Uncertainty Propagation in a 3D Stereo-matching Pipeline

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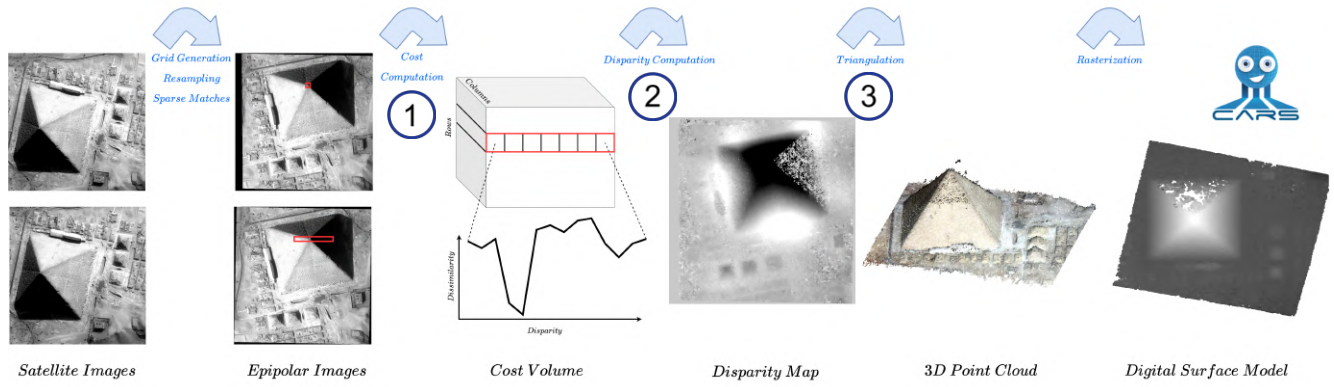
Context

- CO3D mission: provide regularly 3D maps of the Earth
- CARS is CNES's 3D pipeline: computes digital surface models (DSM) from stereo satellite image
- Users need confidence/uncertainty information on the DSM

Imprecise Probabilities

- Classical probability models cannot correctly model epistemic uncertainty
- Imprecise probabilities (IP) are made for representing evidence/lack of knowledge
- IP represent convex sets of acceptable probability distributions
- **Objective: use IP to model and propagate uncertainty in the CARS pipeline**

The CARS pipeline



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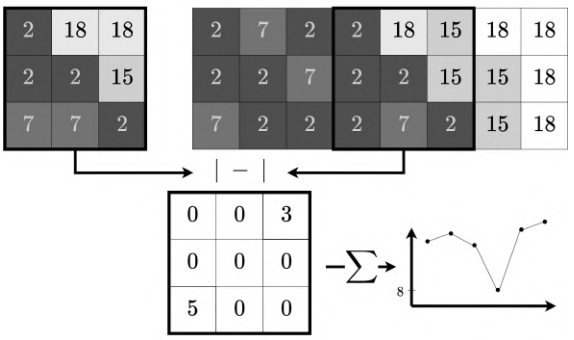
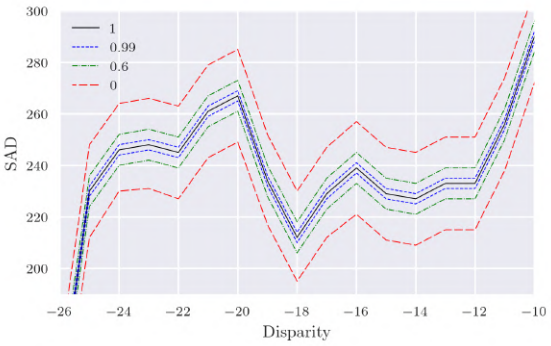


- Uncertainty on the epipolar images is modeled using Imprecise Probabilities
- Use of dependence models, *copulas*, to aggregate and propagate the uncertainty from the images into the uncertainty of the cost volume
- Contributions on how to use copulas with imprecise probabilities
- Monte-Carlo simulations prove the efficiency of this method
- Can we find new strategies for choosing the correct disparity?



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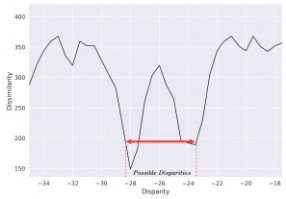
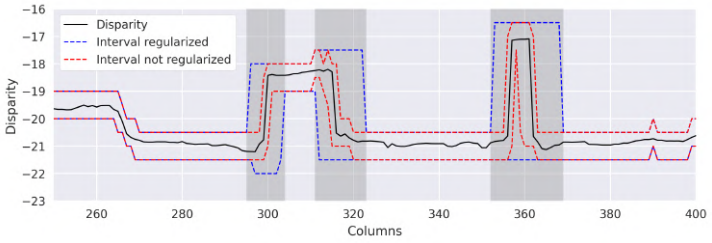
- By interpreting the cost volume as evidence, we can compute intervals of possible disparities
- Novel approach for quantifying uncertainty in stereo-matching algorithms
- Need to regularize disparity intervals near discontinuities





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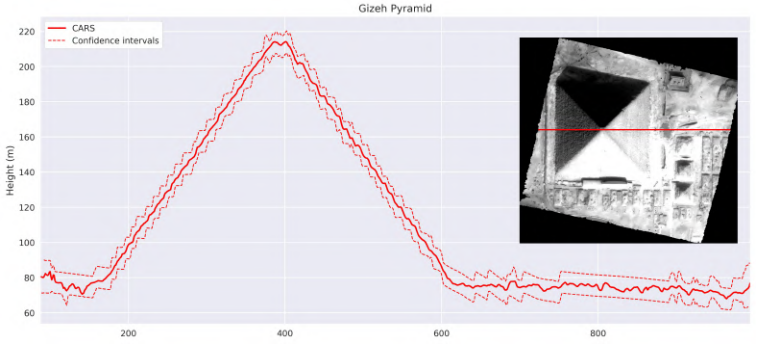
- Intervals bounds are triangulated: we obtain upper and lower 3D point clouds
- Different strategies can be applied for rasterizing the upper/lower point clouds
- Evaluation with LiDAR ground truth: 95% intervals are correct



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