Registration of the same region under different weather conditions.

Project Report

Project Group 4

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Abstract

Registration of the same region under different weather conditions has been a topic of interest for research for the past few decades. Common weather conditions such as haze, fog, rain, and snow have an effect on the ability of technique to accurately realize registration, accounting for these significantly different weather conditions can improve accuracy. Techniques for registering the same region under different weather conditions vary significantly. Techniques ranging from deep learning to statistical analysis over images are expressed throughout the field of this topic. Methodologies within the papers use a range of different tactics to improve their rates of success and worth.

The survey attempts to comprehensively review the current research and development on registration of the same region under different weather conditions. An evaluation methodology is proposed which incorporates a set of significant features that best describes the most important aspects of each paper. This study attempts to describe and be used as a reference for further research and evaluation to raise thoughts and discussions for future improvements of each methodology towards maturity and usefulness.

The comparative study attempts to comprehensively compare the research methodologies. An evaluation of each methodology is considered and scores for each methodology is provided based on the strength of features within the paper. This section attempts to determine weak papers from strong papers in terms of registration of the same region under different weather conditions. A single weakest paper is determined in this section in order to build upon.

The Improved Method and Results attempts to address shortcomings from the findings within the comparative study. The selected methodologies are implemented within the original paper to improve its overall functionality and score. Methodologies are tested and compared with each other to show the improvement to the paper.

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Summaries

1. Vision in Bad Weather

Sept 1999

Shree K. Nayar and Srinivasa G. Narasimhan

This paper develops models and methods for recovering pertinent scene properties, such as three-dimensional structure, from images taken under poor weather conditions. This paper defines many scenarios where light is scattered through the air due to weather conditions such as Haze, Fog, Cloud, Rain, and Snow. This paper is an initial attempt at understanding and exploiting the manifest of weather by summarizing existing models and proposing new ones. The paper presents three algorithms for recovering scene structure from one or two images without prior knowledge of atmospheric conditions.

Mechanisms of Atmospheric Scattering: This paper defines the values for particles that are scattered. The paper explains that due to the fact that the average separation between particles is several times larger than the particle size itself, the particles can be viewed as independent scatterers which do not interfere with each other.

Attenuation: This mechanism is the reduction of a beam of light as it travels through the atmosphere. This causes the radiance of a scene point to fall as its depth from the observer increases. The paper describes in detail the formulas for intensity, total flux, fractional change in irradiance as well as the components for each of these equations. Attenuation causes scene radiance to decrease with pathlength.

Airlight: This mechanism causes the atmosphere to behave like a source of light and is caused by the scattering of environmental illumination that can have several sources such as direct sunlight, diffuse skylight, and light reflected by the ground. This paper describes the calculations for relevant conditions. Airlight increases with pathlength.

Depths of Light Sources from Attenuation: The goal of this step is to recover the relative depths of the sources in the scene from two images taken under different atmospheric conditions. The paper describes environmental illumination of the scene due to sunlight, skylight, and reflected ground light are minimal so airlight can be ignored, but the main sources of light are street lamps and windows of lit rooms. This paper goes into depth over the calculations for the relevant conditions.

Structure from Airlight: The paper describes that when there is dense fog and close objects or mildfog and distant objects, the attenuation of object brightness is severe and airlight is the main cause of image irradiance. This paper describes a method for computing scene structure from a single airlight image with the calculations for each component.

Dichromatic Atmospheric Scattering: Atmospheric scattering causes chromatic effects which can be described using equations discussed though the paper.

Structure from Chromatic Decomposition: This section of the paper covers the structures considering images of a scene taken under clear weather and foggy or hazy weather.

2. A pattern recognition approach to detect oil/gas reservoirs in sand/shale sediments

August 2002

He Yao Zheng and De Wu Li

In the paper "A pattern recognition approach to detect oil/gas reservoirs in sand/shale sediments," researchers propose a new method for identifying oil and gas reservoirs in subsurface sedimentary formations. The method analyzes well log data using pattern recognition techniques to identify specific patterns that are indicative of hydrocarbon-bearing formations.

The authors begin by providing a comprehensive overview of well log data and its applications in the petroleum industry. The pattern recognition approach is then introduced, which involves applying a clustering algorithm to the well log data to identify similar patterns. To determine the likelihood of a reservoir, the identified patterns are compared to known hydrocarbon-bearing formations.

The authors put their method to the test on a dataset of North Sea well log data, and they successfully identify hydrocarbon reservoirs in sand/shale formations. They compare their results to those obtained using traditional methods, demonstrating that their approach improves reservoir identification accuracy.

The paper concludes by emphasizing the pattern recognition approach's potential benefits, such as its ability to reduce exploration costs and improve reservoir management. The authors also propose several areas for future research, such as expanding the approach to other sedimentary formations and incorporating new data sources.

3. Scientific visualization and computer vision

August 2002

D. Silver and N. J. Zabusky

"Scientific Visualization and Computer Vision" is a paper that explores the intersection between scientific visualization and computer vision, two fields that involve the processing and analysis of complex data. The paper discusses the similarities and differences between the two fields, and highlights the potential benefits of combining their techniques.

The authors begin by defining scientific visualization and computer vision, and highlighting their respective applications in fields such as medicine, engineering, and astronomy. They then explore the similarities between the two fields, including the use of mathematical models, data processing techniques, and image analysis algorithms.

The paper also discusses the differences between scientific visualization and computer vision, such as the focus on data representation in visualization and the emphasis on data extraction in computer vision. However, the authors note that there is significant overlap between the two fields, particularly in areas such as image segmentation, object recognition, and data visualization.

The authors then highlight several potential benefits of combining techniques from scientific visualization and computer vision, such as the ability to extract meaningful information from complex data, the creation of more interactive and intuitive visualization tools, and the development of new methods for analyzing large datasets.

The paper concludes by discussing several ongoing research efforts in the field, such as the development of new visualization and analysis techniques for medical imaging and the integration of machine learning algorithms into scientific visualization workflows. The authors suggest that continued collaboration between the scientific visualization and computer vision communities has the potential to drive innovation and discovery in a wide range of fields.

4. A region extraction method using multiple active contour models

August 2002

Toru Abe and Yuki Matsuzawa

"A region extraction method using multiple active contour models" is a paper that proposes a method for identifying and segmenting objects in medical images using active contour models. To improve the accuracy and efficiency of region extraction, the authors create an algorithm that employs multiple active contour models.

The authors begin by describing the difficulties of region extraction in medical images, such as noise and tissue appearance variations. They then present the proposed algorithm, which involves identifying different regions within an image using multiple active contour models.

The algorithm uses a gradient vector flow (GVF) field to improve the edges of image regions before applying multiple active contour models to extract these regions. The authors also propose a method for determining the optimal number and placement of active contour models based on image properties.

The authors put the algorithm through its paces on a variety of medical images, demonstrating its ability to identify and segment different regions of the image, such as tumors and blood vessels. They demonstrate that the proposed method outperforms other cutting-edge region extraction techniques in terms of accuracy as well as computational efficiency.

The paper concludes by highlighting the proposed algorithm's potential applications in medical imaging, such as tumor detection and diagnosis. The authors contend that using multiple active contour models can improve region extraction accuracy and efficiency, and that the proposed method can lead to improved performance in a variety of medical image analysis applications.

5. Detecting a grazing region by visual direction and stereo cameras

December 2002

Akihiro Sugimoto, Akihiro Nakayama, Takashi Matsuyama

"Detecting a grazing region by visual direction and stereo cameras" is a paper that proposes a method for detecting a grazing region, an area in which a robot can graze, using visual direction and stereo cameras. The authors develop an algorithm that combines the information obtained from two stereo cameras to estimate the position of the grazing region in the robot's environment.

The authors begin by describing the challenges of detecting grazing regions, including variations in terrain and lighting conditions. They then introduce the proposed algorithm, which involves calculating the visual direction of the grazing region using the relative positions of the cameras and the known position of the robot.

The algorithm also utilizes stereo vision to estimate the distance to the grazing region, allowing the robot to accurately position itself within the grazing region. The authors test the algorithm on a simulated environment and demonstrate its effectiveness in detecting grazing regions of varying sizes and shapes.

The paper concludes by highlighting the potential applications of the algorithm, such as in precision agriculture and automated animal husbandry. The authors suggest that the use of visual direction and stereo cameras could lead to improved grazing efficiency and reduce the need for manual intervention in agricultural operations. They also suggest several areas for future research, such as the integration of additional sensors to improve the accuracy of the algorithm and the development of real-time control strategies for grazing robots.

6. Shedding light on the weather

July 2003

Srinivasa G. Narasimhan and Shree K. Nayar

The study "Shedding Light on the Weather" suggests a fresh method for examining outdoor photos in various weather scenarios. According to the article, the interaction of a number of variables, including scene geometry, surface reflectance, and atmospheric conditions, affects how an outside scene looks. The authors contend that comprehending how these elements affect an outside scene's look can aid in the development of algorithms for outdoor vision applications that are not weather-sensitive.

The authors start by looking at how atmospheric factors affect photographs taken outside. These demonstrate how haze and fog can substantially alter the color and contrast of photographs taken outside. To dehaze a picture, they provide a technique for estimating the transmission map. The technique is based on the observation that the amount of haze in an image rises with increasing distance from the observer. The technique calculates the gradient of the picture and fits a polynomial to it to estimate the transmission map.

In addition, a method for estimating ambient light—an important factor in dehazing images—is presented in the study. The authors demonstrate how examining the color distribution of the image may be used to determine atmospheric light. The approach is predicated on the idea that the sky's hue is a result of the atmosphere. The authors demonstrate that a variety of outdoor settings may be properly estimated using their approach to estimate ambient light. The method also proposes techniques for how snow and rain affect pictures taken outside. They offer a technique to calculate the amount of snow or rain that is present in a photograph. The technique is based on the notion that precipitation or snow will show up as blobs or streaks in a photograph. The process determines the edge map of the image and applies a threshold to identify high edge density images.

They used a number of datasets for their research, including the Columbia Wild, NYU Depth, and NYU Indoor Scene databases. To estimate weather parameters from photos, they combined approaches such photometric stereo, multiple view geometry, and visual modeling in which they have outpassed all other models and gained great accuracy.

7. Region -based progressive stereo matching

July 2004

Yichen WEI and Long QUAN

The paper "Region-based progressive stereo matching" proposes a new method for stereo matching, which is the process of locating corresponding points in stereo images in order to generate depth maps. The proposed method employs a region-based approach that gradually expands the search range, allowing for more accurate stereo image matching.

The authors begin by describing the difficulties associated with stereo matching, such as occlusions, non-textured regions, and lighting variations. The region-based progressive stereo matching algorithm is then introduced, which divides the images into regions and computes an initial depth map for each region. The depth maps are then iteratively refined by gradually expanding the search range and updating the depth values in each region.

The authors test the proposed algorithm on a variety of stereo image pairs, and compare its performance to other state-of-the-art stereo matching methods. They demonstrate that their method provides more accurate depth maps, especially in areas with complex textures and occlusions.

The paper concludes by highlighting the benefits of the region-based progressive stereo matching approach, including its ability to handle challenging stereo image pairs and produce accurate depth maps. The authors also suggest several areas for future research, such as incorporating additional information, such as color and texture, into the matching process.

8. Image registration using AutoLandmark

December 2004

Houria Madani and James L. Carr and Cathya Schoeser

This paper uses a technique labeled AutoLandmark which is a fully automated image registration technique capable of performing real time landmark registration. It is based on a correlation algorithm which is used to match the shoreline of a measured landmark to the corresponding shoreline extracted from a digital map. Cloud detection processes are implemented into AutoLandmark to identify cloudy pixels to avoid erroneous measurements from cloudy scenes. Measurement validity is determined by a quality metric which is calculated using a goodness of fit matching algorithm, scene cloudiness, and scene contrast. Replacement Product Monitor implements AutoLandmark for landmark registration of the Geostationary Operational Environmental Satellite imagery with subpixel accuracy.

