Pioneer of Solid Modeling Association

Alberto Paoluzzi

Symposium on Solid and Physical Modeling (SPM-2017)

The context of our start in Solid Modeling: 1984-1988

Solid modeling R&D was at the time using Lisp-machines!

Figure 1: Symbolics LISP Machine, from Google NY office computer museum

Figure 2: IBM XT personal computer

Figure 3: Apple Macintosh SE

We started on IBM first PCs and Apple Macintosh writing Solid Modeling software in Pascal

Minerva: the first solid modeler on a PC (1985–)

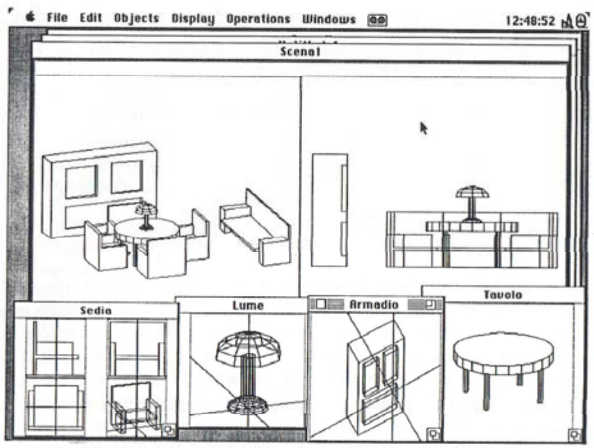


Figure 1: The window-based user interface of *Minerva*, with a structure definition

Figure 4: Apple GUI

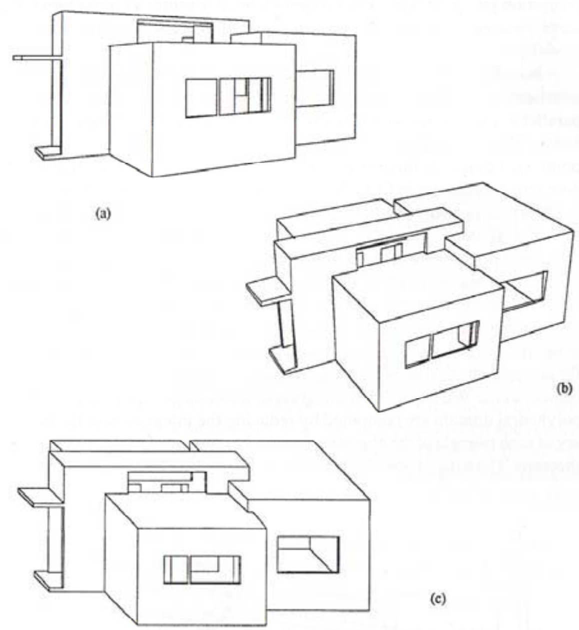


Figure 3: Solid model of the Oud's Mathenesse (Rotterdam, 1923) generated by *Minerva*. (a) Two-point perspective; (b) three-point perspective; (c) dimetric Cavalier axonometric view

Figure 5: Standard views of Mathenesse building

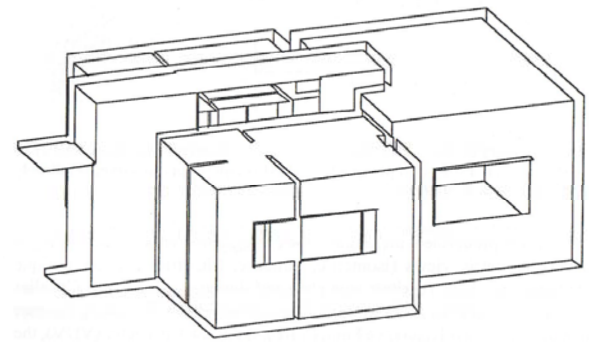


Figure 4: Hidden surface removed view of the complemented Mathenesse building

Figure 6: Boolean Algebra over Linear Polyhedra, CAD 1990

Featuring hierarchical assemblies, Boolean ops, parametric surfaces, integration of polynomials, HSR algorithms, full-fledged Apple GUI

