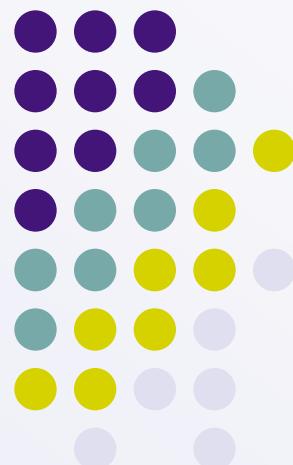




Introdução à Computação Gráfica

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Aula #10

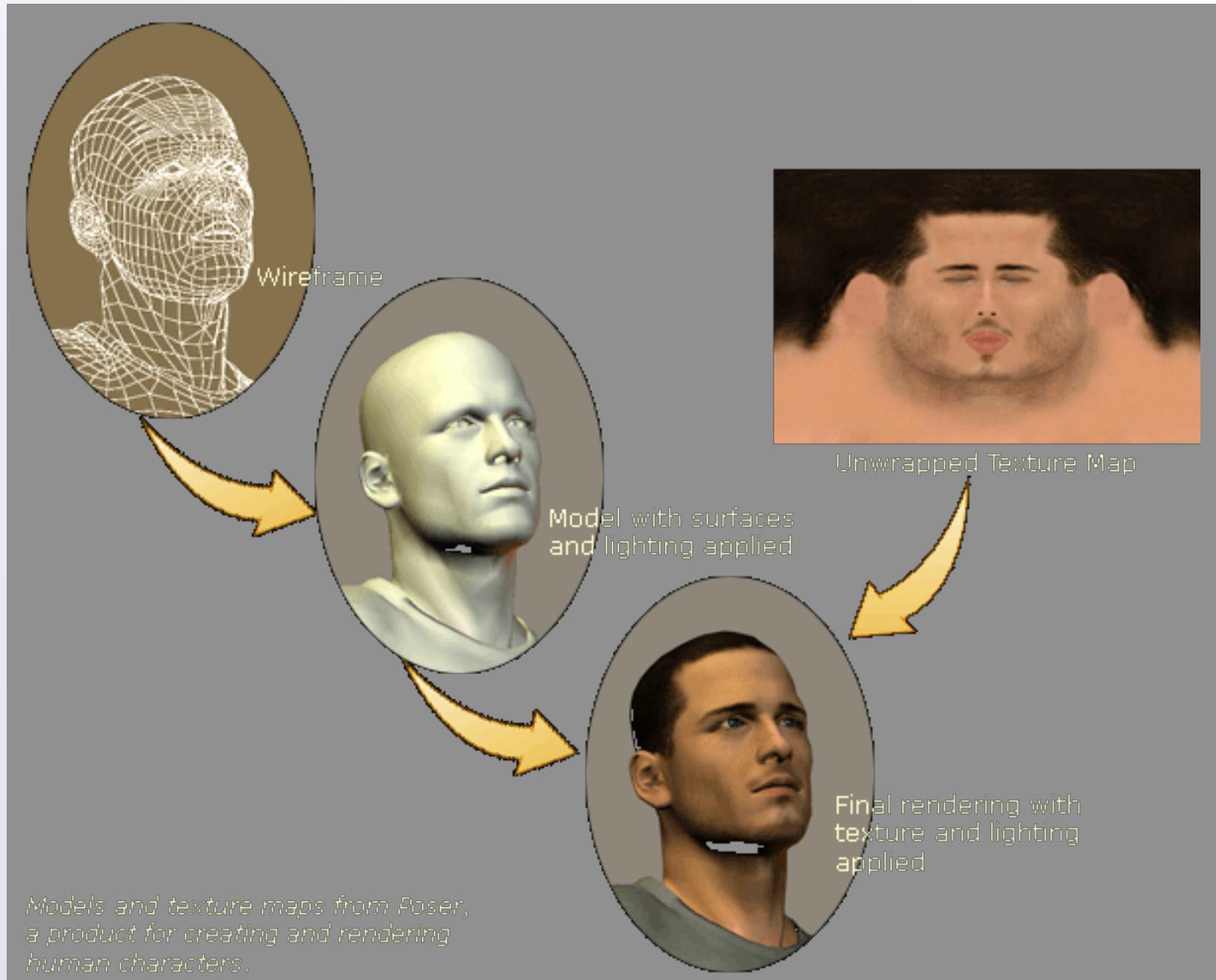


Objetivos

- Mapeamentos de textura
 - Cilíndrico
 - Esférico
 - Generalizado
- Espaço de parâmetros
 - Atribuição de valores para s e t
 - Método de subdivisão de superfícies

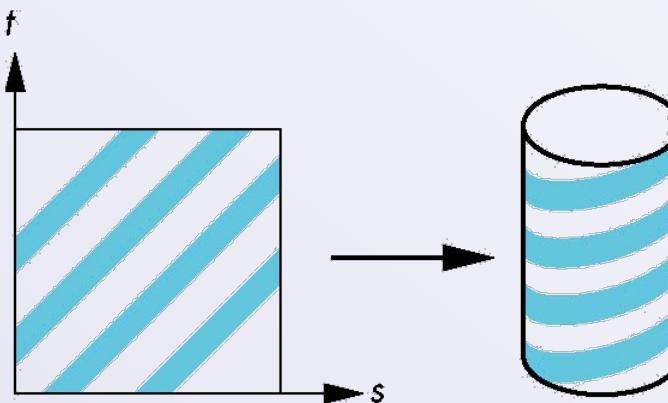
Demo Nate Robins

- texture.c



Mapeamento intermediário

- Uma solução ao problema é primeiro mapear a textura para uma superfície intermediária mais simples
- Exemplo: cilindro



Mapeamento cilíndrico

Equações paramétricas de um cilindro

$$x = r \cos(2\pi u)$$

$$y = r \sin(2\pi u)$$

$$z = v h$$

Mapeia um retângulo no espaço u, v em $[0, 1]$ para um cilindro de raio r e altura h em coordenadas do universo

$$s = u$$

$$t = v$$

Mapeamento esférico

Podemos usar uma esfera paramétrica

$$x = r \cos(\pi u)$$

$$y = r \sin(\pi u) \cos(2\pi v)$$

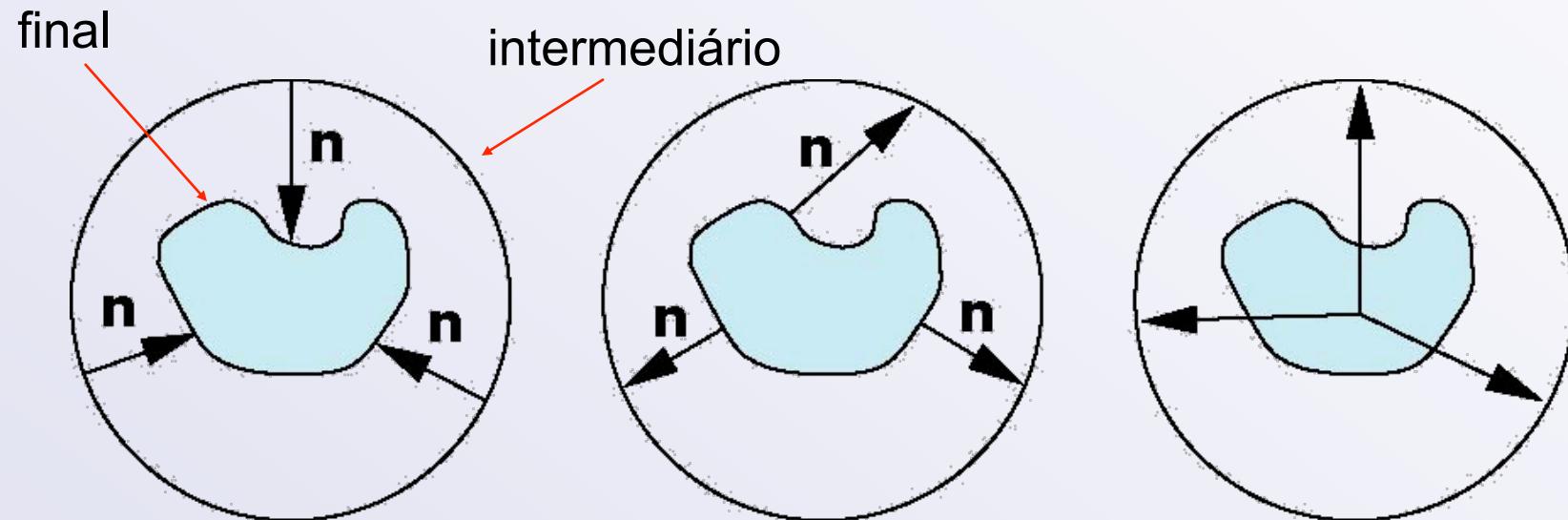
$$z = r \sin(\pi u) \sin(2\pi v)$$

de forma similar ao cilindro, mas temos
que decidir aonde inserir a distorção

Esferas são usadas em mapeamento de ambiente

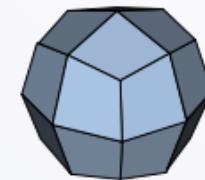
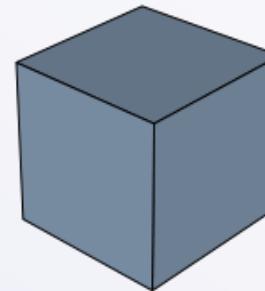
Mapeamento final

