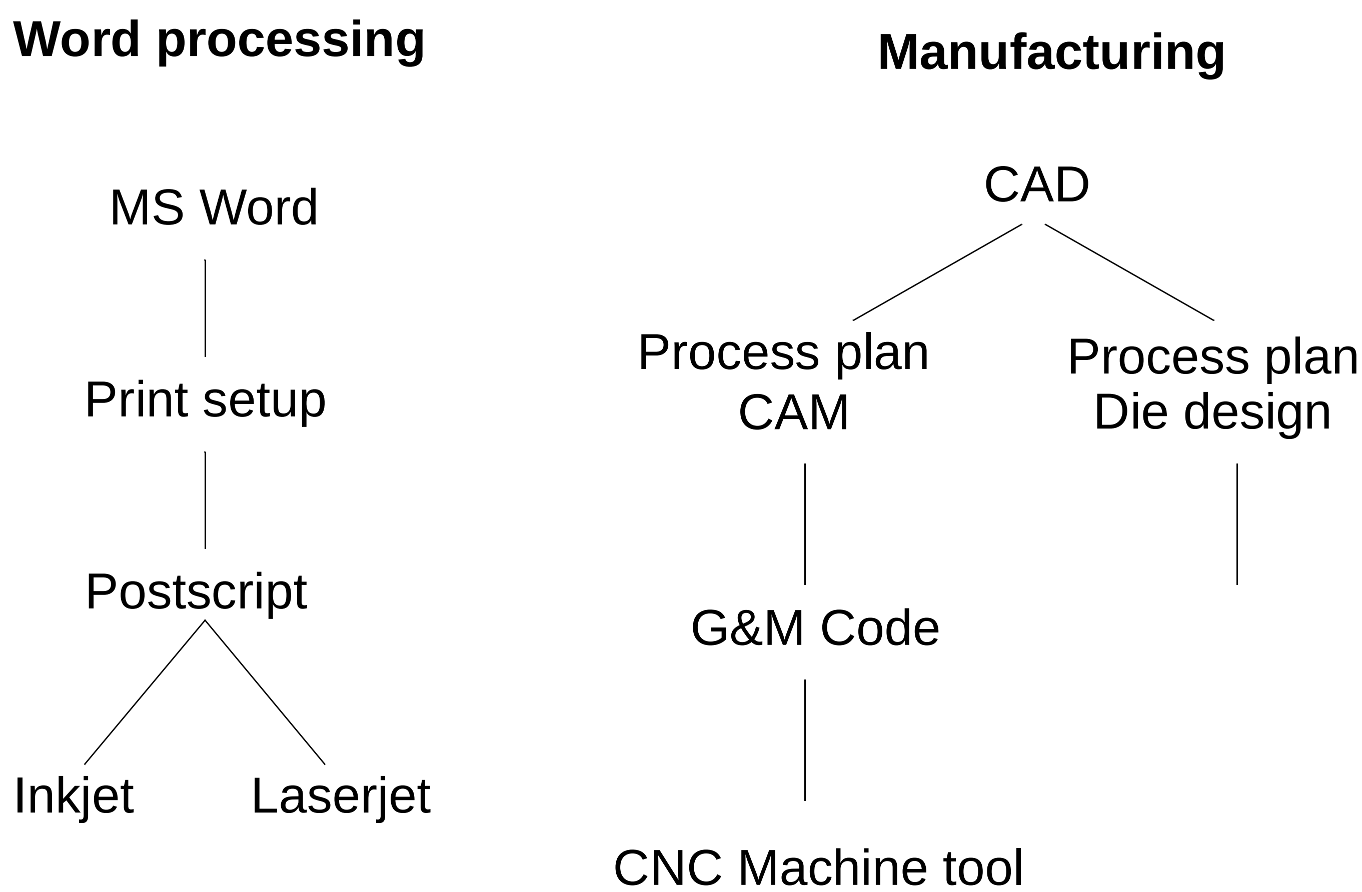
Design → Finished part



Today

1. CAD

-What it isnt.

