

Hierarchical F-rep modeling of muscle cell infrastructure

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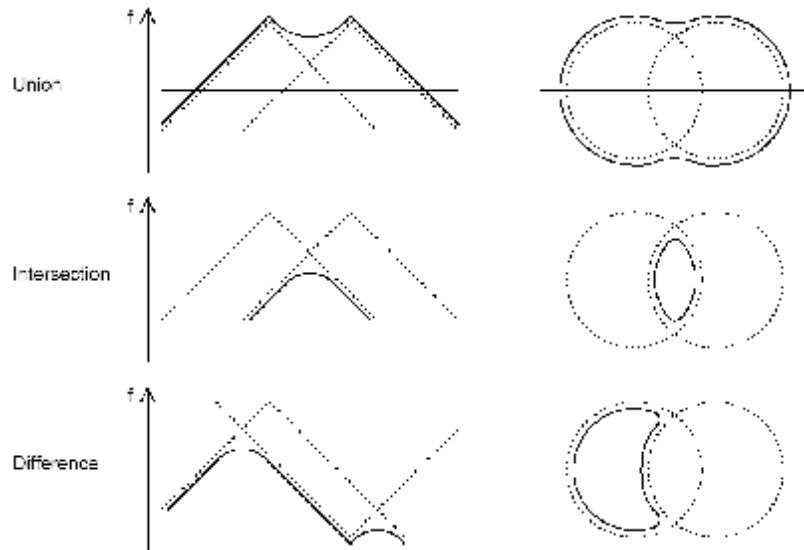
Ivan Zahradnik

Function representation (F-rep)

- $F(X) > 0$
 - describes a half-space in E^n ($X \in E^n$)
 - Implicit solid
- Set-theoretic operations (\wedge, \vee, \setminus)
 - R-functions
 - non-distance properties (proximity alteration)
 - + continuity
 - + algebraic notation
 - min/max operators
 - discontinuous
 - + distance property

Min, Max operators + displacement

Ex: $f_1 \vee f_2 = \max(f_1, f_2) + f_b(f_1 - f_2)$



$$1. f_b(x, n) = \frac{\sqrt{x^2 + n} - x}{2}$$

$$2. f_b(x, n) = \frac{n}{x + \sqrt{2n}}$$

$$3. f_b(x, n) = \begin{cases} n \cos\left(\frac{\pi}{6} + \frac{x}{n}\right) - n & \text{for } x < \frac{5\pi n}{6} \\ 0 & \text{for } x \geq \frac{5\pi n}{6} \end{cases}$$

$$4. f_b(x, n) = \begin{cases} n \cos\left(\frac{5\pi}{6} + \frac{x}{n}\right) + n & \text{for } x < \frac{\pi n}{6} \\ 0 & \text{for } x \geq \frac{\pi n}{6} \end{cases}$$

$$5. f_b(x, n) = \begin{cases} n \left(\frac{x}{n} - \frac{1}{4}\right)^2 & \text{for } x < \frac{n}{4} \\ 0 & \text{for } x \geq \frac{n}{4} \end{cases}$$

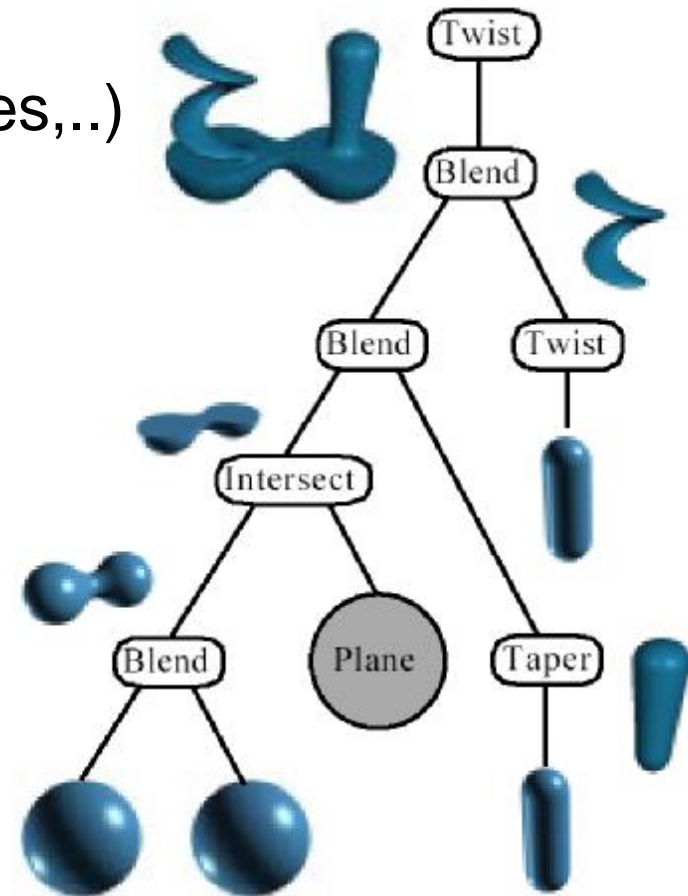
$$6. f_b(x, n) = \begin{cases} -\frac{1}{2}x + n & \text{for } x < 2n \\ 0 & \text{for } x \geq 2n \end{cases}$$

