

Computação Gráfica

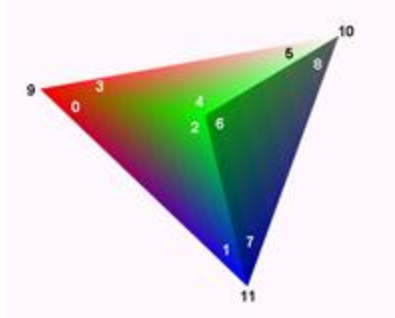
Aula 08x: Revisão 2 Malhas e Grafo de Cena

Tipos de Malhas Triangulares estudadas

- triangleSet
- triangleStripSet
- indexedTriangleStripSet
- indexedFaceSet

TriangleSet

O nó **TriangleSet** representa uma geometria 3D que representa uma coleção de triângulos individuais. Cada triângulo é formado por um conjunto consecutivo de três vértices do nó **Coordinate**. Se o nó de coordenadas não contém um múltiplo de três valores de coordenadas, os vértices restantes devem ser ignorados.



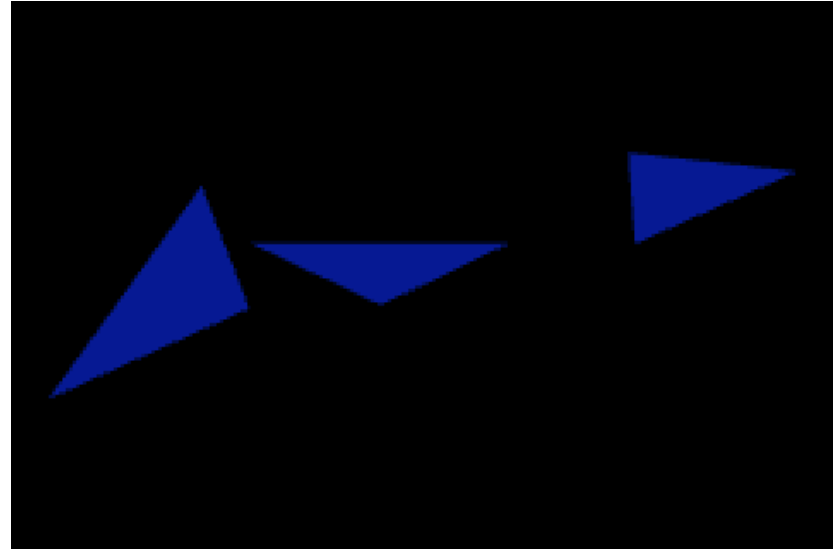
```
TriangleSet : X3DComposedGeometryNode {  
  MFNode [in,out] attrib [] [X3DVertexAttributeNode]  
  SFNode [in,out] color NULL [X3DColorNode]  
  SFNode [in,out] coord NULL [X3DCoordinateNode]  
  SFNode [in,out] fogCoord NULL [FogCoordinate]  
  SFNode [in,out] metadata NULL [X3DMetadataObject]  
  SFNode [in,out] normal NULL [X3DNormalNode]  
  SFNode [in,out] texCoord NULL [X3DTextureCoordinateNode]  
  SFBool [] ccw TRUE  
  SFBool [] colorPerVertex TRUE  
  SFBool [] normalPerVertex TRUE  
  SFBool [] solid TRUE  
}
```

Exemplo de TriangleSet

```
<X3D>
<Scene>
  <NavigationInfo headlight="false"/>
  <Viewpoint orientation='0 -1 0 0.05' position='0.13 2.51 11.24'/>
  <Transform>
    <Shape>
      <Appearance>
        <Material emissiveColor='0 .1 0.6'/>
      </Appearance>
      <TriangleSet>
        <Coordinate point='
          -4 1 3
          -2 2 1
          -3 4 0

          0 2 0
          2 3 1
          -2 3 1

          5 5 -2
          4 3 1
          6 4 2
        ' />
      </TriangleSet>
    </Shape>
  </Transform>
</Scene>
</X3D>
```



TriangleStripSet

Um **TriangleStripSet** representa uma forma geométrica 3D composta por faixas de triângulos. O campo **stripCount** descreve quantos vértices devem ser usados em cada faixa do **Coordinate**. As coordenadas são atribuídas a cada faixa pegando os vértices **stripCount[i]** do campo de coordenadas, onde i é um índice sequencial de stripCount.

```
TriangleStripSet : X3DComposedGeometryNode {  
  MFNode [in,out] attrib [] [X3DVertexAttributeNode]  
  SFNode [in,out] color NULL [X3DColorNode]  
  SFNode [in,out] coord NULL [X3DCoordinateNode]  
  SFNode [in,out] fogCoord NULL [FogCoordinate]  
  SFNode [in,out] metadata NULL [X3DMetadataObject]  
  SFNode [in,out] normal NULL [X3DNormalNode]  
  MFInt32 [in,out] stripCount [] [3,∞)  
  SFNode [in,out] texCoord NULL [X3DTextureCoordinateNode]  
  SFBool [] ccw TRUE  
  SFBool [] colorPerVertex TRUE  
  SFBool [] normalPerVertex TRUE  
  SFBool [] solid TRUE  
}
```

TriangleStripSet (exemplo)

<Shape>

<TriangleStripSet stripCount='13'>

<Coordinate point='

-4.0	-1.0	-0.5	-> P ₀
-4.5	-2.0	-0.5	-> P ₁
-3.0	-0.5	0.0	-> P ₂
-2.5	-1.5	-0.5	-> P ₃
-2.0	-0.5	-1.0	-> P ₄
-1.5	-1.5	-0.5	-> P ₅
-0.5	0.5	-0.5	-> P ₆
0.0	0.0	0.0	-> P ₇
1.0	0.5	-0.5	-> P ₈
1.5	-2.0	-1.0	-> P ₉
2.5	-2.0	-0.5	-> P ₁₀
2.5	-2.5	-0.5	-> P ₁₁
3.5	-2.0	-1.0	-> P ₁₂

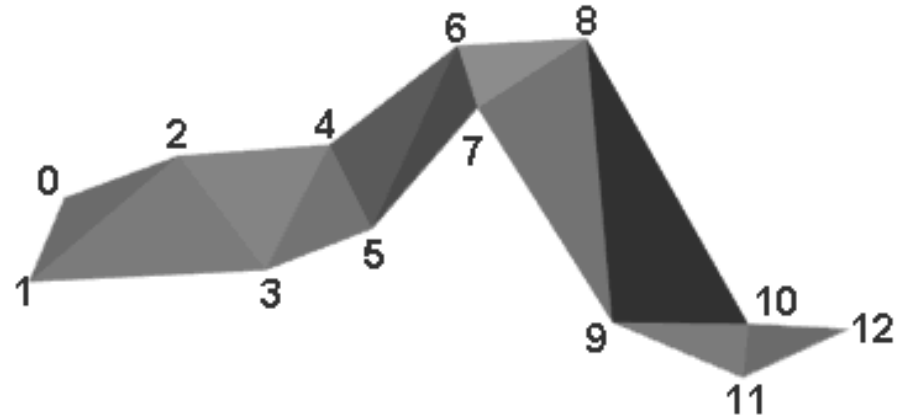
'/>

</TriangleStripSet>

<Appearance> <Material diffuseColor='0.5 0.5 0.5'/> </Appearance>

</Shape>

Os vértices são conectados de 3 em 3. Assim o primeiro triângulos será ligando os vértices (0, 1, 2), o segundo (1, 2, 3) e assim por diante, até chegar a contagem definida em stripCount. Perceba que stripCount é uma lista.



