Casual Stereoscopic Panorama Stitching

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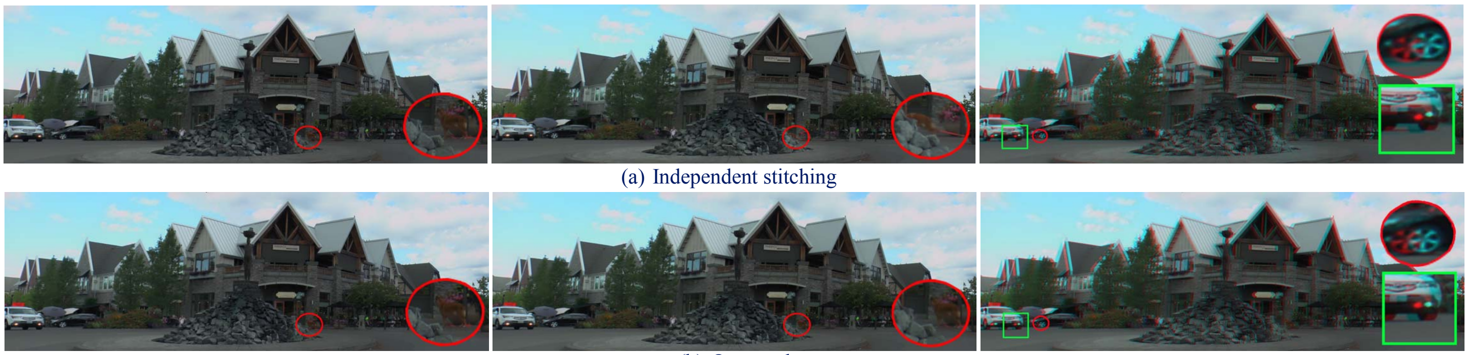

(a) Independent stitching

(b) Our result

Figure 1: Stereoscopic panorama stitching. For each row, we show the left-view, right-view and red-cyan anaglyph of the stereo panorama. Stitching the left- and right-view panorama independently brings in inconsistency artifacts like monocular object (the cat) and vertical disparities (the car headlight and tire), which will bring in "3D fatigue" to viewers. Our result is free from these artifacts.

Panorama stitching is a well studied topic and many software tools are available for users to create panoramas [1]. Most of these methods, however, are designed for monocular image stitching. Employing a monocular image stitching method to independently create the left and right view of a stereoscopic panorama is problematic as the left and right panorama may not be consistent. As shown in Figure 1 (a), the cat in the left panorama is different from that in the right panorama. This is because the input images are taken at different time and the cat appears different in the input images. The left and right panorama take the cat from different input images. This inconsistency will lead to "retinal rivalry" and bring in "3D fatigue" to viewers [2]. Moreover, stereoscopic images have an extra dimension of disparity, which cannot be taken care of by independently stitching the two views. Figure 1 (a) shows that the resulting panorama has vertical disparities in the car headlight and tire area. This will also compromise the 3D viewing experience of viewers. Dedicated stitching methods have been developed for stereoscopic panorama stitching [3, 4, 5]. However, these methods require a user to densely sample the scene using a video camera and/or follow some specific rules to rotate the camera and cannot work well with a sparse set of casually taken input images.

The goal of this paper is to develop a technology that allows users to create stereoscopic panoramas as conveniently as monocular ones. As consumer stereo cameras now become more and more available to daily users, it becomes easy for them to take stereoscopic images. We therefore aim to develop a stereoscopic image stitching method that enables users to generate stereoscopic panoramas from casually taken stereo images. To achieve this goal, we need to address three challenges. First, our method needs to handle parallax well. No matter how a user moves a stereo camera, images from at least one of the left and right view have parallax. As we allow users to freely move the stereo camera, it is common that images from both views have parallax. Second, our method needs to stitch the left and right panorama consistently. Third, our method needs to take care of disparity to deliver a pleasant viewing experience.

To address the above challenges, our method decomposes stereoscopic panorama stitching into three separate steps after a pre-processing step to estimate disparity maps of input stereoscopic images.

1. Stitch the left panorama from the left views of input stereoscopic images using a state-of-the-art monocular stitching algorithm.

2. Stitch the target disparity map of the output stereoscopic panorama from the disparity maps of input stereoscopic images.

3. Warp the right views of input stereoscopic images and stitch the right panorama according to the stitching of the left panorama and the target disparity map.

In Step 1, we use a recent parallax-tolerant monocular image stitching method [6] to create one of the two views of the stereoscopic panorama. Without loss of generality, we always select the left-view panorama to stitch first. In Step 2, a stereoscopic image has an extra dimension of disparity, which controls the perceived depth [2]. To generate a good stereoscopic panorama, we need to not only stitch the input images, but also seamlessly stitch the disparity maps of input images to ensure proper 3D depth perception. We stitch the disparity maps in the disparity gradient domain to create the target disparity map for the stereoscopic panorama by solving a Poisson's equation. This target disparity map is optimized to avoid vertical disparities and seamlessly merge the perceived depth field of the input stereoscopic images. In Step 3, we warp the right views of the input stereoscopic images according to the target disparity map and stitch them into the right-view panorama using an extended seam-cutting algorithm. The stitching of the right views is formulated as a labelling problem that is constrained by the stitching of the left views to make the left- and right-view panorama consistent.

This paper contributes a stereoscopic image stitching method that allows users to generate stereoscopic panoramas as conveniently as they generate monocular ones. To develop this stereoscopic image stitching method, this paper also provides a novel algorithm to seamlessly stitch input disparity maps and a seam-cutting method to stitch the right panorama that is consistent with the stitching of the left panorama and respects the target disparity map. Our experiments show our method allows for easy production of stereoscopic panoramas that deliver a pleasant 3D panoramic viewing experience.

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