# 3D Modeling on the Go: Interactive 3D Reconstruction of Large-Scale Scenes on Mobile Devices

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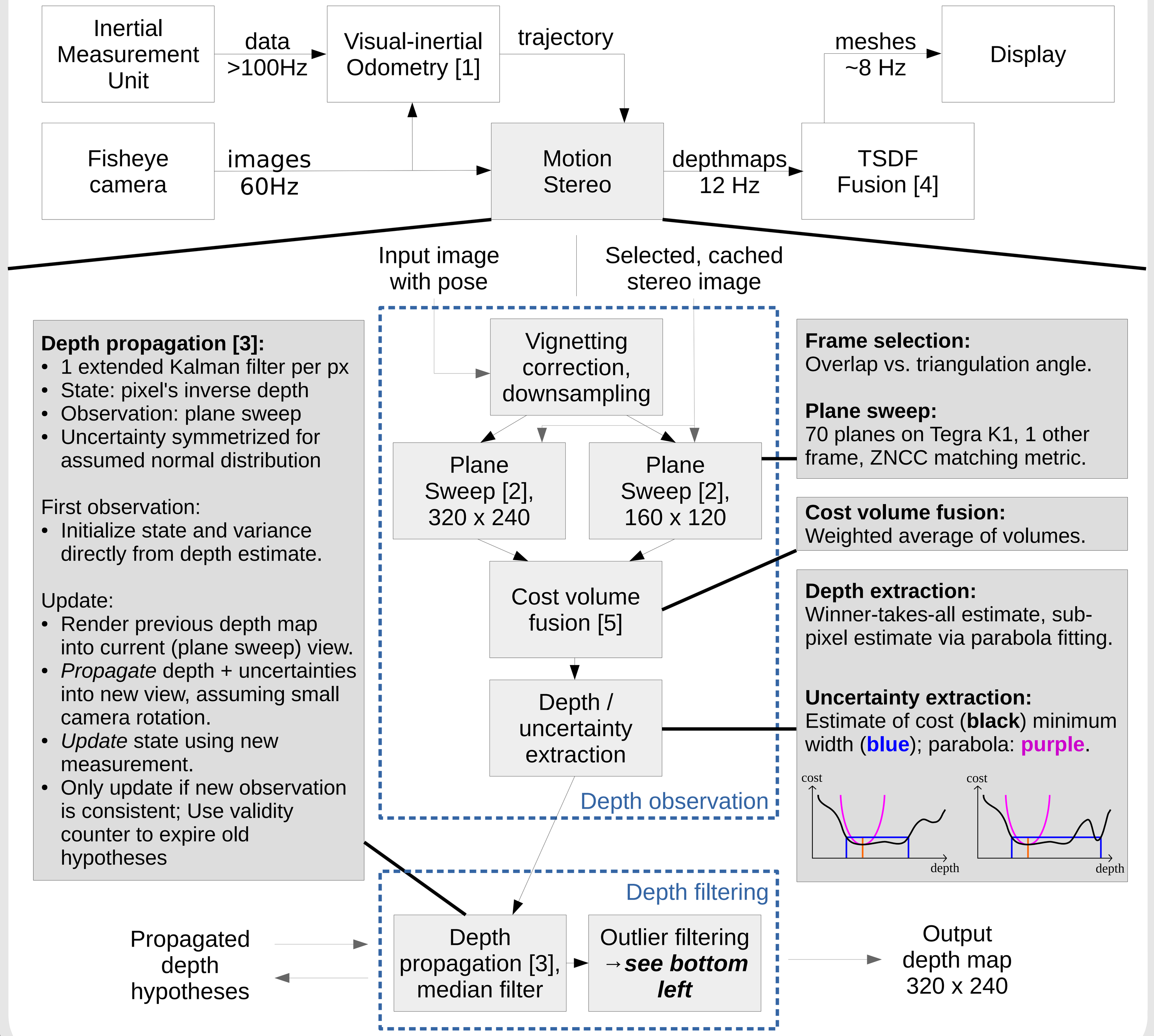
## Goals & key insights

