Contents

1 Non Rigid Tracking and Reconstruction

The general pipeline for Non Rigid Tracking and Reconstruction methods are based on the approach proposed in **Dynamic Fusion**. The idea is very similar to Kinect Fusion and we can view Dynamic Fusion as a generalized version of Kinect Fusion.

The key idea of the DynamicFusion is that, it uses the static scene captured in the first frame as the **canonical rigid scene** and sees every non-rigidly deforming scene captured in the incoming frames as a deformed version of the canonical scene. Thus, just like normal volumetric fusion based rigid reconstruction methods, in each frame we fuse the input depth map into the canonical model and extract the surface of the transformed canonical model, with the only difference that in this case the transformation has many more degrees of freedom and when doing depth fusion we need first to deform the current SDF according to the current estimated model-to-frame wrap.

- Deformation graph (ED) + non-rigid ICP + volumetric fusion

- For each frame
  – Take depth frame
  – Extract depth map from current warped model (using Marching Cubes)
  – Align input frame with extracted frame using (dense) non-rigid ICP
  – Integrate current frame into canonical model
  – Go to next frame

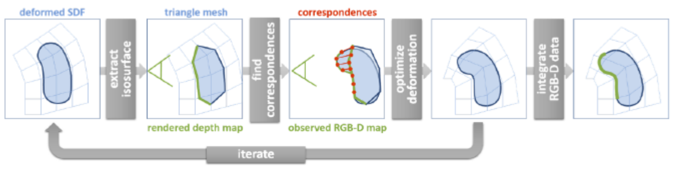
Side note: here we cannot use raycasting to render the current depth map because the SDF is deformed. Instead, we should first use marching cube to extract the surface, and then use a rasterizing rendering pipeline to render the synthetic depth map.
Most other approaches are based on the same idea as DynamicFusion, and we will discuss some of them.

1.1 VolumeDeform

This variation allows fast motion as it uses extra sparse correspondences defined by SIFT features as global anchors in order to better achieve a better and more robust alignment.

- Regular deformation grid (ARAP) + non-rigid ICP (dense depth + sparse SIFT matches) + Volumetric Fusion

- For each frame
  – Take depth frame
  – Extract depth map from current warped model (using Marching Cubes)
  – Align input frame with extracted frame using (dense) non-rigid ICP
  – Integrate current frame into canonical model
  – Go to next frame



- Key differences to [Newcombe et al. 15]
  – Sparse RGB correspondences as global anchors
  – High-resolution deformation field (same as surface)

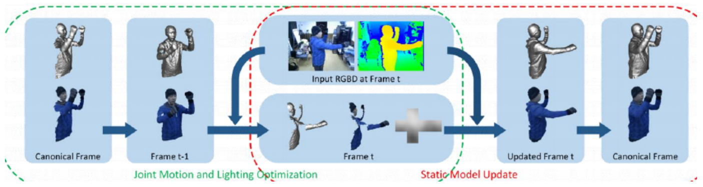
1.2 Real-time Geometry, Albedo and Motion Reconstruction

This variant also reconstructs the albedo of the model in order to achieve effects such as re-lighting.

Real-time Geometry, Albedo, and Motion Reconstruction

Real-time Geometry, Albedo, and Motion Reconstruction

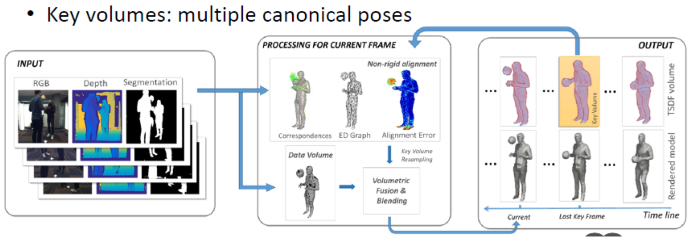
- Deformation graph (ED)
- Non-rigid ICP (dense depth + dense color)
- Illumination correction for color term (more later on lighting)



1.3 Fusion4D/Holoportation

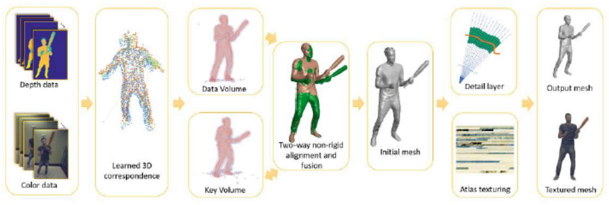
This variant uses MVS to achieve a better reconstruction and instead of using only on single canonical model it uses multiple canonical models selected on different key frames.

