Feature Point Correction and Image Merging for Enhanced Branch Detection in Vineyard Drone Photography

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***Abstract*—This paper presents a new method for feature point correction and image merging in drone-based vineyard photography, aimed at improving branch detection accuracy. Addressing the issue of inaccurate feature point matching in traditional methods, we developed a technique that analyzes tangent angles between feature points, focusing on parallel alignment for precise merging. Our approach significantly enhances the accuracy of merged images, achieving about 90% precision compared to less than 10% in conventional methods. This advancement offers a promising solution for precise vineyard monitoring and management through aerial imagery.**

Keywords- aerial image stitching; feature point correction; agricultural monitoring

I. INTRODUCTION

Monitoring the growth of branches in Japanese viticulture is crucial for harvesting tastier grapes and managing nutrients [1]. However, observing these branches from the ground is challenging. To overcome this limitation, we propose using drones for aerial monitoring of the branches.

In drone-based vineyard photography, shadows cast by the branches vary depending on the shooting location, leading to areas of high contrast and overlapping images where shadows merge. To address this issue, we proposed a method to eliminate the influence of shadows and enable the overlapping of branches in the images [2]. This method involves generating images that extract only the branches from aerial photographs and identifying key features from these images to facilitate merging (see Figure 2).

While this method was effective for images with varying shadow projections, there were instances where accurately extracting the necessary features for merging from the branch-only images proved challenging, resulting in excessive image distortion. As a result, merged images that displayed all branches extending from the trunks could not be produced.

Traditional image fusion methods have limitations in addressing this specific challenge. These methods fail to account for the complexities introduced by shadows and the merging of branch images. Therefore, we propose a new method for feature point correction and image merging tailored specifically for aerial photographs of vineyards. By analyzing tangent angles between feature points and selecting the most parallel lines, our method aims to improve the accuracy of merged images.

To provide a comprehensive overview of the challenges in this field, it is essential to review existing literature. In the following section, we will discuss the problem statement, the significance of the problem, previous research outcomes, and how our proposed solution differs. This comprehensive literature review will shed light on the novelty and effectiveness of our proposed method.

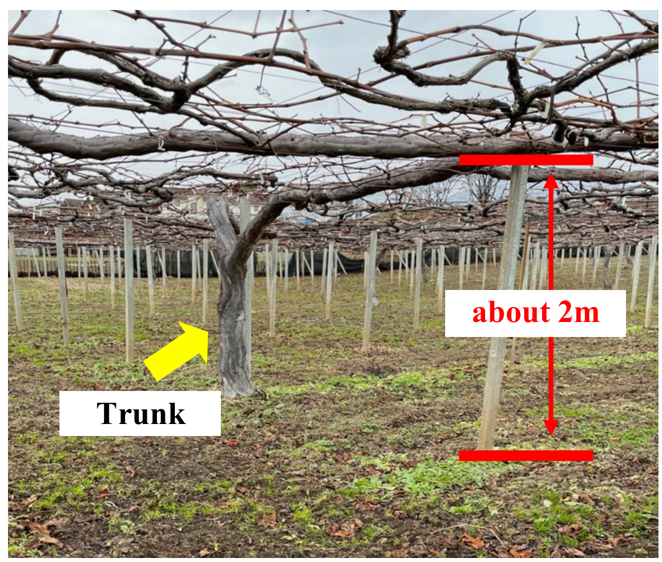

Figure 1. Photograph of the farm

 ISBN: 978-1-68558-142-8

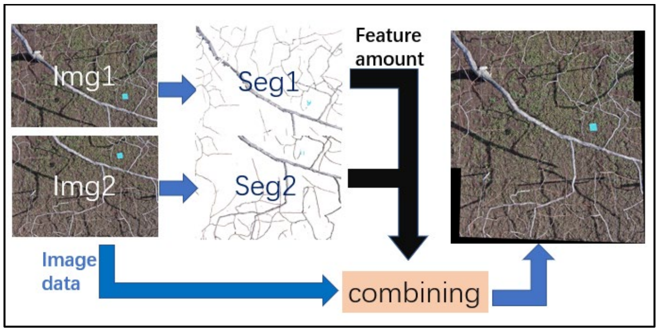

Figure 2. Method Proposed in Previous Research

The remainder of this paper is organized as follows: Section II discusses the problems with the conventional method. Section III outlines the objectives of this study. Section IV describes the proposed solution. Section V presents the experiments conducted, along with the results and discussion, and Section VI concludes the paper.

