N94-22366

UNSTRUCTURED SURFACE GRID GENERATION

JAMSHID SAMAREH-ABOLHASSANI
COMPUTER SCIENCES CORPORATION

PRECEDING PAGE BLANK NOT FILMED

- INTRODUCTION
- REQUIREMENTS
- SURFACE APPROXIMATIONS
- METHODS
- GEOLAB EFFORT

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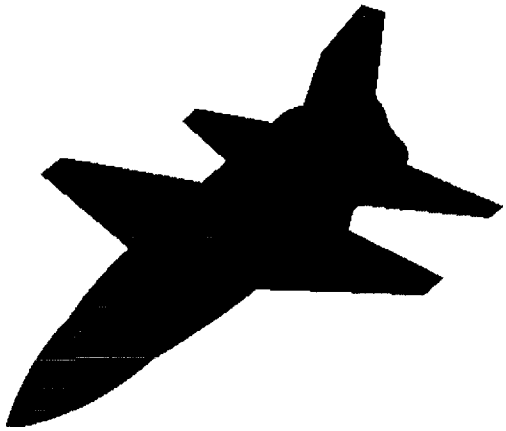
- Complex Shapes
- Turn-Around Time
- CPU Time
- Applications
  - Advancing Front
  - Prismatic Elements
  - Delaunay (Steiner Triangulation)



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REQUIREMENTS

Curves, Surfaces, Solids, Text

- Curves and Surfaces
  - Bicubic Patches
  - Conic Sections
  - Splines (any order)
  - B–Splines
  - Parametric Splines
  - Points and Tabulated data
  - Ruled Surfaces
  - Surfaces of Revolution
  - Trimmed Surfaces

→ Non–Uniform Rational B–Splines **(NURBS)**

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REQUIREMENTS Cont.

- Spacing
- Stretching
- Over 50 Surfaces
  NURBS, Trimmed
- User Input
  Turn–Around Time (Day)
- Adaptivity
- Parametric Study

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REQUIREMENTS Cont.

Few Surfaces
Simple Configurations

Present →

Lots of Patches
More User's Time

Lots of Surfaces
Complex Configurations

Future →

Few Patches
Less User's Time

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SURFACE APPROXIMATION (I)

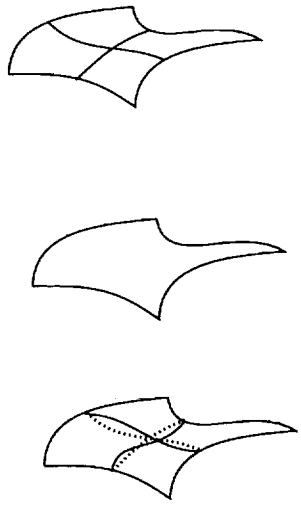
CAD DATA

↓

BOUNDARY CURVES

↓

GRID



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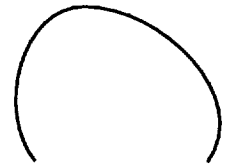
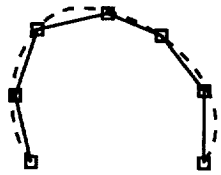
SURFACE APPROXIMATION (II)

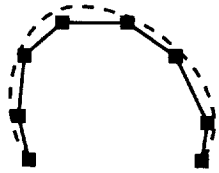
CAD DATA



POINTS



GRID



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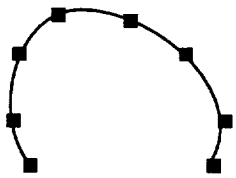
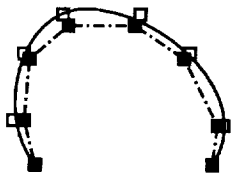
EXACT SURFACE REPRESENTATION

Direct Surface Triangulation



Type I and II + Projection



LANGLEY HAS TWO PROJECTION CODES FOR STRUCTURED AND UNSTRUCTURED GRIDS
AIAA 93-3454 (august 1993)
info: jamshid@geosun1.larc.nasa.gov
copy: pkerr@geolab2.larc.nasa.gov

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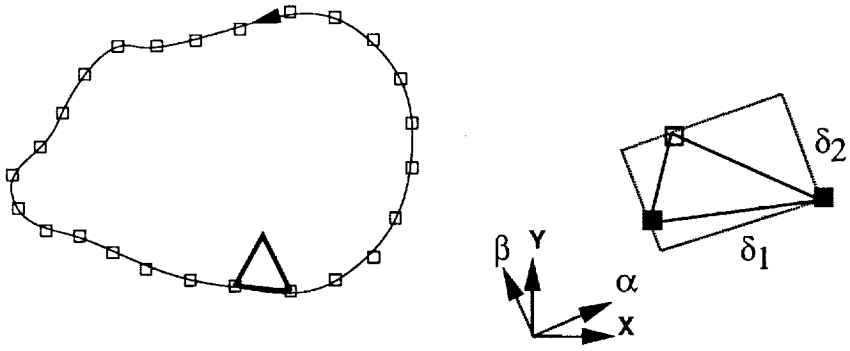
Advancing Front



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METHODS

- 2D (Planes, Triangulation is performed in the parameter space)
- 2 1/2 D (Triangulation is performed in the Parameter Space)
- 3D (Triangulation is performed in the Physical and Parameter Spaces)

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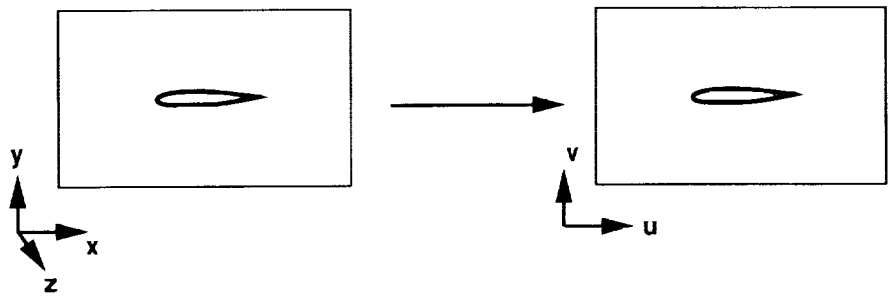
2D (PLANES)



- o Exact
- o No Shearing (Exact shape and size)
- o Speed (0)

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2½D Advancing Front

Type I

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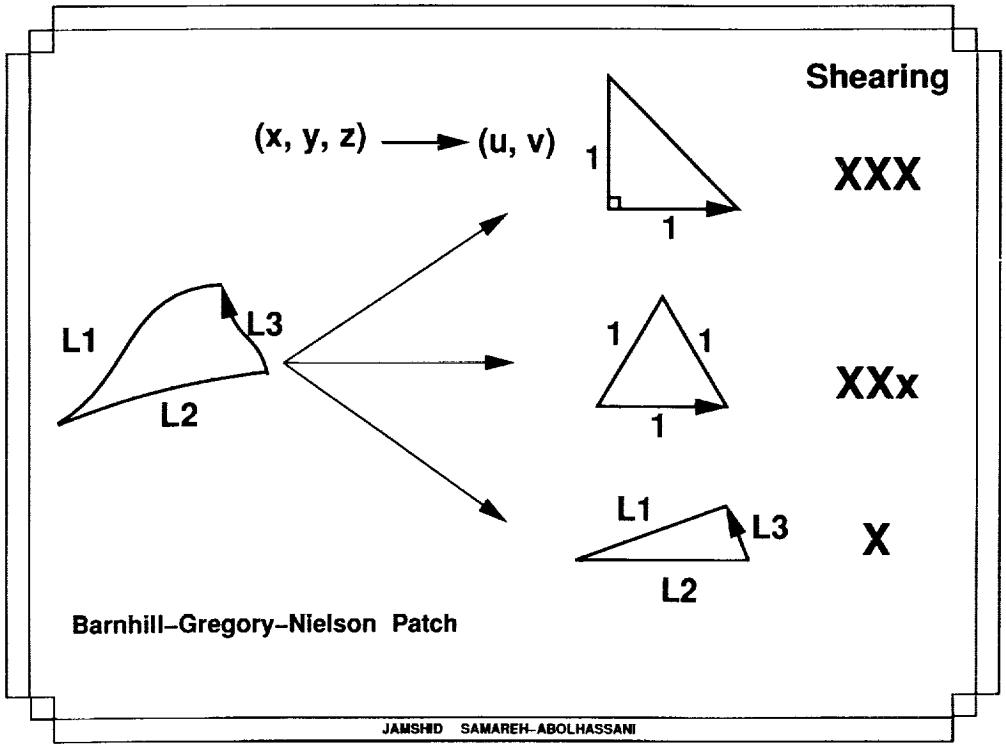
Shearing
(x, y, z) → (u, v)
1
1
XXX
L1
L3
L2
1
1
1
XXx
L1
L3
L2
X
Barnhill–Gregory–Nielson Patch
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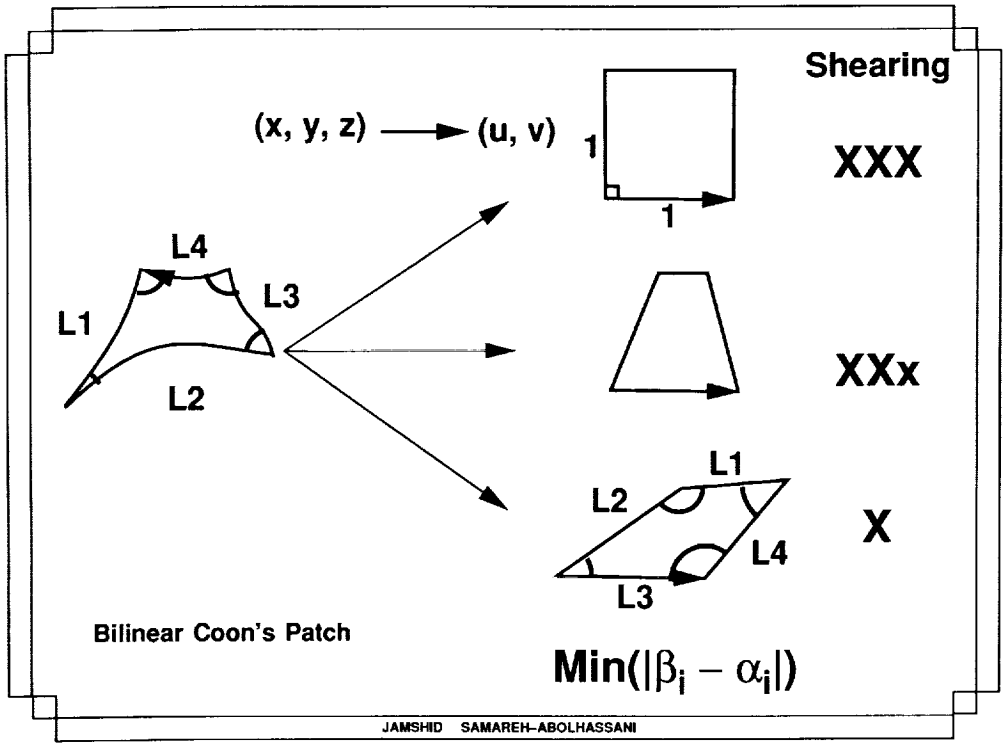
Shearing
(x, y, z) → (u, v)
1
1
XXX
L4
L3
L1
L2
XXx
L1
L2
L4
L3
X
Bilinear Coon's Patch
Min(|β_i − α_i|)
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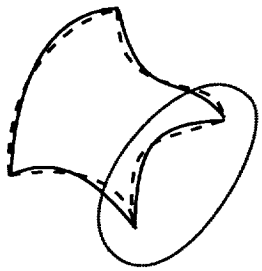
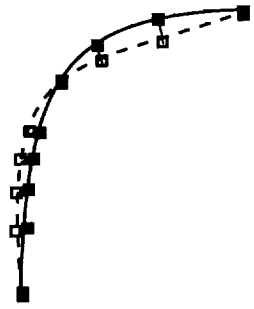
PROJECTION





