Depth map fusion in the presence of vibrations

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Outline

1. Objectives
2. State-of-the-art (KinectFusion)
3. Limitations of KinectFusion
4. Current State
5. Results
6. Discussion
7. Future work

1. Objectives

Fuse multiple depth-maps for:

- increased resolution
- denoising
- populating missing data

1. Objectives

[1]

Depth estimation algorithms from:

- Structured Light
- ToF (Time Of Flight)

→ Point Clouds

2. State-of-the-art - Examples

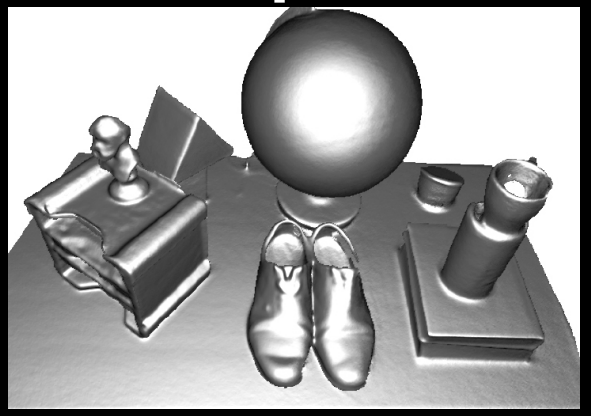
raw output normals Phong shaded

KinectFusion

Newcombe R., et al., 2011 [2]

2. State-of-the-art - Examples

raw output normals Phong shaded



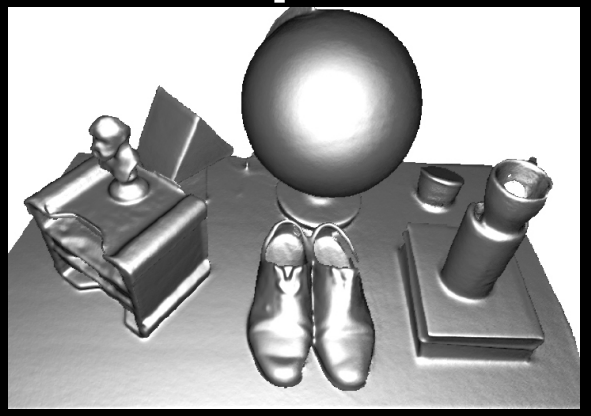
multiple circular passes

KinectFusion

Newcombe R., et al., 2011 [2]

