COMPUTER VISION AND ITS APPLICATION IN AUTONOMOUS VEHICLES

INTRODUCTION

Computer vision is a field of artificial intelligence that trains computers to interpret and understand the visual world. Using digital images from cameras and videos and deep learning models, machines can accurately identify and classify objects — and then react to what they “see.” Computer vision is a field of artificial intelligence that trains computers to interpret and understand the visual world. Using digital images from cameras and videos and deep learning models, machines can accurately identify and classify objects — and then react to what they “see.”

The goal of Computer Vision is to emulate human vision using digital images through three main processing components, executed one after the other:

1. Image acquisition
2. Image processing
3. Image analysis and understanding

As our human visual understanding of world is reflected in our ability to make decisions through what we see, providing such a visual understanding to computers would allow them the same power :

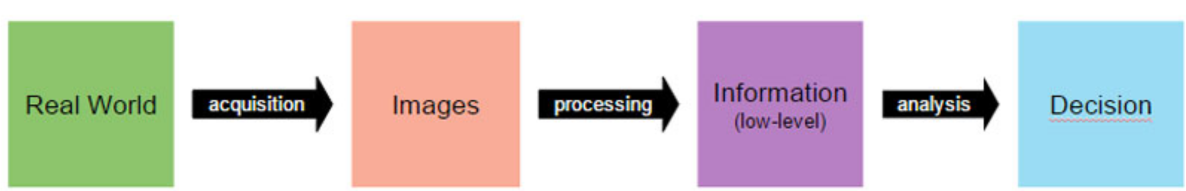

Image acquisition

Image acquisition is the process of translating the analog world around us into binary data composed of zeros and ones, interpreted as digital images.

Different tools have been created to build such datasets:

1. Webcams & embedded cameras
2. Digital compact cameras & DSLR
3. Consumer 3D cameras & laser range finders

<u>Image processing</u>

The second component of Computer Vision is the low-level processing of images. Algorithms are applied to the binary data acquired in the first step to infer low-level information on parts of the image. This type of information is characterized by image edges, point features or segments, for example. They are all the basic geometric elements that build objects in images.

This second step usually involves advanced applied mathematics algorithms and techniques.

Low-level image processing algorithms include:

1. Edge detection
2. Segmentation
3. Classification
4. Feature detection and matching

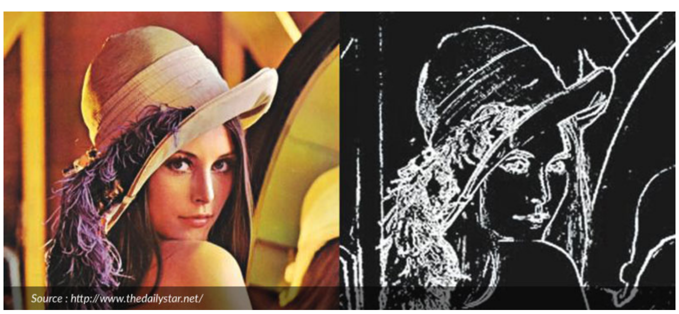

*Fig**.-Edge detection** in a color image.*

*Fig.**-Segmentation** of apples in a basket.*

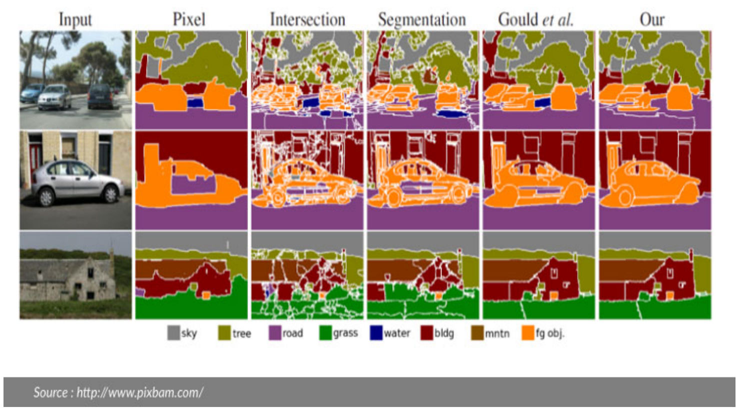

*Fig.**-Classification** of parts of images..*

<u>Image analysis and understanding</u>

The last step of the Computer Vision pipeline if the actual analysis of the data, which will allow the decision making.

High-level algorithms are applied, using both the image data and the low-level information computed in previous steps.

Examples of high-level image analysis are:

1. 3D scene mapping
2. Object recognition
3. Object tracking

APPLICATIONS OF COMPUTER VISION

Computer vision is used across industries to enhance the consumer experience, reduce costs and increase security.

Manufacturing

In manufacturing, businesses use computer vision to identify product defects in real time. As the products are coming off the production line, a computer processes images or videos, and flags dozens of different types of defects — even on the smallest of products.

