Modelagem Geométrica II

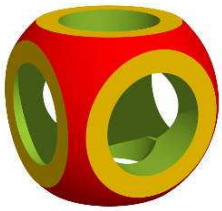
Watt – Capítulo 2

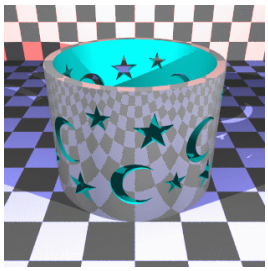
Fomas Geométricas Complexas

- Não há funções capazes de descrevê-las completamente

⇩

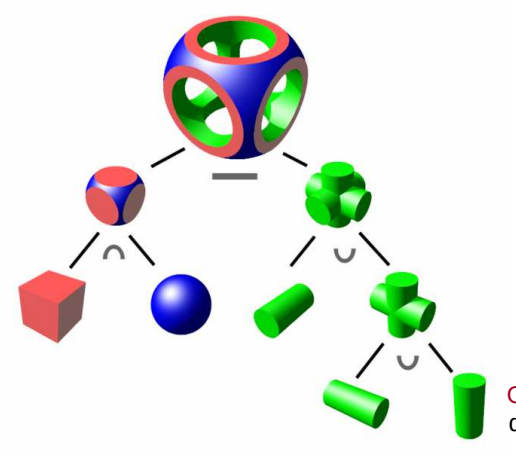
- Representação por partes: Geometria + Topologia





CSG

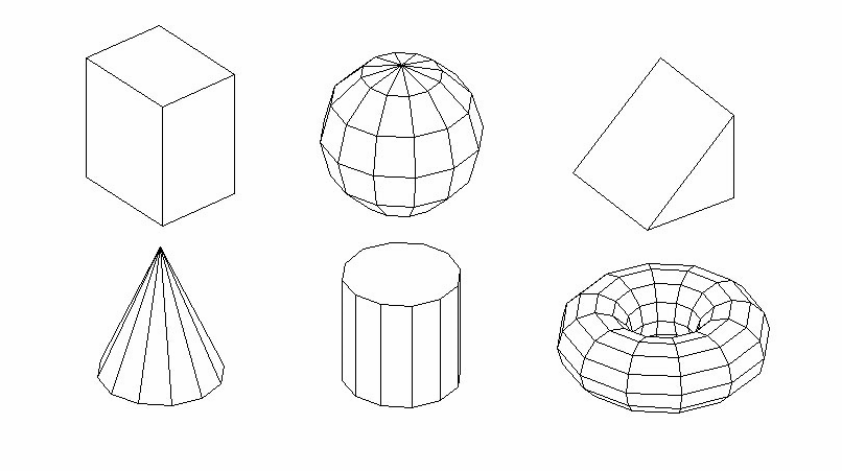
Constructive Solid Geometry



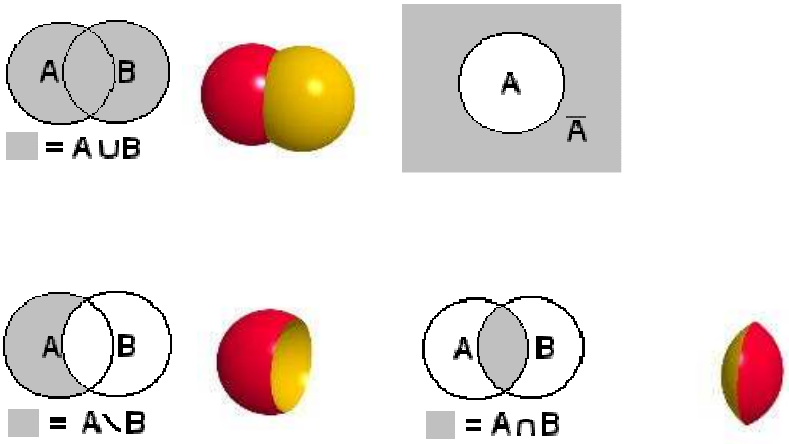
Geometria descritível

Sólido = Operações Booleanas[Sólidos].