- **Large-scale dense 3D reconstruction in real-time on mobile devices (Google Project Tango tablets)**
  - Suitable for AR applications
  - Good quality preview for offline reconstruction
- **Input: Monocular camera, IMU**
  - Unlimited reconstruction range
  - Can operate in sunlight

**Key insights:**

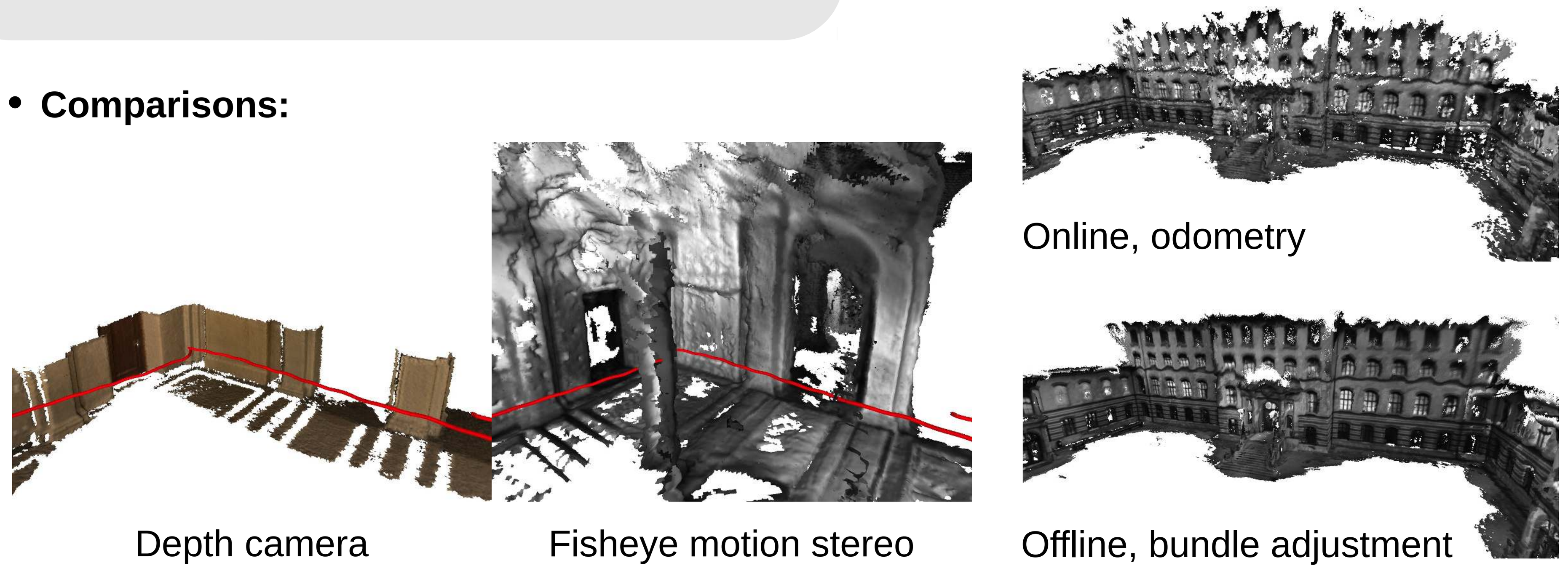
- Motion stereo based, large scale, dense 3D reconstruction is feasible on mobile devices with interactive frame rates.
  → ***See our processing pipeline and results achieved in real-time.***
- In contrast to object reconstruction, large-scale reconstruction with passive sensing needs strong filtering.
- Aggressive filtering is preferable to complete but noisy depth maps for interactive systems.
  → ***See our filtering pipeline.***

