ELSEVIER

Scopus

doi

Journal of Vibration Engineering

ISSN:1004-4523

Registered

- SCOPUS
- GOOGLE SCHOLAR
- DIGITAL OBJECT IDENTIFIER (DOI)
- IMPACT FACTOR 6.1

Our Website
www.jove.science

AUTOMATIC SPEEDCONTROLBYREALTIMEROADLANEAND VEHICLE DETECTIONUSINGHAARCASCADEALGORITHM

K.Alamelu
AssistantProfessor,ECE,ManakulaVinayagarInstituteofTechnology

Abstract——The system uses computer vision to detect roadlanes and vehicles in the real-time, adjusting the vehicle'sspeed for improved road safety. It also prevents accidents duetodrowsydrivingonhighways.Haarcascadealgorithmprovidesfastandaccuratedetection,implementedonRaspberryPi.Thesystemcapturesroadimagesusingacameraandprocessesthemin real-time.Itadjuststhevehicle's speed based on detected road lanes and vehicles,ensuring safe driving and maintaining a safe distance fromother vehicles.

Keywords— image processing; thresholding implementation;edge detection; background subtraction; haar cascade; trackingmovingobjects.

I.INTRODUCTION

The Haar cascade algorithm is a type of machine learning-based approach used for detecting the object in images andvideo. It is a popular algorithm because it is relatively Fastand accurate. It works by training a classifier on a largedataset of positive andNegativesamples. The RaspberryPi isacomputerwhichisassmallascreditcardthatiscapableofrunning a variety of software and operating systems. WhenusedwiththeHaarcascadealgorithm,itcandetectobjectsin real-time. Automatic speed control systems uses sensors andalgorithms which is used to detect and monitor the speed ofvehicles on the road. These systems can help reduce accidentsand improve road safety by alerting drivers when they areexceedingthespeedlimitorwhenthereisariskofcollision.They can also help reduce traffic congestion and improve fuelefficiency.Automaticspeedcontrolsystemshavebeenaround for several decades. The first speed control systemwas introduced in the 1960s and used mechanical devices toregulate vehicle speed. Since then, there have been significantadvancements in detection algorithms and sensor technology.Today, many automatic speed control systems use cameras,radar, and laser sensors to detect and monitor vehicle speeddetection algorithms have also improved significantly overtheyears.TheHaarCascadealgorithmwasintroducedinthe early 2000s and quickly became popular for its speed andaccuracy.Automaticspeedcontrolsystemscanhelpimproveroadsafetybyreducingtheriskofaccidentscausedbyspeeding or reckless driving. They can also help reduce trafficcongestion.Inaddition,theycanhelpreducethecostofhealthcare and insurance by reducing the number of accidentsand fatalitiesontheroad.

II. Literaturesurvey

Vehicle and pedestrian discovery is crucial for IntelligentTransportationSystems,despitechallengeslikevaryingweather and lighting conditions. Detecting climbers amongvehicles is a top priority for automakers, necessitating anautomated system capable of identifying pedestrians amidstthe surrounding vehicles. The performance of the systemdecreases as occlusion increases. This paper introduces theHaar Cascade Classifier and Background Separation system,whichindependentlyenablevehicleandpedestriandiscovery.TheHaarCascadeclassifier,initiallyproposedbyViola-Jones, is an effective method for object detection, whiletheBackgroundSeparationsystemutilizestheK-NNalgorithmtoidentifyclimbers.[1].

Recentadvancementsinartificialintelligence,particularlyindeeplearning,haverevolutionizedautomationacrossvariousindustries.Deeplearningandcomputervisionhaverevolutionizedintelligentsystems.IntelligentVehicleSystems and Intelligent Transport Systems greatly benefitfromvehiclediscovery,whichincludestaskssuchasidentifyingroadscenes,detectingdisabledvehiclesforfindingalternativeroutes,andpreventingaccidents.Thispaper introduces the utilization of the state-of-the-art MaskR-CNNsystem,employingtransferlearning,forvehiclediscovery through case-wise segmentation. This approachsimultaneously produces bounding boxes and object masks,ensuring accurate and flawless vehicle identification. Themodel showcased excellent performance in detecting bothcongestedandsmall-objects.Toconductthestudy,TensorFlowandKerasframeworkswereutilizedwithonlineGPU and also the cloud services from Google Colab. Bycombiningvarious standarddatasets,the modelachievedremarkableaccuracy,reaching90.27%onthechartandscoring92.38%.[2].