- Mapear objeto intermediário para o objeto final

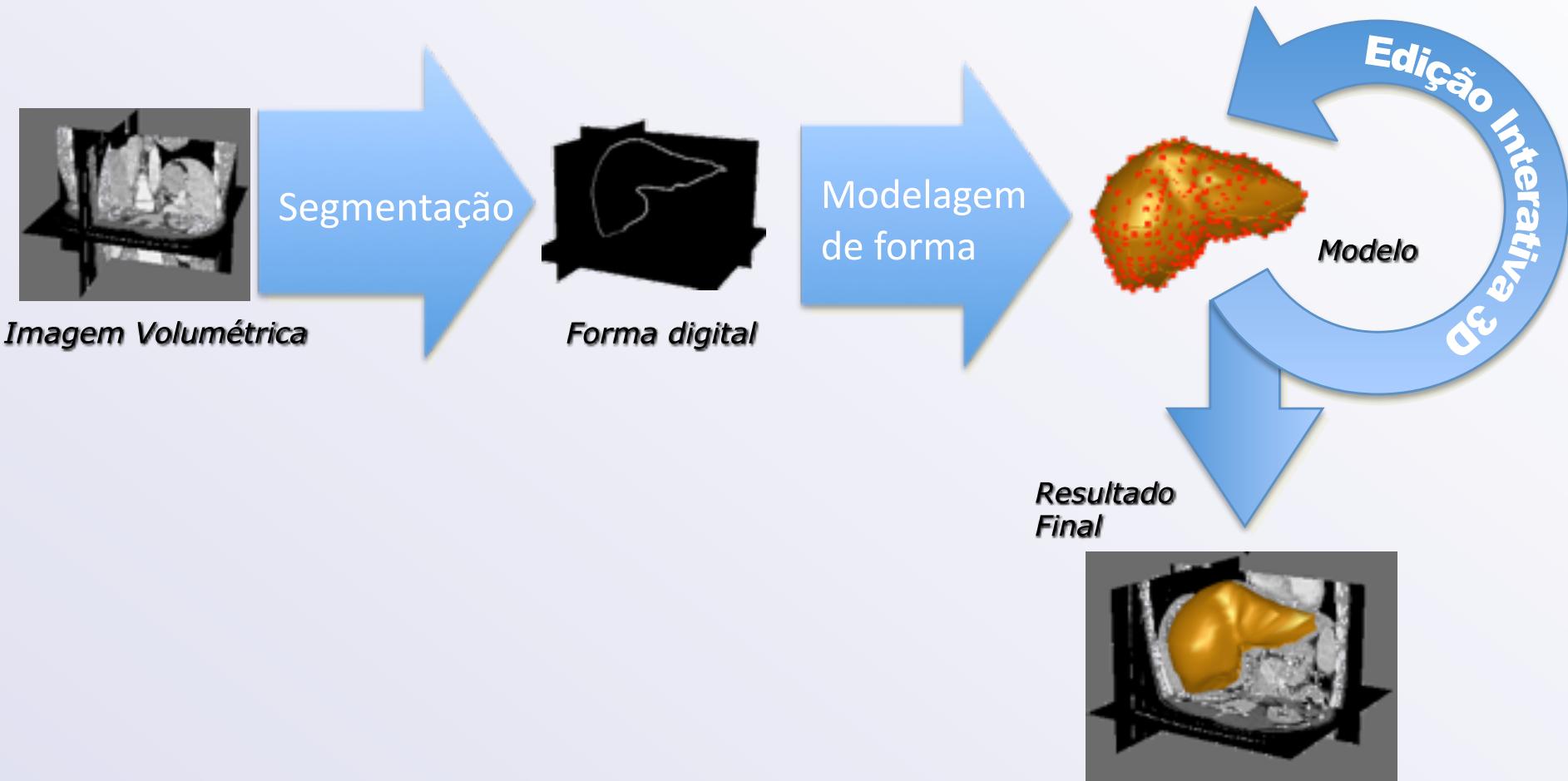


Subdivisão de superfícies

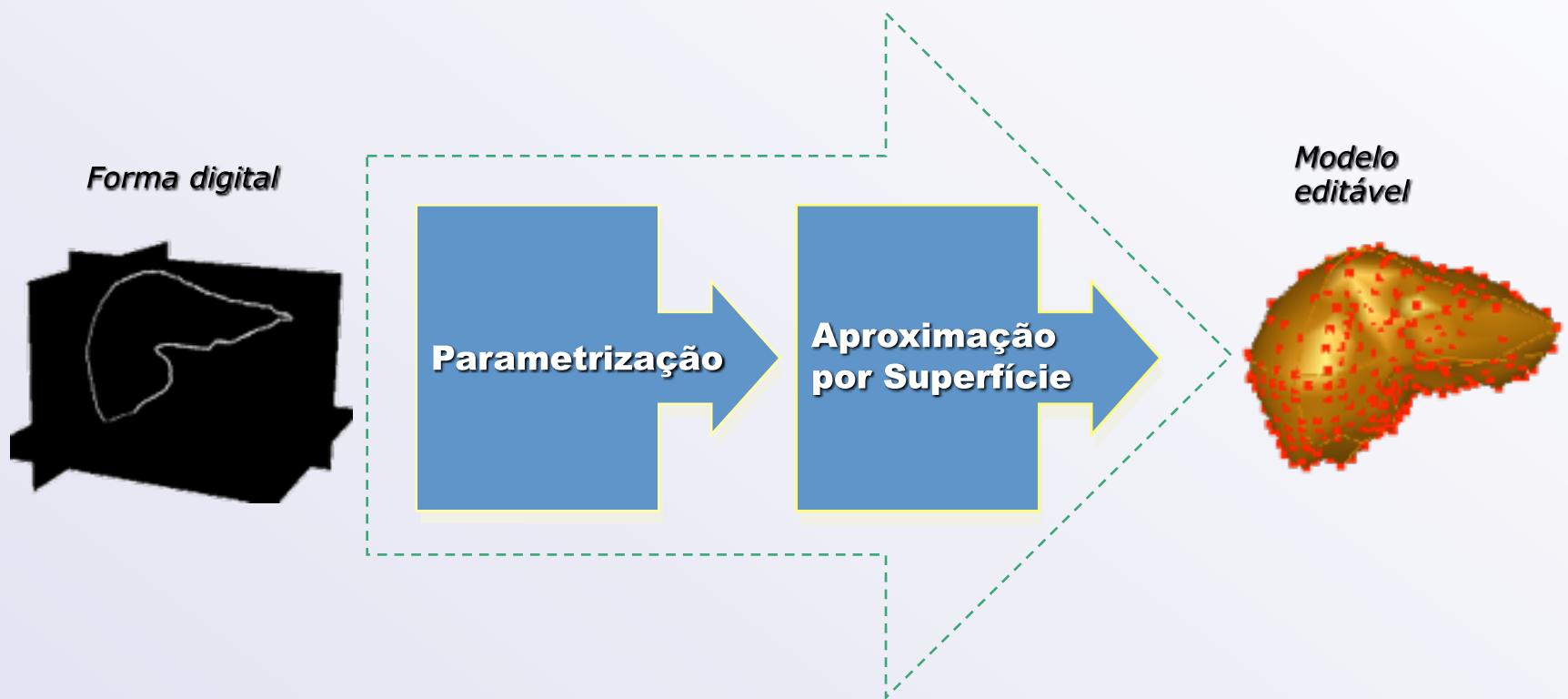
- Catmull-Clark (1978)
- Se soubermos os valores de s e t (u e v) para o poliedro limite, saberemos as coordenadas no objeto transformado.



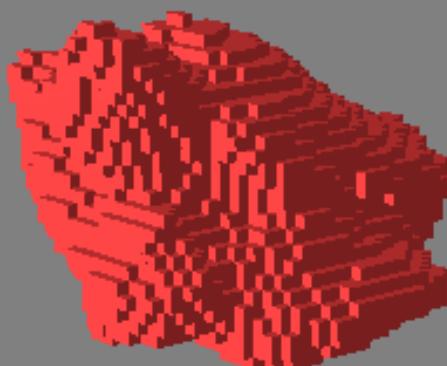
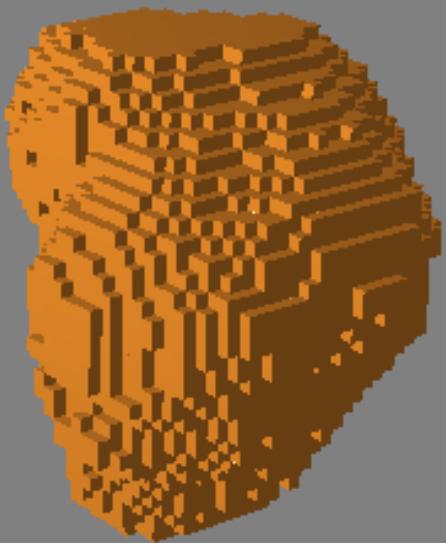
Exemplo: imagens médicas



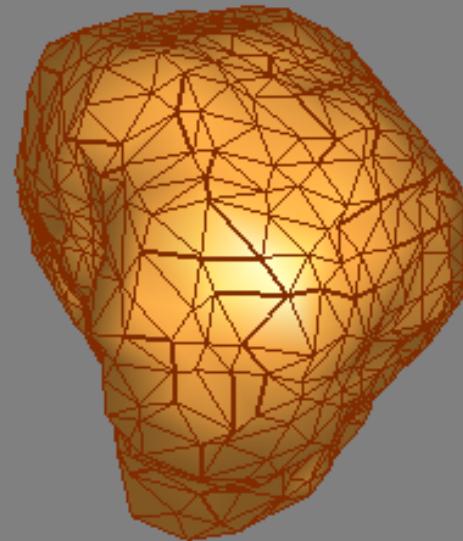
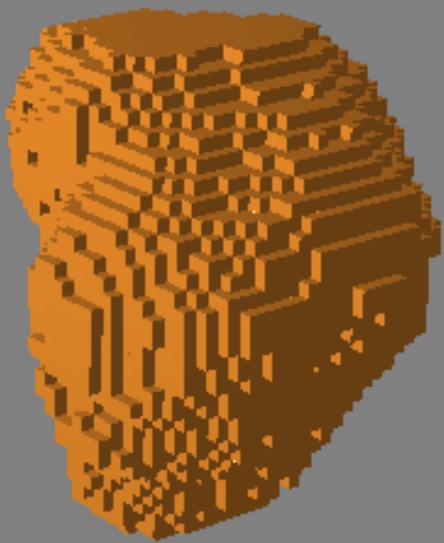
Modelagem de forma



