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Context: US Army (Aviation Material Readiness) ->

[Vitro Labs](#) (BAE) ->

[Informatics, Inc.](#) ([Wikipedia](#)) ->

Sperry Univac (Trilogy/Amdahl, Knowledge Systems Center) ->

Boeing (Military Aircraft Company, Commercial)

Context: Operations Research -> Database Technology -> Expert Systems ->

[Knowledge Based Systems](#) -> [Knowledge Based Engineering](#) -> Truth Engineering

COE Fall 2003 Conference & TechniFair
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Seattle, Washington



Geometric/Knowledge Modeling Challenges

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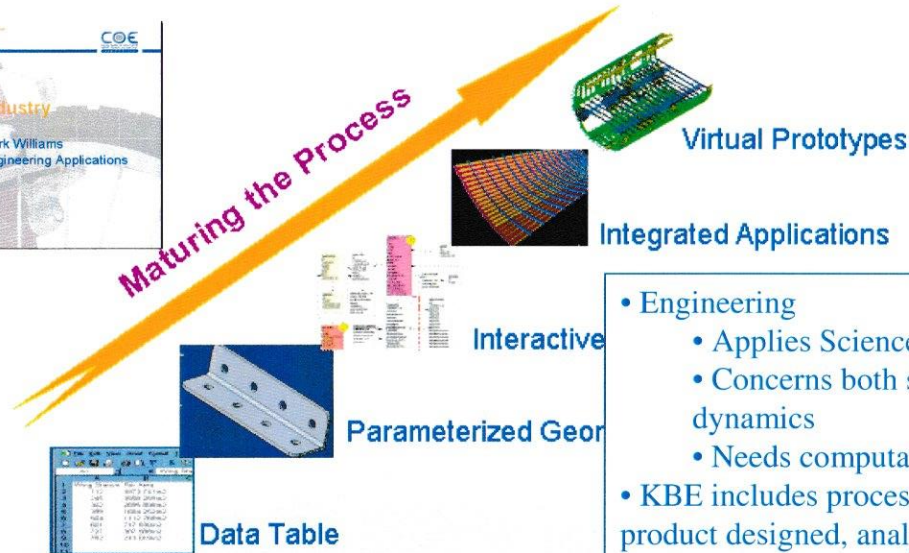
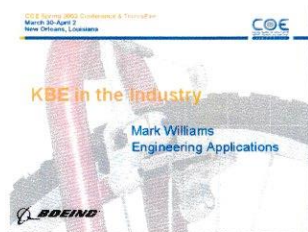
Please turn off cell phones/pagers

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Knowledge Base Engineering (KBE)