Automated vehicles have become an integral part of ourtechnologically advanced world. When discussing vehicles,business and accidents are the foremost concerns. Accidentscan occur due to various factors such as heavy traffic, adverseweather conditions like rainfall, unexpected slowdowns, andchanges in speed. To address these challenges, ML, CV, andDL technologies are employed. The system is to increasevisibilityinlowvisibleregionsandcalculatefutureconditionsbasedonpresentassessments.Thismodelimprovesvisibilityanddrivingexperienceparticularlytargeting sandstorms due to afforestation. It involves twosteps: situation analysis, dehazing and vehicle discovery,andprediction. The estimation of traffic density andfire detectioninworst-casescenariosusingPython,DLtechniques,TensorFlowandvehiclecountingalgorithms.[3].

Unmanned aerial vehicles (UAVs) are increasingly used forcost-effective business monitoringand datacollection onroadways.Thisstudyintroducesanew methodologyforaccurately extracting vehicle trajectories from aerial videos.Thesystememploysanensemblesensorforvehicledetection, kernelized correlation filtering for tracking, and amapping algorithm toconvert positions toFrenet coordinates.A denoising process eliminates biased data. Evaluation withpeak and non-peak hour videos shows precise extraction, withMSDof2.301m,RMSDof0.175m,andPearsoncorrelation of 0.999.[4].

Thispaperintroducesadeeplearningmodelforaccurateandfast detection of vehicles. The model comprises three keymodules:lane sensor, vehicle sensor, andtaillight sensor.Wherepreviousalgorithmsthatrelyonhand-codedschemes,we adopt a data-driven approach in both the vehicle andtaillightmodules.Thelanediscoverymodule,designedintricately,utilizestheintermittentRollingComplication(RRC) mechanism and shadowing medium to detect vehicleboundaries.ThesameRRCmechanismisemployedtoidentify taillight regions on detected buses. The lane andvehiclediscoverymodulesimprovesspeedandtaillightdiscovery.Wevalidatethemodelusingdatasetsfrom(SKKU)Universityand(KITTI)University.Themodelperforms goodevenindifficultconditions,achievingaremarkable99%taillightdetectionrateontheSKKUdatasetand an 86% detection rate on the KITTI 2D Object dataset.Furthermore, this system achieves a 100% taillight detectionrateon aspecificsetoftheKITTITrackingdataset.[5].

Theincreasinguseofvehicle-basedtechnologyandtheupcoming emergence of autonomous vehicles have led to agrowinginterestindetectingroadpotholes.Thisstudypresentsa nautomatedsystemforpotholedetectionusingtheone-dimensionalHaarWaveletTransform(HWT)appliedtoaccelerometersignals.Theproposedmethodologytakesadvantage of low-cost processing in both signal acquisitionandanalysisstages.Theanalysisinvolvesatwo-stepthreshold procedure to identify significant variations in thedata associated with potholes. Adaptive threshold estimationeliminates the need for manual threshold setting and allowsfortheidentificationofnormalsignalpatternscorrespondingto acceptable road conditions. The proposed methodologyproves effective not only in controlled terrain scenarios butalsoinreal-worldconditions.[6].Thispaperpresentsadetailed approach for a small, low-cost autonomous car tofollow lanes. A (DNN) and a(CNN) are trained to processcamera images and generate steering and speed commands.The design of the automatic car and the implementation of theDNN and CNN are explained. Comparison is made withestablished models VGG16 and DenseNet. A FSM controlsthe car's behavior, transitioning between lane-detecting andstopsstatesbasedonstopsigndetectionandobstaclepresence. [7].

Busoperationandcontrollingtrafficviolationsposesignificant challenges for transportation authorities. Manualdetection by placing traffic officers in specific locations is notefficientandcannotcovertheentiremetropolitanarea.Someadvanced countries have implemented stationary cameras tomonitor traffic violations, but their coverage is limited tocertain areas such as main roads, roundabouts, intersectionsetc. The paper introduces a real-time model for detectingtraffic violations using vehicle-mounted cameras and edgedevices. The edge device, equipped with a GPU, cvnnects tothevehiclecameraandmonitorsvehiclesahead,identifying

potential driving violations. Specifically, we examine thedetection of wrong U-turns as a case study, implementing analgorithm on the GPU-enabled edge device. To evaluate thesystem's feasibility, we assess its effectiveness in terms ofvideo generation rate and data size. The results confirm thesystem's ability to efficiently identify violations well beforevideo generation time.[8].