Cons:

- Shearing
- Speed (1)
- 3/4 Sided–Patches Only
- More Patches Are Needed

Pros:

- Surfaces Are Exact
- Multiple Surfaces
- T–Connections

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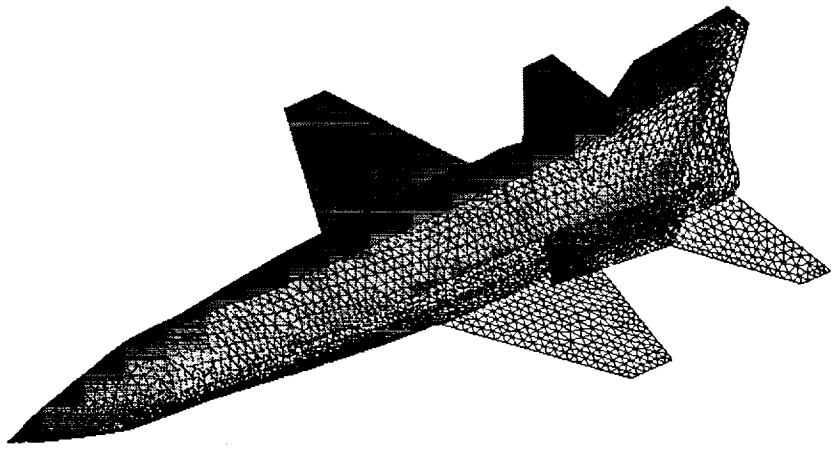
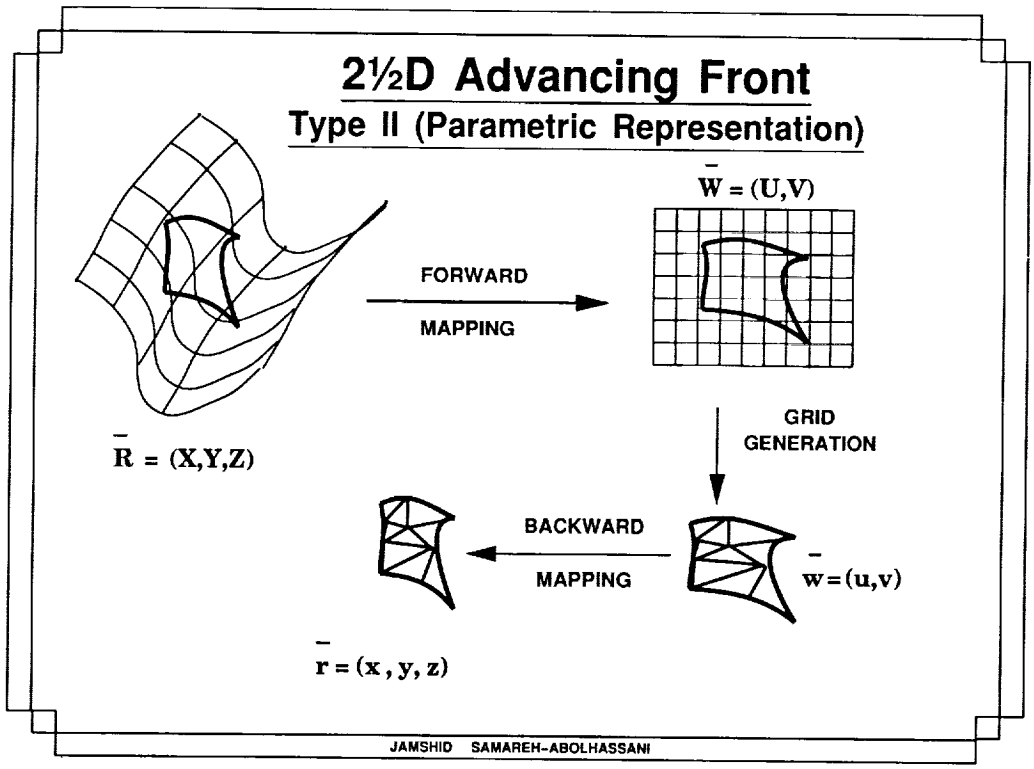
X–15




