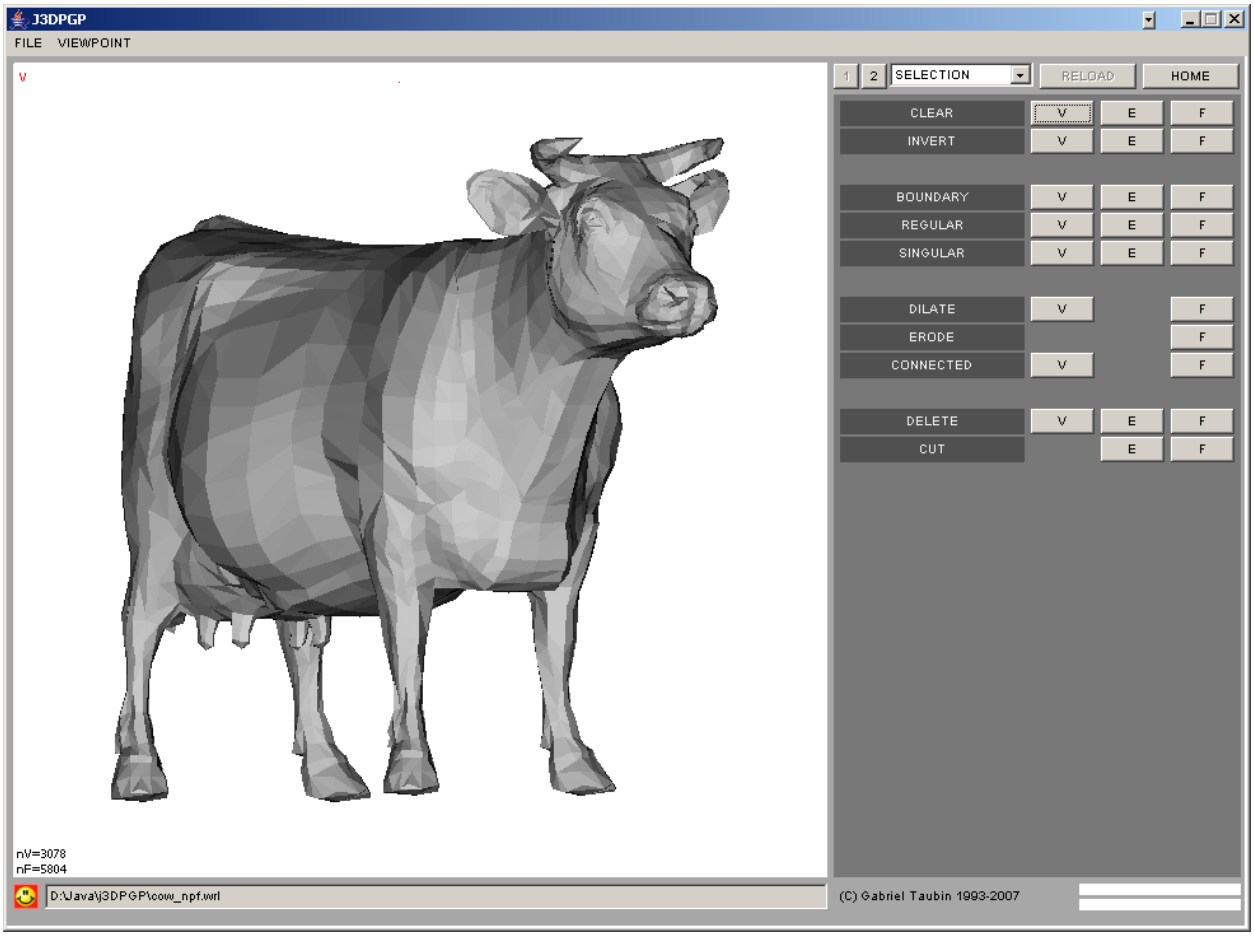
The j3DPGP Application



This application will be used for several software assignments. It provides basic functionality to operate on polygon meshes. It can read a polygon mesh from a file, edit it, and write the modified polygon mesh to a file. In the assignments you will extend the application by writing a number of geometry processing and 3D shape capture modules. For example, in the first assignment you will implement the functionality corresponding to the pushbuttons labeled V, E, and F in the screenshot shown above.

```
#VRML V2.0 utf8
Shape {
 geometry IndexedFaceSet {
 …
 }
}
```

```
#VRML V2.0 utf8
Shape {
 appearance Appearance {
  material Material {
   …
  }
 }
 geometry IndexedFaceSet {
 …
 }
}
```

```
#VRML V2.0 utf8
Shape {
 appearance Appearance {
  texture ImageTexture {
   url "xxx.jpg"
  }
 }
 geometry IndexedFaceSet {
 …
 }
}
```

The main internal data structure is the **Ifs** class, which roughly corresponds to a VRML'97 scene graph composed of: (1) a **Shape** node containing an **IndexedFaceSet** node in the `geometry` field, and (2) a **Material** node or an **ImageTexture** node in the `appearance` field. The previous table illustrates the subset of the VRML'97 file format that this application can parse, as well as the format of the files written out. In these three cases j3DPGP accepts any valid syntax with the **IndexedFaceSet** node, although some fields of these nodes are ignored by the rendering engine. The third case corresponds

to textured meshes. In this case the `url` field of the **`ImageTexture`** node must be a JPEG file stored in the same directory as the VRML file.

Installation

For the first assignment you will receive the basic application in j3DPGP-HW1.zip. To install the application you only need to unzip it in an empty directory. You should have the following files

```
IfsDesktopPanels.java
IfsPanel.java
IfsPanelColors.java
IfsPanelOptions.java
IfsPanelSelection.java
Makefile
cow_npf.wrl
cow_npv.wrl
j3DPGPapp.zip
j3DPGPlib.zip
j3dpgp.bash
j3dpgp.lnk
```

To recompile the source code and to run the application you will need the Java compiler and interpreter version 5, which are included in the Java SE Development Kit (JDK 5). You can download JDK 5 from http://java.sun.com/javase/.