Vehiclediscoveryisacrucialaspectof advanceddriverassistancesystems.Whiledeeplearningtechniques,especiallydeepneural networks, have shown remarkableperformanceonpublicdatasets,theirrelianceoncomputationallyintensivetwo-stagemethodslimitsreal-timedeploymenton embedded platforms. To address this, weproposeareal-timesingle-stagevehiclesensorfortheNVIDIA DrivePX2 platform. This paper presents three keycontributions. Firstly, we introduce a discovery scheme thatutilizesmulti-scalefeaturesandmulti-anchorboxes,enhancing the sensor's sensitivity. Secondly, we propose anoveldataaugmentationstrategythatgeneratesdiversetrainingimageswithrandomizedappearances,improvingthesensor's ability to detect partially visible vehicles. Thirdly, weintroduce a specifically designed multi-stage image-basedonline hard example mining (MSI-OHEM) framework forsingle-stage sensors. MSI-OHEM performs fine-tuning onchallengingexamplesandidentifiesslightlyoverlappingbounding boxes as valid positives. Compared to traditionalobject sensors, our proposed sensor achieves competitiveaverage precision (AP) scores while maintaining efficientcomputationalspeed.UsingbasenetworkslikeMobileNetV2,GoogleNet,Inception-v2,andResNet-50,oursensorachievesAPscoresof85.35,85.62,86.49,and87.81, respectively, at frame rates of 64, 58, 48, and 28 FPS on theNVIDIADrivePX2platform,specificallyforthevehicleclass(automobile)onthe VOC2007testdataset.[9].

Thispaperpresentsaninnovativeapproachcalled"RT_VDT" foraccuratelydetectingandtrackingvehiclesonthe road. RT_VDT is specifically designed to be compatiblewith ADAS and SDC. Its primary objective is to achievepreciseandefficientvehiclerecognitionandtrackingthroughout the drivingprocess.Theapproachoffersfastcomputation capabilities suitable for CPUs with affordableGPUscommonlyfoundinADASsystems.RT_VDTutilizesasetofreliablecomputervisionalgorithmsthatsynergistically process raw RGB images to generate vehiclebounding boxes in the frontal driving space. These algorithmsworkcollaborativelytoenhanceaccuracyandstriveforprecise results. The algorithms are described, implementedusing real road images and videos captured by camera. TheperformanceoftheRT_VDTsystemisthoroughlytestedandassessedusingrealvideos,demonstratingitsconsistentability todetectandtrackvehicleboundaries.Thepaperdiscussesthestrengths,weaknesses,andpotentialfutureadvancementsof theproposedapproach.[10].

Intelligenttransportsystems(ITS) relyon real-time datacollection,processing,andtransmissionforefficientbusinessoperations. Integrated detectors and CCTV cameras providedetailedinformationabouttrafficflowandanomalies. However,accuratecomputervisionalgorithmsfacechallengesinrealterrainwithocclusionsandvideointerruptions. In this paper, we developed and evaluated anobjectshadowingsystemusingrealroadfootage,comparingitsperformancewithothertrackingalgorithms.[11].

Autonomousdrivingvehicles,alsoknownasdriverlessbuses,areamongthemostremarkableadvancementsofthe

twenty-first century. They are expected to become the future'sefficient,crash-avoidingcivicbuses.Thesebusespossesstheabilitytosensetheenvironment,navigate,andperformtransportation tasks without human intervention. Equippedwithcameras,radar,lidar,GPS,andnavigationsystems,theycandetecttheirsurroundingsandadapttochangingconditionsusingadvancedcontrolsystems.Theultimategoalis to completely replace the world's transportation system,andmanycompaniesarealreadyworkingtowardsthisobjective.Autonomousvehiclesoffernumerousbenefits,including reducedcongestion,decreasedpollution,feweraccidents, time savings, energy conservation, and improvedpassenger safety. By embracing autonomous vehicles, we canovercomethechallengeswefaceontheroadandworktowards a safer future. It is high time for Bangladesh to jointhismovementandinvestindriver-lessvehicles.[12].

