

University of Bologna - Department of Mathematics

Piazza di Porta S.Donato, 5 - 40127 - Bologna



xcsurf:
the 3D modeller
User's Guide - Version 1.0

G. CASCIOLA

Department of Mathematics
University of Bologna

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Abstract

This report describes the *xcsurf* system. This is a program for modelling free form 3D curves and tensor product surfaces, which is only based on trimmed NURBS (Non Uniform Rational B-Splines) mathematics primitive.

G. CASCIOLA
Department of Mathematics, University of Bologna, P.zza di Porta S.Donato 5,
Bologna, Italy. E-mail: casciola@dm.unibo.it.

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CHAPTER 1

What is *xcsurf*?

xcsurf is the 3D modeller of the *xcmode* system [XCMODEL00]. This program is self-contained and executable from the *xcmode* console window.

It is distributed with the archive **xcsurfdev.tar.gz** (version in its development phase) and **xcsurfusr.tar.gz** (executable version). Downloading and installation instructions are in [XCMODEL00].

xcsurf is a system for modelling 3D curves and tensor product surfaces, which is only based on trimmed NURBS mathematics primitive (for an introduction see [PITI95] and [CASC98]). This interactive graphics system was principally designed to provide a development environment for the experimentation of methods, algorithms and techniques in the sector of modelling free form curves and surfaces.

xcsurf is very different from other commercial system.

It only deals with the geometric modelling aspect, leaving solid object construction, using trimming surfaces and boundary representation, to *xcbol* system [XCBOOL00].

xcsurf also provides a learning environment for the fundamental aspects of NURBS curves and surfaces and, more generally, for modelling techniques. The code is written in ANSI C language and can be executed on various types of workstation or PC running a Unix operating system with Xwindow. In order to make the system portable, it was decided to use a Graphic User Interface made with *xtools* library [XTOOLS99], provided with this package.

1.1 How to work with *xcsurf*

When *xcsurf* starts, it opens seven windows (see figure 1.1):

- **Render/Icons:** in which the surfaces, and the icons of the surfaces loaded into the system, are viewed.
- **Control Net:** in which the surface control nets are viewed.

- **Up, Side, Front, Persp:** the four fundamental views.
- **Main Menu:** in which nine option buttons and the button to quit the program are viewed.

The user can vary the position and dimensions of the **Render/Icons** and **Control Net** windows, within the limits defined by the program, for a suitable visualization of the windows in the screen. As in any interactive

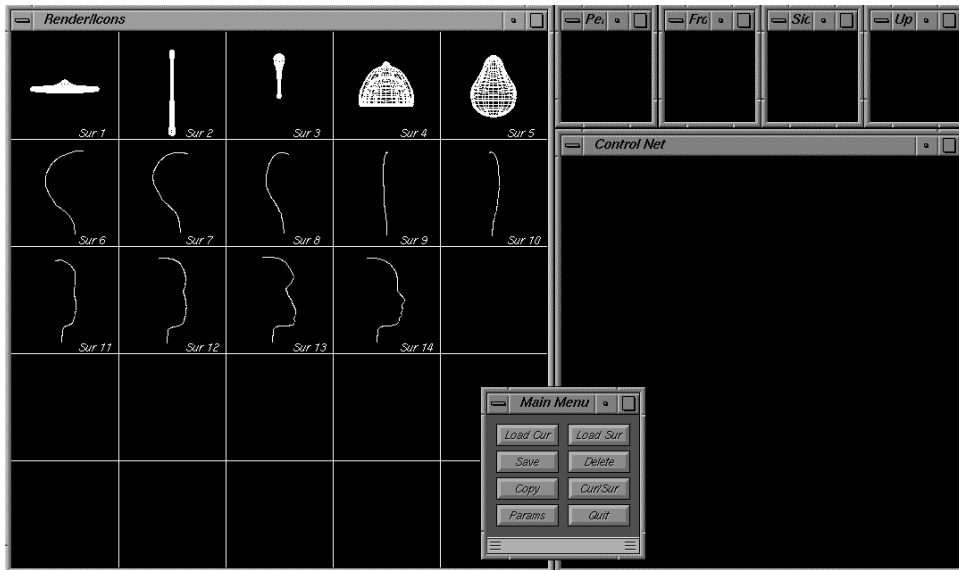


Figure 1.1: *xcsurf* environment

graphics system, *xcsurf* uses the keyboard and the mouse. In the text we use the expression "click on something with the LMB" (Left Mouse Button) or "the CMB" (Centre Mouse Button) or "the RMB" (Right Mouse Button), when the user places the mouse pointer on something on the screen and presses and releases (to click) a mouse button. In order to begin, the user has to click on a **Main Menu** button with the LMB; it is then clear which buttons are active. In fact, *xcsurf* uses a black label on an enabled button and a white one on a deactivated button. The same convention is used for all the *xcsurf* menus.

The *xcsurf* menu windows always contain the **Cancel** button or both the **Cancel** and the **Ok** buttons. When only the **Cancel** button is available (usually in windows only containing buttons) pressing on it closes the related menu window. If both buttons are available (usually in windows containing checkboxes, checkpoints, textboxes, etc.) the **Ok** button activates the set parameters, while the **Cancel** button does not able them and closes these windows.

