Mosaicing of 2D microscopic Images, De-noising using DWT and 3D Reconstruction

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***Abstract*—Image stitching is a technique used to form a high-resolution image of a specimen. This allows for more detail to be captured and displayed. Microscopic images of a specimen provide accurate details of the surface. Stitching those images together to form an extremely high-resolution image which enables enhanced visualization of large-scale specimens. For analysing the surface, it is important to extract useful data in the original form so transformations are required for this. Here, we have used Discrete Wavelet Transform (DWT) for denoising the image.**

I. Introduction

Microscopic images are high resolution images of a specific area. Obtaining these kinds of images to stitch them together to form an extremely high-resolution image enables enhanced visualization of large-scale specimens. To improve quality and reduce noise of the image wavelet based denoising technique is utilised. The 2-Dimension image is converted in 3-Dimension to analyse the artifacts present in the particular part. This (part is to be discussed)

II. Literature Review

A. Towards Robust Monocular Depth Estimation: Mixing datasets for Zero-shot Cross-dataset Transfer [1]
This paper describes a approach at improving the robustness and generalization of molecular depth estimation modules.
Model trained by this approach need diverse data set. Depth estimation requires data set across different environments.
The research introduces tools and techniques that enable the mixing of multiple datasets during training, even when their annotations are not directly compatible. This allows researchers to leverage diverse data sources to improve model performance.
The approach advocates for the use of multi-objective learning, which involves training the model to optimize multiple objectives simultaneously. This allows for a principled combination of data from different sources.

B. ZoeDepth: Zero-shot Transfer by Combining Relative and Metric Depth [2]
The paper describes the framework for monocular depth estimation. It is combination of two techniques:
a. Relative depth prediction
b. Metric depth estimation
The model's training process involves initial pre-training on diverse datasets, enhancing its familiarity with various scenes. Fine-tuning on specific datasets is then performed, potentially employing multiple heads to specialize in different environments, such as indoor or outdoor scenes. This adaptability contributes to improved learning outcomes.
ZoeDepth outperforms prior methods by over 20 percent in indoor depth estimation, thanks to its refined metric bins module. Additionally, the model excels in generalization, achieving up to a 25 percent improvement on new datasets, showcasing its ability to adapt to diverse indoor and outdoor scenarios.

C. New SOTA Depth Estimation Model with a Monocular Camera [3]
The first model is from Google DeepMind. It is still under development, but it shows good accuracy on both indoor and outdoor scenes.
The second model is based on a diffusion-based model and is trained with stable diffusion for generating monocular depth maps. It is available for download and can be run in Google Colab notebook, Haguan faceBas, or locally.
The monocular depth estimation models can estimate the depth using single image. The new Google deepmind model and stable diffusion based model are more accurate than the previous version. These models does not fit for this project. The models work very accurate with images of macro objects, but fail to predict accurate depth for microscopic images.

III. Methodology

Hardware: The setup consists a high resolution 2.4MP (Mega Pixel) camera for capturing images. It is equipped with a fixed focus cylindrical lens having zoom from 2.5x to 10x and a diffused ring light source. The lens's zoom dial is coupled to a stepper motor, to change the zoom. This setup is connected to a stepper motor to move the camera in z axis, which adjusts the object distance for focusing. This is mounted on the base plate of the structure. The base plate is a heavy plate used as anti-vibration mechanism to absorb any vibration from the environment. The specimen to be analysed is placed on a tray, connected to a linearly actuated stepper motor which moves the tray in X direction. This mechanism is connected to a linearly actuated stepper motor which moves the tray in Y direction. Using the proprietary software precise movement of the tray and camera is controlled.

BARC Software: In the software we have to set zoom level, start point of scan, area of the scan, step-size (how much the camera shall move to capture next photo) and path of folder to store images. The software then provides with microscopic images of the specimen. Using a single image as reference a calibration sheet is prepared, which consists of zoom level and pixel per mm value.

Stitcher: To stitch the images a stitcher algorithm by OpenCV is applied. It is a computer vision module within the OpenCV library designed for creating panoramic images by stitching together multiple overlapping images. It offers a high-level interface that simplifies the complex image stitching process, which can be broken down into these key stages:

1. Feature detection and matching

• OpenCV Stitcher employs feature detectors like SIFT (Scale-Invariant Feature Transform) or SURF (Speeded Up Robust Features) to identify keypoints (distinct image regions) within each input image.