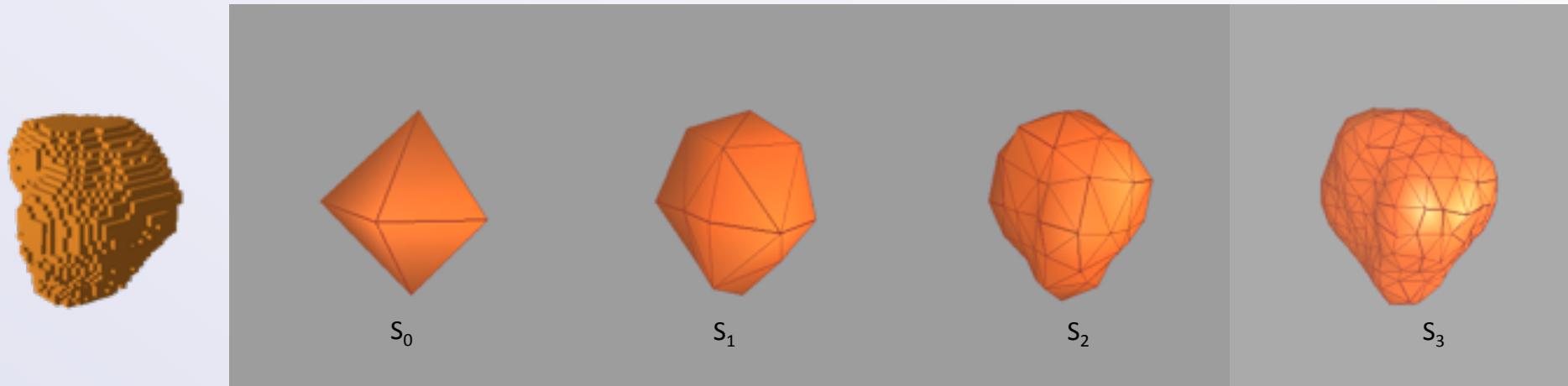
Forma digital



Malha triangular



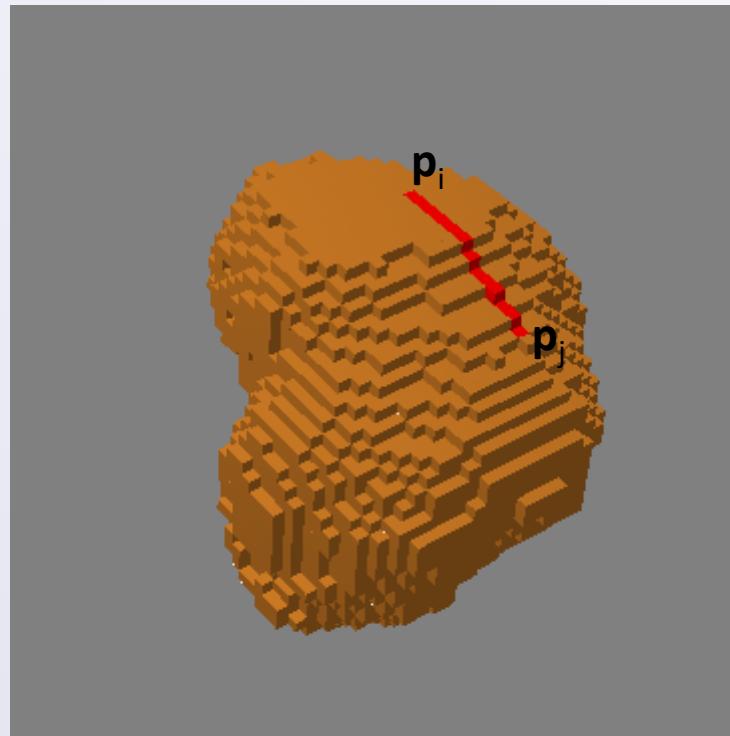
Método de subdivisão



Sucessivas subdivisões de uma forma digital

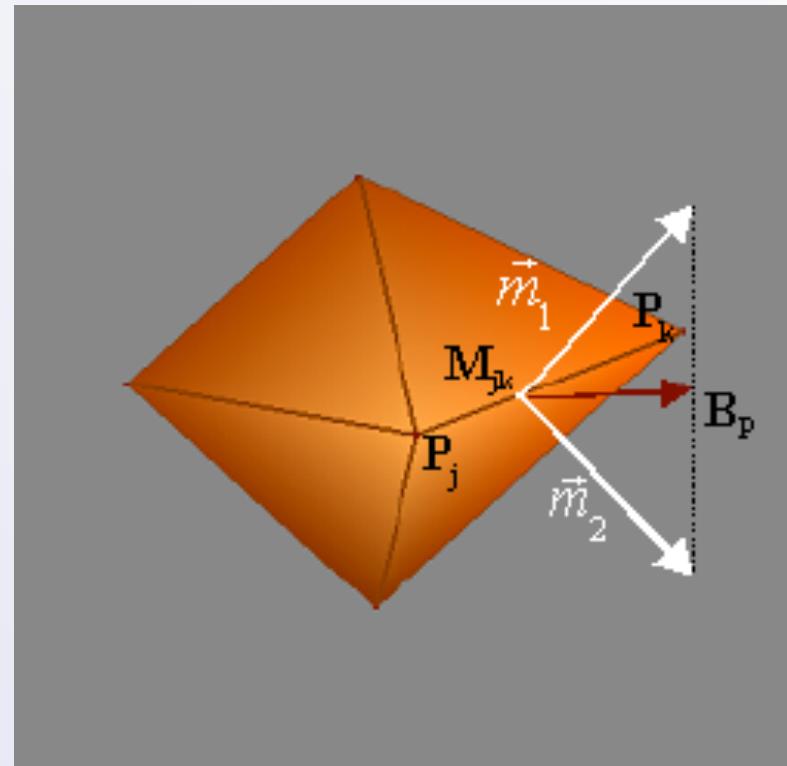
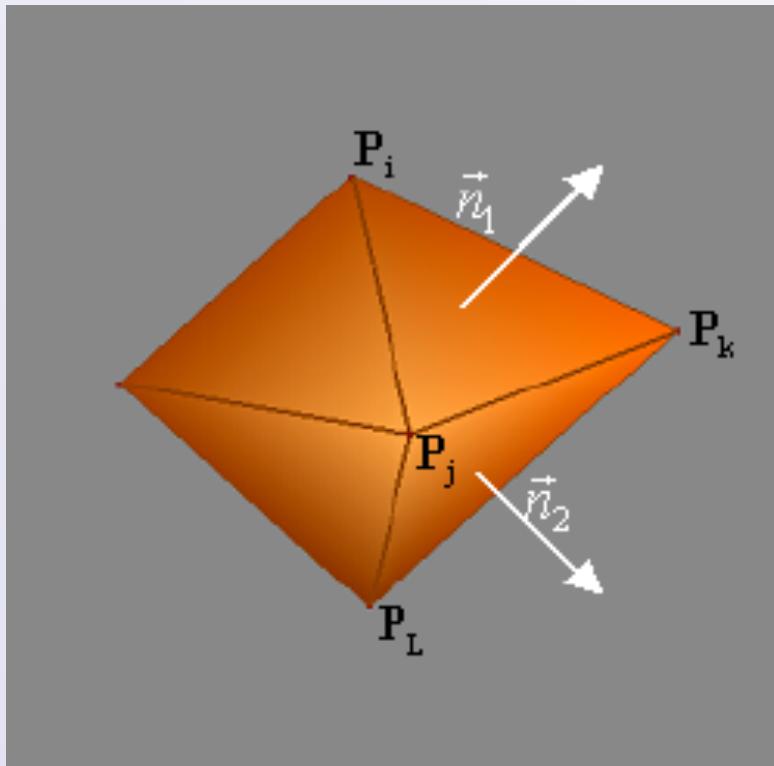
Caminho digital

- Um caminho digital é um conjunto conexo de pontos com início em p_i e fim em p_j , onde nenhum ponto é repetido e cada ponto possui somente dois vizinhos.

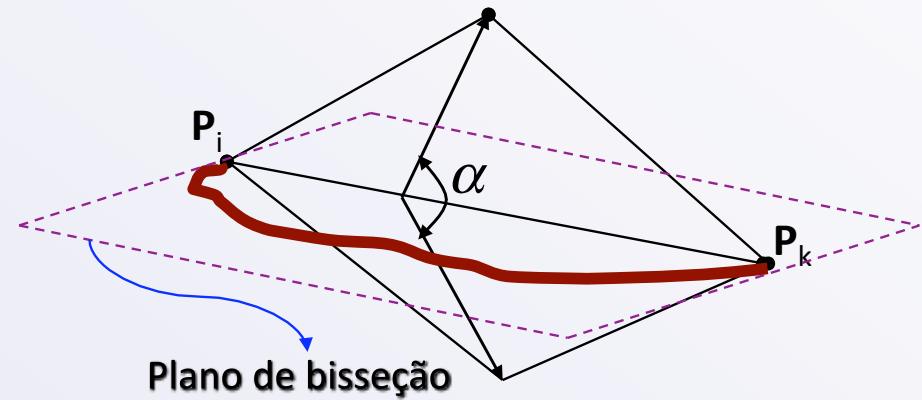
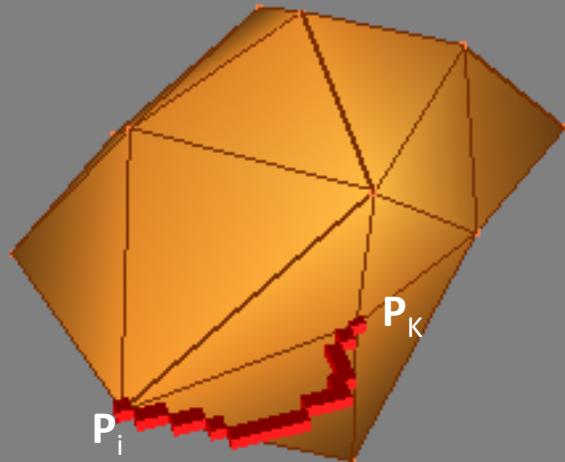


Plano bisetor

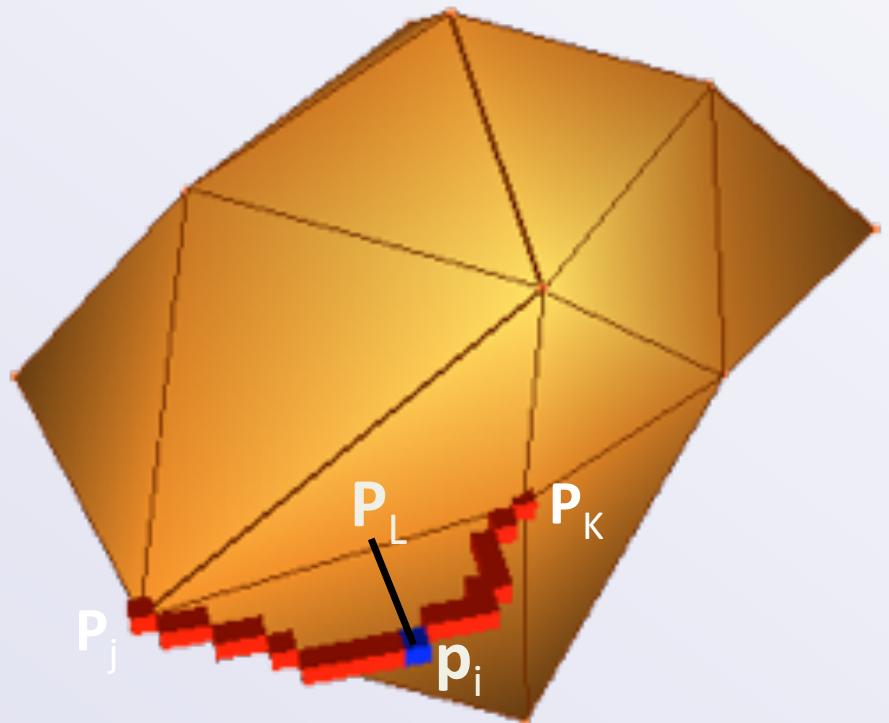
- O ponto de bisseção B_p juntamente com os vértices P_j e P_k determinam o plano de bisseção.



Contorno de aresta



Distância da aresta

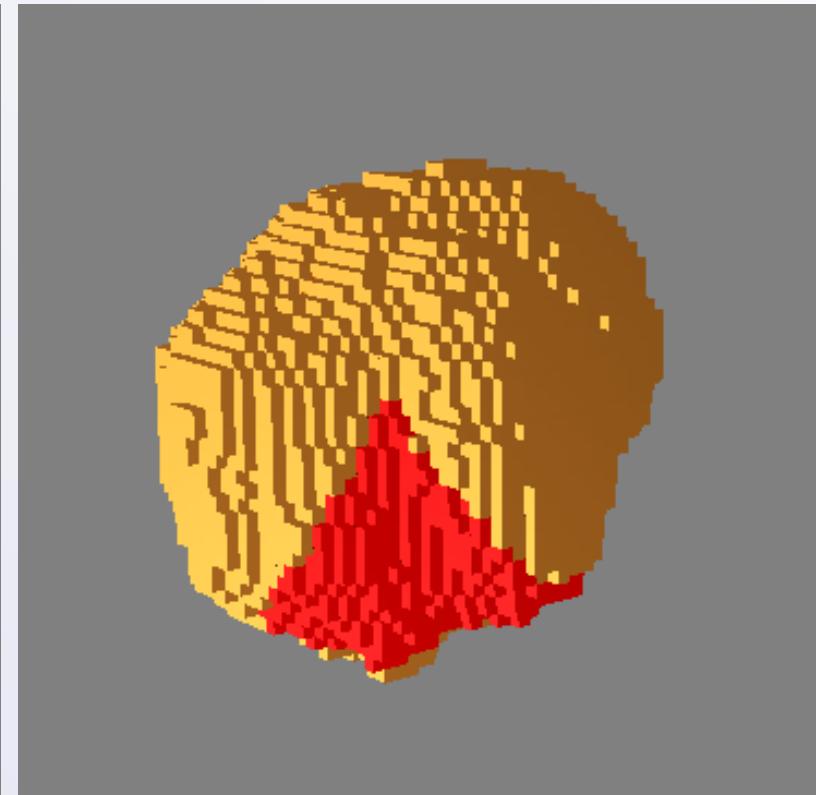
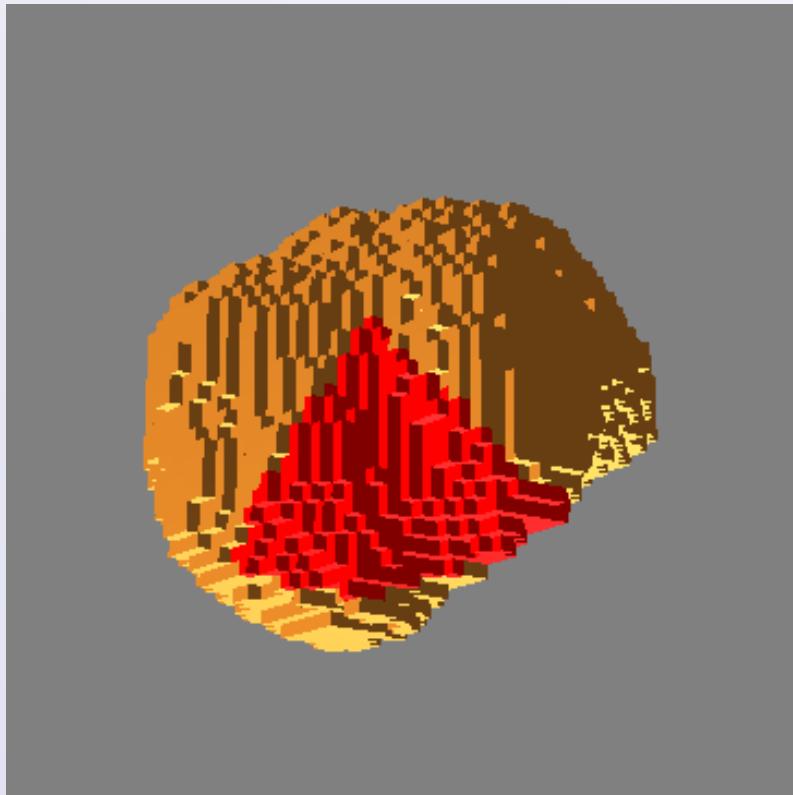