IndexedTriangleStripSet

Um **IndexedTriangleStripSet** representa uma forma 3D composta de um conjunto de triângulos em forma de uma tira, são usados nos índices do campo **index** para especificar como montar faixa de triângulos. Um índice de "-1" indica que a faixa atual terminou e a próxima começa.

```
IndexedTriangleStripSet : X3DComposedGeometryNode {  
  MFInt32    [in]      set_index      []      [0,∞) or -1  
  MFNode     [in,out]  attrib          []      [X3DVertexAttributeNode]  
  SFNode     [in,out]  color          NULL    [X3DColorNode]  
  SFNode    [in,out]  coord          NULL    [X3DCoordinateNode]  
  SFNode     [in,out]  fogCoord        NULL    [FogCoordinate]  
  SFNode     [in,out]  metadata        NULL    [X3DMetadataObject]  
  SFNode     [in,out]  normal          NULL    [X3DNormalNode]  
  SFNode     [in,out]  texCoord        NULL    [X3DTextureCoordinateNode]  
  SFBool     []        ccw             TRUE  
  SFBool     []        colorPerVertex TRUE  
  SFBool     []        normalPerVertex TRUE  
  SFBool     []        solid           TRUE  
  MFInt32   []        index         []      [0,∞) or -1  
}
```

IndexedTriangleStripSet (exemplo)

<Shape>

<IndexedTriangleStripSet index='0 1 2 3 4 5 6 7 8 9 10 11 12 -1'>

<Coordinate point='

-4.0	-1.0	-0.5	-> P ₀
-4.5	-2.0	-0.5	-> P ₁
-3.0	-0.5	0.0	-> P ₂
-2.5	-1.5	-0.5	-> P ₃
-2.0	-0.5	-1.0	-> P ₄
-1.5	-1.5	-0.5	-> P ₅
-0.5	0.5	-0.5	-> P ₆
0.0	0.0	0.0	-> P ₇
1.0	0.5	-0.5	-> P ₈
1.5	-2.0	-1.0	-> P ₉
2.5	-2.0	-0.5	-> P ₁₀
2.5	-2.5	-0.5	-> P ₁₁
3.5	-2.0	-1.0	-> P ₁₂

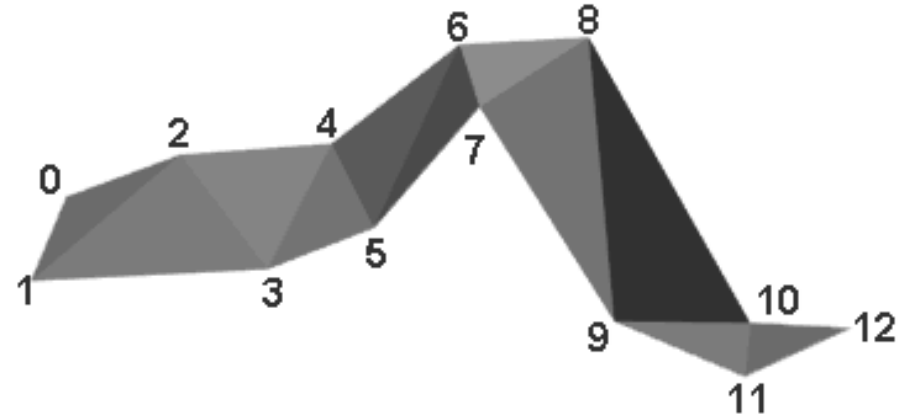
'/>

</IndexedTriangleStripSet>

<Appearance> <Material diffuseColor='0.5 0.5 0.5'/> </Appearance>

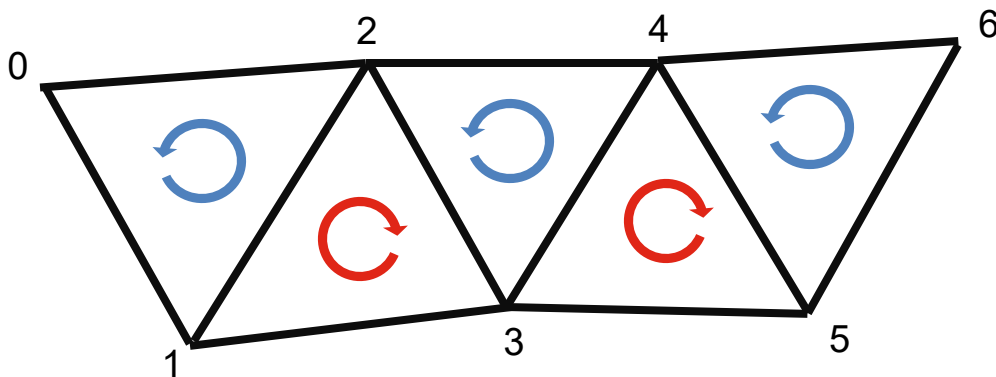
</Shape>

Os vértices são conectados seguindo a ordem definida no campo index. Ligando de 3 em 3 vértices até encontrar um valor -1. Outras listas de índices podem aparecer na sequência.



Cuidado

A direção de montagem dos triângulos precisa ser constantemente alternada, senão a detecção de triângulos irá falhar



Um dos truques é inverter a ordem de conexão, assim nos triângulos pares, inverte a conexão de dois vértices.

Por exemplo, conecte: (0,1,2), depois (1,3,2), depois (2,3,4) e assim por diante.

IndexedFaceSet

Um **IndexedFaceSet** representa uma forma 3D composta de um conjunto de polígonos, são usados nos índices do campo **coordIndex** para especificar como montar os triângulos, o campo **colorIndex** para especificar como mapear as cores por vértices, e o campo **texCoordIndex** para mapear as coordenadas de textura.

```
IndexedFaceSet : X3DComposedGeometryNode {  
  MFINt32 [in]  set_colorIndex  
  MFINt32 [in]  set_coordIndex  
  MFINt32 [in]  set_normalIndex  
  MFINt32 [in]  set_texCoordIndex  
  MFNode [in,out] attrib      [] [X3DVertexAttributeNode]  
  SFNode [in,out] color       NULL [X3DColorNode]  
  SFNode [in,out] coord       NULL [X3DCoordinateNode]  
  SFNode [in,out] fogCoord     NULL [FogCoordinate]  
  SFNode [in,out] metadata     NULL [X3DMetadataObject]  
  SFNode [in,out] normal      NULL [X3DNormalNode]  
  SFNode [in,out] texCoord     NULL [X3DTextureCoordinateNode]  
  SFBool []    ccw            TRUE  
  MFINt32 []    colorIndex     [] [0,∞) or -1  
  SFBool []    colorPerVertex  TRUE  
  SFBool []    convex         TRUE  
  MFINt32 []    coordIndex     [] [0,∞) or -1  
  SFFloat []    creaseAngle    0 [0,∞)  
  MFINt32 []    normalIndex    [] [0,∞) or -1  
  SFBool []    normalPerVertex TRUE  
  SFBool []    solid          TRUE  
  MFINt32 []    texCoordIndex  [] [-1,∞)  
}
```

IndexedFaceSet

O nó IndexedFaceSet representa uma forma 3D formada pela construção de faces (polígonos) de vértices listados no campo coord.