-Solid Modeling

-Boundary Representation

-Surface Modeling

2. CAM

-Tool Path Generation

-Features

-Zig-zag

-Contour Shrinking

-Surface Machining

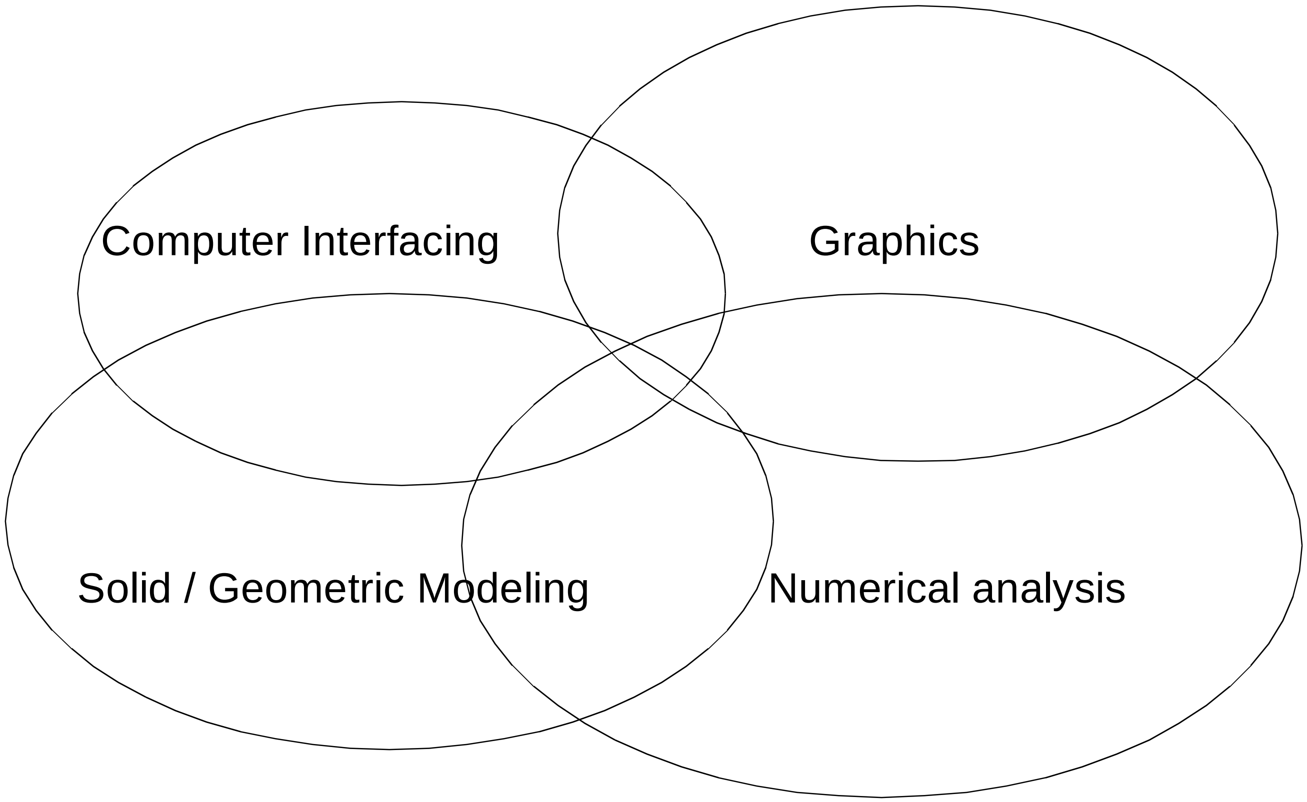
3. CNC

-How CNC works

-G Codes

-M Codes

CAD


Computer Interfacing
Graphics
Solid / Geometric Modeling
Numerical analysis

How to represent solid shapes?

- Constructive Solid Geometry

describe parts by assembling primitive shapes such as blocks, cones and spheres.

- Boundary representation

describe parts by specifying the skin of the required shape as a series of faces bounded by edges bounded by vertices.

- Space Enumeration

build parts with cubical bricks. its like building the shape from 3-d pixels.

The solid modeling engine

this is the core of every CAD system. it’s main functions are:

- point solid classification
- solid-solid interaction
- visualization
- mass and area properties
- generating meshes for finite element analysis

Constructive solid geometry

the designer gives a pallete of shape primitives:

examples: a cube, a cylinder, a taurus, a sphere.

Scale parametrically and use boolean operations:

- union
- subtraction
- intersection

to create shapes.

examples:

addition of two cubes, intersection of two cubes, etc.

Boundary representation

remove everything from the inside and represent the skin as a patchwork, or quilt, of surfaces.

ex: a cube is represented as six plane surfaces.

a cylinder would be represented as the cylindrical surface, plus two circular planes at the ends.

Each smooth surface, meanwhile, can be represented with equations. for ex:

$$z = x + y$$

represents a plane. How would you represent a sphere?

Boundary representation

Euler's rule for solids:

$$V - E + F = 2$$

for ex:

cube: V=8, E=12, F=6

tetrahedron: V=4, E=6, F=4

octahedron: V=6, E=12, F=8

- boundary representation is the most elaborate and robust solid modeling technique

- it is the most widely used approach commercially:

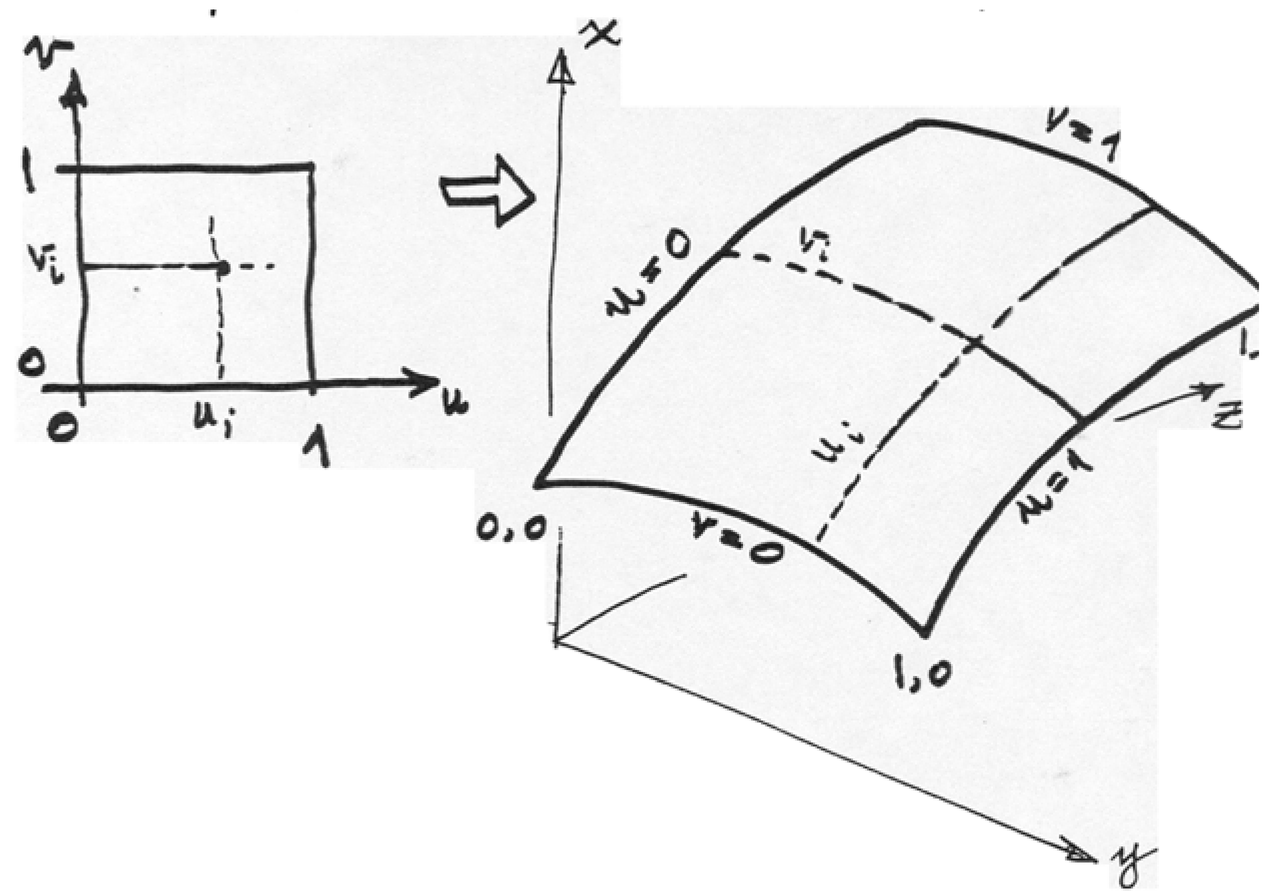
Parasolids, ACIS, AutoCAD, ProEngineer, Intergraph, SDRC, etc.

- computation intensive.

Surfaces

A surface is a 2-D entity

If is parametrised with 2 parameters,



Simple bicubic patch

$$\underset{\sim}{p}(u,v) = \sum_{i=0}^{3} \sum_{j=0}^{3} \underset{\sim}{a}_{ij}\, u^i v^j$$

