Blocked-watershed method: a salience-based optimization of the watershed transformation for low resolution retinal prosthesis

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***Abstract*—A salience-based optimization of the watershed image transformation is proposed for application in a retinal prosthesis. Series of noise-suppression and block-processing yields salient feature extraction. Our algorithm shows promise for near-proximity images enabling ambulation.**

I. Introduction

To restore vision to patients suffering from retinitis pigmentosa or macular degeneration, a wireless retinal implant has been developed to electrically stimulate retinal ganglion cells (RGCs), replacing the function of the affected photoreceptors [2]. The system consists of a glasses-mounted camera, an external controller, inductive telemetry system, eye-side receiver and implanted electrode array for neural interfacing [2]. Spatial constraints hinder the optimal surgical, sub-scleral implantation of the electrode-array, limiting the size, and, subsequently, resolution of the electrode array interfacing with the RGCs. We are faced with the task of determining feature salience to inform the patient of the relative location of obstructions to ambulatory navigation and for visual quality. Determination of feature salience is a typically cognitive task that is, herein, computationally attempted: we refer to this as the *blocked-watershed method*.

II. The Blocked-Watershed Method

The renowned Beucher-Meyer (BM) watershed transform implements a priority queue pixel-labeling process (by intensity) [1]. Adapting this morphological algorithm, we propose optimizations for retinal prosthesis application. Firstly, to reduce harmful noise-contamination, we apply a *Gaussian low-pass filter*, followed by a *grayscale conversion* using minimum variance quantization [3]. Lastly, we apply an adaptation of the *watershed transformation* to subdivisions—"*blocks*"—of the image.

A. Noise Suppression & Grayscale conversion

Noise contamination can compromise the integrity of the watershed transform, resulting in over-segmentation [3]. Use of a Gaussian low-pass filter acts as a form of normalization of pixel intensities. The filter allows for output resolution reduction by eliminating noise around regional minima or maxima that may show false topographical significance in the later transform. We use minimum variance quantization as a function of the retinal stimulator's dynamic range to convert to 8-bit grayscale.

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B. Block-watershed method

Topographically turbulent regions are preserved and can be observed by watershed. We divide the filtered, grayscale image into a grid of k blocks, where k is a function of the electrode-array resolution. At each block, we apply a distance transform for further normalization, followed by the BM watershed transformation.

III. Results and Discussion

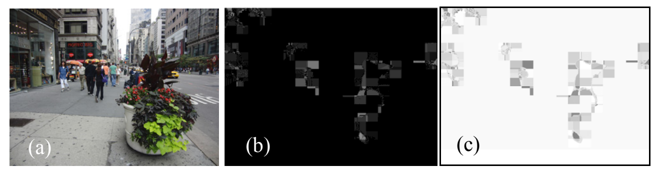

Figure 1. Obstructions on a city street. (a) Original Image. (b) Result of blocked-watershed method. (c) Complement of (b).

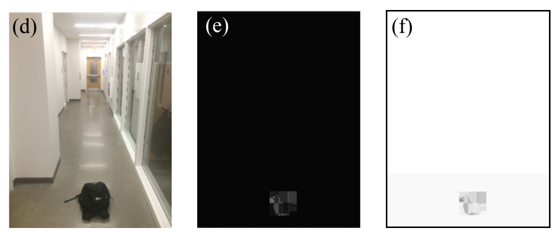

Figure 2. Hallway navigation. (d) Original Image.
(e) Result of blocked-watershed method. (f) Complement of (e).

The algorithm was performed on over a dozen different images (i.e. landscapes, portraits, etc.). Ambulatory salient features in Fig. 1(a)—pot, people, car—are prominently displayed in (b). Also, regions of little-to-no salience are displayed as low-to-no noise regions in (b), or are not displayed at all. Similarly, in Fig. 2, we find the ambulatory salient feature in (c)—backpack—displayed in (d), and all else neglected. As a result of post-filter block-processing, the transform is performed on simpler topographies, minimizing over-segmentation, enabling low-resolution outputs. The blocked-watershed method succeeds in a variety of topographies demonstrating robustness and proof of concept.

References

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