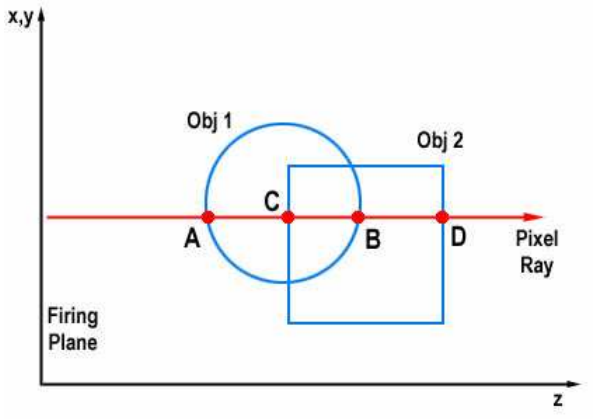
Primitivas



Operações Booleanas



Processamento

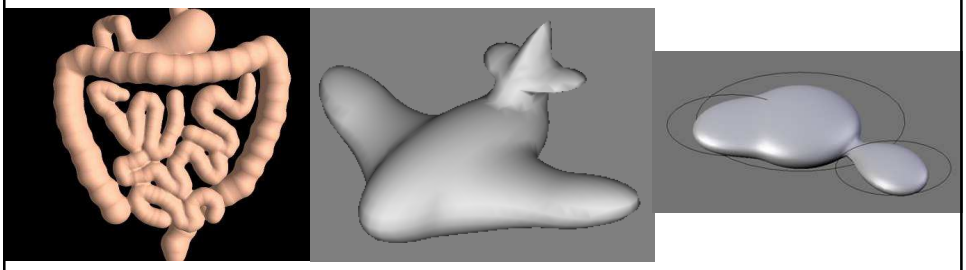


União: A,D
Interseção: C,B
Diferença
Obj_1-Obj_2: A,C
Obj_2-Obj_1: B,D

Ray-casting

http://www.f-lohmueller.de/pov_tut/csg/povcsg1e.htm

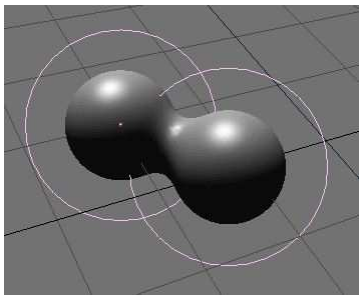
Representação de Formas “Amorfas”

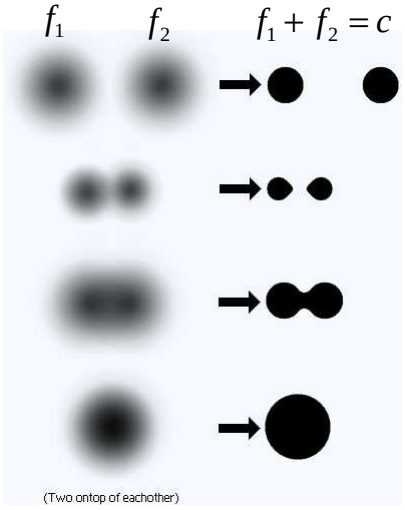


Metaballs

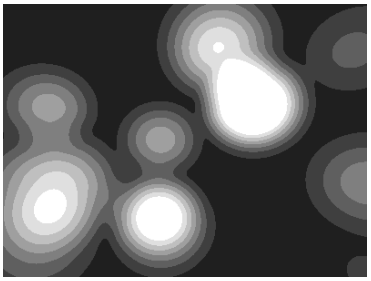
Representar um objeto como um específico nível de um campo escalar

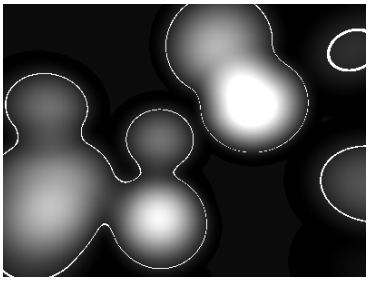
f(x,y,z) = c





Metaballs





Campo de Influência de cada primitiva num raio R

$$f(P) = \begin{cases} \left(\frac{1-(P-P_i)^2}{R^2}\right)^2, d \le R \\ 0, d > R \end{cases}$$

Representação de Formas Complexas

Muitos detalhes representáveis por funções analíticas distintas

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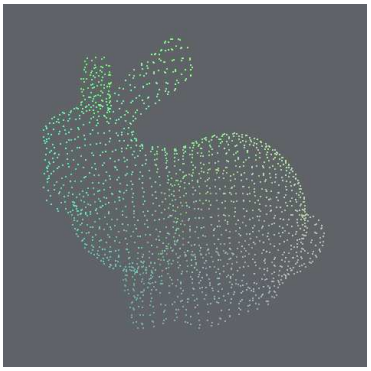
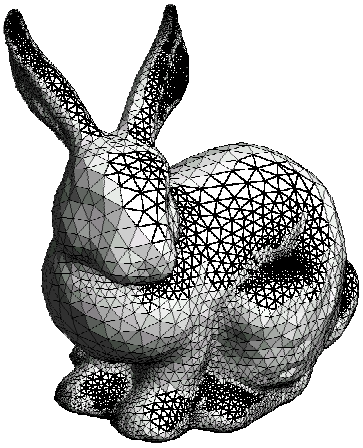
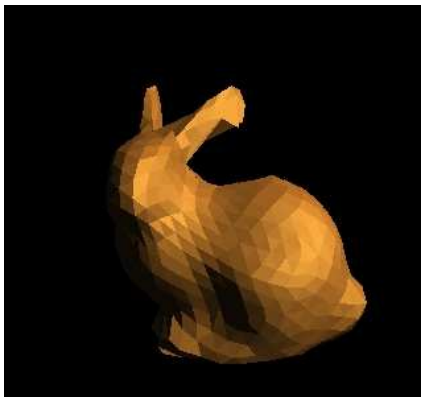
Malhas Poligonais
Subdivisão Espacial