If you work in a Windows environment, you can also install Cygwin from http://www.cygwin.com/. This gives you a Unix-like development environment, including `make` which we use to automate compilation. An alternative to is to install an interactive development environment (IDE) such as Eclipse, which you can download from http://www.eclipse.org/.

Running the Application

To run the application on a Windows machine, double-click `j3dpgp.lnk` within Windows Explorer. If it doesn't work on the first try, you need to edit the link properties. Right-click on the link in windows explorer, select properties, and set the "Start in:" field to the name of the directory where the two zip files are stored.

On a Linux machine, or in a Windows-Cygwin environment, open a bash shell; change directory to the location where you unzipped the files, and run `j3dpgp.bash`. Alternatively, at the command line run

```
> javaw -cp "j3DPGPapp.zip;j3DPGPlib.zip" J3DPGP -w 975 -h 675
```

In a Linux environment you need to run `java` instead of `javaw`. The Java interpreter allocates a fixed amount of memory to each application. The default is usually not enough for large meshes. You can specify the amount of memory to be allocated to the application on the command line. For example, the following command will run the application with 1GB of (virtual) memory.

```
> java -Xmx1000M -cp "j3DPGPapp.zip:j3DPGPlib.zip" J3DPGP -w 975 -h 675
```

For your first assignment, you will modify the file `IfsPanelSelection.java` and recompile `j3DPGPapp.zip`. Afterwards, you can run the application with your extensions as described above.

User Interface

Once the application is up and running, you should see two main panes, as in the screen dump shown above. The rendering panel is located on the left-hand side and the command panel is on the right-hand side. (Initially, the rendering panel will be empty.) The application actually supports multiple command panels, which can be selected from the drop-down menu (showing SELECTION in the screen capture). In the first assignment you will modify the panel defined in the file `IfsPanelSelection.java`. In subsequent assignments you will write new panels. We can reduce

clutter and group functionality in a logical manner using these panels; at the same time, we'll isolate the new code that we write from the core application.

Loading and saving data files

You can load a data file in two ways; you can drag and drop a file onto the rendering panel, or you can select LOAD from the FILE menu in the application menu bar.

