Dense 3D Reconstruction Using Semi-Global Matching (Classical and Deep Learning-Based Approaches)

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1 Project Description

The goal of this project is to implement dense 3D reconstruction from stereo images by generating disparity maps using both classical and deep learning-based Semi-Global Matching (SGM) techniques. The project will focus on:

- Implementing the Semi-Global Block Matching (SGBM) algorithm for dense reconstruction.

- Utilizing a deep learning-based framework for disparity map generation, addressing some limitations of traditional SGBM.

- Investigating how to further improve the deep learning-based method by incorporating various consistency losses during network retraining to produce more accurate disparity maps.

2 Key Objectives

- **Stereo Image Rectification:** Compute rectification matrices for stereo image pairs to align epipolar lines and simplify pixel correspondence search.

- **Classical Semi-Global Block Matching (SGBM):** Implement SGBM for disparity map generation and dense 3D reconstruction.

- **Deep Learning-Based SGM:** Use a deep learning framework for disparity map generation and compare its performance with classical SGBM.

- **Improvement Using Consistency Losses:** Retrain the deep learning-based framework using various consistency losses to enhance the accuracy of disparity maps.

- **Evaluation and Comparison:** Evaluate the results from classical and deep learning-based methods using standard datasets, comparing accuracy and computational performance.

3 Project Timeline

Weeks 1 & 2:

- **Objective:** Implement stereo image rectification and research Semi-Global Matching (SGM) methods (classical and deep learning-based).

- **Activities:**

  - Compute rectification matrices for stereo image pairs to align epipolar lines.
  - Study the SGBM algorithm and deep learning-based SGM-Net approach.
  - Review related papers and gather background knowledge.

Weeks 3 & 4:

- **Objective:** Implement the classical Semi-Global Block Matching (SGBM) algorithm and generate disparity maps.

- **Activities:**

  - Implement SGBM for disparity map generation.
  - Start generating dense 3D reconstructions from the disparity maps.
  - Test the implementation on sample stereo datasets.

Weeks 5 & 6:

- **Objective:** Implement the deep learning-based SGM approach, improve it with consistency losses, and evaluate both methods.

- **Activities:**

  - Set up and train the deep learning-based SGM-Net for disparity map generation.
  - Experiment with consistency losses (e.g., left-right consistency, smoothness) to retrain the network and improve disparity maps.
  - Compare the results from both classical and deep learning approaches regarding accuracy and efficiency.
  - Finalize the project report and prepare the presentation.