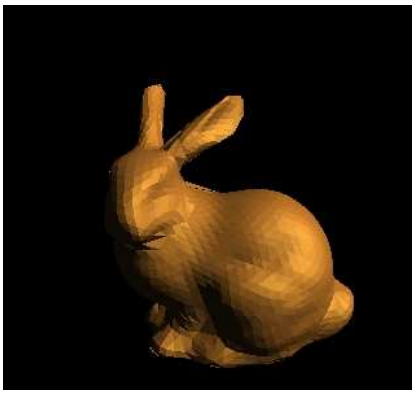
OPÇÃO 1: Malhas Poligonais





Malhas Poligonais





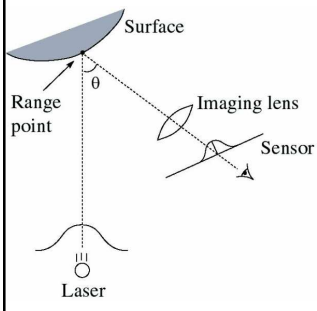
Distintas resoluções:
área das facetas → 0, forma→superfície original

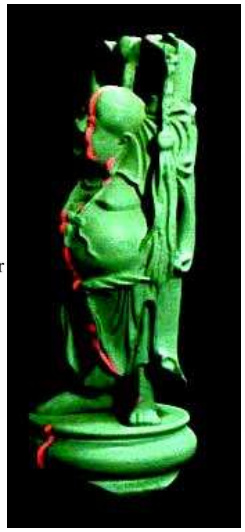
Técnicas de Amostragem

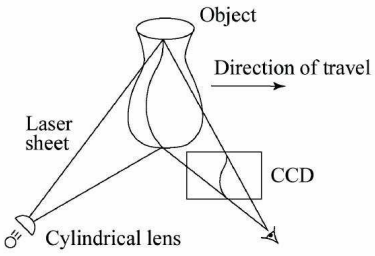
- Manualmente ou digitalizador
- Automáticamente
- Funções matemáticas

A Volkswagan Beetle becomes the subject of a 1970 simulation project. Ivan Sutherland(left) and assistants plot coordinates for digitizing the car.

Técnicas de Amostragem



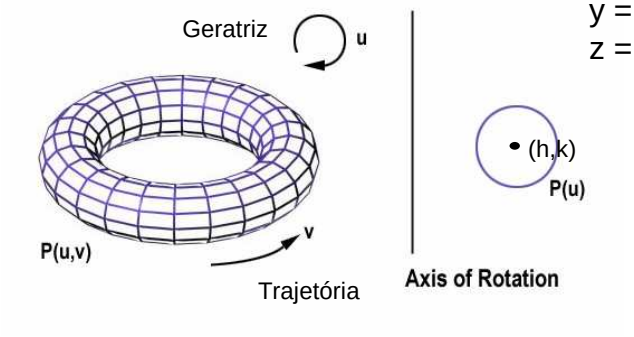




Problemas: concavidade e costura

Discretização

x = h+r cos u
y = (k+r sen u)cos v
z = (k+r sen u)sen v



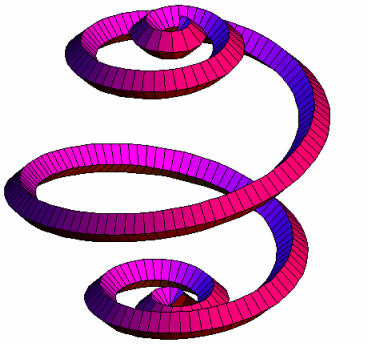
Amostra inicial: $(u_0, v_{0)}$

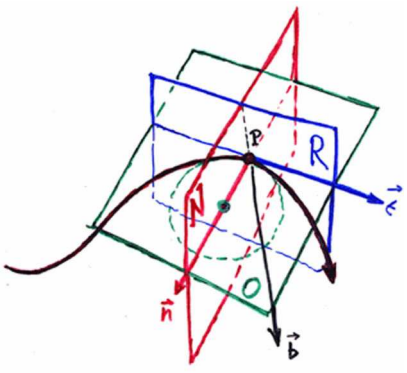
$(u_0 + n\Delta u, v_0 + m\Delta v)$

É comum utilizar representação paramétrica

Se o passo for igual ao comprimento de arco, então o espaçamento das amostras é uniforme.

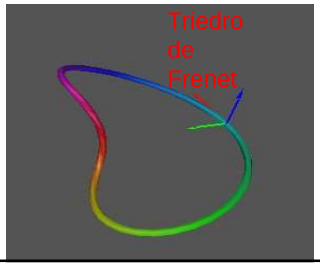
Triedro de *Frenet*





Frenet · Frame

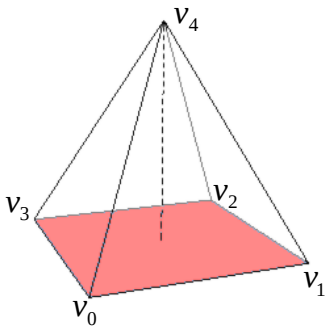
$\vec{t} = \frac{P'}{|P'|}$ $\vec{b} = \frac{P' \times P''}{|P' \times P''|}$ $\vec{n} = \vec{b} \times \vec{t}$



Passo?
Orientação?

