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Automatic Pipeline Threat Detection by Aerial Surveillance

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Abstract:

The pipeline industry has millions of miles of pipes buried along the length and breadth of the country. Since none of the areas through which pipelines run are to be used for other activities, it needs to be monitored so as to know whether the right-of-way of the pipeline is encroached upon at any point in time. Rapid advances made in the area of sensor technology have enabled the use of high end video acquisition systems to monitor the right-of-way of pipelines. Huge amounts of data are thus made available for analysis. However, it would be very expensive to employ analysts to scan through the data and identify threats along the right-of-way in the vast expanse of wide area imagery. This warrants the deployment of an automated mechanism that is able to detect threats and send out warnings in the event of any hint of a threat. The images captured by aerial data acquisition systems are affected by a host of factors that include light sources, camera characteristics, geometric positions and environmental conditions. UD Vision Lab is developing a multistage framework for the analysis of aerial imagery for automatic detection and identification of machinery threats along the pipeline right of way which would be capable of taking into account the constraints that come with aerial imagery such as low resolution, lower frame rate, large variations in illumination, motion blurs, etc. The visibility and features of objects may not be clear because of partial or total occlusion of light sources by buildings and trees which create a shadow. The complexity of large variations in the appearance of the object and the background in a typical image causes the performance degradation of detection algorithms. Our novel preprocessing technique improves the performance of automatic detection and identification of objects in an image captured in extremely complex lighting conditions. This step consists of a new non-linear transformation technique which is capable of simultaneous enhancement of both dark and brighter regions by preserving the main structure of illuminance-reflectance characteristics of an image. A background elimination method employing a relative variance and local entropy based analysis has been developed and it is found to be very effective in reducing the search regions in the aerial imagery for threat detection. Our object detection algorithm can automatically detect and identify machinery threats such as construction vehicles and equipment in the regions designated as the pipeline right-of-way. Our detection algorithm makes use of monogenic signal representation to extract local phase information. A novel classifier using a matching criterion along with a threshold for minimum distance is used to filter out false detections. The algorithm has been successfully tested on the aerial imagery containing different classes of construction equipment. We develop a context information extraction method for aiding the final decision making in the threat detection process. The presence of regions in the image with roads, buildings, and tree canopies can be successfully segmented using local phase and local contrast information features. This would also help in

eliminating the search regions for machinery threats. We develop a real time 3D scene reconstruction technique for aiding machinery threat detection by scene change detection. The 3D reconstruction is based on a transformation of a feature point disparity map to a scene depth map and point localization to obtain a point cloud with color information which is obtained by analyzing the regions around each feature in the input images. UD Vision Lab is planning to establish a data management and storage system to collect and manage the data captured by the cameras in small aircrafts and UAVs. These data have to be directly transmitted from the aircrafts and should be collected by Vision Lab through UD's networking system. We are expecting Terra Bytes of data transmission during the data acquisition experiments. We recently enhanced our network infrastructure to enable data transmission, data management, data processing and automatic decision making in real time.

Biography:

Dr. Vijayan Asari is a Professor in Electrical and Computer Engineering and Endowed Chair in Wide Area Surveillance at University of Dayton, USA. He is the director of the Center of Excellence for Computer Vision and Wide Area Surveillance Research at UD. Dr. Asari received his PhD degree in Electrical Engineering from Indian Institute of Technology, Madras. Dr. Asari holds three patents and has published more than 500 research papers in the areas of image processing, pattern recognition and machine learning. Dr. Asari received several teaching, research, advising and leadership awards. He is a Senior Member of IEEE and SPIE.