2. State-of-the-art - Examples

raw output normals Phong shaded



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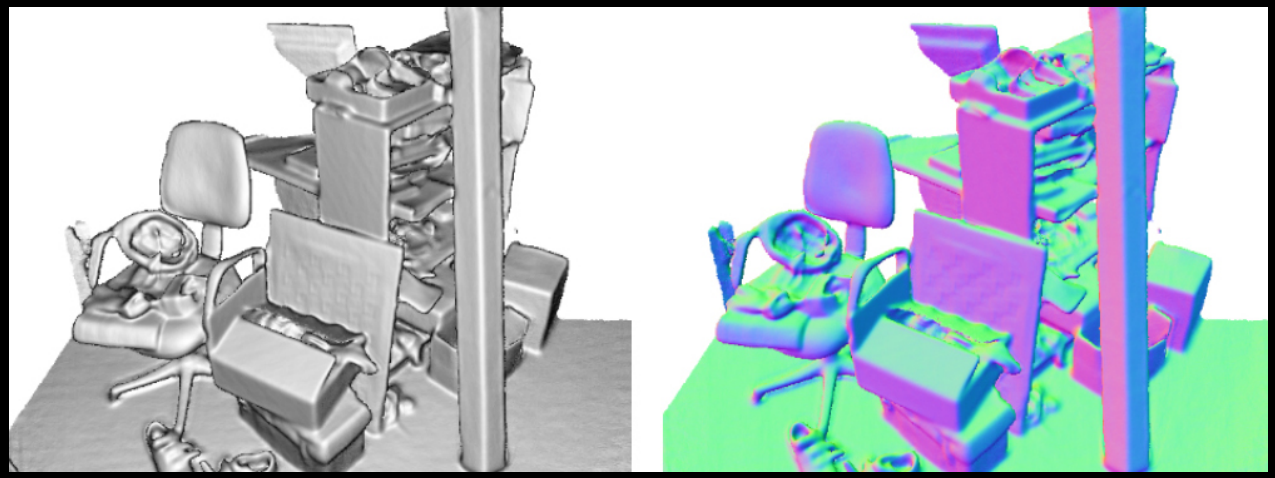
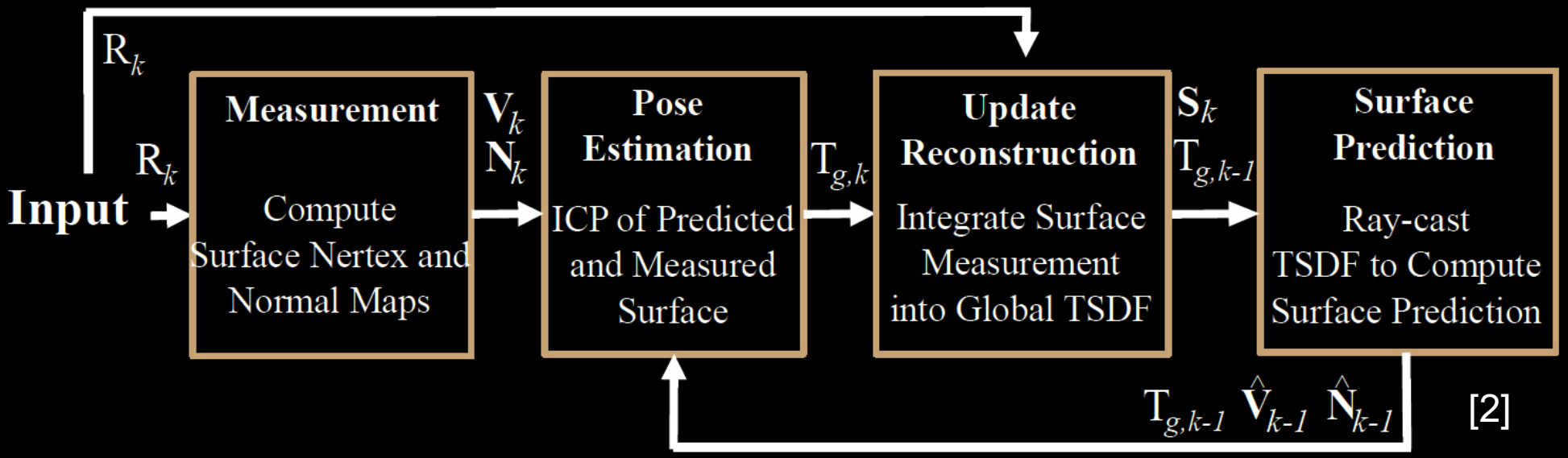


Phong shaded normals

2. State-of-the-art - Method



2. State-of-the-art - Features

- Global model alignment
- Coarse-to-fine ICP (Iterative Closest Point):

$$\mathbf{E}(\mathrm{T}_{g,k}) = \sum_{\substack{\mathbf{u}\in\mathcal{U} \\ \Omega_k(\mathbf{u})\neq\text{null}}} \left\| \left(\mathrm{T}_{g,k}\dot{\mathbf{V}}_k(\mathbf{u}) - \hat{\mathbf{V}}^g_{k-1}(\hat{\mathbf{u}}) \right)^\top \hat{\mathbf{N}}^g_{k-1}(\hat{\mathbf{u}}) \right\|_2 \quad [2]$$

- GPU processing

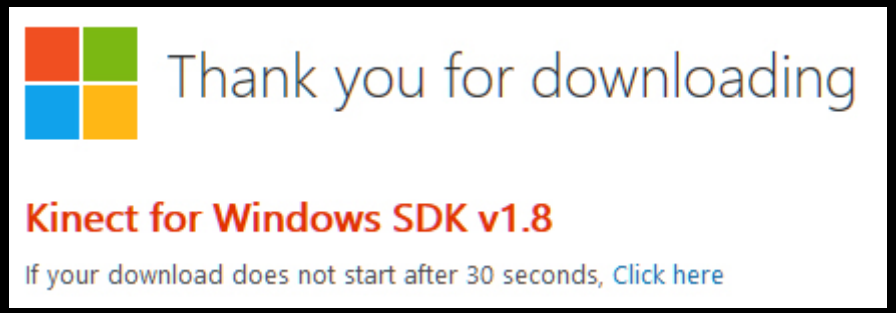
→ Real-time processing!