Conectividade das Amostras

Propriedades geométricas locais
+
Topologia

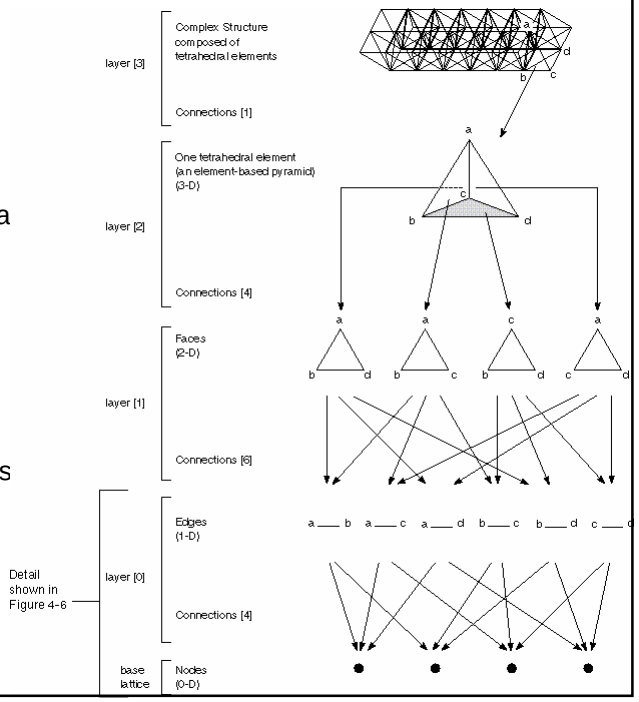


$$v_0 = (-2.,-2.,0.)$$
$$v_1 = (2.,-2.,0.)$$
$$v_2 = (2.,2.,0.)$$
$$v_3 = (-2.,2.,0.)$$
$$v_4 = (0.,0.,4.)$$

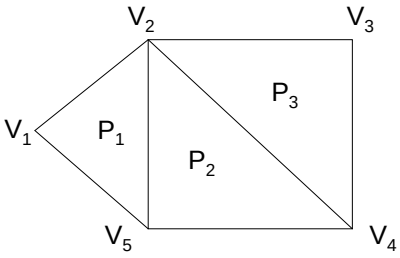
$$(v_4, v_3), (v_4, v_0), (v_4, v_1), (v_4, v_2),$$
$$(v_0, v_1), (v_1, v_2), (v_2, v_3), (v_3, v_0)$$

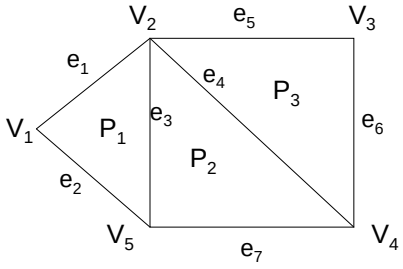
Primitivas

- **Face**: vetor normal, área forma, conexidade, convexidade.
- **Aresta**: comprimento, faces adjacentes
- **Vértice**: vetor normal, faces, arestas adjacentes



Topologia

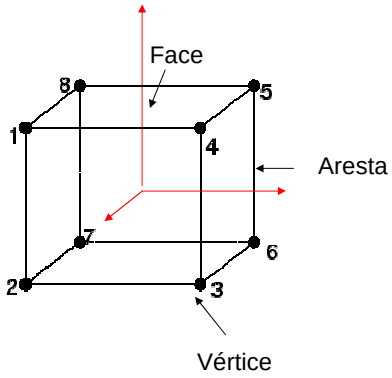




1 x_1 y_1 z_1
2 x_2 y_2 z_2
3 x_3 y_3 z_3
4 x_4 y_4 z_4
5 x_5 y_5 z_5

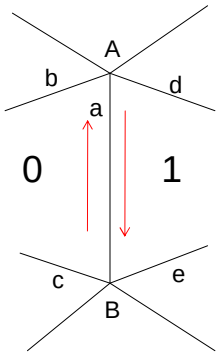
1 5 2
2 4 3
2 5 4

Representação por Bordo



Boundary representation

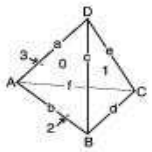
Estrutura Alada



Winged-edge data structure

Aresta	Vértice 1	Vértice 2	Face direita	Face esquerda	Predecessor direito	Sucessor direito	Predecessor esquerdo	Predecessor direito
a	B	A	0	1	c	b	d	e

