An Automated Approach To Evaluate A Stereo Camera's Ability To Generate Point Clouds

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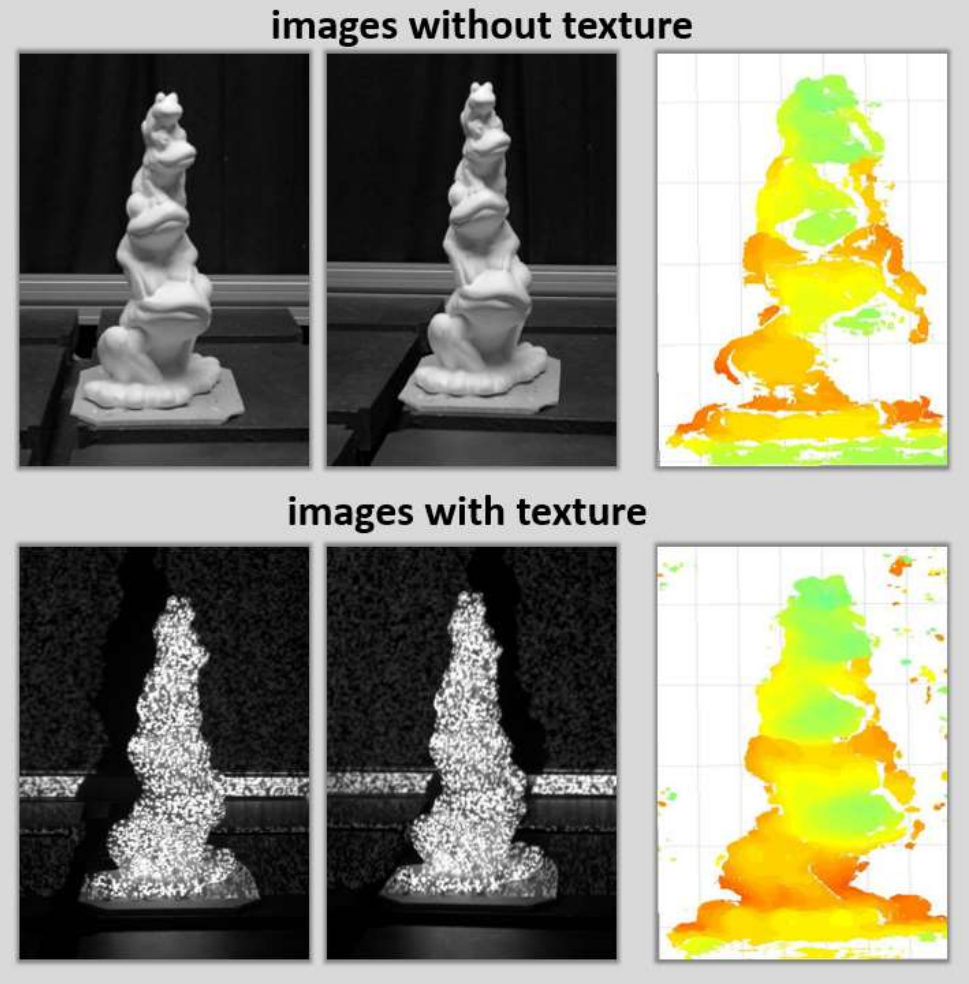
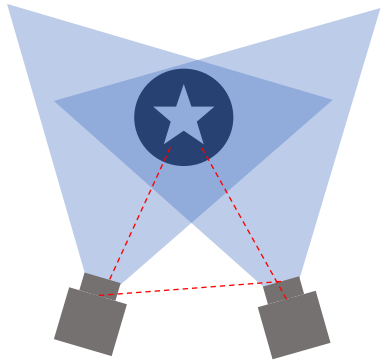
AACHEN, 2022

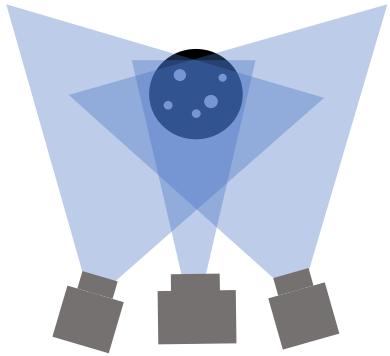
What are Stereo Cameras?