Developing a KBE Capability

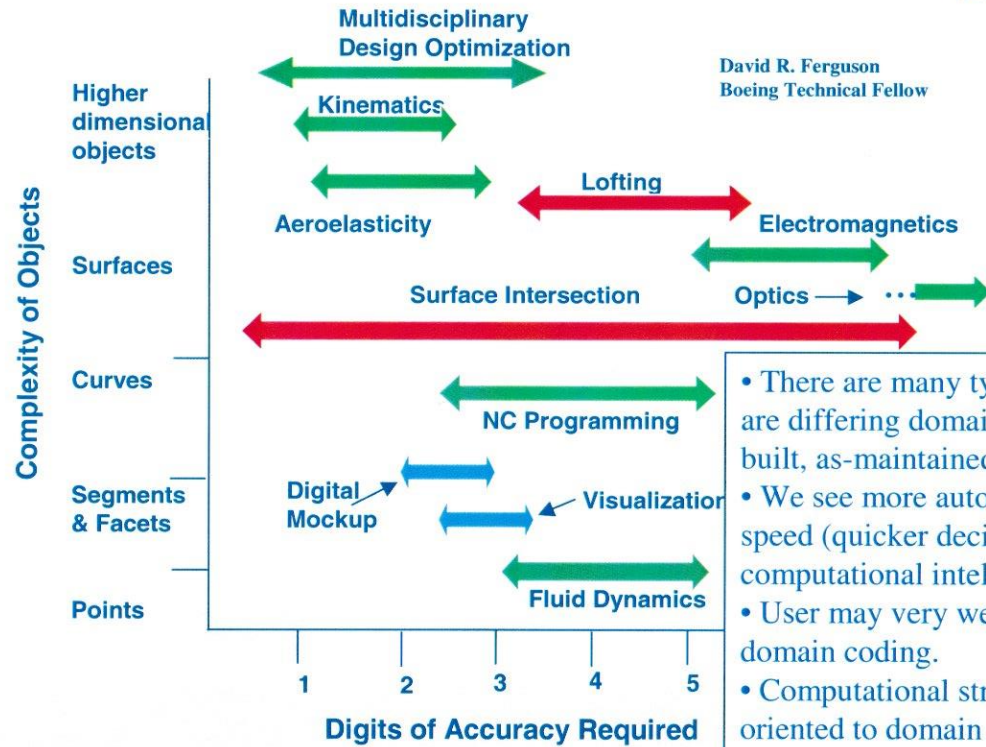


- Engineering
 - Applies Science
 - Concerns both statics and dynamics
 - Needs computation
- KBE includes processes to get the product designed, analyzed, and produced.
- Knowledge comes via controlled experiment, plus support with smart tools.



Context: Operations Research -> Database Technology -> Expert Systems ->
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Representation – General Issues



- There are many types of uses, as there are differing domains (as-defined/as-built, as-maintained).
- We see more automation (black box), speed (quicker decisions) and reliance on computational intelligence.
- User may very well be doing the domain coding.
- Computational structures will be oriented to domain knowledge.
- Need to know properties and behaviors of materials (dynamics) and systems.



Context: Operations Research -> Database Technology -> Expert Systems ->
[Knowledge Based Systems -> Knowledge Based Engineering](#) -> Truth Engineering

Representation - SIAM Warning



SIAM NEWS

Closing the Gap Between CAD Model and Downstream Application

As the world's largest manufacturer of aircraft, Boeing is constantly under attack by its competitors. The company's success is measured by its ability to design, manufacture, and assemble aircraft that are safe, reliable, and cost-effective. The challenge is to design aircraft that are safe, reliable, and cost-effective. The challenge is to design aircraft that are safe, reliable, and cost-effective. The challenge is to design aircraft that are safe, reliable, and cost-effective.

Report on an interdisciplinary workshop at UC Davis in April.

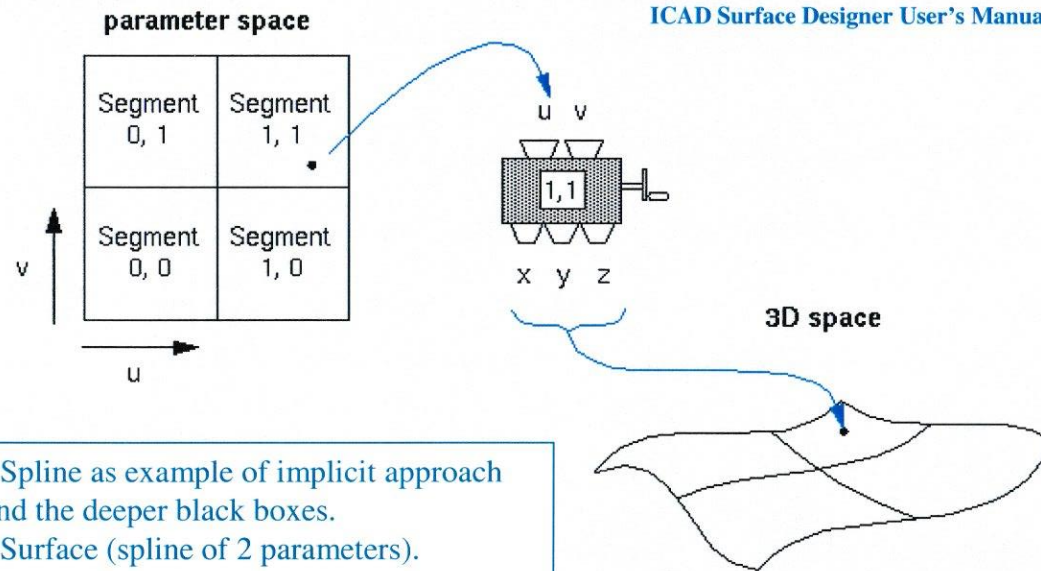
"Although modern CAD systems have attained a certain degree of maturity, their efficiency, reliability, and compatibility with subsequent analysis tools fall far short of what was envisaged at their inception, some 25 years ago. At the heart of this problem lie some deep mathematical issues, concerned with the computation, representation, and manipulation of complex geometries."