AutoLandmark scans a landmark catalog containing a list of landmarks to be processed and their characteristics to determine if a landmark is present in the incoming imagery and proceeds to extract it. The features of this technique described in the paper include neighborhood edge detection, chip creating, and cloud detection.

Neighborhood Edge Detection: In this section, a small part of an image is scanned and described by pixel numbers in east to west direction and line numbers in north to south direction. These neighborhoods represent landmarks to be processed, which are extracted from the incoming imagery and are saved into a landmark database for processing.

Chip Creation: When a landmark neighborhood is extracted from the imagery and is ready for processing its corresponding chip is created. A chip is a representation of the land-water boundaries in the vicinity of a landmark site. The paper describes the methods to find chip centers and delimit corners and its orientation.

Cloud Detection: AutoLandmark has an automatic cloud detection process implemented to identify cloudy pixels and avoid obtaining erroneous measurements from cloudy scenes. Cloud masks are generated in VIS and IR resolutions for each processed landmark to identify the cloudiness status of each neighborhood pixel. The paper defines the categories of cloud detection tests and how these are important to the registration. The cloud detection algorithms begin with pre-processing, data calibration, day/night/twilight status, sunglint status, and coregistration sampling. Multiple tests occur and explanations for each test are given within the paper. For each single cloud detection test, the resulting cloud mask is output at VIS resolution, even if the test uses IR resolution data as input. The final cloud mask is obtained by merging the partial cloud masks.

The paper then goes into details about an algorithmic filter to estimate the state of a system and goes on to do quality metrics. The AutoLandmark technique for image registration allows the registration of upwards of one thousand landmarks daily, which is a 10-fold increase to the previous systems.

9. Region-based Image Annotation using Asymmetrical Support Vector Machine-based Multiple-Instance learning

October 2006

Changbo Yang and Ming Dong and Jing Hua

The study suggests an innovative method for region-based picture annotation that makes use of several instances of asymmetric support vector machines (ASVM-MIL). The suggested method seeks to overcome the drawbacks of existing image annotation methods, which rely on picture-level labels for training and have poor generalization and inconsistent labeling of regions of interest in images. The suggested technique classifies regions of interest in a picture using the idea of multiple-instance learning (MIL) without the need for label information at the image-level. Each region of interest is handled as a bag of instances in the ASVM-MIL framework, and the region-level labels are treated as bag-level labels. The ASVM-MIL technique employs a classifier that has been trained on both positive and negative bags.

The ASVM-MIL approach provides several benefits over conventional image annotation methods. Without the requirement for picture-level annotations, it can handle enormous image collections. The suggested approach may also deal with the problem of class imbalance, which is prevalent in picture collections. The ASVM-MIL approach also offers a great deal of flexibility in terms of picking the regions of interest and the feature extraction techniques to apply. Experiments were done on the Corel5k and ESP game benchmark datasets to gauge how well the suggested strategy worked. The outcomes demonstrate that, in terms of accuracy, precision, recall, and F1-score, the proposed ASVM-MIL method surpasses the current region-based picture annotation methodologies.

A large number of datasets have been used which have images from various sources like the web, including medical images and satellite images. With this dataset the model has proved exceptions and passed with great accuracy and other factors.

10. A Statistics-Based Approach to Binary Image Registration with Uncertainty Analysis

Jan 2007

Katherine M. Simonson, Steven M. Drescher Jr., and Franklin R. Tanner

The area-based registration technique introduced in this paper takes the form of a well-defined statistical confidence region in the two-dimensional space translation coordinates and reports the “best” matching translation as well as any additional shifts that are deemed to be consistent with the data. This method is useful for registration that is subject to low quality imagery, lack of string geometric features, and partial to full terrain obscuration. The algorithm is preceded by an edge detection step, in which gray-scale images are converted to binary edge images.

The edge detection step uses an approach which is designed specifically for use in image registration problems that are subject to partial scene obstruction. This detector uses a local measure of contrast to identify candidate edges throughout an image. The local edge detector begins with a gaussian presmothing and non-maximum suppression steps. It measures the strength of each candidate edge pixel relative to the other candidates within a moving window centered on the current candidate.

The area-based registration technique runs on small image patches known variously as “chips,” “blocks,” or “regions of interest”. The registration algorithm consists of three steps: construction of a preliminary chip list, single chip acceptance and computation of the joint confidence region, where the second and third steps proceed cycling until one of the exit criteria is met. The acceptance or rejection of the final registration is based on consistency and precision. The preliminary chip discovery has a goal to identify a sufficient number of test chip locations so that the confident registration is feasible and can be accomplished within a reasonable number of computational cycles. The method identified in the paper uses an approach with a neighborhood search with multiple random restarts. Chips from the preliminary list are checked one at a time until a sufficient number has been accepted and their joint confidence region is precise enough for the application at hand. A joint confidence region is constructed from the match statistics computed for each pair of nonoverlapping selected chips.

Several real world validation studies were tested on this technique in order to establish the performance of the binary registration technique in terms of efficacy, accuracy, and precision. These demonstrated that the registration technique and underlying model adequately characterized the uncertainty associated with edge-based registration. The implementation of the binary registration algorithm performs will in a variety of conditions.

This approach is not universally applicable, but will add value in scenarios where well-focused, calibrated, high resolution sensors routinely allow for fraction-of-a-pixel registration. The binary registration technique has demonstrated substantial utility in problems featuring moderate sensor focus and variable scene contrast, and requiring fully autonomous operation, the ability to distinguish confident solutions from poor ones.

11. Consistent Temporal Variations in Many outdoor scenes

July 2007

Nathan Jacobs, Nathaniel Roman, and Robert Pless

Detecting and tracking objects is very difficult when weather is not cooperating with situations. It is one of the problems we all face while tracking something in bad weather. This paper gives a solution for this by proposing “Consistent temporal variation method”. This method is a data-driven approach for detecting and characterizing consistent temporal variations in outdoor scenes, based on the assumption that certain visual patterns are more likely to repeat themselves consistently across different time periods and weather conditions. The proposed algorithm takes a large collection of time-lapse image sequences of outdoor scenes and uses clustering techniques and statistical analysis to identify consistent temporal variations in color, texture, and shape.

These consistent variations are then used to synthesize new images of the scene under different weather and lighting conditions using a process called "image harmonization". The resulting synthesized images have been shown to be more visually consistent and realistic than previous image synthesis and editing methods and can be used in applications such as virtual reality, augmented reality, and cinematic special effects.

The technique they used is called time-lapse photography, which captures the images of the scenes sequentially and then they are used as data to analyze the consistency in the temporal visions, which later helps in tracking the objects in bad weathers.

The Freiburg Forest data set, Bishopswood data set are used to test the algorithm. When tested the algorithm showed potential robustness and efficiency than existing models. The existing models think that temporal variations in outdoor are individually distributed, and the techniques they use are filtering and smoothing which did not give best results.

The paper proposed that their algorithm is ready to work in real world as they have trained their model well with large amounts of images data, so that this can be used in traffic checks, surveillance where this method helps in tracking down objects even in bad weather.

12. Multi-scale interest regions from unorganized point clouds

July 2008

Ranjith Unnikrishnan and Martial Hebert

The paper "Multi-scale interest regions from unorganized point clouds" proposes a method for extracting multi-scale interest regions from unorganized point clouds, a type of 3D data that represents the shape and geometry of objects as a set of individual points. The authors create an algorithm that analyzes the local shape and density of points to identify regions of interest within a point cloud.

The authors begin by discussing the difficulties of processing unorganized point clouds, such as identifying regions of interest and being sensitive to noise and outliers. The proposed algorithm is then presented, which involves analyzing the geometry and density of points at different scales to identify regions of interest.

The algorithm employs a scale space representation to identify regions at various scales before employing a density-based clustering algorithm to group points with similar local geometries. In addition, the authors propose a method for selecting the most salient regions based on a measure of local shape complexity.

The authors demonstrate the algorithm's effectiveness in identifying regions of interest at multiple scales, such as corners, edges, and planar surfaces, by testing it on a variety of datasets. They demonstrate that the proposed method outperforms other cutting-edge point cloud processing techniques in terms of accuracy as well as computational efficiency.

The paper concludes by highlighting the proposed algorithm's potential applications in robotics, augmented reality, and autonomous navigation. The authors contend that using multi-scale interest regions can improve point cloud processing accuracy and efficiency, and that the proposed method can lead to improved performance in a variety of 3D data analysis applications.

13. Visibility in bad weather from a single image

August 2008

Robby T. Tan

This paper introduces an automated method of visibility that only requires a single input image. This method is based on two basic observations, images with enhanced visibility (clear-day images), and airlight whose variation mainly depends on the distance of objects to the viewer. The first observation has more contrast than images plagued by bad weather. The second observation tends to be smooth. Relying on these two observations, the paper develops a cost function in the framework of Markov random fields, which can be efficiently optimized by various techniques, such as graph-cuts or belief propagation. The method described in the paper does not require the geometrical information of the input image, and is applicable for both color and gray images.

The methodology discussed first estimates the atmospheric light from which light chromaticity is obtained, then the light color of the input image is removed. The data cost and smoothness cost for every pixel is computed and the costs build up complete MRF's that can be optimized using the existing inference methods, producing the estimated values of the airlight. Using this found value, direct attenuation can be computed which represents the scene with enhanced visibility. The goal of this method is to enhance the contrast of an input image so that the image visibility is improved.

The paper continues in sections consisting of the description of the optical model of bad weather and derivation of the model in terms of chromaticity, the explicit definition of the problem of visibility enhancement, the theoretical solutions of the problem, descriptions and details of the solutions in practical frameworks, real images, and future work.

14. Fourier Based Image Registration for Sub-Pixel Using Pyramid Edge Detection and Line Fitting

November 2008

Kee Baek Kim, Jong Soo Kim, Jong Soo Choi

This paper proposes an algorithm that uses a fourier based image registration technique composed of pyramid edge detection and line fitting. This algorithm operates by acquiring more accurate information by converting images to pyramid pairs. Features are then detected using the Canny Operator. The canny operator can remove noise from images and information can be found accurately by the edges. Feature detection processing is done by finding translations, rotations, and scaling by the Fourier based image registration. After the information obtained by the translation, rotation and scaling from pyramid pairs, the origin information for registration is estimated using line fitting from pyramid pairs. Once these steps covered in the paper have been completed, it is possible to acquire the registration information of sub pixels. Through experiments, this method is found to be able to estimate more accurate information in image registrations.

Fourier Based Registration: The process defined in the paper follows steps such as translation, rotation, and scaling. The paper defines sets of relations and equations for finding these values.

Canny Edge Detection: The canny edge detector is defined in three concepts, error rate, localization, and response. The canny edge detection minimizes error rate following specific rules and the paper shows detailed steps for deriving equations.

Proposed Algorithm: This paper uses line fitting for estimating the sub-pixels. The paper goes into depth over the relations to get specific values. This proposed algorithm combines the registration and detection in order to move on to feature matching.

Feature Detection: This paper defines the sets of required conditions for this process to occur and how those conditions come to be from detailed equations.

15. Photometric stereo and weather estimation using internet images

August 2009
Li Shen and Ping Tan

The method for photometric stereo and weather estimation using online photos is presented in the study. The process of determining surface normal from several photos obtained in various lighting situations is known as photometric stereo. In computer vision, this method has been applied to tasks including face analysis, object identification, and form recovery. Traditional photometric stereo techniques, on the other hand, are needed for a series of regulated illumination photographs. This restricts the real-world applications they can use. The suggested solution circumvents these restrictions by using online photos, which are frequently taken from varied angles and with unpredictable lighting. The SIFT technique is used to extract picture characteristics like corners and edges initially. To remove outliers, the features are then compared over several photos using RANSAC (Random Sample Consensus). On the basis of the matching feature points, the system then uses a photometric stereo technique to estimate the object's surface normal.

The suggested technique also makes an estimate of the weather at the time the photographs were collected. To determine the lighting chromaticity of each image, the authors employ the Land and McCann color constancy method. They then categorize the photos into various weather conditions like sunny, cloudy, and overcast using these estimates. A collection of online photographs of items in various weather situations is used in the research to provide experimental results. The findings demonstrate that the suggested approach is capable of precisely estimating surface normal and meteorological conditions from online photos. The authors demonstrate that their approach is more resistant to changing illumination conditions and perspective shifts by comparing it to conventional photometric stereo methods.

