

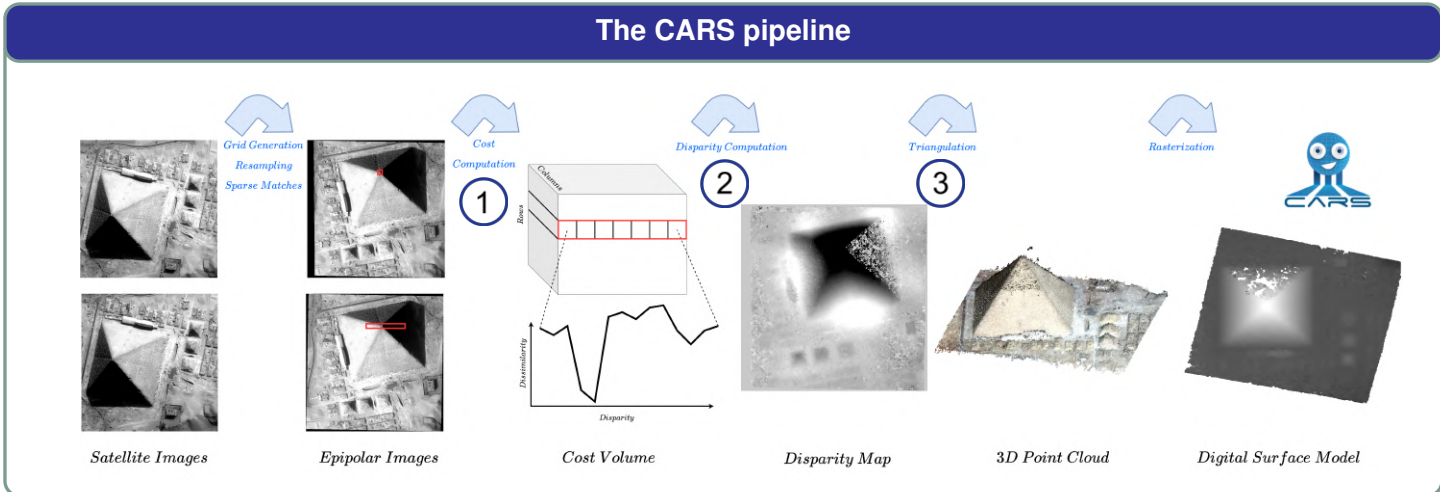
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### Context

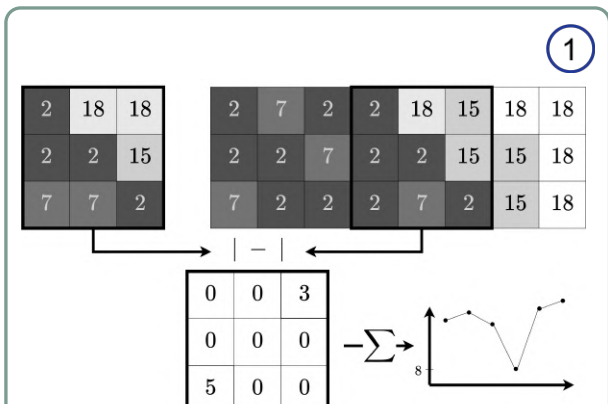
- CO3D mission: provide regularly 3D maps of the Earth
- CARS is CNES's 3D pipeline: computes digital surface models (DSM) from stereo satellite image
- Users need confidence/uncertainty information on the DSM

### 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**

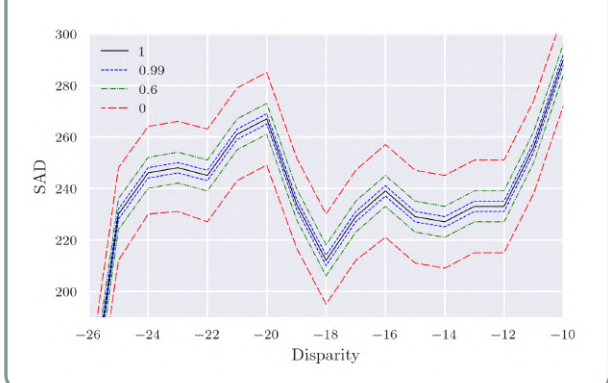


### 1



The diagram shows the process of computing a cost volume. Two 3x3 grids of cost values are compared against a 3x3 grid of weights. The resulting disparity graph shows a sharp peak at a specific disparity value.