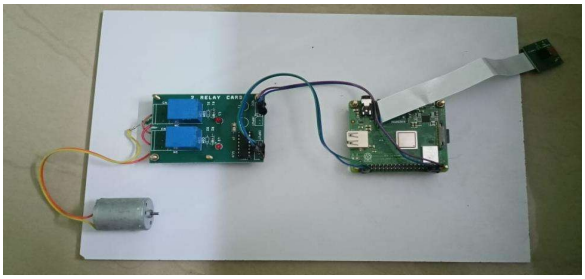
Drowsiness or fatigue is a major contributing factor to roadaccidents and poses significant challenges to ensuring roadsafety.Promptlyadvisingdrowsymotoristscanpreventnumerous fatal accidents. Various methods exist for detectingand alerting drivers about their drowsy state while driving.Facial expressions such as yawning, eye checks, and headmovementscanbeutilizedtoinferdrowsiness.Additionally,thedriver'sphysicalconditionandvehiclebehaviorareanalyzed to detect drowsiness. This paper presents a thoroughanalysisofdifferentapproachestodetectingdriverdrowsiness,categorizingthemintothreemaingroups:behavioral,vehicular,andphysiologicalparameters.Itreviews commonly used supervisedlearningmethods fordrowsinessdetection,discussestheiradvantagesanddisadvantages,andprovidesacomparativeanalysisofdifferentsystems. Moreover,researchframeworksareproposedtoenhancecomprehensioninthisfield.Inconclusion, the paper presents overall research findings basedon extensive analysis, which will aid aspiring researchers inexploringfurtheradvancementsinthisrelevantfield.[13].

In many urban areas, increasing traffic has become a majorproblem, especially at traffic signals. Conventional systemsfailtodetecttrafficordetermineitsdensityatsignals,resultinginineefficientoperations.Imageandvideoprocessing,arapidlygrowingtechnologyandpartofAI,canhelp address this issue. By analyzing real-time images andvideoscapturedbycamerasatintersectionsandtrafficsignals, traffic management can be improved. This systemutilizesRaspberryPiandOpenCVforimageandvideoprocessing.Itincludesvarioustechnologiessuchascontrolling traffic density, handling congestion, calculatingoverlappingimages,implementingalertsystems,andincorporatingmachinelearning.Thepaperconcludesbydiscussingfuturerequirementsfortheseimportanttechnologies..[14].

The problem of traffic congestion is steadily increasing dueto the easy availability of motorcars and a rapidly growingpopulation. This results in commuters being stuck in longtrafficjamsforhours,causingsignificanttimewastage.Another factor contributing to the issue is the emergence ofprivate ride-hailing services as an alternative to insufficientpublic transportation. Unexpected diversions caused by roadmaintenance,constructionwork,andaccidentsfurthercontribute to traffic congestion. In some cases, bad road alsoa significant factor. It is crucial to address this significantproblem as it wastes time and also poses risks to road safetyand the environment. Our objective is to develop a system thatutilizesadvancedtechnologieslikereal-timevideo processing and use it to identify the root causes of congestion.Bydoingso,wecaneliminatetrafficissuesandincreaseroadsafetyeffectively. [15].

III. THEPROPOSEDSYSTEM

Image-based vehicle and lane detection uses computervision to track vehicles and lanes in images or video streamscapturedbycamerasmountedonvehiclesorroadsideinfrastructure.Theprimarygoalistoimprovedriverassistancesystems,autonomousvehiclenavigation,andtrafficmanagementbyprovidingreal-timeinformationaboutthesurroundingenvironment.Thetechnologyinvolvesvarioussteps,includingimageprocessing,detectionofobjects and Tracking which can be implemented using a typesofdeeplearningalgorithms.Itisusedtoenhanceroadsafety, reducethetrafficcongestion,andincreasesthetransportationsystemefficiency.



Fig(a)

Fig(a)-Figureshowsthe connectionofthe hardwaresection.