PLaSM: FL-based Language for Solid Modeling (1992-)

Programming language for solid variational geometry (CAD 92, TOG 95)

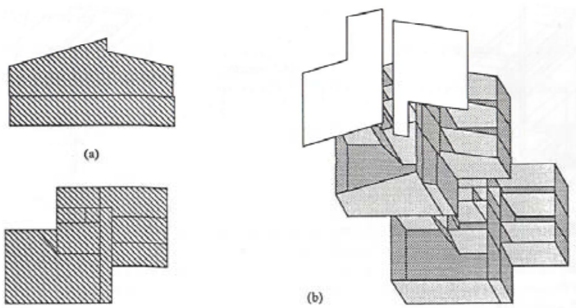


Figure 6: (a) The arguments *Plan* and *Section* of an operation && (intersection cell-by-cell of extrusions) in the *PLASM* language; (b) The two-dimensional polyhedral complex obtained by the evaluation of the expression @2:(*Plan* && *Section*), represented as an exploded drawing

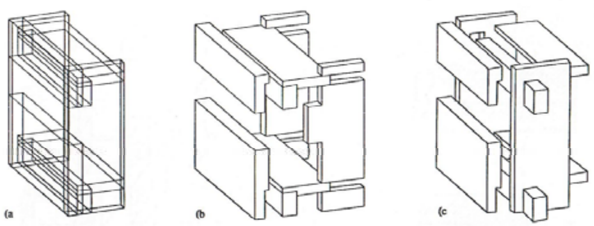


Figure 7: (a) A sequence (Beams, Roofs, Enclosures, Partitions) of isothetic (interpenetrating) pairs of parallelopipeds, for sake of simplicity assumed to be in the same coordinate space; (b) *PLASM* evaluated expression *STRUCT*: (Beams, Roofs, Enclosures, Partitions); (c) STRUCT: (Beams, Partitions, Enclosures, Roofs)

Example 1.5.6 (Building facade)
An example is given in Script 1.5.6, and shown in Figure 1.6a, where a 2D complex is generated by Cartesian product of 1D complexes produced by the QUOTE operator. Several other examples of the QUOTE operator are given in Section 1.6.2.

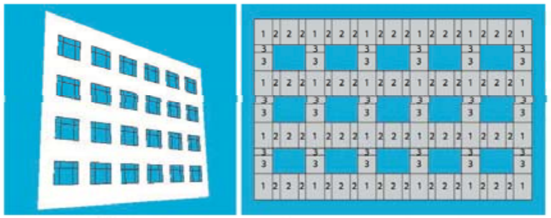


Figure 1.6 (a) the 2D complex generated as facade:<6,4> by combining QUOTE, product and 1-skeleton operators (b) the generating scheme of facade panels

INTRODUCTION TO FL AND PLASM 31

The facade generating function works by assembling three 2D Cartesian products of alternating 1D complexes, produced by Q:xRithm, Q:xVoid and by Q:yRithm, Q:yVoid, respectively. In particular, the xRithm sequence contains the numeric series used in the x direction; analogously yRithm for the y direction. Conversely, xVoid and yVoid host the series with opposite signs of elements. So, the first three Cartesian products in the STRUCT sequence produce a sort of checkboard covering that follows the scheme given in Figure 1.6b.