After the data has been edited, you can also save the data in two ways. If you select SAVE from the FILE menu in the application menu bar, the data will overwrite the original file. The application will not ask any questions. If you don't have a backup copy of the original input file, you will loose it. You can also select FILE→ SAVE AS → WRL, which will let you choose a new name for the output file.

Exporting images

j3DPGP can export the currently rendered frame as either a JPEG or EPS file. This functionality will be useful for documenting your results in the homework assignments. To save a JPEG image, select FILE→ EXPORT → IMG JPEG. Similarly, to save an EPS file, select FILE→ EXPORT → IMG EPS. Note that the output images are rendered using the fixed size of the render frame. To increase the resolution you must increase the j3DPGP window size at runtime.

Navigation

The rendering panel is divided into 3x3 logical regions. The vertical middle and horizontal center bands are wider than the corner regions. If you click and drag in the middle-center region, the object rotates in 3D. If you click and drag on the right-middle or right-upper regions, the camera zooms in and out. If you click and drag on any of the three left regions or the lower-center region, the object translates according to the translation of the mouse with respect to the initial click. In all of these cases the light sources move with the object. If you click and drag on the upper-center region, the light sources rotate with respect to the object (but the object remains in a fixed position). The rendering engine is rather simple; it assumes that light sources are located at infinity and neglects shadows.

Rendering options

If you right click on the rendering panel a pop-up menu becomes visible. The first two options are RENDER and PAINT. Each one has an associated submenu which allows you to control how the mesh is rendered and what parts and associated properties of the mesh are rendered.

Selection

The third option in the rendering panel pop-up menu is SELECT. If you choose VERTICES, EDGES, or FACES in the SELECT submenu, you can select subsets of vertices, edges, and/or faces for the current mesh. These selected elements can be used as additional inputs to the algorithms that you will write. To add to the current selection, first press the SHIFT key and then click and drag on the rendering panel. A red selection box will be drawn, and all the elements (vertices, edges, or faces) contained within or intersected by the box will be selected. The selected elements are rendered with a different color than the unselected elements. To subtract from the selection, first press the CTRL key and then click and drag on the rendering panel. To make more precise selections you may want to zoom in to operate on a small area, then change the viewpoint and continue adding or removing from the selection. (Note that you must release the mouse button before SHIFT or CTRL, otherwise no objects will be selected.)

Compilation

In the first assignment, you will edit the file `IfsPanelselection.java`. To compile just run `make` from the command line (assuming a Linux or Cygwin environment with the bash shell). If you create a new panel, you will also need to modify `IfsDesktopPanels.java` and the `Makefile`.

VRML'97

The Virtual Reality Modeling Language (VRML'97) is the International Standard ISO/IEC 14772-1:1997. The specification can be found here

`http://www.web3d.org/x3d/specifications/vrml/ISO-IEC-14772-VRML97/`

j3DPGP only supports a very limited subset of the VRML'97 standard. However, the files that this application can parse and those that it writes are valid VRML'97 files. The VRML standard has been superseded by the X3D standard. X3D is the enhanced successor to VRML, however the VRML'97 specification and many VRML tools are still very useful and will remain so while developers update their products to support X3D.

As described above, an input file should be a valid VRML'97 file containing one `Shape` node, which comprises two fields: an `appearance` field and a `geometry` field. Either one of the two fields can be missing in the file, in which case they are assigned the default value `NULL`. However, a `Shape` node with a `NULL geometry` field will not be very useful for our purposes.

```
Shape {
  SFNode appearance NULL
  SFNode geometry   NULL
}
```

If not `NULL`, the `appearance` field of the `Shape` node should contain an `Appearance` node.

```
Appearance {
  SFNode material          NULL
  SFNode texture           NULL
  SFNode textureTransform  NULL
}
```

Again, any of the three fields of the `Appearance` node may be missing in the file, in which case it will be assigned the default value `NULL`. If the `material` field of an `Appearance` node is not `NULL`, then it must contain a `Material` node

```
Material {
  SFFloat ambientIntensity  0.2         # [0,1]
  SFColor diffuseColor      0.8 0.8 0.8 # [0,1]
  SFColor emissiveColor     0 0 0       # [0,1]
  SFFloat shininess         0.2         # [0,1]
  SFColor specularColor     0 0 0       # [0,1]
  SFFloat transparency      0           # [0,1]
}
```