Note that there is an online help that can be activated in the **Params** menu window, and that guides the user, step by step, in his/her actions.

1.2 What to do with *xcsurf*

xcsurf serves to model and examine common and free form 3D NURBS curves and surfaces. In *xcsurf* a curve is considered a degenerated surface, that is, the two dimensional parametric domain $[0, 1] \times [0, 1]$ degenerates into a one dimensional domain $[0, 1] \times [0, 0] \equiv [0, 1]$. Everything that *xcsurf* allows you to do to a surface will therefore also be possible for a curve.

In the following sections we refer to a surface even when we mean a degenerated surface or, for the above consideration, a curve. Any special case will be underlined.

After starting, the first and only thing the program allows you to do is to load a single surface or list of surfaces.

Loading a surface means creating a new surface or opening a surface file (.db file) previously created and saved, and storing it in the system memory.

Loading a list of surfaces means opening a file (.obj file) containing a list of file surface names, that will be opened and stored in the system memory. *xcsurf* can store up to MAXSUR surfaces (in this release MAXSUR is defined as 25). All the stored surfaces are iconised and viewable in the **Render/Icons** window (see figure 1.1).

When a surface has been loaded, all the buttons in the **Main Menu** win-

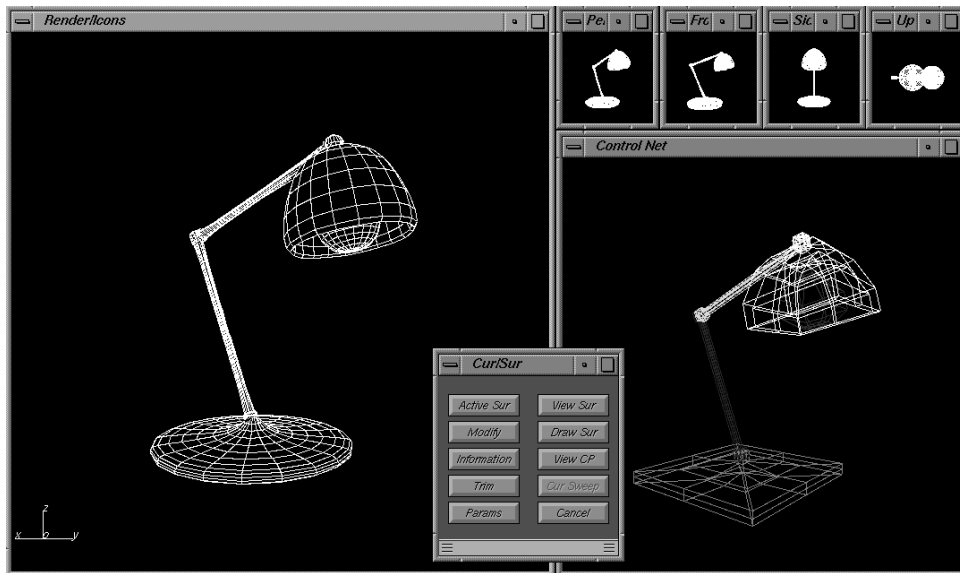


Figure 1.2: Cur/Sur environment

dow, are enabled, so it is possible to save it in a file, delete one or all the surfaces from the system memory, make a copy of a surface, or set a large number of parameters to manage the system and viewing mode.

With the **Cur/Sur** button, which will later be described in detail, it is possible to model, examine and do a lot of things on a single surface or a list of surfaces selected from those already loaded. This is the environment in which we can interactively model the surface shape.

In the same environment it is also possible to position a surface with respect to the others, so that they describe the boundary of an object. This is not a solid modelling tool, but only an opportunity to position some surfaces appropriately in the 3D space (see figure 1.2).

CHAPTER 2

Load Cur button

This button allows the user to load a curve or list of curves into the system memory. Remember that *xcsurf* manages a curve like a degenerated surface. At the end of the procedure used to load a curve, the user must indicate the position of the related icon. In the case of a list of curves, the related icons will be positioned automatically by the system. It opens the window shown in fig. 2.1

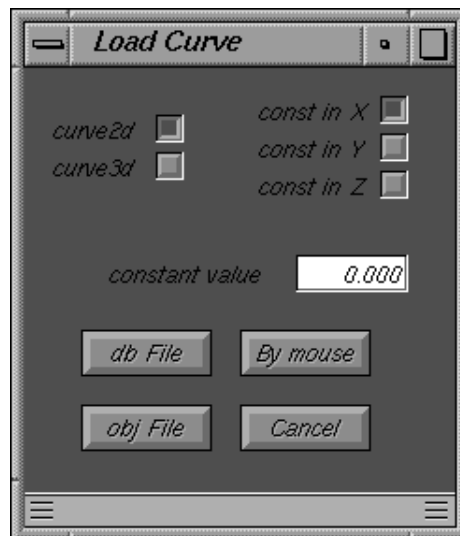


Figure 2.1: Load curves menu window

2.1 curve2d and curve3d checkpoints

These checkpoints allow the user to choose to load a 2D or 3D curve. If a 2D curve is chosen, it will appear in the 3D space on a plane parallel to

one of the three planes of co-ordinates (XY, XZ or YZ). In order to choose this plane, select the checkpoint corresponding to one of the planes of co-ordinates (constant in Z for XY, constant in Y for XZ or constant in X for YZ) and the value of the constant by giving it in the textbox.

