Edge-Aware Monocular Dense Depth Estimation with Morphology

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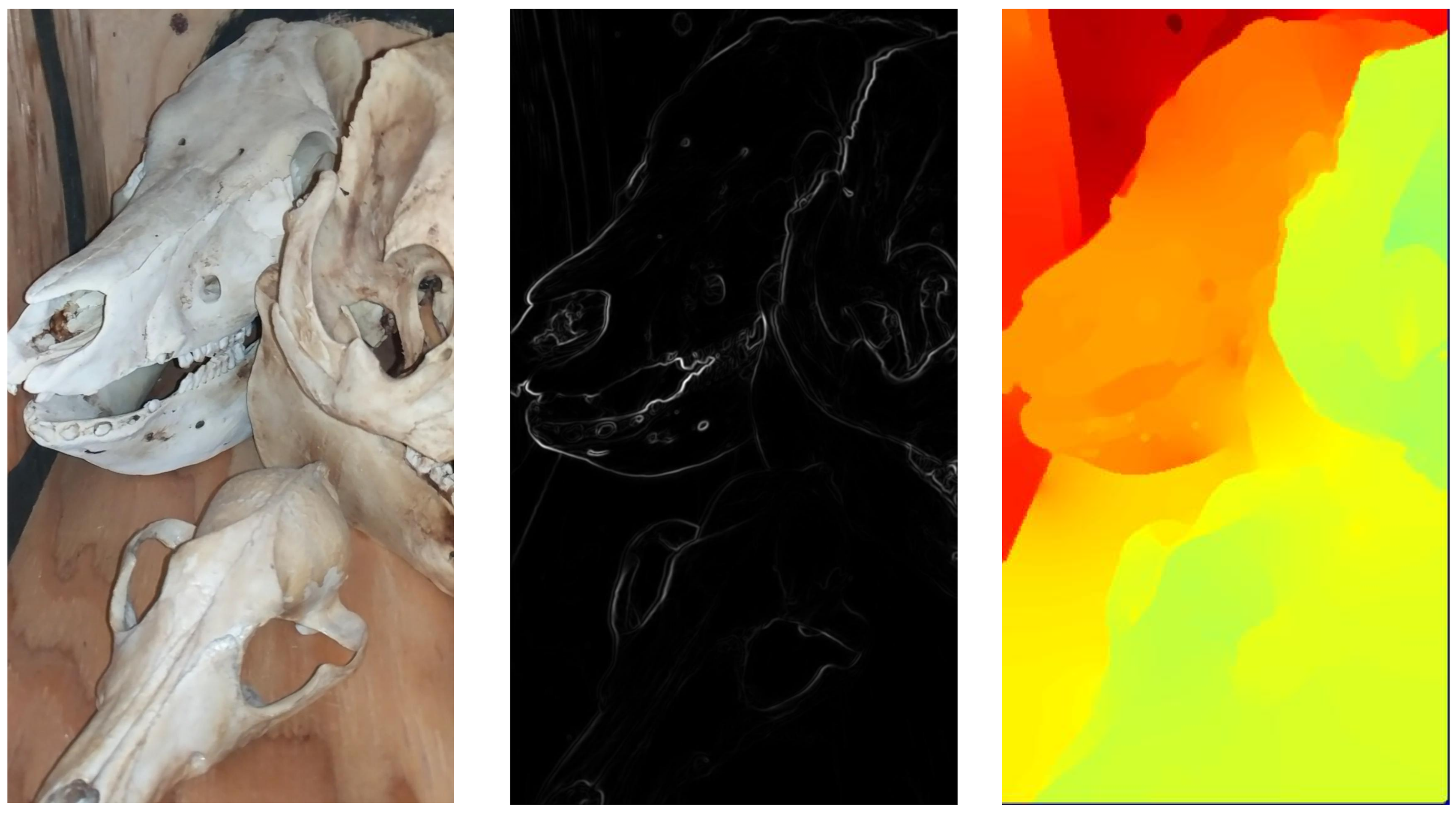
Introduction

Dense depth maps play an important role in Computer Vision and AR (Augmented Reality). We present a novel algorithm that produces low latency, spatio-temporally smooth dense depth maps using only a CPU. The depth maps exhibit sharp discontinuities at depth edges in low computational complexity ways.