2½D Advancing Front
Type II (Parametric Representation)
$\bar{W} = (U,V)$
FORWARD
MAPPING
GRID
GENERATION
$\bar{R} = (X,Y,Z)$
BACKWARD
MAPPING
$\bar{w} = (u,v)$
$\bar{r} = (x, y, z)$
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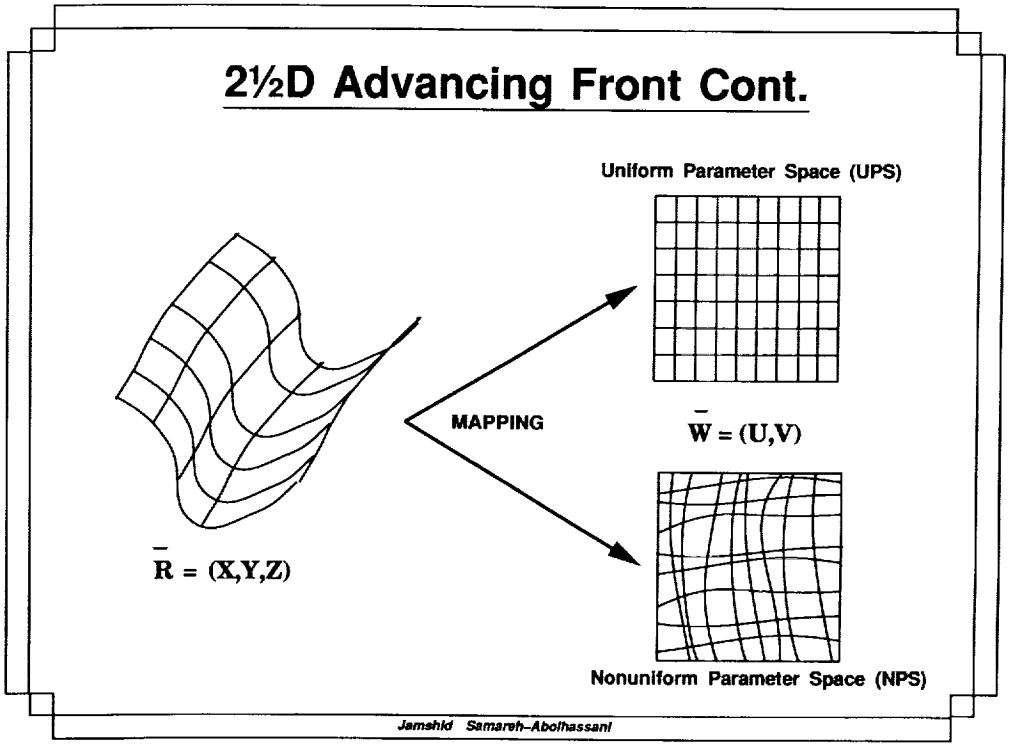
2½D Advancing Front Cont.
Uniform Parameter Space (UPS)
MAPPING
$\bar{W} = (U,V)$
$\bar{R} = (X,Y,Z)$
Nonuniform Parameter Space (NPS)
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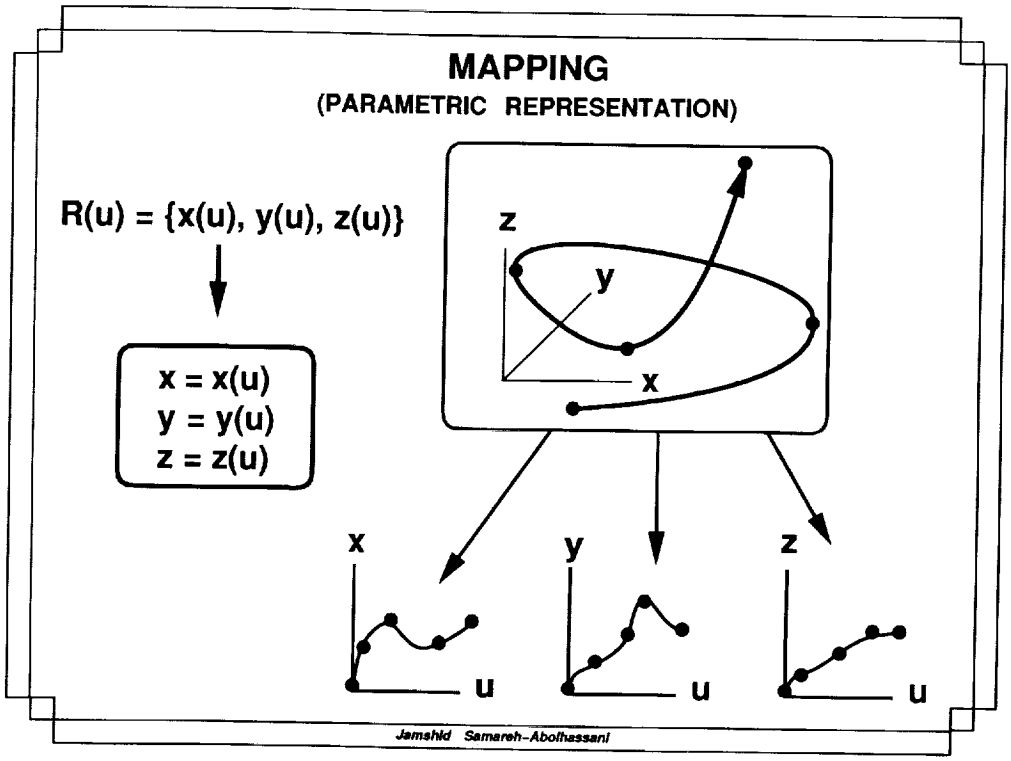
MAPPING
(PARAMETRIC REPRESENTATION)
R(u) = {x(u), y(u), z(u)}
x = x(u)
y = y(u)
z = z(u)
z
y
x
x
u
y
u
z
u
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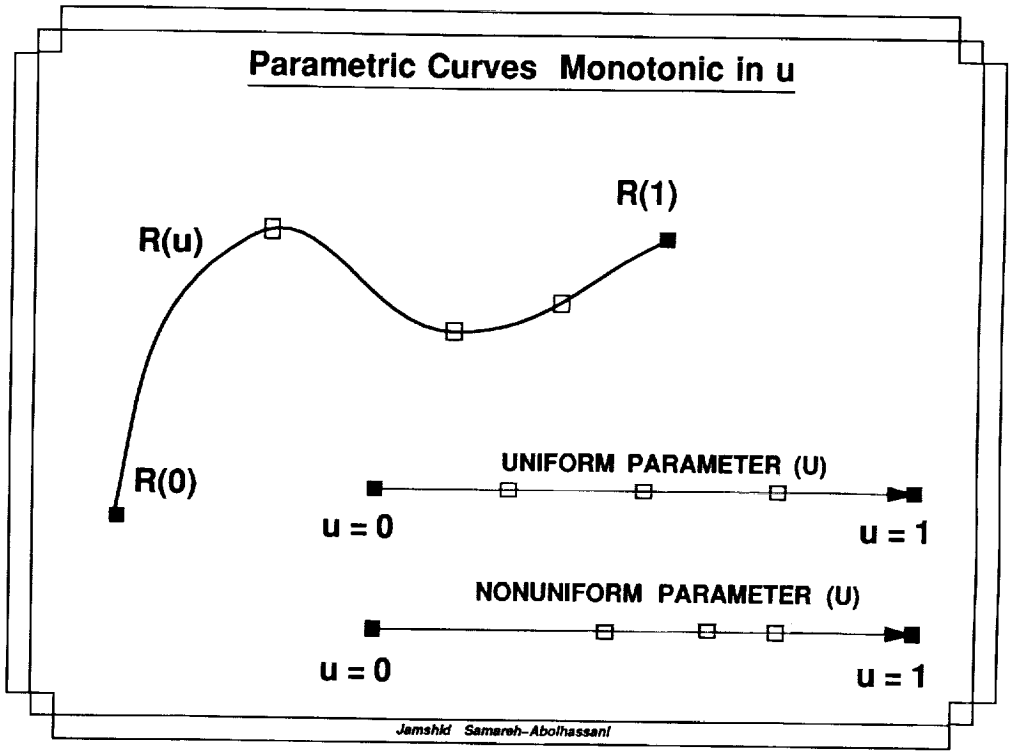
Parametric Curves Monotonic in u
R(1)
R(u)
R(0)
UNIFORM PARAMETER (U)
u = 0
u = 1
NONUNIFORM PARAMETER (U)
u = 0
u = 1
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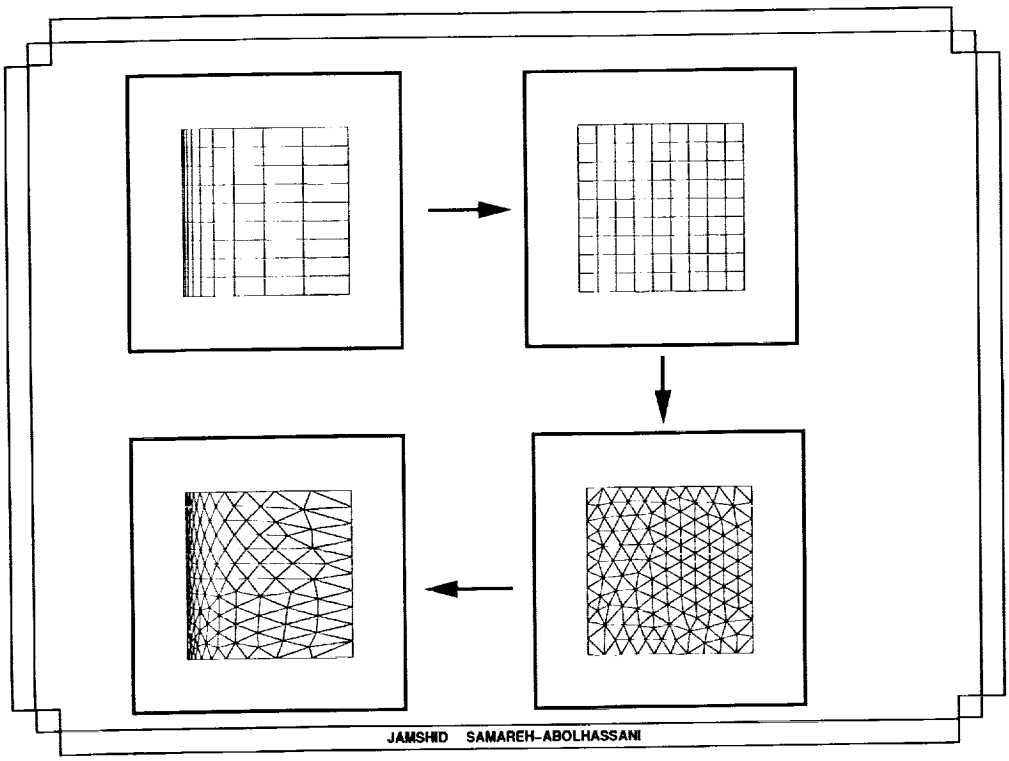
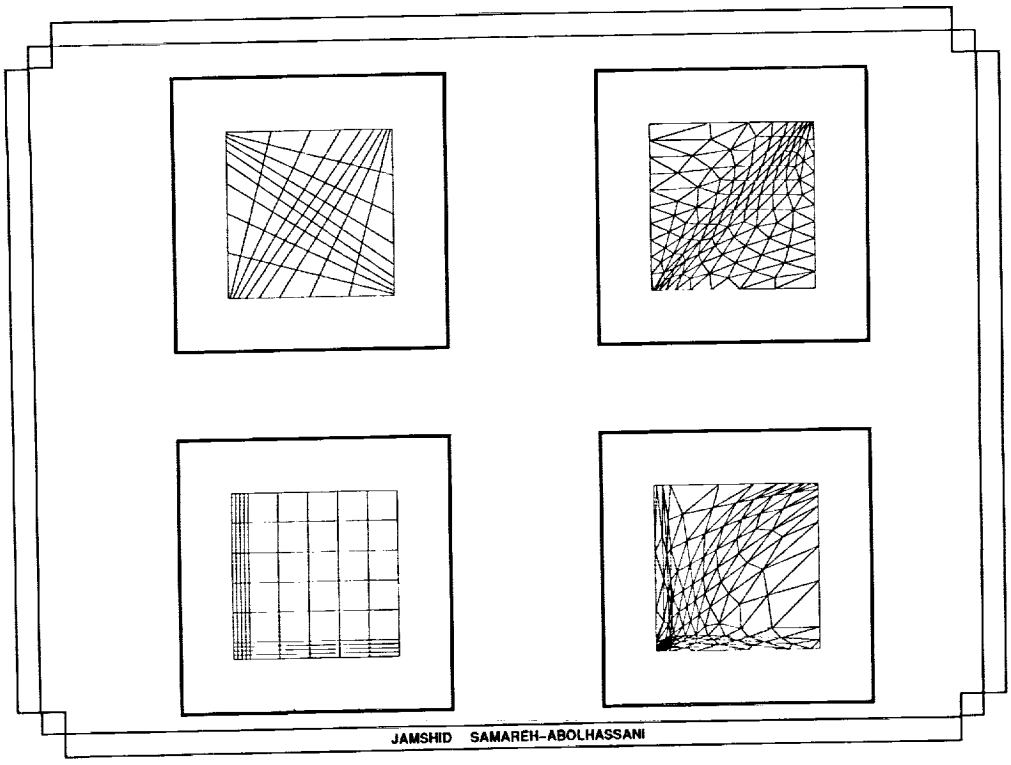
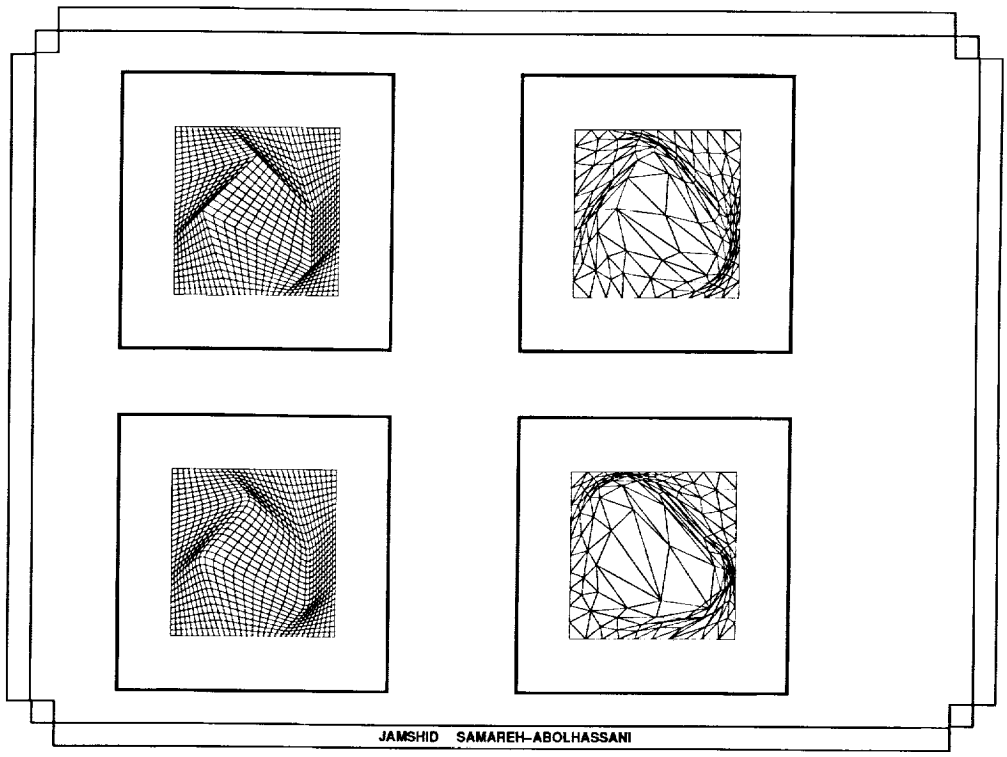