$$d_i = \|p_i - P_L\|$$

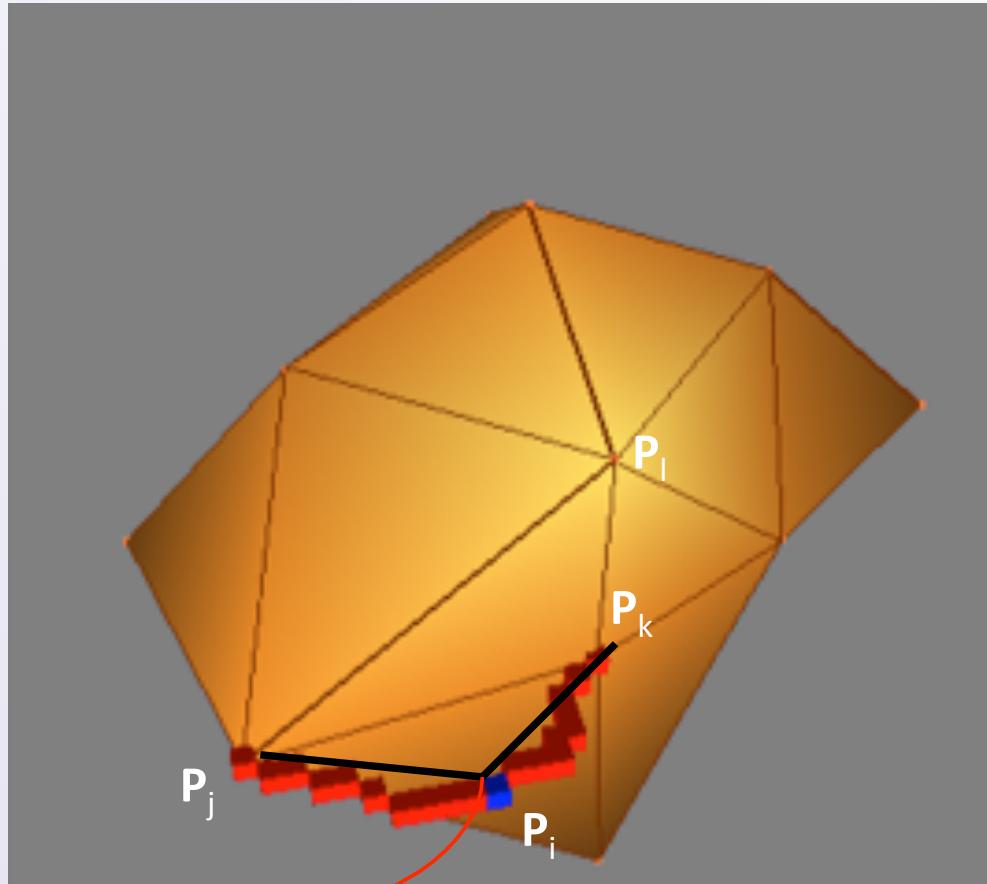
$$D_e = \max_i \{d_i\}$$

“Patch” triangular

- Um retalho triangular é um conjunto conexo de pontos delimitados por três contornos digitais.

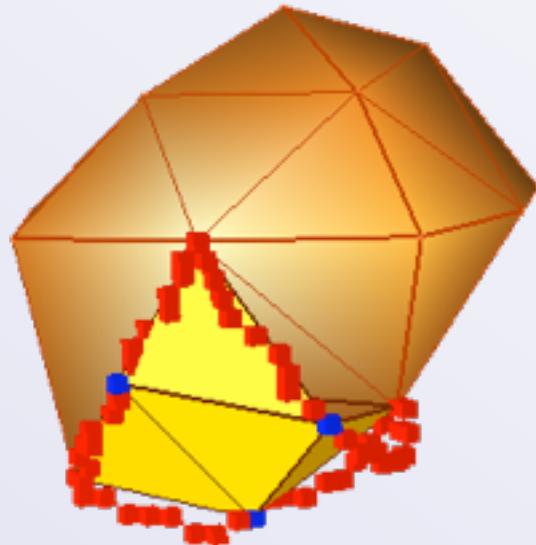


Subdivisão de arestas

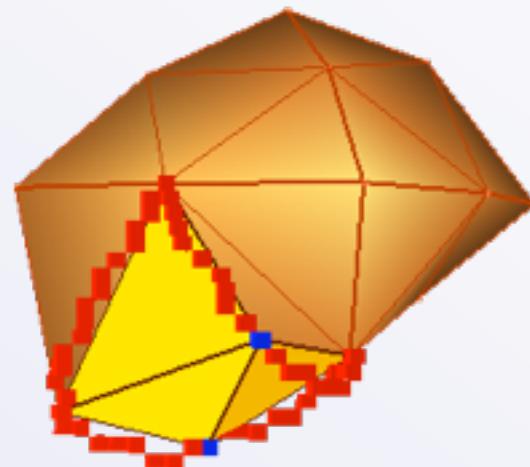


Contorno de aresta

Subdivisão triangular

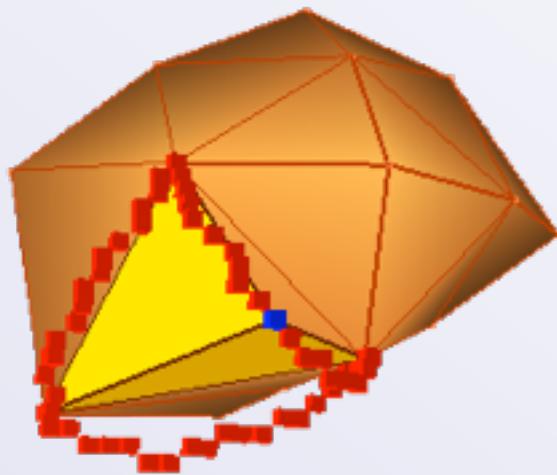


Distâncias entre as três arestas são maiores que o valor de tolerância.

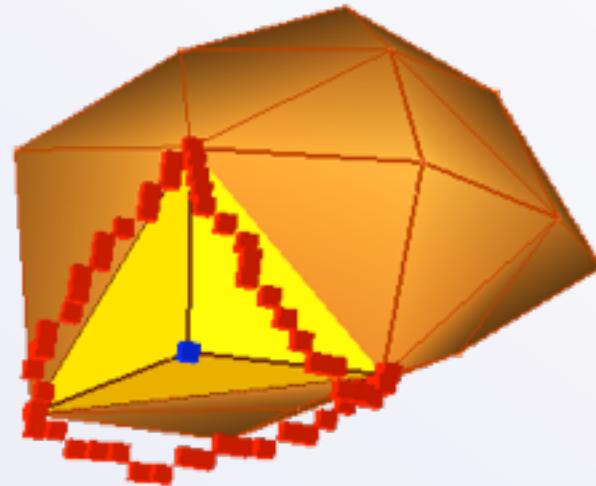


Distâncias entre as duas arestas são maiores que o valor de tolerância.

Subdivisão triangular

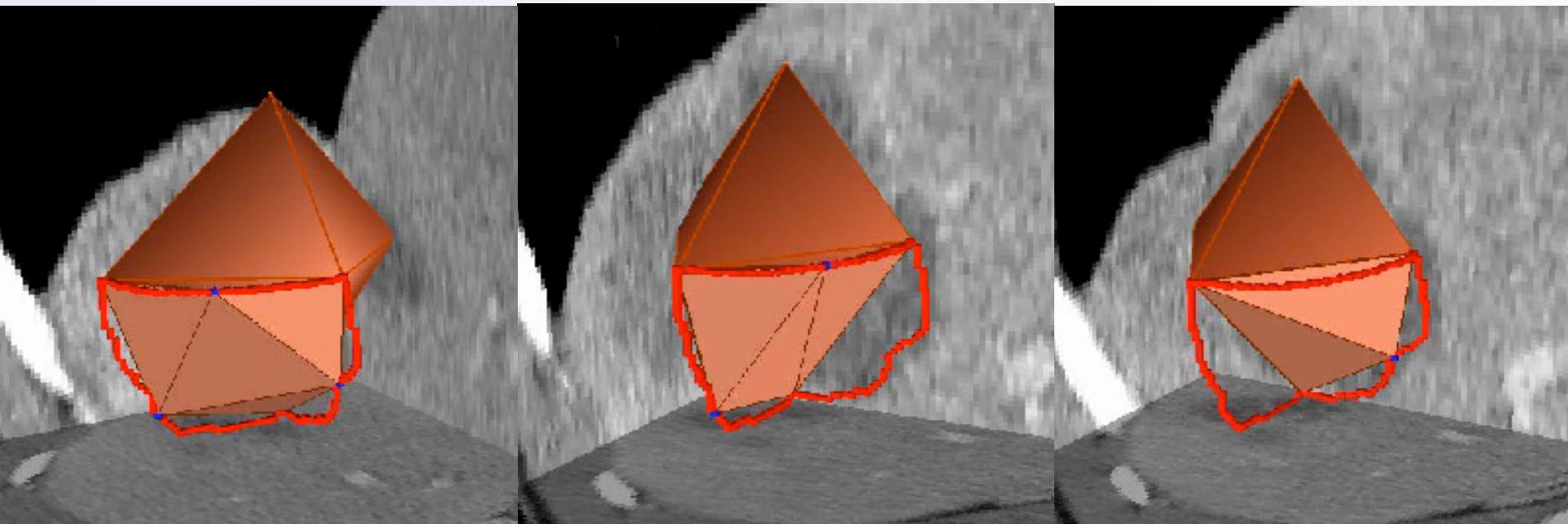


Distâncias entre uma das arestas
são maiores que o valor de
tolerância.



Distâncias entre todas as três
arestas são menores que a
tolerância, porém a distância entre
o retalho e o triângulo é maior.

Exemplo de subdivisão



4 novas faces

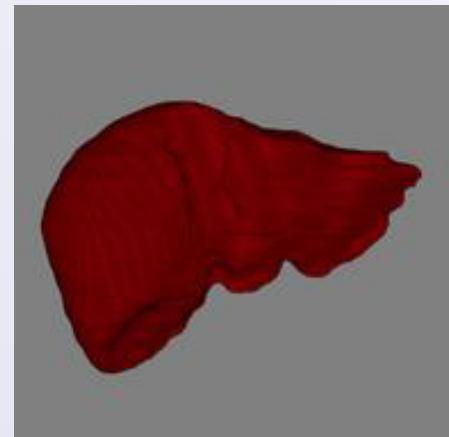
3 novas faces

2 novas faces

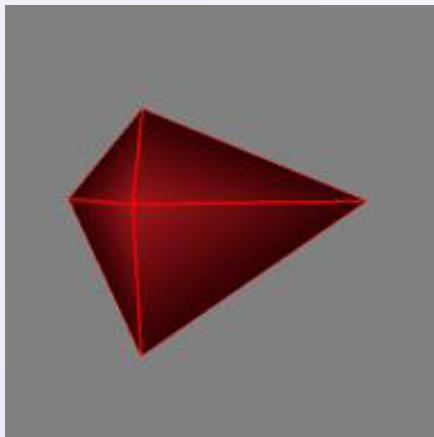
Algoritmo

- **Inicialização:**
 - Determinar os eixos principais da forma e inicializar o modelo inicial através de um octaedro.
- **Passo principal:**
 - Remova um triângulo da lista. Se a distância entre um triângulo e o retalho (“patch”) correspondente é maior que a tolerância, subdivida e insira novos triângulos na lista.
- **Critério de parada:**
 - Se a lista estiver vazia, termine a subdivisão; caso contrário retorne ao passo anterior.

