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Construction Site Scene Understanding: A 2D Image Segmentation and Classification

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Abstract: ***A computer vision-based scene recognition algorithm is proposed for monitoring construction sites. The system analyzes images acquired from a surveillance camera to separate regions and classify them as building, ground, and hole. Mean shift image segmentation algorithm is tested for separating meaningful regions of construction site images. The system would benefit current monitoring practices in that information extracted from images could embrace an environmental context.***

Keywords: Scene Understanding, Construction Site, Image Segmentation, Image Classification, Monitoring, Computer Vision

I. Introduction

Data-driven decision making has emerged as an innovative business strategy in most of industries. A primary condition to do a data analysis is abundant data relevant to the analysis purpose. Construction industry tries to use a monitoring system relying on image data from construction sites, as-built buildings and facilities.

Construction site images contain abundant raw information that can be transformed into high level information. Raw information, for example, consists of objects and spatial information–location and distance. The information could produce high level concepts such as progress, productivity, and safety.

With regards to safety management, a vision-based monitoring system can identify latent hazards to entities (here, entity refers to workers or heavy equipment) by using geometrical information–distance between entities. For example, a system can automatically assess one's safety levels by converting a physical distance between worker and heavy equipment to potential danger, which may cause a struck-by accident.

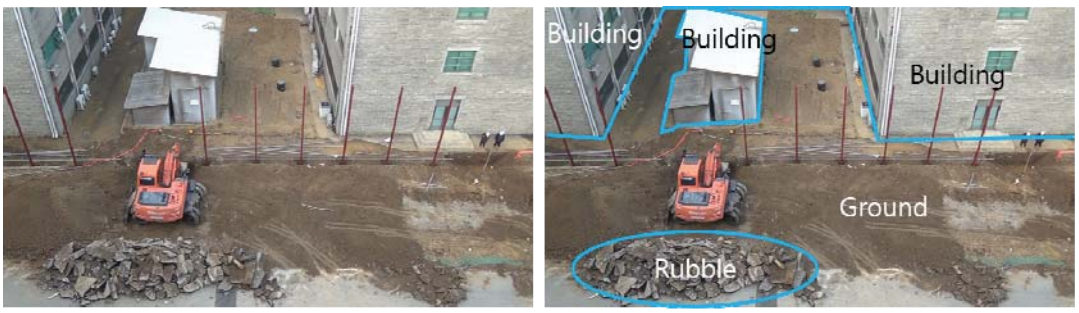
Since digital images reflects three-dimensional (3D) reality into a two dimensional (2D) space, distortion arises in the geometrical projection process. Previous research focused on this issue to extract precise and accurate detection of entity and a distance. However, studies on extracting environmental information (e.g. topography) are relatively insufficient. Since construction operations are conducted in highly changeable environment, latent hazards may vary during construction. Recognizing variations of working environment enables collection of safety information.

This paper presents a construction site scene analysis system using an image segmentation and classification algorithm. 2D image segmentation algorithms are tested to select an appropriate segmenting method suitable for construction site image characteristics.

II. Scene Recognition System

A. Related Work

Computer vision applications in the construction industry are mainly divided into three categories: progress monitoring, productivity analysis, and safety monitoring. Safety related applications identify risk factors based on object detection, object tracking, and action recognition [4]. To name a few in this type of research, Chi and Caldas used a stereo vision camera to track heavy equipment thereby assessing safety level [1]. Han and Lee proposed vision-based motion capture and recognition framework for identifying worker's behavior related to unsafe action [3].