IndexedFaceSet usa os índices em seu campo coordIndex para especificar as faces poligonais indexando nas coordenadas no nó Coordinate. Um índice de "-1" indica que a face atual terminou e a próxima começa.

Cada face do IndexedFaceSet deve ter:

- **pelo menos três vértices não coincidentes;**
- **vértices que definem um polígono planar;**
- **vértices não possuem auto-intersecção.**

Exemplo IndexedFaceSet

<Shape>

<IndexedFaceSet coordIndex='0 1 2 3 4 5 6 7 -1'>

<Coordinate point='

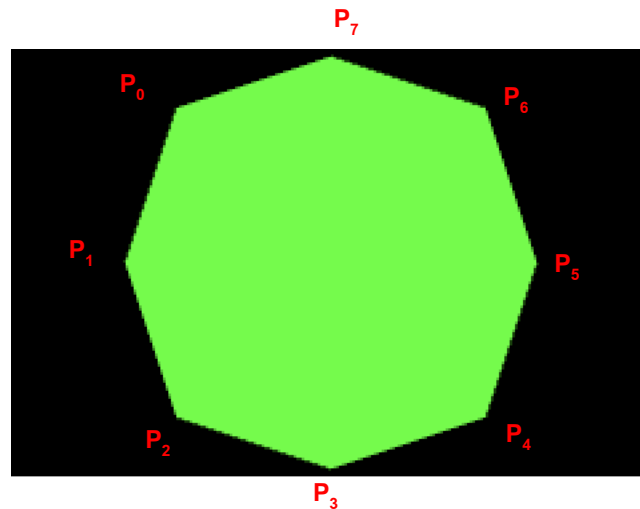
-3	3	0	-> P ₀
-4	0	0	-> P ₁
-3	-3	0	-> P ₂
0	-4	0	-> P ₃
3	-3	0	-> P ₄
4	0	0	-> P ₅
3	3	0	-> P ₆
0	4	0	-> P ₇

'/>

</IndexedFaceSet>

<Appearance> <Material emissiveColor='0 1 0' /> </Appearance>

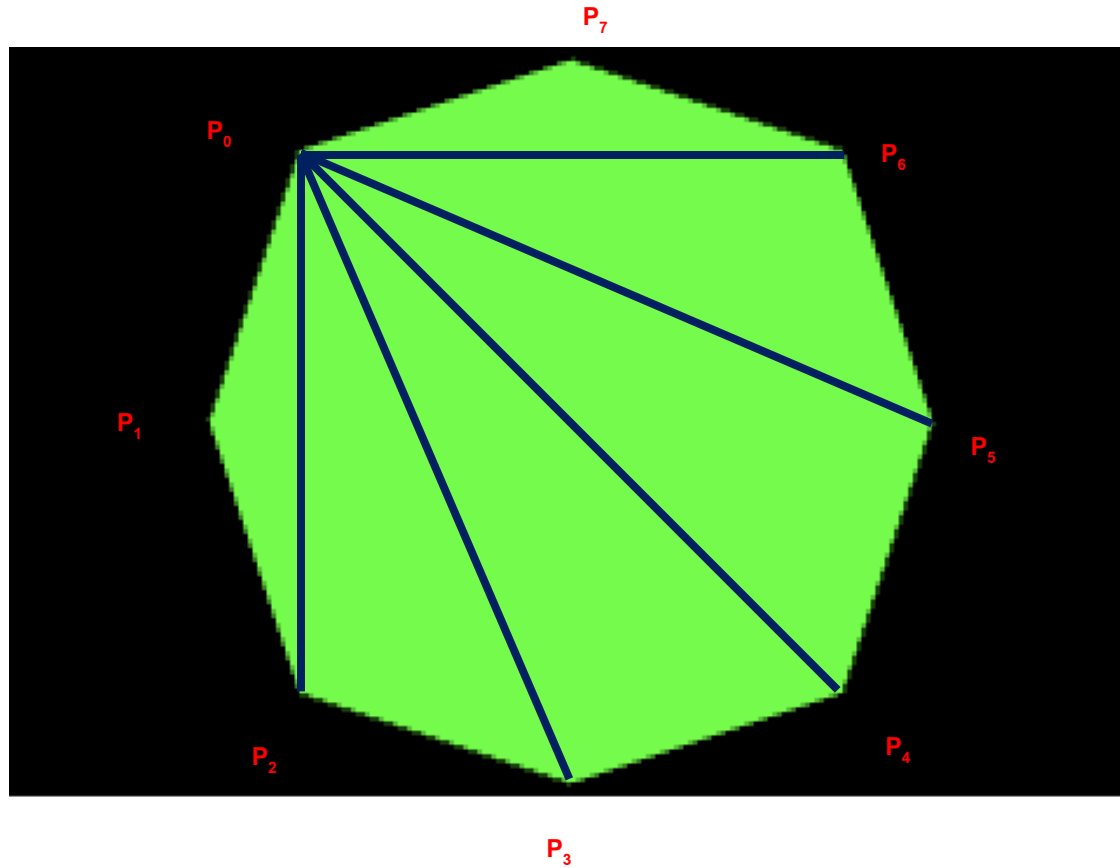
</Shape>



Os pontos são o contorna da superfície.

Exemplo IndexedFaceSet

Possível solução



Exemplo IndexedFaceSet

Mas e se a geometria fosse assim:

<Shape>

<IndexedFaceSet coordIndex='0 1 2 3 4 5 6 7 -1'>

<Coordinate point='

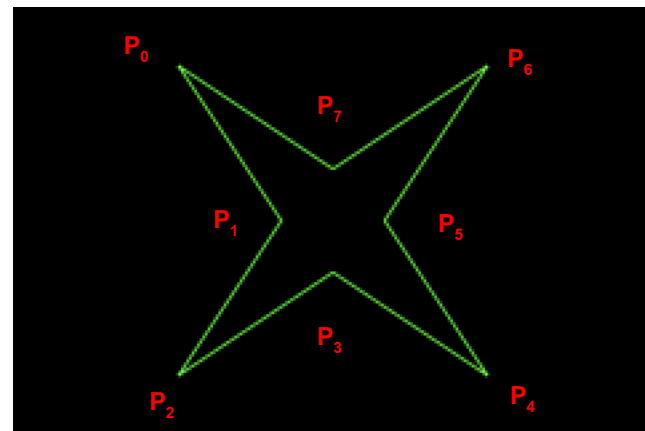
-3	3	0	-> P ₀
-1	0	0	-> P ₁
-3	-3	0	-> P ₂
0	-1	0	-> P ₃
3	-3	0	-> P ₄
1	0	0	-> P ₅
3	3	0	-> P ₆
0	1	0	-> P ₇

'/>

</IndexedFaceSet>

<Appearance> <Material emissiveColor='0 1 0' /> </Appearance>

</Shape>



Dessa forma também não funcionaria pela especificação X3D e geraria uma geometria errada. Para funcionar você deveria especifica **convex="false"**, porém não vamos trabalhar com essa situação.