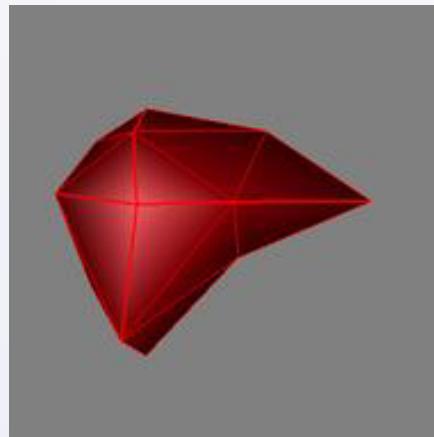
Exemplos



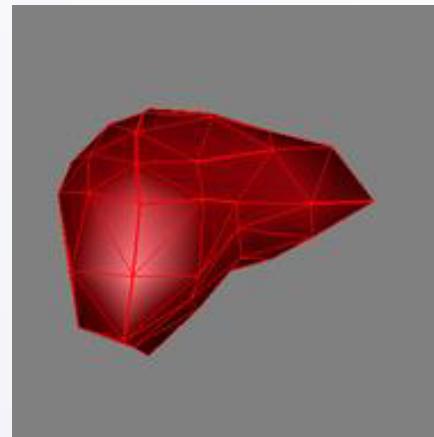
Fígado humano em forma digital (53.268 voxels).



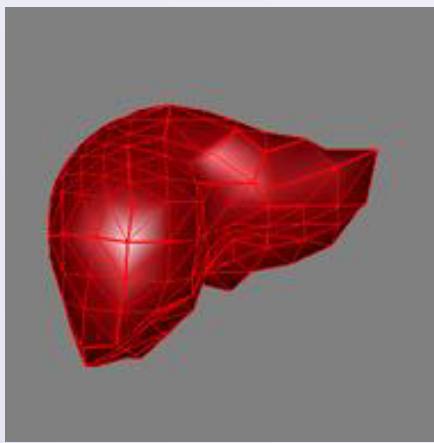
(a) $E=17.55$



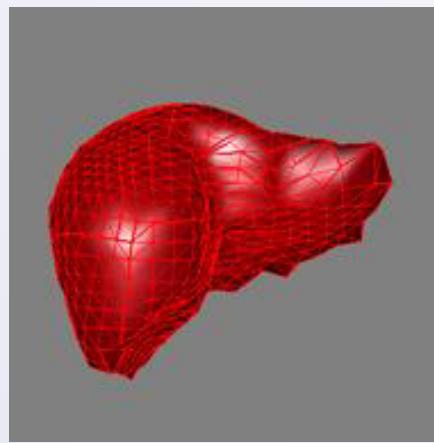
(b) $E=8.16$



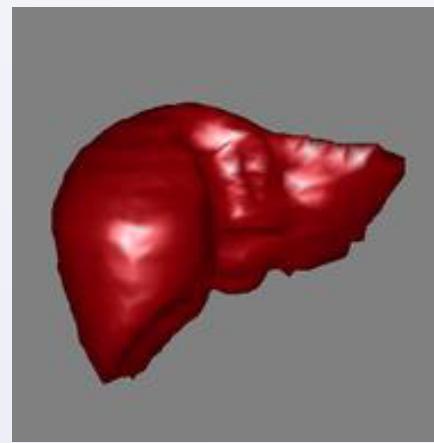
(c) $E=3.79$



(d) $E=1.95$



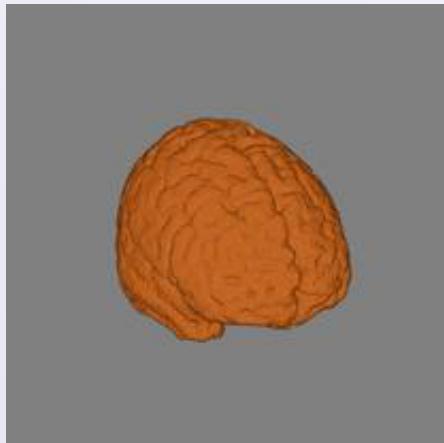
(e) $E=1.20$



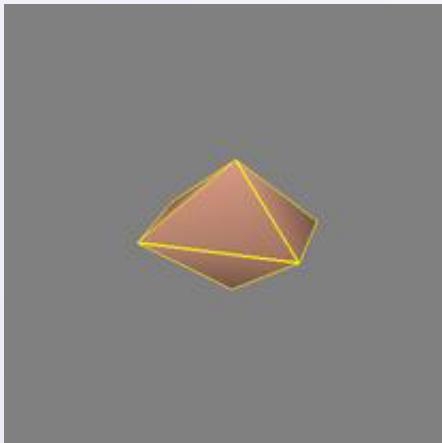
(f) $E=0.83$

Aproximação final contém 4.098 vértices e 8.192 faces triangulares. (Courtesy University of Iowa, Dr. Sonka).

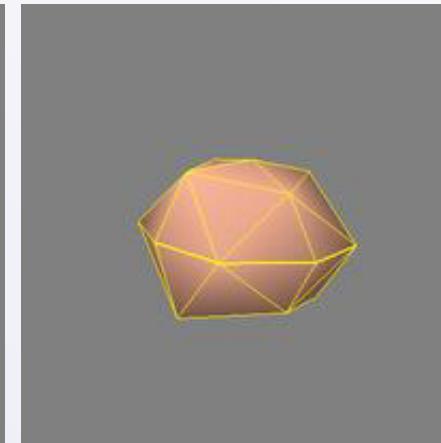
Exemplos



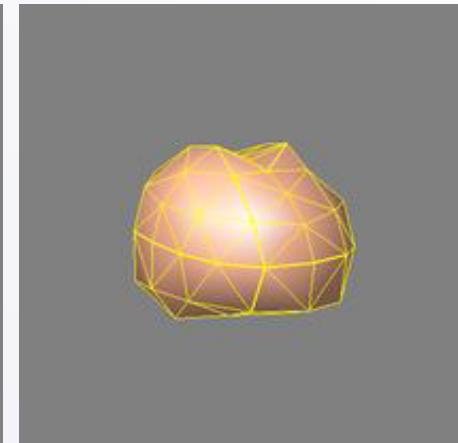
Cérebro humano em forma digital (83.815 voxels).



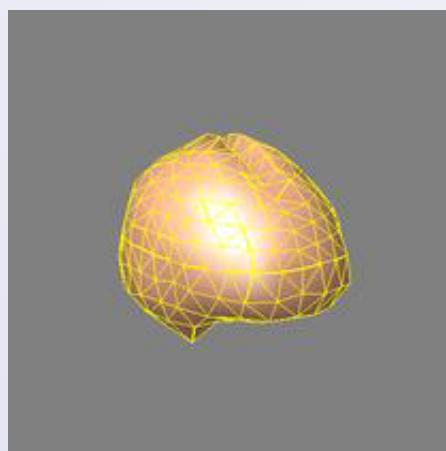
(a) $E=24.35$



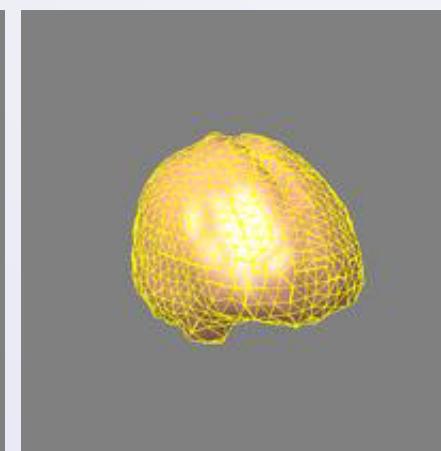
(b) $E=9.75$



(c) $E=4.28$



(d) $E=1.88$



(e) $E=1.06$



Aproximação final contém 5.828 vértices e 11.652 faces triangulares. (Courtesia da Kettering Medical Center, Dr. Martin Satter)

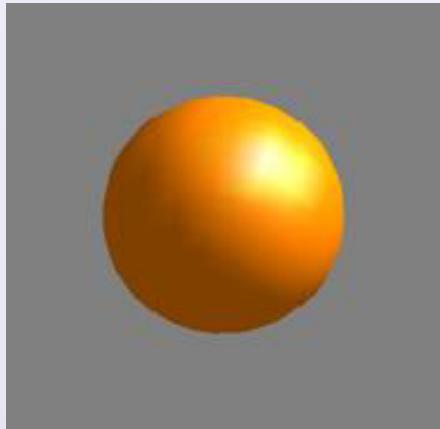
Propriedades

- Uma única subdivisão é obtida independente da orientação ou posição da forma.
- Taxa de compressão depende da complexidade da forma em questão.
- O processo automaticamente ajusta os tamanhos dos triângulos para reproduzir detalhes da forma.

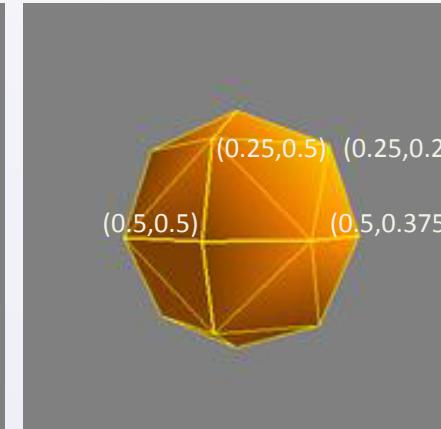
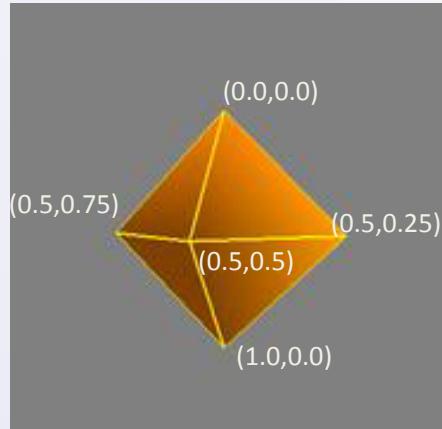
E a parametrização ?

- Para parametrizar vértices da malha, parâmetros do octaedro aproximando a forma são inicialmente determinados.
- A medida que a malha que aproxima a forma é subdividida, cada triângulo correspondente na esfera também é, e parâmetros nos novos pontos serão conhecidos.
- Assim, o processo de subdivisão facilita o cálculo dos parâmetros dos vértices da malha triangular que aproxima a forma digital.

