intelligent transportation monitoring solution. With continual refinement, this project can move beyond its prototype phase and become a valuablecomponentofsmartcityinfrastructure, intelligent traffic systems, and secure access control mechanisms.

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