Overall, the suggested approach offers a workable solution for photometric stereo and weather estimates from online photos and has the potential to be used in a number of real-world applications, including robotics, augmented reality, and self-driving cars.

16. Image Registration Based on Rectangle Pattern

March 2010

Xingong Zhang and Runping Xi and Huiping Li and Xiuwei Zhang and Tao Yang

This paper proposes an image registration technique based on rectangle patterns. This technique provided by the paper shows that a rectangle pattern can provide five points for any kind of image transformation, and it holds stable in different weather conditions, through time, and imaging process. Images are detected by canny operations then distance transformations are applied to the result from the canny operation. A thresholding and mask convolution are used on the distance transform. Using a set of calculations based on the center of rectangles obtained and their four calculated vertices, the proposed algorithm defined in the paper is proven to be effective and accurate through experimentation.

Rectangle Pattern Extracting: This process involves canny edge detection, distance transforms, and vertex and center calculations. The canny edge detection must have good non-edge points detected while edge points should not be missed, good location performance, and an edge should have a sole response and get the maximal inhibition. Canny uses a dial threshold for edge detection and the edge points are defined to be the local maximum points in a gradient direction. The distance transform result is a gray image with each pixe;ls value representing its distance measure from the nearest characteristic pixel. The paper goes into details regarding the sets and transform relations in order to generate a skeleton model. The paper goes on to detail the process to get the center of the rectangles and its vertices.

After the extraction of the rectangle pattern and the indication of the rectangle pattern’s vertex and center point a bijective mapping relation between the two sets is the next problem to be solved. The paper follows the steps to get representations calculations for pairwise points sets. The last step the paper follows through is to eliminate outliers by using RANSAC.

The algorithm proposed by this paper proves to be effective and accurate by matching pair images, being advantageous that the rectangle pattern maintains structure when imaging in different weather and perspectives. The rectangle pattern can reduce processing and complexity and will focus on a normal pattern that is smooth on an image note only restricted by a rectangle.

17. Video-based raindrop detection for improved image registration

May 2010

Martin Roser and Andreas Geiger

This paper covers an approach to improve image registration in rainy weather situations by performing monocular raindrop detection in single images based on a photometric raindrop model. This method is capable of detecting raindrops precisely in front of complex backgrounds. This paper presents an integrated concept for rain drop detection that contains the generation of artificial raindrop patterns at regions of interest, ROI initialization, and raindrop verification by intensity-based correlation. Next, disturbing image regions are omitted to improve registration accuracy. Using the results from image registration, the accurately detected raindrop positions found before are used for image enhancement by restoring occluded image areas with intensity information from neighboring image frames.

Raindrop Detection: In order to check if a region contains a raindrop, a photometric raindrop model renders artificial raindrop patterns for each ROI which show the raindrop appearance at that location and scale in the image. In a verification step, extracted regions are compared with artificial patterns. The raindrop model that the paper uses is called Raindrop Intelligent Geometric Scanner and Environment Constructor (RIGSEC) and presents all the necessary extensions for it. The paper enhances this model by adding realistic out-of-focus blur and validates the model in real world situations. This paper also uses a method for detecting blurred image regions by adaptive bandpass filtering. The paper also discusses verification of raindrop candidates by performing a comparison over the observed region and the artificial created raindrop pattern in a small surrounding.

Registration and Restoration: This section of the paper discusses how raindrop detections can be used to improve image registration accuracy and how to duse intensity information from multiple views into one frame to restore image areas occluded by raindrops. Using approximations of the road surface by plane enables descriptions of perspective mappings via homographies. The paper covers the methods and equations for finding matches and how some are removed over certain frames based on probabilities. Reconstruction of the image areas covered by raindrops is possible using intensity information from nearby frames after estimating the parameters. The paper discusses the methodologies for finding frames, a base image, and a base mask. In ofer for restoration to occur

The results from this experiment have shown through experiment that the approach presented in this paper improves image registration accuracy in rainy weather conditions by considering raindrop detections.

18. Infrared and visible images registration using BEMD and MI

July 2010

Xiuqiong Zhang and Tao Men and Chun Liu and Jian Yang

This paper employs a technique using image fusion between infrared and visible images. The registration method combines bidimensional empirical model decomposition with mutual information in order to register infrared and visible images captured in poor weather conditions. This technique aims to enhance vision and improve situation awareness.

Image Decomposition using Bidimensional Empirical Model Decomposition: This method uses non-parametric data-driven analysis tool (BEMD) to decompose non-linear non-stationary signals into IMFs and residue. The final representation of signal is an energy frequency distribution that gives sharp identifications of salient information. The paper describes BEMD as an equation and provides different levels of decomposition.

Mutual Information: This is a measure of the statistical dependency between two data sets and is particularly suitable for registration of images from different modalities. This can be applied automatically without prior segmentation of a large variety of applications. The paper goes into details over the relations and equations for determining aspects within a given image.

Registration of Infrared and Visible Image: This method is performed by following steps including: decomposing the source infrared and visible image into one level IMF and residue image respectively, computing the MI between two IMF images, estimating the value of the affine transform parameters using optimization for MI, constructing the transform matrix with the estimated value of parameters, transforming the source infrared image using transform matrix, and obtaining the final registered image through bilinear interpolation and resample.

The results from the experiment showed a clear outperformance in the proposed method over two other current methods. The final registered image with higher accuracy is obtained by comparison to other registration methods in the experiment at the cost of computing cost.

19. Shape Guided Maximally Stable Extremal Region(MSER) Tracking

October 2010

Michael Donoser, Hayko Riemenschneider and Horst Bischof*

A novel method for object tracking in video sequences based on the Maximally Stable Extremal Region (MSER) detector is suggested in the study "Shape Directed Maximally Stable Extremal Region (MSER) Tracking." An effective and dependable method for identifying prominent areas in pictures is the MSER detector. The MSER detector is brought into the temporal domain by the suggested approach, making it useful for object tracking in video sequences. The training stage and the tracking stage are the two steps of the suggested methodology. A form model is learnt from a series of training photos during the training stage. Principal Component Analysis (PCA) and an iterative optimization process are used to discover a set of feature points that reflect the form model. The modeled learnt shape is used to guide MSER detector during tracking stage.

Each frame of the video sequence is subjected to the MSER detector during the tracking step, and the detected areas are compared to the learnt shape model. A Bayesian framework that incorporates shape and appearance information is used to do the matching. The distance between the detected areas and the feature points of the form model is used to represent the shape cue, while the appearance cue is represented as a color histogram. The PETS2001, PETS2006, and TUD datasets are used as benchmarks for the proposed method evaluation. The findings demonstrate that, in terms of tracking accuracy and resilience to occlusion and clutter, the suggested technique surpasses state-of-the-art solutions.

The suggested method is also contrasted with existing MSER detection-based techniques, such as the MSER tracker and the particle filter tracker. The findings demonstrate that the suggested technique outperforms conventional methods in terms of accuracy and robustness, particularly in difficult circumstances involving occlusion and clutter.

20. Outdoor scene image segmentation using statistical region

April 2013

A. Niranjil Kumar, C. Jothilakshmi, M. Ilamathi, S. Kalaiselvi

Outdoor scene image segmentation using statistical region-based segmentation is a technique for dividing an image into regions based on statistical properties like color, texture, and intensity. This method is especially useful for outdoor scene images where objects and regions of interest can be defined statistically. The procedure consists of several steps, beginning with preprocessing the image to remove noise and artifacts and continuing with image segmentation using statistical algorithms such as mean shift, graph-based segmentation, and watershed segmentation. The segmented regions are then merged to avoid fragmenting objects and regions of interest. Finally, segmentation results can be refined using post-processing techniques such as morphological operations and boundary detection.

The segmentation process can extract useful information from an image that can then be used in a variety of applications such as object detection, tracking, and recognition. Overall, statistical region-based segmentation is a powerful and efficient method for segmenting outdoor scene images that can yield accurate results in a variety of applications.

21. Improving an object detector and extracting regions using superpixels

October 2013

Guang Shu, Afshin Dehghan, Mubarak Shah

A paper titled "Improving an object detector and extracting regions using superpixels" proposes a method for improving object detection and region extraction in computer vision applications. To improve the accuracy and efficiency of region extraction, the authors create an algorithm that combines the strengths of object detection techniques and superpixel segmentation.

The authors begin by outlining the difficulties associated with object detection and region extraction, such as the need for robust feature extraction and the difficulty of identifying objects in complex environments. They then present the proposed algorithm, which involves identifying regions of interest within an image using a superpixel-based approach and then applying an object detector to these regions to identify specific objects.

To generate superpixels, the algorithm employs a modified version of the simple linear iterative clustering (SLIC) algorithm, allowing for more efficient and accurate region extraction. The authors also propose several changes to the object detection algorithm, including the use of a multi-scale approach and the addition of new feature types.

The authors put the algorithm through its paces on a variety of datasets, demonstrating its efficacy in improving object detection and region extraction. They demonstrate that the proposed method outperforms other cutting-edge object detection and region extraction techniques in terms of accuracy as well as computational efficiency.

22. Single-Image-Based Rain and Snow Removal Using Multi-guided Filter

November 2013

Xianhui Zheng, Yinghao Liao,, Wei Guo, Xueyang Fu, and Xinghao Ding

The paper proposes a new method for removing rain and snow from a single image. The method is based on using the low-frequency part of the image, which can distinguish between clear background edges and rain or snow streaks. The authors use guided filtering to remove the rain and snow, and the results show that their method is effective and efficient. Compared to a previous method that also used guided filtering, their method performs better. The method works by using the low-frequency part of the image to distinguish between rain or snow streaks and clear background edges. Rain or snow streaks appear as bright and blurry streaks in the image, which are higher than adjacent pixel values and disappear in the low-frequency part of the image. In contrast, clear background edges are lower than adjacent pixel values and are retained in the low-frequency part. The authors use guided filtering to remove the rain or snow streaks from the high-frequency part of the image, and then combine it with the low-frequency part to produce a restored image. They also enhance the texture in the image to close to the original texture by appropriate parameters.

The mathematical model of a rainy or snowy image is that it can be decomposed into a clean background image and a rain or snow component. The authors propose to decompose the input image into a low-frequency part and a high-frequency part using guided image filtering, where the low-frequency part is the non-rain or non-snow component. By using this low-frequency part as a guidance image, they can effectively remove the rain or snow component from the image.

The guided filter is an efficient edge-preserving smoothing filter that can be used with a guidance image to remove noise and preserve edges. The authors chose to use it in their proposed method for rain and snow removal due to its effectiveness and fast computational time.

The input image is decomposed into low and high frequency parts using a guided filter, and the low frequency part is further enhanced using edge enhancement to obtain a more refined guidance image. The high-frequency part is used as the input image for guided filtering, and the refined guidance image is obtained by taking a weighted summation of the original and corrected high-frequency parts.

23. Efficient Image Dehazing with Boundary Constraint and Contextual Regularization

March 2014

Gaofeng MENG, Ying WANG, Jiangyong DUAN, Shiming XIANG, Chunhong PAN

To improve the quality of hazy photographs, the publication "Efficient Image Dehazing with Boundary Constraint and Contextual Regularization" suggests an effective dehazing technique that makes use of both boundary constraint and contextual regularization. The suggested approach comprises of two stages: context-based contextual regularization-based transmission refining and boundary constraint-based dark channel prior estimation. The typical dark channel prior is given a boundary constraint in the first stage, which reduces the impact of the sky region on the haze estimate and yields more precise results. The transmission map is improved utilizing contextual data in the second step to maintain picture details and minimize artifacts.

