Interative closest point

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A method for Registration of 3-D Shapes

- ICP is a ground stone of most registration algorithms to day
- Old from 1992
- General algorithm: point clouds, polygons to surfaces
- Local and Global Registration

ICP

- Based on Euclidean distance
- Distance to a triangle t

$$d(q,r) = \sqrt{\sum_{i=1}^{n}(r_i - q_i)^2}$$

$$d(\vec{p},t) = \min_{u+v+w=1} \|u\vec{r}_1 + v\vec{r}_2 + w\vec{r}_3 - \vec{p}\|$$

- The distance between point p and the triangle set T

$$d(p,T) = \min_{i\in\{1,\ldots,Nt\}} d(p,t_i)$$

- The closest point y on triangle set T satisfies the equality

$$d(p,y) = d(p,T)$$

Working on parametric serfaces

- First is to split into simplex based representation then approximate with Euclidean distance
- Then approximate to the parametric curve/surface with Newton's minimization

Pipeline of ICP

- Compute the closest points. For each point in N_p to shape X
- Compute registration. The translation vector and rotation vector for data P
- Apply translation and rotation
- Terminate iterations if mean-square error lower then the wanted threshold

Convergence Theorem

- Theorem: The iterative closest point algorithm always converges monotonically to a local minimum with respect to the mean-square distance objective function.

An Accelerated ICP Algorithm

Q unit quaternion

$q_r = [q_0 q_1 q_2 q_3]^T$

Sum = 0

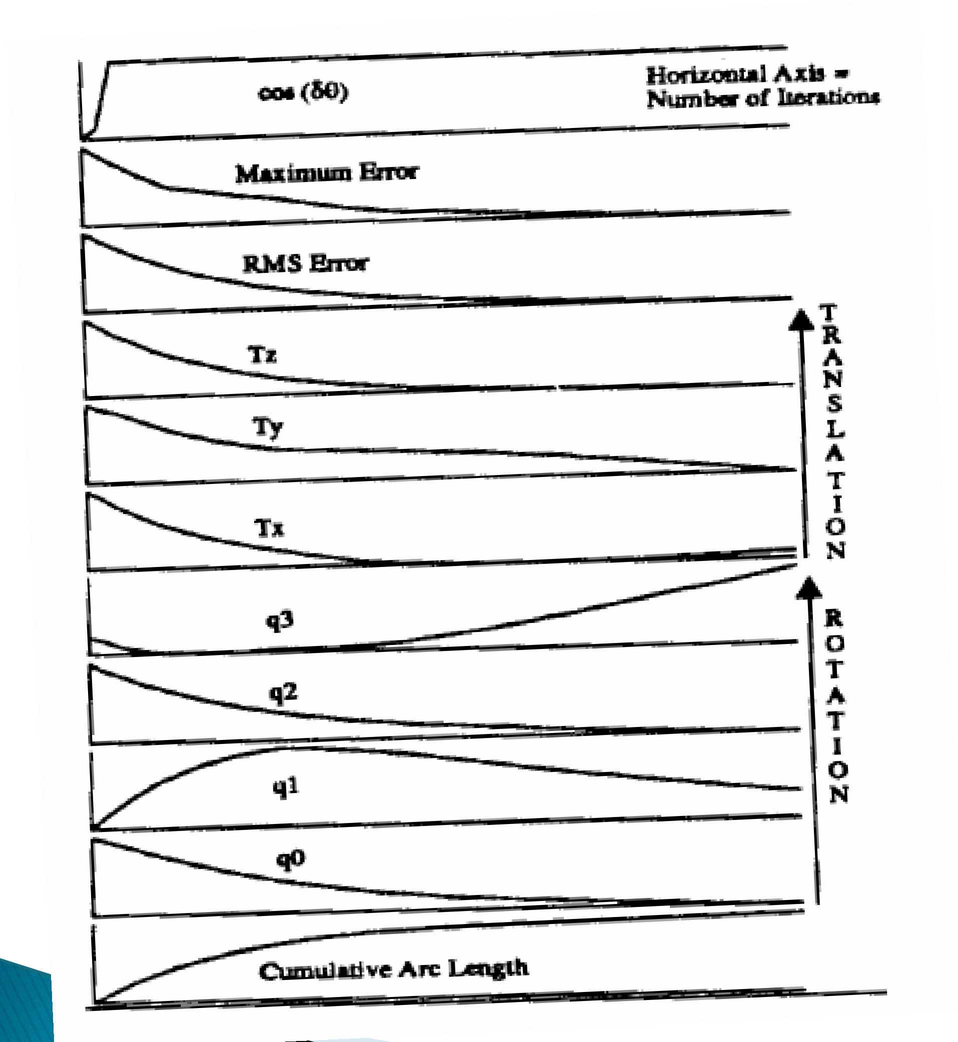
$q_t = [q_4 q_5 q_6]^T$

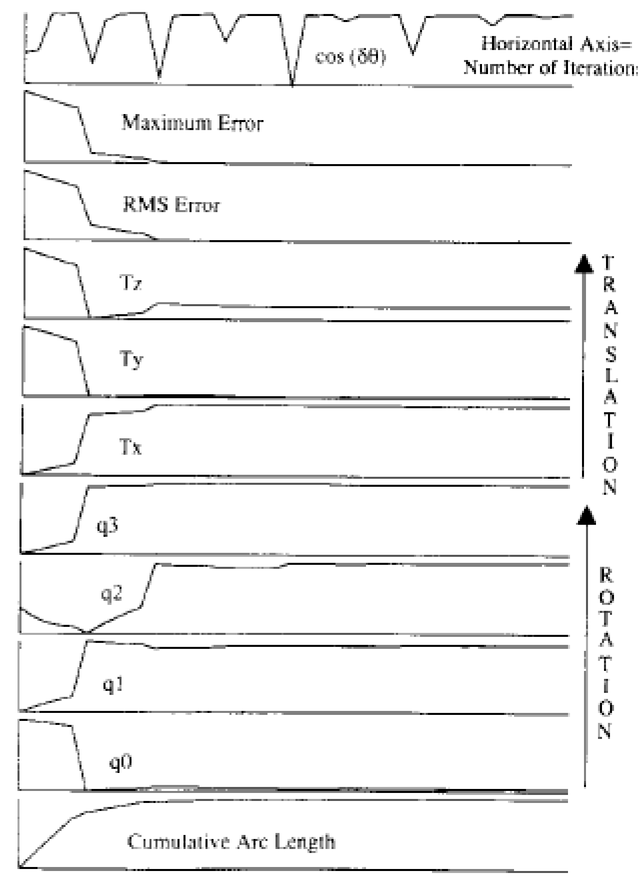
$$Q = [q_r | q_t]^T$$

$$\Delta\vec{q}_k = \vec{q}_k - \vec{q}_{k-1}$$

$$\theta_k = \cos^{-1}\left(\frac{\Delta\vec{q}_k{}^t \Delta\vec{q}_{k-1}}{\|\Delta\vec{q}_k\| \|\Delta\vec{q}_{k-1}\|}\right)$$

An Accelerated ICP Algorithm





Global registration

- Can get stuck in a local minimum

- Uses fast convergence to pick the best starting values
- Some imposible cases

Experimental Results

- Good results
- All six degrees of freedom
- Relatively insensitive to minor local errors
- Gives good match even with the Gaussian noise up to 10% of model size