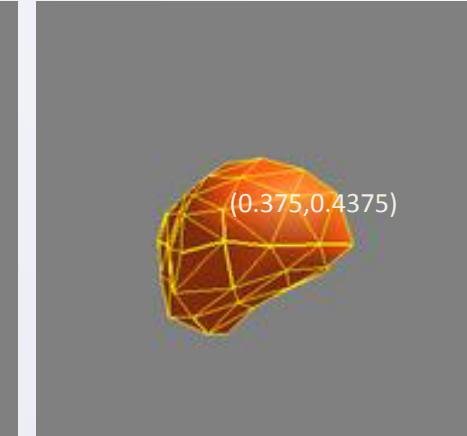
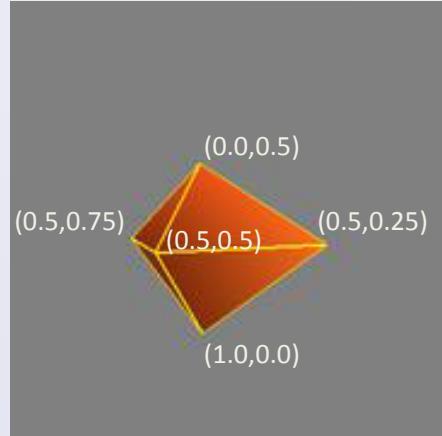
Exemplo de parametrização



esfera



forma digital



Superfícies gaussianas (RaGs)

Assumindo que os vértices obtidos pela subdivisão são representados por P_i

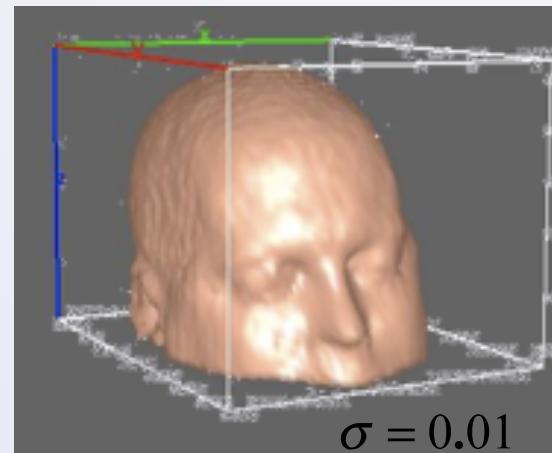
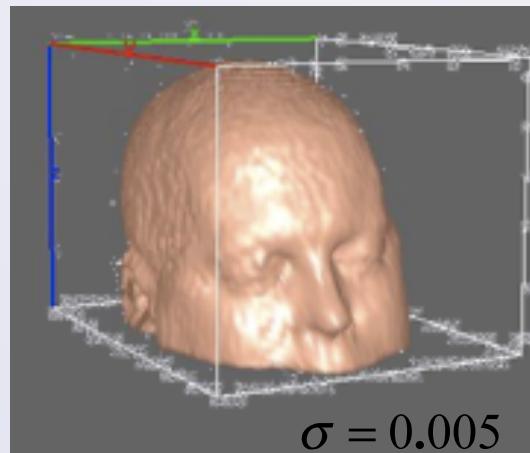
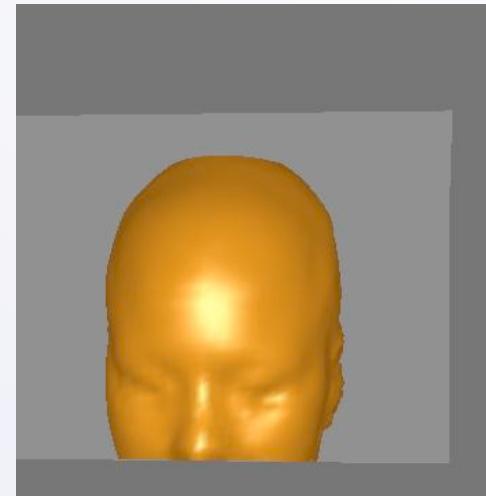
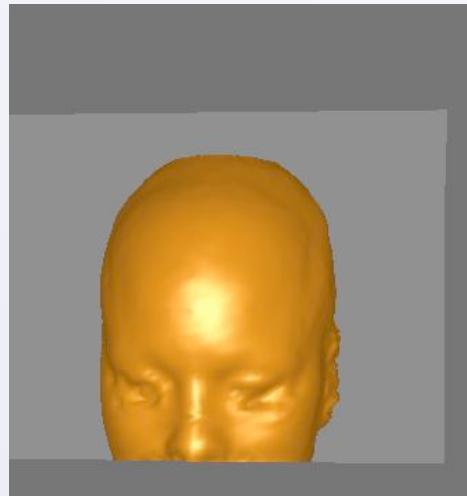
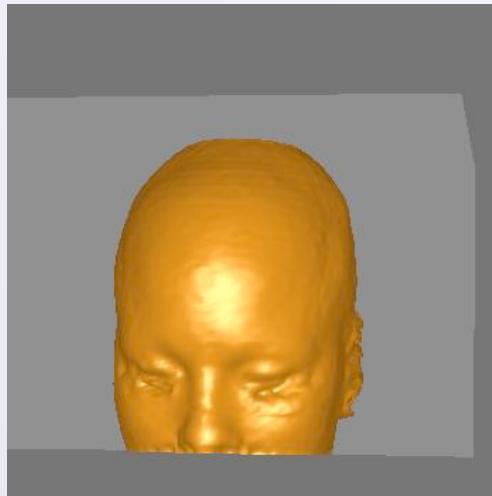
- Uma superfície RaG é definida por

$$P(u, v) = \sum_{i=1}^N P_i g_i(u, v),$$

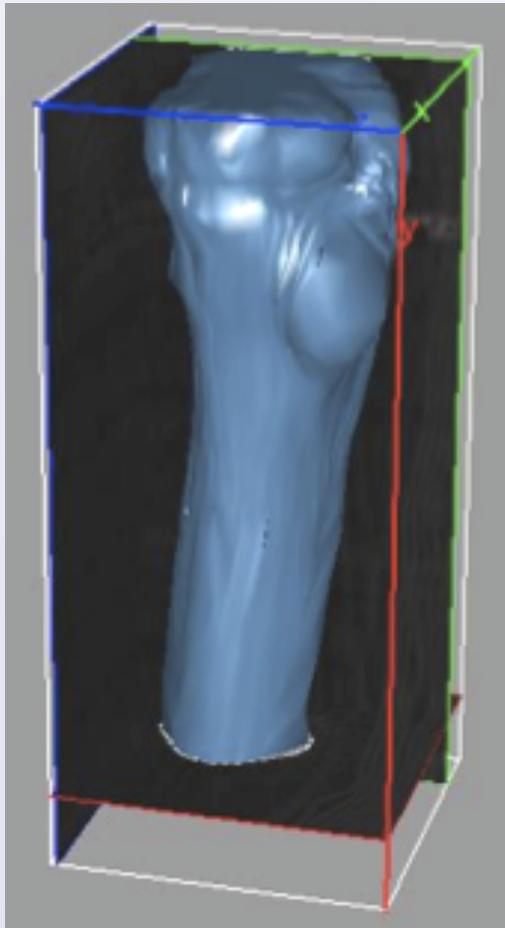
$$g_i(u, v) = \frac{G_\phi(u - u_i, v - v_i)}{\sum_{j=1}^N G_\phi(u - u_i, v - v_j)}$$

- Onde G é uma Gaussiana (com altura unitária) em 2D centralizada em cada ponto de controle.

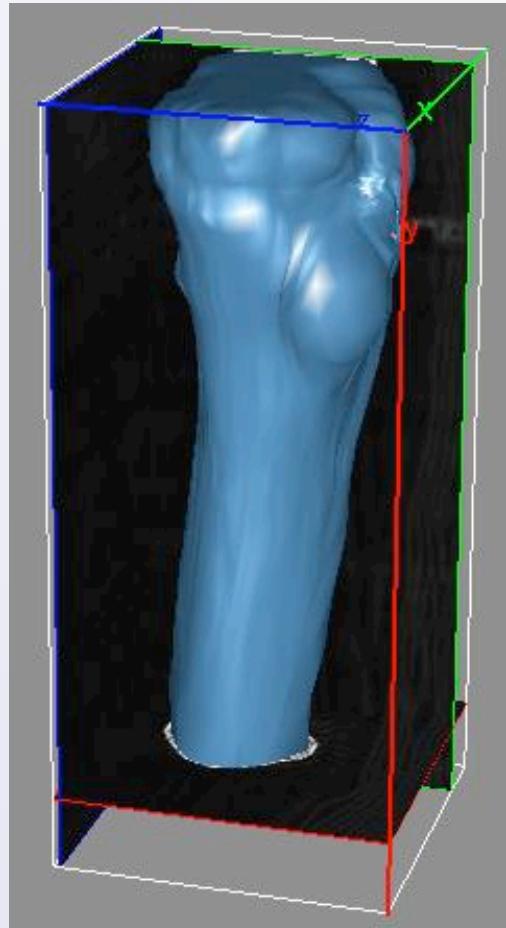
Exemplo



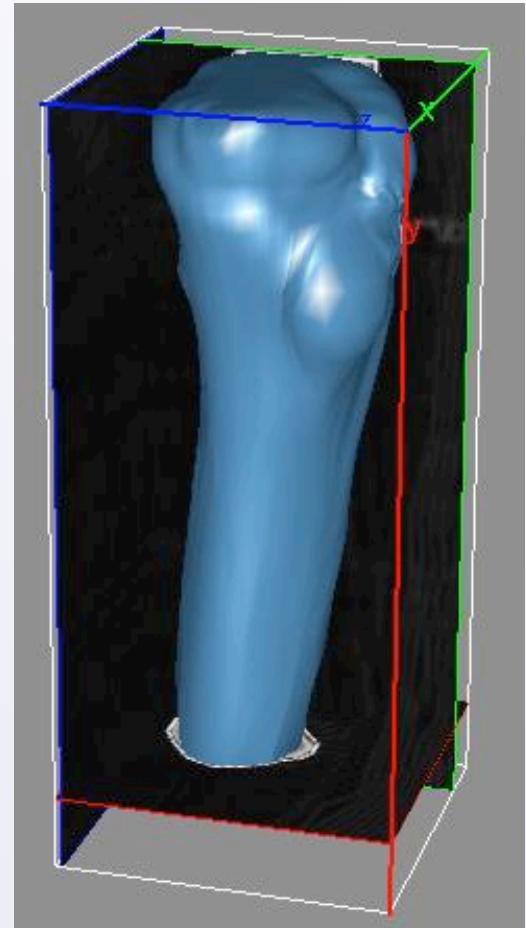
Exemplo



$$\sigma = 0.001$$



$$\sigma = 0.005$$



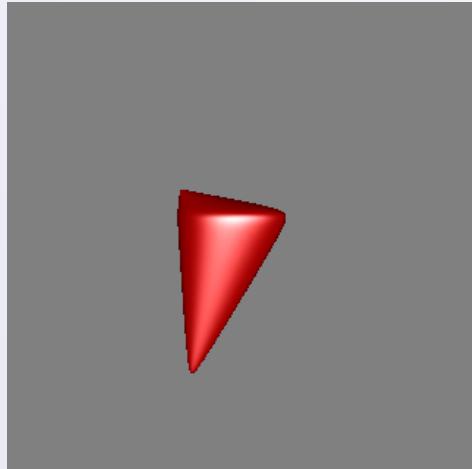
$$\sigma = 0.01$$

$$V=2601, F=3187, E=1.024$$

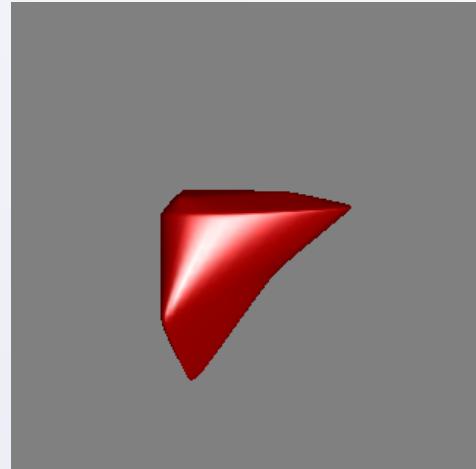
Aproximação via RaGs

- Já que sabemos os parâmetros de todos os pontos, para cada ponto \mathbf{p}_i podemos determinar o ponto correspondente na superfície $\mathbf{P}(\mathbf{u}_i, \mathbf{v}_i)$.
- Substituímos a tolerância $D_e = \max_i \{d_i\}$ por $D_T = \max_i \|\mathbf{P}(u_i, v_i) - \mathbf{p}_i\|$
- Desta forma obteremos um novo algoritmo que aproxima uma forma digital através de uma superfície RaG, com uma tolerância desejada.

