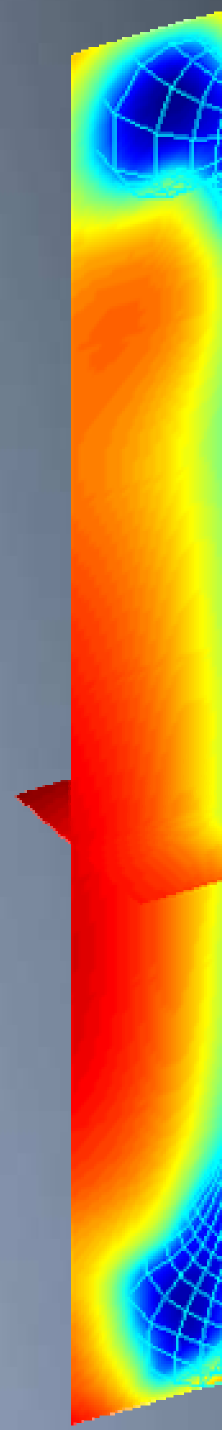
pRob

PLICIT AND PARAMETRIC FEMUR RFACE RECONSTRUCTION



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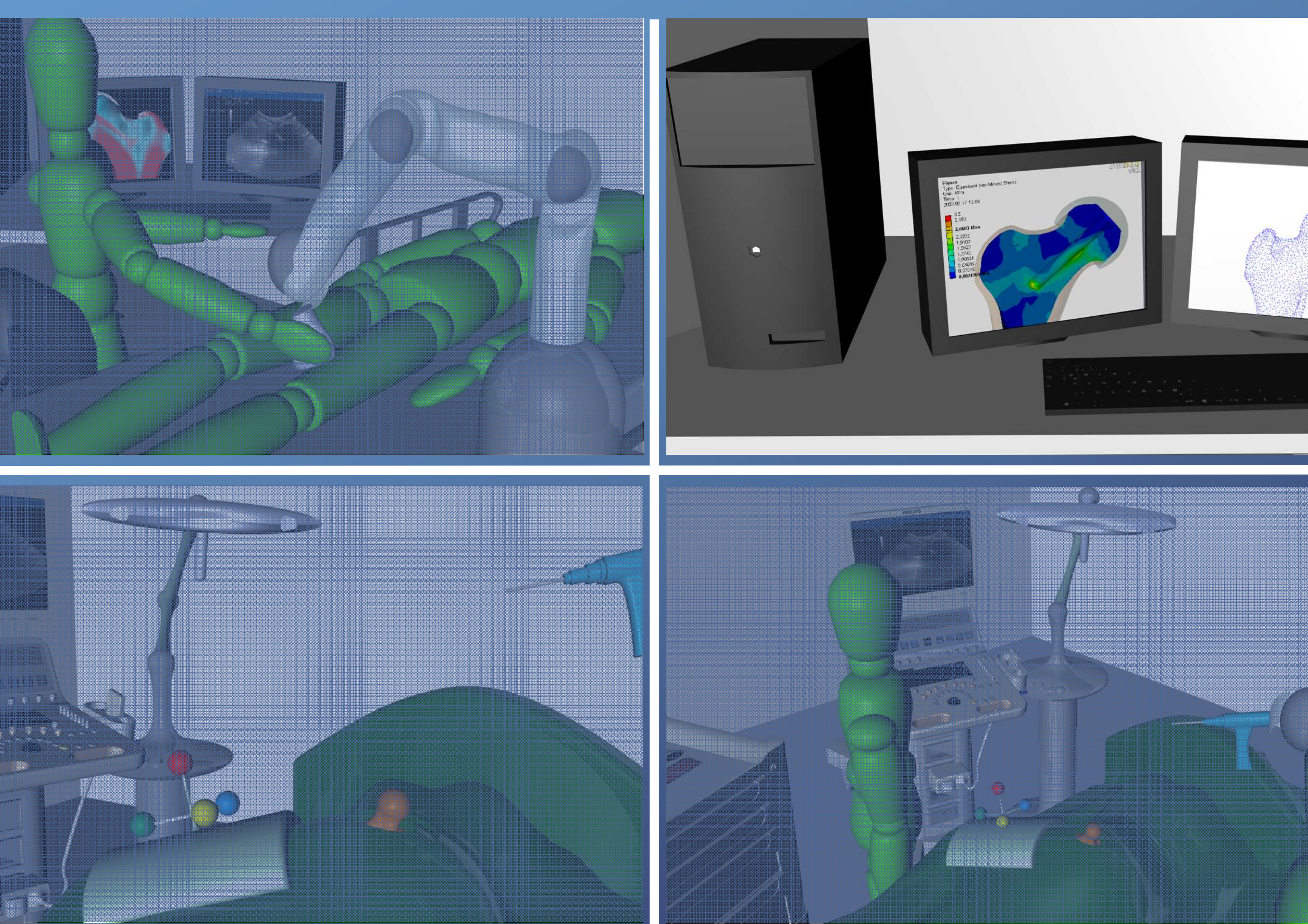
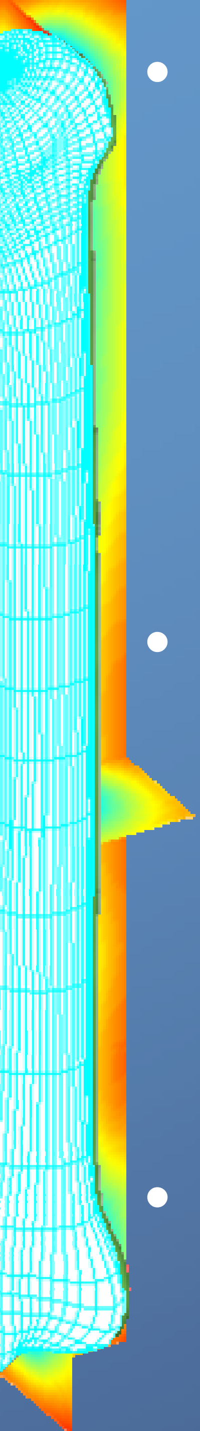




- From a CT scan, distinct points of a femur, scattered and no
uniformly distributed are obtained

RBF+PU

- Using radial basis functions plus a Gaussian based partition
unity, the data is implicit approximated.