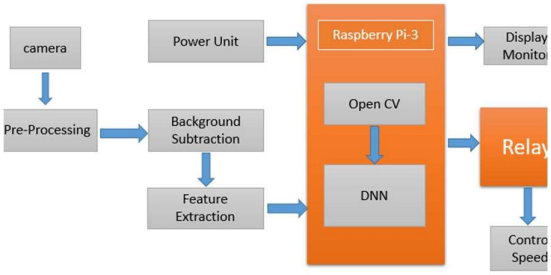
A. Algorithm

HaarCascadeClassifiers

TheHaarcascadealgorithmisamethodofobjectdetectionwhichusesatrainedclassifierthatcandetectobjectsinimagesorvideos.Thealgorithmworksbyanalyzing different features of the image, such as edges, lines,and textures, to identify objects. In the context of the road laneand vehicle detection, the Haar cascade algorithm is used torecognize the specific features of lanes and vehicles. Forexample,theHaarcascadelanedetectionalgorithmisusedtorecognize the distinctive texture and color patterns of roadlanes, while the Haar cascade vehicle detection algorithm istrained to recognize the shapes and proportions of differenttypesofvehicles.

B. BlockDiagram

In the hardware section consists of variouscomponents,suchasrelaymodule,motor,raspberryPi, PiCamera.



Fig(b)

Fig(b)-Figureshowsfunctionaltheblockdiagram.

1. Camera

Here, Pi camera is used to because it can capture high-resolutionimagesandvideos,andinterfacedwiththeRaspberryPitocreateacompactandaffordableimage-baseddetectionsystem.Thismakesitanidealchoiceforapplications such as vehicle and lane detection, where real-timeimageprocessingand analysisisrequired.

2. Pre-Processing

It is used in applications, such as computer vision,medical imaging, and remote sensing. Proper pre-processingcanimprovetheaccuracyandefficiencyofsubsequentprocessing steps and help extract meaningful informationfromimages.

3. BackgroundSubtraction

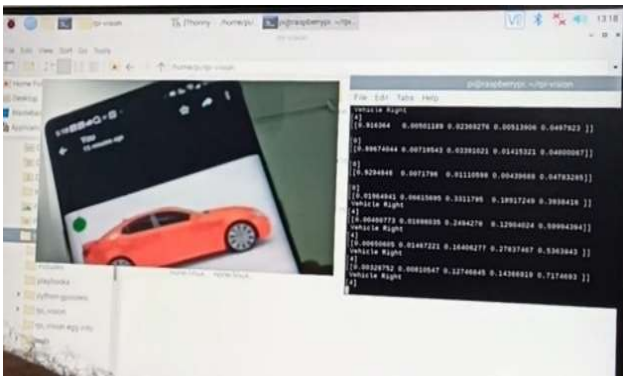
Backgroundsubtractionisanimporanttechniquewhich is used to track the objects and to analyze the motion.By identifying the moving objects in a scene, it can helpextract meaningful information and improve the accuracy ofsubsequentprocessingsteps.

4. FeatureExtraction

Featureextractioninimageprocessingistheprocessofextracting meaningful information or features from digitalimages. These features can be used in subsequent processingsteps, such as classification, recognition, or segmentation. Inimage processing,Features can be defined as characteristicsoftheimagethatrepresentspecificvisualpatternsorstructures.Thesecanincludeedges,corners,textures,colors,orshapes.Featureextractionalgorithmsidentifythesepatternsandextractthemfromtheimage,oftenusingmathematicaloperationssuchasconvolutionorfiltering.

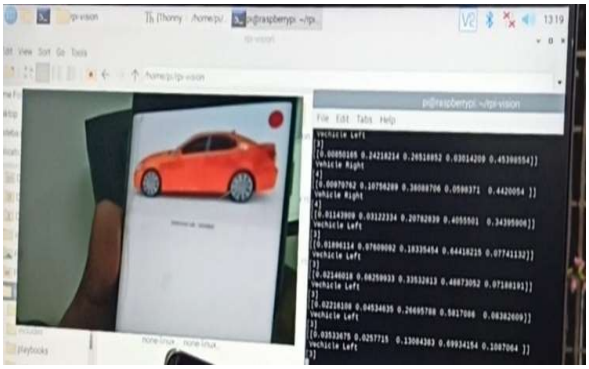
5. OpenCV

OpenCVisanopensourcelibraryofprogrammingfunctions andalgorithmsforcomputervision,imageprocessing, and machine learning. It is used for image andvideo processing functions such as filtering, segmentation,and feature extraction. For Object detection and recognitionfunctions such as Haar cascades and deep learning-basedmethods.