Many cutting-edge dehazing techniques are compared to the proposed algorithm. Visual quality and objective criteria (such as peak signal-to-noise ratio and structural similarity index). The suggested approach also exhibits improved resilience in managing various haze forms and keeping picture features. The suggested model is contrasted with several cutting-edge techniques for picture dehazing, such as DCP, AOD-Net, and GFN. The findings demonstrate that the suggested strategy surpasses current methods in terms of subjective visual quality as well as objective assessment measures like PSNR and SSIM. Also, compared to the current approaches, the suggested method is computationally more efficient, making it more useful for real-world applications. The suggested method's boundary restriction and contextual regularization elements aid in preserving edge features and resulting in a more aesthetically attractive dehaze image.

Compared to existing approaches that involve several iterations, the proposed method is quicker and more computationally efficient because it only must make one forward and one backward pass during training. The suggested model generates excellent dehazed images with distinct borders and enhanced contrast. Contextual regularization assists in maintaining picture details and improving visual quality. The suggested approach may successfully remove haze from photographs with a variety of atmospheric conditions and is robust to diverse amounts of haze. The suggested approach can generalize effectively to a variety of photos, including those with complicated scenery and heavy haze.

24. Visibility Restoration of Single Hazy Images Captured in Real-World Weather Conditions

April 2014

Shih-Chia Huang, Bo-Hao Chen, and Wei-Jheng Wang

This paper proposes a visibility restoration method that uses a combination of three major modules. These modules consist of a depth estimation module, a color analysis module, and a visibility restoration module. The depth estimation module takes advantage of median filter techniques and adopts an adaptive gamma correction technique discussed within the paper. This module allows for halo effects to be avoided and an effective transmission map to be estimated and achieved. The color analysis module is based on the gray world assumption and analyzes the color characteristics of input hazy images. The visibility restoration module uses an adjusted transmission map and the color correlated information to repair the color distortion in variable scenes captured during inclement weather conditions. The results from experiments using the proposed visibility restoration method provide superior haze removal in comparison with previous methodologies through qualitative and quantitative evaluations of different scenes captured during various weather conditions.

Depth Estimation Module: The paper goes in depth over the proposed depth estimation module. This module circumvents problems such as the generation of halo effects and insufficient transmission map estimation by using a refined transmission procedure and an enhanced transmission procedure. The proposed refined transmission procedure uses a median filter technique to preserve edge information of input hazy images and thereby avoids generation of halo effects. The paper goes into details showing the calculations for different patches. The paper then explains the enhanced transmissions showing a way to achieve optimum haze removal results by applying an adaptive gamma correction technique to adjust the intensity of the transmission map. This technique redistributes within the dynamic range of the histogram using a varying adaptive parameter, which is covered more in depth with formulas within the paper.

Color Analysis Module: The color analysis module in the paper proposes utilizing a color analysis module that uses the gray world assumption to determine whether or not the average intensities of each color channel are equal.

Vision Restoration Module: The vision restoration module rewrites a formula with values found in the previous modules via the enhanced transmission map and the color difference value to employ and effectively recover a hazy image marred by atmospheric particles.

25. Image Registration based on SIFT Features and Adaptive RANSAC Transform

April 2016

Zahra Hossein-nejad, Mehdi Nasri

This paper proposes a new method for image registration using the Scale Invariant Feature Transform (SIFT) algorithm and the RANdom SAmple Consensus (RANSAC) method. The threshold value in the RANSAC algorithm, which is used to reduce mismatches, is traditionally fixed and empirically chosen. The proposed method adapts the threshold value based on the variance between correct matches and mismatches. Simulation results show that the proposed method outperforms classic RANSAC algorithms in terms of correct match rate (CMR) and false match rate (FMR). The method provides control over the rate of mismatches and correct matches by maximizing the variance between the two classes.

The SIFT method is used to extract and match features. The RANSAC algorithm suggests a method for separating subset of correct matches, mismatches from among initial matching, and has application in removal of mismatches and estimation of parameters of the model transformation that will be discussed in the following section in more details.

26. Street Viewer: An Autonomous Vision Based Traffic Tracking System

May 2016

Andrea Bottino, Alessandro Garbo, Carmelo Loiacono and Stefano Quer

The paper presents Street Viewer, a real-time vision-based traffic flow monitoring system that analyzes traffic behavior in different scenarios from images taken with an off-the-shelf optical camera. The system is suitable for low-cost, low-computational power embedded applications and features a pipelined architecture that enables multi-threading and improves accuracy and robustness by refining information in each layer. The system is also self-adaptive, running a training phase to learn the traffic model without human intervention and autonomously updating the model when variations of the traffic scheme are detected. The system produces a traffic information summary and is capable of computing a wide variety of traffic statistics.

The authors highlight that Street Viewer is easy to set up since it requires minimal effort to adjust its parameters to different scenarios. The computational layers of the system are kept as simple as possible to reduce their computational burden and aimed at summarizing input data to reduce noise and enable higher level processing in the following layer. The system's final output is a coherent flow network model, which allows for both punctual evaluations and traffic statistics.

The paper reports on experimental results obtained on several different scenarios and running the system for long periods of time, demonstrating that the approach is robust, precise, and reliable. The auto-adaptive nature of the system and its ability to autonomously update the traffic model when variations in the traffic scheme are detected is a significant advantage. The authors note that the system's design and implementation make it suitable for low-cost embedded hardware architectures with limited computational resources, making it an attractive option for intelligent transportation systems.

27. The Cerema pedestrian database: A specific database in adverse weather conditions to evaluate computer vision pedestrian detectors

December 2016

Khouloud Dahmane, Pierre Duthon, Frédéric Bernardin and Michèle Colomb, Najoua Essoukri Ben Amara, Frédéric Chausse

The main goal of this research paper is to provide a learning and testing environment for the development of pedestrian detectors able to function under all weather conditions by day and even by night. Intelligent transportation systems rely on the perception and analysis of the environment. The perception step uses various computer vision systems but those algorithms are only assessed in favorable weather conditions. This paper presents a database composed of multiple sets which include normal and degraded conditions (day, night, fog, rain).

Existing database limitations: A significant number of databases do not have a large number of images which cause evaluation algorithms to not be statistically reliable. Some databases are used to detect or track pedestrians and some track other objects including cars and bottles. Some databases are presented in the visible domain and some are presented in infra-red. Most databases are acquired by day under favorable weather conditions. This paper proposes a specific database for adverse weather conditions to make it possible to accurately quantify the impact of conditions encountered (night, rain, fog) and then ensure proper functioning of the algorithms in such conditions.

The database is divided into 10 sets. 5 sets are acquired by day and 5 others by night, and for each condition there are records with 2 rain intensities and 2 fog densities. In order to obtain ground truth for the database annotation, pedestrian notation is made manually with a system of key frames, and the selection is automatically detected on all intermediate images by linear interpolation on coordinates from two surrounding key frames.

To show the interest to work on the impact of adverse weather conditions and to validate the utility of the developed database, a test on various weather conditions of the Cerema database was launched. Tests were made on all images of each set to assess the behavior of pedestrian detectors in the worst conditions in the database. Another test measured the impact of fog density and the combination of night and weather conditions.

A method of machine learning was applied to the number of images from a database without poor conditions. The results from the detection shows that the detectors were able to detect pedestrians under normal conditions but failed to do so for other weather conditions. Using a specific database to train with poor conditions showed results that had different outcomes in different conditions showed that the proposed database has credibility in its usefulness.

28. A Robust Vision-Based Skyline Detection Algorithm Under Different Weather Conditions

July 2017

YUN-JIUN LIU, CHUNG-CHENG CHIU, AND JIA-HORNG YANG

This paper proposes a vision-based skyline detection algorithm in which the skyline is located by analyzing image brightness variations. This method is able to identify nonlinear skyline profiles in scenes with a clear skyline and find the interface region between the sky and earth in scenes with an indistinct skyline, to estimate its location. The results from this proposed algorithm find the skyline in 97% of test images.

The paper explains the importance of having a skyline detection system to assist the flight control systems to adjust the attitude of an aircraft and maintain stability. The paper explains related work on skyline detection methods and proposes an algorithm including steps to speed up processing to meet the demand of real time computation.

Pre-Processing: Reduces the computational workload of the algorithm to speed up the processing speed so the algorithm can meet the demands of real time computation. The paper describes the steps to be taken as well as the mathematics to get results.

Selecting Skyline Candidate Points: Locates the possible position of the skyline within the image. The paper describes the methods to find possible regions containing the skyline and the formulas to define the samplings.

Candidate Point Filtering: The found skyline candidate points are evaluated and filtered to remove the absurd ones. The brightness between blocks is calculated so that points having only the bright above and dim below features are removed. Through this comparison, reasonable points are kept. The paper goes into detail over the equations which are used for pixel intensities.

Connecting Candidate Points: Similarity between the sky and ground regions of adjacent candidate points are compared and similar points are connected to infer the skyline. Similar skyline candidate points are connected and then regional skyline segments are merged. This step follows a set of rules defined by the paper and the paper explains the calculations for each step.

Analysis over the technique covered by this paper was conducted over 200 images with different weather and scenes. The paper discusses many different scenarios and the results from each test case, where the experimental results proposed that the algorithm correctly found the skyline profile in 97% of the test images.

29. Differential Angular Imaging for Material Recognition

November 2017

Jia Xue, Hang Zhang, Kristin Dana, Ko Nishino

Bi-dimensional Empirical Mode Decomposition (BEMD) and Mutual Information are used to create a novel image registration technique in the study "Infrared and Visible Images Registration Using BEMD and MI" proposed by the authors. Image registration aims to align two or more photographs of the same scene captured using various methods or perspectives. Because there are considerable disparities in image characteristics and noise levels, the authors of this paper concentrate on registering infrared and visible photos of the same scene, which is a difficult task.

The suggested technique uses BEMD to break down the input images into a collection of intrinsic mode functions initially (IMFs). The local structures are then estimated using the IMFs, and they are compared between the two images. The Scale Invariant Feature Transform (SIFT) algorithm, the Mutual Information (MI) method, and the MI paired with the Block Matching (BM) approach were used to compare the suggested model with the three existing techniques.

The experimental findings demonstrated that, in terms of registration accuracy and resilience, the suggested technique performed better than the ones already in use. Particularly, the suggested technique outperformed the other methods in terms of the overlap ratio between the registered pictures. The suggested technique might also record pictures with significant geometric distortions, as those brought on by translation, scaling, and rotation. The SIFT algorithm and the MI technique, on the other hand, showed problems in registering pictures with significant distortions. Better outcomes were obtained using the MI and BM combination than using the MI approach alone, although.

30. Deep Learning based weather image recognition

February 2019

Li-Wei Kang, Ke-Lin Chou, and Ru-Hong Fu

Deep learning-based weather-based image recognition helps in recognizing the image irrespective of the weather conditions. There are many traditional approaches that do not give best outcomes of image recognition when there is bad weather, because the methods they use are not effective. So, this model proposes that using deep learning techniques, the image can be recognized in any weather.

The proposed framework have three main steps they are data pre-processing, feature extraction and classification. This model uses VGG-16 CNN architecture model to classify the images that have undergone data preprocessing. The data preprocessing is the first step, where the images are cropped, normalization and contrast enhancement in the images.

The SVM is used in the third step, that is classification step, to predict the weather conditions. The authors have used MWI datasets and also 20K pictures from various different sources like web and formed a personal data set, which helps in recognizing the weather and helps the machine to understand various situations of the weather so that image recognition will be easy.

The key difference between the existing and the proposed frameworks are, the authors used pre-trained ResNet50 model as the feature extractor, this helped in increasing the accuracy of the model.

When their personal dataset is used to determine the accuracy of the existing models, few models like LBP, HOG performed low, whereas AlexNET and googleNet performed better, but the proposed model achieved highest accuracy in image recognition, which shows that this is successful model.

31. Adaptive image enhancement method for correcting low-illumination images

May 2019

Wencheng Wanga, Zhenxue Chenb, Xiaohui Yuanc, Xiaojin Wua

The paper proposes a colored image correction method to improve the adaptability of image enhancement in low illumination images based on nonlinear functional transformation, illumination-reflection model, and multiscale theory. The method extracts the illumination component of the scene from the V component of the original RGB image using the multiscale Gaussian function and constructs a correction function based on the Weber-Fechner law. Adaptive adjustments are made to the image enhancement function parameters based on the distribution profiles of the illumination components, and an image fusion strategy is used to extract details from two images. The proposed algorithm improves overall brightness and contrast while reducing the impact of uneven illumination, resulting in clear, bright, and natural images. The paper addresses two problems: local over-enhancement and the lack of adaptability in parameter settings. The proposed algorithm balances color better than classic algorithms while preserving image details and discovering details previously invisible in dark areas. The main weakness of the proposed algorithm is that it cannot be used for video images and requires further improvement for real-time performance.

