Detection and estimation of inundation and associated risks using traffic monitoring cameras and image processing under extreme flooding conditions

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Detect inundation by using de-noising and image segmentation technique

Extreme weather such as Hurricane Harvey is one of the most severe natural disasters which threatens the safety and resiliency of the communities and transportation infrastructure in Region 6. During extreme flooding, photo images from traffic monitoring cameras provide critical information, sometimes as the only reliable source, to identify whether or not a road is flooded. The advent of new image processing and filtering technologies has enabled us to extract the extent of inundation from low-resolution photos with reasonable accuracy. It is possible to extract accurate flood information using objective and automatic ways like the image processing technique. Therefore, the main goal of this project is to develop an inundation detection and evaluation framework using images from traffic monitoring cameras and image processing under extreme precipitation conditions.

Background

The low resolution due to inaccurate equipment in severe weather conditions (e.g., raindrops or light refraction on camera lenses), low-resolution images are subject to noises that degrade the quality of information. De-noising procedures are carried out for the enhancement of images by removing different types of noises, and this stage is called image pre-processing. After de-nosing, the inundation area can be found by the Image segmentation technique by using pixel (color) value to classify the information in the image. Normally, the edge between objects has a similar pixel (color) value. The image segmentation technique can extract this information to find the edge. In this project, two commonly used segmentation which is OTSU and k-mean, and a new developed Bayesian were used to find the inundation area.

Project Summary

The main goal of this project is to develop an inundation detection and evaluation framework using images from traffic monitoring cameras and image processing under extreme precipitation conditions. Specific objectives are to (i) develop an inundation detection technique, (ii) evaluate a framework using images from traffic monitoring cameras under extreme precipitation conditions, and (iii) comparative assessment of developed image processing, including de-noising and segmentation techniques. The inundation could be detected from low-resolution images taken by the existing road traffic monitoring cameras by three specific objectives.

Status Update

CCTV images were testing comprehensively with several de-noising methods and image segmentation methods, including one newly developed Bayesian segmentation method. The flowchart is shown in Figure1.

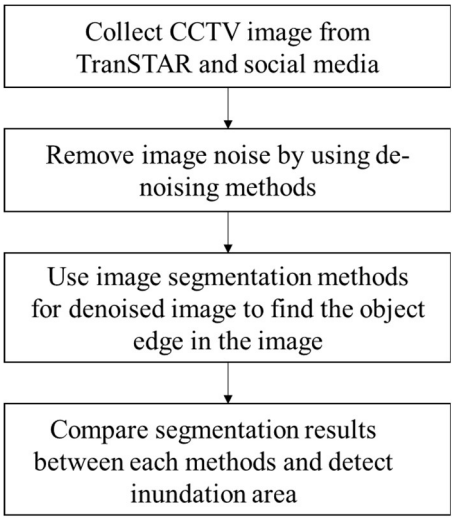


Figure 1. The basic flowchart of this study for inundation detection.

The comprehensive results with different de-nosing as shown in Figure 2. Wavelet coefficients have better de-noising performance for CCTV images.

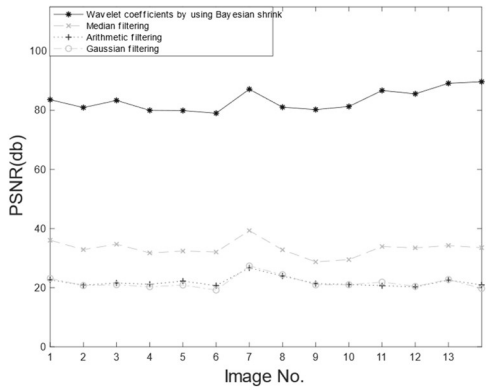
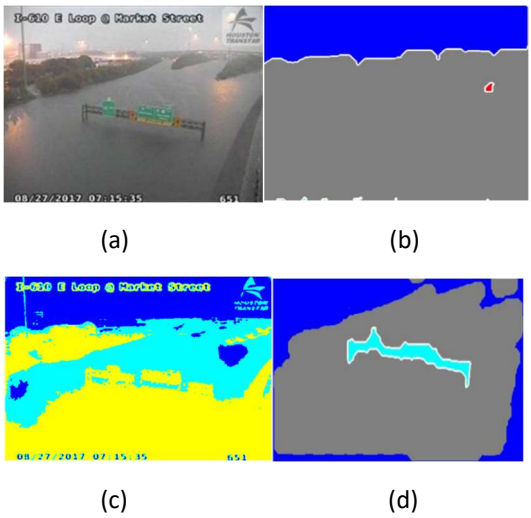


Figure 2. The chart of PSNR for each method with different 14 CCTV images. High PSNR indicates better performance of de-noise.

The inundation detection with two commonly used segmentation methods (OTSU and k-mean) and new developed Bayesian method is shown in Figure 3. The edge of inundation can be detected clearer by the Bayesian segmentation method.



(a) (b)

(c) (d)

Figure 3. The results from different segmentation method. (a) original image, (b) OTSU segmetation, (c) k-mean segmentation and (d) Bayesian segmentation.

Impacts

The main benefits of this study are: (a) develop a reliable image segmentation method for detect inundation by using low-resolution CCTV image, (b) enhance training opportunity for students in the image processing field, (c) the government or transportation organization can use the output tool to detect the inundation area automatically. Besides, the depth of inundation can be further calculated by coordinate relationships, (d) transportation can use image segmentation to monitor the inundation area by using CCTV image per few mins (based on setting with monitor system), and (e) the concept of using image processing to detect inundation can be further improved and developed by researchers.

A major outcome of this project is to estimate the inundation from low-resolution images taken by the existing road traffic monitoring cameras to assess flooding risks in the vicinity of the local flooding locations, which meets transportation departments' goal of transportation safety in an urban area in Region 6.

Tran-SET

Tran-SET is Region 6's University Transportation Center. It is a collaborative partnership between 11 institutions (see below) across 5 states (AR, LA, NM, OK, and TX). Tran-SET is led by Louisiana State University. It was established in late November 2016 "to address the accelerated deterioration of transportation infrastructure through the development, evaluation, and implementation of cutting-edge technologies, novel materials, and innovative construction management processes".

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