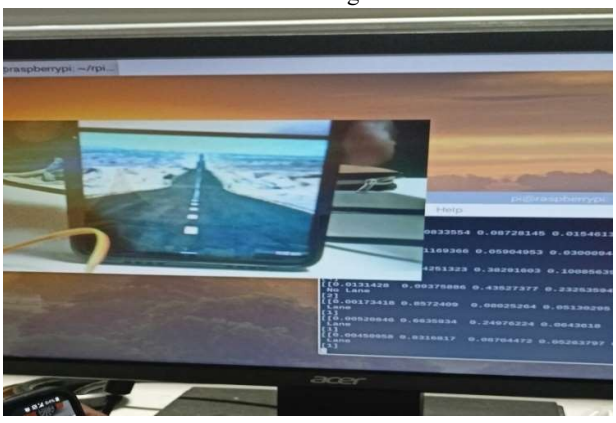
Fig(c)

In this scenario, the system has detected a vehicle positionedon the right side of the road. This information is valuable forvarious purposes, including speed control. By knowing theposition of the vehicle, the system can adjust the vehicle'speedaccordingly, maintaining a safe distance fromthedetectedvehicleandensuringsmoothtrafficflow.Thedetection of the vehicle's right position contributes to theoverallfunctionalitythat providestheessentialinputfordecision-making and adaptive speed adjustment. It enhancesthe system's ability to respond to changing road conditionsandcontributestoimprovedsafetyandefficiencyontheroad.



Fig(d)

Inthisscenario,thesystemhasdetectedavehiclepositioned on the left side of the road. This information isvaluable for various purposes, including speed control. Byknowingthepositionofthevehicle,thesystemcanadjustthevehicle's speed accordingly, maintaining a safe distance fromthedetectedvehicleandensuringsmooth trafficflow.



In this above illustration, the system has detected a lane,which provides valuable information for various purposes,includingspeedcontrol.Byknowingthelocationandboundaries of the lane, the system can adjust the vehicle'sspeed accordingly, ensuring that it stays within the designatedlane and maintains safe driving The detection of the lanecontributestotheoverallfunctionalitythatprovidestheessentialinputfordecision-makingandadaptivespeedadjustment. It helps the system to accurately determine thevehicle's position on the road and optimize its speed based onlaneboundaries.Bydetectingandtrackinglanesinreal-time,the system can enhance the accuracy and effectiveness ofspeed control, ensuring that the vehicle remains within theappropriatelaneand adherestothespecifiedspeedlimits.

Fig(e)

The system's failure to detect any lane boundaries ormarkings on the road signifies the absence of lane detectionunder automatic speed control through real time road lane andvehicledetectionusingtheHaarcascadealgorithm.Alternative methods or driver intervention may be required tomaintainsafedrivingconditionsintheabsenceoflaneinformation.

D. MERITSOFTHEPROPOSEDWORK

Theproposedworkthataddressthedemeritsofexistingwor kare:-

1. ImagePreprocessing:Thissystemwilluseimagepreprocessing techniques that improves the reliability ofobject detectionand increases the features of inputimages.
2. Object Detection: This systemwill utilize advancedobject detection algorithms, such as Haar Cascade orDNN-basedmodels,toaccuratelydetectandtrackvehiclesand roadlanesinreal-time.
3. Feature Extraction: This system will perform featureextraction on detected objects, enabling you to identifyandclassifyspecifictypesofvehiclesand/orroadlanes.
4. SpeedControl:Thissystemwillusetheextractedfeaturesto automaticallyadjustthespeedofthevehicle,promotingsafe andefficientdrivingbehaviors.
5. HardwareImplementation:Thissystemwillbedesigned to run on low-cost hardware platforms, such astheRaspberryPi,makingitaccessibleandeasytodeploy at scale.

E. Conclusion

TheHaarCascadeAlgorithmisatoolwhichisusedtodetectobjects,todetectvehiclesandroadlanesinreal-time.Byusingthisdetectedvehicleandroadlaneinformation, an automatic speed control system can beimplemented,whichcanadjustthevehiclespeedtoensure safety and efficiency on the road. The proposedsystem can help reduce the number of accidents on theroad, especially in Highways where the driver may bedistractedor not payingattention.

REFERENCES

[1] Suryakala,S.,K.Muthumeenakshi,andS.JosephGladwin. "Vision based vehicle/pedestrian detection intrafficsurveillancesystem."In2019InternationalConference on Communication and Signal Processing(ICCSP),pp. 0506-0510.IEEE,2019.