2.2 db File button

The system opens the file request allowing the user to select a .db extension file, contained in the `xcmode1/curves2d` or in the `xcmode1/curves3d` directory, depending on the selected checkpoint. The `xcmode1/curves2d` directory contains the 2D curves previously modelled and saved using *xc-curv* (see [XCCURV00]). The `xcmode1/curves3d` directory contains the 3D curves previously modelled and saved using *xcsurf*.

2.3 obj File button

The system opens the file request allowing the user to select an .obj extension file, contained in the `xcmode1/curves3d` directory and containing a list of the file names of the 3D curves previously saved with *xcsurf*.

2.4 By mouse button

This option allows the user to create a new 2D or 3D curve (depending on the selected checkpoint) by specifying the control points interactively in the **Control Net** window by mouse. For 2D curve, this is simply done with the LMB to add and the RMB to stop. If the curve to be inserted is 3D, the control points must be inserted in two steps:

- first give the projection of the control points on the XY plane in the correct order, by clicking with the LMB;
- then give the Z co-ordinates for the control points in the correct order, by clicking with the LMB.

These two steps are guided by *xcsurf*.

Once the control points have been inserted, the **New Curve** menu window opens (see fig.2.2), in which the following parameters must be defined: the curve degree, the knot partition choice between automatic (the internal knots are equally spaced, while the external ones are set to coincide with the end interval points) and manual (the internal knots are explicitly marked by the user in a textbox window, while the external ones are set to coincide with the end interval points). The user must choose whether the curve will be open or closed (in the latter case *xcsurf* manages the given control points in order to define a closed and periodic curve).



Figure 2.2: New curve parameter window

When all the parameters have been set, the user presses the **Ok** button which closes the curve creation and loading procedure. By clicking on the **Cancel** button it is possible to cancel the curve creation and loading.

CHAPTER 3

Load Sur button

This button allows the user to load a surface or a list of surfaces into the system memory. At the end of the procedure for loading a surface, the user must indicate the position of the related icon in the **Render/Icons** window. In the case of a list of surfaces, the related icons are automatically positioned by the system. It opens the window shown in fig.3.1

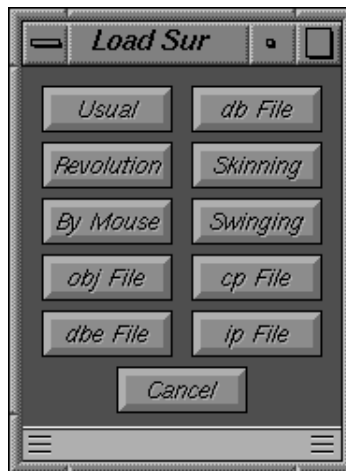


Figure 3.1: Load surface menu window

3.1 Usual button

This opens the menu window shown in fig.3.2 in which the user can select a surface type.



Figure 3.2: Usual surfaces menu window

3.2 db File button

The system opens the file request and the user selects a file with a `.db` extension contained in the `xcmode1/surfaces` directory and containing a surface previously saved.

3.3 Revolution button

This option allows the user to create a revolve surface starting from a profile curve. Only the curve icons are shown in the **Render/Icons** window and the user has to choose one by clicking on it with the LMB.

3.4 Skinning button

This option allows the user to create a surface by skinning, that is, by curve interpolation. Only the curve icons are shown in the **Render/Icons** window and the user has to choose the curves in the order in which he/she wishes them to appear; click on them with the LMB.

3.5 By mouse button

This option allows the user to load a new surface by giving the control net interactively with the mouse and then defining the remaining parameters. The control points should be inserted in two stages:

- specify the projection of the control points on the XY plane; the net will be inserted by giving the control points of the first line by clicking with the LMB (RMB to close the row), then the remaining control points for rows with the LMB (RMB to close the net);
- specify the Z co-ordinates of the control points by clicking with the LMB.

These two steps are guided by *xcsurf*.

Once the control net has been defined, the window in fig.3.3 will open, in

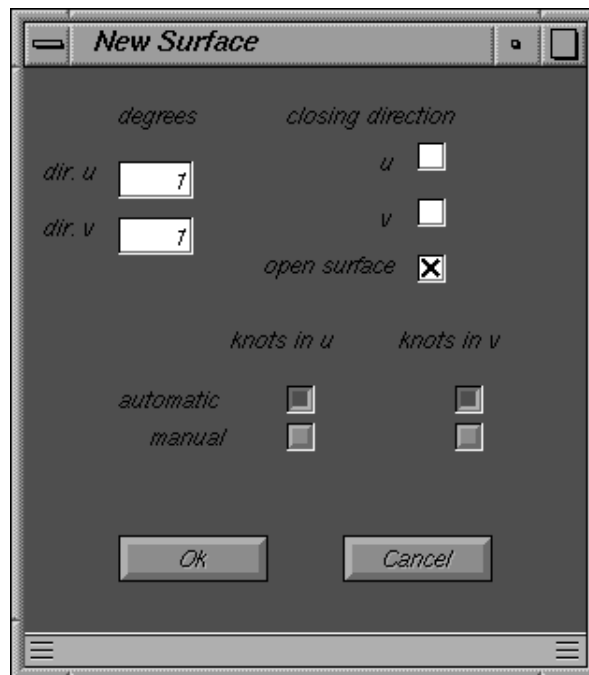


Figure 3.3: New surface parameter window

which it is possible to set the surface degrees in u and v , the knot partitions in u and in v that can be manually assigned by the user (manual) or automatically by *xcsurf* (automatic); in the latter case, the internal knots are equally spaced while the external ones coincide with the end interval points. It is important to choose whether the surface should be closed in u , v or in both directions. In these cases *xcsurf* manages the given control net in order to make a closed and periodic surface.

