Intuitive and Smart Editing of 3D Geometrical Heart Valve Models from Cardiac CT Data

Master Thesis Introductory Presentation

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Outline

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- Valve Models
- 3D Model Editing
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Motivation

Fully automatic vs. manual segmentation

- fully automatic segmentation is not always reliable
- manual segmentation can be very time-consuming

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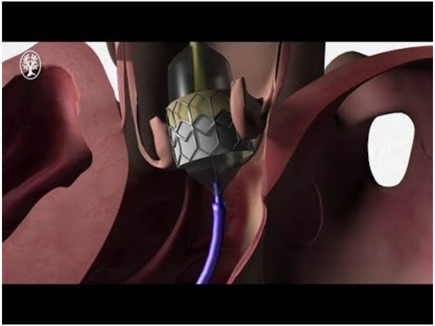
$\Rightarrow$ Solution: Intuitive and Smart Post-Editing

- should be applied as fast as possible ($\Rightarrow$ timesaving)
- drag as few points as possible ($\Rightarrow$ simpliness)
- result should correlate with image data ($\Rightarrow$ reliability)

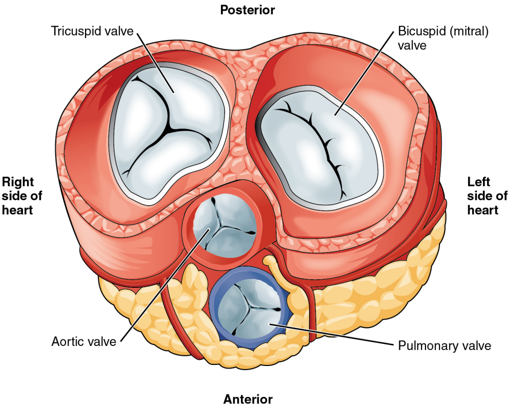
Editing of Heart Valve Models

Purpose: e.g. Transcatheter Aortic Valve Implantation (TAVI)



Valve Models

Anatomy of the Mitral and Aortic Valve



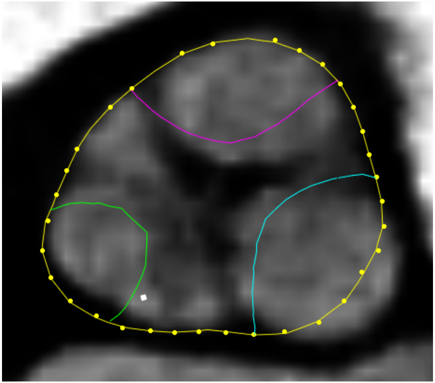
3D Models of the Mitral and Aortic Valve

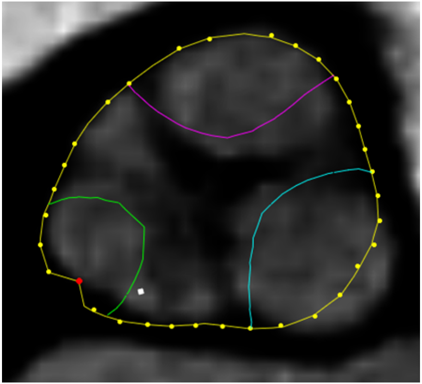
(mitral.u3d)

(aortic.u3d)

3D Model Editing

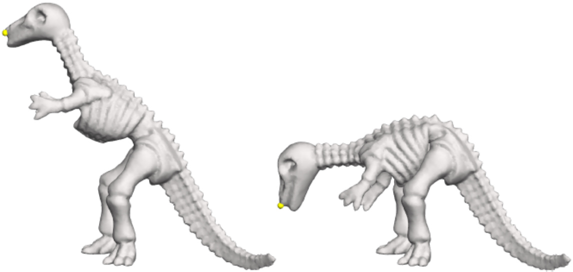
Trivial editing





Better approach

- fix some nodes
- remaining nodes should be deformed physically plausible



⇒ As-Rigid-As-Possible Surface Modeling (Olga Sorkine, 2007)

As-Rigid-As-Possible (ARAP) Mesh Deformation

- v_i: original node position
- $\hat{v}_i$: deformed node position
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$$\forall\, j \in N(i) : \;\; \hat{v}_i - \hat{v}_j = \boldsymbol{R_i}(v_i - v_j)$$

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Rigid transformation

$$\forall\, j \in N(i) :\ \hat{v}_i - \hat{v}_j = \boldsymbol{R_i}(v_i - v_j)$$

Non-rigid transformation: find rotation $\boldsymbol{R_i}$ that fits best

$$\mathrm{E} = \sum_{j \in N(i)} \left\| (\hat{v}_i - \hat{v}_j) - \boldsymbol{R_i}(v_i - v_j) \right\|^2 \rightarrow min$$

ARAP: Objective function

$$\mathrm{E} = \sum_{i=1}^{n} \sum_{j \in N(i)} \left\| (\hat{v}_i - \hat{v}_j) - \boldsymbol{R_i}(v_i - v_j) \right\|^2 \rightarrow min$$

ARAP: Objective function

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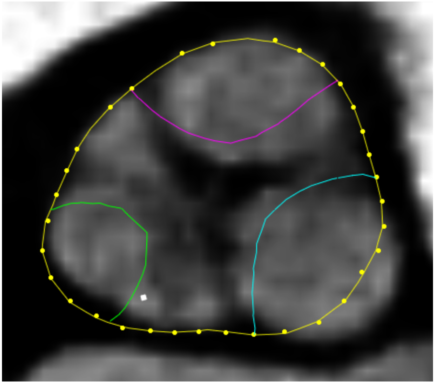
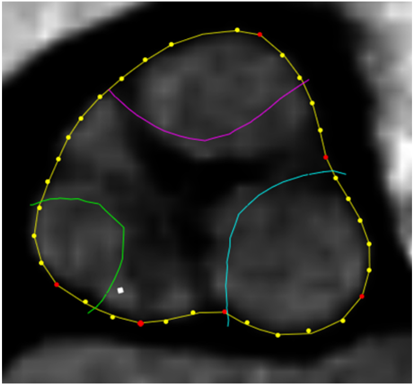
Solve by iterative flip-flop optimization

1. fix node-positions $\hat{v}_i$, solve for optimal rotations $\boldsymbol{R_i}$
2. fix $\boldsymbol{R_i}$, solve for $\hat{v}_i$

Result with 6 constraints





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- leaflet editing
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Evaluation

- performance
- accuracy based on manually segmented data
- intra/inter variability

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As-Rigid-As-Possible Mesh Deformation ...

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- move some nodes (= constraints) to their correct position ...
- ...and the remaining nodes get deformed physically plausible

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Intuitive and Smart Post-Editing ...

- ... is a timesaving alternative to fully manual segmentation
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Enhance the user-friendliness by involving image data (e.g. edge affinity)

Sources

- Olga Sorkine, Marc Alexa: *As-Rigid-As-Possible Surface Modeling*. *EUROGRAPHICS/ACM SIGGRAPH Symposium on Geometry Processing,* Vol. 27, 2007

Thank you for your attention!