Script 1.5.6 (Building facade)

```
DEF facade (n,m::IsIntPos) = STRUCT:<
   Q:xRithm * Q:yRithm,
   Q:xVoid * Q:yRithm,
   Q:xRithm * Q:yVoid ,
   @1:(Q:xVoid * Q:yVoid) >
WHERE
   xRithm = ##:n:<5,-2,-5,-2> AR 5,
   yRithm = ##:m:<7,-5,-2> AR 7,
   xVoid = AA:-:xRithm,
   yVoid = AA:-:yRithm
END;
```

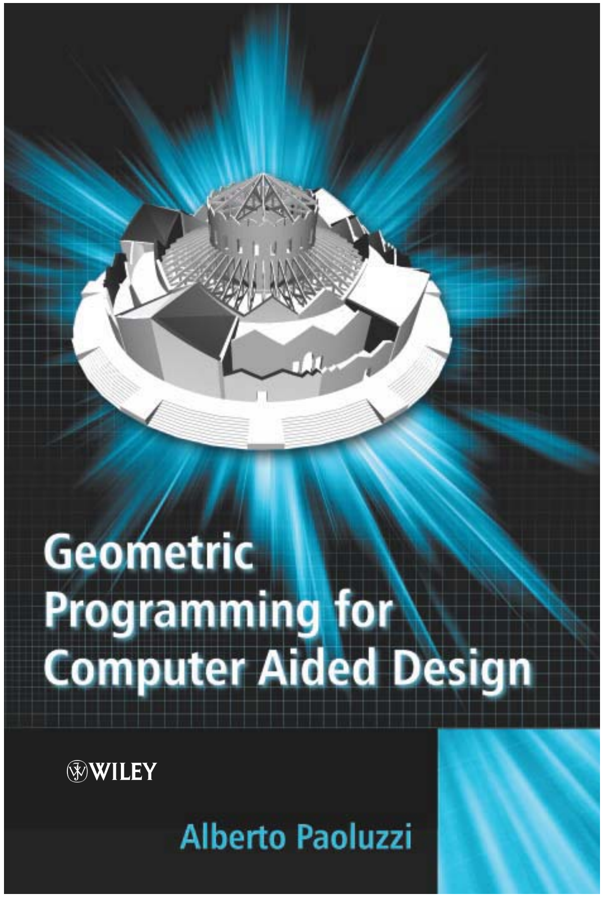


Figure 7: GP4CAD (2003)

Multidimensional representations and algorithms

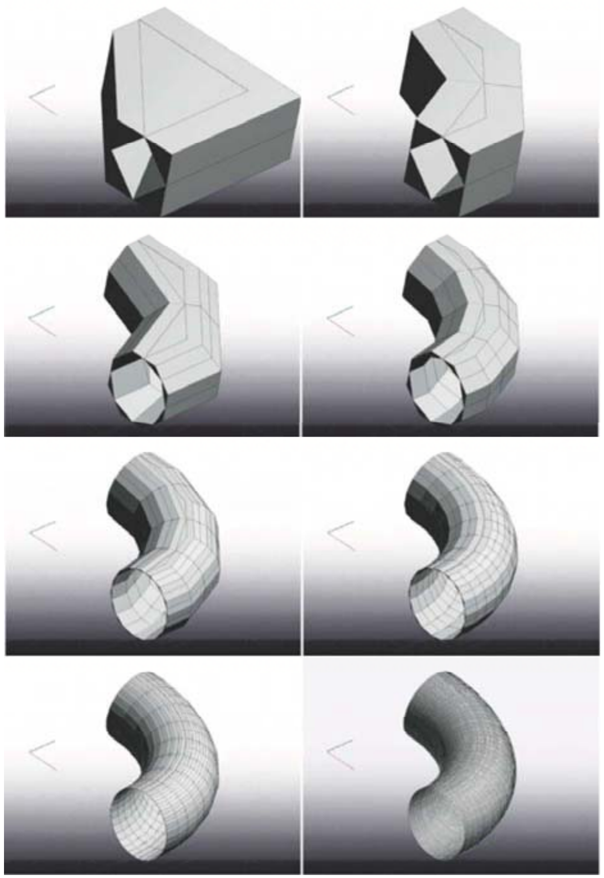


Figure 8: Dataflow refinement of rational B-spline with BSP nodes (SM&A, 2004)