3.6 Swinging button

This option allows the user to create a swinging surface starting from a profile and a trajectory curve. It is possible to set an arbitrary scale factor

for the XY dimension of the surface. Only the curve icons are shown in the **Render/Icons** window and the user has to choose from these, first the profile curve and then the trajectory by clicking on them with the LMB.

3.7 obj File button

A file request opens, allowing the user to select a file with an .obj extension contained in the `xcmode1/surfaces` directory and containing a list of surface file names, that have previously been saved with *xcsurf*.

3.8 cp File button

This button allows the user to create a new surface by loading a file of control points. A file request opens, allowing the user to select a file with a .cp extension contained in the `xcmode1/surfaces` directory and containing the control net. The window in fig.3.3 then opens, in which the user can specify the remaining parameters in order to define the surface completely (see By mouse button section).

3.9 dbe File button

This opens the file request allowing the user to select a file with a .dbe extension contained in the `xcmode1/surfaces` directory and containing a trimmed surface previously saved with *xcsurf*.

3.10 ip File button

This option allows the user to create a new surface by interpolating a 3D point mesh stored in a file. This opens the file request allowing the user to select a file with a .ip extension contained in the `xcmode1/surfaces` directory. This then opens a menu window from which to choose a method of interpolation (this *xcsurf* release only provides the bicubic interpolation method).

CHAPTER 4

Params button

This button allows the user to set some *xcsurf* parameters regarding interactivity and viewing (see fig.4.1) that are explained as follows.

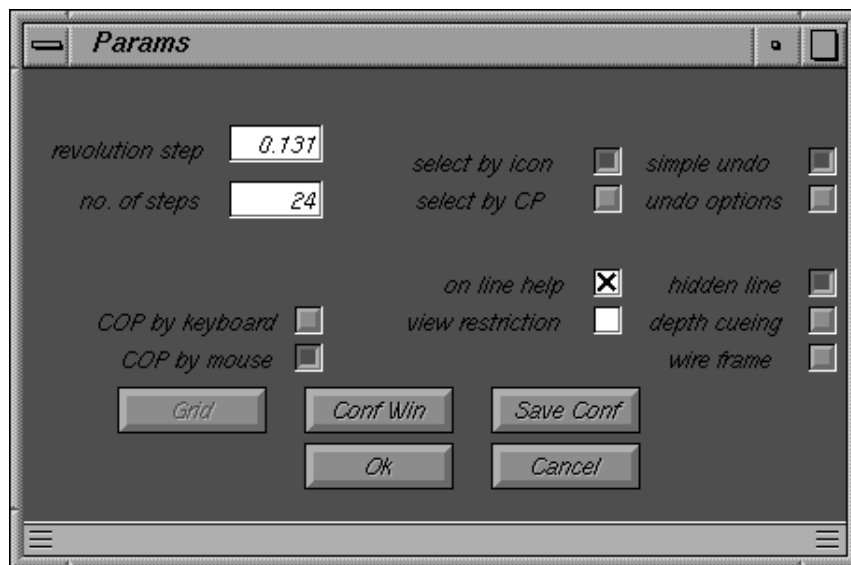


Figure 4.1: Parameters window

4.1 no. of steps textbox

The value specified in this textbox defines the number of steps in which the camera completes a 180 degree rotation to view the surfaces. The associated parameter, "revolution step" shows the step value in radians.

4.2 on line help checkbox

This checkbox ables/unables the online help of *xcsurf*. For every operation, this help guides the user on how to carry out the operation correctly.

4.3 COP by keyboard and COP by mouse checkpoints

These checkpoints allow the user to specify the COP (Center Of Projection or camera position) according to its coordinates using the keyboard or using the mouse cursor. This only affects the surface view (**View Sur** button) and the control points view (**View CP** button) in the **Cur/Sur** menu window.

4.4 select by icon and select by CP checkpoints

These checkpoints allow the user to select the active surface either by clicking on its icon or by clicking near one of its control points. This only affects the choice of surface viewed in the **Cur/Sur** menu window.

4.5 Render method checkpoints

These checkpoints allow the user to choose the viewing method for our surfaces in the **Render/Icons** window. *xcsurf* provides three methods:

- hidden line
- depth cueing
- wire frame

which vary in rendering quality and viewing speed.

4.6 simple do and undo options checkpoints

These checkpoints allow the user to carry out an undo procedure that provides the simultaneous viewing of the surface before and after modification, in order to appreciate the difference.

4.7 view restriction checkbox

This checkbox allows the user to view a sub-patch of the surface, during the procedure activated using the **View Sur** button.

4.8 Grid button

This button opens a window allowing the user to set the dimensions in u and v of its grid rendering through the numerical index of one of the curves or surfaces in the system.