Grafo de Cena



Criando Matriz Identidade



```
<Scene>
  <Transform scale="2 2 2">
    <Shape>
      <TriangleSet>
        <Coordinate point='-1 -1 0 1 -1 0 0 1 0'>
      </TriangleSet>
      <Appearance>
        <Material diffuseColor='1 0 0'>
      </Appearance>
    </Shape>
  </Transform>
  <Transform scale="2 1 1">
    <Transform translation="0 -1 -1">
      <Shape>
        <TriangleSet>
          <Coordinate point='-1 -1 0 1 -1 0 0 1 0'>
        </TriangleSet>
        <Appearance>
          <Material diffuseColor='0 1 0'>
        </Appearance>
      </Shape>
    </Transform>
  </Transform>
  <Transform translation="0 1 -2">
    <Transform rotation="0 0 1 3.14">
      <Shape>
        <TriangleSet>
          <Coordinate point='-1 -1 0 1 -1 0 0 1 0'>
        </TriangleSet>
        <Appearance>
          <Material diffuseColor='0 0 1'>
        </Appearance>
      </Shape>
    </Transform>
  </Transform>
</Transform>
</Scene>
```



$$\begin{bmatrix} 1 & 0 & 0 & 0 \\ 0 & 1 & 0 & 0 \\ 0 & 0 & 1 & 0 \\ 0 & 0 & 0 & 1 \end{bmatrix}$$

MATRIZ

PILHA

Empilhando e Atualizando Transformação

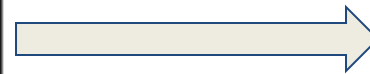
```
<Scene>
  <Transform scale="2 2 2">
    <Shape>
      <TriangleSet>
        <Coordinate point='-1 -1 0 1 -1 0 0 1 0'/>
      </TriangleSet>
    <Appearance>
      <Material diffuseColor='1 0 0'/>
    </Appearance>
  </Shape>
  <Transform scale="2 1 1">
    <Transform translation="0 -1 -1">
      <Shape>
        <TriangleSet>
          <Coordinate point='-1 -1 0 1 -1 0 0 1 0'/>
        </TriangleSet>
      <Appearance>
        <Material diffuseColor='0 1 0'/>
      </Appearance>
    </Shape>
  </Transform>
  <Transform translation="0 1 -2">
    <Transform rotation="0 0 1 3.14">
      <Shape>
        <TriangleSet>
          <Coordinate point='-1 -1 0 1 -1 0 0 1 0'/>
        </TriangleSet>
      <Appearance>
        <Material diffuseColor='0 0 1'/>
      </Appearance>
    </Shape>
  </Transform>
</Transform>
</Transform>
</Scene>
```



$$\begin{bmatrix} 1 & 0 & 0 & 0 \\ 0 & 1 & 0 & 0 \\ 0 & 0 & 1 & 0 \\ 0 & 0 & 0 & 1 \end{bmatrix} \times \begin{bmatrix} 2 & 0 & 0 & 0 \\ 0 & 2 & 0 & 0 \\ 0 & 0 & 2 & 0 \\ 0 & 0 & 0 & 1 \end{bmatrix}$$

$$\begin{bmatrix} 2 & 0 & 0 & 0 \\ 0 & 2 & 0 & 0 \\ 0 & 0 & 2 & 0 \\ 0 & 0 & 0 & 1 \end{bmatrix}$$

$$\begin{bmatrix} 1 & 0 & 0 & 0 \\ 0 & 1 & 0 & 0 \\ 0 & 0 & 1 & 0 \\ 0 & 0 & 0 & 1 \end{bmatrix}$$



MATRIZ

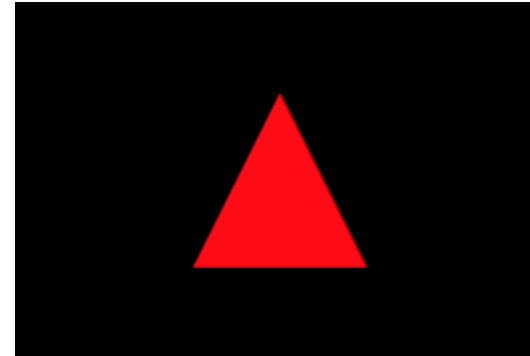
PILHA

Desenhando Triângulo Vermelho

```

<Scene>
  <Transform scale="2 2 2">
    <Shape>
      <TriangleSet>
        <Coordinate point='-1 -1 0 1 -1 0 0 1 0'/>
      </TriangleSet>
      <Appearance>
        <Material diffuseColor='1 0 0'/>
      </Appearance>
    </Shape>
  </Transform>
  <Transform scale="2 1 1">
    <Transform translation="0 -1 -1">
      <Shape>
        <TriangleSet>
          <Coordinate point='-1 -1 0 1 -1 0 0 1 0'/>
        </TriangleSet>
        <Appearance>
          <Material diffuseColor='0 1 0'/>
        </Appearance>
      </Shape>
    </Transform>
  </Transform>
  <Transform translation="0 1 -2">
    <Transform rotation="0 0 1 3.14">
      <Shape>
        <TriangleSet>
          <Coordinate point='-1 -1 0 1 -1 0 0 1 0'/>
        </TriangleSet>
        <Appearance>
          <Material diffuseColor='0 0 1'/>
        </Appearance>
      </Shape>
    </Transform>
  </Transform>
</Scene>

```



$$\begin{bmatrix} 2 & 0 & 0 & 0 \\ 0 & 2 & 0 & 0 \\ 0 & 0 & 2 & 0 \\ 0 & 0 & 0 & 1 \end{bmatrix}$$

MATRIZ

$$\begin{bmatrix} 1 & 0 & 0 & 0 \\ 0 & 1 & 0 & 0 \\ 0 & 0 & 1 & 0 \\ 0 & 0 & 0 & 1 \end{bmatrix}$$

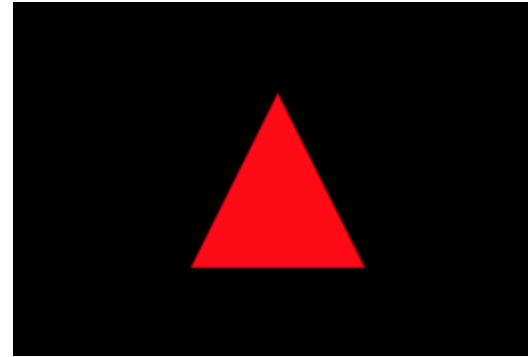
PILHA

Empilhando e Atualizando Transformação

```

<Scene>
  <Transform scale="2 2 2">
    <Shape>
      <TriangleSet>
        <Coordinate point='-1 -1 0 1 -1 0 0 1 0' />
      </TriangleSet>
      <Appearance>
        <Material diffuseColor='1 0 0' />
      </Appearance>
    </Shape>
    <Transform scale="2 1 1">
      <Transform translation="0 -1 -1">
        <Shape>
          <TriangleSet>
            <Coordinate point='-1 -1 0 1 -1 0 0 1 0' />
          </TriangleSet>
          <Appearance>
            <Material diffuseColor='0 1 0' />
          </Appearance>
        </Shape>
      </Transform>
      <Transform translation="0 1 -2">
        <Transform rotation="0 0 1 3.14">
          <Shape>
            <TriangleSet>
              <Coordinate point='-1 -1 0 1 -1 0 0 1 0' />
            </TriangleSet>
            <Appearance>
              <Material diffuseColor='0 0 1' />
            </Appearance>
          </Shape>
        </Transform>
      </Transform>
    </Transform>
  </Transform>
</Scene>

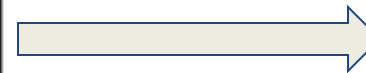
```



$$\begin{bmatrix} 2 & 0 & 0 & 0 \\ 0 & 2 & 0 & 0 \\ 0 & 0 & 2 & 0 \\ 0 & 0 & 0 & 1 \end{bmatrix} \times \begin{bmatrix} 2 & 0 & 0 & 0 \\ 0 & 1 & 0 & 0 \\ 0 & 0 & 1 & 0 \\ 0 & 0 & 0 & 1 \end{bmatrix}$$

$$\begin{bmatrix} 4 & 0 & 0 & 0 \\ 0 & 2 & 0 & 0 \\ 0 & 0 & 2 & 0 \\ 0 & 0 & 0 & 1 \end{bmatrix} \begin{bmatrix} 2 & 0 & 0 & 0 \\ 0 & 2 & 0 & 0 \\ 0 & 0 & 2 & 0 \\ 0 & 0 & 0 & 1 \end{bmatrix}$$