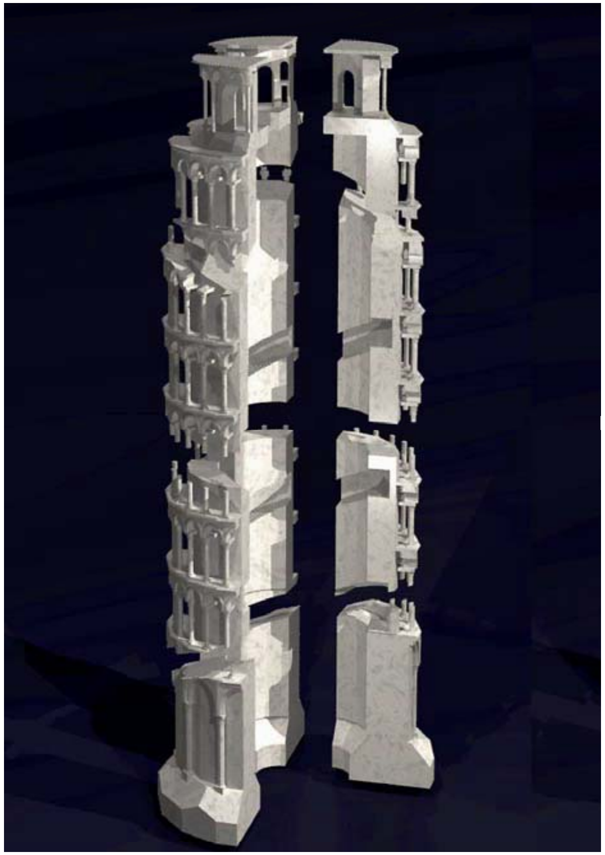


Figure 9: Parallel & distributed computing (IJCGA, 2008)

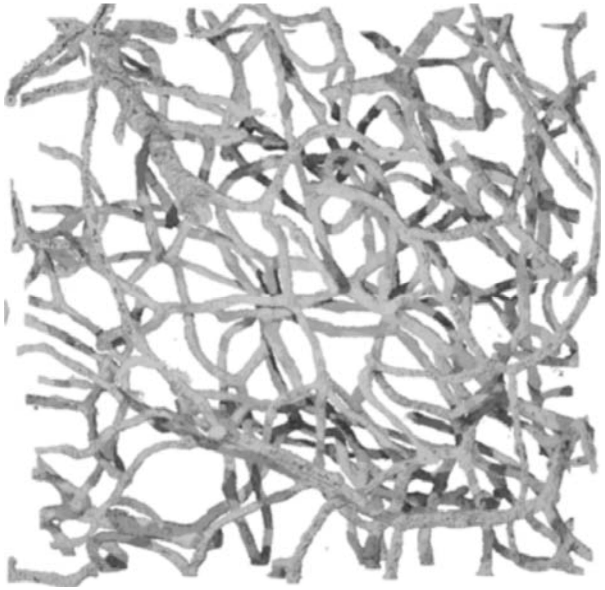


Figure 10: Topologically exact LAR models of microvessels between neurons (CAD&A, 2016)

LAR – Linear Algebraic Representation: $M \Leftrightarrow R$

In development with Julia + CUDA + Sparse Tensorflow

models $M =$ category of chain complexes:

$$C_3 \underset{\partial_3}{\overset{\delta_2}{\leftrightarrows}} C_2 \underset{\partial_2}{\overset{\delta_1}{\leftrightarrows}} C_1 \underset{\partial_1}{\overset{\delta_0}{\leftrightarrows}} C_0$$

reprs $R =$ sparse matrices and vectors

(CAD,14) and (in development, 2017)