- KBE success in VLSI came from application of ground rules plus geometric constraints and carried over to mechanical CAD.
- There are limitations that are easy to forget such as this SIAM warning.
- Of course, at the deepest level, we have an old friend, undecidability.



Representation - Spline as Example

ICAD Surface Designer User's Manual



- Spline as example of implicit approach and the deeper black boxes.
- Surface (spline of 2 parameters).
- Piecewise, polynomial, abstract entity.
- We only know its control information.
- 3D information derived on demand.
- Links to other types of information.

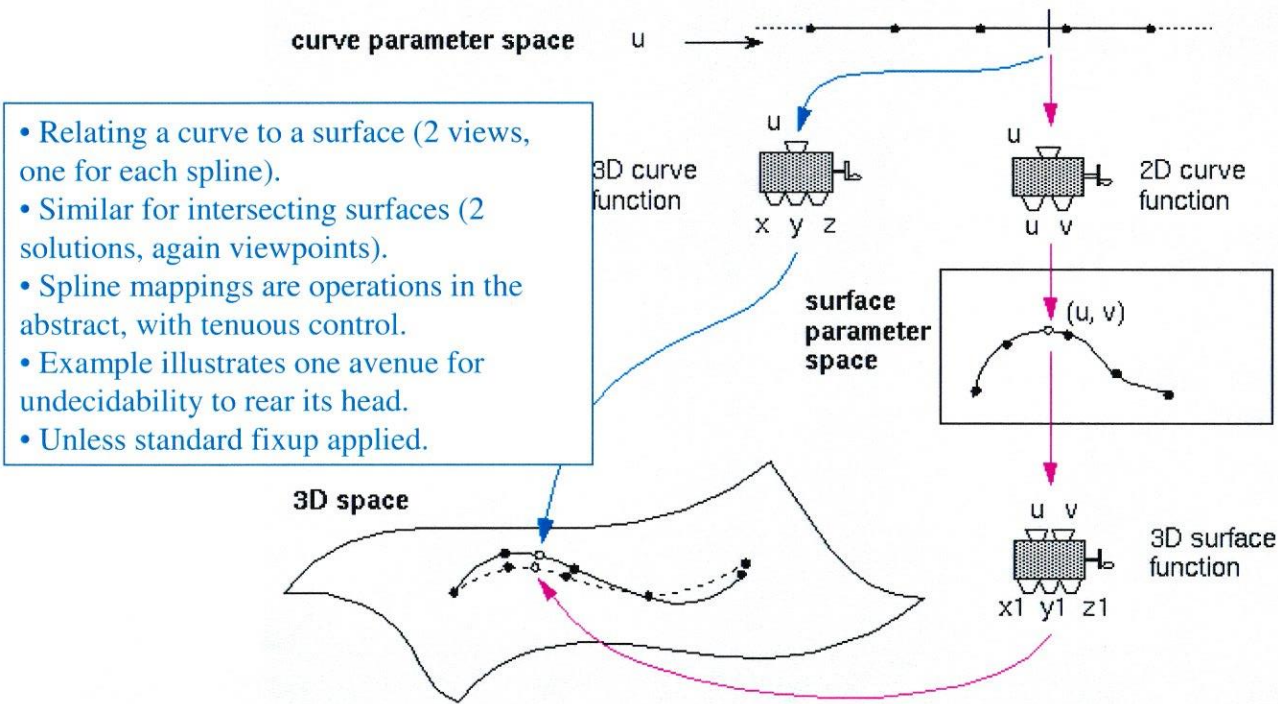
A nonuniform rational B-spline surface of degree (p, q) is defined by

$$S(u, v) = \frac{\sum_{i=0}^m \sum_{j=0}^n N_{i,p}(u) N_{j,q}(v) w_{i,j} \mathbf{P}_{i,j}}{\sum_{i=0}^m \sum_{j=0}^n N_{i,p}(u) N_{j,q}(v) w_{i,j}}$$

where $N_{i,p}$ and $N_{j,q}$ are the B-spline basis functions, $\mathbf{P}_{i,j}$ are control points, and the weight $w_{i,j}$ of $\mathbf{P}_{i,j}$ is the last ordinate of the homogeneous point $\mathbf{P}_{i,j}^w$.



