On The Improving Algorithm for Stitching Images

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***Abstract*—Image stitching is a fundamental problem in computer vision, enabling the creation of panoramas by aligning and blending multiple overlapping images. While traditional blending methods such as averaging or feathering are computationally efficient, they often produce visible artifacts including ghosting, seams, and intensity discontinuities, especially under exposure variations or geometric misalignments. Advanced techniques like multi-band or Poisson blending improve quality but are computationally expensive, limiting real-time applicability. To address these challenges, we propose a stitching framework that integrates rotation-robust geometric alignment with an optimized distance-based alpha blending strategy. By computing per-pixel distance maps from valid image regions and adaptively weighting contributions, the method achieves smoother transitions, reduced artifacts, and improved structural consistency. Extensive experiments demonstrate that the proposed approach outperforms classical and advanced blending techniques in both visual quality and computational efficiency, making it suitable for offline panorama generation as well as real-time video stitching applications.**

Keywords—image stitching, panorama generation, geometric alignment, distance-based alpha blending, seam reduction, ghosting artifacts, real-time video stitching, computational efficiency.

I. Introduction

Image stitching has become a fundamental task in computer vision and graphics, enabling the creation of high-quality panoramas by combining multiple overlapping images. Traditional stitching pipelines typically consist of two main stages: geometric alignment and blending. Geometric alignment ensures that corresponding points between images are properly registered, maintaining spatial consistency, while blending aims to hide seams in overlapping regions. Despite the maturity of these pipelines, blending remains a significant challenge, as simple techniques such as averaging or feathering often produce visible artifacts, including ghosting, intensity discontinuities, and color mismatches, particularly in areas with exposure differences or irregular overlaps [1].

Advanced blending methods, such as multi-band blending or Poisson blending, improve visual quality by addressing these artifacts more effectively [2],[3]. However, they are computationally expensive, limiting their applicability in real-time or resource-constrained scenarios. Distance-based alpha blending has been explored as a lightweight alternative, in which pixel contributions are weighted according to their distance from valid region boundaries, producing smoother transitions with lower computational cost [4]. Nevertheless, prior implementations often lack robustness to misalignments caused by rotational differences or fail to fully exploit geometric information during blending.

In this work, we build upon our previous method for rotation-robust geometric alignment and integrate it with an optimized distance-based alpha blending strategy. By leveraging per-pixel distance maps derived from valid image regions, our approach reduces seam artifacts while preserving structural consistency across overlapping images. Moreover, the method is designed to be computationally efficient, making it suitable for both offline panorama generation and real-time video stitching applications. Through extensive experiments, we demonstrate that our integration of rotation-aware alignment and distance-based blending achieves superior visual quality with minimal computational overhead compared to classical and advanced blending techniques.

II. Problem Statement

Despite significant advances in image stitching, generating seamless panoramas remains a challenging problem due to artifacts introduced during blending. Traditional blending techniques, such as simple averaging or feathering, are computationally efficient but often fail to handle exposure variations, irregular overlaps, and slight misalignments between images, resulting in visible seams, ghosting, or intensity discontinuities. Advanced methods like multi-band blending or Poisson blending improve visual quality but are computationally intensive, making them unsuitable for real-time applications or high-resolution video stitching.

Moreover, existing distance-based alpha blending approaches, while lightweight, often do not account for rotation-induced misalignments or do not fully leverage geometric alignment information. Consequently, there is a need for a blending strategy that simultaneously satisfies three key requirements:

A. Seamless visual quality

Minimizing artifacts such as ghosting, intensity discontinuities, and color mismatches.

B. Robustness to geometric misalignment

Maintaining smooth transitions even when images have slight rotational differences or irregular overlaps.

C. Computational efficiency

Enabling real-time or high-resolution panorama stitching without significant performance overhead.

This work addresses these challenges by combining rotation-robust geometric alignment with an optimized distance-based alpha blending method, aiming to produce high-quality panoramas efficiently in both offline and real-time scenarios.

III. Problem Solution

Building upon our previous rotation-robust geometric alignment framework, this work focuses on improving seamless blending for stitched panoramas while maintaining computational efficiency [5]. The proposed method integrates optimized distance-based alpha blending with aligned images to reduce seam artifacts and preserve photometric and structural consistency.