4.9 Conf Win and Save Conf buttons

These buttons allow the user to modify the position of all *xcsurf* windows and the dimensions of the **Render/Icons** and **Control Net** windows. It is possible to save this configuration in the `.xcsurfrc` file. The system will use this file to configure the windows for subsequent work sessions.

Click on the **Conf Win** button with the mouse; now you can modify the positions and dimensions of *xcsurf* windows as usual with your Window Manager; when you have finished, click on the RMB. If you don't click on the **Save Conf** button, but on **Cancel**, your configuration will only be set for your actual work session.

CHAPTER 5

Other buttons

5.1 Save button

This button opens a window (see fig. 5.1) allowing the user to choose whether to save a surface, a list of surfaces, a surface control net, a 3D curve or a list of 3D curves on file. The curves or surfaces must be selected from the **Render/Icons** window with the mouse. Open the file request allowing the user to specify the name to be used to save the curve, surface or control net. In the case of a list, if the individual surfaces do not already have an associated file name, one explicit name is requested for each one; finally, the file request opens allowing the list to be named.



Figure 5.1: Save menu window

5.2 Delete button

This button allows the user to delete one or more surfaces from *xcsurf*'s memory. Click with the LMB on the curve or surface icon to delete. By

clicking with the CMB on the **Render/Icons** window you can delete all the curves and surfaces loaded into the system. To stop the delete procedure, click on the **Render/Icons** window with the RMB.

5.3 Copy button

This button allows the user to make a copy of a surface; click with the LMB on the surface icon to copy, then click with the CMB on an empty position. To quit the copy procedure, click on the **Render/Icons** window with the RMB.

CHAPTER 6

Cur/Sur button

This option allows the user to enter the modelling, analysis and viewing mode of one or more surfaces. The user is asked to select the surfaces on which to work by clicking with the LMB on the relative icons. Click with the CMB on the surface icon you want to be active, that is, the surface to model and analyse. Click with the RMB to quit the selection procedure. The **Control Net** window shows the control nets of all the selected surfaces, each presented in a different colour; the net of the viewed surface will be drawn in white. The selected surfaces in wire-frame can be viewed in the **Render/Icons** window. The menu window of fig. 6.1 proposes the following options.

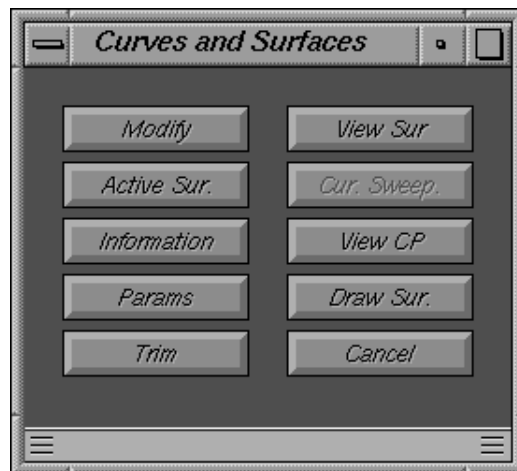


Figure 6.1: Curves/Surfaces environment

6.1 Modify button

This button allows the user to change the shape of the active surface, or to move it into the 3D space. The window of fig. 6.2 opens; this contains three parts: geometric transformation, modify surface parameters and set COP.