$$u, v \in [0, 1]$$

Where $\underset{\sim}{p}$ is a point on the patch,

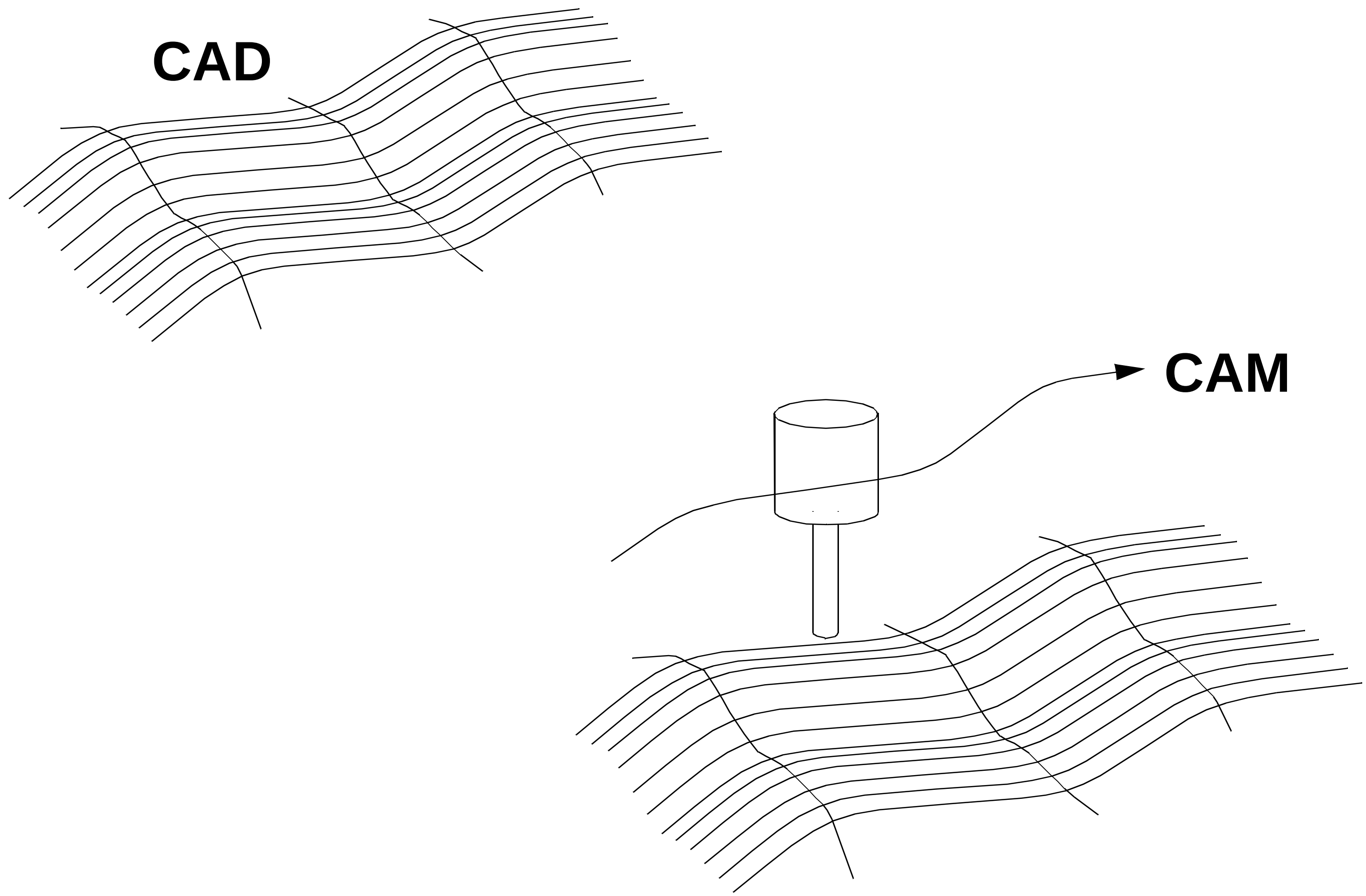
u, v are parameters,

& $\underset{\sim}{a}_{ij}$ are algebraic coefficients.

— x —

$$\begin{aligned} p(u,v) = {} & a_{33} u^3 v^3 + a_{32} u^3 v^2 + a_{31} u^3 v + a_{30} u^3 \\ & + a_{23} u^2 v^3 + a_{22} u^2 v^2 + a_{21} u^2 v + a_{20} u^2 \\ & + a_{13} u v^3 + a_{12} u v^2 + a_{11} u v + a_{10} u \\ & + a_{03} v^3 + a_{02} v^2 + a_{01} v + a_{00} \end{aligned}$$

CAD and machining:



CAM : Computer Aided Manufacturing

- Should really be : Computer Assisted Tool Path Generation
- Given primitive shapes, a CAM program will generate sweeping tool paths.
- Modes:

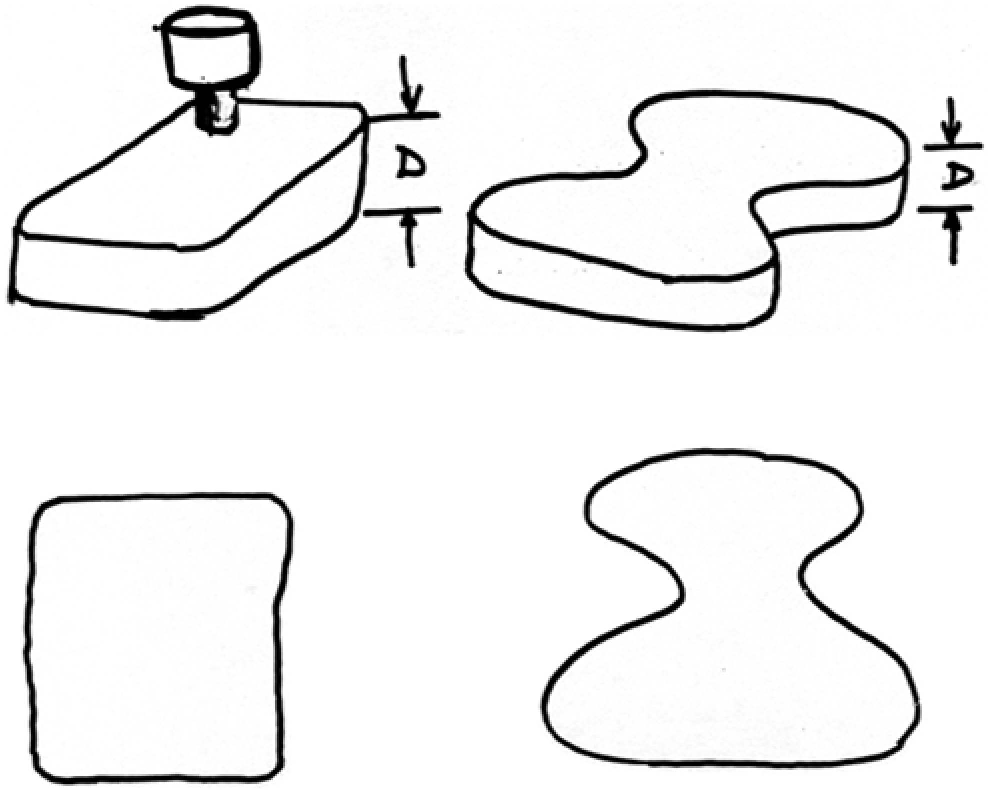
  2 1/2 D

  3 Axis Surface

  5 Axis Surface

2 1/2 D Machining

Machining of 2-D contours with depth:

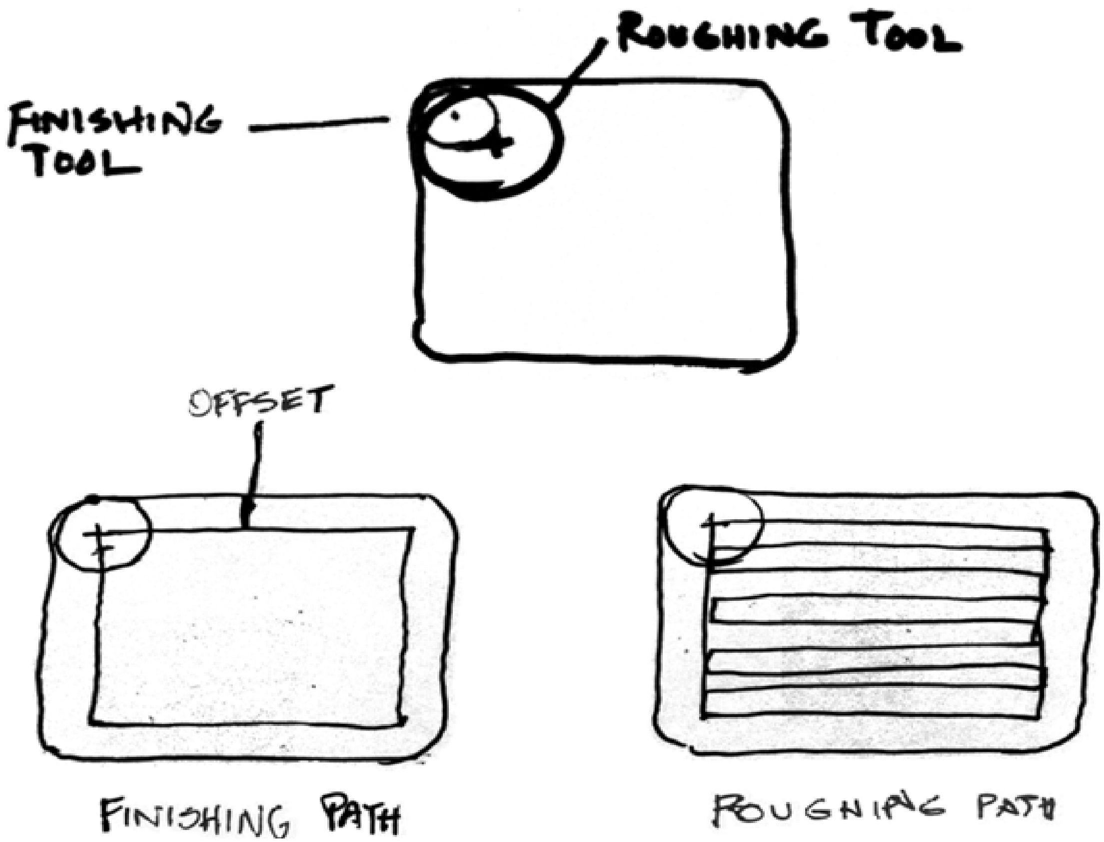


Organize shape in terms of slabs.

Stages in Machining

- Roughing : Heavy Cut, Gross Removal

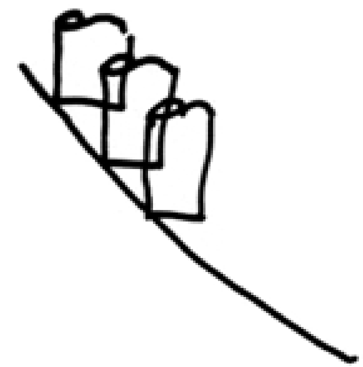
- Finishing : Fine Cut, Delicate Removal