Active Cameras Vs Passive Cameras





Passive



Active

Consider:

- Lighting conditions
- Texture of target
- Distance to target

Then why consider passive stereo cameras:

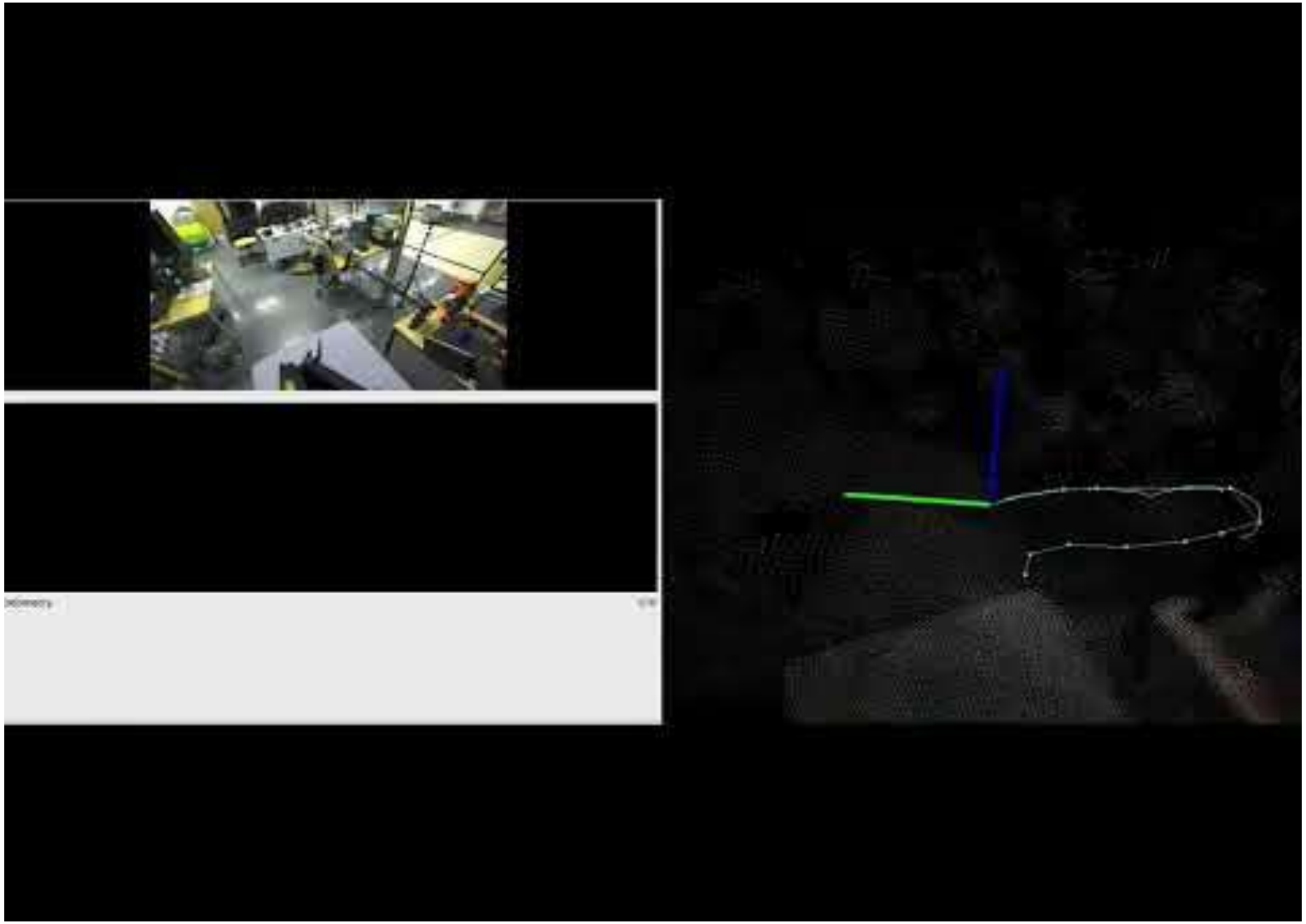
As the view is not limited by a projected light:

1. Can perform well both indoors and outdoors.

2. Multiple passive cameras can be used together.

Benefits of the Zed 2 Stereo Cameras

- Affordable
- API included
- Multiple sensors integrated
- Machine Learning applicable
- Small & Compact
- **Create Point Clouds**



Challenges for using passive stereo cameras

Issue 1. **Find the best stereo camera settings.**

Issue 2. **No point cloud accuracy benchmark.**

Issue 1: Finding the best stereo camera settings.

- Comparing available settings is a **combinatorial optimization problem**.
- Too many variables to consider:
  - Depth Mode
  - Saturation
  - Resolution
  - Confidence
  - Texture Confidence
  - Sharpness
  - Contrast
  - …

89,238,348 tests

We need to consider these issues to find the best point cloud

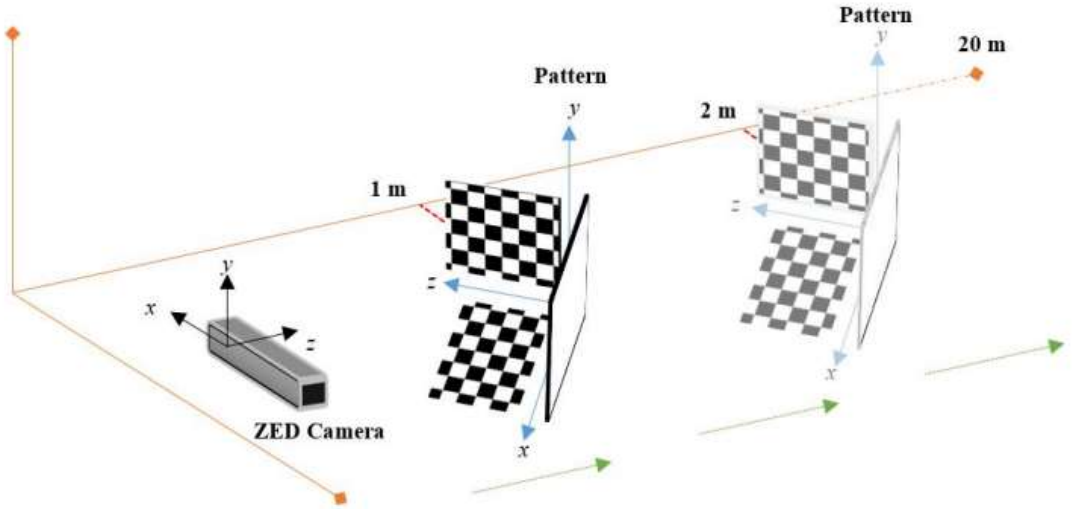
Issue 1. **Find the best stereo camera settings.**