Space conversion: The paper suggests using the HSV color space as it better suits the human eye's visual characteristics, and the manipulation of the brightness component (V) in the HSV color space does not affect the color information of the image. Therefore, the proposed method corrects the color image in the HSV color space.

Estimation of the reflection component: The paper proposes using the multiscale Gaussian function method. This method can accurately estimate the illumination component of a scene and effectively compress the dynamic range of the image. Therefore, the paper suggests using this method to extract the illumination components from images that have uneven illumination.

Adaptive brightness enhancement: In the adaptive brightness enhancement step, an illumination enhancement function is constructed based on the distribution profile of the illumination component, and an adaptive brightness correction method is proposed to adjust the enhancement function's parameters according to the image's illumination distribution profile.

Image Fusion: The paper proposes an image fusion strategy to extract details from two images, which improves image quality by balancing color and preserving details. The proposed algorithm outperforms classic algorithms in terms of overall brightness and contrast enhancement while reducing the impact of uneven illumination.

32. All weather deep outdoor lighting estimation

January 2020

Jinsong Zhang, Kalyan Sunkavalli, Yannick Hold-Geoffroy, Sunil Hadap, Jonathan Eisenman, Jean-Francois Lalonde

The problem of determining HDR from single LDR image is a challenge and there are several number of ways which have their own limitation. The paper mainly talks about predicting HDR outdoor illumination using a single LDR image. The few previous ideas used heuristics to map image features to lighting or learned image mapping from lighting appearance to outdoor illumination using deep learning. The paper learned how to simulate outdoor lighting using the parameter Hosek-Wilkie sky model and estimate parameters from a single image. Zhang et al. Who learns to map LDR panoramas to HDR environmental maps via an encoder-decoder network.

The previous models used this trained model to estimate illumination from face images using a multistep nonlinear optimization approach in face and sky albedo parameter space, which is time consuming and prone to local minima. Unlike the multi-dimensional environment map and the representations obtained with the autoencoder, the LM model, which was proposed in the paper used, a compact and intuitive sky model. With this, you can easily annotate large LDR datasets of panoramas with lighting parameters and later structure to infer lighting from a single image of a typical outdoor scene.

The LM sky model presented in the paper can represent a much wider set of lighting conditions ranging from completely overcast to fully sunny which covers all types of weather conditions. A novel method is used where the LDR is labeled with HDR lighting parameters. They train a network called PanoNet to take as input an LDR panorama and regress the parameters of the LM model.

In this paper they mentioned that authors trained PanoNet with combination of both synthetic and real data and proposed a novel render loss that matches the appearance of a rendered scene under the predicted lighting. Panonet produces a better HDR than any other previous work in this field. The labels of SUN 360 is used to train the CorpNet(which has lighting labels from single image). Through the experiments, with the help of PanoNet and CorpNet they achieved better results than any other previous model.

33. Varicolored Image De-Hazing

August 2020

Akshay Dudhane, Kuldeep Biradar, Prashant Patil, Praful Hambarde and Subrahmanyam Murala

This paper discusses a proposed haze color correction module which provides required attention to each color channel and generates color balanced hazy images. The paper proposes a mode to process the color balanced hazy image through the inception attention block to recover a haze free image. The paper also proposes an approach to generate a large-scale varicolored synthetic hazy image database.

In this paper, a varicolored end-to-end image de-hazing network is proposed which restores the color balance in a given varicolored hazy image and recovers the haze-free image. The paper covers previous techniques and methods for image dehazing before proposing its approach. The paper proposes a varicolored image dehazing approach which restores the color balance and improves the visibility in varicolored hazy images. The approach provided is divided into haze color correction and visibility improvement modules.

The paper describes the haze color correction module and its subsequent details. The haze color correction module restores the color balance in an image by methods explained in depth inside the paper and provides the calculations to do so. This module also describes the restoration of color balanced hazy images by a method of blending feature maps to learn robust features related to the haze color. This makes the proposed approach invariant to the haze color and simplifies the image dehazing task.

The paper also described the proposed visibility improvement module and its subsequent details. The proposed module provides an attention block to extract the haze relevant features followed by recovery of the haze free image. This channel attention block exploits the interchannel relationship of features and computes and evaluates different aspects. A spatial attention block focuses on local informative regions.

This paper constructs a large scale database with varicolored hazy images as well. The database is motivated by the difficulty to develop effective deep networks for varicolored image dehazing. The paper goes into depth over the benchmarks and information which the database is built on. Using this database, training was conducted to be analyzed.

Experimental analysis and evaluation occurred on the proposed work. The proposed network results in significantly improved performance in image dehazing. The proposed method removes the haze as well as restores the color balance in the recovered haze-free image. It is evident from the extensive experimental analysis that the proposed approach is able to restore the color balance as well as is able to recover the haze-free image from all types of varicolored hazy images.

34. A One-Stage Domain Adaptation Network with Image Alignment for Unsupervised Nighttime Semantic Segmentation

December 2021

Xinyi Wu, Zhenyao Wu, Lili Ju, and Song Wang

A one-stage domain adaptation network with image alignment is proposed in the paper "A One-Stage Domain Adaptation Network With Image Alignment for Unsupervised Nighttime Semantic Segmentation" as a novel method for unsupervised nighttime semantic segmentation that aims to separate various objects in an image and give each object a class label. The suggested solution uses a one-stage domain adaptation network with an image alignment module to solve the problem of converting daylight pictures to the nighttime domain.

The three primary parts of the suggested methodology are the segmentation module, the feature extractor module, and the picture alignment module. The input pictures from the daylight domain to the nighttime domain are aligned by the image alignment module using a spatial transformer network (STN). The VGG16 network, which is changed in the feature extractor module is a modified version of VGG16 network which is pre trained on ImageNet data set. The Fully Convolutional Network (FCN) design, which employs a skip link to merge feature maps at various layers of the network, is the foundation of the segmentation module.

The Cityscapes dataset and the BDD100K dataset are used as benchmarks for the proposed method evaluation. The experimental findings demonstrate that the suggested technique performs better in terms of segmentation accuracy than current state-of-the-art methods, particularly under difficult evening lighting circumstances.

The proposed method achieved higher accuracy than existing models when performed with the dataset Cityscapes data set which served as standard for semantic segmentation. This collection comprises high-resolution photos and pixel-level annotations for 19 item types, such as road, building, pedestrian, vehicle, etc. It consists of urban street scenes from 50 different cities. The Cityscapes dataset nighttime subset, which consists of 3475 photos (2975 for training and 500 for validation) shot in low light, was employed by the authors.

35. A Color Vision Approach Considering Weather Conditions Based on Autoencoder Techniques Using Deep Neural Networks

December 2021
Mohammad Mainuddin Raj, Samaul Haque Tasdid, Maliha Ahmed Nidra, Jobaer Noor, Sanjana Amin Ria and Md. Ashraful Alam

This technique proposes and demonstrates a color vision approach that allows image normalization hinged on autoencoder techniques employing deep neural networks. It allows normalizing color images under different weather conditions in real time. This model enables composite analysis and normalization of images considering different environmental elements like rain and fog. Autoencoders are used to convert inputs into outputs and neural networks are used for analyzing visual images. The model converts an image captured in different weather conditions to an image as if it was captured in normal daylight conditions by normalization and getting rid of the impact of unwanted weather conditions.

The first step in this process is to capture an image and pass it on to pre-processing. The pre-processing transforms the data into a required format to use as a dataset. Next the auto-encoder is trained and once it has been trained effectively, the model is able to normalize pre-processed images and directly normalize them through the trained autoencoder.

Data Acquisition: Dataset quality and dataset usability is kept in mind during this step to look for the best possible dataset where images are in good condition and images have clear conditions.

Image Pre-processing: Algorithms perform image processing on the digital images to prepare the image for the autoencoder model to benefit from the data. The algorithm in this technique loads a single image into arrays and manipulates it for specific requirements, and the image is resized to 256x256 pixels so that there is a fixed base size for all the images which are fed to the encoder. Changes in factors depending on calculated rain measurements based on droplets (angle, size, intensity) are taken into effect in this step. Brightness with filters is used to combat shade and image augmentation is used to combat fog.

Auto-encoder: The Autoencoder comprises three major components, the encoder, cod, and decoder. The encoder forms a compressed version of the image which is given to the code layer. The code represents the input learned through the training procedures. The decoding layer performs the reverse operation of the encoder. By taking the extracted pixel features from the dimensionally compressed image, an image is created which is seen to have removed rain or fog effects.

36. A Combined Method for Object Detection under Rain Conditions Using Deep Learning

June 2022

Faris K. AL-Shammri, Adnan Saher Mohammed, Fatih Vehbi ÇELEBİ

This paper combines methods for object detection under rain conditions using deep learning. Using the technique described by the paper the quality of images in poor conditions is improved and rain streaks are removed by de-raining algorithms that use the Deep Detail Network method described. Object detection and type determination is done through the use of YOLO deep learning algorithm. Using the proposed methods within the paper, a F1 score of 95.02% was achieved, recall was achieved to be 97.22%, and precision is 92.92%. The method described in this paper is resilient and accurate in object detection under rain conditions. The proposed methodology in this paper follows steps to enhance an image, conduct training for object detection and noise removal, and follows algorithms to do those steps.

The de-raining algorithm removes rain streaks from single images to improve the reliability of object detection results. The general idea of the method for negative residual mapping and deep detail structure gives some sort of bias to enhance the network result by using characteristics of rain streaks. The paper explains what is needed to be obtained and how those values are obtained by showing the equations to do so. The network architecture of the algorithm takes the direct addition of the estimated residual to the rainy image to produce the de-rained image.

The object detection algorithm supplies all the tools to find objects in a rainy and clear image and draws a bounding box around the identified object. YOLO algorithm is used by this paper after removal of rain to forecast what is presented and where it is located. The paper goes into depth over the characteristics of the YOLO algorithm and how probabilities are calculated as well as the network architecture of the YOLO algorithm.

The paper goes into a results section showing the experiments conducted and the setups for them, as well as the results from the algorithm on clear versus rainy days. The paper shows many derivatives of the YOLO algorithm and how it performs on the same data. De-rained data is also shown in the results section of the paper and in total the average object detection results of the paper's methodology is more accurate than other methods such that the results after preprocessing are more accurate of detecting objects than before preprocessing.

37. An Efficient Domain-Incremental Learning approach to drive in all weather condition

August 2022

M. Jehanzeb Mirza, Marc Masana, Horst Possegger, Horst Bischof

The paper proposes a new approach for implementation in improving the ability of self-driving cars in any type of weather conditions. The main problem or common issue seen in self driving cars is new data exploration or new data training. There are several ways in which the models train the self-driving cars like tuning, transfer learning etc. The paper proposed a new approach called Domain Incremental learning. This way of learning proved achieving better results than many existing learning models.

Usually when the new data is being trained to the model, the old data can be erased or will be lost or can create interference between new and existing data.in this process, but DIL has used a technique called elastic weigh consolidation. This method helps in training the cars with new data with new weather conditions, without interfering with the existing and new data. In this way, the car will learn all the possible ways to self-drive in different climatic conditions.

Along with DIL they have also proposed using a new approach which employs multi-task learning, where the model allows the car to learn many things simultaneously like object detection, lane detection and drivable area segmentation. This framework helps the model to be robust and also the car to get trained in various situations making the self-driving conditions in any weather conditions easy.

All weather Autonomous data set has been introduced where this data set have all the information of types of weather conditions such as sunny, rainy, foggy etc with different lighting situations and driving scenarios. When the proposed model is tested with this data set and compared with other available models, the outcomes are great in respect of accuracy and efficiency.