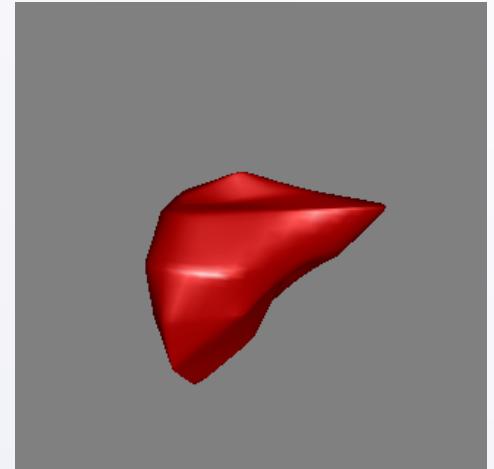
Resultados via RaG



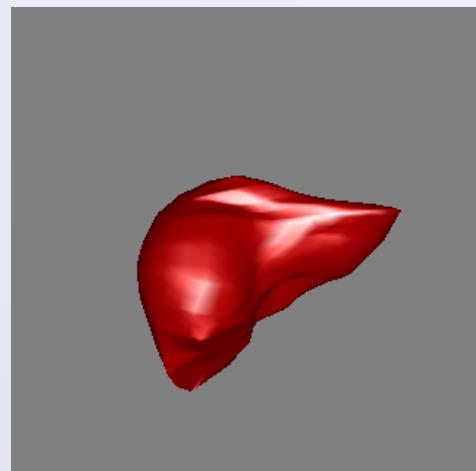
(a) $E=26.5$



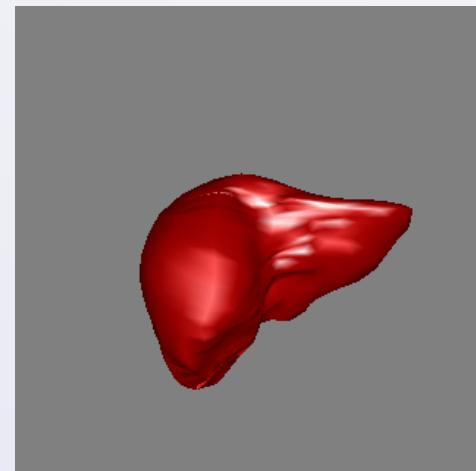
(b) $E=13.0$



(c) $E=6.25$



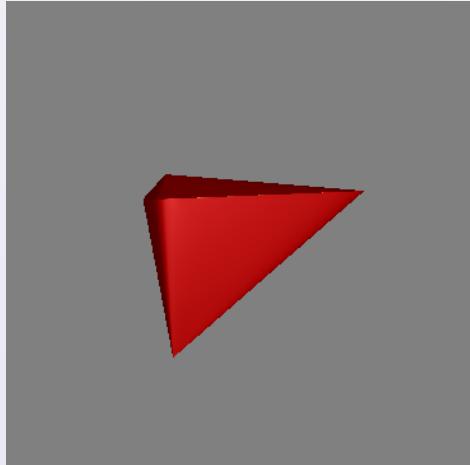
(d) $E=2.95$



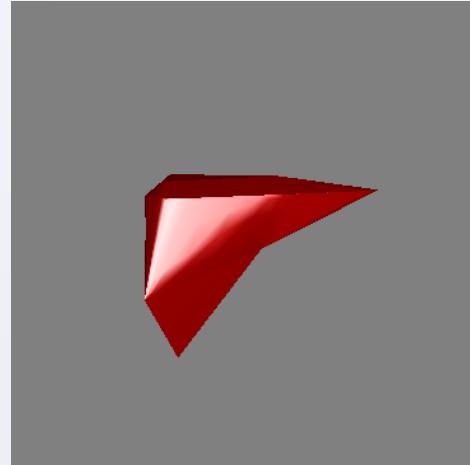
(e) $E=1.37$

$s_0=0.2$

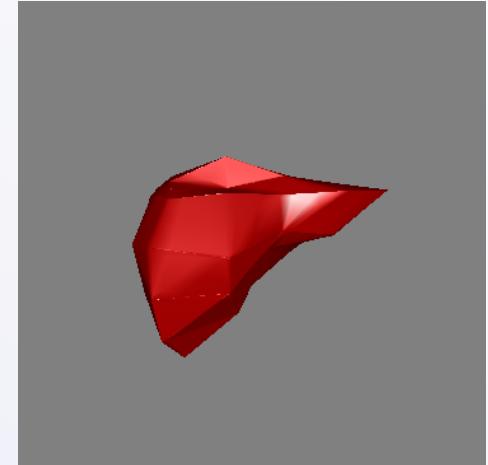
Exemplo



(a) $E=10.79$

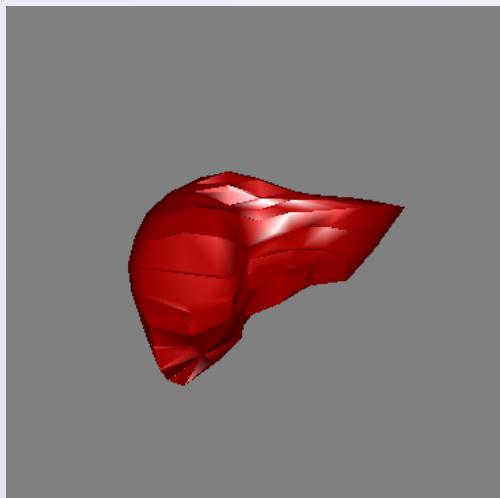


(b) $E=8.97$

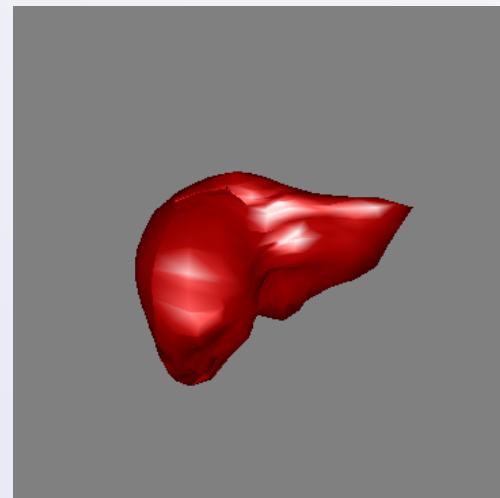


(c) $E=4.78$

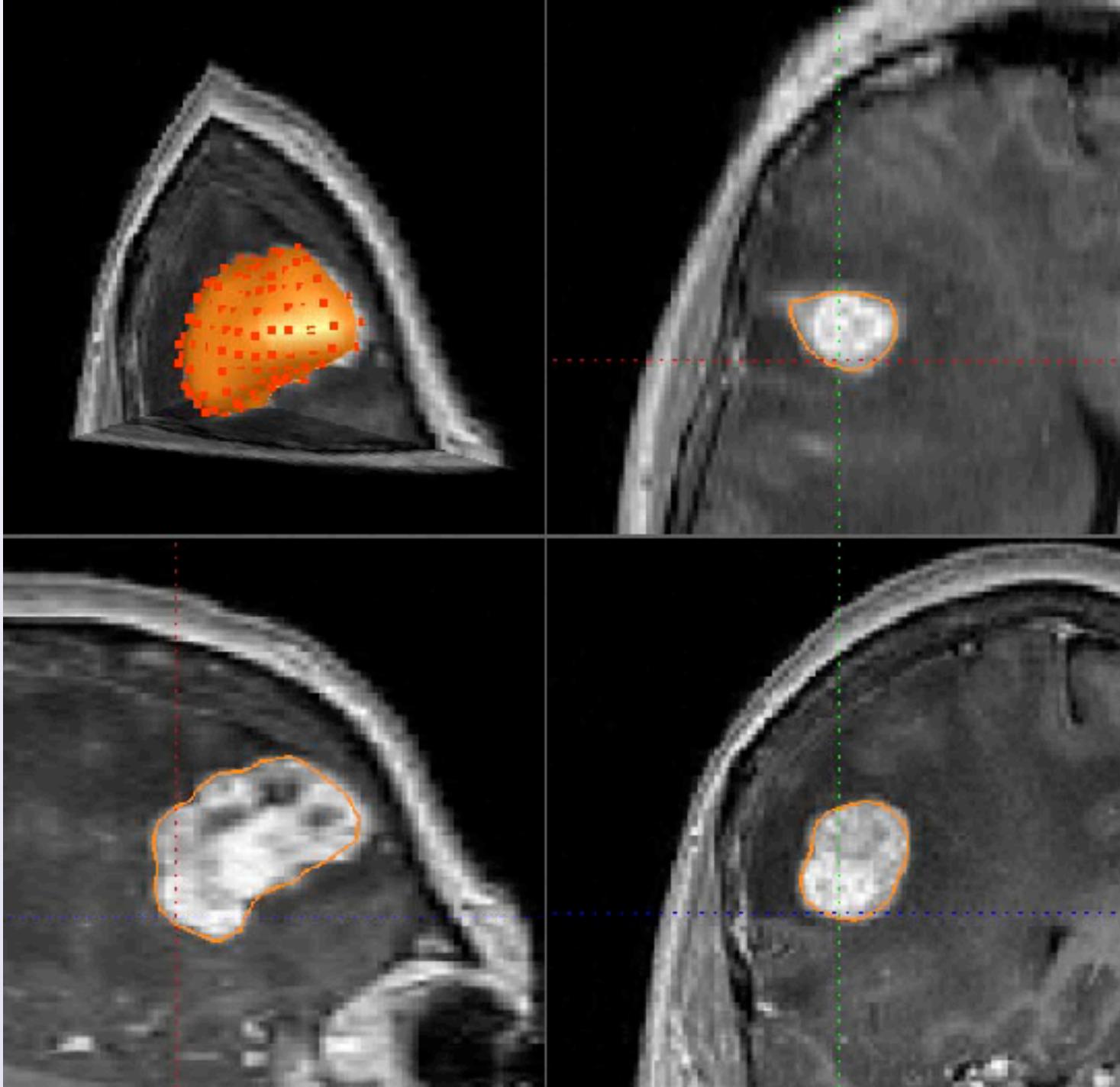
$s_0=0.1$

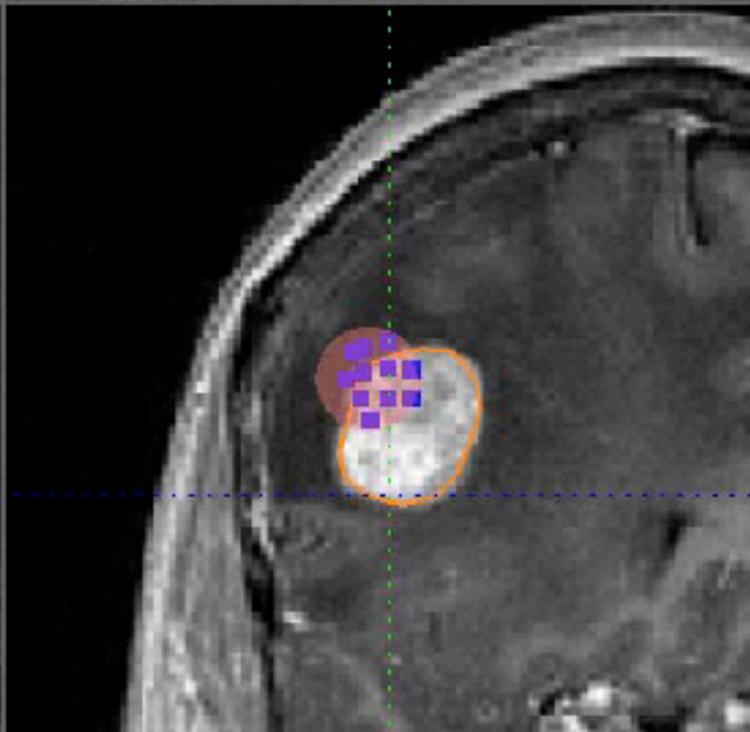
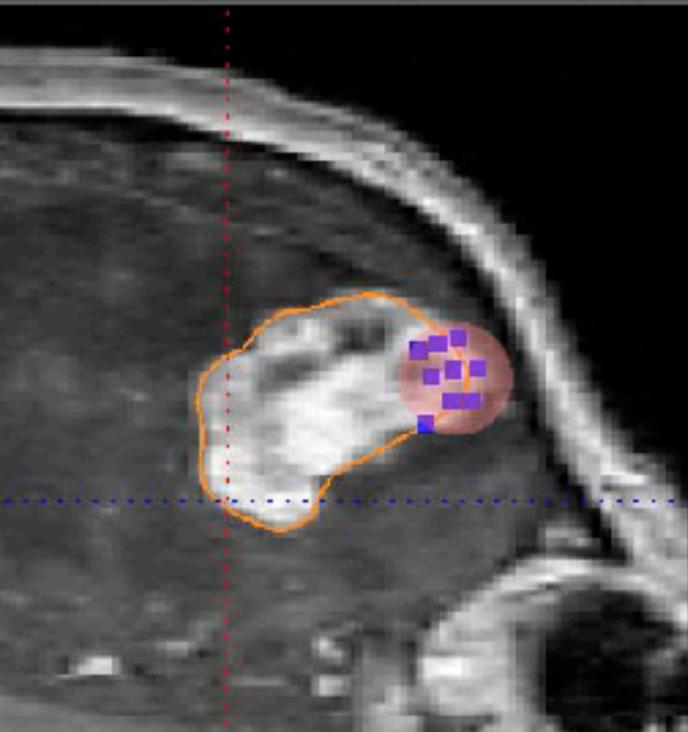
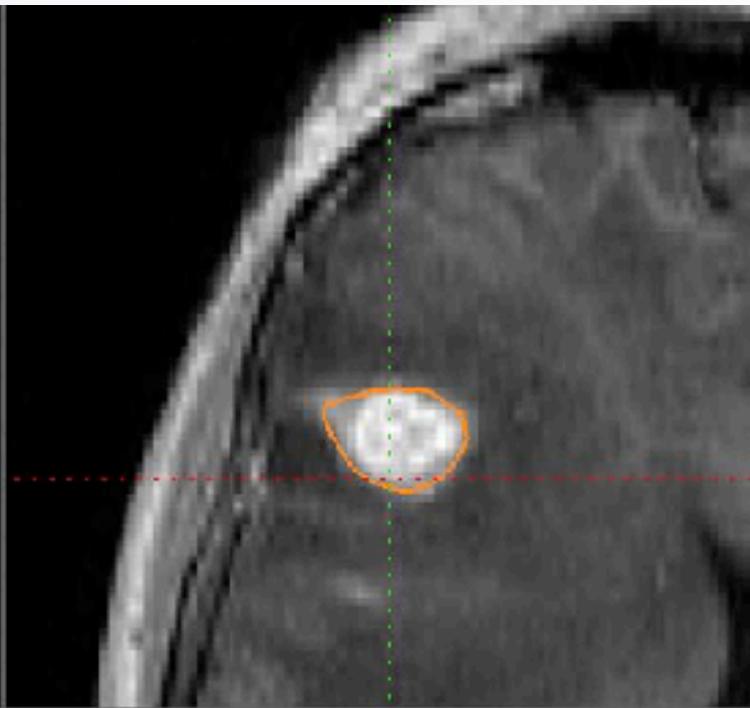
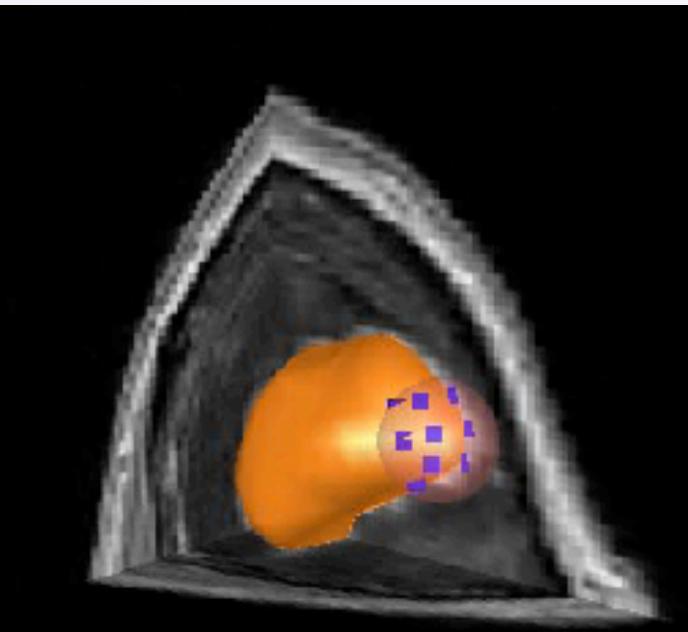


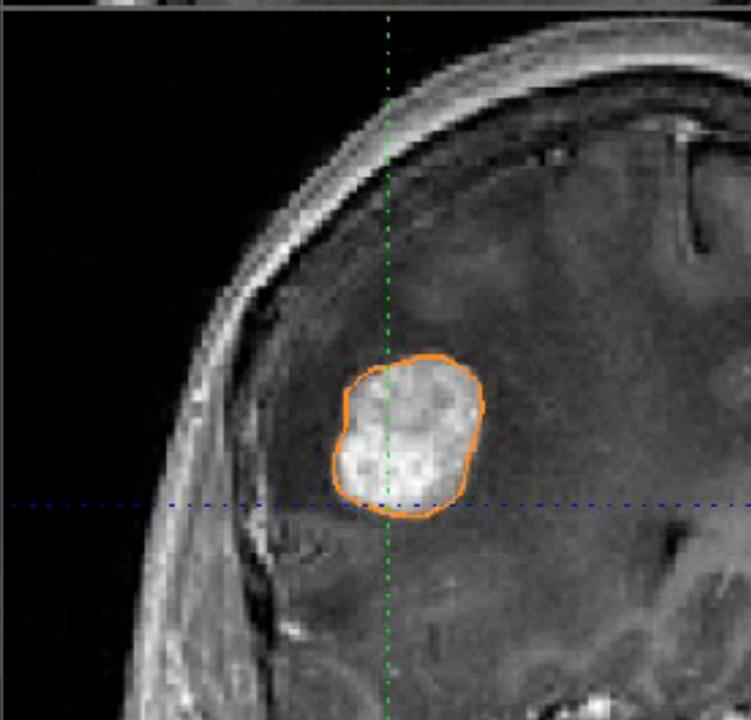