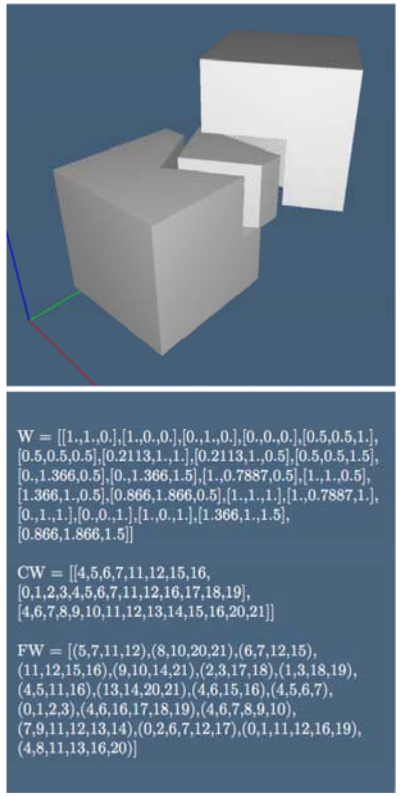


Figure 11: user-readable LAR format

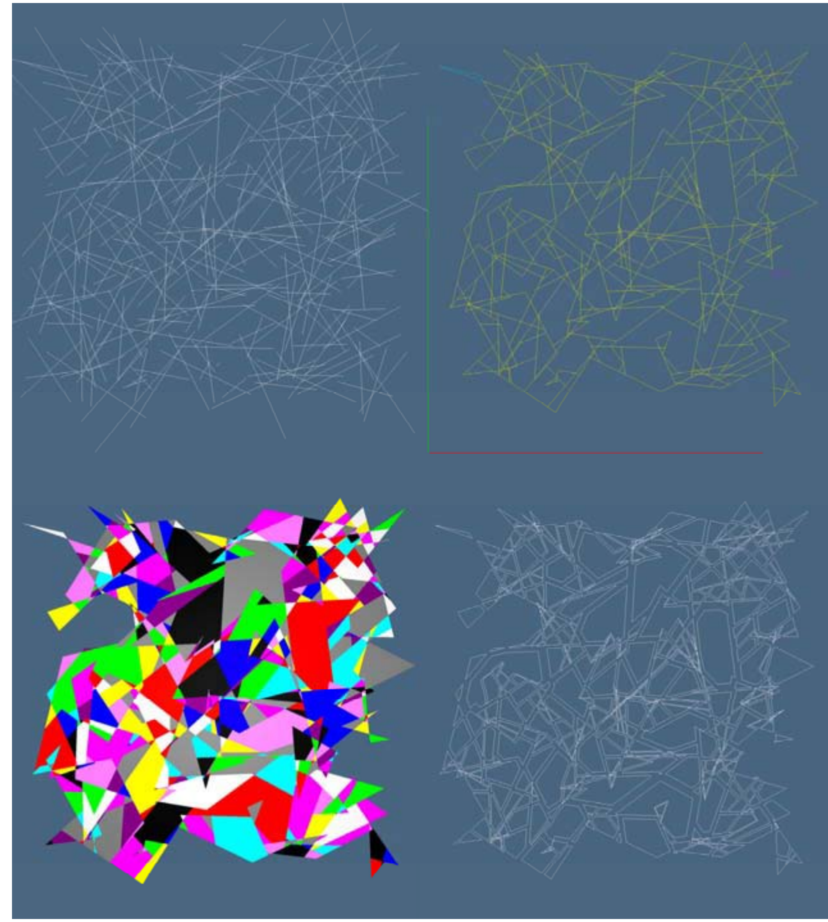
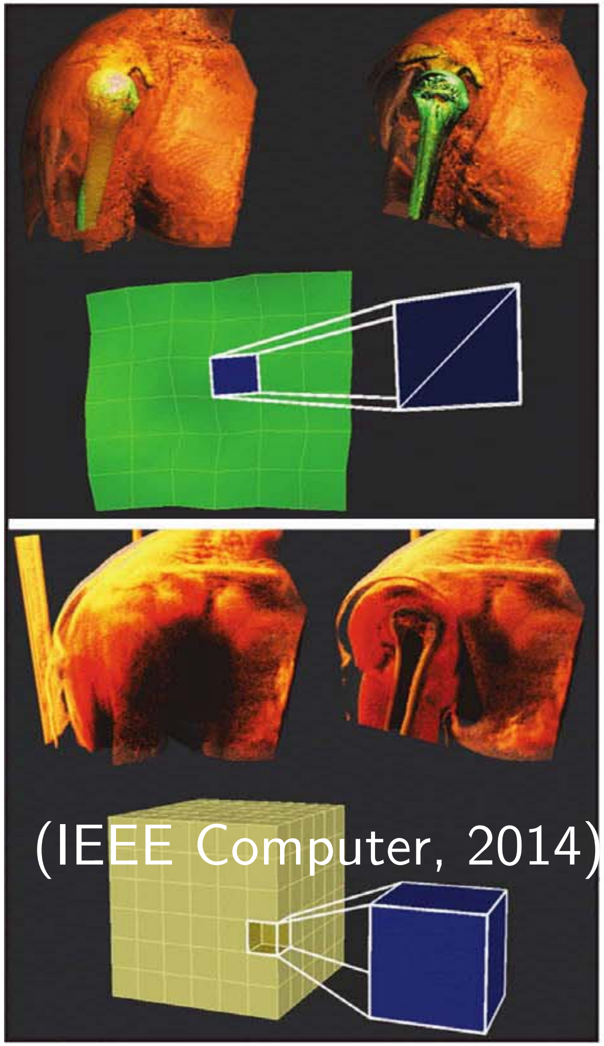