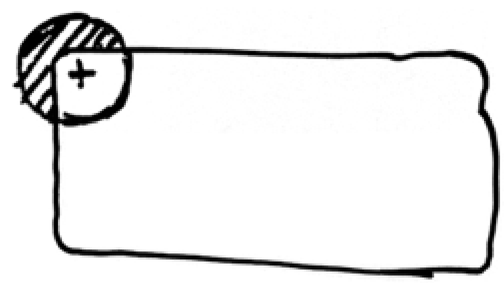
Pitfalls

VERTICAL ACCESS NOT CONSIDERED

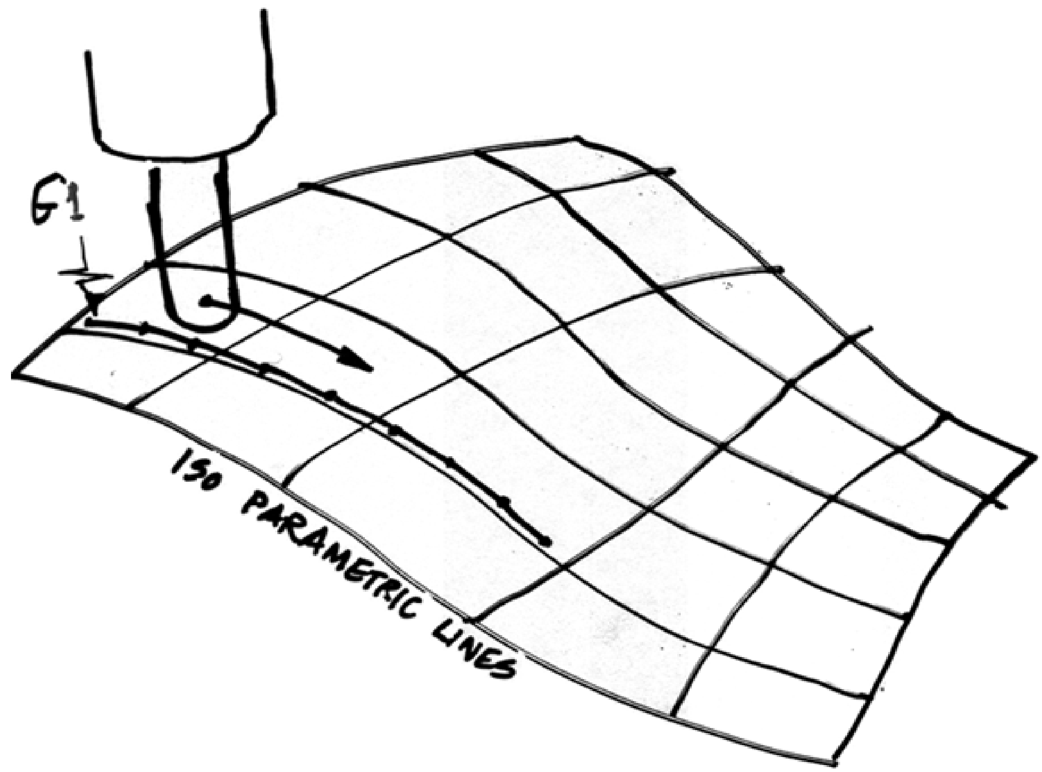
CUSPS

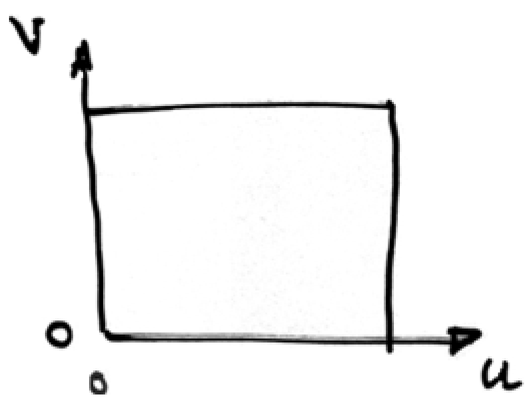


GOUGING

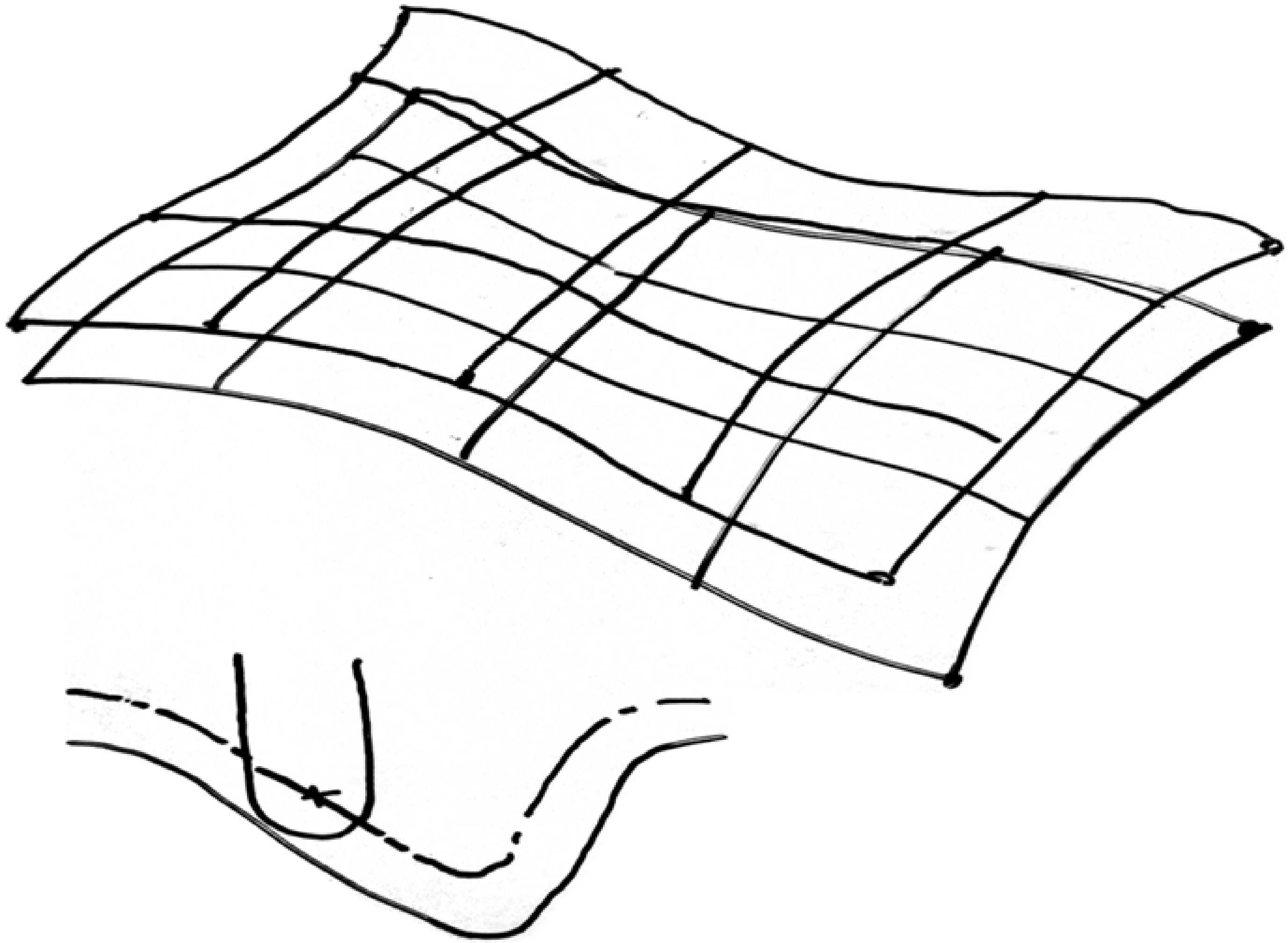