$$x = |f_1 - f_2|$$

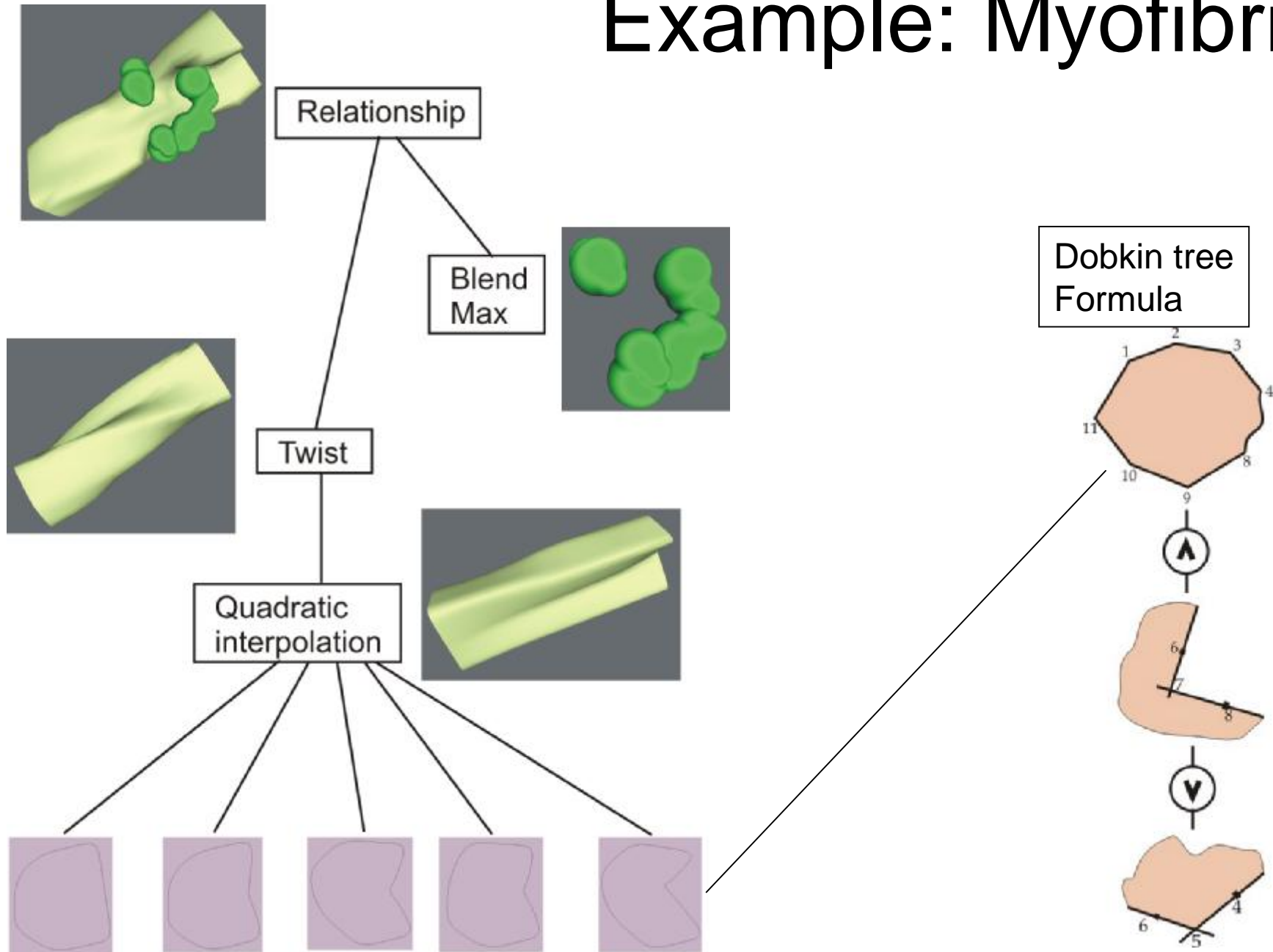
n controls amount of blended material

BlobTree – CSG data structure for F-rep objects

- Leaves
 - Skeletal primitives (points, lines,..) generates distance function
- Nodes
 - Blending, warping, extended space mapping operations (metamorphosis, projections)