Health Care

In the medical field, computer vision systems thoroughly examine imagery from MRIs, CAT scans and X-rays to detect abnormalities as accurately as human doctors. Medical professionals also use neural networks on three-dimensional images like ultrasounds to detect visual differences in heartbeats and more.

Defense and Security

In high-security environments like banking and casinos, businesses use computer vision for more accurate identification of customers when large amounts of money are being exchanged. It’s impossible for security guards to analyze hundreds of video feeds at once, but a computer vision algorithm can.

Insurance

In the insurance industry, companies use computer vision to conduct more consistent and accurate vehicle damage assessments. The advancement is reducing fraud and streamlining the claims process.

Automotive

Some of the most famous applications of computer vision has been done by Tesla with their Autopilot function. The automaker launched its driver-assistance system back in 2014 with only a few features, such as lane centering and self-parking, but it's set to accomplish fully self-driving cars sometime in 2018. Features like Tesla's Autopilot are possible thanks to startups such as Mighty AI, which offers a platform to generate accurate and diverse annotations on the datasets to train, validate, and test algorithms related to autonomous vehicles.

Retail

Computer vision has made a splash in the retail industry as well. Amazon Go store opened up its doors to customers on January 22 this year. It's a partially automated store that has no checkout stations or cashiers. By utilizing computer vision, deep learning, and sensor fusion customers are able to simply exit the store with products of their choice and get charged for their purchases through their Amazon account.

COMPUTER VISION IN AUTONOMOUS VEHICLES

Autonomous vehicle is an engineering technology that can improve transportation safety, alleviate traffic congestion and reduce carbon emissions. Research on autonomous vehicles can be categorized by functionality, for example, object detection or recognition, path planning, navigation, lane keeping, speed control and driver status monitoring.An autonomous car is a vehicle that can guide itself without human conduction. This kind of vehicle has become a concrete reality and may pave the way for future systems where computers take over the art of driving. An autonomous car is also known as a driverless car, robot car, self-driving car or autonomous vehicle. Autonomous cars use various kinds of technologies. They can be built with GPS sensing knowledge to help with navigation. They may use sensors and other equipment to avoid collisions. They also have the ability to use a range of technology known as augmented reality, where a vehicle displays information to drivers in new and innovative ways.

Autonomous driving technology consists of three major subsystems: algorithms, including sensing, perception, and decision; the client system, including the robotics operating system and hardware platform; and the cloud platform, including data storage, simulation, high-definition (HD) mapping, and deep learning model training. The algorithm subsystem extracts meaningful information from raw sensor data to understand its environment and make decisions about its actions. The client subsystem integrates these algorithms to meet real-time and reliability requirements.

Advanced driver-assistance systems (ADAS) are electronic systems that aid a vehicle driver while driving. When designed with a safe human-machine interface, they are intended to increase car safety and more generally road safety.

Most road accidents occur due to human error. Advanced driver-assistance systems are systems developed to automate, adapt and enhance vehicle systems for safety and better driving. The automated system which is provided by ADAS to the vehicle is proven to reduce road fatalities, by minimizing the human error. Safety features are designed to avoid collisions and accidents by offering technologies that alert the driver to potential problems. Few of them are listed here -

1. Adaptive cruise control

2. Adaptive light control

3. Automatic braking

4. Automatic parking

5. Blind spot detection

6. Collision avoidance systems

7. Driver drowsiness detection

8. GPS navigation

9. Hill descent control

10. Intelligent speed adaptation

11. Lane departure warning systems

12. Night vision

13. Tire pressure monitoring

1. Autonomous parking systems

An autonomous parking system of a vehicle includes a camera that, when disposed at the vehicle, has a field of view exterior of the vehicle. An image processor is operable to process image data captured by the camera to detect parking space markers indicative of a parking space and to identify empty or available parking spaces. The image processor includes a parking space detection algorithm that detects parking space markers by (i) extracting low level features from captured image data, (ii) classifying pixels as being part of a parking space line or not part of a parking space line, (iii) performing spatial line fitting to find lines in the captured images and to apply parking space geometry constraints, and (iv) detecting and selecting rectangles in the captured images.

Research on Automatic Parking Systems Based on Parking Scene Recognition

IEEE Access

2017

Aim

This paper describes three fundamental features of system solutions for an automated parking system that is based on the recognition of the parking scene: recognition of parking scene, parking pavement planning, and tracking and control of parking path.

Summary

Automatic parking technology is becoming a popular topic of research as a vital element of intelligent vehicle technology. It completes parking related operations quickly and efficiently without a driver and also improves the comfort in driving effectively while significantly minimizing the probability of parking accidents .The intelligent recognition of parking areas is closely linked to computer vision and , recognition and target detection technology. Current automated parking systems have two major drawbacks .First, the techniques for parking scene recognition are less intelligent, and there are higher number of restrictions and requirements on the parking spots .Second, the degree of automation in vehicle control is small.