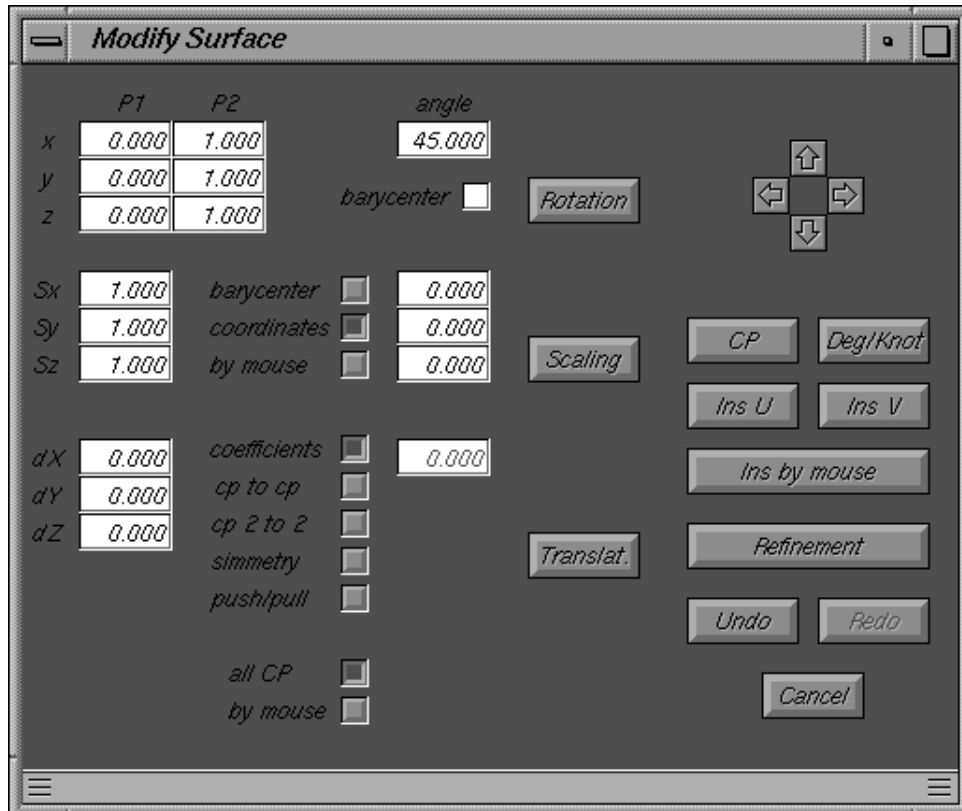


Figure 6.2: Modify Surface menu window

- Set COP, which is made using the four arrow buttons in the top right-hand corner, enables the user to obtain the best view of the part of the surface which is to be modified.
- geometric transformations modify the whole surface (all CP) or only part of it (selecting some CPs with the mouse). They consists in:
 - translation. The relative checkpoints show:
 - * coefficients; the values selected in the textboxes dX , dY and dZ are taken as the co-ordinates of the translation vector.
 - * cp to cp; defines the translation vector as the difference between two CPs on the surface, localized by mouse.

-
- * cp 2 to 2; enables the translation of individual CPs on the surface. To do this, select the CP to be moved and another CP as a point to which the previous CP will be translated (it is useful in order to make several CPs coincide).
 - * symmetry; affects all the CPs and translates them in such a way that the surface remains symmetrical with respect to a given point chosen with mouse among the CPs.
 - * push/pull; the translation vector is automatically computed to be orthogonal to the viewplane. The value selected in the textbox on the right is taken as the translation vector length.
 - scaling. The relative checkpoints indicate:
 - * barycenter; the barycenter of the surface is taken as the scaling center.
 - * coordinates; through the textbox on the right it is possible to provide a scaling center. The textboxes Sx , Sy and Sz enable the scaling factors to be given.
 - * by mouse; it is possible to give a CP as the scaling center using the mouse.
 - rotation. The rotation is around an axis of a given angle in degrees. The axis is defined by two 3D points P1 and P2 whose coordinates are given in the textboxes. By setting the "barycenter" checkbox, P1 will be the surface barycenter.
 - to modify the surface parameters we have (fig.6.2):
 - CP button; enables a CP to be selected with the mouse, then by opening an appropriate window, allows the user to modify the CP coordinates and weight.
 - Degree button; enables the degree in u and in v of the surface and therefore the knot partition to be changed.
 - Ins U and Ins V buttons; enable a knot insertion of a numerically specified knot to be made in u or in v through a textbox.
 - Knot by mouse; enables a knot insertion to be made interactively on the knot map in the **Render/Icons** window.
 - Refinement; carries out a repeated knot insertion in both u and v directions at the mid-point of each knot interval.
 - Undo and Redo buttons; respectively allow the user to return to the surface situation previous to the latest modification and to repeat the latest modification eliminated with Undo.

6.2 Information button

Pressing the **Information** button in menu illustrated in fig.6.1, will be shown the menu of fig.6.3 in which the user can obtain general information about the surface/s (**General** button) and, guided by the system, can explore the connections between the knots and CPs on the enabled surface (**Knot-CP** button) or the connections between the knots and CPs in a hypothetical knot insertion operation (**Knot-Ins** button). In any case, the



Figure 6.3: Information menu window

parametric domain of the surface with the knot partition is shown in the **Render/Icons** window, next to a matrix of symbols representing the matrix of the CPs; information about the degrees, number of knots and number of CPs are shown too.

- General button; gives information about the center and radius of the smallest sphere containing the surfaces, about the center and radius of the smallest sphere containing the active surface, about the COP and about the three segments considered and shown as axes.
- Knot-CP button; provides two functions:
 1. click with the LMB on a CP shown in the **Control Net** window. The position of the selected control point will be viewed in the **Render/Icons** window in the matrix and rectangle of the parametric domain affected by the CP.
 2. click with the LMB on a matrix row (click under the first row element) or on a matrix column (click to the right of the first element in the column) in the **Render/Icons** window. The related

row of CPs will be viewed in the **Control Net** window as well as the rectangle of the parametric domain affected by these CPs.

- Knot-Ins button; allows for two functions:
 1. click with the LMB on the u or v axes where you want to insert a new knot. The related rows and columns of the matrices of the CPs which would be modified by the knot-insertion operation in that position will be viewed.
 2. click with the LMB on the CP matrix exactly between two rows (click between the first two row items) or between two columns (click between the first two column items). Rows and columns of the CPs which could be involved in a knot-insertion operation will be viewed in the **Control Net** window.

6.3 Params button

This button, in the menu of fig.6.1, opens the same menu window of the **Params** button in the **Main Menu** (see fig.1.1); this button also appears in the **Cur/Sur** menu because when it is active, the main menu is not active and viceversa, although it must always be possible to set the system parameters at any moment.

6.4 Trim button

This button allows the user to cut out a patch from the surface. The parametric domain of the surface with the knot grid and, at the top, information about the degrees, number of knots and CPs are shown in the **Render/Icons** window. The user is guided in selecting a rectangle within the parametric domain with vertices, which are knots in the partition.

By doing this, the user defines the surface, trimming away the rectangular regions selected; the cut-out part of the surface is memorised as a separated non-trimmed region of the surface and is iconised in the first free position. It should be noted that this operation can result in a trimmed surface made up of disconnected patches, as well as being used to trim a previously trimmed surface.