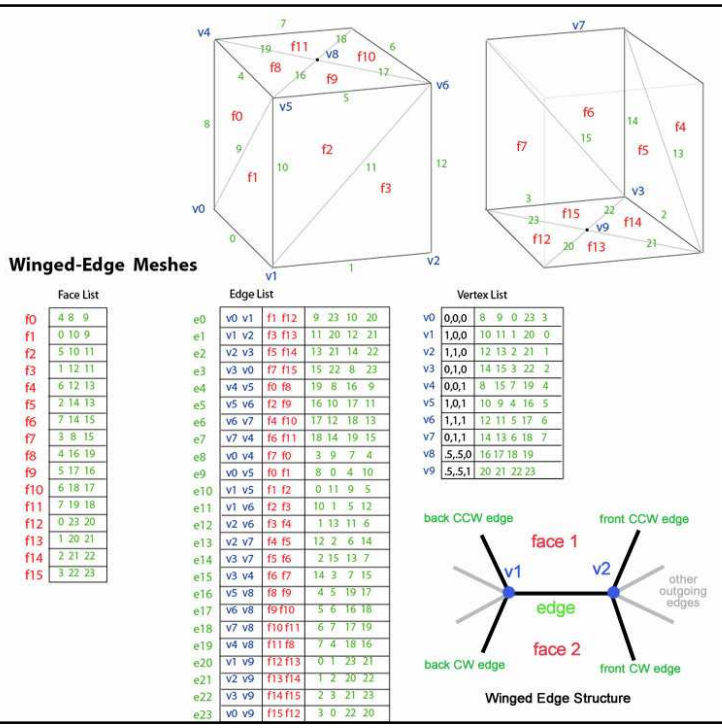
Estrutura Alada



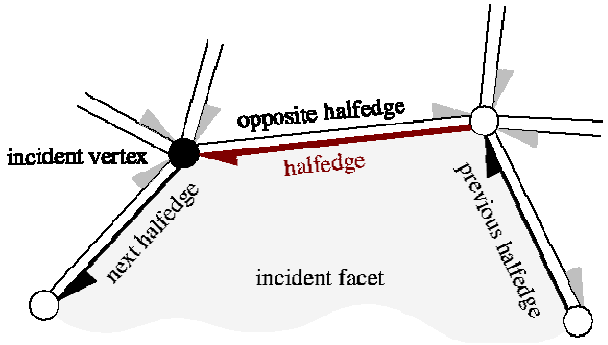
edge	vertex 1	vertex 2	face left	face right	pred left	succ left	pred right	succ right
a	A	D	3	0	f	e	c	b
b	A	B	0	2	a	c	d	f
c	B	D	0	1	b	a	e	d
d	B	C	1	2	c	e	f	b
e	C	D	1	3	d	c	a	f
f	C	A	3	2	e	a	b	d

Face	Aresta
0	a
1	c
2	d
3	a

Vértice	Aresta
A	a
B	d
C	e
D	c

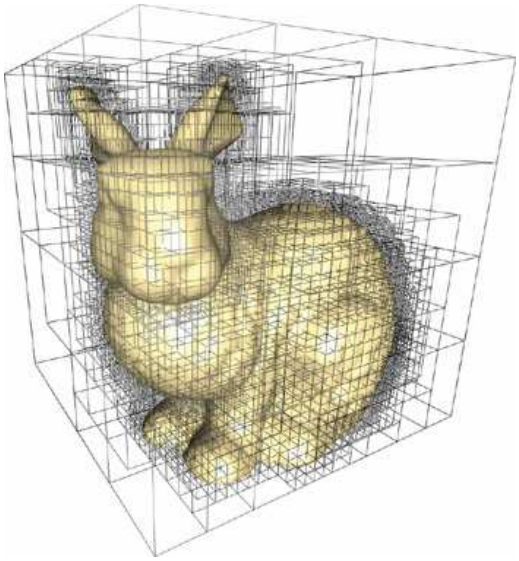


Estrutura Meia-aresta

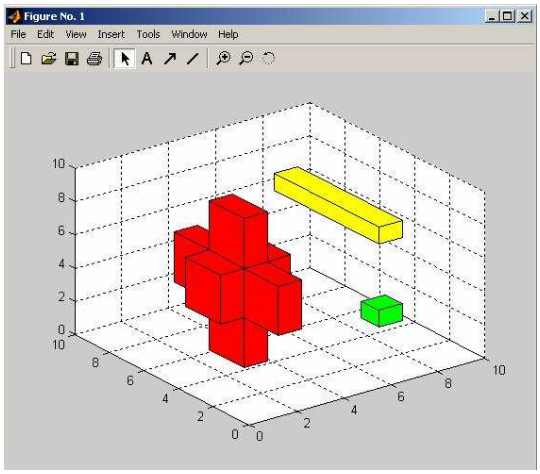


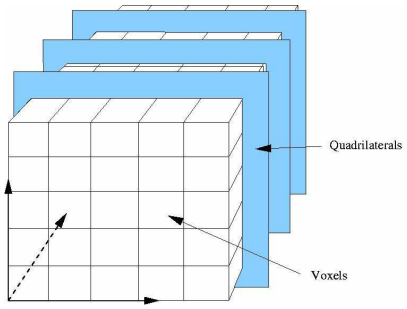
http://www.flipcode.com/archives/The_Half-Edge_Data_Structure.shtml

