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Title: Recent Progress in Wide-Area Surveillance: Protecting Our Pipeline Infrastructure

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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. 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. We present 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.

Our novel preprocessing technique improves the performance of automatic detection and identification of objects in an image captured in extremely complex lighting conditions. 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 object 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.

In a real world application, a pipeline operator has to know the geolocation of a detected threat object to assess the severity of threat for preventing any damage to the pipeline. Sometimes a detected machinery threat object may be located far away from the pipeline or it may not be even functional, where the probability of that object to be a threat is significantly low. This requires a registration process to match the pixel location of the threat object in the images with the geographical map and prioritize the risk factor based on the proximity of the object with the pipeline right-of-ways and the operating condition of the equipment. The temperature information of the target is obtained using an infrared camera in the sensor suite used for capturing the aerial data. We designed an automatic threat assessment framework to assess the severity of threats to pipelines based on the geolocation and the temperature information of the threat objects, which assigns a risk level of a threat as high, medium or low. The proposed scheme is tested on several real-world datasets that were captured along the pipeline right-of-ways.

We are currently developing a persistent surveillance system using satellite imagery, captured by satellite data providers such as Google Earth, for automatic detection of any intrusions to the pipeline right-of-ways. We are also developing a less expensive and extremely efficient computing framework employing the currently available cloud computing facility to instantaneously report any kind of intrusions to the pipeline right-of-ways to authorized personnel on their mobile devices.