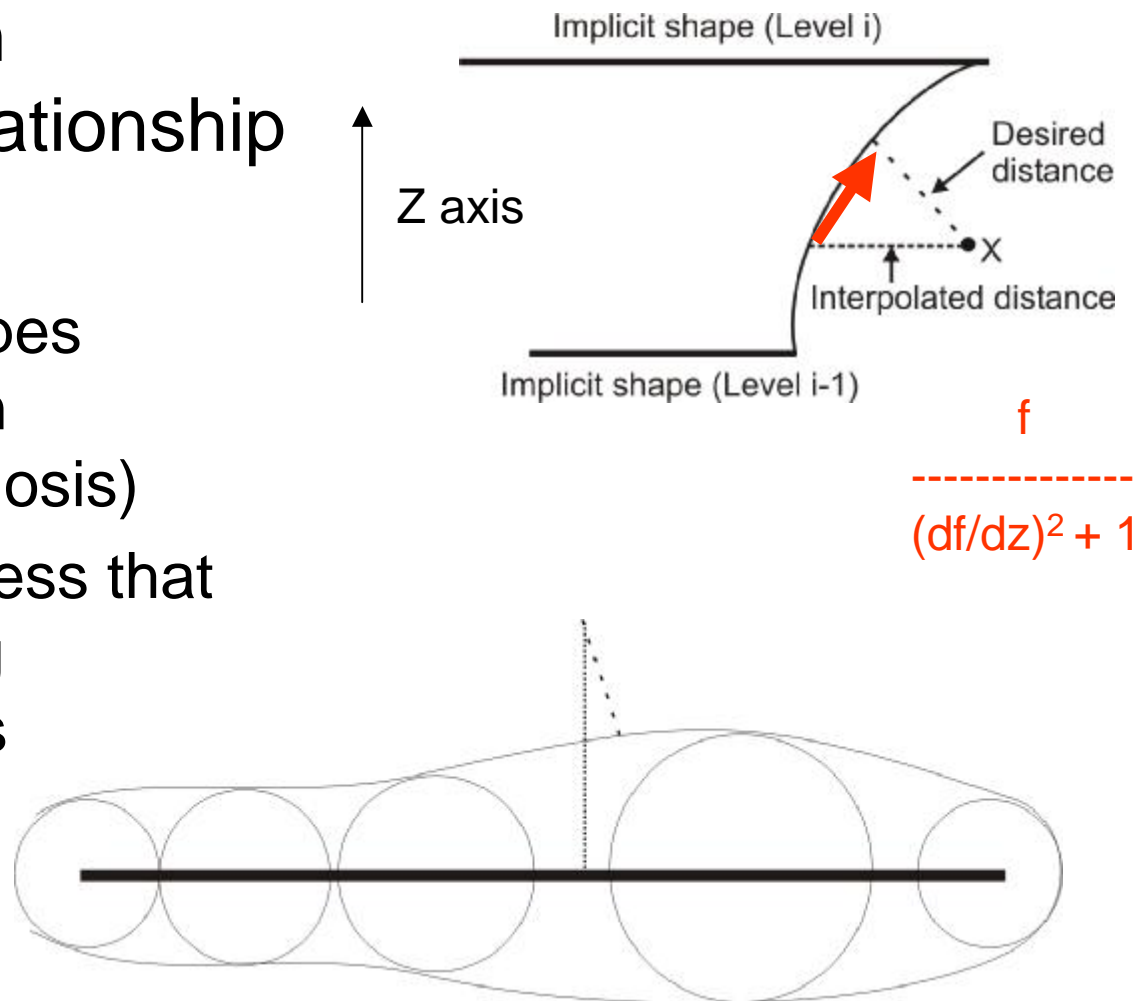


Example: Myofibril



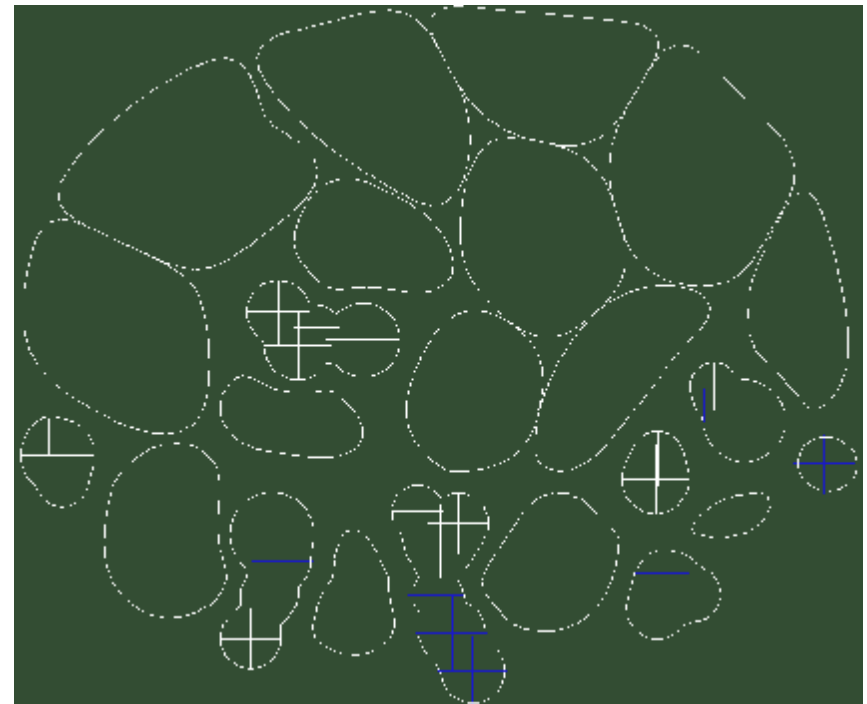
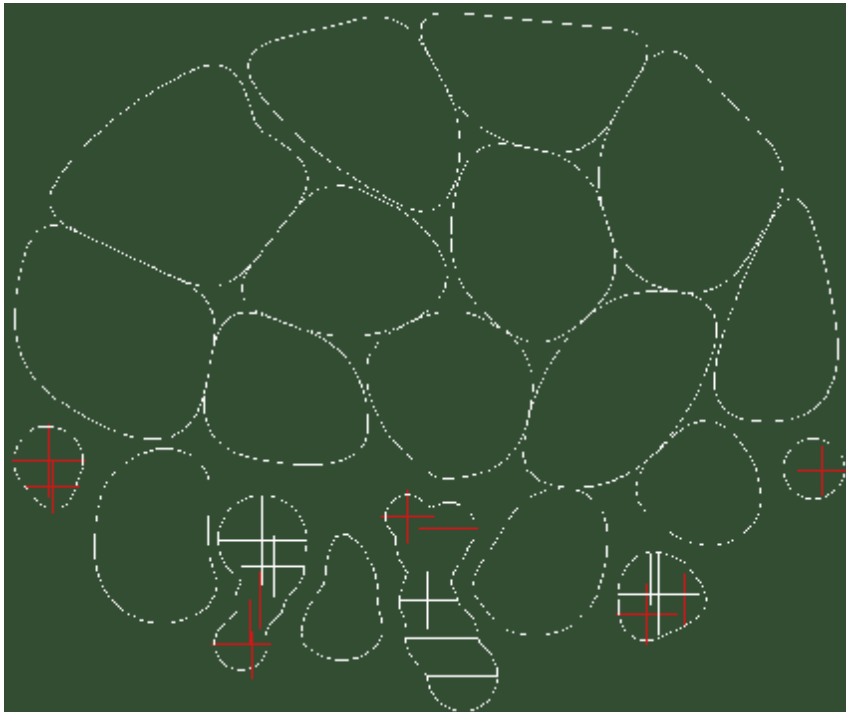
Distance correction

- Necessary in organelle relationship
- Examples
 - Implicit shapes interpolation (metamorphosis)
 - Tube thickness that varies along skeletal axis