Our algorithm runs at near realtime only by using a desktop computer with CPU. The produced dense depth maps can be seen in Figure 1.



a: Input image b: Morphological edge c: Depth map

Fig 1. The edges and the detph map proposed in our work.

METHOD

Pipeline

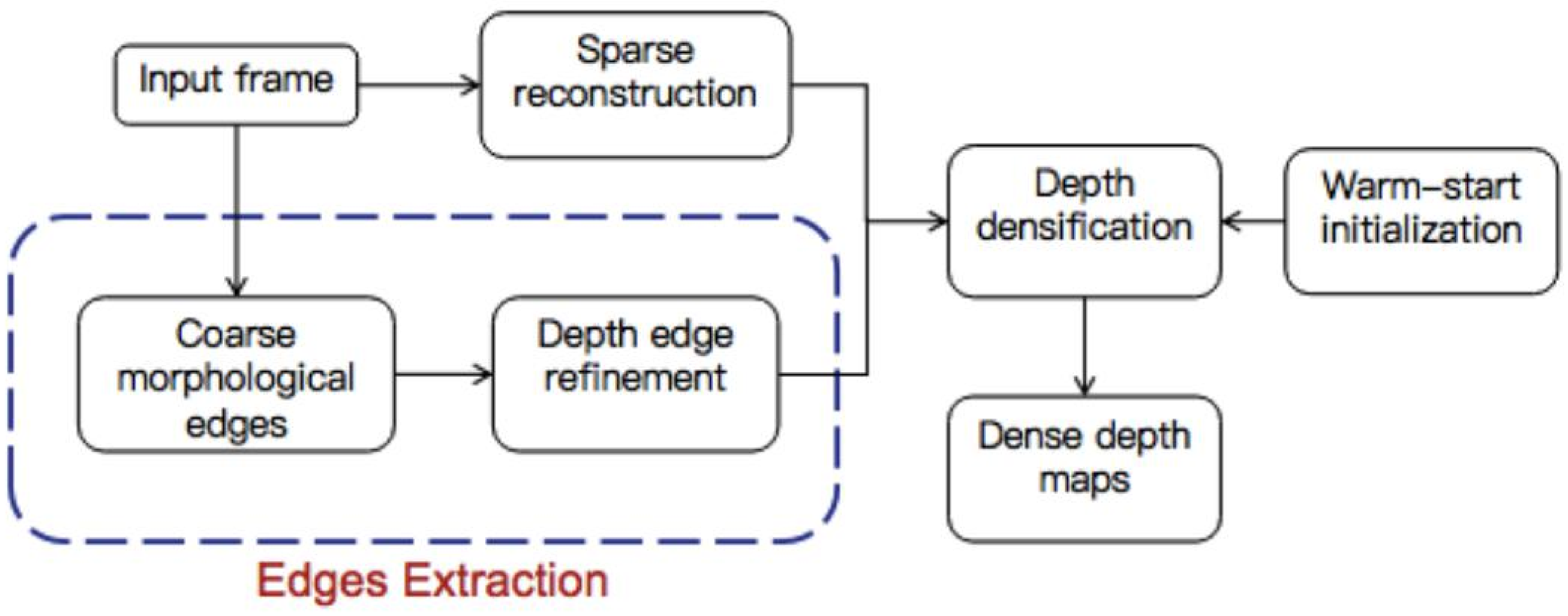


Fig 2. Our whole algorithm's pipeline

- Get the sparse reconstruction from DSO-SLAM system.
- Extract coarse depth edges by morphology operations.
- Depth edges refinement by improved Canny edge detector.
- Construct an improved optimization solver to propagate the sparse depth values and achieve depth densification.