JAMSHID SAMAREH-ABOLHASSANI


JAMSHID SAMAREH-ABOLHASSANI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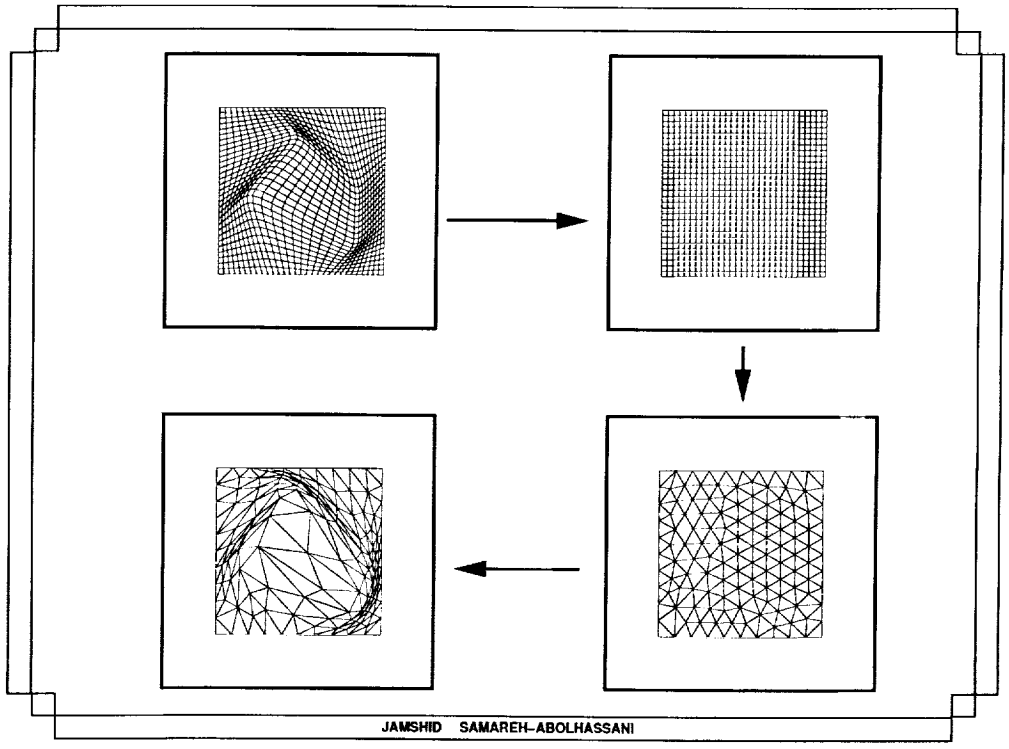
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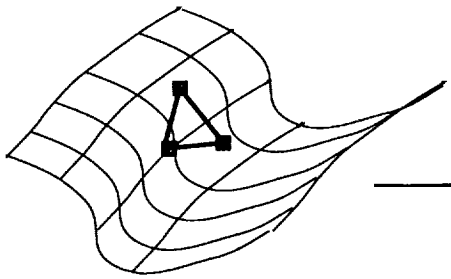
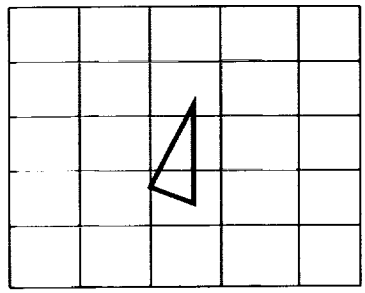
PARAMETER SPACE





PHYSICAL SPACE

PARAMETER SPACE

$\delta_1, \delta_2, \alpha, \beta$ → Transformation → $\delta'_1, \delta'_2, \alpha', \beta'$

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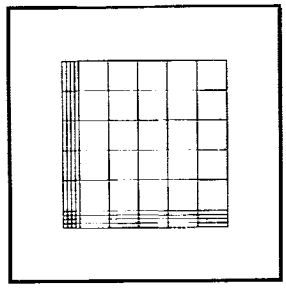

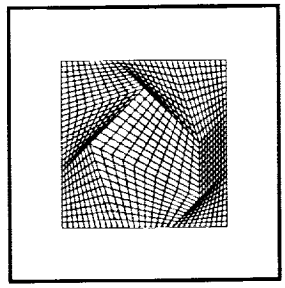

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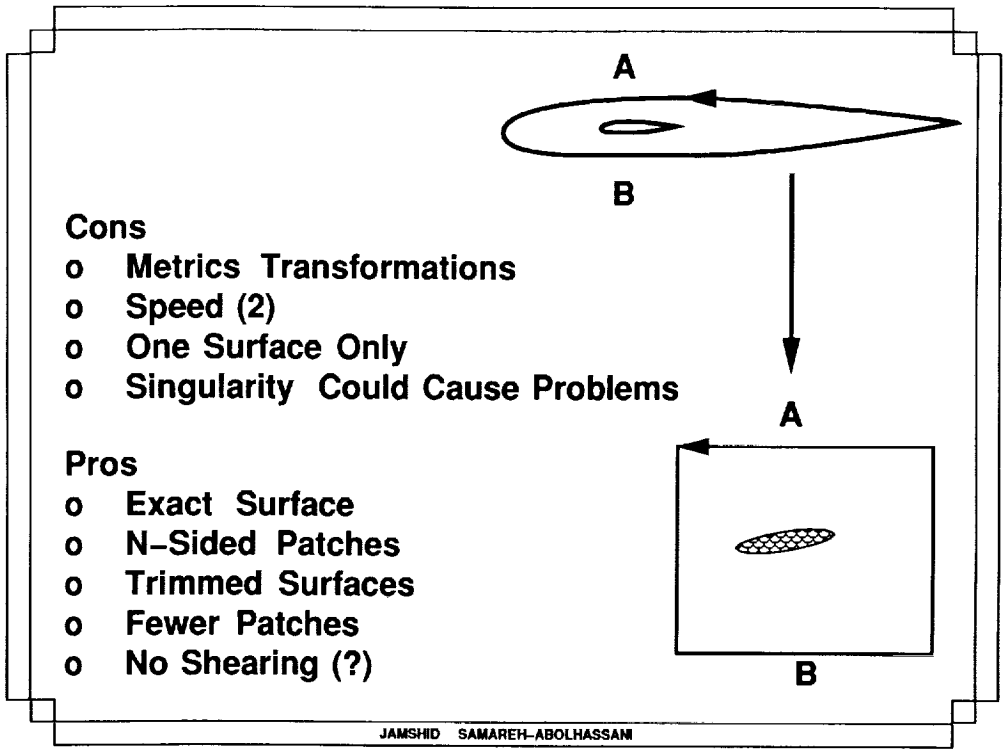
A
B
Cons
o Metrics Transformations
o Speed (2)
o One Surface Only
o Singularity Could Cause Problems
A
Pros
o Exact Surface
o N-Sided Patches
o Trimmed Surfaces
o Fewer Patches
o No Shearing (?)
B
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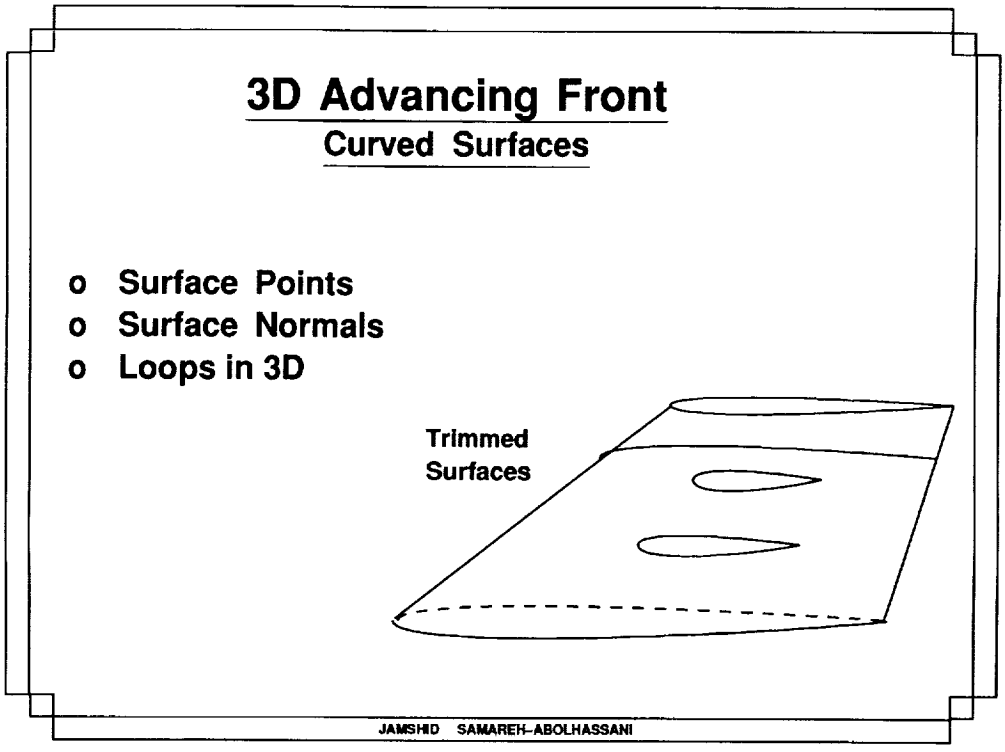
3D Advancing Front
Curved Surfaces
o Surface Points
o Surface Normals
o Loops in 3D
Trimmed
Surfaces
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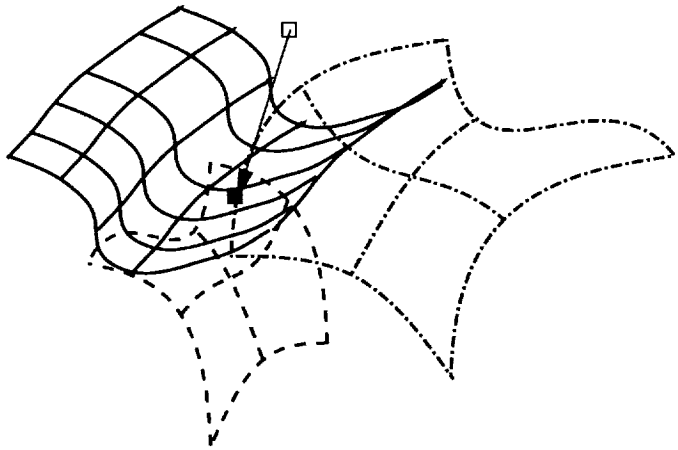
PROJECTING POINTS ONTO NURBS SURFACES
AIAA-93-3454