3 Axis Surface Machining





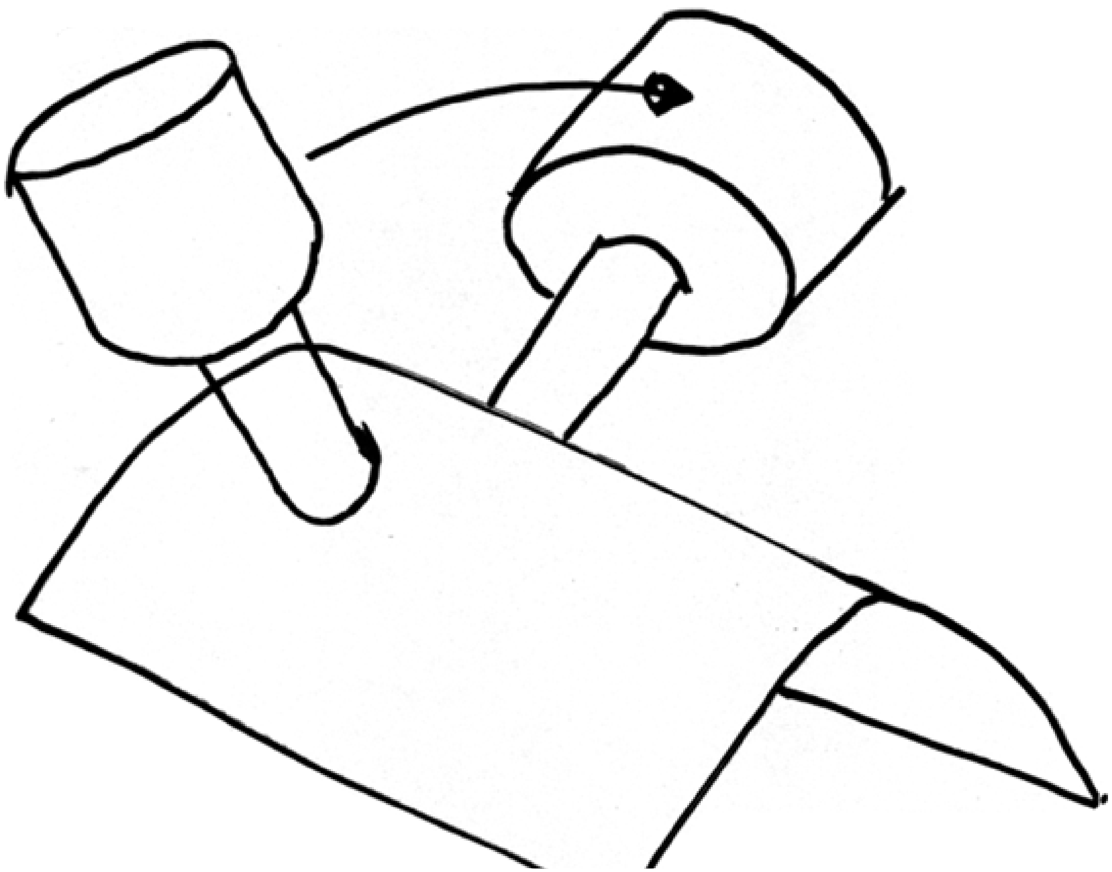
Offsets in 3-Axis



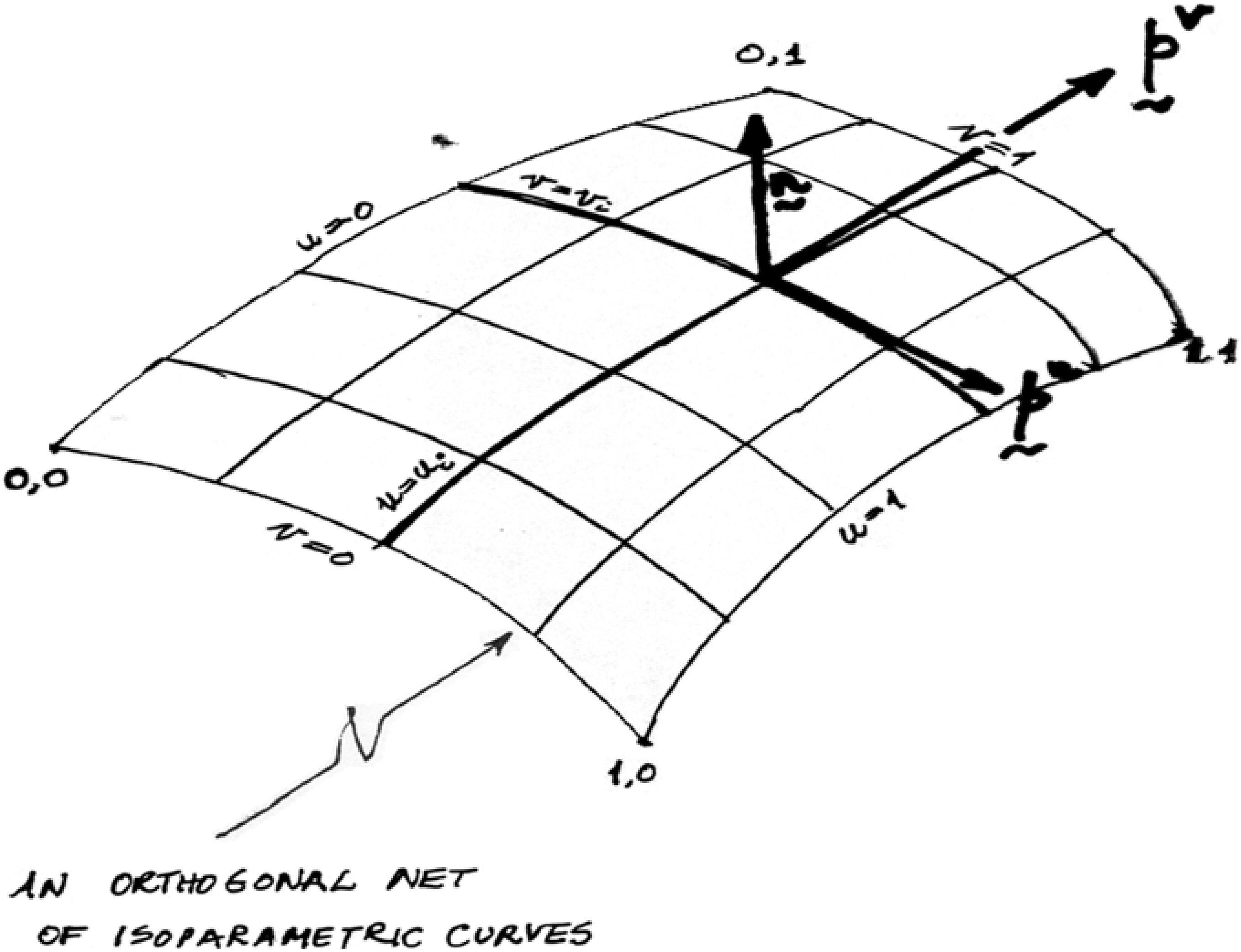
5-Axis Machining

Surface Normal

Drive Surface



Tangents?


0,1
0,0
1,0
1,1
u=0
u=1
v=0
v=1
v=vi
u=ui
AN ORTHOGONAL NET
OF ISOPARAMETRIC CURVES

When tool paths are done . . .

output of CAM program

- centerline data

centerline --->post processor ---->Machine Path