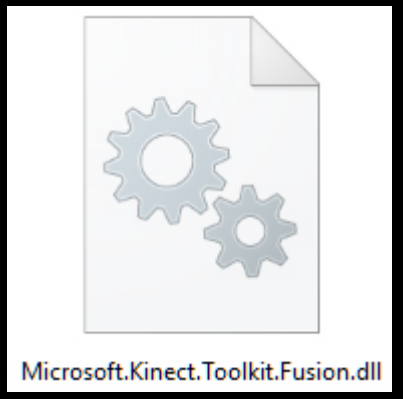
3. Limitations of KinectFusion

KinectFusion requires:

- specific hardware → Kinect
- GPU processing → need GPU...
- limited resolution → ~256 voxels per meter
- small movement between frames

4. Current State

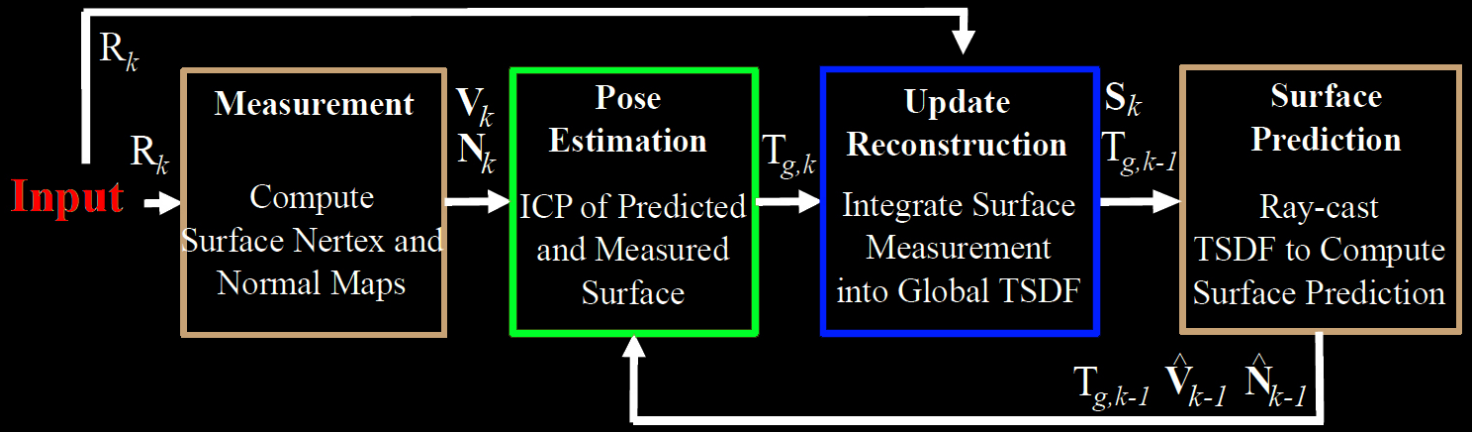




Kinect SDK → code samples