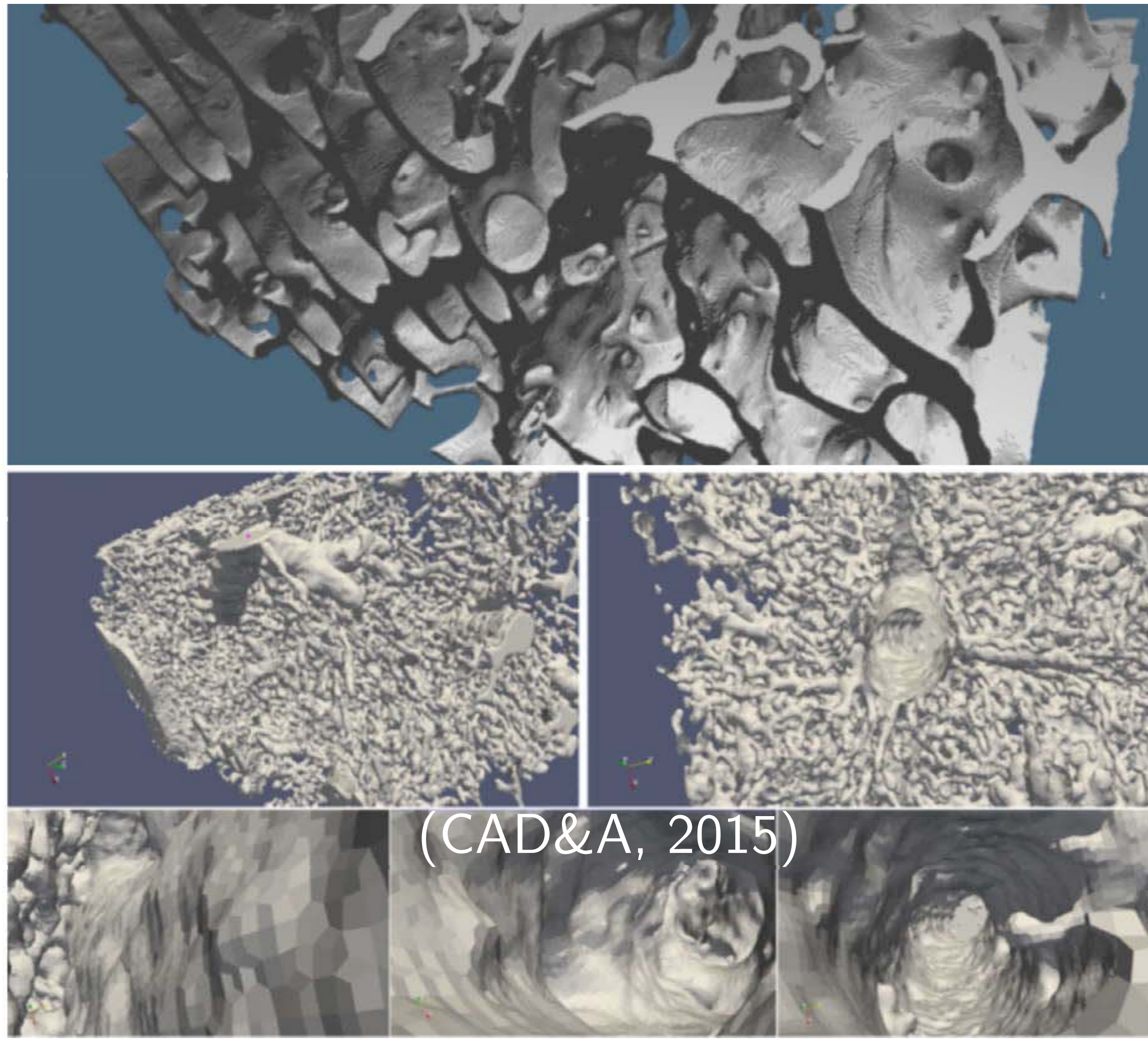
Figure 12: Plane arrangement from random line segments

