



NSF Engineering Research Center
for Computer Integrated Surgical
Systems and Technology



LABORATORY FOR
**Computational
Sensing + Robotics**
THE JOHNS HOPKINS UNIVERSITY

Notes for PA5: Deformable Registration to a Statistical Shape Model



**WHITING
SCHOOL OF
ENGINEERING**
THE JOHNS HOPKINS UNIVERSITY

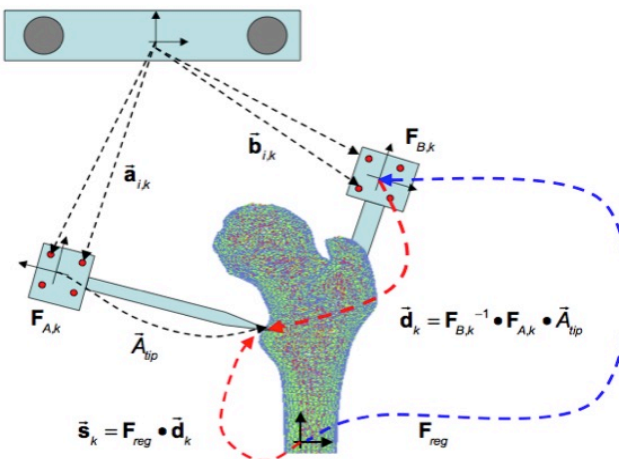
Russell H. Taylor

John C. Malone Professor of Computer Science,
with joint appointments in Mechanical Engineering, Radiology & Surgery
Director, Laboratory for Computational Sensing and Robotics
The Johns Hopkins University
rht@jhu.edu



1

Problem 5 Scenario



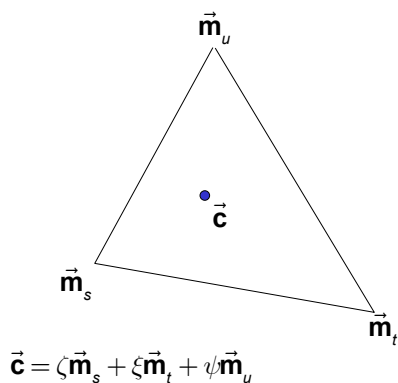
Copyright 2025 R. H. Taylor

Computer Integrated Surgery 600.455/655



2

Barycentric Coordinates of Deforming Triangle



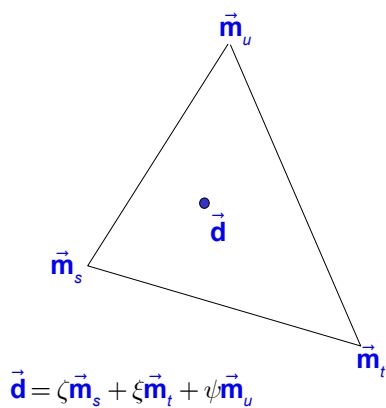
Copyright 2025 R. H. Taylor

Computer Integrated Surgery 600.455/655



3

Barycentric Coordinates of Deforming Triangle



$$\vec{m}_s = \vec{m}_{0,s} + \sum_{m=1}^{N_{\text{modes}}} \lambda_m^{(t)} \vec{m}_{m,s}$$

$$\vec{m}_t = \vec{m}_{0,t} + \sum_{m=1}^{N_{\text{modes}}} \lambda_m^{(t)} \vec{m}_{m,t}$$

$$\vec{m}_u = \vec{m}_{0,u} + \sum_{m=1}^{N_{\text{modes}}} \lambda_m^{(t)} \vec{m}_{m,u}$$

$$\vec{q}_{m,k} = \zeta_k \vec{m}_{m,s} + \xi_k \vec{m}_{m,t} + \psi_k \vec{m}_{m,u}$$

$$\vec{d}_k^{(t)} = \vec{q}_{0,k} + \sum_{m=1}^{N_{\text{modes}}} \lambda_m^{(t)} \vec{q}_{m,k}$$

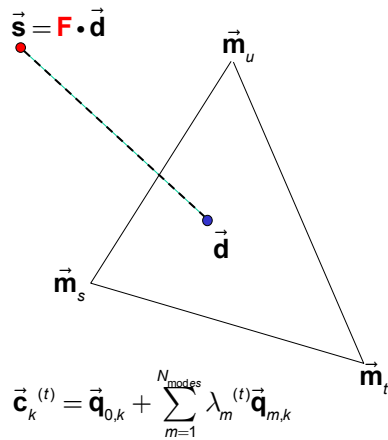
Copyright 2025 R. H. Taylor

Computer Integrated Surgery 600.455/655



4

Deformable Registration to SSM



Step 1 For sample points, find closest matches to current mesh

Step 2 Solve $\mathbf{F} \cdot \vec{d}_k \approx \vec{q}_{0,k} + \sum_{m=1}^{N_{modes}} \lambda_m^{(t)} \vec{q}_{m,k}$ for \mathbf{F} and/or $\lambda_m^{(t)}$

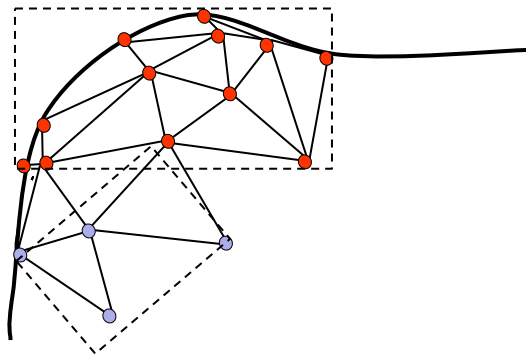
Step 3 If change the shape parameters then update bounding boxes

Step 4 Iterate to convergence



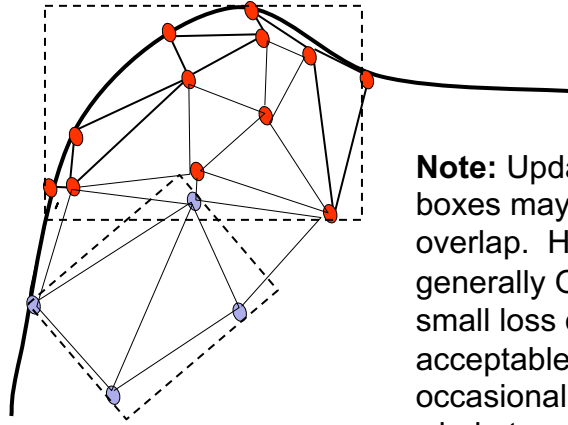
5

Updating Bounding Boxes



6

Updating Bounding Boxes



Note: Updated bounding boxes may increase overlap. However, this is generally OK, since some small loss of efficiency is acceptable. You can occasionally rebuild the whole tree if it becomes an issue.