Methods – Spline Operations



- Relating a curve to a surface (2 views, one for each spline).
- Similar for intersecting surfaces (2 solutions, again viewpoints).
- Spline mappings are operations in the abstract, with tenuous control.
- Example illustrates one avenue for undecidability to rear its head.
- Unless standard fixup applied.

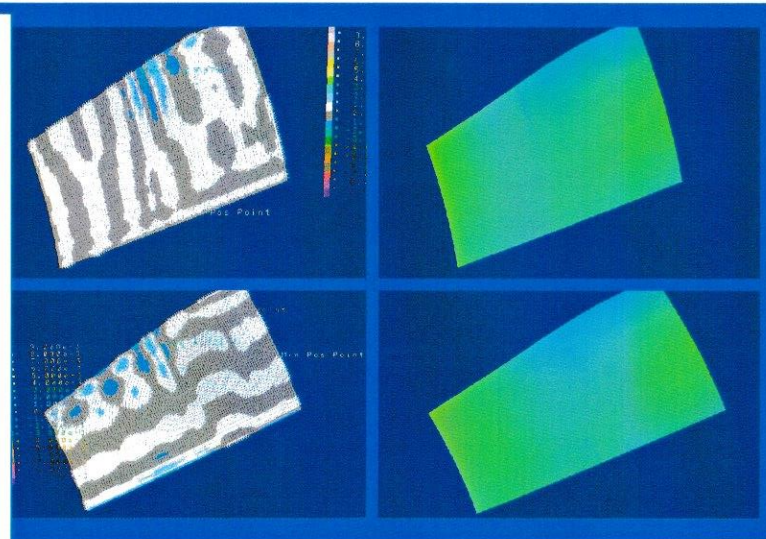
ICAD Surface Designer User's Manual



Quality – Example Trades

Undecidability: Equivalence
Action: Fixed point logic

- Fit and smoothness are classic trades (inversely correlated).
- Table on right shows fit similar by approach.
- Colors on left illustrate subtle varying radii.
- Colors on right show continuity properties.
- One way to handle undecidability is to not care about subtle differences.
- Applications set the pace for what's important, in part.
- But, need to remember certain types of decisions.



	deg	patches	fit
Algo1	5,5	32	0.00253
Algo2	5,5	36	0.00267



Quality - Representation Issues

Undecidability: Convergence
 Action: Iteration/Time limits

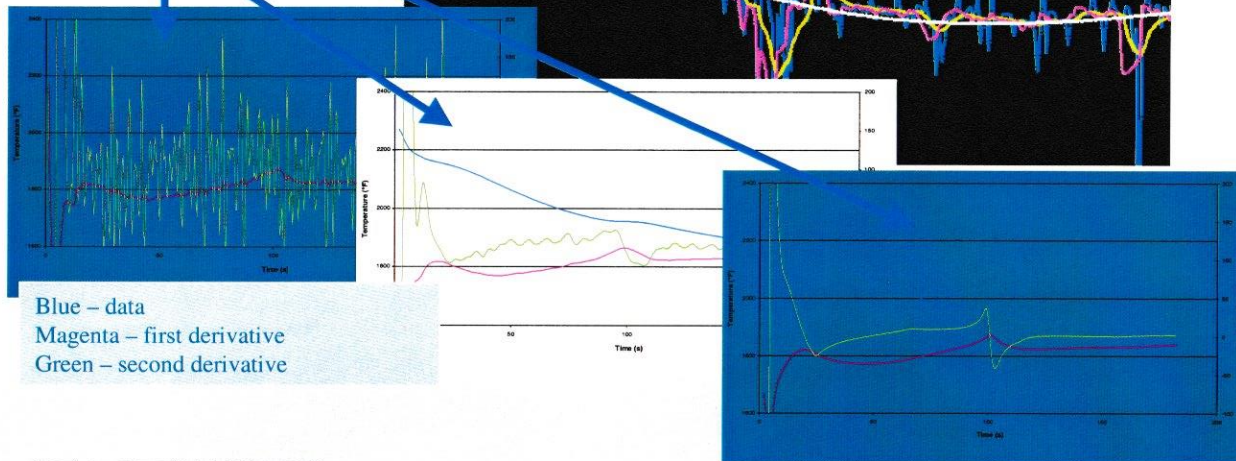
Acquisition error

Exaggerated example

Blue – unfiltered data
 Magenta – linear filter
 Yellow – least square filter
 White – MSJO based