Challenges: persolized biomedicine & virtual surgery

Solid Modeling Association should enter the IEEE-SA P.3333.2 WG !!



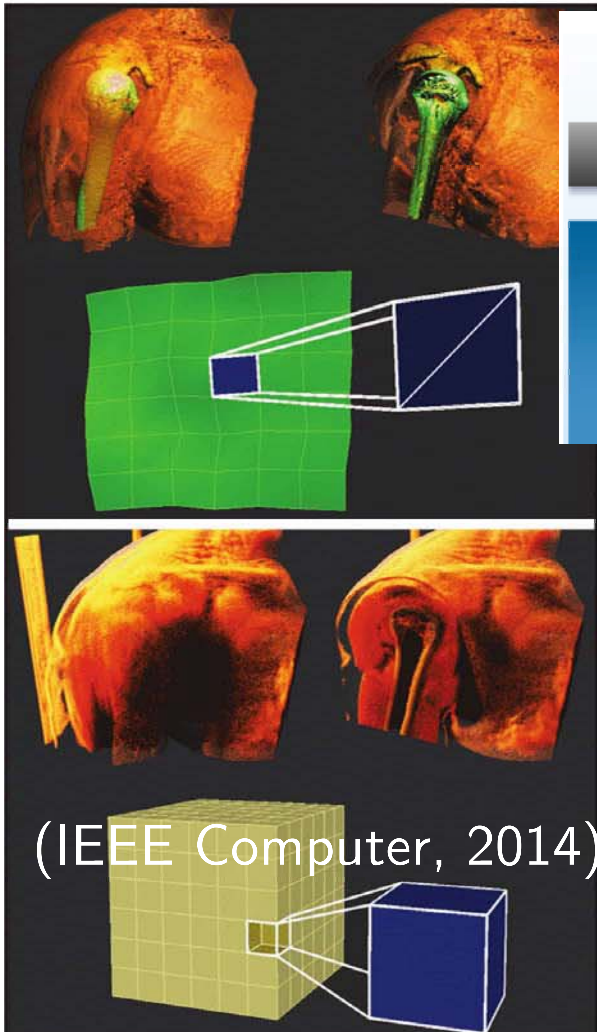
(IEEE Computer, 2014)