In j3DPGP, if the `texture` field of an `Appearance` node is not `NULL`, then it must contain an `ImageTexture` node, and the `url` field of the `ImageTexture` node should contain the name of a JPEG file stored in the same directory as the VRML file.

```
ImageTexture {
  MFString url     []
  SFBool   repeatS TRUE
  SFBool   repeatT TRUE
}
```

In j3DPGP, if the `geometry` field of a `Shape` node is not `NULL`, then it must contain an `IndexedFaceSet` node, which is where polygon meshes can be represented

```
IndexedFaceSet {
  SFBool  ccw              TRUE
  SFBool  convex           TRUE
  SFFloat creaseAngle      0          # [0,∞)
  SFBool  solid            TRUE
  MFInt32 coordIndex       []         # [-1,∞)
  SFNode  coord            NULL
  SFBool  colorPerVertex   TRUE
  MFInt32 colorIndex       []         # [-1,∞)
```

```
  SFNode  color             NULL
  SFBool  normalPerVertex   TRUE
  SFNode  normal            NULL
  MFInt32 normalIndex       []        # [-1,∞)
  SFNode  texCoord          NULL
  MFInt32 texCoordIndex     []        # [-1,∞)
}
```

All the valid VRML'97 property bindings are supported in j3DPGP.

j3DPGP Data Structures

The fundamental data structure in j3DPGP is the **Ifs** class, which corresponds to the information contained in an input file as described above (i.e, a file containing a single `Shape` node, with an `Appearance` node in its `appearance` field and an `IndexedfaceSet` node in its `geometry` field). The `Appearance` node has a `Material` node in its `material` field and an `ImageTexture` node in its `texture` field. Nodes not present in the input file receive default values when parsed. On output, fields and nodes with default values are not written in the output file. The following is the public interface to the **Ifs** class. It includes a number of other classes, which we proceed to describe.

```
public class Ifs extends Img
{
  public             Ifs();
  public void        swap(Ifs src);
  public void        erase();

  // connectivity
  public void         makeConnectivity();
  public IfsFaces     getFaces();
  public GraphFaces   getEdges();
  public IfsSelection getSelection();

  // material
  public Material    getMaterial();
  public void        setMaterial(Material m);

  // global variables
  public void        setDiffuseColor(float[] dC);
  public float[]     getDiffuseColor();
  public void        setCcw(boolean value);
  public boolean     getCcw();
  public void        setConvex(boolean value);
  public boolean     getConvex();
  public void        setSolid(boolean value);
  public boolean     getSolid();
  public void        setCreaseAngle(float value);
  public float       getCreaseAngle();

  // coord
  public int         getNumberOfCoord();
  public void        setCoord(VecFloat value);
  public void        setCoord(int index, float value);
  public void        setCoord(int iV, int j, float value);
  public VecFloat    getCoord();
  public float       getCoord(int index);
  public float       getCoord(int iV, int j);

  // coordIndex
  public void        setCoordIndex(VecInt value);
  public void        setCoordIndex(int index, int value);
  public VecInt      getCoordIndex();
  public int         getCoordIndex(int index);
```

```
// normalPerVertex
public void        setNormalPerVertex(boolean value);
public boolean     getNormalPerVertex();

// normal
public int         getNumberOfNormal();
public void        setNormal(VecFloat value);
public void        setNormal(int index, float value);
public void        setNormal(int i, int j, float value);
public VecFloat    getNormal();
public float       getNormal(int index);
public float       getNormal(int i, int j);
public void        eraseNormal();

// normalIndex
public void        setNormalIndex(VecInt value);
public void        setNormalIndex(int index, int value);
public VecInt      getNormalIndex();
public int         getNormalIndex(int i);
public void        pushBackNormalIndex(int value);
public void        pushBackNormalIndex(int[] face);

// colorPerVertex
public void        setColorPerVertex(boolean value);
public boolean     getColorPerVertex();

// color
public int         getNumberOfColor();
public void        setColor(VecFloat value);
public void        setColor(int index, float value);
public void        setColor(int i, int j, float value);
public VecFloat    getColor();
public float       getColor(int index);
public float       getColor(int i, int j);
public void        eraseColor();

// colorIndex
public void        setColorIndex(VecInt value);
public void        setColorIndex(int index, int value);
public VecInt      getColorIndex();
public int         getColorIndex(int i);

// texCoord
public int         getNumberOfTexCoord();
public void        setTexCoord(VecFloat value);
public void        setTexCoord(int index, float value);
public void        setTexCoord(int i, int j, float value);
public VecFloat    getTexCoord();
public float       getTexCoord(int index);
public float       getTexCoord(int i, int j);
public void        eraseTexCoord();

// texCoordIndex
public void        setTexCoordIndex(VecInt value);
public void        setTexCoordIndex(int index, int value);
public VecInt      getTexCoordIndex();
public int         getTexCoordIndex(int index);

// texture
public void        setTextureUrl(String value);
public String      getTextureUrl();
public int         getTextureWidth();
public int         getTextureHeight();
public void        setTexture(int w, int h);
public void        setTexture(Img img);
```

```
  public boolean     isTextured();
  public boolean     isColored();
  public boolean     isShaded();

  // property bindings
  public final static int PB_NONE       = 0;
  public final static int PB_PER_VERTEX = 1;
  public final static int PB_PER_FACE   = 2;
  public final static int PB_PER_CORNER = 3;

  public int         getCoordBinding();
  public int         getNormalBinding();
  public int         getColorBinding();
  public int         getTexCoordBinding();

  public synchronized void    setDone(boolean value);
  public synchronized boolean getDone();
  public synchronized void    waitUntilDone();
  public synchronized boolean getHasChanged();
  public synchronized void    setHasChanged(boolean value);
}
```