This paper is structured as follows: Initially, methods for detection of the parking scene are examined .To start with, multiple samples are used for training of the vehicle detector AdaBoost ,and a transplant test is performed .The color model algorithm is then used to identify red tail lights .Finally, the vehicle's parking orientation is procured .Secondly, a parking scene model is created by assessing the operating principle of the automatic parking model .The parking movement template and parking movement limitations are fully reviewed for practical application of vertical parking, and a feasible and sustainable program for vertical parking path planning is put forward .Third, a tracking controller for automatic parking is designed and it is based on the vehicle dynamics mode .It is so designed to improve parking accuracy and control the planning route in order to reflect vehicle movement accurately.

Methodology

VEHICLE DETECTION-First, the techniques of parking scene recognition are analysed. The AdaBoost algorithm is used to detect vehicle orientation. Multiple samples are used in training the vehicle detector (AdaBoost) and then a transplant test is run. The above-mentioned vehicle detector is deployed on a video image processing board. After this the vehicle region is spotted in the camera's video images.

VEHICLE TAIL LIGHT IDENTIFICATION- The orientation of a vehicle that is parked in a vertical parking space should be identified on the basis of the detected vehicle areas .All vehicles have red tail lights, that are a notable regional feature in distinguishing the front and rear of a vehicle .The distinctive colour information of the red taillights is used for identifying and locating the red taillights based on the detected vehicle area .Hence, in this way the alignment of a vehicle that is parked in a vertical parking space can be deduced.

MODELING AND ROUTE PLANNING FOR PARKING- The parking movement model and the constraint on the parking movement is analyzed and an effective and practicable path planning strategy for vertical parking to improve convenience in parking and also to improve the rate of utilization of parking places is presented, to attain practical applications to vertical parking.

Software used

AdaBoost algorithm, MATLAB

Constraints

Future scope

Other points

Experiments have shown that 90% of all cars are correctly authenticated from a single image only.

One of the main causes for incorrect recognition are very dirty plates.

Image Segmentation for Efficient Parking Space Analysis

2018 International Conference on Informatics Computing in Engineering Systems (ICICES)

Aim

This paper aims to detect vacant parking spaces efficiently using Image Segmentation and Processing.

Summary

Current parking spaces include manual parking systems where a parking officer helps the driver find an empty space for the vehicle.It turns out to be far more difficult for the officer to monitor if the parking areas and spaces increase. By designing a smart parking system, these problems could be solved.Picture based framework is one of the methods used to locate empty spaces . Image-based parking systems provide drivers with information either by using display boards at the entrance to each parking section or by sending a message directly to their mobile phones.A new method is proposed here to process the image and remove noises/distortions from the segmented image-

A. Image Processing-this helps improve image data that eliminates unwanted distortions and enhances certain image features that are important for further processing. In order to better detect objects in the image, non-uniform illumination of the image is corrected before processing the image.

B. Segmentation and Labelling-Segmentation of the binary image is an important aspect of the image processing to segregate the image into binary form. Prominent features of the image are displayed when an image is segmented to it's binary form

Methodology

A. Correcting Non-Uniform Illumination-Correction of illumination is based on the subtraction of the background.The background illumination is calculated and the background is subtracted from the image. The image is further split into the corresponding RGB channels after the correction of the non-uniform illumination.For best possible display of image features, the intensity values of each channel are adjusted and combined back into a single image.

B. Image Segmentation - The corrected image is then converted into its corresponding gray image and then segmented into a binary image. This process tends to increase the prominent non-zero pixels in the image to make the features easy to identify.

C. Connected Components and Region Properties -Using 8-connectivity,the connected components in the Binary Image are scanned for. 8-connected pixels are neighbors to every pixel that touches one of their edges or corners.These pixels are connected diagonally,vertically and horizontally, . In the form of a structure, the regional properties of labels such as Major Axis Length,Area and Pixel Coordinates are computed and stored.

D. Removing Undesired Components and Enhancing Prominent Features - Morphological transformation is used in the binary image to improve car features. Unwanted binary image elements are removed.

E. Adaptive Cropping -After Noise removal,the binary image is split mainly into 3 regions vertically.Each region is scanned for non-zero pixels, and if the non-zero pixels in the region are found to be below the 10 pixel threshold, that region is cropped from the Binary Image that was obtained after Noise removal.

Then a sliding window technique is used to detect the above image.The window slides across each region and recognizes the region's number of non-zero pixels.If the region has non-zero pixels over a 30 pixel threshold, the region will be marked as occupied or else the region should be free to park.

Software used

MATLAB

Constraints

Future scope

Other points

A Convenient Vision-Based System for Automatic Detection of Parking Spaces in Indoor Parking Lots Using Wide-Angle Cameras

IEEE TRANSACTIONS ON VEHICULAR TECHNOLOGY

2014

Aim

This paper aims to develop a smart vision-based system for parking space management using wide-angle cameras.