MATRIZ



$$\begin{bmatrix} 1 & 0 & 0 & 0 \\ 0 & 1 & 0 & 0 \\ 0 & 0 & 1 & 0 \\ 0 & 0 & 0 & 1 \end{bmatrix}$$

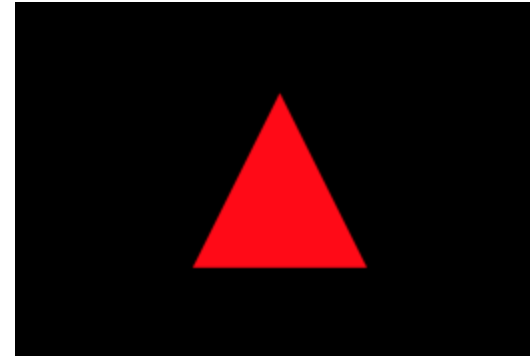
PILHA

Empilhando e Atualizando Transformação

```

<Scene>
  <Transform scale="2 2 2">
    <Shape>
      <TriangleSet>
        <Coordinate point='-1 -1 0 1 -1 0 0 1 0'/>
      </TriangleSet>
      <Appearance>
        <Material diffuseColor='1 0 0'/>
      </Appearance>
    </Shape>
  </Transform>
  <Transform scale="2 1 1">
    <Transform translation="0 -1 -1">
      <Shape>
        <TriangleSet>
          <Coordinate point='-1 -1 0 1 -1 0 0 1 0'/>
        </TriangleSet>
        <Appearance>
          <Material diffuseColor='0 1 0'/>
        </Appearance>
      </Shape>
    </Transform>
  </Transform>
  <Transform translation="0 1 -2">
    <Transform rotation="0 0 1 3.14">
      <Shape>
        <TriangleSet>
          <Coordinate point='-1 -1 0 1 -1 0 0 1 0'/>
        </TriangleSet>
        <Appearance>
          <Material diffuseColor='0 0 1'/>
        </Appearance>
      </Shape>
    </Transform>
  </Transform>
</Scene>

```

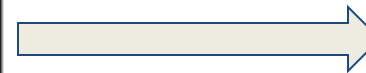


$$\begin{bmatrix} 4 & 0 & 0 & 0 \\ 0 & 2 & 0 & 0 \\ 0 & 0 & 2 & 0 \\ 0 & 0 & 0 & 1 \end{bmatrix} \times \begin{bmatrix} 1 & 0 & 0 & 0 \\ 0 & 1 & 0 & -1 \\ 0 & 0 & 1 & -1 \\ 0 & 0 & 0 & 1 \end{bmatrix}$$

$$\begin{bmatrix} 4 & 0 & 0 & 0 \\ 0 & 2 & 0 & -2 \\ 0 & 0 & 2 & -2 \\ 0 & 0 & 0 & 1 \end{bmatrix}$$

$$\begin{bmatrix} 4 & 0 & 0 & 0 \\ 0 & 2 & 0 & 0 \\ 0 & 0 & 2 & 0 \\ 0 & 0 & 0 & 1 \end{bmatrix}$$

MATRIZ



$$\begin{bmatrix} 2 & 0 & 0 & 0 \\ 0 & 2 & 0 & 0 \\ 0 & 0 & 2 & 0 \\ 0 & 0 & 0 & 1 \end{bmatrix}$$

$$\begin{bmatrix} 1 & 0 & 0 & 0 \\ 0 & 1 & 0 & 0 \\ 0 & 0 & 1 & 0 \\ 0 & 0 & 0 & 1 \end{bmatrix}$$

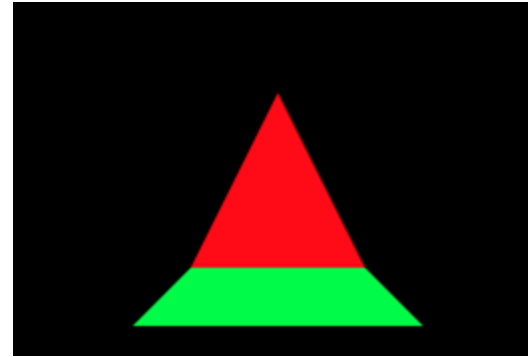
PILHA

Desenhando Triângulo Verde

```

<Scene>
  <Transform scale="2 2 2">
    <Shape>
      <TriangleSet>
        <Coordinate point='-1 -1 0 1 -1 0 0 1 0'>
      </TriangleSet>
      <Appearance>
        <Material diffuseColor='1 0 0'>
      </Appearance>
    </Shape>
    <Transform scale="2 1 1">
      <Transform translation="0 -1 -1">
        <Shape>
          <TriangleSet>
            <Coordinate point='-1 -1 0 1 -1 0 0 1 0'>
          </TriangleSet>
          <Appearance>
            <Material diffuseColor='0 1 0'>
          </Appearance>
        </Shape>
      </Transform>
    </Transform>
    <Transform translation="0 1 -2">
      <Transform rotation="0 0 1 3.14">
        <Shape>
          <TriangleSet>
            <Coordinate point='-1 -1 0 1 -1 0 0 1 0'>
          </TriangleSet>
          <Appearance>
            <Material diffuseColor='0 0 1'>
          </Appearance>
        </Shape>
      </Transform>
    </Transform>
  </Transform>
</Scene>

```



$$\begin{bmatrix} 4 & 0 & 0 & 0 \\ 0 & 2 & 0 & -2 \\ 0 & 0 & 2 & -2 \\ 0 & 0 & 0 & 1 \end{bmatrix}$$

MATRIZ

$$\begin{bmatrix} 4 & 0 & 0 & 0 \\ 0 & 2 & 0 & 0 \\ 0 & 0 & 2 & 0 \\ 0 & 0 & 0 & 1 \end{bmatrix}$$

$$\begin{bmatrix} 1 & 0 & 0 & 0 \\ 0 & 1 & 0 & 0 \\ 0 & 0 & 1 & 0 \\ 0 & 0 & 0 & 1 \end{bmatrix}$$