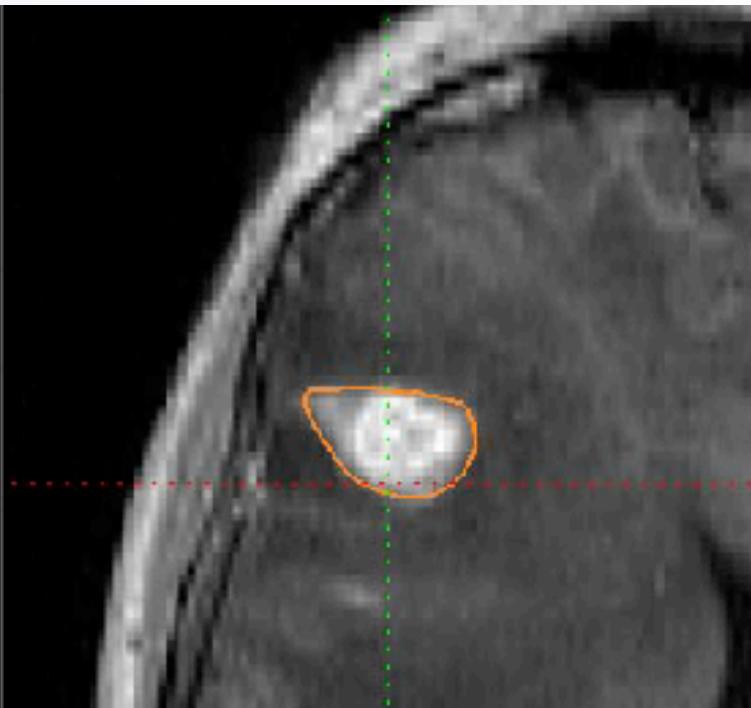
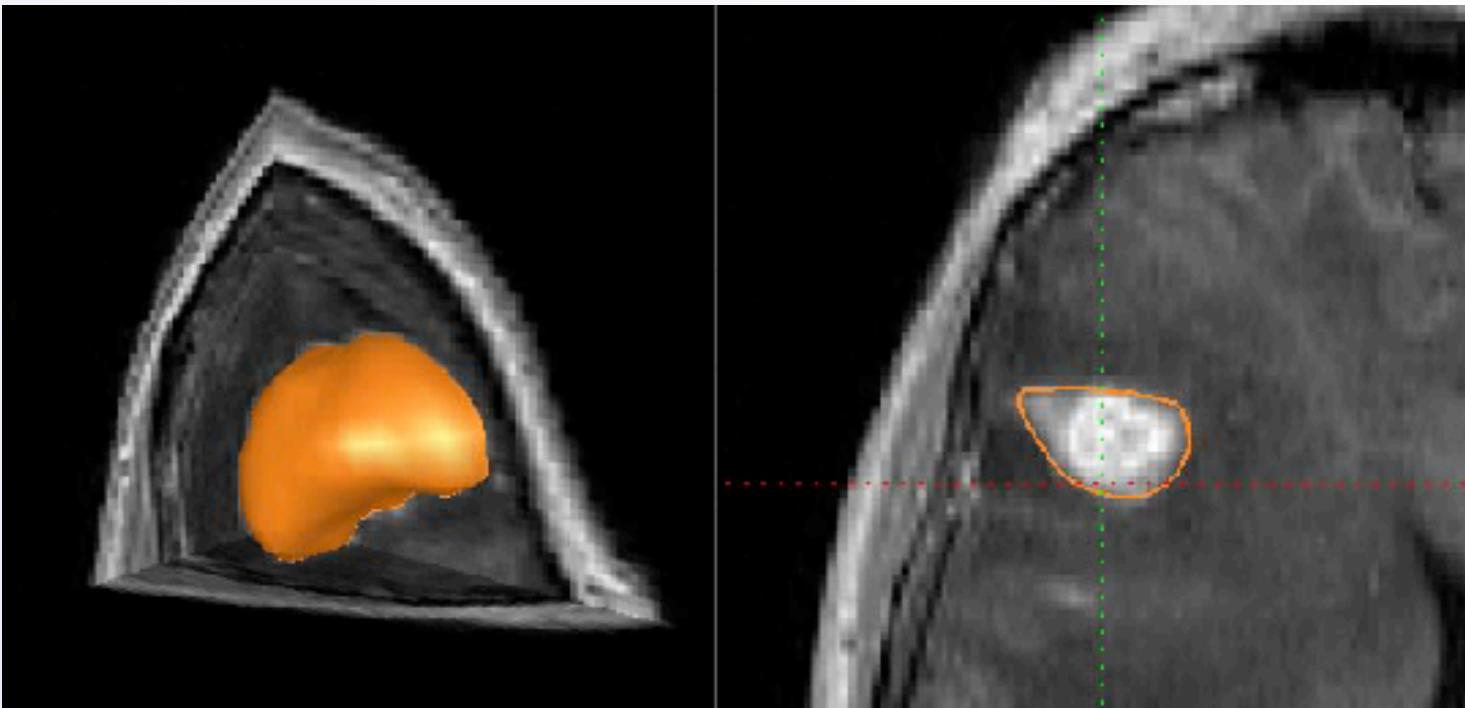
(d) $E=2.09$



(e) $E=1.10$







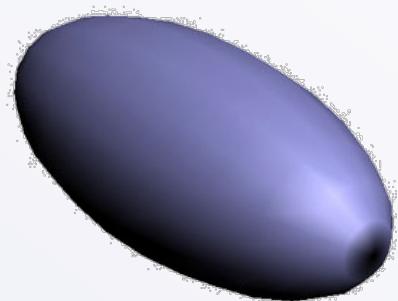
Discussão

- Parametrização de formas com protusões ?
 - “Rosquinha” ou toro

Tarefa de casa

Uma elipsóide é descrita pelas seguintes equações paramétricas:

- $P_x(\theta, \phi) = a \cos(\theta) \sin(\phi)$
- $P_y(\theta, \phi) = b \sin(\theta) \sin(\phi)$
- $P_z(\theta, \phi) = c \cos(\phi)$



Onde $\theta \in [0, 2\pi]$ e $\phi \in [0, \pi]$, e a, b, c são os comprimentos de seus semi-eixos

- Crie uma função que desenhe uma elipsóide dados a, b, c e o número de subdivisões de θ e ϕ
- Calcule o vetor normal em cada ponto P utilizando os vetores componentes de cada face
 - Ou diretamente da equação paramétrica!