## Processing pipeline

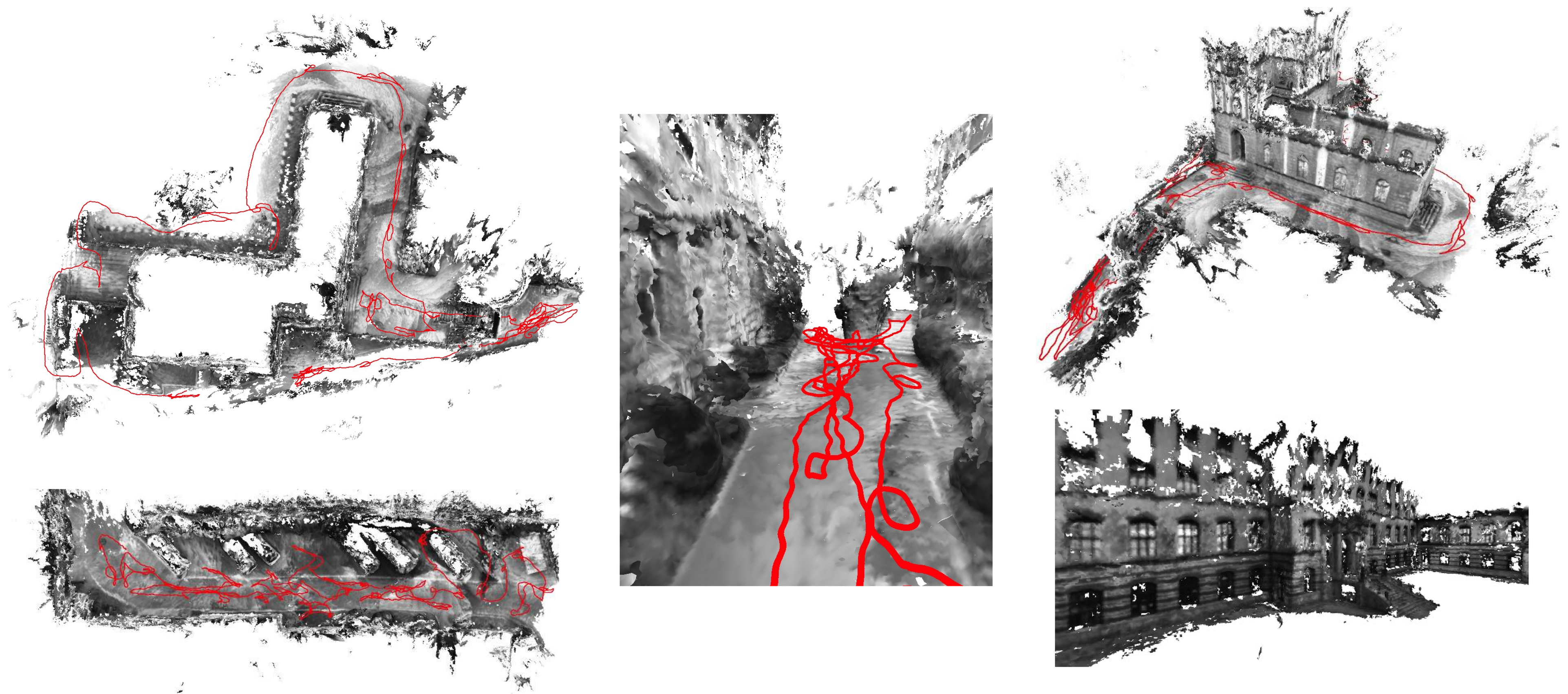



## Results

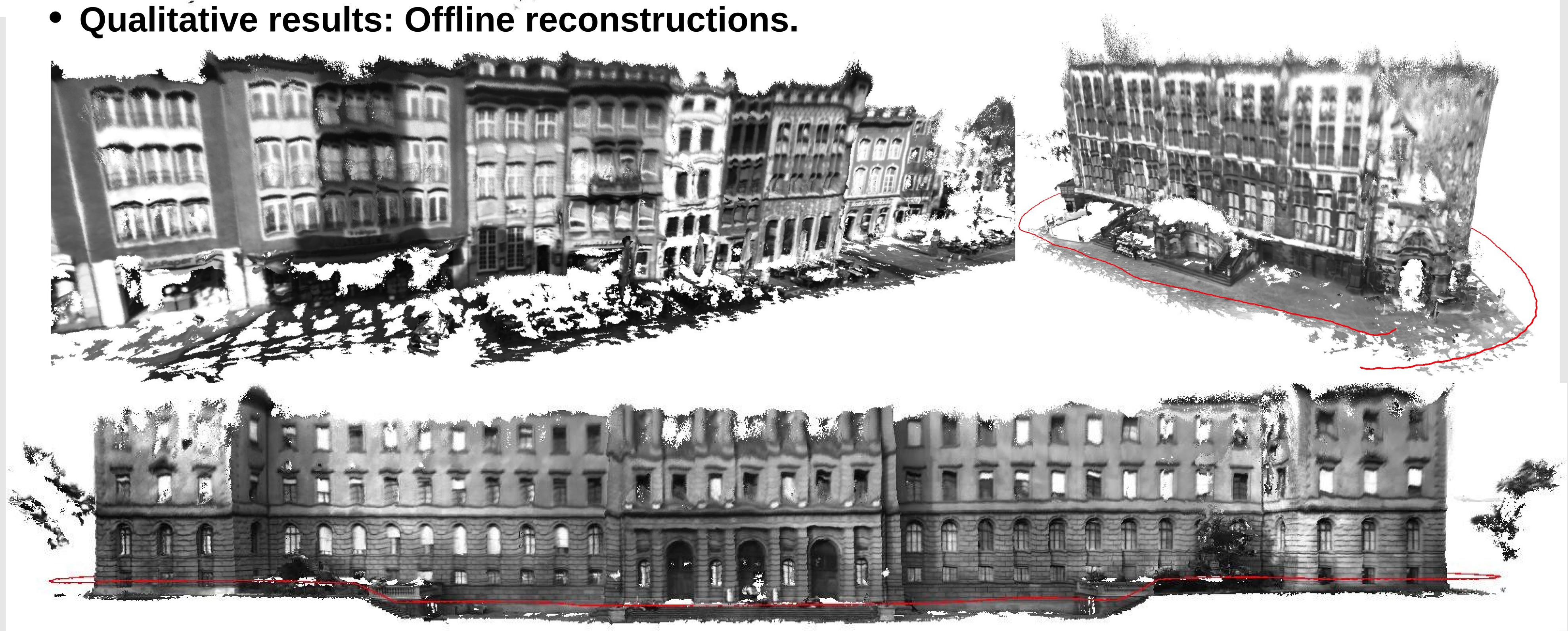
- **Comparisons:**




- **Qualitative results: Real-time reconstructions.**



- **Qualitative results: Offline reconstructions.**



- **Quantitative results: see our paper.**

## Filtering steps

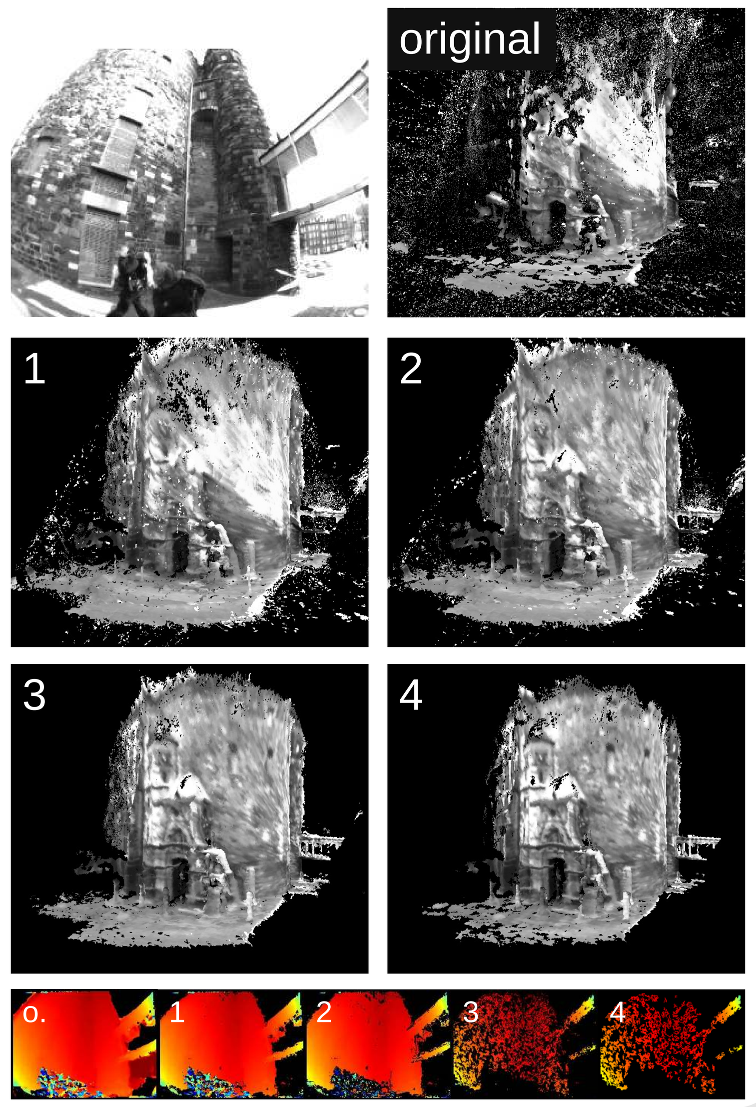
**Improving accuracy: Kalman filtering [3]**
Per-pixel ext. Kalman filters for inverse depth. Integrate only points that are stable.

**Spatial regularization: 3x3 median filtering**
Suppress outlier noise, smooth the depth map.

**Outlier suppression**

1. Variance thresholding:
   Discard pixels with high estimated variance.