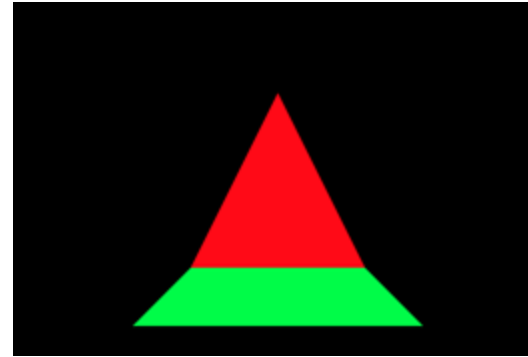
PILHA

Desempilhando e Atualizando Transformação

```

<Scene>
  <Transform scale="2 2 2">
    <Shape>
      <TriangleSet>
        <Coordinate point='-1 -1 0 1 -1 0 0 1 0'>
      </TriangleSet>
      <Appearance>
        <Material diffuseColor='1 0 0'>
      </Appearance>
    </Shape>
  </Transform>
  <Transform scale="2 1 1">
    <Transform translation="0 -1 -1">
      <Shape>
        <TriangleSet>
          <Coordinate point='-1 -1 0 1 -1 0 0 1 0'>
        </TriangleSet>
        <Appearance>
          <Material diffuseColor='0 1 0'>
        </Appearance>
      </Shape>
    </Transform>
  </Transform>
  <Transform translation="0 1 -2">
    <Transform rotation="0 0 1 3.14">
      <Shape>
        <TriangleSet>
          <Coordinate point='-1 -1 0 1 -1 0 0 1 0'>
        </TriangleSet>
        <Appearance>
          <Material diffuseColor='0 0 1'>
        </Appearance>
      </Shape>
    </Transform>
  </Transform>
</Transform>
</Scene>

```



$$\begin{bmatrix} 4 & 0 & 0 & 0 \\ 0 & 2 & 0 & -2 \\ 0 & 0 & 2 & -2 \\ 0 & 0 & 0 & 1 \end{bmatrix}$$

MATRIZ

$$\begin{bmatrix} 4 & 0 & 0 & 0 \\ 0 & 2 & 0 & 0 \\ 0 & 0 & 2 & 0 \\ 0 & 0 & 0 & 1 \end{bmatrix}$$

$$\begin{bmatrix} 2 & 0 & 0 & 0 \\ 0 & 2 & 0 & 0 \\ 0 & 0 & 2 & 0 \\ 0 & 0 & 0 & 1 \end{bmatrix}$$

$$\begin{bmatrix} 1 & 0 & 0 & 0 \\ 0 & 1 & 0 & 0 \\ 0 & 0 & 1 & 0 \\ 0 & 0 & 0 & 1 \end{bmatrix}$$

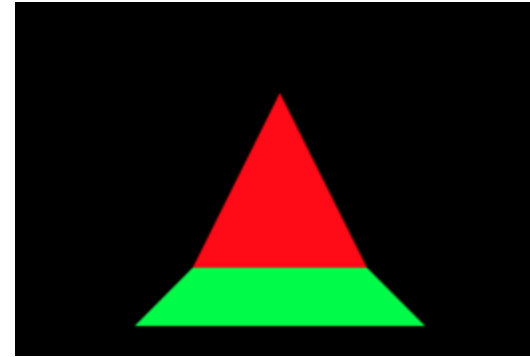
PILHA

Empilhando e Atualizando Transformação

```

<Scene>
  <Transform scale="2 2 2">
    <Shape>
      <TriangleSet>
        <Coordinate point='-1 -1 0 1 -1 0 0 1 0'/>
      </TriangleSet>
      <Appearance>
        <Material diffuseColor='1 0 0'/>
      </Appearance>
    </Shape>
  </Transform>
  <Transform scale="2 1 1">
    <Transform translation="0 -1 -1">
      <Shape>
        <TriangleSet>
          <Coordinate point='-1 -1 0 1 -1 0 0 1 0'/>
        </TriangleSet>
        <Appearance>
          <Material diffuseColor='0 1 0'/>
        </Appearance>
      </Shape>
    </Transform>
  </Transform>
  <Transform translation="0 1 -2">
    <Transform rotation="0 0 1 3.14">
      <Shape>
        <TriangleSet>
          <Coordinate point='-1 -1 0 1 -1 0 0 1 0'/>
        </TriangleSet>
        <Appearance>
          <Material diffuseColor='0 0 1'/>
        </Appearance>
      </Shape>
    </Transform>
  </Transform>
</Scene>

```



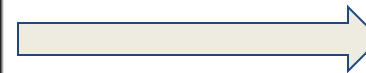
$$\begin{bmatrix} 4 & 0 & 0 & 0 \\ 0 & 2 & 0 & 0 \\ 0 & 0 & 2 & 0 \\ 0 & 0 & 0 & 1 \end{bmatrix} \times \begin{bmatrix} 1 & 0 & 0 & 0 \\ 0 & 1 & 0 & 1 \\ 0 & 0 & 1 & -2 \\ 0 & 0 & 0 & 1 \end{bmatrix}$$



$$\begin{bmatrix} 4 & 0 & 0 & 0 \\ 0 & 2 & 0 & 2 \\ 0 & 0 & 2 & -4 \\ 0 & 0 & 0 & 1 \end{bmatrix}$$

$$\begin{bmatrix} 4 & 0 & 0 & 0 \\ 0 & 2 & 0 & 0 \\ 0 & 0 & 2 & 0 \\ 0 & 0 & 0 & 1 \end{bmatrix}$$

MATRIZ



$$\begin{bmatrix} 2 & 0 & 0 & 0 \\ 0 & 2 & 0 & 0 \\ 0 & 0 & 2 & 0 \\ 0 & 0 & 0 & 1 \end{bmatrix}$$

$$\begin{bmatrix} 1 & 0 & 0 & 0 \\ 0 & 1 & 0 & 0 \\ 0 & 0 & 1 & 0 \\ 0 & 0 & 0 & 1 \end{bmatrix}$$

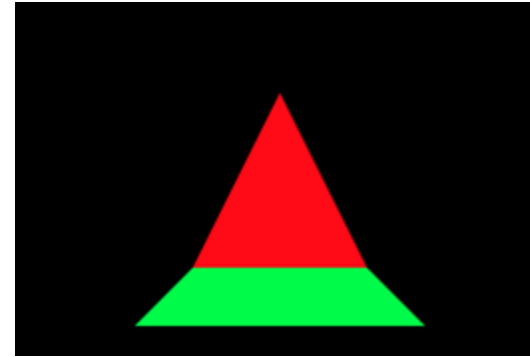
PILHA

Empilhando e Atualizando Transformação

```

<Scene>
  <Transform scale="2 2 2">
    <Shape>
      <TriangleSet>
        <Coordinate point='-1 -1 0 1 -1 0 0 1 0'/>
      </TriangleSet>
      <Appearance>
        <Material diffuseColor='1 0 0'/>
      </Appearance>
    </Shape>
  </Transform>
  <Transform scale="2 1 1">
    <Transform translation="0 -1 -1">
      <Shape>
        <TriangleSet>
          <Coordinate point='-1 -1 0 1 -1 0 0 1 0'/>
        </TriangleSet>
        <Appearance>
          <Material diffuseColor='0 1 0'/>
        </Appearance>
      </Shape>
    </Transform>
  </Transform>
  <Transform translation="0 1 -2">
    <Transform rotation="0 0 1 3.14">
      <Shape>
        <TriangleSet>
          <Coordinate point='-1 -1 0 1 -1 0 0 1 0'/>
        </TriangleSet>
        <Appearance>
          <Material diffuseColor='0 0 1'/>
        </Appearance>
      </Shape>
    </Transform>
  </Transform>
</Scene>