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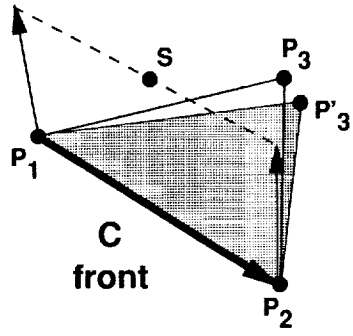

Steps:

1. Compute a plane normal to (P_1, P_2, S)
2. Generate a New Point (P'_3) on the Plane (Spacing and Stretching)
3. Project Point (P'_3) onto the Appropriate Surfaces
4. Compute a Plane Based on (P_1, P_2, P'_3)
5. Repeat Steps 2-4 Till Changes in P'_3 Are Very Small

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3D Advancing Front

Curved Surfaces

Cons:

- Surface Normals Are Required
- Projection Is Required
- Trimmed Surfaces
- Speed (4)

Pros:

- Triangulation Is Performed in the Physical Space
- No Shearing Due Parameter Space
- Metric Transformation Is not Needed
- N-Sided Patches with With Multiple Loops
- Multiple Surfaces
- Fewer Patches

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	2D	Type I 2½ D	Type I 2½DP	Type 2 2½ D	3D
User Input Factor(# of Patches)	1	4	4	3	2
CPU Time Factor	1	2	3	4	5
Surface Types	P	NA	NURBS	NURBS	NURBS
Surface Accuracy	good	poor	Good	Good	Good
δ, α, β Transformation	simple	simple	simple	Difficult	NA
Problems With Shearing	None	Yes	Yes	Possible	None
Parametric Study	0	0	2	3	3
Number of Surfaces	NA	Many	Many	One	Many
N-Sided Patches Possible	Yes	No	No	Yes	Yes
Problems with Singularity	No	No	Yes	Yes	Yes
Surface Normals Required	No	No	No	No	Yes
History	4	3	3	1	0

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CSC/GEOLAB/TAB EFFORT

- o NURBS Based (IGES , NASA IGES)
  - o NURBS Surfaces
  - o NURBS Curves
  - o Trimmed Surfaces
- o Points (network)
- o Single Interactive Interface
- o Surface Grid Generation
  Based on 3D Advancing Front
- o Projection

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STEPS

- o STEP 1 POINTS/CURVES/PATCHES
  - o allowing for future ***additions***
  - o Surface (points)
  - o create points/curves/patches for vgrid3d (or other systems)
- o STEP 2 Background Grid
- o STEP 3 PROJECTION/SMOOTHING/QUALITY CHECK
- o STEP 4 ADD SURFACE GRID GENERATION
  (Direct Surface Triangulation)
- o STEP 5 MOTIF / X BASED (other platform)

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I / O

	INPUT ASCII	INPUT Binary	OUTPUT ASCII	OUTPUT Binary
Restart	X	???	X	???
HESS	X	NA	X	NA
D3M	X	NA	X	NA
GRIDGEN	X	X	X	X
PLOT3D	X	X	X	X
LaWGS	X	NA	X	NA
IGES-128	X	NA		

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SURFACES

- NURBS (NonUniform Rational B-Spline)
- Converts hess, gridgen, plot3d, lawgs to equivalent NURBS surfaces
- Defined everywhere
- Display Path (write the grid out)