2. Homography estimation

• OpenCV Stitcher utilizes techniques like RANSAC (Random Sample Consensus) to estimate the homography matrix.

3. Image warping and blending

• Based on the estimated homography matrices, each input image is warped (transformed) to align with a reference image (typically the central image in the panorama).

• OpenCV Stitcher employs blending techniques to seamlessly stitch the warped images together. This process often involves feathering or averaging the overlapping regions between images to create a natural-looking panorama.

3D modelling: The 2D reconstructed image is converted to a 3D file by using a model ZoeDepth. There it uses MiDaS in the backgroud to first convert the 2D image in heat depthmap. Then using

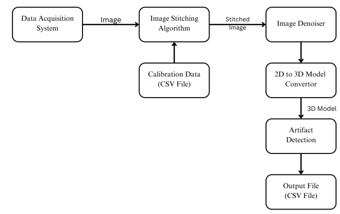

Fig. 1. Block diagram of working of system

IV. Result

By stitching the images we got fig. 2

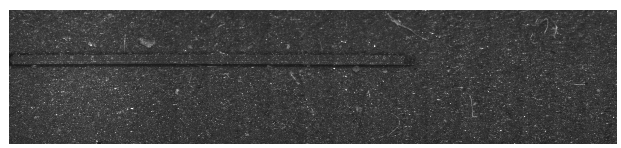

Fig. 2. Stitched image

By denoising the image we obtained fig. 3

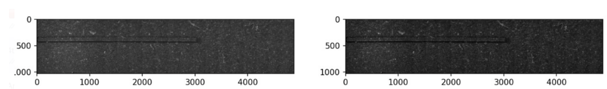

Fig. 3. Symlet output, left is input image and right is reconstructed image

3D construction oof model with depth estimation is showed in fig. 4

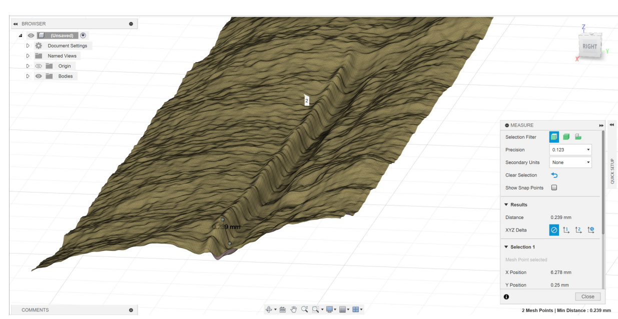

Fig. 4. Accurate 3D model (estimated depth is 0.239mm)

V. Conclusion

The open stitcher by OpenCV is state of the art image stitcher which accurately stitches without introducing any abnormality in image. It overlaps the common part efficiently without need of high computation.

This study conducted a comparative analysis of different 3D model generation algorithms. ZoeDepth produced precise structure from 2D image.
Denoising is performed using Symlet 12 wavelet. At level 1, Horizontal, vertical, and diagonal noise removal using thresholding. At level 2, DWT is applied to vertical edges and they are eliminated using thresholding the high frequency. The image is reconstructed. It has PSNR in a range of 50-60, indicating a high level of fidelity in the denoised output.

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REFERENCES

[1] R. Ranftl, K. Lasinger, D. Hafner, K. Schindler and V. Koltun, "Towards Robust Monocular Depth Estimation: Mixing Datasets for Zero-Shot Cross-Dataset Transfer" in IEEE Transactions on Pattern Analysis Machine Intelligence, vol. 44, no. 03, pp. 1623-1637, 2022.

[2] S. F. Bhat, R. Birkl, D. Wofk, P. Wonka, and M. Müller, "ZoeDepth: Zero-shot Transfer by Combining Relative and Metric Depth," in 2023 IEEE Conference on Computer Vision and Pattern Recognition (CVPR), 2023

[3] "New SOTA Depth Estimation Model with a Monocular Camera" YouTube, Nicolai Nielsen 18th January 2024, https://www.youtube.com/watch?v=Xjs4RQpViO4