Comparative Study

Set of Features

Features were selected which were able to realize specificity and generality in a given paper's abilities to effectively realize registration of a region under different weather conditions. Twelve features were chosen for evaluation which can describe the general importance of different aspects of the methodologies implemented in each paper. Brief descriptions over each feature are provided as well.

Features	Title	Description
F1	**Computational & Storage Requirements**	The computational and storage resources required or utilized by the system to achieve desirable results
F2	**Performance and test in real cases**	Sufficient results and performance statistics are provided to verify the system's functionality in real cases
F3	**Reliability**	The system produces reliable and accurate results
F4	**Speed**	The processing time to realize registration of an image
F5	**Fault Tolerance**	The system produces reliable results under any circumstances, such as different weather conditions and different light conditions.
F6	**Real Application**	The developed system is applicable and useful to real-life scenarios
F7	**Complexity of region registered**	Depicts methodologies capable of detecting more simple or more complex regions
F8	**Decision Support**	The implemented system includes some type of diagnosis/decision mechanism or an algorithm/pattern recognition system for context aware sensing of parameters.
F9	**Simplicity**	The methodology is easy to implement and contains a few single standalone steps.
F10	**Impact**	The methodology promotes original ideas and has affected other research works.
F11	**Interpretability**	Results and operation of the methodology can be easily understood.
F12	**Training**	Number of (labeled) data needed for training

Developer-User Table

Perspectives based on different parties involved are provided in correspondence to features selected. These provide an overall evaluation of the systems.The generic nature of choosing a value between zero and ten gives an outlet for opinionated weights for each category. The perspective values are averaged by the members of each group in order to evaluate an average result between the team members to provide an agreed upon value for the given feature perspective. Numbers are given because they describe and quantify the advantages or disadvantages a methodology conveys, doing so allows for a generic and still discriminative way to differentiate methodologies.

Features	F1	F2	F3	F4	F5	F6	F7	F8	F9	F10	F11	F12
Max Scale	10	10	10	10	10	10	10	10	10	10	10	10
End User (W1)	2	3	10	10	10	10	6	5	2	1	5	1
Developer (W2)	8	8	10	6	8	7	7	8	9	7	9	7
Average (W3)	5	5.5	10	8	9	8.5	6.5	6.5	5.5	4	7	4
Aspect Weight	0.5	0.55	1	0.8	0.9	0.85	0.65	0.65	0.55	0.4	0.7	0.4

Maturity Formula

A maturity formula is calculated to give a score to each selected paper. Some features contradict each other within the selected feature list. Scores in F1-Computational & Storage Requirements and F12-Training are linked together where one is usually high and one is usually low thus they are linked. Scores in F9-Computational & Storage Requirements and F8-Decision Support are liked where they both rely on one another for their feature value. Both of these sets of features are related to one another in terms of paper strength because of how different and distinct the methodologies for those specific values are evaluated. The maturity formula for this specific paper is found by taking a graded approach. The sum of all of the set feature value weights is calculated but there is a bias for the linked features that equates to a value of 20 due to their respective max values defined in the user developer table.

$$M = \frac{\sum_{i=1}^{12} (F_i)}{\sum_{i=1}^{12} (F_{i_{Max\,Value}}) - F_{12_{Max\,Value}} - F_{8_{Max\,Value}}}$$

Methodologies Comparative Table

Comparative	F1	F2	F3	F4	F5	F6	F7	F8	F9	F10	F11	F12	M
1	6	3	1	0	4	5	5	2	7	10	10	10	0.63
2	6	5	3	7	0	0	0	3	6	5	5	8	0.48
3	2	2	0	0	0	5	8	2	7	10	10	10	0.56
4	6	5	3	7	2	2	4	4	6	6	7	8	0.6
5	8	0	0	0	0	0	0	0	0	0	2	10	0.2
6	4	5	5	8	6	6	3	5	4	7	3	8	0.64
7	3	5	4	3	0	3	6	4	7	5	6	9	0.55
8	5	8	7	10	7	7	4	6	6	6	6	3	0.75
9	5	5	5	1	0	4	4	5	3	3	4	8	0.47
10	7	6	5	5	5	4	6	7	4	7	5	8	0.69
11	4	4	7	1	8	7	1	1	6	8	7	2	0.56
12	7	2	4	2	1	3	3	4	3	3	5	8	0.45
13	4	7	6	4	7	7	1	7	3	6	5	8	0.65
14	7	3	6	6	0	5	4	5	4	5	5	8	0.58
15	4	7	7	5	1	1	2	5	5	5	6	3	0.51
16	7	3	4	3	5	6	5	7	7	6	6	8	0.67
17	5	4	6	6	6	3	2	5	6	7	5	10	0.65
18	3	6	6	3	6	7	5	5	4	5	6	6	0.62
19	9	4	6	9	0	3	3	5	6	4	4	8	0.61
20	7	3	5	2	0	2	5	6	8	5	8	8	0.59
21	4	8	7	5	1	5	9	4	4	5	5	2	0.59
22	8	7	8	0	8	8	0	6	4	5	6	9	0.69
23	7	8	5	3	7	7	3	3	4	5	2	8	0.62
24	7	4	5	2	7	8	1	5	5	8	5	9	0.66
25	3	3	6	7	1	6	5	5	5	5	5	8	0.56
26	4	6	7	7	3	3	1	6	5	3	6	1	0.52
27	2	5	6	5	7	1	2	3	5	4	5	2	0.47
28	5	8	3	8	8	3	1	3	4	5	4	8	0.6

29	4	3	5	7	7	4	2	3	3	4	3	1	0.46
30	4	7	9	3	7	7	3	5	4	5	5	2	0.61
31	5	8	7	1	7	6	1	5	4	6	6	7	0.63
32	5	7	4	2	5	2	1	1	3	7	3	2	0.42
33	6	8	7	3	5	6	3	4	5	6	6	3	0.62
34	5	8	6	5	7	9	7	7	2	7	3	2	0.68
35	8	2	0	0	0	5	7	2	7	10	10	10	0.61
36	5	9	9	5	7	8	8	7	3	5	3	2	0.71
37	6	6	7	5	6	6	6	6	3	5	3	2	0.61

Weak Paper Discussion

The weakest paper within this selection is determined by the maturity level provided from the comparative table. There are multiple papers within the 0.4 to 0.5 range which correlates to weaker paper methodologies. The lowest few scores did not directly match the requirements for registration of the same region under different weather conditions so those papers received low scores due to features having very low relevance scores.

The paper, *Image Registration based on SIFT Features and Adaptive RANSAC Transform*, had the lowest relevant score of 0.62. The paper proposes a new method for calculating the threshold value in the RANSAC algorithm based on the variance between correct matches and mismatches, which is shown to be superior to the classic RANSAC algorithms in image registration problem in terms of Correct Match Rate (CMR) and False Match Rate (FMR). The low score is attributed to this because it lacked details in features. The weights for this paper were as follows,

25	3	1	6	6	1	6	5	8	5	5	5	8	0.59

Weight Reasoning

The score is set based on an average of each group member's evaluation of the paper on a scale of 1-10. Values that are at a fixed whole number are values that the group members agreed upon thus the average would be that number, had the members not agreed on that value the value would then be the average of each of the group members selected values.

F1: Computational & Storage Requirements

This feature was given a score of 3. This feature dealt with the computational and storage resources required or utilized by the system to achieve desirable results. This paper implemented Scale-invariant feature transform (SIFT) algorithm as well as the RANdom SAmple Consensus (RANSAC) method. Threshold values are calculated alongside the proposed algorithm which adds computational complexities. The implementations of these methods and algorithms add to the complexity of the paper and decrease its score.

F2: Performance and Test in Real Cases

This feature was given a score of 1. This feature dealt with the paper having sufficient results and performance statistics are provided to verify the system’s functionality in real cases. This paper used a single example of the RANSAC algorithm and SIFT method and defined a few different rates describing the correct matching rate and mismatch rate. Due to the lack of examples provided, this score was low.

F3: Reliability

This feature was given a score of 6. This feature dealt with the system producing reliable and accurate results. The paper used a SIFT method and RANSAC algorithm to enable image registration. The proposed method leads to mismatch rate and correct matches control based on the variance maximization between correct matches and mismatch classes. The proposed method has a correct matching rate of .8106 and a mismatch rate of .06. The paper does not give details over the unmatched images and why they were not matched. Due to this, the reliability of this implemented algorithm causes this to be a mid score.

F4: Speed

This feature was given a score of 6. This feature dealt with the processing time to realize registration of an image. The RANSAC algorithm implemented by this methodology uses a fast RANSAC method proposed by another paper that improved execution time. This paper built on top of it to decrease and eliminate mismatches. Because of this, this paper was given a mid/high score.

F5: Fault Tolerance

This feature was given a score of 1. This feature dealt with the system producing reliable results under any circumstances, such as different weather conditions and different light conditions. This paper implemented just a RANSAC algorithm and SIFT method in order to eliminate mismatches. The paper proved stable against changes of illumination and affine distortion and noise, however it does not prove stable against any type of weather conditions. Due to the heavy reliance on the topic of this improvement research in different weather conditions, this score was rated low.

F6: System Development

This feature was given a score of 6. This feature dealt with whether the developed system is applicable and useful to real-life scenarios. The algorithm defined in this paper is useful when the provided input is under good quality and circumstances. The algorithm can be used in many systems for image registration and extracting or matching features, and can be used for matching images with different rotations and scalings. Due to these, the score was given a mid level score.

F7: Complexity of Region Registered

This feature was given a score of 5. This feature depicts methodologies capable of detecting more simple or more complex regions. This paper depicts an algorithm for image registration applicable for extracting and matching of features. The complexity of the region able to be registered in this methodology depends on the SIFT method and the RANSAC algorithm to eliminate a mismatch. This paper does not go into details over the complexity of the region able to be registered but it does accomplish registration, thus the mid score.

F8. Decision Support

This feature was given a score of 8. This feature shows that the implemented system includes some type of diagnosis/decision mechanism or an algorithm/pattern recognition system for context aware sensing of parameters. The registration completed by the SIFT method is used in parallel with a RANSAC algorithm to eliminate mismatches in order to show an improved matching rate. Adaptive changing of the threshold value in the RANSAC algorithm allows for this proposed method to lead to an increase in correct matches. Because of these systems, a high score was given.

F9. Simplicity

This feature was given a score of 5. This feature dealt with the methodology being easy to implement and contains a few single standalone steps. The paper implements a SIFT and RANSAC algorithm in order to eliminate mismatches. This algorithm suggests a method for separating subset of correct matches, mismatches from among initial matching, and has application in removal of mismatches and estimation of parameters of the model transformation. Due to these methodologies being hard to understand within the paper, the score is impacted, however, the paper does put each section of the paper into its own distinct area which positively impacts its feature performance.

F10. Impact

This feature was given a score of 5. This feature dealt with the methodology promoting original ideas and has affected other research works. This methodology promotes original ideas by selecting the threshold in the RANSAC algorithm adaptively. The proposed method leads to mismatch rate and correct matches control based on the variance maximization between correct matches and mismatch classes. The paper does not go into details over what research or other applicable areas can benefit from using this methodology. Using the IEEE publication listing to see how many other papers this paper has been referenced in, the number is low while comparing to other related papers. These determining aspects cause the score for this feature to be at a middle rating.

F11. Interpretability

This feature was given a score of 5. This feature depicts that the results and operation of the methodology can be easily understood. The paper implements a SIFT and RANSAC algorithm in order to eliminate mismatches. In the paper, a SIFT and RANSAC algorithm are utilized to address mismatches by identifying and separating correct matches from initial matching. The algorithm can be applied to eliminate mismatches and estimate the parameters of model transformation. Although the technical details may be challenging to comprehend, the paper's organization into distinct sections enhances its feature performance. These attributes provide this feature with a medium level score.

F12. Training

This feature was given a score of 8. This feature depicts the number of (labeled) data needed for training. Due to this paper not implementing any type of a neural network or database, the training for this is nonexistent and thus a higher score. This paper however, uses an algorithm to determine a threshold value adaptively for use with the RANSAC algorithm, thus, the maximal score is reduced due to this.