Depth edges

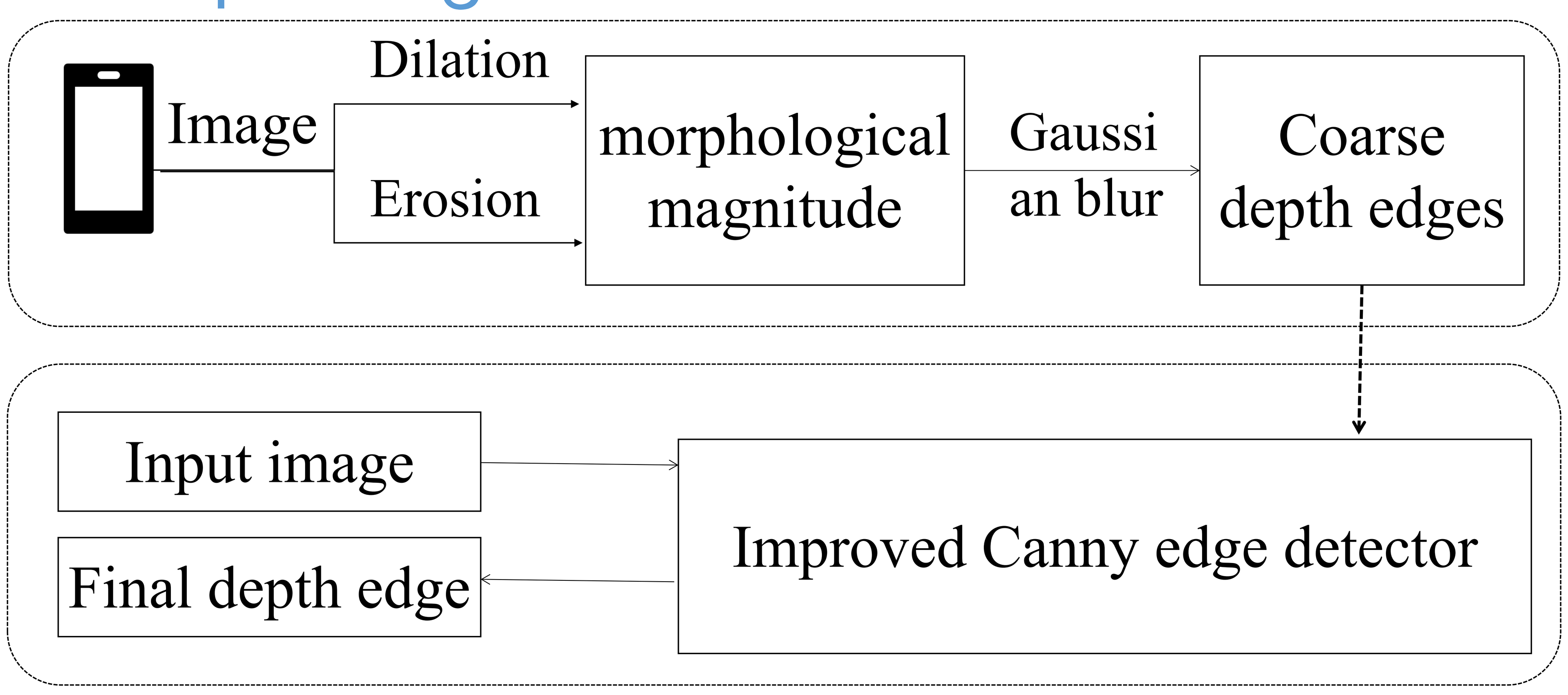


Fig 3. Implementation Process about depth edges extraction

Densification

We propose a novel optimization problem to propagate the sparse depth values. The depth densification includes three aspects:

- Align with the depth of the sparse depth.
- Sharp depth edges.
- Temporal coherence.

To accelerate the iteration, we use an effective initialization and speed up the solver by virtue of hierarchical iteration. Also, we set up different numbers of iterations divided by keyframes. Finally, a bilateral filter is used to smooth the possibly remaining texture depth edges

Results

Qualitative Comparison

We compare our method with the state-of- the-art algorithm provided by Facebook and the baselines.

