Elastic Fragments for Dense Scene Reconstruction

Jacques-Henri Lartigue
"Car Trip"
State of the art
Depth images

RGB-D Camera

Depth Map
Conventional reconstruction (1)

RGB

Depth

Initial estimate
Conventional reconstruction (2)

RGB          Depth

Project additional data onto shape
Camera Trajectory Estimation

Video stream

Feature point matching

Can now estimate camera transformations
Dense point clouds
Noise
Many noisy images
Noise
Integrates into less noise
Other types of errors

Camera transformation alone may be insufficient to align the data.
Elastic fragments
Fragment construction (1)

Partition video into short sequences

Sequence 0

Sequence 1

Sequence 2...
Fragment construction (2)

Generate triangle mesh from each sequence

Fragment 0

Fragment 1

Fragment 2...
Initial alignment

- Find pairs of fragments that overlap
- using off-the-shelf software system
- Affine transform
Elastic registration

Low frequency distortions

=> Fragments not perfectly aligned

Need an elastic mapping $T$ to stretch the fragments to fit
\( T \) should minimize Point-to-plane distance:

\[ (p-q) \cdot N \]

(For each corresponding point)
should minimize Point-to-plane distance:

\[(p-q) \cdot N\]

(For each corresponding point)
should also minimize the elastic strain.
Assume $T$ does this.
$p$ has 4 neighbours (q0..3).
given the normals of p and p’ we can compute two tangent spaces S and S’
Compute a rotation $R$ around $p$ which takes us from $S$ to $S'$
We can apply the rotation to the neighbours of $p$
The elastic strain is the sum of the squared distance between the transformed neighbours and the rotated neighbours.
Elastic registration (cont.)

Point-to-plane distance and elastic strain are minimized as an energy function.

Unfortunately, doing this for each point is computationally infeasible.
Volumetric Registration

- Energy function redefined in terms of a lattice
- Much fewer control points