Summary

The indoor parking lot system introduced in this study uses multiple wide-angle cameras held in place at the ceiling and looking vertically downwards. The system operations can be divided into four phases: camera calibration, space line detection,parking space segmentation, and vacancy detection.In the first stage,a new c
amera model is proposed, resulting in fewer parameters being used than traditional systems and a single space line to calibrate the model. In the second stage, spatial line
s appearing in the image taken are spotted by an edge detection process followed by a Hough transformation based on a new cell accumulation mechanism._Thus, equal-width curves are obtained, likely to result in more precise space line detection results for use as parking space boundary lines .In the third stage,the measured boundary lines a
re automatically analyzed and displayed , and the user can then click on the image to add or remove boundary lines.

At last, after knowing the background parameters of vacant parking spaces for different environmental conditions, vacant slots for use in parking management can be found by background subtraction.

Hereby,the proposed vision-based parking lot system will have at least one of the following advantages-
1) even a common user with no technical background can set up the camera system ea sily 2) parking lots can be detected accurately and 3) vacant parking spaces can be det ected automatically for convenient parking.

Methodology

PROPOSED CAMERA MODEL AND CALIBRATION METHOD-

A method of calibration is proposed to obtain the parameters of the proposed general model for catadioptric parabolic,fisheye-lens, and catadioptric hyperbolic cameras just by using one space line in the environment without knowing its direction and position.

PROPOSED SPACE LINE DETECTION METHOD-

Following the completion of camera calibration based on the new camera model, wide-angle cameras project space lines to form conic sections in the resulting image, called t he line image as of now. The current approach for detecting the conic section curve pro duces equal-width regions along a curve.
As a result, the proposed method can detect thick curves in images more accurately, ov ercome the noise generated by edge detection and be used more accurately to detect p arking space boundary lines in accordance with the proposed camera model.

DETECTION OF PARKING SPACE VACANCY-

A. Properties of the Boundary Lines Around Parking Spaces

Each parking lot is usually marked by some colored boundary lines. Three characteristic s of the boundary lines of parking spaces can be defined: 1) lying on the ground ; 2) bei ng either perpendicular or parallel to each other ; and 3) ignored if very far from the ca mera.

B. Automatic Detection of Boundary Lines

Car par boundary lines are automatically extracted by a modified Hough transform from input wideangle images with a new cell accumulation scheme that can produce more accurate equalwidth curves using the geometric relationships of line positions and directions.

C. Parking Space Segmentation and Vacancy Detection

Finally, the parking space regions are marked using boundary lines and a simple method for detecting vacancies centered on background subtraction is proposed to determine whether a car is parked in a parking space.
The first step is to manually adjust the boundary lines by clicking on the image to add or remove the boundary line, i.e. one line at a time. The second step is to find empty parking slots.

Software used

Hough Transform method

Constraints

Future scope

At present, the background images should be trained for various lighting conditions to conduct parking space vacancy detection based on background subtraction. Future work is to develop more intelligent methods to remove this weakness .

Other points

Intelligent Parking Space Detection System Based on Image Processing

International Journal of Innovation, Management and Technology

2012

Aim

The aim of this paper is to present an intelligent system for parking space detection based on image processing technique.

Summary

There is no systematic structure in most existing car parks.Most of them are managed manually and are somewhat inefficient. Numerous systems have been put in place to ensure traffic in parking spaces is smooth.They have evolved into completely automated, computerized systems from manual frameworks used in the older systems.A camera is used as a sensor for video image identification in this project.Parking lot detection is performed by identifying each parking lot's brown rounded image. It comprises of five modules. The first module is system initialization as a method for automatically identifying the location of each parking lot in the image.The second is the image acquisition module, where digital images taken from video camera are captured and collected.The input received by this module is a car park scene.The third module is the segmentation of the image, that separates the objects from the background and distinguishes the pixels with nearby values to improve the contrast.The fourth module is image enhancement.In this module, the noise is removed by using morphology processes that remove pixels that do not belong to the objects of interest.The last module is image detection, that is used to assess the brown rounded image at each parking lot .

Methodology

A. System Initialization -The objective of this procedure is to identify each parking lot in the image automatically.A brown rounded image is drawn manually on each parking lot (with zero car in the parking area). The initialization process starts with the program searching for the rounded brown image by detecting the shape of the image.The detected images are then analysed to determine available parking slots

B. Image Acquisition- The image is now processed in the module for image acquisition. In this module digital images obtained from the video cameras are captured and stored , which are then linked to a processing unit.

C. Image Segmentation- In the image segmentation module, the RGB image obtained from the camera is converted to a gray-scale image and the binary images are created . The binary images contain all the vital information about the position and shape of the objects of interest.It is obtained after converting gray-scale image using threshold technique.

D. Image Enhancement - In this module ,noise is removed from image and boundary of detected object is traced .A morphology function is used to remove the noise.