OPÇÃO 2: Subdivisão Espacial

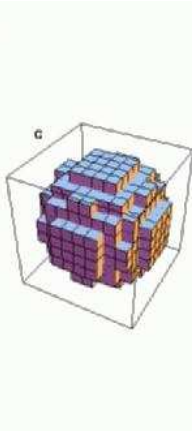


Subdivisão Espacial

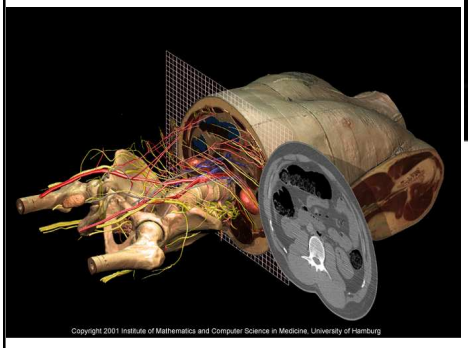


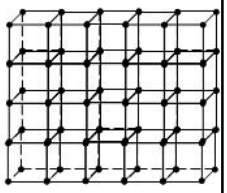


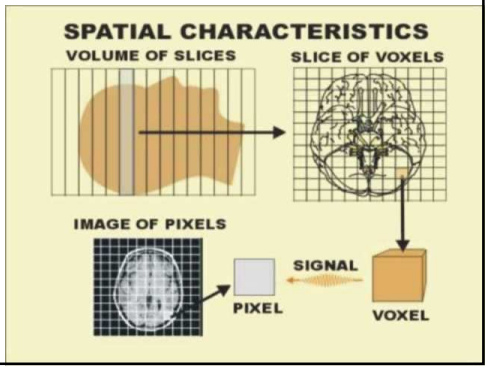
Subdivisão Espacial



Imagens Médicas 3D

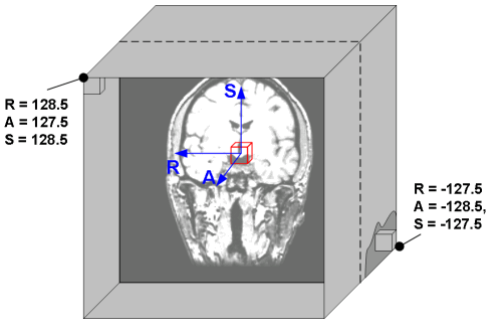






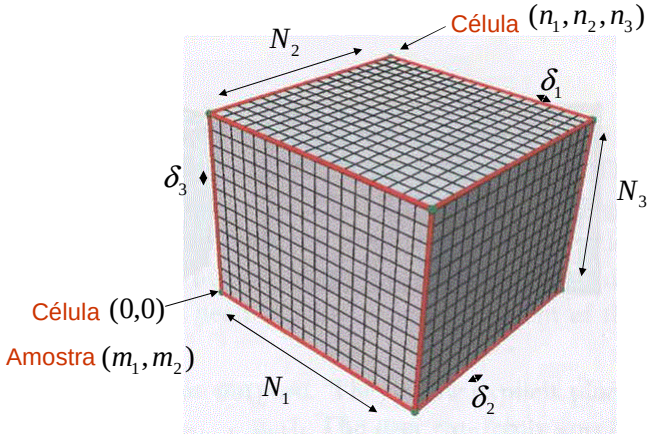
Imagens Médicas 3D

- Dados = Um “bloco” de *voxels*.
- Cada *voxel* ↔ “extensão” de uma fatia de amostras (imagem 2D).
- Cada amostra ↔ uma densidade/coeficiente de absorção s(t)
- Cada densidade ↔ um meio (ar, gourdura, tecido mole, osso ou combinação destes).



Reticulados Uniformes

Amostras p_i são igualmente espaçadas e paralelas aos eixos de referência



$$N_1 = \frac{M_1 - m_1}{\delta_1}$$

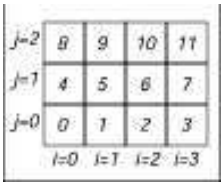
$$N_2 = \frac{M_2 - m_2}{\delta_2}$$

$$N_3 = \frac{M_3 - m_3}{\delta_3}$$

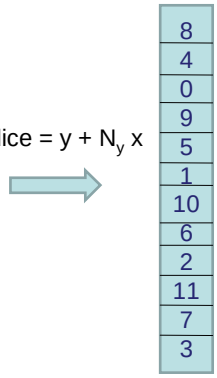
Arranjo $N_1 \times N_2 \times N_3$ *elementos*