```



$$\begin{bmatrix} 4 & 0 & 0 & 0 \\ 0 & 2 & 0 & 2 \\ 0 & 0 & 2 & -4 \\ 0 & 0 & 0 & 1 \end{bmatrix} \times \begin{bmatrix} -1 & 0 & 0 & 0 \\ 0 & -1 & 0 & 0 \\ 0 & 0 & 1 & 0 \\ 0 & 0 & 0 & 1 \end{bmatrix}$$

$$\begin{bmatrix} -4 & 0 & 0 & 0 \\ 0 & -2 & 0 & 2 \\ 0 & 0 & 2 & -4 \\ 0 & 0 & 0 & 1 \end{bmatrix}$$

$$\begin{bmatrix} 4 & 0 & 0 & 0 \\ 0 & 2 & 0 & 2 \\ 0 & 0 & 2 & -4 \\ 0 & 0 & 0 & 1 \end{bmatrix}$$

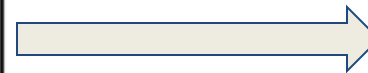
MATRIZ

$$\begin{bmatrix} 4 & 0 & 0 & 0 \\ 0 & 2 & 0 & 0 \\ 0 & 0 & 2 & 0 \\ 0 & 0 & 0 & 1 \end{bmatrix}$$

$$\begin{bmatrix} 2 & 0 & 0 & 0 \\ 0 & 2 & 0 & 0 \\ 0 & 0 & 2 & 0 \\ 0 & 0 & 0 & 1 \end{bmatrix}$$

$$\begin{bmatrix} 1 & 0 & 0 & 0 \\ 0 & 1 & 0 & 0 \\ 0 & 0 & 1 & 0 \\ 0 & 0 & 0 & 1 \end{bmatrix}$$

PILHA

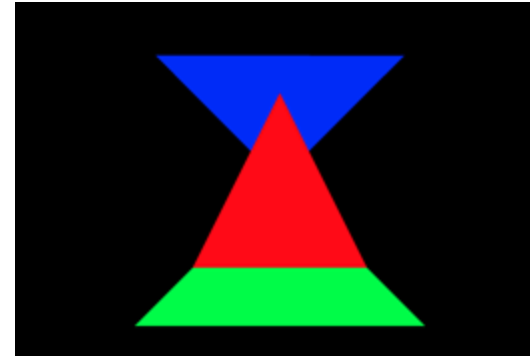


Desenhando Triângulo Azul

```

<Scene>
  <Transform scale="2 2 2">
    <Shape>
      <TriangleSet>
        <Coordinate point='-1 -1 0 1 -1 0 0 1 0'/>
      </TriangleSet>
      <Appearance>
        <Material diffuseColor='1 0 0'/>
      </Appearance>
    </Shape>
  </Transform>
  <Transform scale="2 1 1">
    <Transform translation="0 -1 -1">
      <Shape>
        <TriangleSet>
          <Coordinate point='-1 -1 0 1 -1 0 0 1 0'/>
        </TriangleSet>
        <Appearance>
          <Material diffuseColor='0 1 0'/>
        </Appearance>
      </Shape>
    </Transform>
  </Transform>
  <Transform translation="0 1 -2">
    <Transform rotation="0 0 1 3.14">
      <Shape>
        <TriangleSet>
          <Coordinate point='-1 -1 0 1 -1 0 0 1 0'/>
        </TriangleSet>
        <Appearance>
          <Material diffuseColor='0 0 1'/>
        </Appearance>
      </Shape>
    </Transform>
  </Transform>
</Scene>

```



$$\begin{bmatrix} -4 & 0 & 0 & 0 \\ 0 & -2 & 0 & 2 \\ 0 & 0 & 2 & -4 \\ 0 & 0 & 0 & 1 \end{bmatrix}$$

MATRIZ

$$\begin{bmatrix} 4 & 0 & 0 & 0 \\ 0 & 2 & 0 & 2 \\ 0 & 0 & 2 & -4 \\ 0 & 0 & 0 & 1 \end{bmatrix}$$

$$\begin{bmatrix} 4 & 0 & 0 & 0 \\ 0 & 2 & 0 & 0 \\ 0 & 0 & 2 & 0 \\ 0 & 0 & 0 & 1 \end{bmatrix}$$

$$\begin{bmatrix} 2 & 0 & 0 & 0 \\ 0 & 2 & 0 & 0 \\ 0 & 0 & 2 & 0 \\ 0 & 0 & 0 & 1 \end{bmatrix}$$

$$\begin{bmatrix} 1 & 0 & 0 & 0 \\ 0 & 1 & 0 & 0 \\ 0 & 0 & 1 & 0 \\ 0 & 0 & 0 & 1 \end{bmatrix}$$

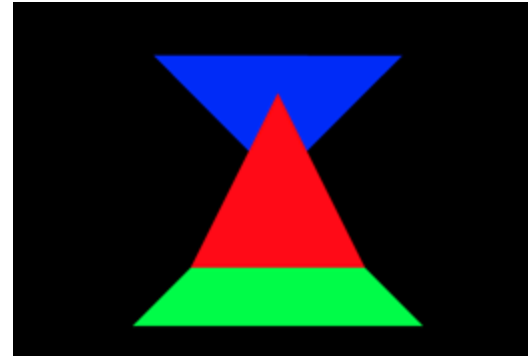
PILHA

Desempilhando e Atualizando Transformação

```

<Scene>
  <Transform scale="2 2 2">
    <Shape>
      <TriangleSet>
        <Coordinate point='-1 -1 0 1 -1 0 0 1 0' />
      </TriangleSet>
      <Appearance>
        <Material diffuseColor='1 0 0' />
      </Appearance>
    </Shape>
  </Transform>
  <Transform scale="2 1 1">
    <Transform translation="0 -1 -1">
      <Shape>
        <TriangleSet>
          <Coordinate point='-1 -1 0 1 -1 0 0 1 0' />
        </TriangleSet>
        <Appearance>
          <Material diffuseColor='0 1 0' />
        </Appearance>
      </Shape>
    </Transform>
  </Transform>
  <Transform translation="0 1 -2">
    <Transform rotation="0 0 1 3.14">
      <Shape>
        <TriangleSet>
          <Coordinate point='-1 -1 0 1 -1 0 0 1 0' />
        </TriangleSet>
        <Appearance>
          <Material diffuseColor='0 0 1' />
        </Appearance>
      </Shape>
    </Transform>
  </Transform>
</Scene>

```



$$\begin{bmatrix} 4 & 0 & 0 & 0 \\ 0 & 2 & 0 & 2 \\ 0 & 0 & 2 & -4 \\ 0 & 0 & 0 & 1 \end{bmatrix}$$

$$\begin{bmatrix} 4 & 0 & 0 & 0 \\ 0 & 2 & 0 & 0 \\ 0 & 0 & 2 & 0 \\ 0 & 0 & 0 & 1 \end{bmatrix}$$

$$\begin{bmatrix} 1 & 0 & 0 & 0 \\ 0 & 1 & 0 & 0 \\ 0 & 0 & 1 & 0 \\ 0 & 0 & 0 & 1 \end{bmatrix}$$

PILHA

$$\begin{bmatrix} -4 & 0 & 0 & 0 \\ 0 & -2 & 0 & 2 \\ 0 & 0 & 2 & -4 \\ 0 & 0 & 0 & 1 \end{bmatrix}$$

