Improving Stereo Correspondence in Scattering Media by Incorporating Backscatter Cue

Amin Sarafraz, *Member, IEEE,* Shahriar Negahdaripour, *Member, IEEE,* and Yoav Y. Schechner, *Member, IEEE*

***Abstract*—Image contrast can deteriorate significantly in scattering media, such as underwater, due to backscatter. This affects the performance of many computer vision techniques developed for open-air conditions, including the stereo matching algorithms, when applied to images acquired in these environments. It has been demonstrated that the backscatter field embodies depth information, thus can potentially provide an effective visual cue for 3-D reconstruction. In this paper, we address the estimation of the backscatter component in stereo images, in order to employ it as an additional cue for disparity estimation. More precisely, we decouple the stereo images into signal and backscatter components, and thus are able to make use of depth cues offered by both components in order to devise a more robust technique for disparity computation. Our method is invariant to illumination setup, and requires neither lighting calibration nor the knowledge of medium optical properties. Results of experiments with synthetic and real data are provided to demonstrate the performance of our new method.**

***Index Terms*—Stereo, Scattering.**

I. Introduction

FEATURE matching, the primary challenge in stereovision, has been studied over several decades; e.g. [1]. Despite extensive work dealing with open-air images, only a small number of studies has addressed the problem when the images are taken in scattering media, e.g., in fog, haze, and underwater [2], [3], [4], [5]. Most computer vision methods face significant difficulties if employed directly for underwater images [6], and those recorded in other scattering environments.

In such domains, the backscatter field can significantly corrupt the scene radiance, which comprise the signal component of the image. Additionally, the signal component undergoes attenuation due to the medium absorption and scattering as the light rays travel from the object to the camera. Since backscatter increases with the distance between the camera and the scene, this leads to a contrast decay that varies across the image [7]. In low-light environments, artificial sources are necessary, adding other complexities.

In this case, corresponding patches in stereo images might have different brightness levels with dissimilar backscatter components. These effects make stereo matching even more challenging in scattering media. To demonstrate the negative impact of these effects on stereo matching results, we picked the standard normalized SSD method and run it on original Poster image from Middlebury dataset [1] and its corresponding synthetic stereo pair in turbid water. The validity map of estimated disparities are illustrated in Fig. 1. Comparing the validity maps of open air and turbid water images, one can readily see that the depth map estimation over the low-contrast areas is affected due to the signal attenuation and backscatter presence. Standard deviation of pixel values in a local window is used as the contrast measure and the contrast map is shown in Fig. 1 for reference. In scattering media, backscatter

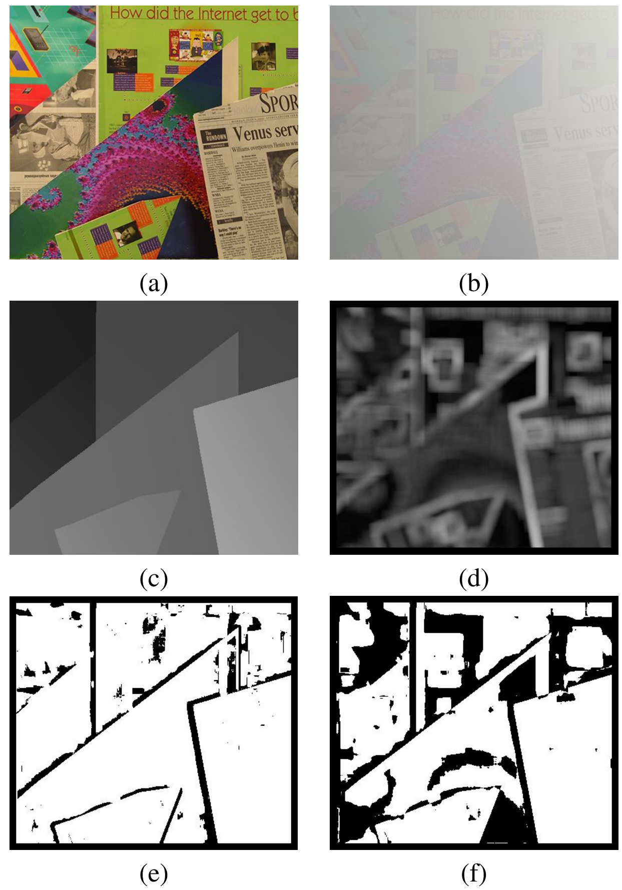

Fig. 1. Turbidity affects the performance of stereo matching methods. Left image of a stereo pair in (a)open air, (b)turbid water. (c)Ground truth disparity map: pixels with brighter gray value are closer to the camera. (d)Contrast map: pixels with higher contrast values are shown in brighter pixels, . Validity map of the estimated depth map using normalized SSD in (e)open air, (f)turbid water. Pixels with correct estimated disparity are shown in white.

Amin Sarafraz is with the Department of Civil, Architectural and Environmental Engineering, University of Miami, Coral Gables, FL, 33124 USA e-mail: a.sarafraz@umiami.edu.

Shahriar Negahdaripour is with the Department of Electrical and Computer Engineering, University of Miami, Coral Gables, FL, 33124 USA e-mail: shahriar@miami.edu .

Yoav Y. Schechner is with the Department of Electrical Engineering, Technion-Israel Institute of Technology, Haifa 32000, Israel e-mail: yoav@ee.technion.ac.il.

Manuscript received this date; revised that date.