Arranjos Multidimensionais

$N_x = 4$ $N_y = 3$

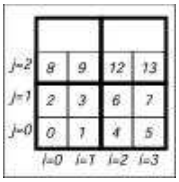


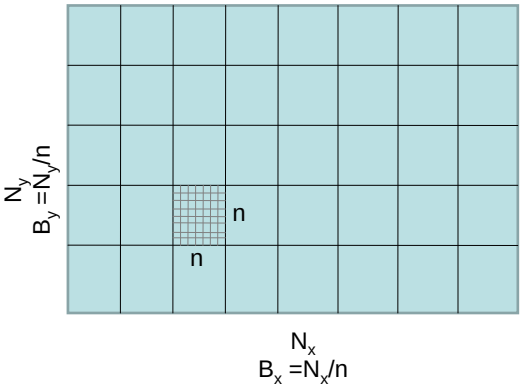
Índice = y + N_y x



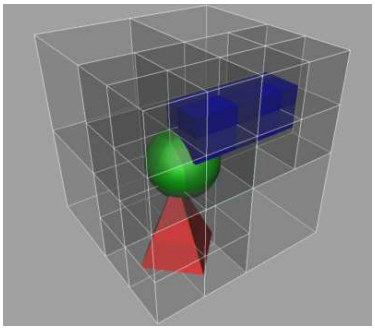
Arranjos Multidimensionais

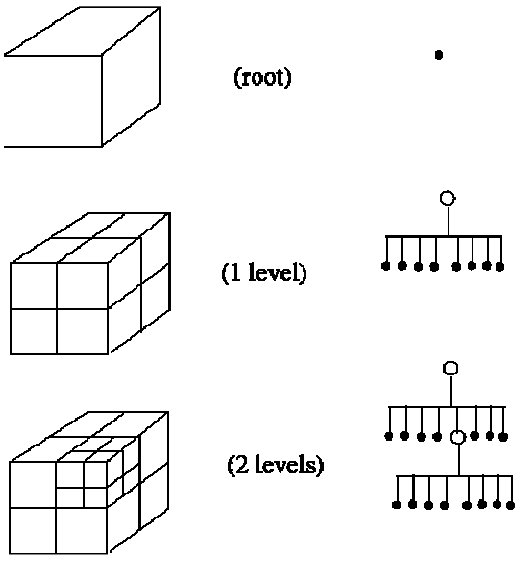
Ladrilhamento (*Tiling*)