(a) sample site **(b) ideal region classification**

Figure 1. Sample construction site and ideal region classification

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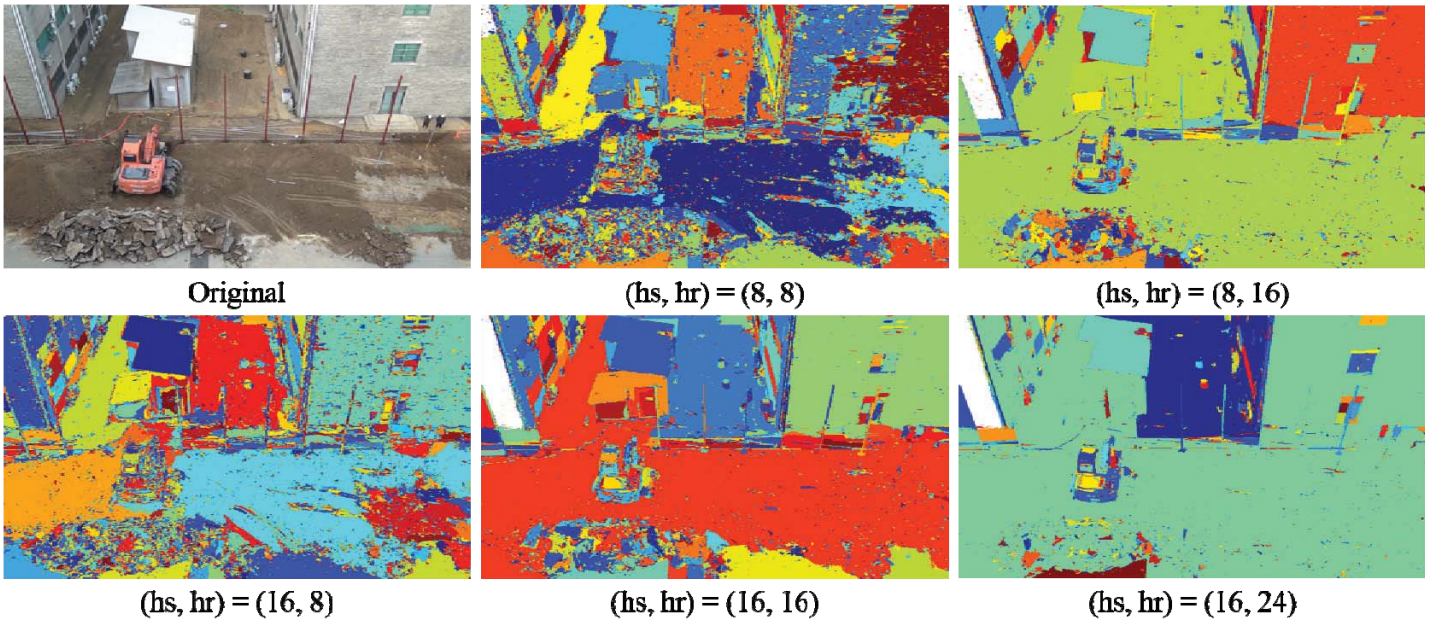

Figure 2. Results of the Mean shift image segmentation

This paper presents a region separating and classification method in order to obtain rich information of working environment on construction sites.

B. Image Region Segmentation

The mean shift algorithm is a clustering-based image segmentation method [2]. The algorithm is tested for construction site image. Building a model of the probability density function using a kernel function on each pixel, the algorithm searches a closest peak point of a pixel. A search window on a pixel is used to iteratively find a peak point by tracking a mean point inside the window. A mean point is calculated by an average density (center of mass). If a new mean point lies in a position different from the previous mean point, the search window moves to the new point and iterates the process until the mean point stops moving. Clusters generated by this algorithm are labeled as different regions.

C. Image Region Classification

Image regions, generated by the image region segmentation algorithm, are classified using texture features such as edge and color patterns. Training data contains important environmental region classes related to safety context. Ground, hole, building, pile of stones, and material are examples of class labels. As for now, the image region classification part is not yet fully implemented as a part of the system.

III. Experimental Result

The sample images shown in Fig. 1(a) and Fig. 1(b) show an ideal region segmentation and classification result. To achieve this goal, the mean shift image segmentation algorithm was applied to a sample construction site image with different parameter settings. Spatial domain (pixel location) and color information were used to generate the joint domain of image features. An Epanechnikov kernel function has two parameters–hs and hr–that adjust the kernel bandwidth. A range of values were used for those parameters as shown in Fig. 2. Different color denotes the different class region. The experimental results show that the algorithm produces a wide spectrum of performance depending on the input parameters. In a sense, with hs being 8 and hr being 16, a relatively successful classification result was shown; the three building regions, equipment, rubble, and ground were roughly differentiated. However, many small particles that are independently recognized suggest the need to improve the performance.

IV. Conclusion

This study presents a vision-based scene understanding method using image segmentation and classification technique. The mean shift algorithm was tested as a main region classification method. A range of performance was observed with different input parameters. Thus, the algorithm needs to be improved for more accurate and reliable classification of regions in construction images.

Probable alternatives to obtain a desirable result using the mean shift algorithm are (1) adding more features to cluster image region, (2) using pruning modes (eliminating trivial convergence points), and (3) using adaptive window size depending on pixel location or region characteristics.

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