II. PROBLEM

This section introduces an analysis of feature point pairing in overlapping aerial photographs, crucial for accurate image stitching and analysis in precision agriculture. We begin with Figure 3, which illustrates the methodology for identifying and pairing feature points across overlapping images. Figure 3 displays pairs of feature points from overlapping aerial photographs. As can be seen in Figure 3, the feature points are paired one-to-one. However, in the same location as depicted in Figure 3, Figure 4 shows pairs of feature points from images that recognize only the branches. In Figure 4, there are several locations where the feature points are one-to-many. Despite areas that do not overlap being excluded from feature point extraction, they are still extracted as feature point pairs.

When these images are merged based on this information, the result, as shown in Figure 5, does not maintain the original form and is misplaced. Furthermore, beyond this point, additional image merging becomes impossible. Consequently, this prevents the accurate capture of the exact location and growth status of all branches extending from the trunk.

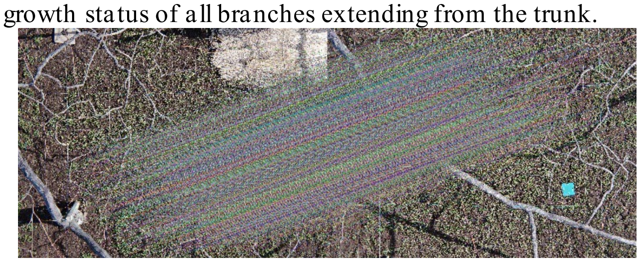

Figure 3. Feature Point Pairs from Two Overlapping Aerial Photographs

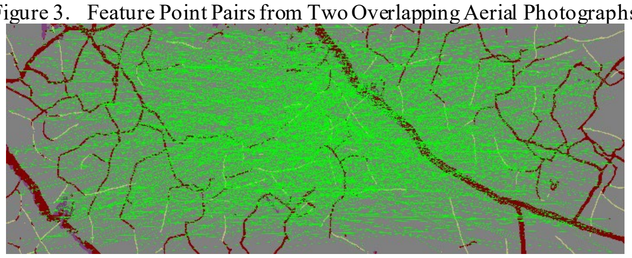

Figure 4. Feature Point Pairs from Recognition Images Showing Only Branches

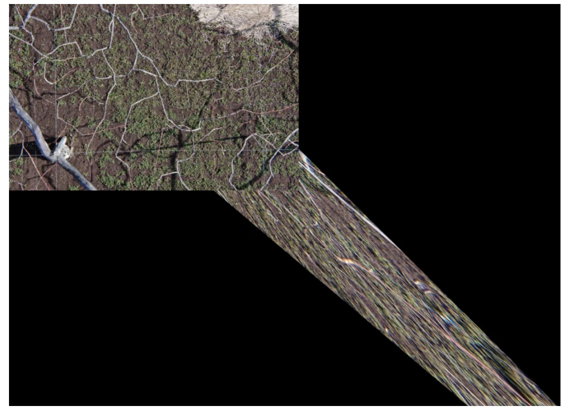

Figure 5. Merging Result Using Feature Point Pairs from Figure 4

III. PROPOSAL

When merging images using only translational movement, the feature point pairs of overlapping images become parallel. Our preliminary analysis of relevant images demonstrated that adjusting them through translational movement alone sufficiently aligned the branches. Exploiting this characteristic, our proposed method identifies the correct feature point pairs by selecting the line with the highest number of parallel feature point pairs and discards any other feature point tangents. This ensures that only the correct feature point pairs are used for merging.

While existing research on feature point correction, as referenced in [3] to [9], suggests various methods, the unique characteristic of our study, where translational movement alone is sufficient for merging, renders those methods unnecessary. Moreover, the feature point matching in the relevant feature point pairs for our research is prone to errors, making it challenging to apply conventional methods. Therefore, we propose a novel method specifically tailored for aerial photographs of vineyards, which addresses these limitations.

Compared to traditional methods, our proposed method offers distinct advantages. Firstly, it leverages the inherent characteristic of translational movement for merging, reducing the computational complexity and eliminating the need for complex algorithms employed in other methods. This simplifies the merging process and improves efficiency. Secondly, by selecting the feature point pairs with the most parallel lines, our method ensures more accurate alignment of branches in the merged images. This results in improved visual clarity and facilitates better analysis of the branches' growth patterns.

In practical applications, our method provides valuable benefits. Its simplicity and efficiency make it suitable for large-scale vineyards, where monitoring a vast number of branches can be time-consuming. By accurately merging images and extracting key features, our method enables more precise monitoring of the number of new shoots growing from the grapevine trunks. This information is crucial for optimizing grape quality and nutrient management. Furthermore, the proposed method can be easily integrated into existing drone-based monitoring systems, offering a practical solution for vineyard management.