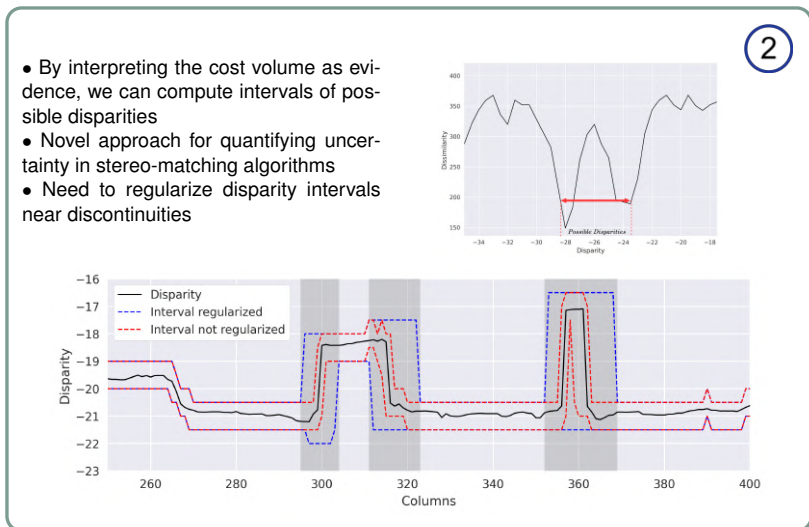
- Uncertainty on the epipolar images is modeled using Imprecise Probabilities
- Use of dependence models, *copulas*, to aggregate and propagate the uncertainty from the images into the uncertainty of the cost volume
- Contributions on how to use copulas with imprecise probabilities
- Monte-Carlo simulations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



The graph shows the Sum of Absolute Differences (SAD) versus Disparity. It illustrates the confidence intervals for different probability levels (1, 0.99, 0.6, 0).

### 2

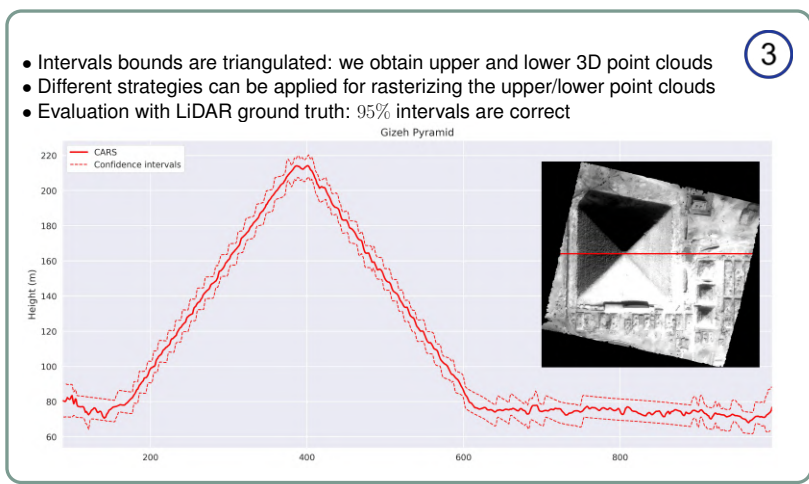
- By interpreting the cost volume as evidence, we can compute intervals of possible disparities
- Novel approach for quantifying uncertainty in stereo-matching algorithms
- Need to regularize disparity intervals near discontinuities



The graph shows Disparity versus Columns. It compares the results of a regularized interval (dashed blue line) and a non-regularized interval (dashed red line). The regularized interval is smoother and more accurate.

### 3

- 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



The graph shows Height (m) versus Disparity for the Gizeh Pyramid. It compares the results of CARS (solid red line) and Confidence Intervals (dashed red line). The CARS result is more accurate and matches the LiDAR ground truth.

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