Since it is necessary for many algorithms to support variable length arrays for the connectivity (`coordIndex`), geometry (`coord`), and attached properties (`color`, `colorIndex`, `normal`, `normalIndex`, `texCoord`, `texcoordIndex`), the classes `VecInt` and `VecFloat` are provided.

```
public class VecInt
{
  public VecInt()
  public VecInt(int[] i)
  public VecInt(int nI_reserve)
  public VecInt(int nI_reserve, int value)
  public VecInt(VecInt src)
  public int    capacity()
  public void   copy(VecInt dst)
  public VecInt duplicate()
  public void   erase()
  public int    get(int j)
  public int    getBack()
  public int    getFront()
  public void   popBack()
  public void   popBack(int n)
  public void   pushBack(int[] v)
  public void   pushBack(int v)
  public void   pushBack(int v0, int v1, int v2)
  public void   pushBack(int v0, int v1, int v2, int v3)
  public void   pushBack(int v0, int v1, int v2, int v3, int v4)
  public void   pushBack(int n, int v)
  public void   pushBack(VecInt v)
  public void   reserve(int n)
  public void   set(int j, int vj)
  public int    size()
  public void   swap(VecInt otherVecInt)
}

public class VecFloat
{
  public VecFloat()
  public VecFloat(float[] f)
  public VecFloat(int nI_reserve)
  public VecFloat(int nI_reserve, float value)
  public VecFloat(VecFloat src)
  public int      capacity()
  public void     copy(VecFloat copyVecFloat)
  public VecFloat duplicate()
```

```
  public void     erase()
  public float    get(int j)
  public float[]  getArray()
  public float    getBack()
  public void     getBack(float[] v)
  public float    getFront()
  public void     popBack()
  public void     popBack(int n)
  public void     popBack(float[] v)
  public void     pushBack(float[] v)
  public void     pushBack(float v)
  public void     pushBack(float v0, float v1)
  public void     pushBack(float v0, float v1, float v2)
  public void     pushBack(int n, float v)
  public void     pushBack(VecFloat v)
  public void     reserve(int n)
  public void     set(int j, float vj)
  public void     set(int j, float vj0, float vj1)
  public void     set(int j, float vj0, float vj1, float vj2)
  public boolean  eq(int j, float vj0)
  public boolean  eq(int j, float vj0, float vj1)
  public boolean  eq(int j, float vj0, float vj1, float vj2)
  public void     add(int j, float vj)
  public void     mult(int j, float vj)
  public int      size()
  public void     swap(VecFloat otherVecFloat)
}
```