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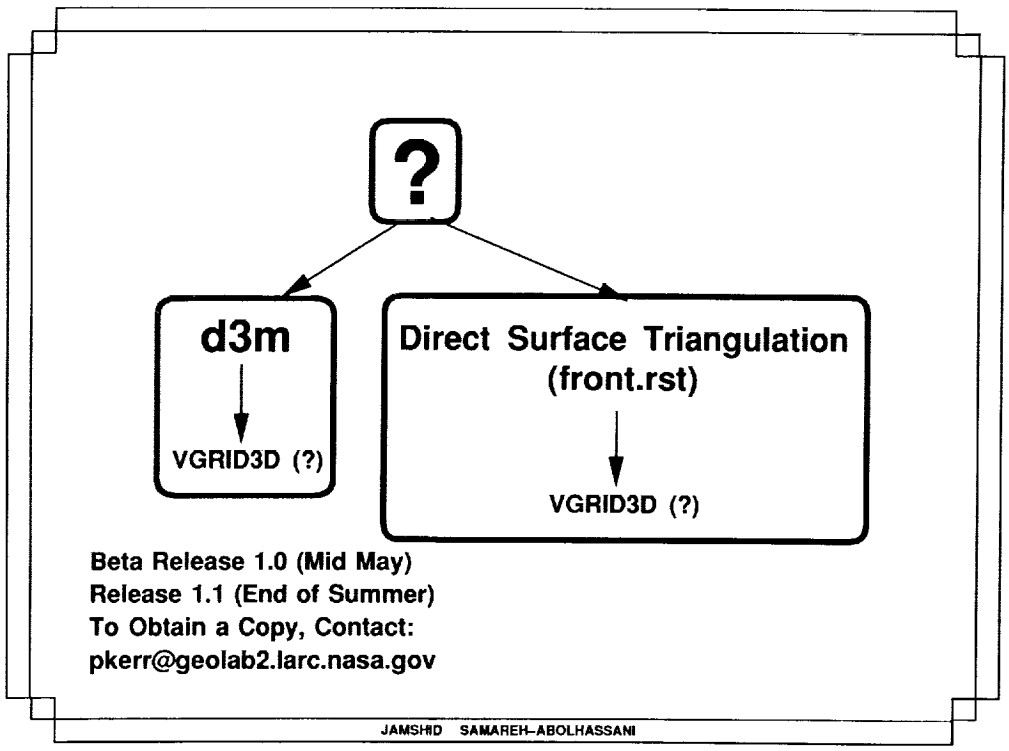
?
d3m
VGRID3D (?)
Direct Surface Triangulation
(front.rst)
VGRID3D (?)
Beta Release 1.0 (Mid May)
Release 1.1 (End of Summer)
To Obtain a Copy, Contact:
pkerr@geolab2.larc.nasa.gov