Solution: Zed API and Genetic Algorithm

Issue 2. **No point cloud accuracy benchmark.**

Issue 2: No Standard Benchmark for depth estimation

Systematic Target-Based

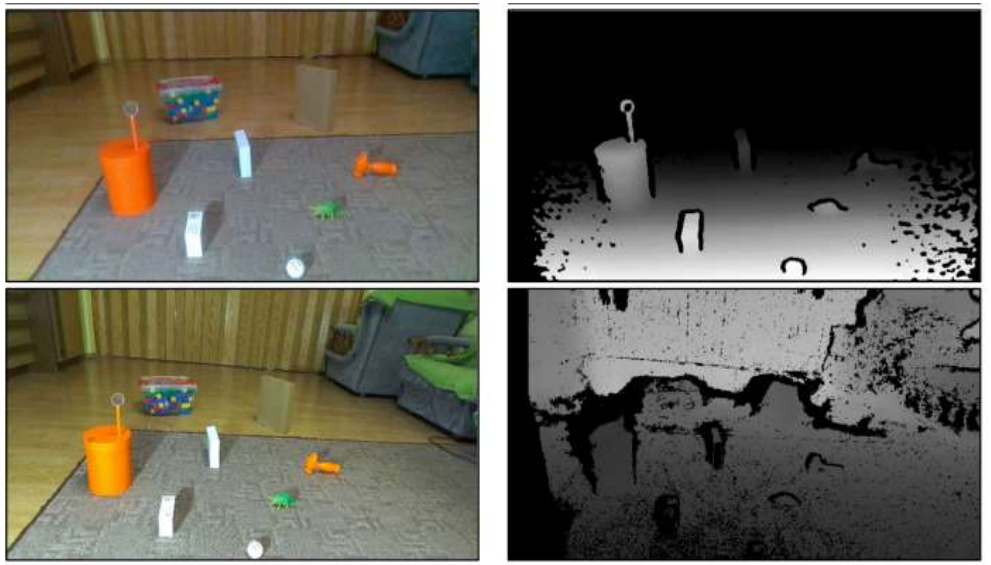


Ortiz, Luis Enrique, Elizabeth V. Cabrera, and Luiz M. Gonçalves. "Depth data error modeling of the ZED 3D vision sensor from stereolabs." *ELCVIA: electronic letters on computer vision and image analysis* 17.1 (2018)

Comparative Evaluations

ZED

ZED2



Tadic, Vladimir, et al. "Perspectives of RealSense and ZED Depth Sensors for Robotic Vision Applications." *Machines* 10.3 (2022): 183.

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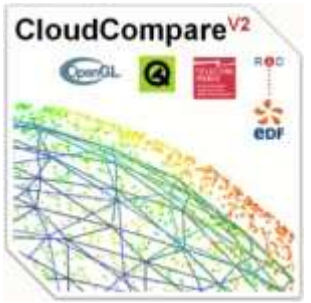
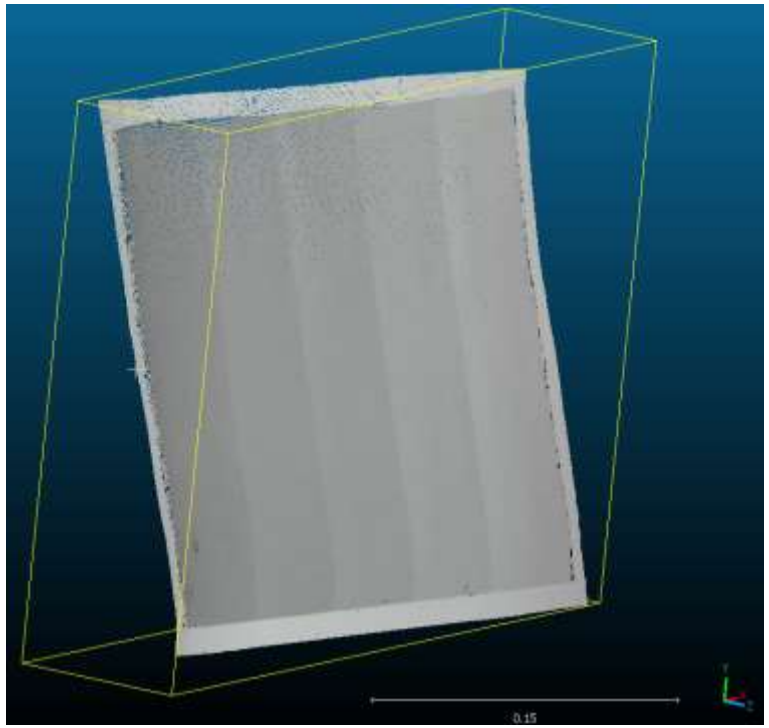
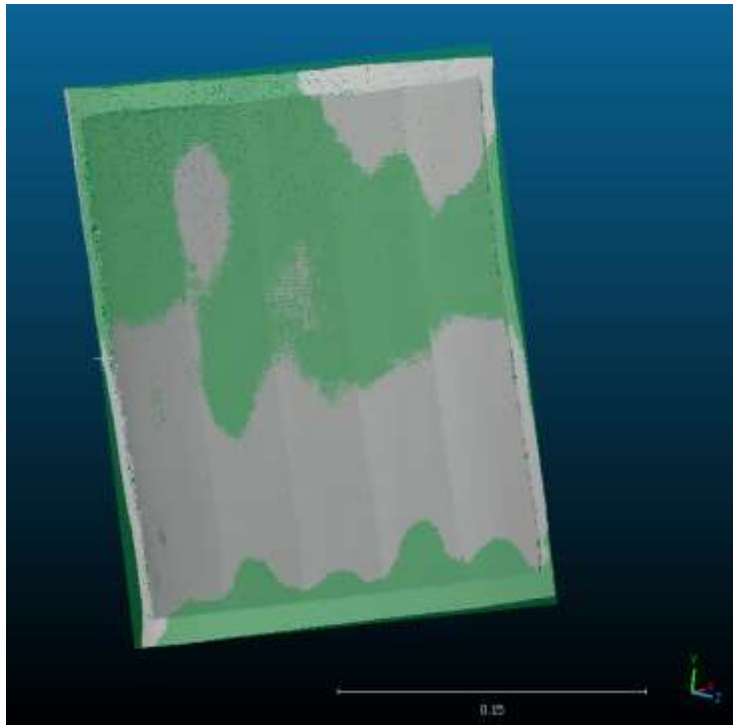
Solution 2: Flatness as a benchmark for accuracy.