If the `Ifs` is textured, then the class `Img` contains the texture data. Texture coordinates are normalized to [0,1].

```
public class Img
{
  public Img()
  public Img(int w, int h)
  public void    set(int w, int h)
  public boolean hasAlphaChannel()
  public void    addAlphaChannel()
  public void    set(Img img)
  public void    set(int w, int h, int[] data)
  public void    clear()
  public int     getWidth()
  public int     getHeight()
  public int     get(float x, float y)
  public int     get(int x, int y)
  public int     get(int x, int y, int gray)
  public int     getA(int x, int y)
  public int     getR(int x, int y)
  public int     getG(int x, int y)
  public int     getB(int x, int y)
  public void    set(int x, int y, int argb)
}

public class Material
{
  public float   ambientIntensity
  public float[] diffuseColor
  public float[] emissiveColor
  public float   shininess
  public float[] specularColor
  public float   transparency
  public Material()
  public void    setDefaultValues()
  public boolean hasDefaultValues()
  public void    copy(Material src)
}
```

```
public class IfsFaces
{
  public IfsFaces(VecInt coordIndex)
  public int     getNumberOfFaces()
  public int     getNumberOfTriangles()
  public boolean isTri()
  public boolean isQuad()
  public int     getNumberOfCorners()
  public int     getNumberOfFaceIndices(int i)
  public int     getFaceCoordIndex(int iF, int iFC)
  public void    setFaceCoordIndex(int iF, int iFC, int iV)
  public int     getCorner(int iF, int iV)
}

public class GraphEdge
{
  public GraphEdge(int v0, int v1, int indx, int next)
  public GraphEdge(int v0, int v1, int indx)
  public GraphEdge(int v0, int v1)
  public GraphEdge(VecInt vI, int j)
  public int     getVertex(int i)
  public int     getIndex()
  public void    set(VecInt vI, int j)
  public void    setIndex(int indx)
  public int     getNext()
  public void    setNext(int next)
  public int     getOtherVertex(int vi)
  public boolean isVertex(int vi)
}

public class Graph {
  public Graph()
  public Graph(Graph src)
  public Graph(boolean isOriented)
  public Graph(int nV)
  public Graph(int nV, boolean isOriented)
  public Graph(VecInt coordIndex, int nVsrc)
  public boolean   isConst()
  public boolean   isOriented()
  public int       getNumberOfVertices()
  public int       getNumberOfEdges()
  public GraphEdge getEdge(int i, int j, GraphEdge e)
  public GraphEdge getEdge(int i, int j)
  public GraphEdge getInverseEdge(GraphEdge e)
  public boolean   hasInverseEdge(GraphEdge e)
  public GraphEdge getFirstEdge(int i, GraphEdge e)
  public GraphEdge getFirstEdge(int i)
  public GraphEdge getNextEdge(GraphEdge e)
  public int       getIndexEdge(int i, int j)
  public int       getIndexEdge(GraphEdge e)
  public void      setIndexEdge(int i, int j, int indx)
  public void      setIndexEdge(GraphEdge e, int indx)
  public GraphEdge getOneEdge(int i, GraphEdge e)
  public GraphEdge getOneEdge(int i)
  public void      enumerateEdges()
  public void      insertEdge(int iV0, int iV1, int indx)
  public void      insertEdge(int i, int j)
  public void      insertEdge(int[] e)
}

public class GraphFaces extends Graph
{
  public GraphFaces(VecInt coordIndex, int nV)
  public int     getNumberOfFaces()
  public int     getNumberOfEdgeFaces(int eIndx)
```

```
  public int     getNumberOfEdgeFaces(GraphEdge e)
  public int     getEdgeFace(int eIndx, int i)
  public int     getEdgeFace(int eIndx)
  public int     getEdgeFace(GraphEdge e, int i)
  public int     getEdgeFace(GraphEdge e)
  public int     getOtherEdgeFace(int eIndx, int fi)
  public int     getOtherEdgeFace(GraphEdge e, int fi)
  public boolean isEdgeFace(int eIndx, int fi)