E. Image Detection Module- The image detection module is implemented for tracing the boundaries of object in images. By estimating the area and perimeter of each object, this module will establish which objects are round.For only the rounded image, this project uses a threshold value of 0.9. This project uses a threshold value of 0.9 for only the rounded image. Any identified rounded image with a threshold value of 0.9 will be regarded and represented as an available parking slot.

Software used

MATLAB

Constraints

Future scope

Future work is to focus on security parking system in addition to this intelligent parking space detection.

Also setting additional guidance devices such as light guidance to the available parking and placing LED at each car parking lot.

Other points

The main concept of this project is to discover the parking system by using image processing instead of using sensor base.

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Vision-Based Parking-Slot Detection: A DCNN-Based Approach and a Large-Scale Benchmark Dataset

IEEE TRANSACTIONS ON IMAGE PROCESSING

NOVEMBER 2018

Aim

This paper presents a novel parking-slot detection model based on deep convolution neural network (DCNN), i.e. DeepPS (deep parking slot), to address the problem of unfavorable factors in vision-based parking slot detection.

Summary

Recent times have seen an increasing interest in building self-parking systems in the automobile industry .These systems can be considered as an exceptional type of non-manual driving system. A general self-parking system's workflow is somewhat as follows .The vehicle switches to the unmanned low-speed mode when approaching the parking space and travels automatically along a predefined track. In this paper, vision-based approach has been used to detect available parking slots.A vision-based approach is aimed at recognizing and tracking down the parking slots represented by segments of the parking line that is painted on the ground. Such approaches’ performance, apparently, does not depend on adjacent vehicles ' existence. In addition, in many other instances, parking line segments give out parking information that is more precise than the "free-space method" for locating available parking spaces. For such systems, detecting and locating accurately and effectively the parking spaces that are marked by regular line segments close to the car is an important and unsolved issue .As a matter of fact, various adverse factors, such as alterations in illumination/lighting conditions, the difference in the ground materials, and unexpected shadows cast by trees in its vicinity, make vision-based parking-slot detection far more tougher than it appears .This paper tries ,to a certain extent, to solve this issue. First, a novel deep convolutional neural network (DCNN)-based parking-slot detection approach is proposed, specifically, DeepPS, that takes as input a surround-view image. DeepPS contains two important steps to recognize all the marking points in the input image and to categorize local image patterns that are created by pairs of marking points .Both are formulated as learning problems that modern DCNN systems can solve naturally. Second, a large-scale labeled dataset is established to aid in this study of vision-based parking slot detection. The marking points and parking slots are neatly defined for each image. On the data set collected, DeepPS ' efficacy and efficiency have been verified.

Methodology

DeepPS takes an input surround-view image and can tackle nearly all commonly seen parking-slot types consisting of "T-shaped" or "L-shaped" marking-points. DeepPS takes three important steps to detect parking-slots, which include detection of marking-points, local image pattern classification , and inference of parking-slot.

A. Marking-Point Detection-

In the testing phase, DeepPS first spots all the marking points in a surround-view image .A marking-point detector (D) is trained offline in advance for this purpose. Training samples need to be prepared to train the detector.The positions of all the marking points on a given surround-view image are manually specified at the preparation stage of the training sample.

B. Local Image Pattern Classification- Once detection of the marking-points is done , the local image pattern determined by two marking-points p1 and p2 on a surround-view image, is extracted .A set C consisting of possible local image patterns that are defined by marking-point pairs is obtained at the training stage, based on label data .The samples in C are categorized as per the characteristics of the identified parking spots , into 7 classes, 3 "slanting anticlockwise with an acute parking angle," "right-angled anticlockwise", 4 "slanting anticlockwise with an obtuse parking angle", "slanting clockwise with an obtuse parking angle","right-angled clockwise", and "invalid".

C. Parking-Slot Inference

Parking-slots are usually considered to be parallelograms and are mostly depicted by the coordinates of their 4 vertices. The two non-marking point vertices in each slot are not clearly visible in most cases and their coordinates can only be obtained by deduction(inference) .The "depth" of the parking spaces is assumed to be known in advance as a priori knowledge.

Software used

C++

Constraints

Sometimes, there is a possibility that it misses a true candidate (false negative) when the imaging or lighting conditions are bad(e.g., when there are dark shadows caused by trees nearby),

The local image pattern classification design might wrongly classify a valid entrance-line candidate as “invalid.”

Future scope

Future work is to continue increasing the dataset for DeepPS to make it a better point of reference in this field.

Other points

A YoloV2-based approach in DeepPS is used for marking-point detection.

II. Road surface maintenance

T HE maintenance of roads is a critical problem to improve their sustainability and the security of the vehicles. Road sections that contain a high density of cracks should be periodically reviewed in order to avoid problems in the future. Their detection is critical, especially concerning some problematic cracks. Crack type, severity and size are important criteria to maintain and repair roads. Pavement distress refers to the visible imperfection of the pavement surface.