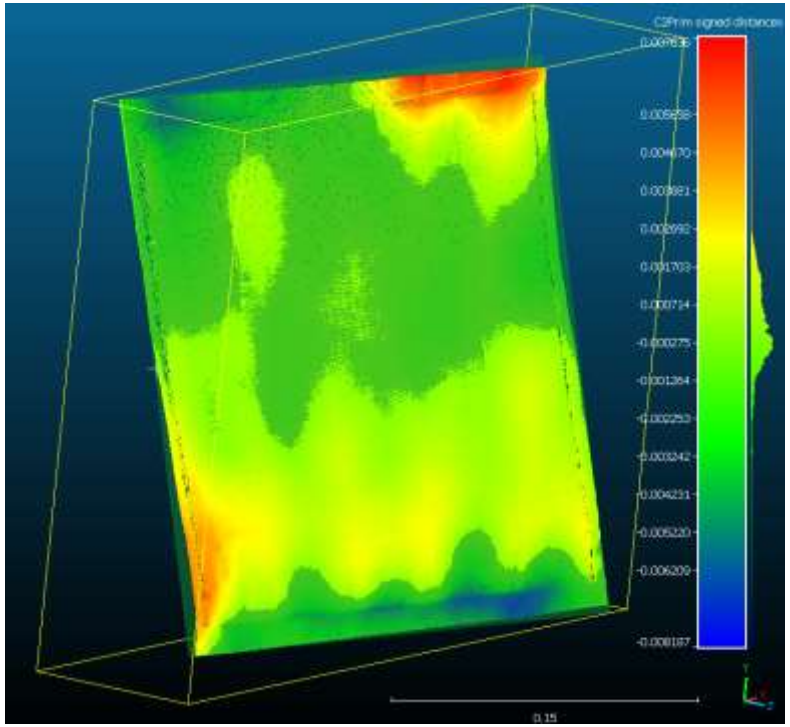
1. Take point cloud



2. Calculate best-fit-plane



3. Analysis



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We need to consider these issues to find the best point cloud

Issue 1. **Find the best stereo camera settings.**

Solution: Zed API and Genetic Algorithm.

Issue 2. **No point cloud accuracy benchmark.**

Solution: Measure flatness as a benchmark.