  public boolean isEdgeFace(GraphEdge e, int fi)
}

public class IfsSelection
{
  public IfsSelection(int nVertices, int nEdges, int nFaces)
  public IfsSelection(IfsSelection s)
  public IfsSelection(Ifs ifs)
  public void    setIfs(Ifs ifs)
  public void    clear()
  public void    clearAllVertices()
  public void    clearAllEdges()
  public void    clearAllFaces()
  public void    selectAllVertices()
  public void    selectAllEdges()
  public void    selectAllFaces()
  public void    invertAllVertices()
  public void    invertAllEdges()
  public void    invertAllFaces()
  // vertex
  public boolean isSelectedVertex(int iV)
  public int[]   getSelectedVertices()
  public int     getClearVertexIndex()
  public void    setClearVertexIndex(int value)
  public int     getDefaultVertexIndex()
  public void    setDefaultVertexIndex(int value)
  public void    newDefaultVertexIndex()
  public void    setNumberOfVertices(int nVertices)
  public int     getNumberOfVertices()
  public int     getVertexIndex(int i)
  public void    setVertexIndex(int i, int value)
  public void    setVertexIndex(int i)
  public void    selectVertex(int i)
  public void    clearVertexIndex(int i)
  public void    invertVertexIndex(int i)
  // edge
  public boolean isSelectedEdge(int iE)
  public int[]   getSelectedEdges()
  public int     getClearEdgeIndex()
  public void    setClearEdgeIndex(int value)
  public int     getDefaultEdgeIndex()
  public void    setDefaultEdgeIndex(int value)
  public void    newDefaultEdgeIndex()
  public void    setNumberOfEdges(int nEdges)
  public int     getNumberOfEdges()
  public int     getEdgeIndex(int i)
  public void    setEdgeIndex(int i, int value)
  public void    setEdgeIndex(int i)
  public void    selectEdge(int i)
  public void    clearEdgeIndex(int i)
  public void    invertEdgeIndex(int i)
  // face
  public boolean isSelectedFace(int iF)
  public int[]   getSelectedFaces()
  public int     getClearFaceIndex()
  public void    setClearFaceIndex(int value)
  public int     getDefaultFaceIndex()
  public void    setDefaultFaceIndex(int value)
```

```
  public void    newDefaultFaceIndex()
  public void    setNumberOfFaces(int nFaces)
  public int     getNumberOfFaces()
  public int     getFaceIndex(int i)
  public void    setFaceIndex(int i, int value)
  public void    setFaceIndex(int i)
  public void    selectFace(int i)
  public void    clearFaceIndex(int i)
  public void    invertFaceIndex(int i)
}

public class Partition {
  public Partition(int n)
  public void  restart(int n)
  public int   find(int i)
  public int   join(int i, int j)
  public int   getN()
  public void  end()
  public void  makeParts()
  public int   getNumberOfParts()
  public int   getNumberOfElementsInPart(int i)
  public int[] getPart(int i)
}

public class StaticHalfEdges
{
  public StaticHalfEdges(int nV, VecInt  coordIndex)
  public int     getSrcVertex(int c)
  public int     getDstVertex(int c)
  public int     getNextCorner(int c)
  public int     getPrevCorner(int iC)
  public int     getTwinCorner(int c)
  public int     getNumberOfCorners(int iV, int jV)
  public int     getCorner(int iV, int jV)
  public int     getStarFirst(int iV)
  public int     isStarFirst(int iC)
  public int     getStarNext(int iC)
  public int     getTwinCorner(int iV, int jV)
  public int     getVertex(int c)
  public int     getOldVertex(int c)
  public int     getTwinVertex(int c)
  public int     getOneCorner(int iV)
  public int     getFace(int c)
  public int     getFaceCorner(int iF, int i)
  public int     getFaceVertex(int iF, int i)
  public int     getNumberOfVertices()
  public int     getNumberOfFaces()
  public int     getNumberOfCorners()
  public int     getNumberOfFaceCorners(int iF)
}
```