Photographic Mosaic Creation: An Exploration of Color Matching, Adaptive Tiling, and Aesthetic Enhancement in Computational Photography

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***Abstract*—This project aims to explore photographic mosaic creation, an art form that merges computational photography and computer vision. The objective is to reconstruct a target image using a large collection of smaller images (tiles) that collectively form a visually coherent representation. We focus on optimizing key techniques such as color matching, adaptive tiling, and blending to enhance both visual quality and computational efficiency. Through comparative analysis, we investigate the effectiveness of different color spaces, tiling methods, and blending approaches, aiming to achieve a balance between detail preservation and processing speed. Our findings will contribute insights valuable for both computational photography and applications in digital media, visual data representation, and image retrieval systems.**

I. Motivation

Photographic mosaic creation lies at a unique intersection of technical and artistic challenges, providing a practical way to explore computational photography and computer vision challenges. This project aims to refine key techniques—such as color matching, adaptive tiling, and blending—to achieve high-quality mosaics that are both visually accurate and computationally efficient. Photographic mosaics not only appeal aesthetically but also showcase the potential of image processing methods in broader applications. For example, adaptive tiling and color similarity calculations can support advances in content-based image retrieval, efficient data compression, and dynamic digital media presentations. By comparing and optimizing these methods, this project seeks to balance visual accuracy with performance, addressing trade-offs that are critical in computer vision. The findings contribute to visual data handling and could enhance tools across fields requiring both image analysis and design, including creative media, digital art, and educational tools for computer vision concepts.

II. Planned Implementation and Major Milestones

- **Initial Design:** Review mosaic techniques, define baseline methods and advanced features. *(Status: Complete)*
- **Dataset Preprocessing:** Select and preprocess images, calculating tile color data for efficient matching. *(Status: In-Progress)*
- **Target Image Preprocessing:** Segment target image; implement basic color-matching algorithm to match tiles. *(Status: In-Progress)*
- **Tile Selection Optimization:** Implement adaptive tiling and tile diversity constraints to enhance detail and reduce redundancy. *(Status: To be Started)*
- **Advanced Methodology:** Add blending techniques (alpha and Poisson blending) to minimize seams and improve quality. *(Status: To be Started*
- **Post-Processing:** Apply brightness adjustment, sharpening, and other enhancements for final visual quality. *(Status: To be Started)*
- **Comparative Evaluation:** Evaluate comparative insights. *(Status: To be Started)*
- **Documentation:** Document findings and complete the final report. *(Status: Being Done Simultaneously)*

III. Evaluation Metrics

The evaluation will involve testing how accurately the mosaic matches the target image, focusing on visual resemblance, smooth transitions, and reduced seam visibility. Key metrics will include tile reuse frequency to ensure there's enough variety, color similarity scores for accuracy, and processing time to measure efficiency. We will also compare different blending techniques and tiling strategies to see how they impact both the final look and the computational performance. Success means creating a visually cohesive mosaic that's efficient to generate, meets aesthetic standards, and ultimately looks appealing, with feedback from users as a final check on the visual quality.

IV. Key Resources

Our project leverages a mix of resources, ensuring a good foundation for developing our idea. Below, we highlight the key resources that have significantly contributed to our progress.

A. Datasets

The cornerstone of our implementation and evaluation is the *COCO dataset* along with the *Flickr Creative Commons images* , both of which are open source. These datasets should enable us to fine-tune and test our implementations under a variety of scenarios reflecting real-world scenarios.

B. Code Bases and Computing Platforms

Our development process integrates a combination of custom-coded elements and adaptations from existing code bases. We plan to draw inspiration and technical insights from various GitHub repositories, which have informed the structure of our streamlined code base. This approach will allow us to focus on method initialization, ensuring compatibility and efficiency across different methods with minimal adjustments required.

We majorly plan on utilizing sources like Google Colab, UIUC GPU Clusters (if needed).

C. Software and Libraries

The plan is to mainly use Python and its various libraries. The primary ones would be OpenCV for image processing, NumPy for data handling, and SciPy for computational tasks.

D. Hardware

Access to a machine with sufficient CPU/GPU capacity for processing large datasets and implementing advanced blending techniques. (Colab Pro, NCSA UIUC Servers)

E. Documentation Tools

Tools like Jupyter Notebook or Google Colab for development and LaTeX for detailed report preparation.

V. Team Background

- **Amaan Aijaz Sheikh**: Pursuing Masters in CS at UIUC, has over 3 years experience in the field of AI, ML. Most notable works include works/publications on "Stock Market Analysis and Prediction using Machine Learning, Graph Neural Network and NER-Based Text Summarization as well as several industry based internships at companies like Qualcomm and Deloitte.
- **Imaad Zaffar Khan**: CS graduate student at UIUC with a background in Data Science, AI, ML, and with experience as a data engineer and internships in AI and Data Analytics. Currently also serving as a Research Assistant at UIUC.

VI. Team Contributions

The team has planned to complete the work with equal contribution from both the individuals.

- **Data Pre-Processing:** This part of the project is being implemented in coalition by the us, ensuring both of us had the opportunity to understand the various aspects of the data which would be a key foundation for setting up the code bases and potentially come up with a mechanism to streamline the solution.
- **Code Base setup:** The idea became is to set up a code base, in which the only difference would be that of initialization of various methods. This would included several hours of research on Github and various online resources. Decisions were made in agreement with each other while the code base will be set up by **Amaan**, and testing of the flexibility of the same will be done by **Imaad**.
- **Method Initialization and Evaluation:** With the way the codebase is set up, we plan on dividing the project implementation onto ipynb files in such a way that both the participants have an equal opportunity to implement every aspect. We plan to alternate tasks, so roles in color matching, adaptive tiling, and blending techniques are rotated, ensuring that both participants gain hands-on experience with each method. For tile selection and post-processing, we'll use an iterative trial-and-error approach to refine the mosaic quality, with the best-performing techniques used in the final submission.
- **Report Writing:** The report is being worked on in parallel wherein we plan to simultaneously write the various sections once we are done with the task. The plan here is for both the individuals to write a few lines on their own based on understanding, which before the final submission can be refined.

References

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