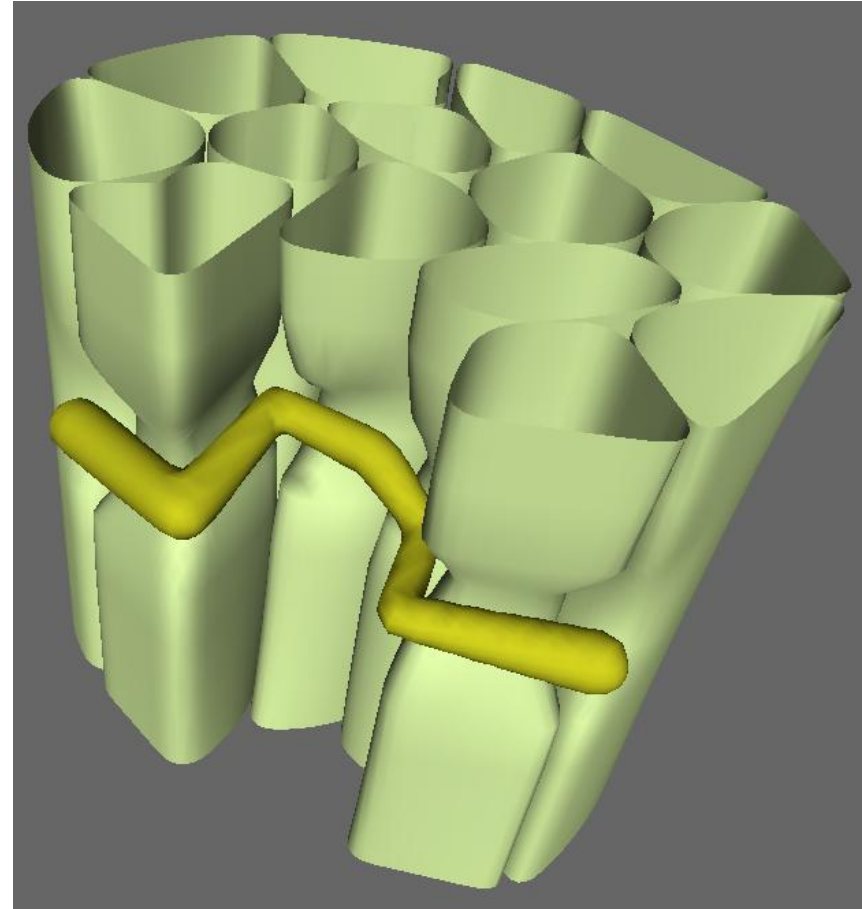
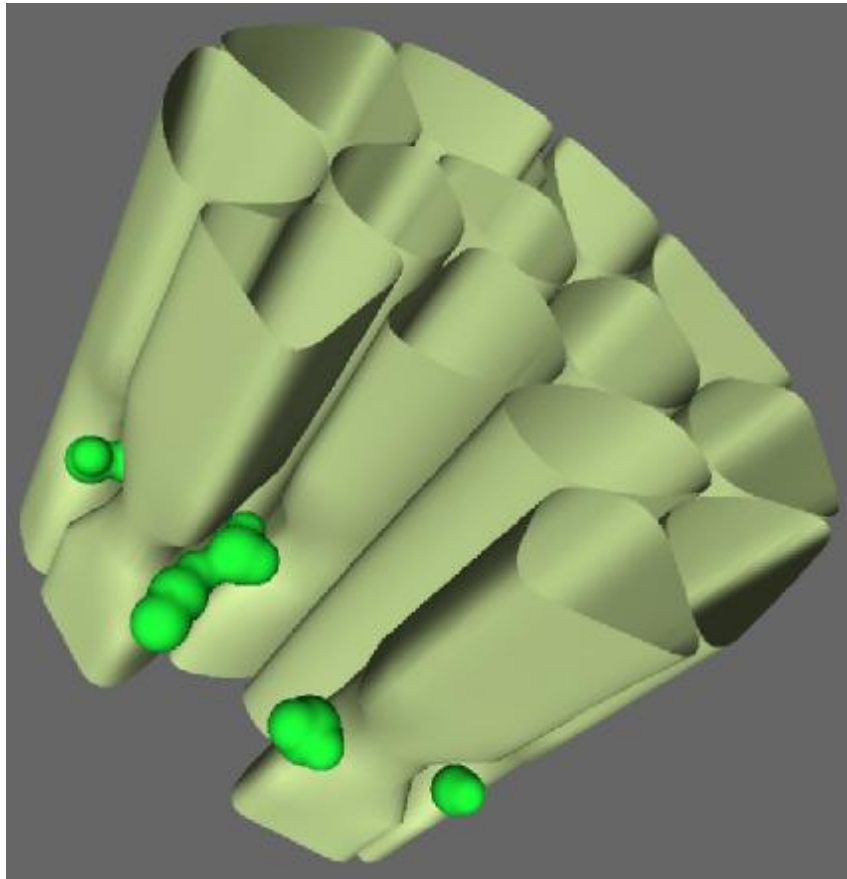


The tree refinement

Drawing and editing the skeletal primitives within a customized 2D plane in an arbitrary position



Example: Constructed in a “minute”



Current work

- Binding the solids
 - Projecting skeletal elements (points, lines) on the iso-surface in a specified distance
 - Tight relationship of two distinct F-rep objects (extended space mapping)