Hidden code in DLLs

4. Current State

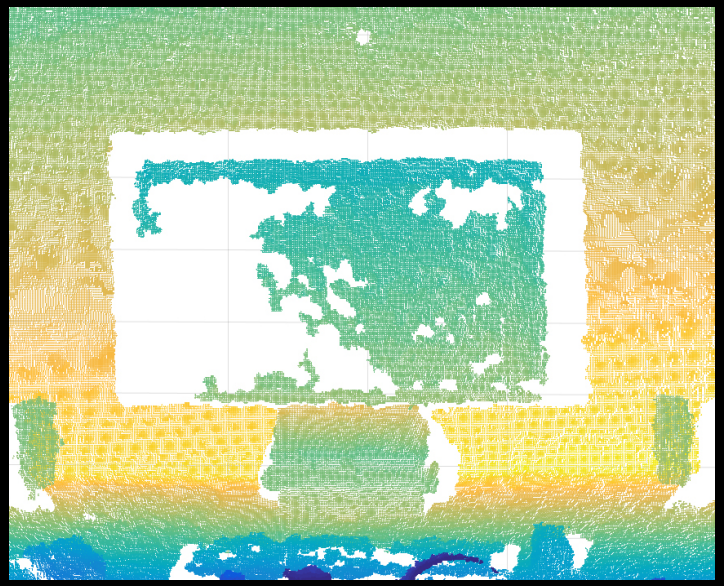


[2]

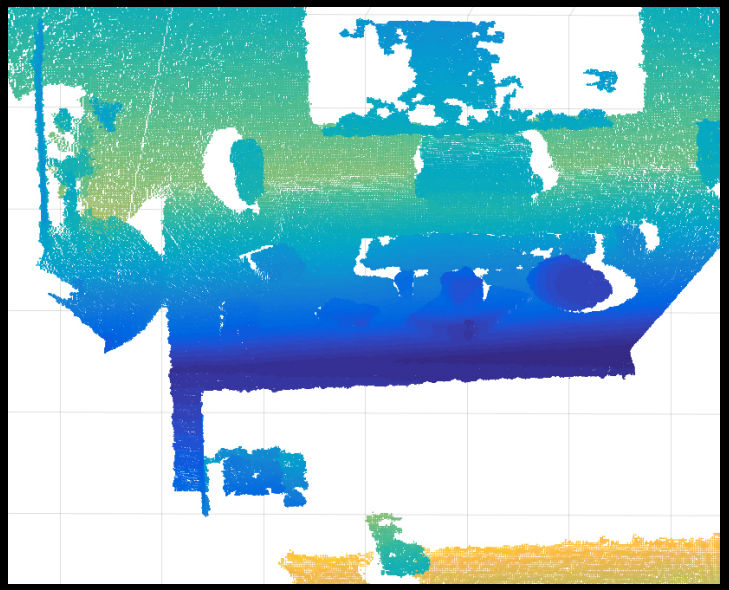
Matlab to the rescue!

- pcfromkinect()[3] to capture
- pcregrigid()[4] to align → ICP
- pcmerge()[5] to fuse → box grid filter

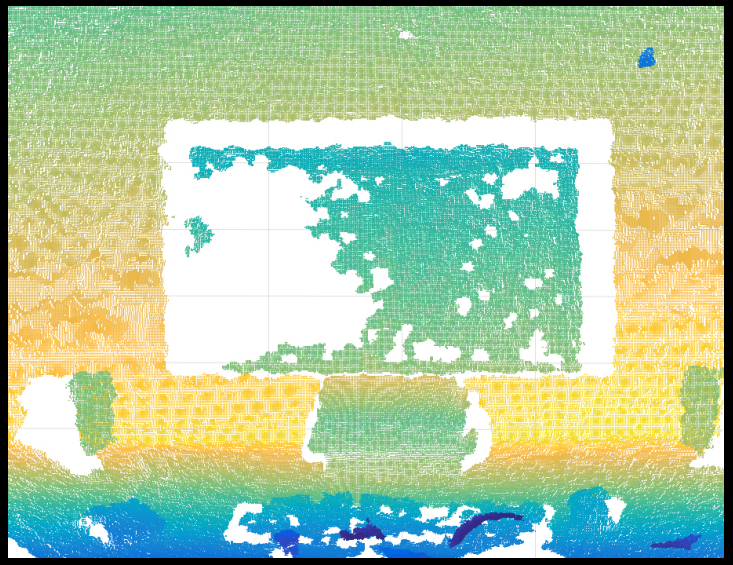
pcfromkinect()