2. Angle thresholding:
   Discard surfaces with slanted angles.
3. Consistency over time:
   Current depth map is compared to (warped) previous one 0.25 seconds ago.
   Keep consistent estimates only.
4. Connected component analysis:
   Discard small connected components.

**Outlier suppression visualization**




## Timings

**Tango Tablet**
- Nvidia Tegra K1 (quad core) chipset
- 70 planes, 7.5cm voxel resolution

**Desktop PC**
- Nvidia GeForce 780 GTX, Intel Core i7-4770K
- 200 planes, 4cm voxel resolution

| | PC | Tango Tablet |
|---|---|---|
| **Addition of a reference frame** | $1.5 \pm 0.2$ | $6.2 \pm 3.3$ |
| Vignetting correction | $1.0 \pm 0.1$ | $1.2 \pm 0.7$ |
| Downsampling, transfer to GPU | $0.5 \pm 0.2$ | $4.9 \pm 3.0$ |
| **Depth estimation** | $8.1 \pm 0.9$ | $83.0 \pm 7.6$ |
| Plane sweep ($320 \times 240$) | $3.9 \pm 0.6$ | $35.2 \pm 2.1$ |
| Plane sweep ($160 \times 120$) | $1.3 \pm 0.2$ | $13.4 \pm 2.6$ |
| Multires. fusion, depth extraction | $1.6 \pm 0.4$ | $15.2 \pm 2.6$ |
| Depth propagation | $1.3 \pm 1.7$ | $10.3 \pm 5.8$ |
| Filtering, transfer to CPU | $1.3 \pm 0.4$ | $13.5 \pm 5.9$ |
| **TSDF integration, remeshing** (CPU) | $30.2 \pm 23.7$ | $122.1 \pm 74.6$ |

Timings in milliseconds. Components run in parallel.
→ **Depth maps estimated with 12 FPS on Tango tablet.**

## References

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