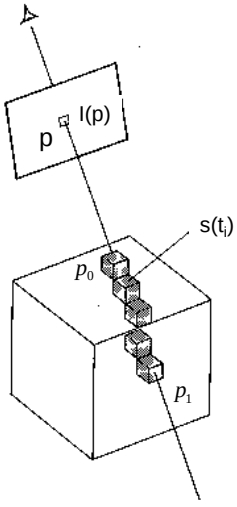


Octree

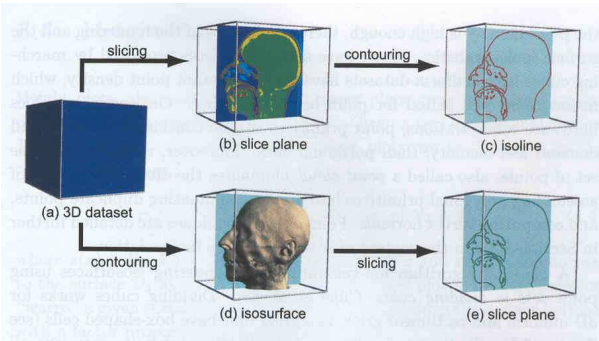




Processamento

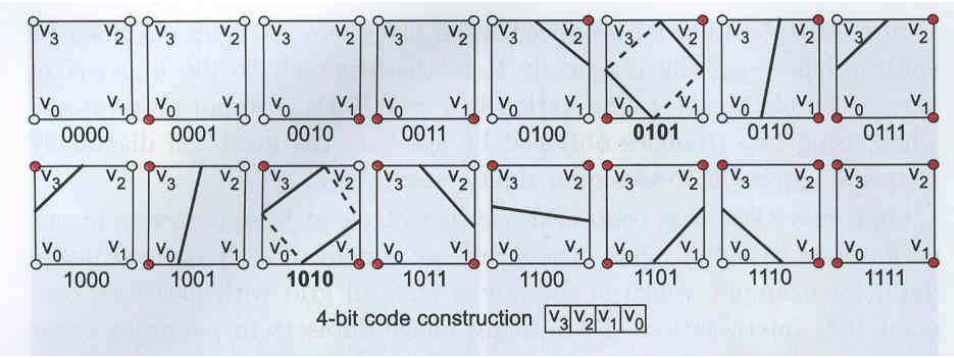


Ray-casting



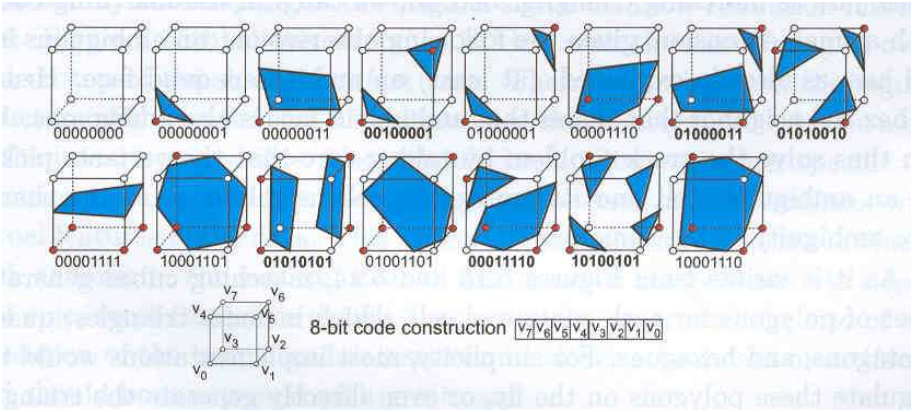
Redução em malhas poligonais

Algoritmo *Marching Square*
2D



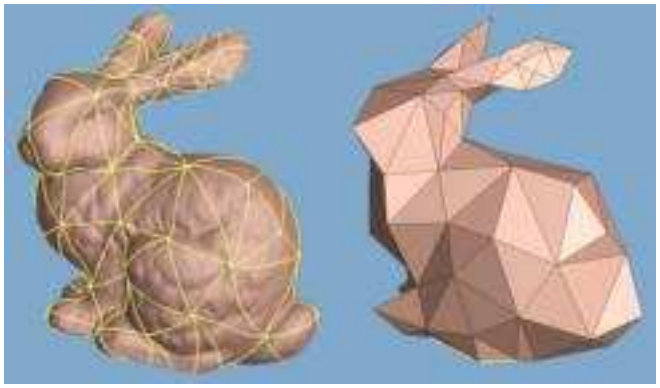
4 vértices → 2^4 possibilidades

Algoritmo *Marching Cube*
3D

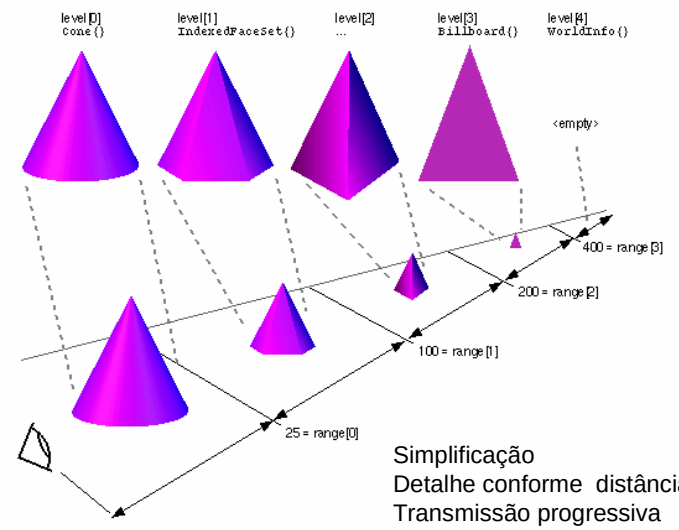


8 vértices → 2^8 possibilidades→ 15 casos

Níveis de Resolução



Níveis de Detalhe



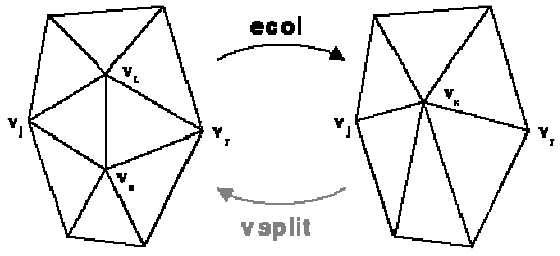
Simplificação
Detalhe conforme distância de visão
Transmissão progressiva
Refinamento seletivo

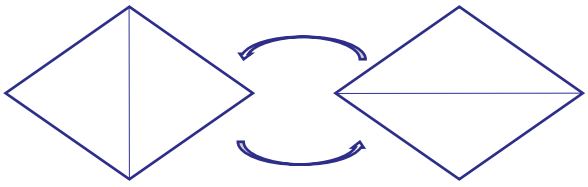
Níveis de Detalhe

Imagem					
Vértices	~5500	~2880	~1580	~670	140
Nota	Máximo de detalhes (próximo)				Mínimo de detalhes (distante)

Níveis de Detalhe

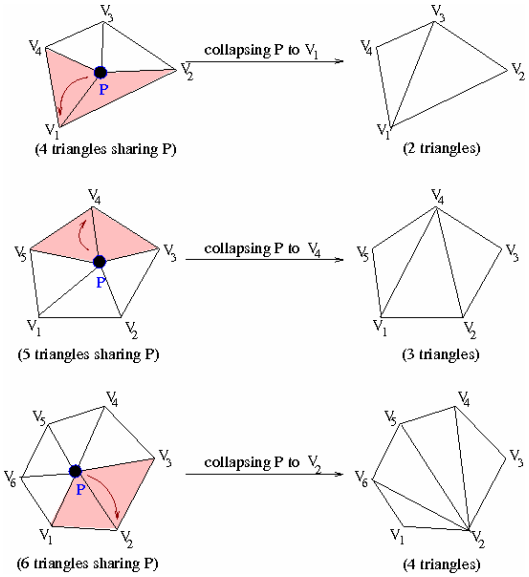
Operações Básicas (Lawson)





Flip/swap

Níveis de Detalhe



Características

1. Dimensão
2. Representatividade/Precisão
3. Concisão
4. Univocidade
5. Interface
6. Complexidade
7. Estrutura de dados
8. Editabilidade

Quadro Comparativo

	Malha	F.Paramétrica	CSG	S.Espacial	F. Implícita
Dimensão	2D	2D	3D	3D (*voxel*)	2D/3D
Representatividade	Abrangente	restrito/ preciso	restrito/ preciso	abrangente	restrito/ preciso
Concisão	Baixa	boa	Boa	baixa	boa
Univocidade	não	não	não	sim	não
Interface	tediosa	Conhecimento matemático	intuitiva	tediosa	Conhecimento matemático
Complexidade	simples	“complexa”	+-	simples	“complexa”
Estrutura de dados	lista		árvore	arranjo	
Editabilidade	baixa	alta	alta	baixa	baixa