6.5 View Sur button

This button allows the user to view the selected surface from various points of view. The user can choose to view only a part of the surface or, even to restrict the view to a rectangle in the knot grid. This can be done by giving the indices of the external points of the required rectangle (see **View**

restriction checkbox in the **Params** menu window).

Therefore, according to whether **COP by keyboard** or **COP by mouse** have been selected in the **Params** menu window, a window will appear in which either the COP co-ordinates can be specified or a cursor can be activated by the mouse; in the latter case there are 4 buttons allowing the user to view the surface from 3 basic viewpoints and to return to the original perspective at any time (see fig.6.4).

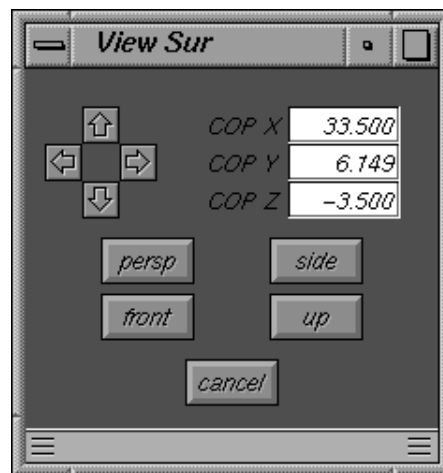


Figure 6.4: View sur menu window

6.6 View CP button

This button allows the user to view the CPs on the surface from various point of view. As with **View Sur**, according to what has been set in the **Params** menu window, the COP co-ordinates can be assigned using the keyboard or the mouse cursor (see **View Sur** button).

6.7 Draw Sur button

This option simply draws the surface in the **Control Net** window, showing the grid of CPs and the surface together, so that it is possible to observe the relationship between the CPs and the surface they define. This view is temporary and every other operation in the **Control Net** window only returns to the control net.

6.8 Active Sur button

This button allows the user to select another surface as the active surface. If the checkpoint "select by icon" has already been set in the **Params** menu window, the selection will be made by clicking on the surface icon, shown in the **Render/Icons** window, with the LMB; if, on the other hand, the checkpoint "select by CP" has been set, the selection will be made by clicking on a CP surface, shown in the **Control Net** window, with the LMB.

6.9 Cur Sweep button

This option allows the user, guided by the system, to carry out a sweeping operation on a profile curve along a spine curve. Remember that sweeping consists in the interpolation of many copies of the same curve placed in different positions, and usually placed along a spine curve. Using "Cur Sweep" *xcsurf* allows the user to position a profile curve correctly along a spine curve, and therefore to obtain the interpolating surface through the application of the skinning procedure (see **Skinning** button). Before accessing "Modify Surface" and clicking on "Cur Sweep", the user should already have prepared a spine curve and several copies of the profile curve (use the "copy" button to create as many copies of the profile curve as positions that you wish this curve to take along the spine curve).

Enter the "Cur/Sur" mode by selecting the spine curve and all the copies of the profile curve. Now the user can act on the **Cur Sweep** button; the following steps must be followed:

- select the profile curves by clicking on their icons with the LMB; use the RMB to stop.
- select the spine curve by clicking on its icon with the LMB.
- define a point on the profile curve with the LMB.
- define as many points on the spine curve, by clicking with the LMB, as copies of the profile curve.
- the profile curve will be viewed along the spine curve in the points defined and at right angles to it; it is then possible to rotate each profile curve around the point of contact with the spine curve and along the plane at right angles to the spine curve.
- quit "Cur/Sur"; at this point, guided by the system, the user has profile curves that are correctly positioned in the 3D space.
- Enter the "Load sur" mode, then "skinning" and select the profile curves in order.

The result of this whole procedure will be a surface interpolating these profile curves.

CHAPTER 7

Data file formats

In this section the syntax of each file format used by *xcsurf* is given and explained. The data files created by *xcsurf* are stored in `xcmodel/surfaces` and `xcmodel/curves3d` directories as default, while the data files used are loaded by the above-mentioned and `xcmodel/curves2d` directories as default. The `#` character in the following introduces a comment on the data in the file.

7.1 3D NURBS curve

The following example file is `xcmodel/curves3d/curve08.db`. The files with a `.db` extension contained in the `curves3d` directory, identify 3D NURBS curves or degenerated surfaces (compare with a file surface). The format is self-explanatory.

```
FILENAME : curve08.db                #curve file name
DEGREE_U_V                #introduces the curve degree
      2          0                #curve degree
N.C.P._U_V                #introduces the CPs number
      45          1                #number of CPs
KNOTS_U_V                #introduces the knot number
      48          0                #number of knots
COORD.C.P.(X,Y,Z,W)      #introduces the CPs coord. and weights
-4.000000e-01 4.000000e+00 -1.050000e+01 1.000000e+00
-4.000000e-01 4.100000e+00 -1.000000e+01 1.000000e+00
....
-4.000000e-01 4.000000e+00 -1.050000e+01 1.000000e+00
-4.000000e-01 4.000000e+00 -1.050000e+01 1.000000e+00
KNOTS_U      #introduces the knot vector in not decreasing order
0.000000e+00
0.000000e+00
```

```

....
1.000000e+00
1.000000e+00
KNOTS_V