- The issues start early due to black box processing.
- Algorithms/heuristics want good behavior in the derivatives.
- Solid modeling expects C^2 .
- Anyone for C^k ?

Derivatives least square, COTS, MSJO/SOCS



Blue – data
 Magenta – first derivative
 Green – second derivative



MSJO/Sfab/SOCS – Comparative Analysis



Surfaces from points

Method patch count
(udeg x vdeg)

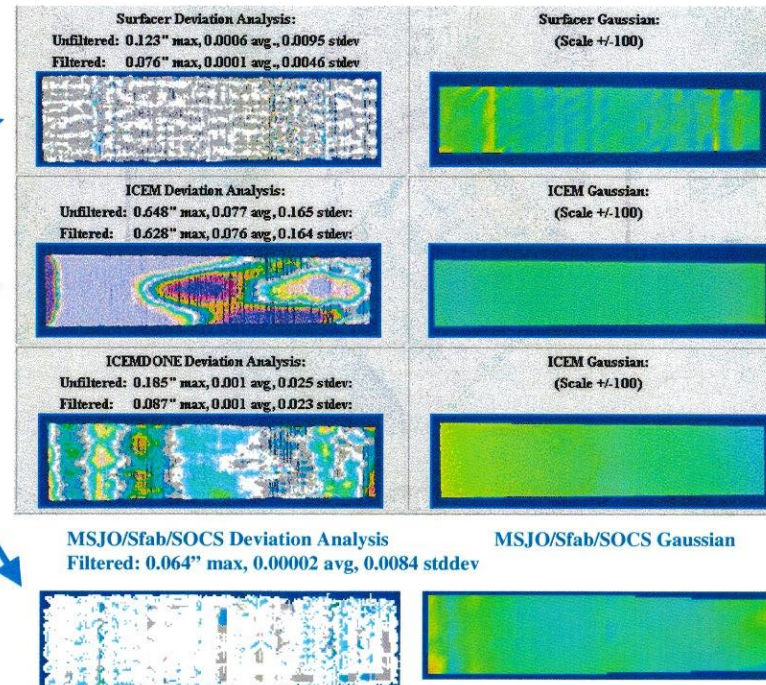
Surfacer 288 (3x3)

ICEM 1 (4x4)

ICEM 1 (6x6)

MSJO Sfab 63 (3x3)

- The goal includes single surface that fits with good properties.
- Early look at Surfacer and ICEM Surf.
- MSJO Sfab/SOCS example includes boundary control.
- Clear example of trades and the need to handle them.



References



In terms of Geometric/Knowledge Modeling Challenges, the presentation looks at Background, Representation, Methods, Quality, and one example from on project, MSJO/Sfab/SOCS.

At several points, there are references to related issues (see links below).

In the operational mode, issues can be handled using trades. That implies the making of decisions by resources. Issues raise costs. They can be particularly troublesome in computing. An automated process trying to eliminate issues must deal with undecidability. This leads to the requirement for time limits, iteration limits, fixed point logic, etc.

The prowess of the computer to guide itself will be become increasingly interesting. Our work will be to determine the appropriate amount that will be necessary for us to apply for control of the situation.

References

Knowledge - <http://www.mel.nist.gov/msid/sima/item2000/09srinivasan.pdf>

Issues - <http://www.siam.org/meetings/cadcf99/>

NURBS - <http://mathworld.wolfram.com/NURBSSurface.html>

Undecidability list - <http://www.wolframscience.com/nks/index/u.html>

Undecidability history - <http://www.wolframscience.com/reference/notes/1136d>

Sparse Optimal Control Software - <http://www.boeing.com/phantom/socs/>