A Simplified Computer Vision System for Road Surface Inspection and Maintenance

IEEE TRANSACTIONS ON INTELLIGENT TRANSPORTATION SYSTEMS

2016

Aim

This paper presents a computer vision system whose aim is to detect and classify cracks on road surfaces.

Summary

Road maintenance is a critical issue in improving their sustainable development and vehicle safety.Road sections containing a high crack density should be reviewed regularly to prevent future problems. This paper describes a simple yet effective low-cost computer vision in-vehicle structure capable of detecting and classifying cracks on roads. The system doesn't have any additional light source other than the Sun.Two phases are included in this : acquisition and analysis.The first involves image acquisition and the second is the analysis step, carried out offline, which includes delimitation, crack detection and classification of the Region Of Interest (ROI).

Methodology

There are three steps in the algorithm: hard shoulder detection, proposal for cell candidates, and classification of cracks.First, to detect the hard shoulders, the region of interest (ROI) is delimited using the Hough transform (HT).The step of the cell candidate proposal is split into two sub-steps: Hough transform features (HTF) and Local binary pattern (LBP). Both divide the image into non-overlapping small grid cells and, respectively, extract edge orientation and texture features. By mixing these techniques and obtaining the crack seeds, the detection is completed at the fusion stage.

Software used

HOUGH TRANSFORM

Constraints

Future scope

Other points

An Automatic Road Distress Visual Inspection System Using an Onboard In-Car Camera

Hindawi Advances in Multimedia

2018

Aim.

The aim of this paper is to study and build a easy to use , non-destructive and low cost, automatic road inspection system that uses an onboard in-car camera, focusing primarily on detecting a particular kind of road distress ,pothole.

Summary

In order to implement the preventive maintenance approach successfully, regular survey/check of roads is needed to detect and immediately repair any minor road distress before it might become a serious road distress that leads to unforeseen consequences. Automatic road inspection systems are needed for the frequent thousands of kilometers of roads. In the process of detection and classification of road distresses, three main characteristics to be taken under consideration are : on-surface pattern (area pattern, linear pattern, or both),dimension(2D, 3D, or both), on-surface location and orientation .The general computational workflow for an automated road analysis system that is vision based is as follows.

A: Preprocessing- Preprocessing the input image to prepare it for further processing. Preprocessing may range from image subsampling or resizing , noise removal, geometric calibration, image rectification, and few other image processing techniques and tools that help improve input image quality, increase precision, and decrease computational time in the latter processes.

After this **B: Detecting, Grouping, and Classifying** –In this process , road distress present (if there is any) are identified in the preprocessed image, grouping together the observed results (that are in reasonable proximity) and classifying each of the grouped results to the distress that is most suitable for them.

C:Counting/Tracking results –The process that count precisely the number of distresses on road that are identified in a sequence of continuous images(a clip).

D: Measuring and **E: Pricing** – These processes require specialized knowledge in measuring the size and magnitude of each type of road distress and estimating the cost of fixing.

Methodology

As a prototype system, this main focus is on developing a visual identification algorithm for potholes that are a type of road distress.

Image-Based Pothole Detection Algorithm-

(1) Preprocessing (a) Convert input image from color to grayscale.(b) Resize (i.e., sub-sampling) the gray-scale input image to eliminate noise and reduce computation loads for steps further.(c) Denoising the resized image by using non-local mean denoising algorithm to eliminate noise while maintaining fine structures and information. (d) Applying histogram equalization to enhance contrast values from the denoised image.

(2) Detecting (a) Binarizing the image that is histogram-equalized with a threshold value (b) Morphological erosion that is followed by dilation which aids in removal of tiny black noises and connecting white areas in the binarized image.(c) Finding in the morphed image all contours. Immediately rejecting the contour if its area is too small or too large compared to the entire image area.(d) Calculating the first pothole-likelihood score by calculating the value of the difference between mean pixel intensities in and outside each contour .The greater the difference, the greater is the score of the first pothole-likelihood.(e) When Nall is the total number of pixels in the contour perimeter and Nsharp is the number of sharp contour perimeter pixels , the second pothole-likelihood score is calculated by using a Nsharp / Nall ratio. The greater the ratio, the greater is the score of the second pothole-likelihood.(f) For all remaining contours, a contour acceptance score is computed by taking the equally weighted average of the two pothole-likelihood scores (g) Detection result is a set of contours that represent all detected pothole road distresses.

(3) Grouping/Clustering –The corresponding minimum bounding (rotated) rectangle is found for every contour from the pothole detection result and one cluster is assigned to each of these rectangles .(b) For each of these clusters, the minimum distance between that cluster and the other clusters is computed.(c) two clusters are merged into a new cluster only when the minimum distance between the two falls below a predefined threshold.

<u>Software used</u>

<u>Constraints</u>

False alarms are caused by shadows and white line lane markings.