[2] Ojha,Apoorva,SatyaPrakashSahu,andDeepakKumarDewangan."Vehicledetectionthroughinstancesegmentation using mask R-CNN for intelligent vehiclesystem."In20215thinternationalconferenceonintelligentcomputingandcontrolsystems(ICICCS),pp.954-959.IEEE,2021.

[3] Singh, Arun, Dora Praveen Kumar, KelothuShivaprasad,MohitMohit,andAnkitaWadhawan." Vehicledetectionand accident prediction in sand/dust storms." In 2021InternationalConferenceonComputingSciences(ICCS),pp. 107-111.IEEE,2021.

[4] Chen, Xinqiang, Zhibin Li, Yongsheng Yang, Lei Qi,andRuiminKe."High-resolutionvehicletrajectoryextractionanddenoisingfromaerialvideos."IEEETransactions on Intelligent Transportation Systems 22,no.5 (2020):3190-3202.

[5] Jeon,Hyung-Joon,VinhDinhNguyen,TinTrungDuong,andJaeWookJeon."ADeepLearningFrameworkforRobustandReal-TimeTaillightDetectionUnderVariousRoadConditions." IEEETransactions on Intelligent Transportation Systems 23,no.11(2022): 20061-20072.

[6] Rodrigues,RicardoSilveira,MarciaPasin,AliceKozakevicius,andViniciusMonego."Potholedetectioninasphalt:Anautomatedapproachtothresholdcomputation based on the haar wavelet transform." In2019IEEE43rdAnnualComputerSoftwareandApplicationsConference(COMPSAC),vol.1,pp.306-315.IEEE,2019.

[7] Simmons, Bryce, PashamAdwani, Huong Pham, YazeedAlhuthaifi,andArturWolek."Trainingaremote-controlcar to autonomously lane-follow using end-to-end neuralnetworks."In201953rdAnnualConferenceonInformationSciencesandSystems(CISS),pp.1-6.IEEE, 2019.

[8] Rathore, M. Mazhar, YaserJararweh, Hojae Son, andAnandPaul."Real-timeTrafficManagementModelusingGPUenabledEdgeDevices."In2019FourthInternationalConferenceonFogandMobileEdgeComputing(FMEC),pp.336-343.IEEE,2019.

[9] Lin,Che-Tsung,Shu-PingChen,PatrisiaSherrylSantoso,Hung-JinLin,andShang-HongLai."Real-time

single-stage vehicle detector optimized by multi-stageimage-basedonlinehardexamplemining."IEEETransactionsonVehicularTechnology69, no.2(2019): 1505-1518.

[10] Farag, Wael, and Zakaria Saleh. "An advanced vehicledetection and tracking scheme for self-driving cars." In2nd Smart Cities Symposium (SCS 2019), pp. 1-6. IET,2019.

[11] Makhmutova, Alisa, Igor V. Anikin, and MariaDagaeva."Objecttrackingmethodforvideomonitoring in intelligent transport systems."In2020InternationalRussianAutomation Conference(RusAutoCon),pp.535-540.IEEE,2020.

[12] Adnan, Ashik, GM Mahbubur Rahman, MdMahafujHossain,MahfuzaSultanaMim,andMdKhalilurRahman. "A Deep Learning Based Autonomous ElectricVehicle on Unstructured Road Conditions." In 2022IEEE 12th Symposium on Computer Applications &IndustrialElectronics(ISCAIE),pp.105-110.IEEE,2022.

[13] Ramzan, Muhammad, Hikmat Ullah Khan, Shahid Mahmood Awan, Amina Ismail, MahwishIlyas, andAhsanMahmood."Asurveyonstate-of-the-artdrowsinessdetectiontechniques."IEEEAccess7(2019): 61904-61919.

[14] Reddy, K. Venkata Rama Durgaprasad, R. ShanmukhaPriya,PankajSingh,V.RaviKishore,andBSKiruthikaDevi."TrafficManagementSchedulingusingImage/Video Processing for Smart Cities." In 2022 4thInternationalConferenceonInventiveResearchinComputingApplications(ICIRCA),pp.295-302.IEEE,2022.

[15] Yadav, Mukesh, KasturiGhadge, Nitya Shetty, DeepaChanchlani,PriyankaNarwani,andRichardJoseph. "Smart Road Traffic Handler: Cause Identification andResolutionUsingImageProcessing."In20199thInternationalConference on CloudComputing, DataScience&Engineering(Confluence),pp.498-503.IEEE,2019.