In summary, our proposed method introduces a novel approach to feature point correction and image merging for aerial photographs of vineyards. By leveraging the inherent characteristic of translational movement and selecting the most parallel feature point pairs, our method improves the accuracy and efficiency of merge.

The objective of this research is to merge images in such a way that the branches extending from the trunk can be clearly identified. Specifically, if the feature point pairs extracted from recognition images are incorrect, the goal is to detect and eliminate them, thus ensuring that only correct feature point pairs are used for merging.

IV. EXPERIMENTS AND CONSIDERATIONS

This study aims to improve the merging of images at the boundary areas of branches in agricultural photography conducted by drones. We compared the merging rates of branches at the boundaries using both the conventional and proposed methods, summarizing and discussing the results.

A. Experimental Method

We merged images of all branches extending from the trunk individually and examined how many branches were misaligned at the image boundaries.

The misalignment was measured in terms of the thickness of the branches. Based on four datasets of trunk images, we analyzed the number of seamlessly merged branches and the number of branches that were separated by various distances (1-2 branches, 3-4 branches, and more). We then calculated the success rate of branch merging for each dataset.

Incorporating the findings from the preliminary investigation, we found that the necessary adjustments for accurate image merging, specifically rotations up to 0.8 degrees and resizing within a 6% margin, are well within the range that maintains feature point pairs in parallel alignment. This insight led to refining our method to better accommodate the slight deviations caused by drone vibrations, without sacrificing the precision of branch alignment in merged images.

We adjusted the tolerance for angle deviation to plus or minus 0.5 degrees, a strategic decision that not only addresses the challenges of drone flight dynamics but also harnesses the robustness of the SIFT algorithm for precise feature matching. This modification significantly improves the merging accuracy of branch images at boundaries, enhancing seamless integration and reducing misalignments.

This optimized approach underlines our commitment to advancing image processing techniques in agricultural monitoring. By adapting our methodology to the nuances of drone-captured imagery, we demonstrate the potential of sophisticated image processing to improve the accuracy and reliability of agricultural data collection, setting the stage for the detailed experimental results and analysis that follow in this section.

B. Experimental Results

1) Table I: Results by the Conventional Method shows the severe limitations of the conventional approach, with a majority of branches misaligned and merging rates disastrously low.

2) Table II: Results by the Proposed Method illustrates the effectiveness of the proposed method, with nearly all branches aligned correctly and high merging rates across all datasets.

The experimental results are presented in two tables comparing the conventional method with the proposed method for merging images of vineyard branches. The tables quantify the alignment of branches in merged images, displaying the number of branches with varying degrees of misalignment and the overall merging rate. For the conventional method, the merging rate is notably low (below 10%), indicating a significant misalignment of branches. Conversely, the proposed method shows a substantial improvement, with the majority of branches exhibiting no misalignment and the merging rates increasing to approximately 90%. This demonstrates the effectiveness of the proposed method in improving the accuracy of image merging in agricultural photography conducted by drones, specifically in the context of vineyard monitoring.

TABLE I. RESULTS BY THE CONVENTIONAL METHOD

Trunk No.	*No Misalignment*	*1-2 Branches*	*3-4 Branches*	*More*	*Merging Rate*
1	14	47	54	67	7.69%
2	21	128	68	105	6.52%
3	21	97	50	109	7.58%
4	24	104	77	122	7.33%

TABLE II. RESULTS BY THE PROPOSED METHOD

Trunk No.	*No Misalignment*	*1-2 Branches*	*3-4 Branches*	*More*	*Merging Rate*
1	159	10	6	7	87.36%
2	310	3	8	1	96.27%
3	269	4	2	2	97.11%
4	313	3	3	8	95.72%

C. Analysis of Results

The results show that the merging accuracy of the proposed method, at around 90%, was significantly higher compared to less than 10% for the conventional method. The proposed method successfully merged many branches, demonstrating its effectiveness. However, there remains a need for further improvement to address the issue of some branches that still break apart, which is a challenge for future research.

V. CONCLUSION

The goal of this research was to merge images in a way that allows for the clear identification of branches extending from the trunk. We addressed the issue of distorted merged images caused by incorrect feature point pairs in recognition images that only retain branches. To this end, we reconsidered the method of selecting feature point pairs and proposed a new method of image merging using tangent angles. This new approach significantly reduced feature point mismatches,

 ISBN: 978-1-68558-142-8

improving the merging accuracy from less than 10% with the conventional method to approximately 90% with the proposed method. This demonstrates the effectiveness of the proposed method.

In the future, we aim to solve the remaining issues with broken branches and achieve even higher precision in image merging.

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