Road patchings are often misinterpreted as potholes.
Cannot detect large road distresses.
There is no mechanism to accurately pinpoint the detected road distress.

Future scope

In future focus will be on improving the issue of false alarms that are caused by unrelated visual salient objects and non-pothole road distresses.

Other points

Automatic Traffic Signs and Panels Inspection System Using Computer Vision

IEEE TRANSACTIONS ON INTELLIGENT TRANSPORTATION SYSTEMS,
VOL. 12,
2011

Aim

This paper presents an outlook on the VISUAL Inspection of Signs and panEls ("VISUALISE"), an automatic system for inspection that performs inspection related tasks at ordinary driving speeds.

Summary

VISUALISE is a modified inspection system for road signs (even panels above the road included), mounted on board a vehicle that is capable of performing inspection related tasks at conventional driving speeds with the help of computer vision techniques, hence leading to a set of advantages over traditional means that are based on static measurements. 1) It avoids the presence of vehicles and people near the roads, close to the areas where the measurements are taken. 2) It is no longer necessary to use additional heavy pieces of measuring equipment (particularly on the panels above the road).3) The inspection process' efficiency is increased. Hence, enormous amount of signs can be analyzed in a smaller time period. All of the above advantages lead to the most important one: a better awareness of the signposting state of the road network, that supports decision-making and planning on the the infrastructure operators' part and adds to improving road safety.

<u>Methodology</u>

The VISUALISE system relies on the light retroreflection principle. The inspection/examination process may be split into the following two steps having different tasks.1) **Online process**- A vehicle operated by two people (a supervisor and a driver) is used at this first step of the process. It is fitted with all essential software applications and devices for the on-board infrared illumination system to acquire and record stereoscopic input sequences corresponding to actively illuminated roads. 2)**Offline process**- In the next stage, the sequences recorded previously are processed with the help of a image processing device based on a PC.A report that contains the retroreflection and contrast values of each sign and panel in the analyzed stretch of road is generated as outcome. The algorithm's main tasks are-

1) Candidate Extraction: an examination of the shapes acquired from the edge image is performed to identify the exact location of the image panels and signs using the Hough Transform and the Canny method.

2) Stereo Classification:In order to minimize the distance (between the vehicle and the panels or signs)estimation error value, the relative distance is calculated by putting together the stereo vision sensor with the odometer.

3) Multiframe Validation: a multiframe validation strategy is proposed to improve single frame detection figures.

4) Sign Classification: Each identified panel and sign is subsequently analyzed as a result of its shape and luminosity to classify the signs and panels into different shapes**.**

5) Luminance and Retroreflection Curves Computation: A segmentation process is performed to separate the basic elements (border, background and text pictogram) for each sort of sign and panel. A difference of the brightness values observed in two consecutive frames by the two cameras is performed to minimize the impact of ambient lighting.

6) Report Generation: The system creates a report containing information such as road type, milestone, GPS coordinate, carriageway,lateral distance from the center of the road/lane (in which the vehicle is moving),material, road, lane,height above ground etc. for each panel and sign.

Software used

Hough transform method

Constraints

Future scope

The aim is to expand the system ratios in future through the experience that will be gained from covering the kilometers planned for inspection in Spain (more than 30 000) and to redesign the system to the signposting rules and regulations of other countries.

Other points

An innovative road marking quality assessment mechanism using computer vision

Advances in Mechanical Engineering

2016

Aim

The purpose of this paper is to develop an innovative quality assessment system for road markings that uses machine vision technologies to improve road marking aesthetic quality acceptance.

Summary

Road markings play an important role in guiding vehicle drivers while simultaneously enhancing safety. Due to the absence of certain standard operating procedures for quality acceptance, the inspection of quality of finished road markings has always been based on subjective visual inspection, resulting in high quality variations in road marking works.This research builds a novel road marking quality assessment system by making use of machine vision technology to improve the aesthetic quality acceptance process of road markings by detecting uneven and rough edges. Using the smoothness of edge as an indicator of its aesthetic quality, the system takes in digital images of the road surface marking and processes and analyzes the images to capture the marking's geometric features.Based on the geometric features, a system of scoring is formed so that a credible quality indicator can be deduced to aid in the process of accepting road markings.

Methodology

This article uses edge evenness as an indicator of aesthetic quality to determine whether or not the marking should be considered acceptable after all other basic quality criteria have been met.

Assessment procedure Following are the steps of aesthetic analysis of automated road marking using machine vision.

Image of road markings are captured.The research team used a Canon 450D to capture images of the road marking.

Prepare image through preprocessing.

For further interpretation, the captured images are prepared. The procedures necessary for this preparation are calibration of image distortion, image transformation to gray-scale, image enhancement, and noise reduction.

1. Calibrate image distortion-The image captured is subjected to a Photoshop distortion correction process to bring back a true vertical and horizontal alignment of the image.