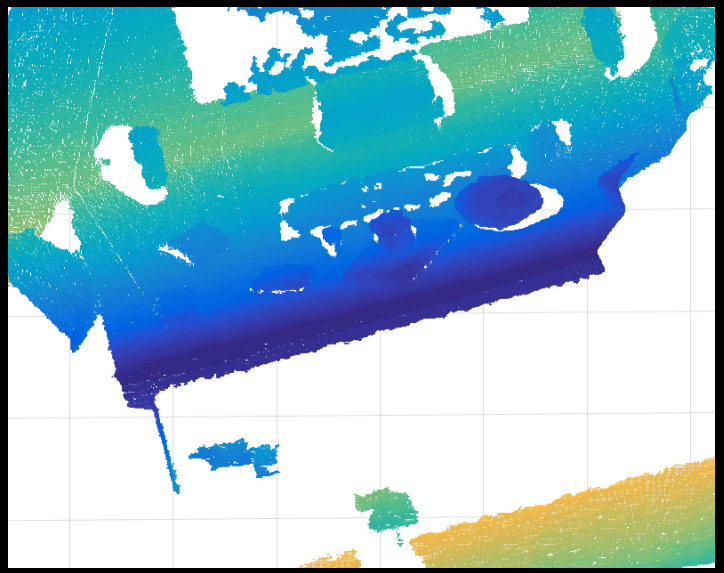
frame 1



frame 10

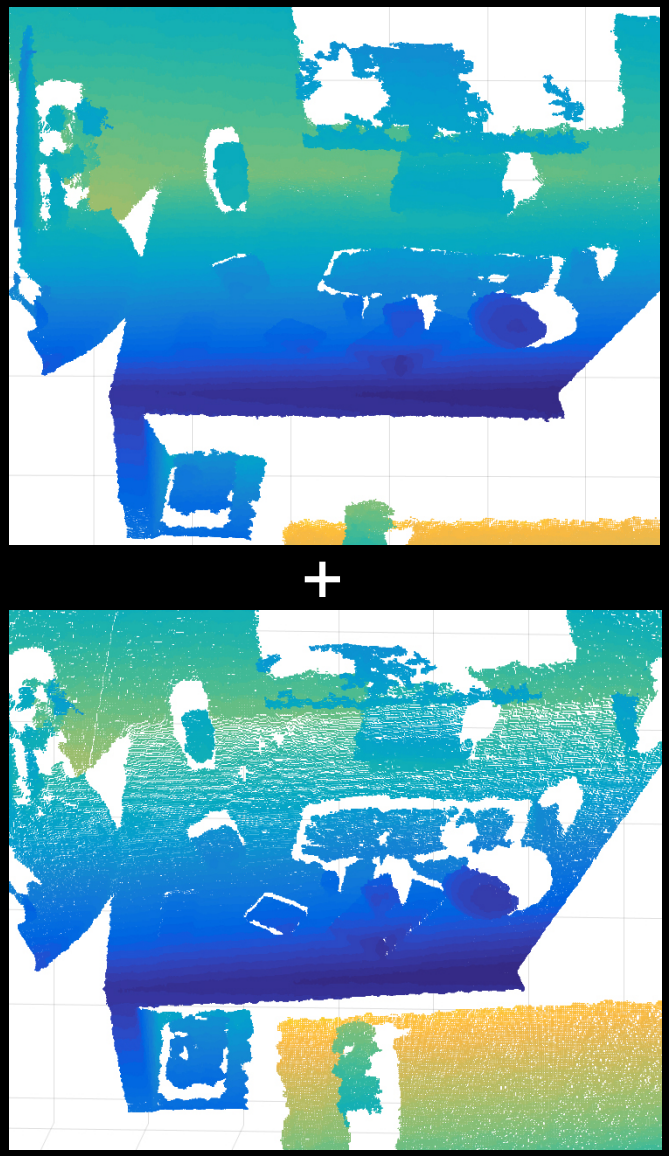


frame 2



frame 25

pcregrigid() and pcmerge()