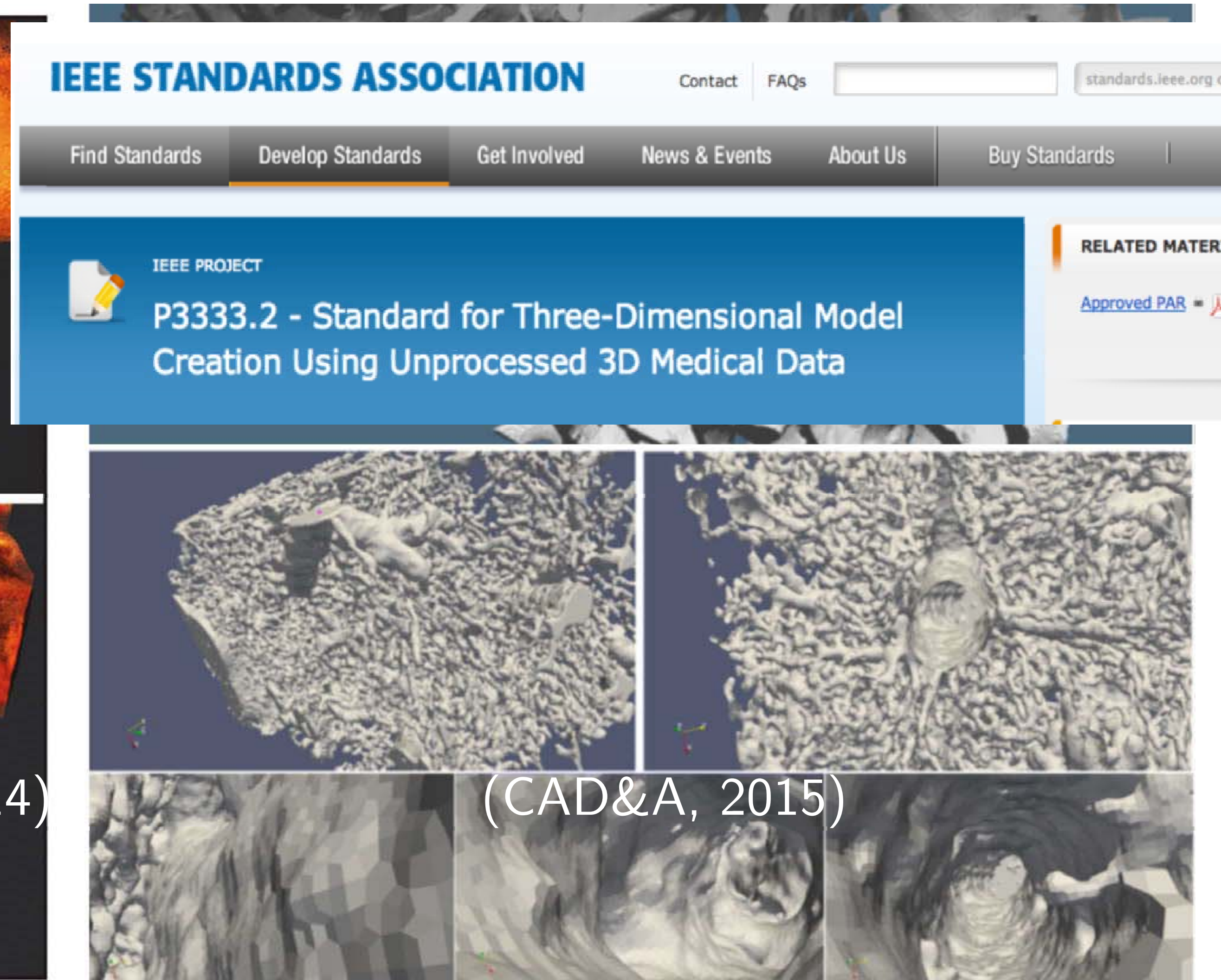
(CAD&A, 2015)

Challenges: persolized biomedicine & virtual surgery

Solid Modeling Association should enter the IEEE-SA P.3333.2 WG !!



(IEEE Computer, 2014)



(CAD&A, 2015)