2. Gray-scale image transformation-Using Photoshop, colour images are converted to gray-scale images.

3. Image enhancement and noise reduction-Inspector's(a software package) image processing methods, such as median filtering ,brightness and edge sharpening and contrasting, are used to improve the quality of the points of interest and in eliminating noise.

Perform edge detection procedure

Edge detection is the numerical approach to identify boundaries of objects that lie within the image. The system proposed here, takes into account Canny edge detection in which an ideal/optimal function defined by the sum of four exponential terms determines the edge of the object.

Calculate edge deviation

It should look like a straight line when the edge is perfect. To deduce this line from the edge pixel points, this research utilizes linear regression. The avg. of edge deviation in pixel is calculated.

Evaluate quality score

Its average edge deviation is assessed to decide whether a road marking conforms with aesthetic quality standards.

If the average edge deviation is greater than 1 mm, the work should be evaluated as unqualified and requires redesign. If the deviation is exactly 1 mm, the marking is evaluated with a score of 60, which is considered to be the threshold of aesthetic evaluation.

Software used

MATLAB ,Photoshop ,Inspector

Constraints

Future scope

Other methods like the the Hough transform also can be used in the future to improve the efficiency of edge detection.

Other points

Commercial software packages (Photoshop and Inspector) were used in noise reduction and image enhancement for completion of the prototype system.

Vision for Road Inspection

IEEE Winter Conference on Applications of Computer Vision

2014

Srivatsan Varadharajan, Karan Sharma, Lars Wander and Christoph Mertz , Sobhagya Jose

Aim

This paper proposes a road inspection system based on computer vision and data driven methods for detecting distresses on road surfaces.

<u>Summary</u>

For a road surface inspection system, an economical system that can monitor roads continuously with minimal human intervention is desirable .The system proposed here operates on images gathered from a camera that is mounted on a vehicle's windshield. Automatic procedures are used to select inspection suited images on the grounds of lighting and weather conditions.The ground plane is segmented from the selected data and texture, location information , and color are used to indicate the presence of pavement distress. The primary focus here is on identifying cracks in particular as they have strong texture indications and are also the most common type of road damage. The data collected are then studied to determine the road distress level.

<u>Methodology</u>

1.Data Collection-A camera mounted on a vehicle's windshield was the main device used for data collection. Images that are taken during the daytime and when the weather is cloudy or overcast (which provides good lighting conditions) are chosen.

2.Segmentation for Crack Detection- Since,in this paper the topic of interest is detecting cracks on pavements, the first step of crack detection is to separate the ground plane from the rest of the picture. Regions with cracks generally have a unique texture, so texture based features are used to distinguish them against the background.

3.Obtaining Superpixels with Consistent Texture-After obtaining the segmentation mask for the ground plane , the next step is to generate an over-segmentation of the region that is bounded by the mask. Produce noticeable regions (or superpixels) that have consistent texture and colour, as opposed to just colour ,using SLIC superpixel algorithm .

The SLIC algorithm works by recursive pixel clustering over a five-dimensional feature space. Superpixels gradually segregate textured areas from non-textured areas.

4.Classifier for Distress Detection-

<u>Feature Descriptor</u> -Descriptors are calculated for each superpixel ,based upon colour and texture , and associated with a binary label implying the absence or presence of

cracked pavement. Colour elements as features make it easier to distinguish grass and lane markings from road and features based on location help in suppressing sidewalks and other areas on the road side.

Software used

Multiple Instance Learning Library, LIBSVM package

Constraints

Future scope

Other points

The design is very conventional and can be used for other road objects such as patches, potholes, manholes, lane markings, road signs, etc.

INTELLIGENT ROAD MAINTENANCE: A MACHINE LEARNING APPROACH FOR SURFACE DEFECT DETECTION

2018

European Conference on Information Systems

Aim

This paper proposes a machine learning based system to handle the problem of crack and related detection of defects on road surfaces using front view images taken from the driver's point of view under various conditions.

Summary

A smart road surface defect detection system can improve maintenance efficiency and reduce manual work associated with the inspection of road conditions .This study deals with automatic crack detection, the most prevalent form of surface defects, and the related surface degradation from scene images using ML strategies. Complete scene images are taken as input and output are the recognized crack and degraded surface area on roads.For the same purpose, extracted features obtained from superpixels and supervised classifiers based on ML are used.

Methodology

Data Collection and Preparation-As the scene images taken from the front-view cameras are processed, the scene image's region-of-interest(ROI) is first extracted, i.e. the road area has to be extracted.Pre-processing steps are as follows: (1) Road area extraction to generate "road images" from the "scene images," (2) Road image segmentation into superpixels (pixel groups) from which to extract features, (3) usage of CLAHE(to solve the information loss in general transformation) .

Feature Extraction - Features that are extracted from image regions (superpixels), are used to classify the regions as one with defects or no defects.

Software used

Python,OpenCV

Constraints

Future scope

Other points

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