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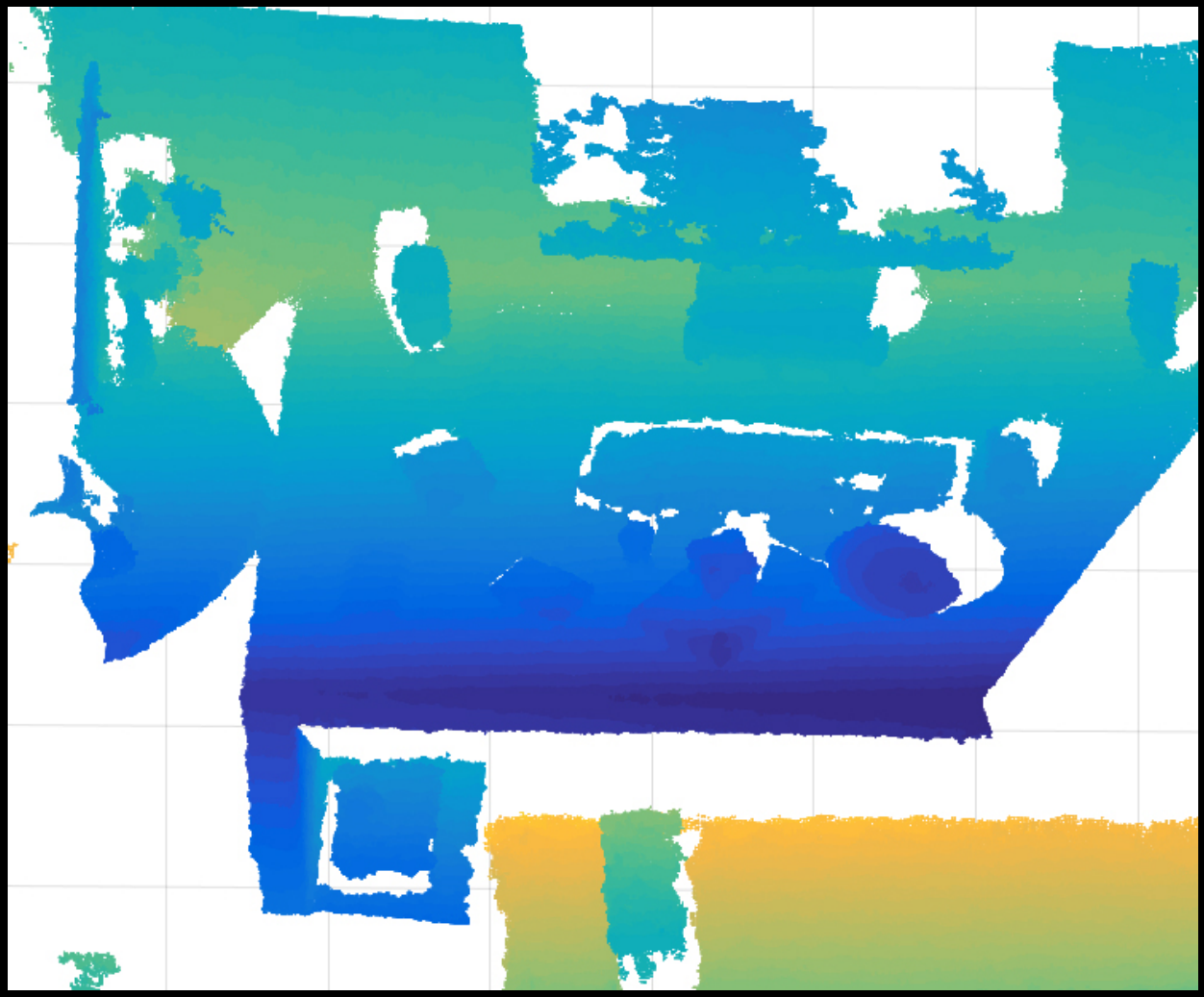
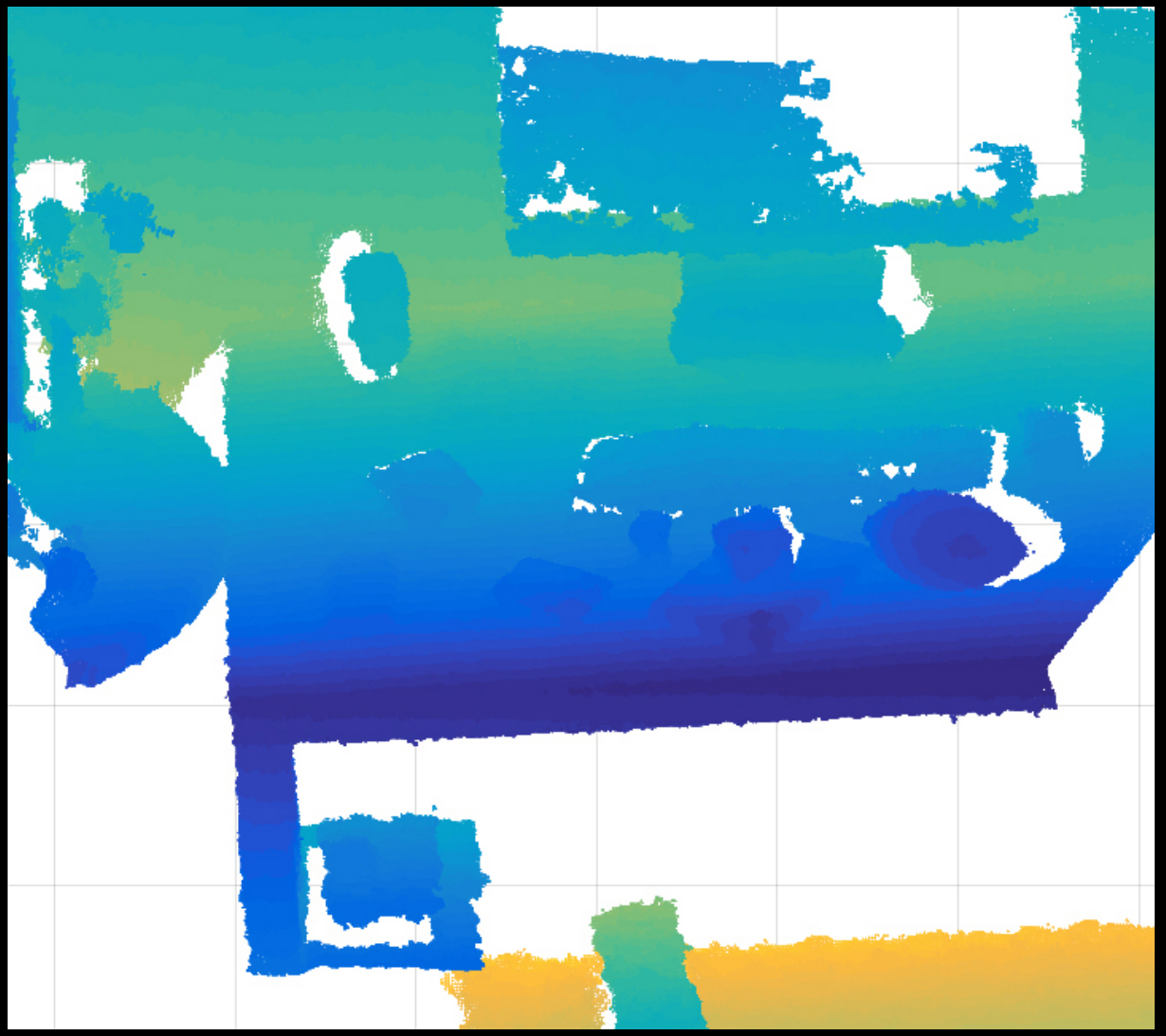
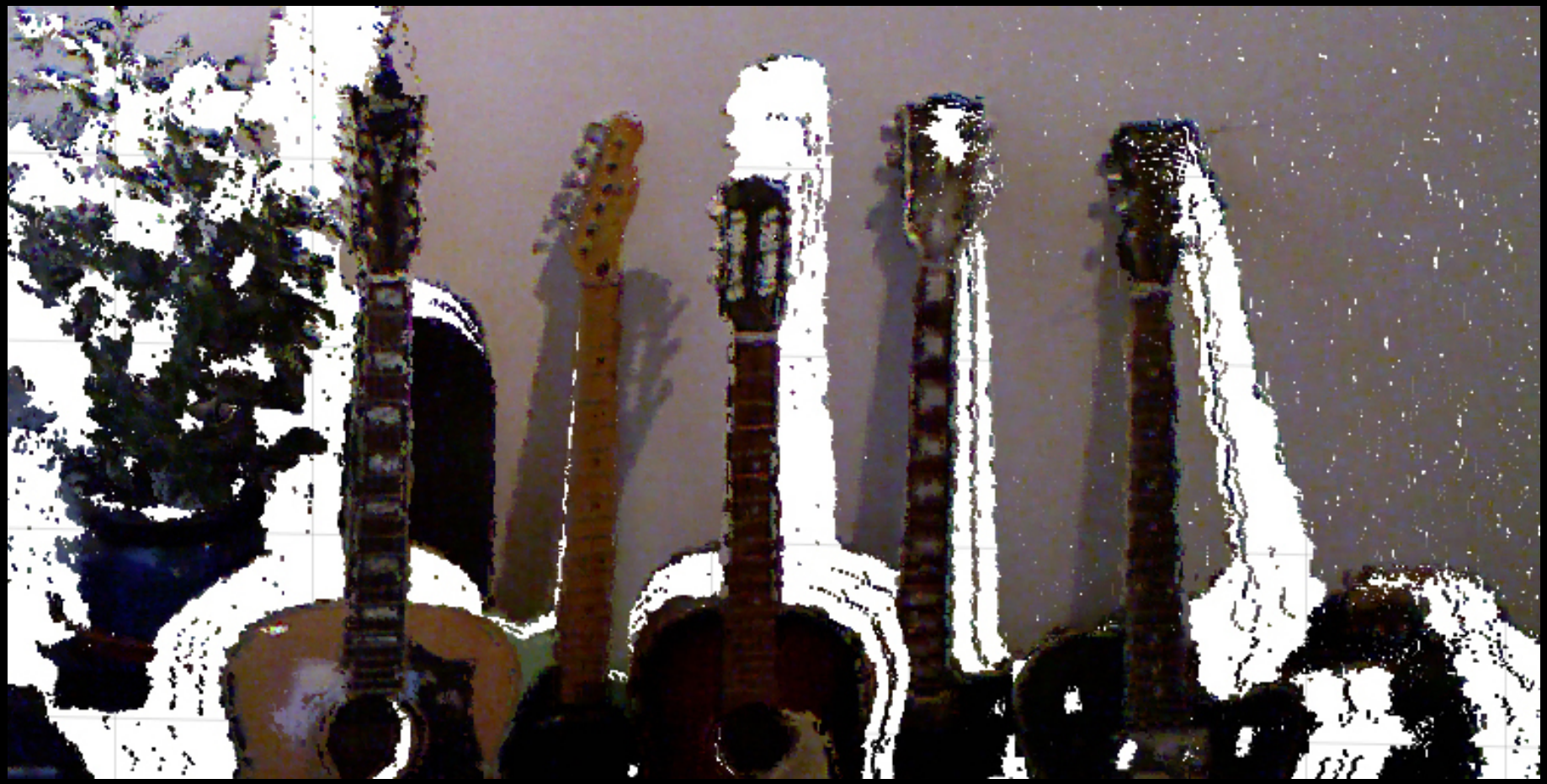


5. Results

Works well with clean data (5 frames are fused)





2 frames fused

3 frames fused

6. Discussion

- Kinect data → very noisy
- ICP → local minima
- ICP fails with large discontinuities
- Data gets huge:
  - ~260K points for 1 frame
  - >1.6M points for 10 fused frames

7. Future work

- Coarse-to-fine implementation
- Try GoICP (Global Optimum ICP)
- Capture better data

References

- [1] Matthew Fisher, 2014
http://graphics.stanford.edu/~mdfisher/Kinect.html

- [2] *KinectFusion: Real-Time Dense Surface Mapping and Tracking*, Newcombe R., et al., 2011
https://www.microsoft.com/en-us/research/wp-content/uploads/2016/02/ismar2011.pdf

- [3] pcfromkinect, Matlab
https://ch.mathworks.com/help/vision/ref/pcfromkinect.html

- [4] pcregrigid, Matlab
https://ch.mathworks.com/help/vision/ref/pcregrigid.html

- [5] pcmerge, Matlab
https://ch.mathworks.com/help/vision/ref/pcmerge.html

Questions?