Proposed Approach:

STEP 1: Set up environment with iPad.

Clouds

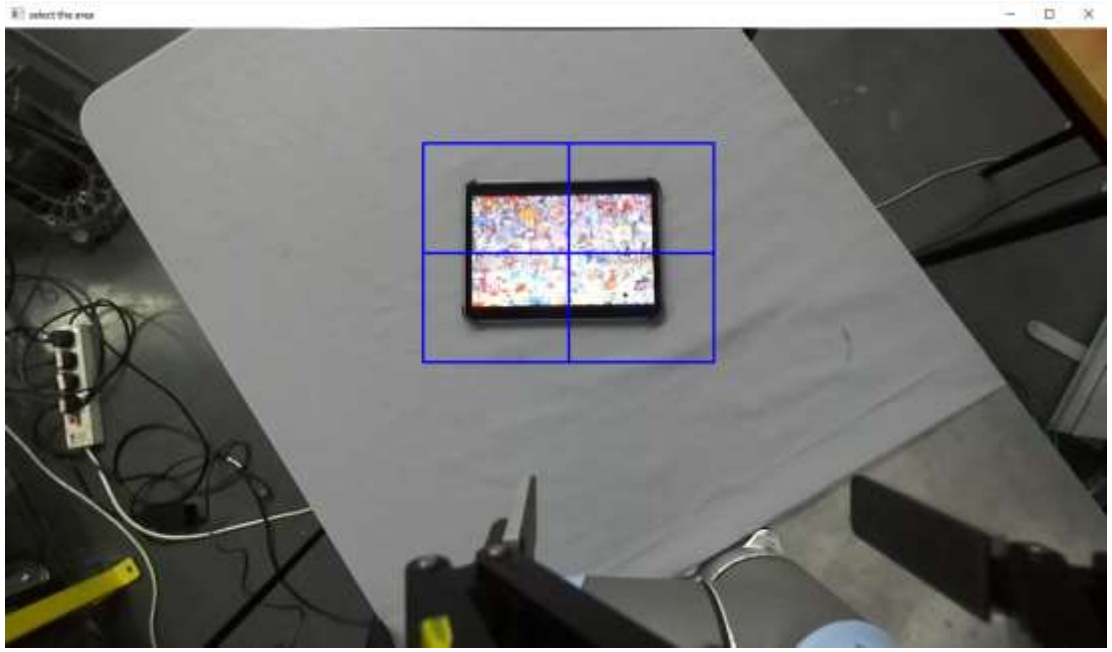
Comic

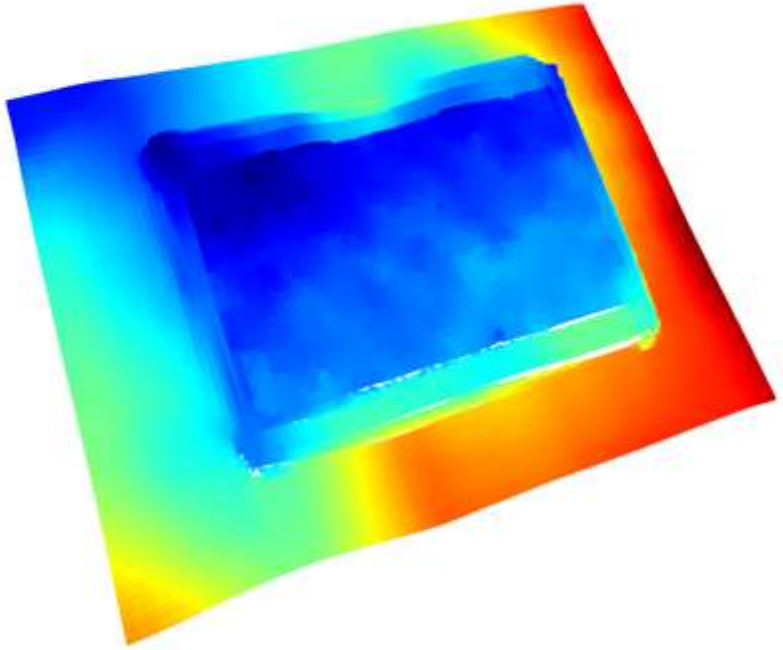
Waldo

Increasing order of texture

Proposed Approach:

STEP 2: Segment region of interest





Proposed Approach:

STEP 3: Apply genetic algorithm

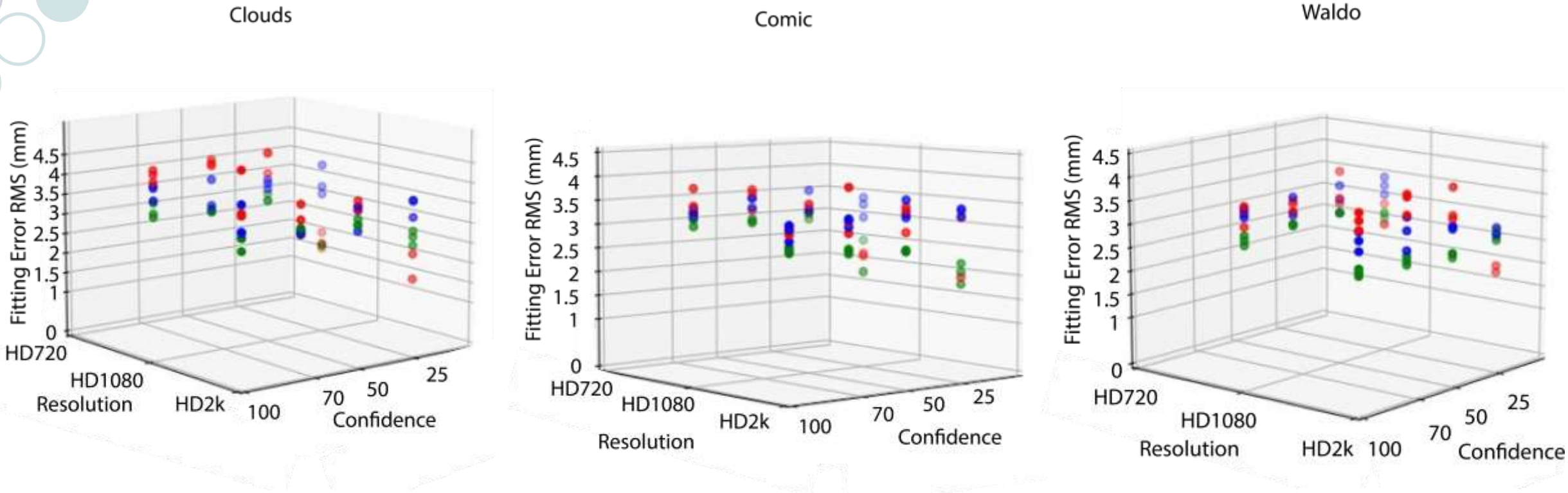
Objective Function:

The Fitting RMS between the best fit plane and segmented region.

Stereo Camera Parameters used:

Depth Mode	{Performance, Quality, Ultra}
Camera Resolution	{HD720, HD1080, HD2K}
Confidence Threshold	{25-100}

Brute force method used as ground truth for GA:



Depth Mode:

Red = Performance

Green = Quality

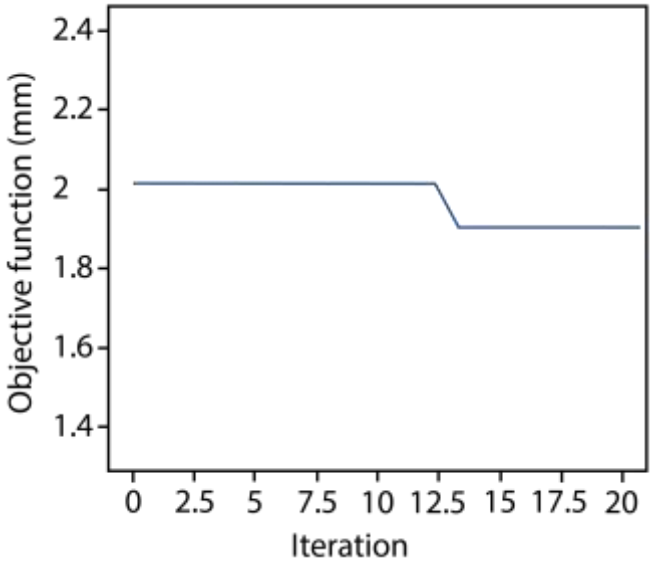
Blue = Ultra

Findings in the data:

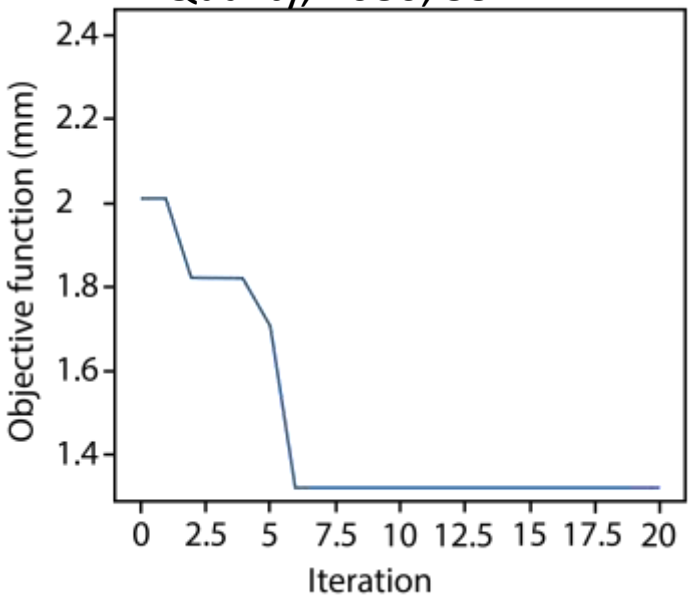
- Lower the confidence, the better the fit but the quality of point cloud is poor.
- Cannot calculate fitting error with HD720 and lower resolutions.
- Zed 2 Camera can measure at the millimetre scale.

Genetic Algorithm Results

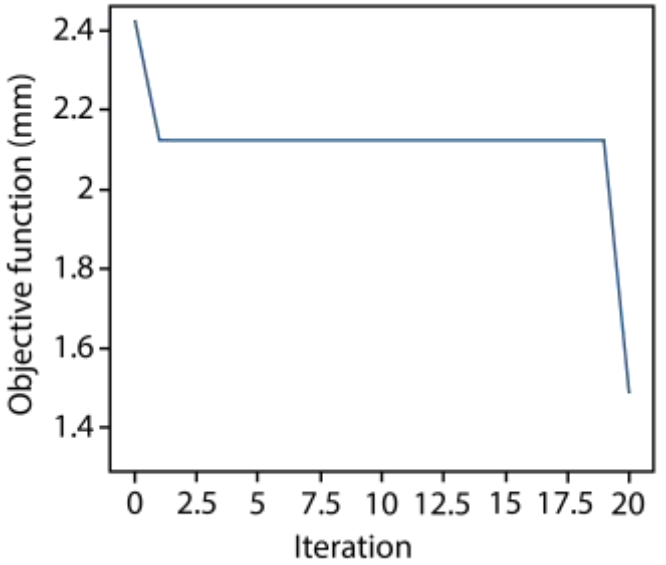
Performance, 2k, 27



Quality, 1080, 55



Ultra, 1080, 74



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Conclusion

- Developed a flexible approach for evaluating stereo cameras:
  - Enable different textures and distances.

- The approach improves the speed for camera optimization using a genetic algorithm.

Next steps

1. Add more parameters as genetic algorithm matches brute force approach.

2. Consider different objective functions.

Thank you!

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