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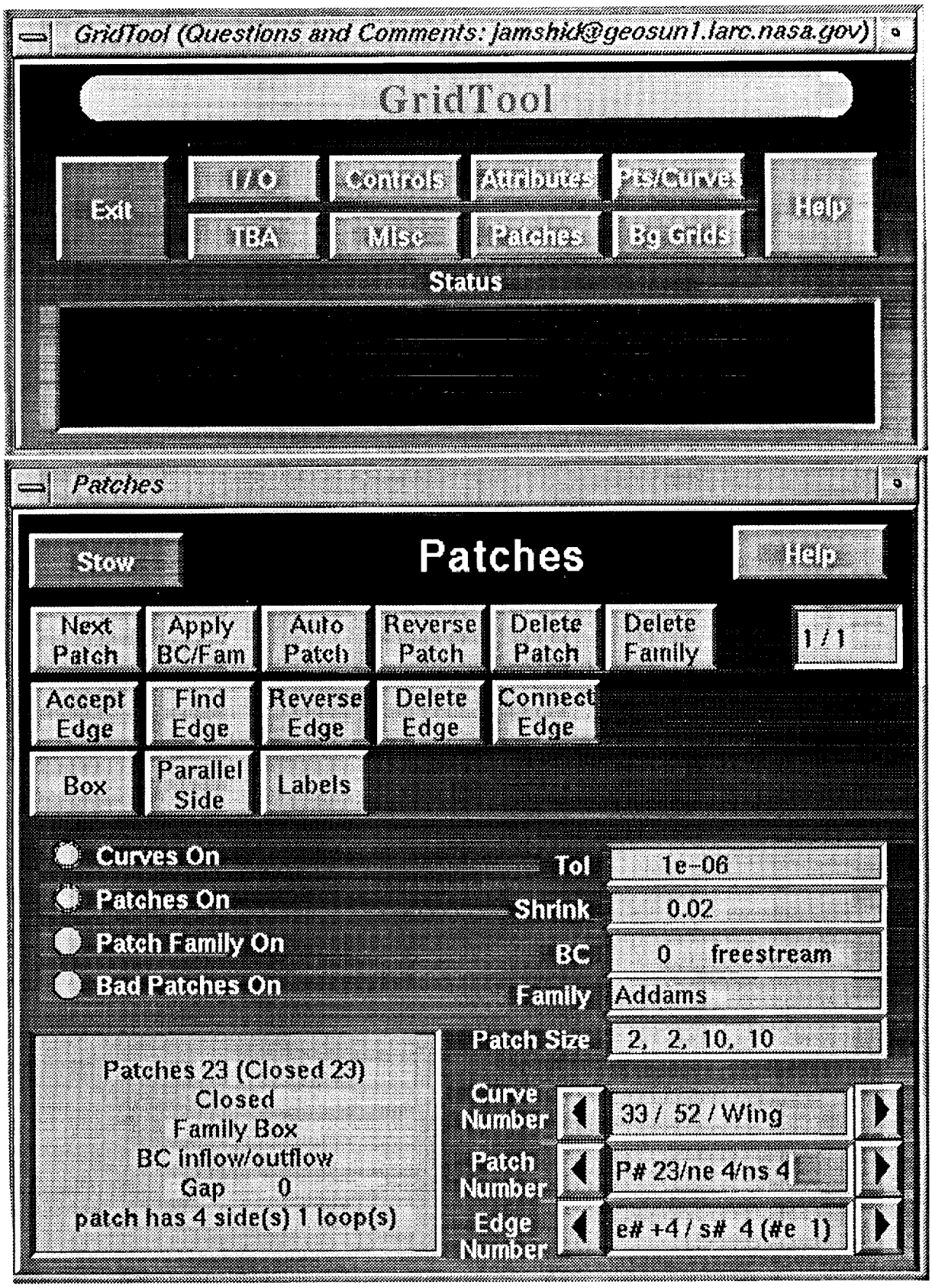
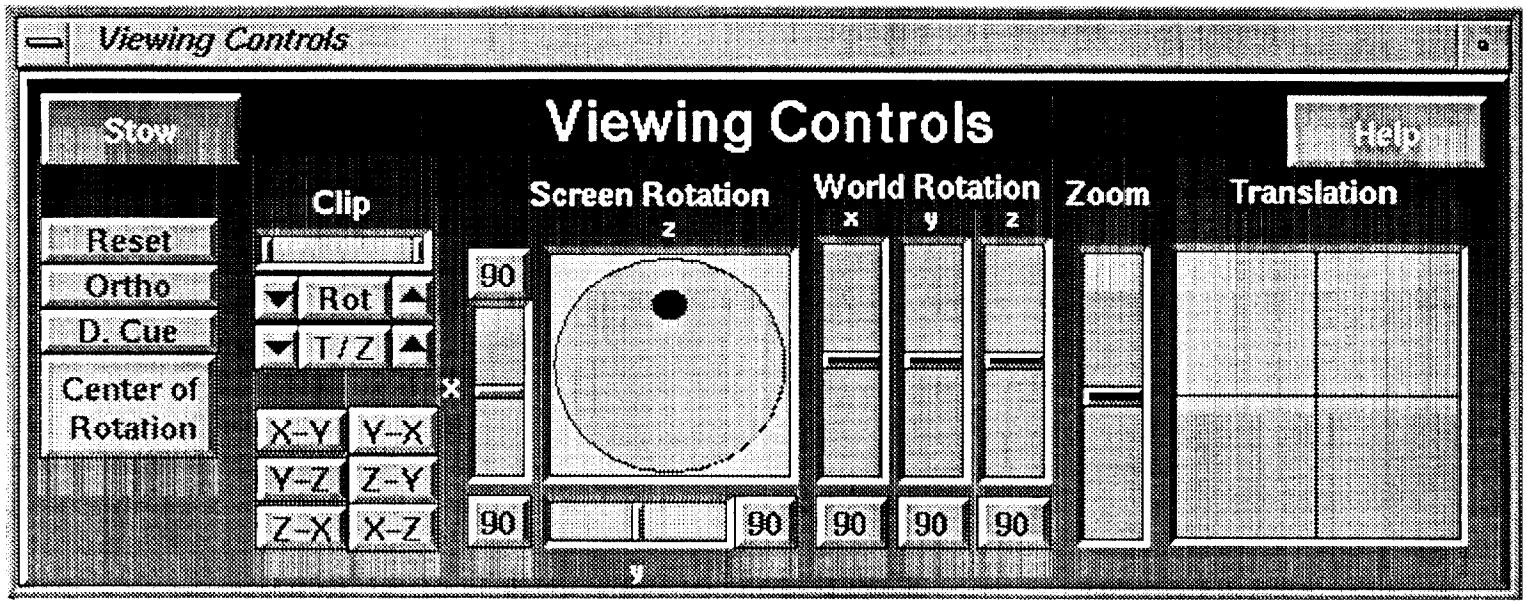
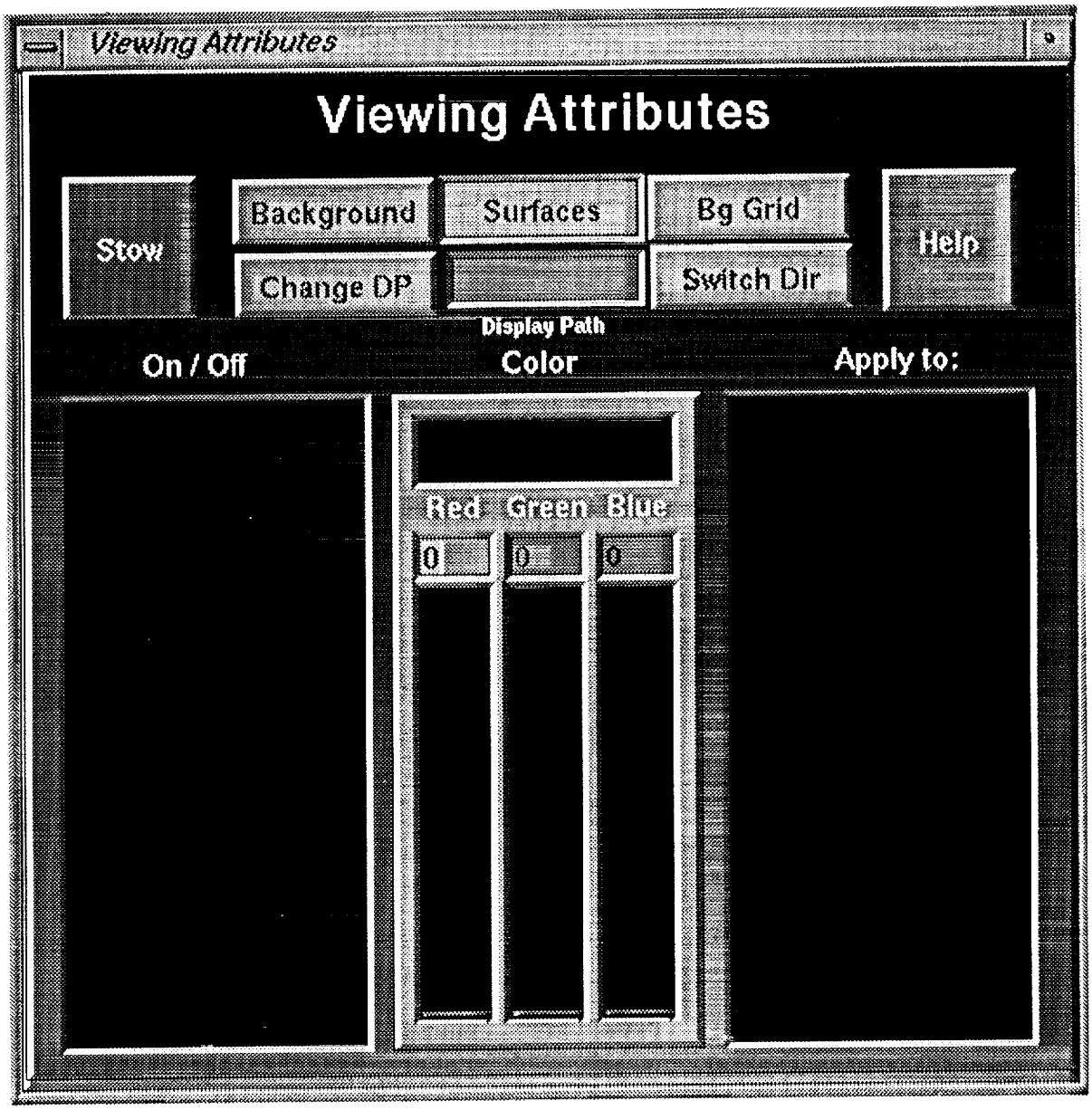
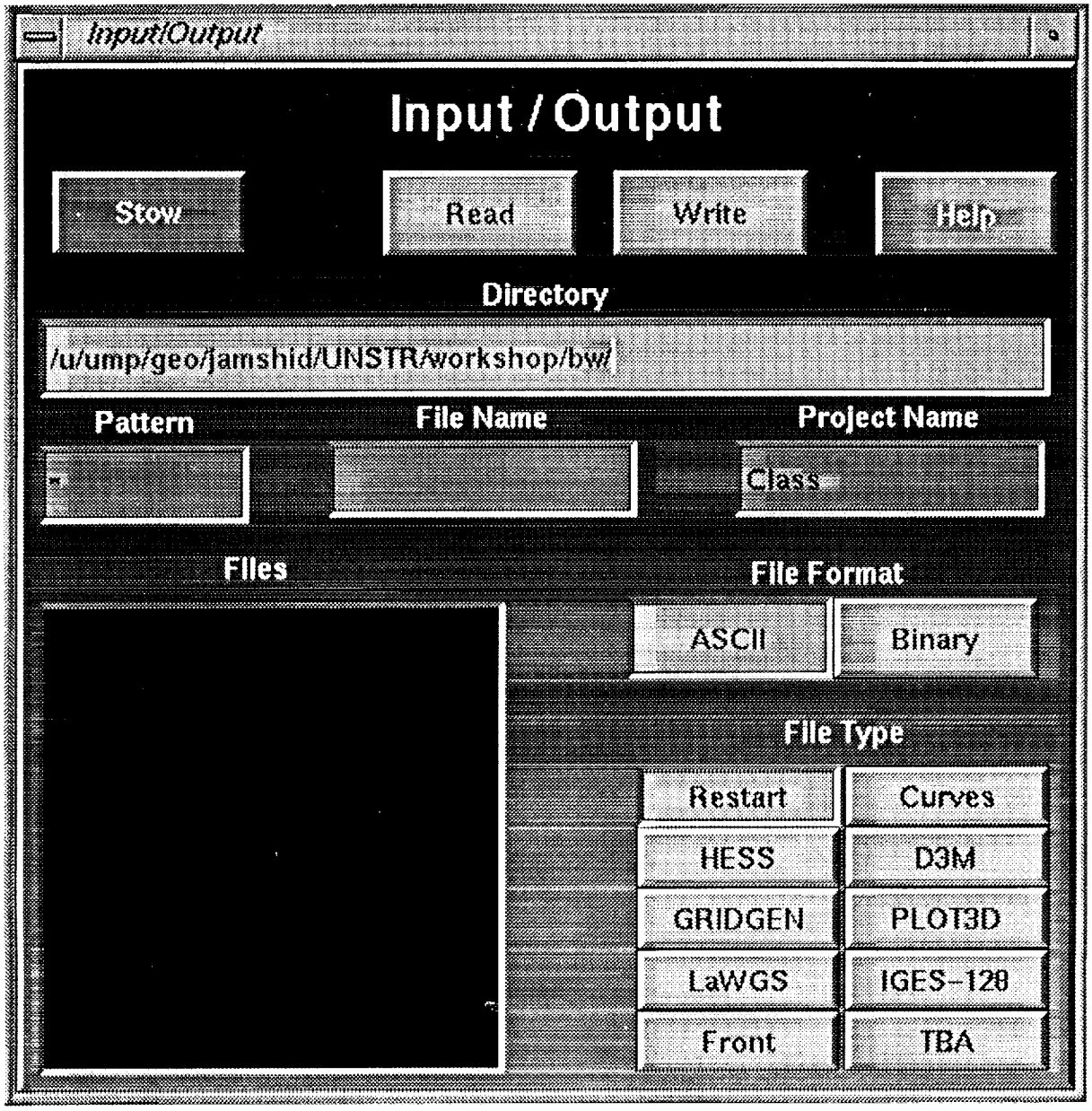
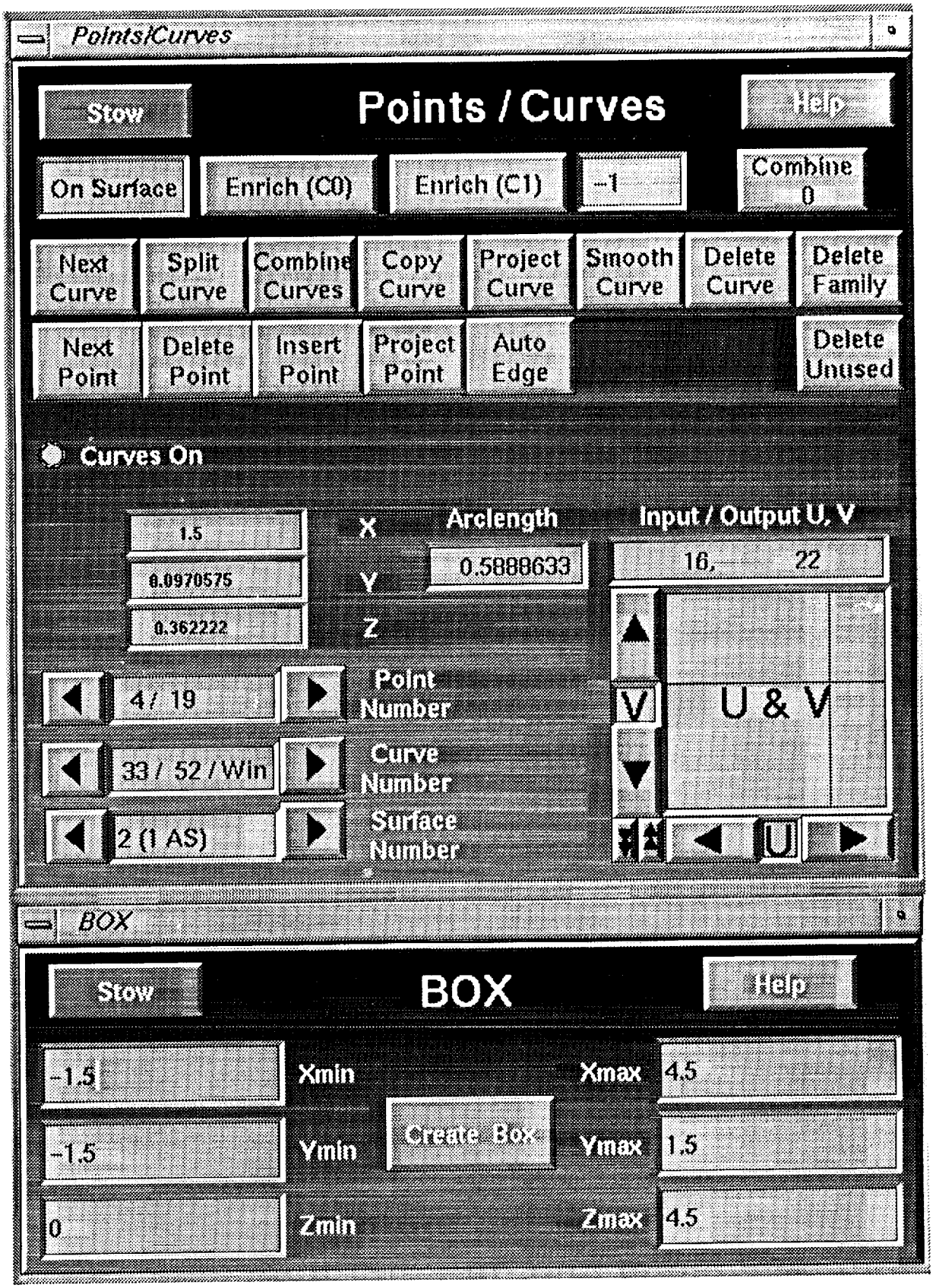
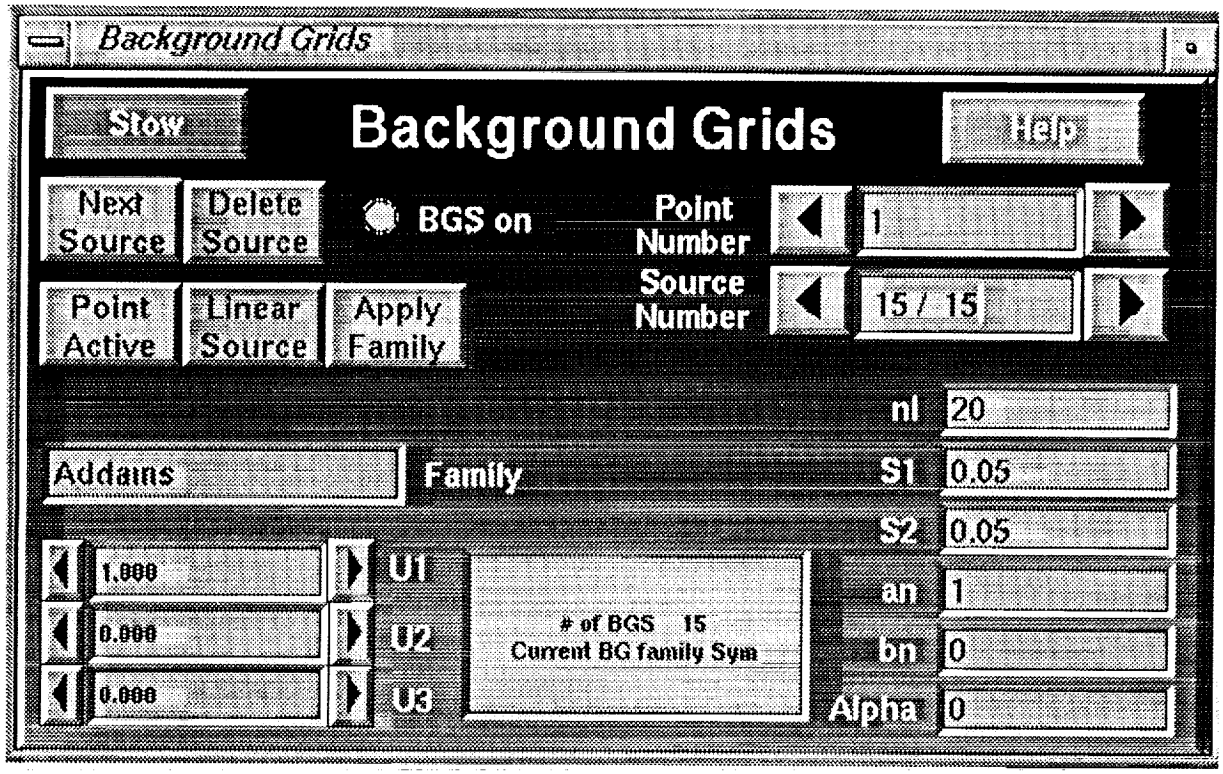