Further Developments

In the future, we can expect to see significant developments in the field of image recognition, particularly in the context of improving matching rates and reducing computational requirements. Research can explore new approaches to data pre-processing, feature extraction, and feature selection that may further improve pattern recognition accuracy and efficiency. These advancements will enable the development of more sophisticated systems that can recognize images in a wide range of data sources and contexts.

Another key area of future development in image recognition is the incorporation of fault tolerance mechanisms. As pattern recognition systems become more complex, the likelihood of errors or failures increases. By integrating fault tolerance features, such as redundancy and error correction, into image recognition algorithms, improvements to the robustness and reliability of these systems can occur. In addition, the integration of modules designed to handle different weather conditions can further enhance the fault tolerance capabilities of pattern recognition systems.

Finally, as the amount of available data continues to increase, there is a growing need for more extensive testing and validation of image recognition algorithms. The development of more comprehensive test cases and datasets can help to identify potential weaknesses or limitations in pattern recognition systems, and provide valuable feedback for further improvement. In addition, the development of standardized benchmark datasets and evaluation metrics can enable more objective comparisons between different pattern recognition approaches. Overall, these future developments are likely to have a significant impact on the field of image recognition, enabling the development of more accurate, efficient, and robust systems.

Comparative Study Conclusion

The different methodologies compared within the papers evaluated showed many different strengths and weaknesses. Reviewing the state of the art research and developments regarding registration of the same region under different weather conditions provided insight on the different methodologies able to provide computationally efficient, reliable, fast, and fault tolerant systems which were fast and allowed for complex region detection. Highlighting each study individually showed the challenges individual papers have and need resolved in order to be more applicable to real life situations with great reliability, speed, and a multitude of other quality features. These challenges can be related to various factors, including the complexity of the registration process, the need for robustness to handle variations in the input data, and the requirement of real-time performance for practical applications. Additionally, the studies reviewed also revealed that the choice of registration method is highly dependent on the specific requirements and constraints of the given application, such as the accuracy needed, the computational resources available, and the level of user interaction required. Thus, a thorough evaluation of the different methodologies is necessary to select the most suitable one for a particular application. In conclusion, this review provides a comprehensive overview of the state of the art research on registration of the same region under different weather conditions, and highlights the strengths and weaknesses of different methodologies, as well as the challenges and opportunities for future research.

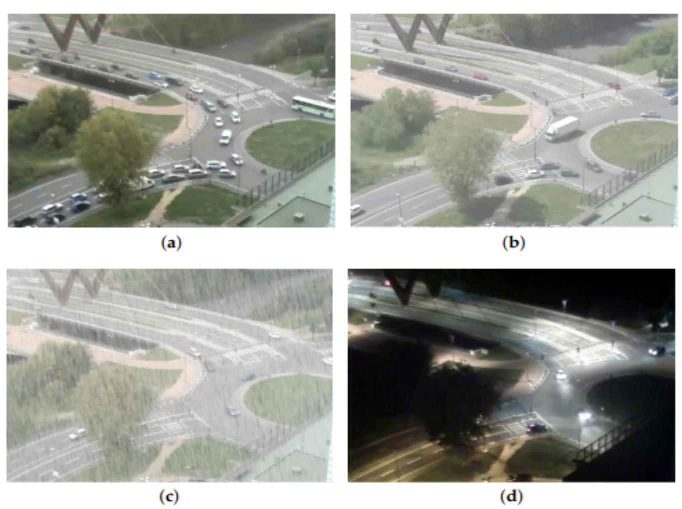
Improved Method and Results

Discussions stemming from the comparative study have shown that the paper, *Image Registration based on SIFT Features and Adaptive RANSAC Transform,* has some weaknesses when trying to attempt the requirements for registration of the same region under different weather conditions. In order to improve the weaknesses within this paper, many different methodologies have been considered for implementation on top of this algorithm. The implementation of the new methodologies is found on GitHub.

The Weak Paper Improvements

Example Test Images

The authors of the paper, *Street Viewer: An Autonomous Vision Based Traffic Tracking System,* use a set of images depicting a clear scene, sunny scene, hazy/foggy scene, and a dark scene all of the same region. Borrowing this set of test images enhances the defined weak paper performance in the "Performance and Test in Real Cases" feature category. The original paper only provided one example of the methodology working successfully, which involved an image of a different scale and rotation. However, the implementation did not take into account the effect of varying weather conditions on the images. To overcome this limitation, the series of test images that are representative of different weather conditions can be used. These images included cloudy, hazy/foggy, rainy, and night-time conditions.



(a) Cloudy, (b) Hazy/Foggy, (c) Rainy, (d) Night

The results of using these images allows for assessment as to how well a system performs under different weather conditions. The use of these test images helped to accurately depict the region to be registered under various weather conditions, thereby improving the overall performance of the system.

Haze Correction Module

A haze correction module can be a valuable addition to various image processing systems and can offer several benefits, including improved reliability, fault tolerance, and real-world application. Haze is a common problem in image registration, where the presence of airborne particles such as dust, smoke, and water vapor can reduce image quality by reducing contrast and color saturation. By integrating a haze correction module into an image processing system, images can be automatically corrected to remove the haze, resulting in clearer and more vibrant images that can be registered easier and more effectively.

Reliability: Haze correction can help ensure that images captured in challenging outdoor environments are of high quality and can be reliably used for analysis or other purposes such as image registration.
Fault tolerance: In situations where the quality of image data is critical, a haze correction module can provide an additional layer of fault tolerance. By ensuring that images are of high quality, even in challenging environmental conditions such as different weather, systems can be designed to be more robust and better able to cope with unexpected events.
Real-world application: Haze correction can have a significant impact on the real-world application of image processing systems. Haze correction can help to improve the accuracy of recognition systems, which rely on high-quality image data.

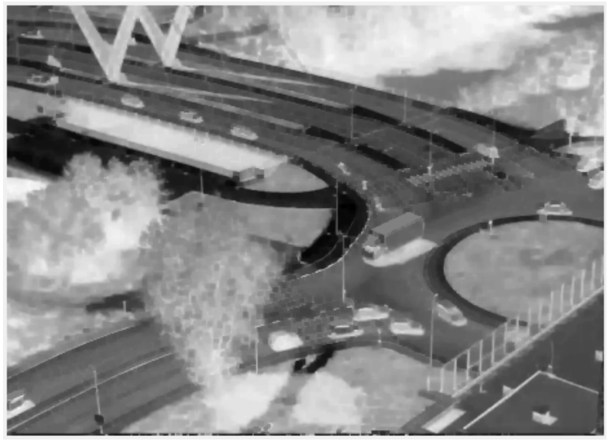
The authors of the paper, *Efficient Image Dehazing with Boundary Constraint and Contextual Regularization,* propose a way to remove haze from a single input image captured in foggy weather conditions. The proposed method requires only a few general assumptions and can restore a haze-free image with faithful colors and fine image details. The method also benefits from a filter bank that helps in attenuating the image noises and enhancing interesting image structures such as jump edges and corners. This expanded example below provides accurate results to correction of haze from the input image.

The method utilizes a new constraint on the scene transmission and a contextual regularization method to estimate the unknown transmission of the input image. The constraint is based on the inherent boundary of the transmission function, and it is combined with a weighted L1-norm based contextual regularization to model an optimization problem. The optimization problem is solved using an efficient algorithm based on variable splitting.

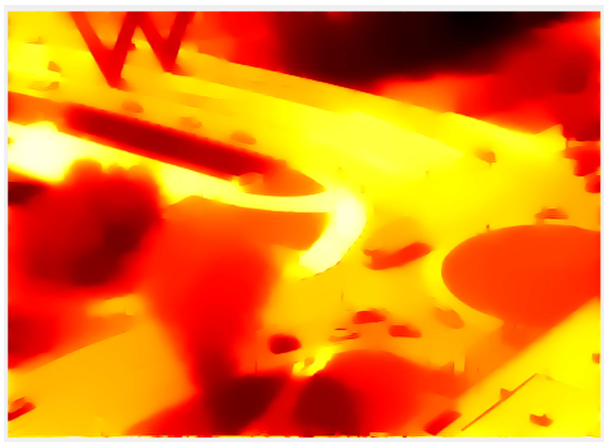
Input Haze Image

Dehazing Results

Scene Transmission Estimation- Iteration 6, β = 181, This step is used for fine-tuning the dehazing effects



Recovered transmission functions-The recovered transmission gives an estimation of the density map of hazes in the input image.



Dark Image Correction Module

Adding a dark image correction module can improve the reliability, fault tolerance, and real-world application of an image processing system in various ways. Dark images can occur due to several reasons, including low light conditions, sensor noise, or incorrect camera settings. These dark images can result in reduced image quality and affect the performance of the image processing system. By integrating a dark image correction module into the image processing system, dark images can be automatically corrected, leading to improved image quality.

Reliability: Dark image correction can help ensure that images captured in low light conditions are of high quality and can be reliably used for analysis or registration.
Fault tolerance: In situations where the quality of image data is critical, a dark image correction module can provide an additional layer of fault tolerance. By ensuring that images are of high quality, even in challenging environmental conditions such as different weather, systems can be designed to be more robust and better able to cope with unexpected events.

Real-world application: Haze correction can have a significant impact on the real-world application of image processing systems. Haze correction can help to improve the accuracy of recognition systems, which rely on high-quality image data.

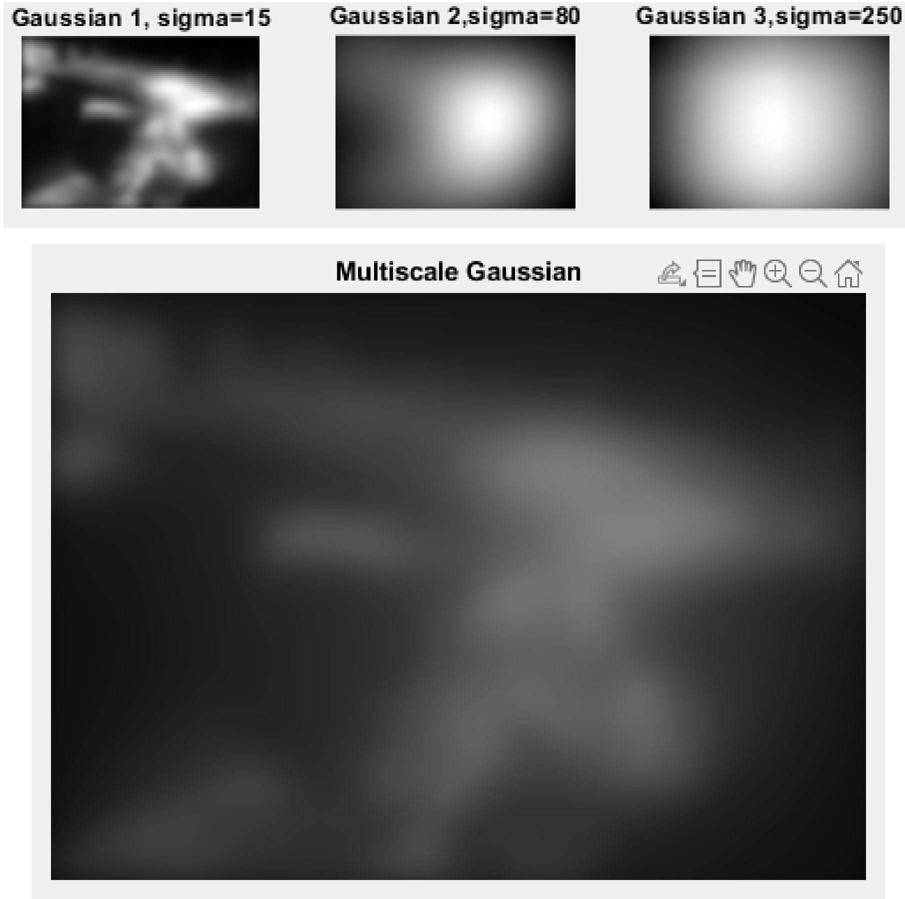
The authors of the paper, *Adaptive image enhancement method for correcting low-illumination images,* propose a colored image correction method to improve the adaptability of image enhancement in low illumination images. The proposed method is based on the nonlinear functional transformation according to the illumination-reflection model and multiscale theory. This expanded example below provides accurate results to correction of a dark image from the input image.