- 8 depth maps (16 IR cameras)
- Key volumes: multiple canonical poses

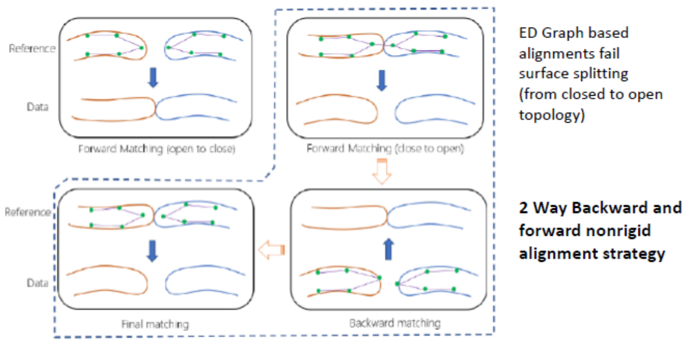


1.4 Motion2Fusion

Same idea as Fusion4D but this one is much faster and it uses a 2 way backward and forward nonrigid alignment strategy to reinforce consistency.

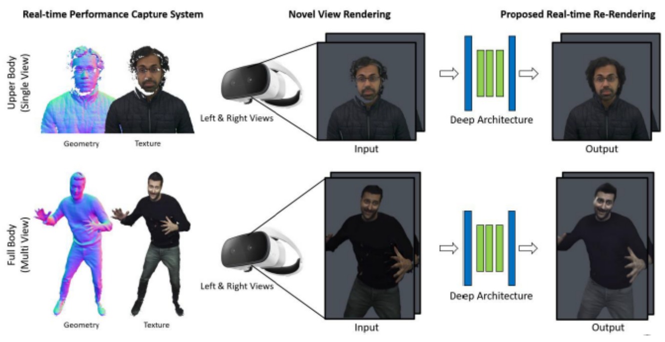


- ED graph, key volumes, multiple depth cameras
- Much faster: 200 FPS => Faster motion tracking


Reference
Data
Forward Matching (open to close)
Forward Matching (close to open)
ED Graph based alignments fail surface splitting (from closed to open topology)
Reference
Data
Final matching
Backward matching
2 Way Backward and forward nonrigid alignment strategy

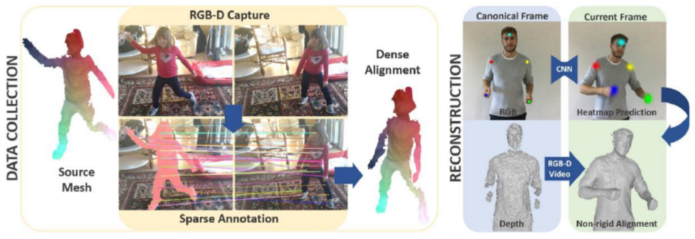
1.5 LookinGood

This variant uses DL models to achieve a better re-rendering of the surface by for example fill missing parts or enhance texture.

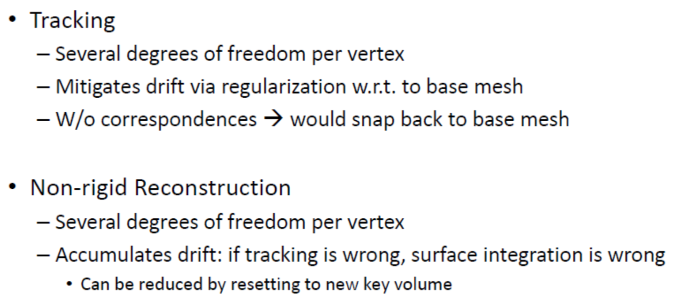


1.6 DeepDeform

Use DL models to learn correspondences.



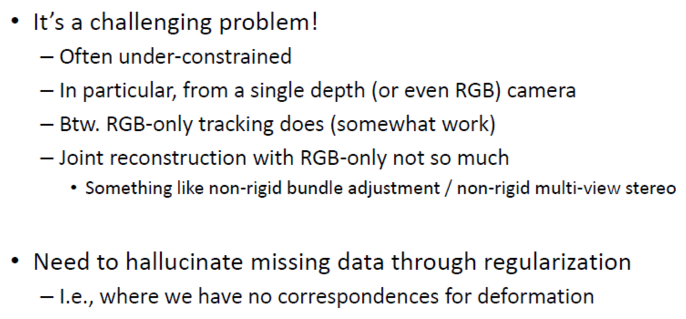
1.7 Summary on Non-rigid tracking vs Non-rigid Reconstruction



- Tracking
  - Several degrees of freedom per vertex
  - Mitigates drift via regularization w.r.t. to base mesh
  - W/o correspondences → would snap back to base mesh
- Non-rigid Reconstruction
  - Several degrees of freedom per vertex
  - Accumulates drift: if tracking is wrong, surface integration is wrong
    - Can be reduced by resetting to new key volume

Side note: In tracking there's no drift because the base mesh regularized by the regularizer. In reconstruction, however, each frame the base model is fused with the current depth map, so if the tracking is wrong, then we will accumulate drift on the base mesh.

1.8 Summary on Non-rigid/Dynamic Capture



- It’s a challenging problem!
  - Often under-constrained
  - In particular, from a single depth (or even RGB) camera
  - Btw. RGB-only tracking does (somewhat work)
  - Joint reconstruction with RGB-only not so much
    - Something like non-rigid bundle adjustment / non-rigid multi-view stereo
- Need to hallucinate missing data through regularization
  - I.e., where we have no correspondences for deformation