GridTool (Questions and Comments: jamshid@geosun1.larc.nasa.gov)
GridTool
Exit
I/O
Controls
Attributes
PBS/Curves
Help
TBA
Misc
Patches
Bg Grids
Status
Patches
Stow
Patches
Help
Next Patch
Apply BC/Fam
Auto Patch
Reverse Patch
Delete Patch
Delete Family
1 / 1
Accept Edge
Find Edge
Reverse Edge
Delete Edge
Connect Edge
Box
Parallel Side
Labels
Curves On
Patches On
Patch Family On
Bad Patches On
Tol
1e-06
Shrink
0.02
BC
0 freestream
Family
Addams
Patch Size
2, 2, 10, 10
Patches 23 (Closed 23)
Closed
Family Box
BC inflow/outflow
Gap 0
patch has 4 side(s) 1 loop(s)
Curve Number
33 / 52 / Wing
Patch Number
P# 23/ne 4/ns 4
Edge Number
e# +4 / s# 4 (#e 1)

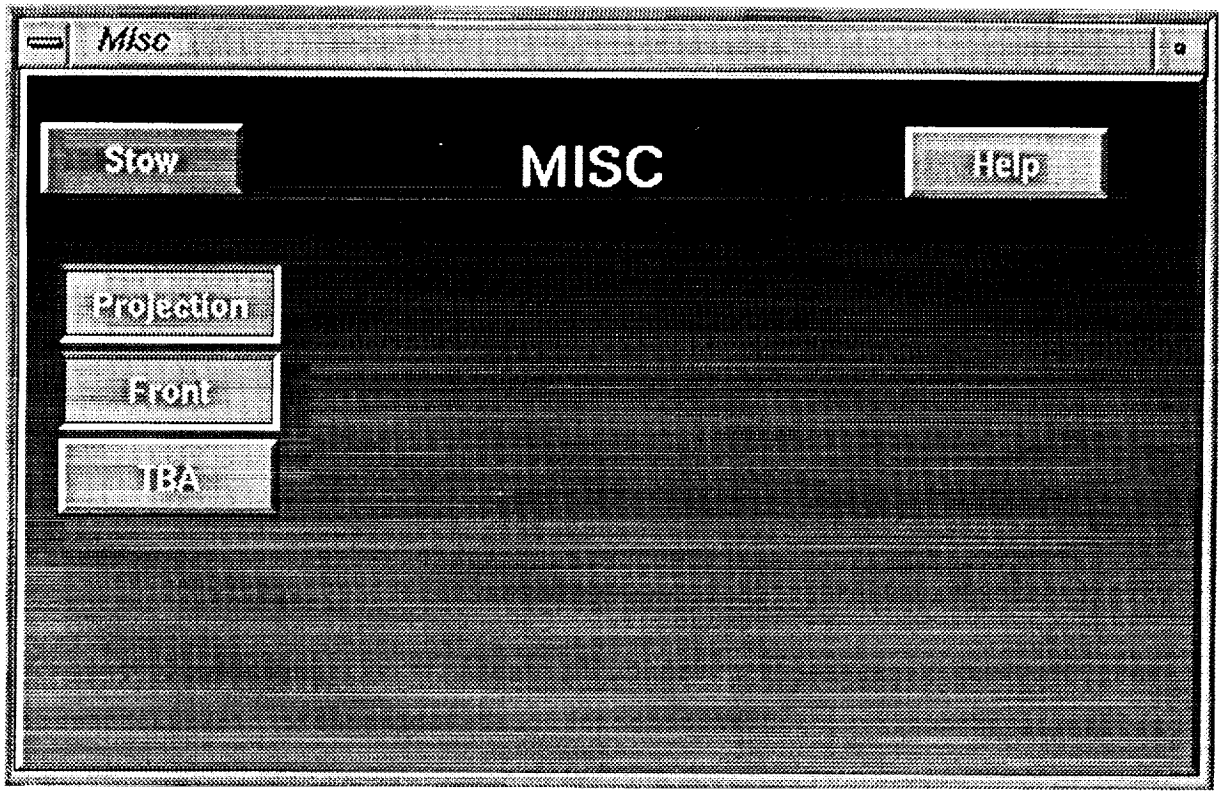

Viewing Controls
Viewing Controls
Stow
Help
Reset
Ortho
D. Cue
Center of Rotation
Clip
Rot
T/Z
X-Y
Y-X
Y-Z
Z-Y
Z-X
X-Z
Screen Rotation
z
90
90
90
y
World Rotation
x
y
z
90
90
90
Zoom
Translation

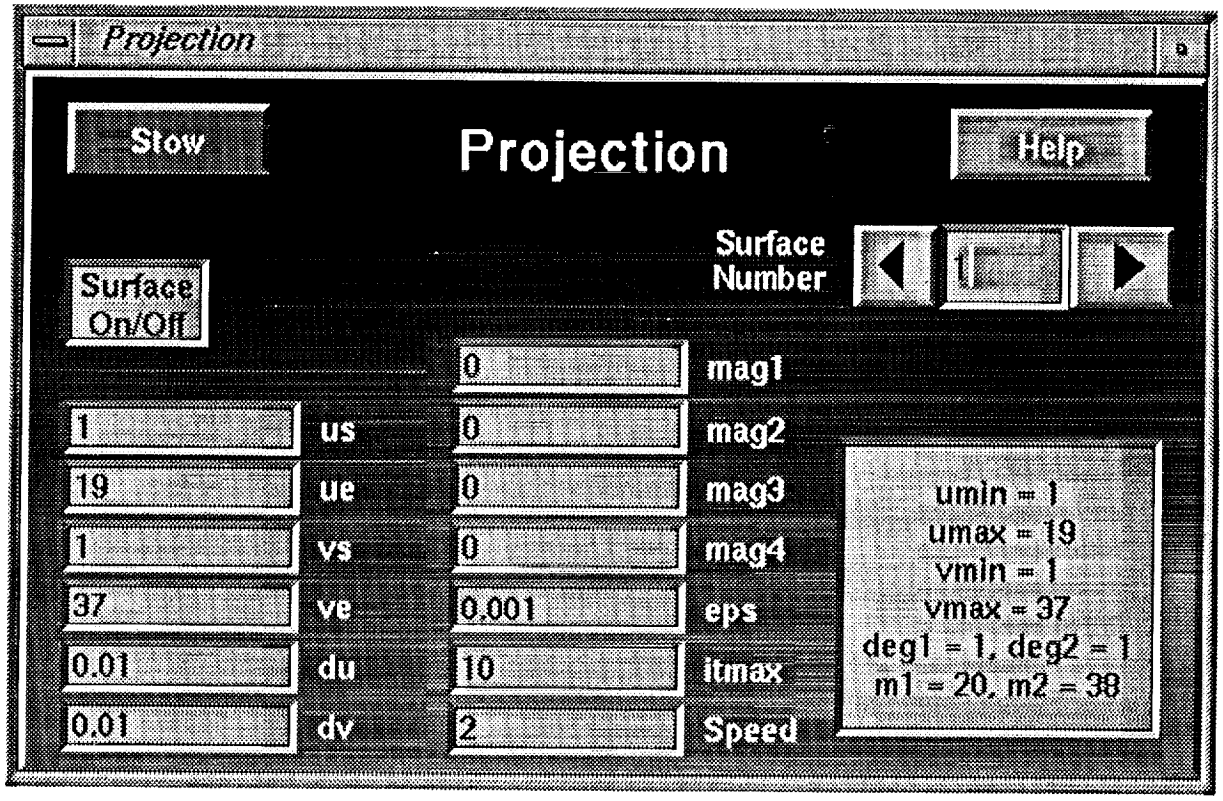

Viewing Attributes
Viewing Attributes
Stow
Background
Surfaces
Bg Grid
Help
Change DP
Switch Dir
Display Path
On / Off
Color
Apply to:
Red
Green
Blue
0
0
0

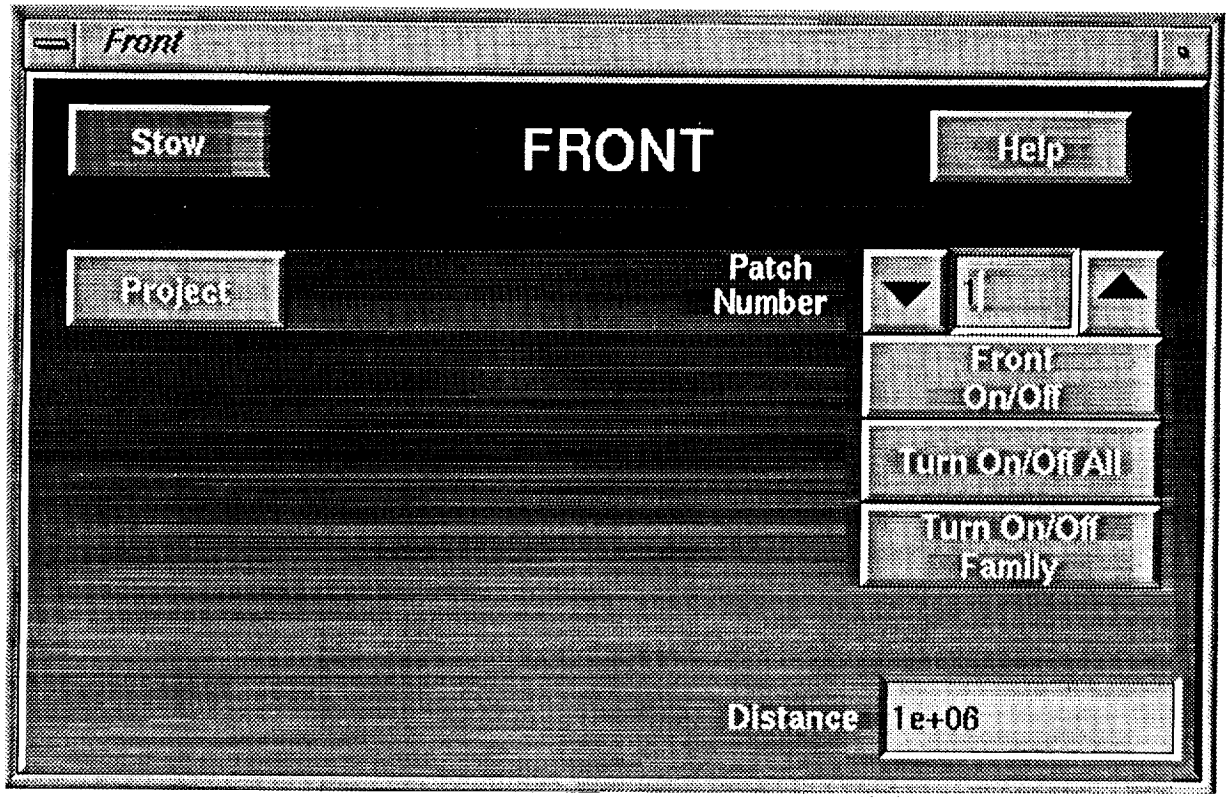

Input/Output
Input / Output
Stow
Read
Write
Help
Directory
/u/ump/geo/jamshid/UNSTR/workshop/bw/
Pattern
File Name
Project Name
Class
Files
File Format
ASCII
Binary
File Type
Restart
Curves
HESS
D3M
GRIDGEN
PLOT3D
LaWGS
IGES-128
Front
TBA


Points/Curves
Stow
Points / Curves
Help
On Surface
Enrich (C0)
Enrich (C1)
-1
Combine
0
Next Curve
Split Curve
Combine Curves
Copy Curve
Project Curve
Smooth Curve
Delete Curve
Delete Family
Next Point
Delete Point
Insert Point
Project Point
Auto Edge
Delete Unused
Curves On
1.5
0.0970575
0.362222
X
Y
Z
Arclength
0.5888633
Input / Output U, V
16, 22
4 / 19
Point Number
33 / 52 / Win
Curve Number
2 (1 AS)
Surface Number
U & V
U
V
BOX
Stow
BOX
Help
-1.5
Xmin
Xmax
4.5
-1.5
Ymin
Create Box
Ymax
1.5
0
Zmin
Zmax
4.5


Background Grids
Stow
Background Grids
Help
Next Source
Delete Source
BGS on
Point Number
1
Source Number
15 / 15
Point Active
Linear Source
Apply Family
nl
20
Addains
Family
S1
0.05
S2
0.05
1.000
U1
an
1
0.000
U2
# of BGS 15
Current BG family Sym
bn
0
0.000
U3
Alpha
0


Misc
Stow
MISC
Help
Projection
Front
IBA


Projection
Stow
Projection
Help
Surface Number
1
Surface On/Off
0
mag1
1
us
0
mag2
19
ue
0
mag3
1
vs
0
mag4
37
ve
0.001
eps
0.01
du
10
itmax
0.01
dv
2
Speed
umin = 1
umax = 19
vmin = 1
vmax = 37
deg1 = 1, deg2 = 1
m1 = 20, m2 = 38


Front
Stow
FRONT
Help
Project
Patch Number
1
Front On/Off
Turn On/Off All
Turn On/Off Family
Distance
1e+06