```

7.2 List of curves

The following example file is `xcmodel/curves3d/profiles.obj`. The files with an `.obj` extension contained in the `curves3d` directory, identify lists of 3D NURBS curves. The format is self-explanatory.

```

FILENAME:profiles.obj                #file name
8                                     #number of curve file names
curve1.db                            #curve file name
curve2.db
....
curve7.db
curve8.db

```

7.3 3D NURBS surface

The following example file is `xcmodel/surfaces/sphere.db`. The files with a `.db` extension contained in the `surfaces` directory, identify 3D NURBS surfaces. The format is self-explanatory.

```

FILENAME:sphere.db                  #surface file name
DEGREE_U_V                          #introduces the surface degrees
  2          2                      #surface degrees
N.C.P._U_V                          #introduces the control net dimensions
  5          9                      #control net dimensions
N.KNOTS_U_V                          #introduces the knot partition dimensions
  8          12                     #knot partition dimensions
COORD.C.P.(X,Y,Z,W)                #the 3D CPs coord. and weights by row
  0.00000E+00 0.00000E+00 1.00000E+00 1.00000E+00
  0.00000E+00 0.00000E+00 1.00000E+00 7.07107E-01
....
  0.00000E+00 0.00000E+00-1.00000E+00 7.07107E-01
  0.00000E+00 0.00000E+00-1.00000E+00 1.00000E+00
KNOTS_U                              #the U knot vector in not decreasing order
  0.00000E+00
  0.00000E+00
....
  1.00000E+00

```



```

1.00000E+00
KNOTS_V          #the V knot vector in not decreasing order
0.00000E+00
0.00000E+00
....
1.00000E+00
1.00000E+00

```

7.4 3D trimmed NURBS surface

The following example file is `xcmodel/surfaces/sphere.dbe`.

The files with a `.dbe` extension contained in the `surfaces` directory, identify 3D trimmed NURBS surfaces. This format consists in the same information already given for a 3D NURBS surface, plus appended information on the 2D trimming curves on the parametric surface domain. The format is self-explanatory.

```

FILENAME:sphere.dbe          #same as a .db file
DEGREE_U_V
      2          2
N.C.P._U_V
      5          9
N.KNOTS_U_V
      8          12
COORD.C.P.(X,Y,Z,W)
0.00000E+00 0.00000E+00 1.00000E+00 1.00000E+00
0.00000E+00 0.00000E+00 1.00000E+00 7.07107E-01
....
0.00000E+00 0.00000E+00-1.00000E+00 7.07107E-01
0.00000E+00 0.00000E+00-1.00000E+00 1.00000E+00
KNOTS_U
0.00000E+00
0.00000E+00
....
1.00000E+00
1.00000E+00
KNOTS_V
0.00000E+00
0.00000E+00
....
1.00000E+00
1.00000E+00
1 #this is a flag; it signals that other information follows
0 # normal versus; 0 for computed versus, 1 opposite versus

```

```

0          # flag not used (see .tree format)
8          # number of trimming curves
0          # flag not used (see .tree format)
5          # number of points for first trimming curve
0.634467 0.496372  #(v,u) coord. in the param. surface domain
.....
0.634467 0.496372
0          # flag not used (see .tree format)
5          # number of points for second trimming curve
0.384467 0.496372  #(v,u) coord. in the param. surface domain
.....
0.384467 0.496372
.....
#etc.

```

7.5 List of surfaces

The following example file is `xcmodel/surfaces/skittles.obj`.

The files with an `.obj` extension contained in the `surfaces` directory, identify lists containing 3D NURBS or trimmed NURBS surface names. The format is self-explanatory.

```

FILENAME:skittles.obj          #file list name
10                             #number of surface file names
skittle01.dbe                 #trimmed surface name
skittle02.db                  #surface name
....
skittle09.dbe
skittle10.db

```

7.6 3D control points

The following example file is `xcmodel/surfaces/sphere.cp`.

The files with a `.cp` extension contained in the `surfaces` directory, identify control point nets. The format is self-explanatory.

```

FILENAME:sphere.cp           #control net file name
N.C.P._U_V                  #introduces the control net dimensions
      5          9          #control net dimensions
COORD.C.P.(X,Y,Z,W)        #the 3D CPs coord. and weights by row
0.00000E+00 0.00000E+00 1.00000E+00 1.00000E+00
0.00000E+00 0.00000E+00 1.00000E+00 7.07107E-01
....
0.00000E+00 0.00000E+00-1.00000E+00 7.07107E-01
0.00000E+00 0.00000E+00-1.00000E+00 1.00000E+00

```

7.7 3D points

The following example file is `xcmodel/surfaces/random.ip`.

The files with an `.ip` extension contained in the `surfaces` directory, identify point arrays. The format is self-explanatory.

```
FILENAME:random.ip                #point array file name
N.P._U_V                          #introduces the array dimensions
      5          7                #array dimensions
COORD.P.(X,Y,Z)                   #introduces the 3D point coord. by row
0.00000E+00 1.00000E+00 1.00000E+00
0.00000E+00 1.00000E+00 7.07107E-01
....
0.00000E+00-1.00000E+00 7.07107E-01
0.00000E+00-1.00000E+00 1.00000E+00
```


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