This proposed methodology converts the original RGB image to the HSV color space, and the V component is used to extract the illumination component of the scene using the multiscale Gaussian function. A correction function is constructed based on the Weber-Fechner law, and two images are obtained through adaptive adjustments to the image enhancement function parameters based on the distribution profiles of the illumination components. An image fusion strategy is formulated and used to extract the details from the two images.

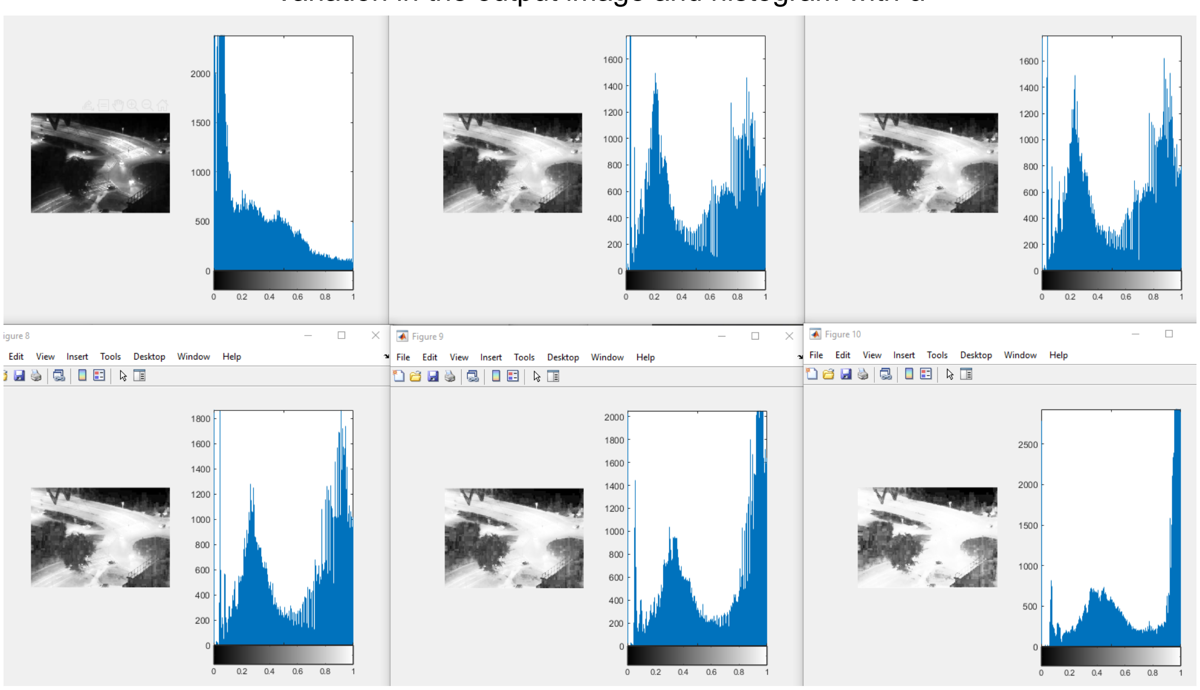
Source Image

Conversion fromRGB to HSV space

Extraction of the illumination component on a single scale and multiple scales



Variation in the output image and histogram with α



Fused Image based on PCA

Output Image

Rainy Image Restoration Module

Adding a rainy image restoration module can improve the reliability, fault tolerance, and real-world application of an image processing system in various ways. Rainy weather can cause significant degradation in image quality due to the presence of raindrops and streaks, leading to reduced visibility and image clarity. A rainy image restoration module can remove these artifacts and restore the image to its original quality, enabling better analysis and registration.

Reliability: Rainy image restoration can help ensure that images captured in wet weather are of high quality and can be reliably used for analysis or other purposes.
Fault tolerance: In situations where the quality of image data is critical, a rainy image restoration module can provide an additional layer of fault tolerance. By ensuring that images are of high quality, even in challenging weather conditions, systems can be designed to be more robust and better able to cope with unexpected events.
Real-world application: Rainy image restoration can have a significant impact on the real-world application of image processing systems. Rainy image restoration can help to improve the accuracy of recognition systems, which rely on high-quality image data.

The authors of the paper, *Single-Image-Based Rain and Snow Removal Using Multi-guided Filter*, propose a new method for removing rain and snow from images using the low-frequency part of a single image. This approach can differentiate between clear background edges and rain streaks or snowflakes. The low-frequency part is used as a guidance image, and the high-frequency part is used as input for a guided filter to obtain a non-rain or non-snow component. This component is then added to the low-frequency part to restore the image. The method is further refined based on the properties of clear background edges. This expanded example below provides accurate results to correction of a rainy image from the input image.

The proposed method is based on the difference between clear background edges and rain or snow streaks. Rain or snow streaks are imaged as bright and blurry streaks due to the size and speed of raindrops or snowflakes. These streaks are higher than adjacent pixel values and will disappear in the low frequency part of the image. In contrast, clear background edges are lower than adjacent pixel values and cannot be rain or snow streaks. However, these edges can be enhanced using a guided filter.

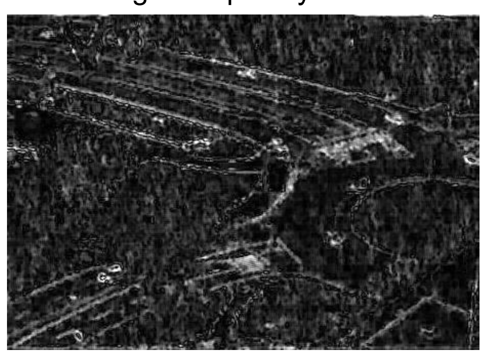
The authors propose using a mathematical model of a rainy or snowy image that decomposes the input image into two components: a clean background image and a rain or snow component. This can be done by using a guided filter to decompose the image into low and high frequency parts. The low frequency part is considered the non-rain or non-snow component, which contains the edges of the background. The high-frequency part contains all the rain and snow streaks, as well as non-rain or non-snow textures.

The authors then use the low-frequency part as a guidance image to remove the rain or snow streaks from the high-frequency part using a guided filter. However, the edges in the guidance image can become a little smooth due to the effect of the guided filter. To address this, the authors use an edge enhancement method to make the edges in the image more similar to the edges in the input image.

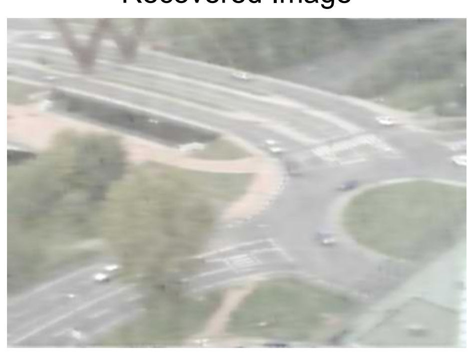
Input Image

Low Frequency Part

High Frequency Part



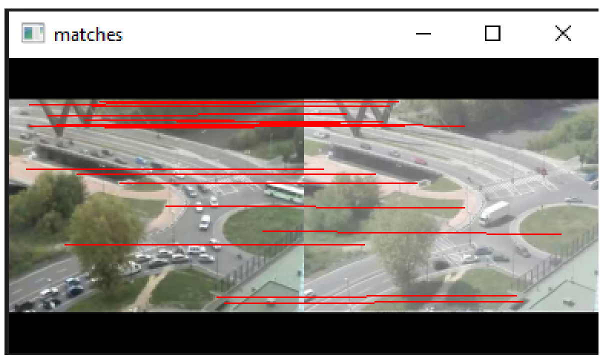
Recovered Image



Comparisons

Comparisons using the registration method from, *Image Registration based on SIFT features and adaptive RANSAC transform,* were completed in this step. The paper uses the SIFT method for image registration, which extracts and matches features, and the RANSAC algorithm to eliminate mismatches. The RANSAC algorithm works by randomly selecting a minimal subset of data points from the entire set and fitting a model to them. The remaining data points are then tested against the fitted model, and those that fit the model within a given threshold are considered inliers. The process is repeated for a certain number of iterations, and the model with the largest set of inliers is selected as the best fit to the data. The threshold value in the RANSAC algorithm is calculated based on the variance between correct matches and mismatches. The SIFT algorithm detects key points, refines their location and orientation, generates unique descriptors, and matches features between two images using a distance metric. Combining these two algorithms from this paper provides a way to register images with a good correct match rate.

Clear vs Hazy Matching




```
coordinate reconstruction error:  19.501582064871034
Cross-correlation:  0.8886556215097633
Mutual Information:  1.9432916529020023
```

The two tables represent the degree of cross-correlation for the registration between pairs of images. The values in the tables indicate the strength of correlation between each pair of images, with higher values indicating stronger correlation.

Comparisons from the original images:

Comparisons	Clear	Hazy	Dark	Rainy
Clear	1	0.8886	0.3344	0.5214
Hazy	0.8886	1	0.2261	0.8143
Dark	0.3344	0.2261	1	0.5006
Rainy	0.5214	0.8143	0.5006	1

Comparisons from the corrected images from implemented methodologies:

Corrected Comparisons	Clear	Hazy	Dark	Rainy

Clear	1	0.9096	0.7749	0.9426
Hazy	0.9096	1	0.5875	0.9103
Dark	0.7749	0.5875	1	0.6976
Rainy	0.9426	0.9103	0.6976	1

Comparing the two tables, we can see that the values in Table 2 are generally higher than those in Table 1. This suggests that the methodology discussed within *Image Registration based on SIFT features and adaptive RANSAC transform* have been refined and improved in every resulting category, resulting in better cross-correlation between the images.

Specifically, it can be seen that the degree of cross-correlation between Clear and Hazy images has increased from 0.8886 to 0.9096, while the degree of correlation between Clear and Dark images has increased from 0.3344 to 0.7749. The cross-correlation between the Rainy and Clear images has increased from 0.5214 to 0.9426. The cross-correlation between the Dark and Hazy images has increased from 0.2261 to 0.5875. The cross-correlation between the Rainy and Hazy images has increased from 0.8143 to 0.9103. Similarly, the degree of correlation between Dark and Rainy images has increased from 0.5006 to 0.6976. These improvements suggest that the updated methodology is better able to perform registration between images, resulting in more accurate registration and higher cross-correlation values.

Conclusions

25	2	6	8	6	8	8	5	8	5	5	5	8	.74

To conclude, a new score for the paper with the additional methodologies is found.Scores improved in feature categories of: Performance and test in real cases, Reliability, Fault Tolerance, and System Development. Based on the comparative study of the paper, *Image Registration based on SIFT Features and Adaptive RANSAC Transform*, several weaknesses were identified in the methodology of registering the same region under different weather conditions. To overcome these limitations, different methodologies were considered for implementation. The authors of, *Street Viewer: An Autonomous Vision Based Traffic Tracking System*, use a set of images depicting a clear scene, sunny scene, hazy/foggy scene, and a dark scene all of the same region. The authors of the paper, *Efficient Image Dehazing with Boundary Constraint and Contextual Regularization*, proposed a way to remove haze from a single input image captured in foggy weather conditions. The authors of the paper, *Adaptive image enhancement method for correcting low-illumination images*, proposed a colored image correction method to improve the adaptability of image enhancement in low illumination images. The authors of the paper, *Single-Image-Based Rain and Snow Removal Using Multi-guided Filter*, propose a new method for removing rain and snow from images using the low-frequency part of a single image. The addition of test images depicting a clear scene, hazy scene, dark scene, and a rainy scene of the same region enhanced the performance of the weak paper in the feature category of Performance and Test in Real Cases. The integration of a haze correction module, dark image correction module, and rainy image restoration module offered several benefits, including improved reliability, fault tolerance, and real-world application. In conclusion, by considering alternative methodologies and integrating various image enhancement techniques, the weaknesses identified in the original study were addressed, resulting in improved performance and adaptability for real-world applications.

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