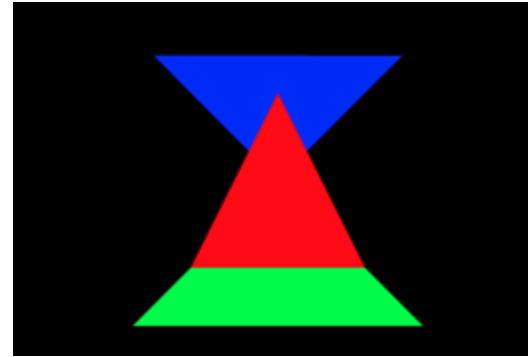
MATRIZ



Desempilhando e Atualizando Transformação

```
<Scene>
  <Transform scale="2 2 2">
    <Shape>
      <TriangleSet>
        <Coordinate point='-1 -1 0 1 -1 0 0 1 0'/>
      </TriangleSet>
      <Appearance>
        <Material diffuseColor='1 0 0'/>
      </Appearance>
    </Shape>
  </Transform>
  <Transform scale="2 1 1">
    <Transform translation="0 -1 -1">
      <Shape>
        <TriangleSet>
          <Coordinate point='-1 -1 0 1 -1 0 0 1 0'/>
        </TriangleSet>
        <Appearance>
          <Material diffuseColor='0 1 0'/>
        </Appearance>
      </Shape>
    </Transform>
  </Transform>
  <Transform translation="0 1 -2">
    <Transform rotation="0 0 1 3.14">
      <Shape>
        <TriangleSet>
          <Coordinate point='-1 -1 0 1 -1 0 0 1 0'/>
        </TriangleSet>
        <Appearance>
          <Material diffuseColor='0 0 1'/>
        </Appearance>
      </Shape>
    </Transform>
  </Transform>
</Scene>
```

← pop



$$\begin{bmatrix} 4 & 0 & 0 & 0 \\ 0 & 2 & 0 & 2 \\ 0 & 0 & 2 & -4 \\ 0 & 0 & 0 & 1 \end{bmatrix}$$

MATRIZ



$$\begin{bmatrix} 4 & 0 & 0 & 0 \\ 0 & 2 & 0 & 0 \\ 0 & 0 & 2 & 0 \\ 0 & 0 & 0 & 1 \end{bmatrix} \begin{bmatrix} 2 & 0 & 0 & 0 \\ 0 & 2 & 0 & 0 \\ 0 & 0 & 2 & 0 \\ 0 & 0 & 0 & 1 \end{bmatrix} \begin{bmatrix} 1 & 0 & 0 & 0 \\ 0 & 1 & 0 & 0 \\ 0 & 0 & 1 & 0 \\ 0 & 0 & 0 & 1 \end{bmatrix}$$

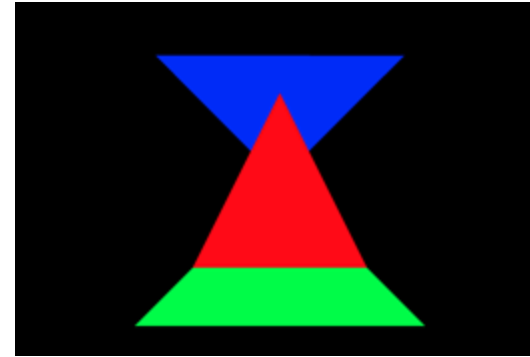
PILHA

Desempilhando e Atualizando Transformação

```

<Scene>
  <Transform scale="2 2 2">
    <Shape>
      <TriangleSet>
        <Coordinate point='-1 -1 0 1 -1 0 0 1 0' />
      </TriangleSet>
      <Appearance>
        <Material diffuseColor='1 0 0' />
      </Appearance>
    </Shape>
  </Transform>
  <Transform scale="2 1 1">
    <Transform translation="0 -1 -1">
      <Shape>
        <TriangleSet>
          <Coordinate point='-1 -1 0 1 -1 0 0 1 0' />
        </TriangleSet>
        <Appearance>
          <Material diffuseColor='0 1 0' />
        </Appearance>
      </Shape>
    </Transform>
  </Transform>
  <Transform translation="0 1 -2">
    <Transform rotation="0 0 1 3.14">
      <Shape>
        <TriangleSet>
          <Coordinate point='-1 -1 0 1 -1 0 0 1 0' />
        </TriangleSet>
        <Appearance>
          <Material diffuseColor='0 0 1' />
        </Appearance>
      </Shape>
    </Transform>
  </Transform>
</Scene>

```



$$\begin{bmatrix} 4 & 0 & 0 & 0 \\ 0 & 2 & 0 & 0 \\ 0 & 0 & 2 & 0 \\ 0 & 0 & 0 & 1 \end{bmatrix}$$

MATRIZ



$$\begin{bmatrix} 2 & 0 & 0 & 0 \\ 0 & 2 & 0 & 0 \\ 0 & 0 & 2 & 0 \\ 0 & 0 & 0 & 1 \end{bmatrix}$$

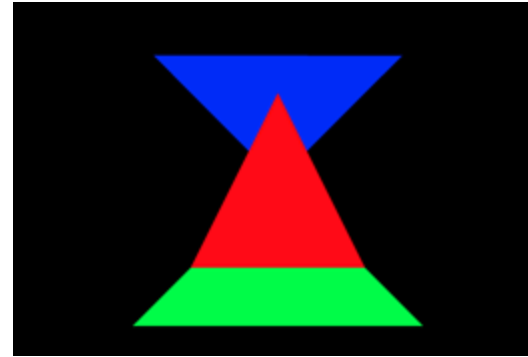
$$\begin{bmatrix} 1 & 0 & 0 & 0 \\ 0 & 1 & 0 & 0 \\ 0 & 0 & 1 & 0 \\ 0 & 0 & 0 & 1 \end{bmatrix}$$

PILHA

Desempilhando e Atualizando Transformação

```
<Scene>
  <Transform scale="2 2 2">
    <Shape>
      <TriangleSet>
        <Coordinate point='-1 -1 0 1 -1 0 0 1 0' />
      </TriangleSet>
      <Appearance>
        <Material diffuseColor='1 0 0' />
      </Appearance>
    </Shape>
  </Transform>
  <Transform scale="2 1 1">
    <Transform translation="0 -1 -1">
      <Shape>
        <TriangleSet>
          <Coordinate point='-1 -1 0 1 -1 0 0 1 0' />
        </TriangleSet>
        <Appearance>
          <Material diffuseColor='0 1 0' />
        </Appearance>
      </Shape>
    </Transform>
  </Transform>
  <Transform translation="0 1 -2">
    <Transform rotation="0 0 1 3.14">
      <Shape>
        <TriangleSet>
          <Coordinate point='-1 -1 0 1 -1 0 0 1 0' />
        </TriangleSet>
        <Appearance>
          <Material diffuseColor='0 0 1' />
        </Appearance>
      </Shape>
    </Transform>
  </Transform>
</Scene>
```

← pop



$$\begin{bmatrix} 2 & 0 & 0 & 0 \\ 0 & 2 & 0 & 0 \\ 0 & 0 & 2 & 0 \\ 0 & 0 & 0 & 1 \end{bmatrix}$$

MATRIZ



$$\begin{bmatrix} 1 & 0 & 0 & 0 \\ 0 & 1 & 0 & 0 \\ 0 & 0 & 1 & 0 \\ 0 & 0 & 0 & 1 \end{bmatrix}$$

PILHA

Computação Gráfica

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