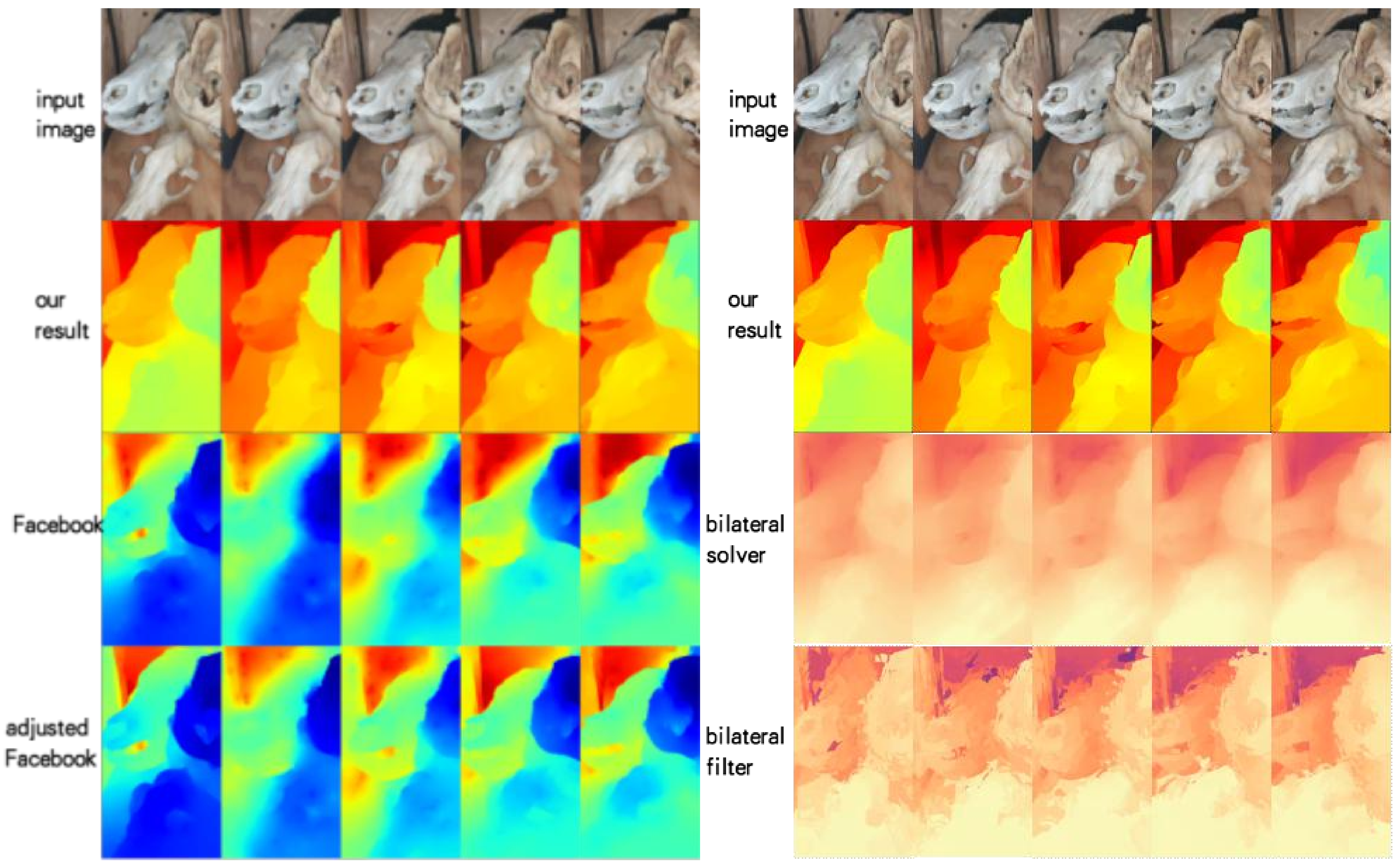


Fig 4. Evaluate with state-of-the-art method and two baseline algorithms. We offer five dense depth maps from different frames in the bones dataset.

Quantitative Comparisons

Two Evaluation Metrics:

- Sharp depth edges.

Dense depth maps need to produce a sharp depth distribution across the depth edges.

- Smooth texture edges.

The texture areas should maintain smoothness without large depth differences.

Algorithm	Edge Error	Texture Error
Petschnigg et al	/	4.12
Barron et al	/	5.10
Holynski et al	0.95	2.52
Ours	0.34	2.13

Table 1. Quantitative depth evaluation using two evaluation metrics