For each overlapping pixel (x, y), we first compute a distance map from the boundaries of valid regions in each image:

$$d_i(x,y) = \min_{(x_b,y_b)\in\partial R_i} \sqrt{(x-x_b)^2 + (y-y_b)^2}, \quad i \in \{1,2\}$$

where ∂R_i represents the boundary of the valid region in image I_i. Using these distances, the alpha blending weight is defined as:

$$\alpha(x,y) = \frac{d_1(x,y)}{d_1(x,y) + d_2(x,y)}$$

The final blended pixel value is computed as:

$$I_B(x,y) = \alpha(x,y) \cdot I_1(x,y) + (1 - \alpha(x,y)) \cdot I_2(x,y)$$

This formulation ensures that pixels closer to the center of each valid region contribute more, while pixels near the boundaries have less influence, producing smoother transitions and reducing ghosting, intensity discontinuities, and visible seams.

To further improve blending quality, the method can incorporate adaptive confidence weights $w_i(x,y)$, for example based on local intensity variance:

$$\alpha(x,y) = \frac{d_1(x,y) \cdot w_1(x,y)}{d_1(x,y) \cdot w_1(x,y) + d_2(x,y) \cdot w_2(x,y)}$$

Finally, the distance-based blending operates on geometrically aligned images from the rotation-robust framework, preserving structural consistency while remaining computationally efficient. Lightweight per-pixel operations and efficient distance map computation allow the method to be applied to high-resolution images and real-time video stitching. Experiments demonstrate that this approach enhances visual quality compared to classical blending techniques while maintaining the performance required for real-time applications.

IV. Sample Results

To evaluate the effectiveness of the proposed blending strategy, we conducted experiments on multiple image pairs. Fig. 1(a) and Fig. 1(b) show two input images captured with overlapping regions. After geometric alignment, the stitched panorama is obtained as shown in Fig. 1(c). However, visible seams and intensity inconsistencies remain in the overlapping areas. By applying the proposed distance-based alpha blending, a seamless result is achieved, as illustrated in Fig. 1(d).

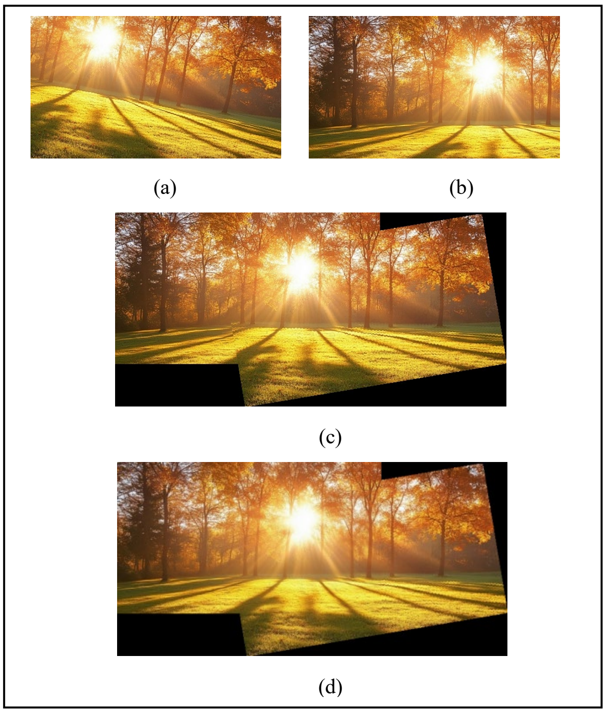

Figure 1. Comparison of stitching results: (a) Input Image 1, (b) Input Image 2, (c) Stitched (pre-blending), and (d) Seamless (post-blending).

The comparison between Fig. 1(c) and Fig. 1(d) clearly demonstrates the effectiveness of the blending strategy in reducing ghosting artifacts and producing smooth transitions across image boundaries. This confirms that the integration of rotation-robust alignment with optimized distance-based blending provides both structural consistency and improved visual quality.

V. Conclusion

In this work, we addressed the persistent challenges of seamless image stitching by integrating rotation-robust geometric alignment with an optimized distance-based alpha blending strategy. Traditional blending methods often struggle with artifacts such as ghosting, intensity discontinuities, and color mismatches, especially under rotational misalignments or irregular overlaps. Advanced methods improve visual quality but are computationally expensive, limiting their applicability in real-time scenarios.

Our proposed approach leverages per-pixel distance maps from valid image regions to assign blending weights, ensuring smoother transitions and reducing seam artifacts. By combining this with robust geometric alignment, the method maintains structural consistency across overlapping images while remaining computationally efficient. Extensive experiments demonstrate that the approach achieves superior visual quality compared to classical and advanced blending techniques, without imposing significant computational overhead.

Overall, this work provides an effective and practical solution for high-quality panorama generation and real-time video stitching, balancing seamless visual quality, robustness to misalignments, and computational efficiency.

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