MC+PP+PNT+C

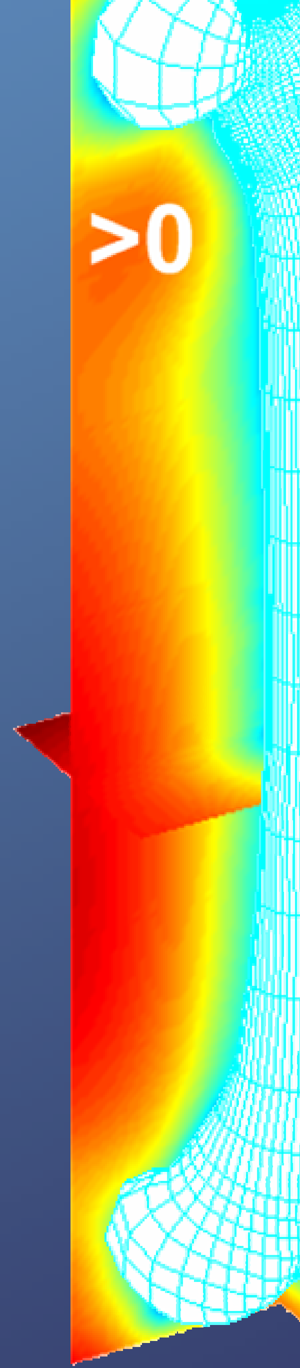
- A triangular mesh, obtained through marching cubes, is spli
two halves planar parameterizations. Applying the curved P
triangle method, these parameterizations are quadrilateral r
meshed and interpolated with a bi-cubic TP-B-spline, obtain
therefore the parametric reconstruction of the femur.

- Implicit representation

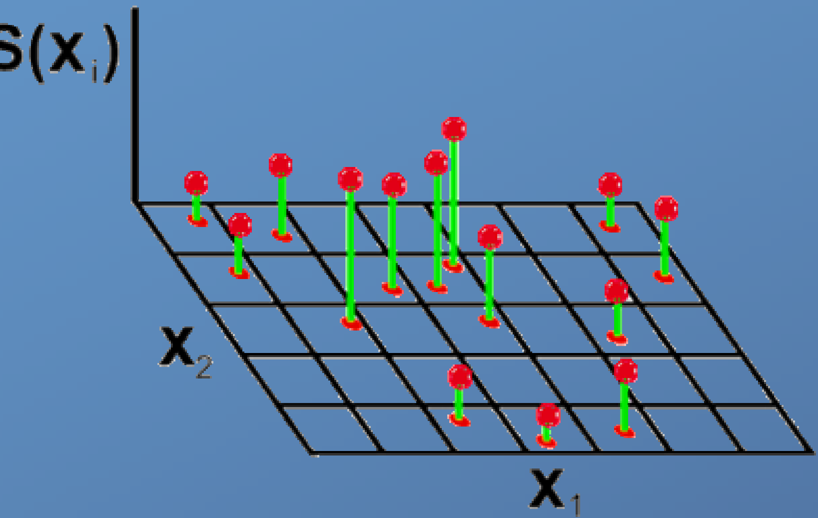
$$F(x, y, z) = 0$$

- Parametric representation

$$(x, y, z) = (s_x(u, v), s_y(u, v), s_z(u, v))$$



Radial Basis Function scattered data interpolation:



$$S(\mathbf{x}) = \sum_{i=1}^{N} \lambda_i \varphi\left(\|\mathbf{x} - \mathbf{x}_i\| \right) + P(\mathbf{x})$$

- λ_i is the *weight* of centre $\mathbf{x}_i$
- $\varphi(r) = r^{2n-1}$ is the *basis function*
- $P(\mathbf{x})$ is a low-degree polynomial
- $\|.\|$ is the Euclidean norm

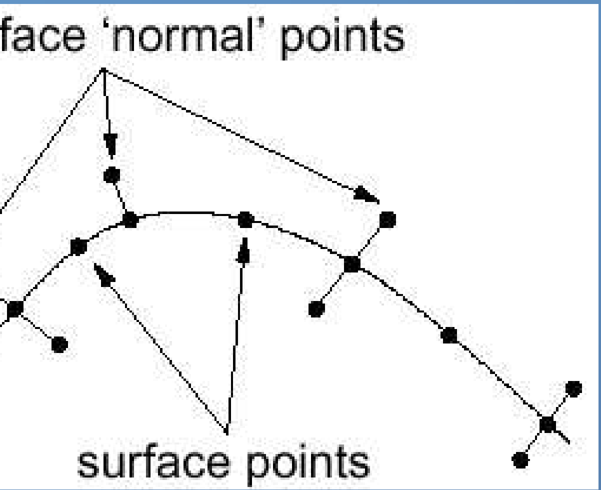
Solution:

$$\begin{pmatrix} A & P \\ P^T & 0 \end{pmatrix} \begin{pmatrix} \lambda \\ c \end{pmatrix} = \begin{pmatrix} f \\ 0 \end{pmatrix}$$

$$A_{i,j} = \phi(\| x_i - x_j \|), \quad i, j = 1, \ldots, n$$

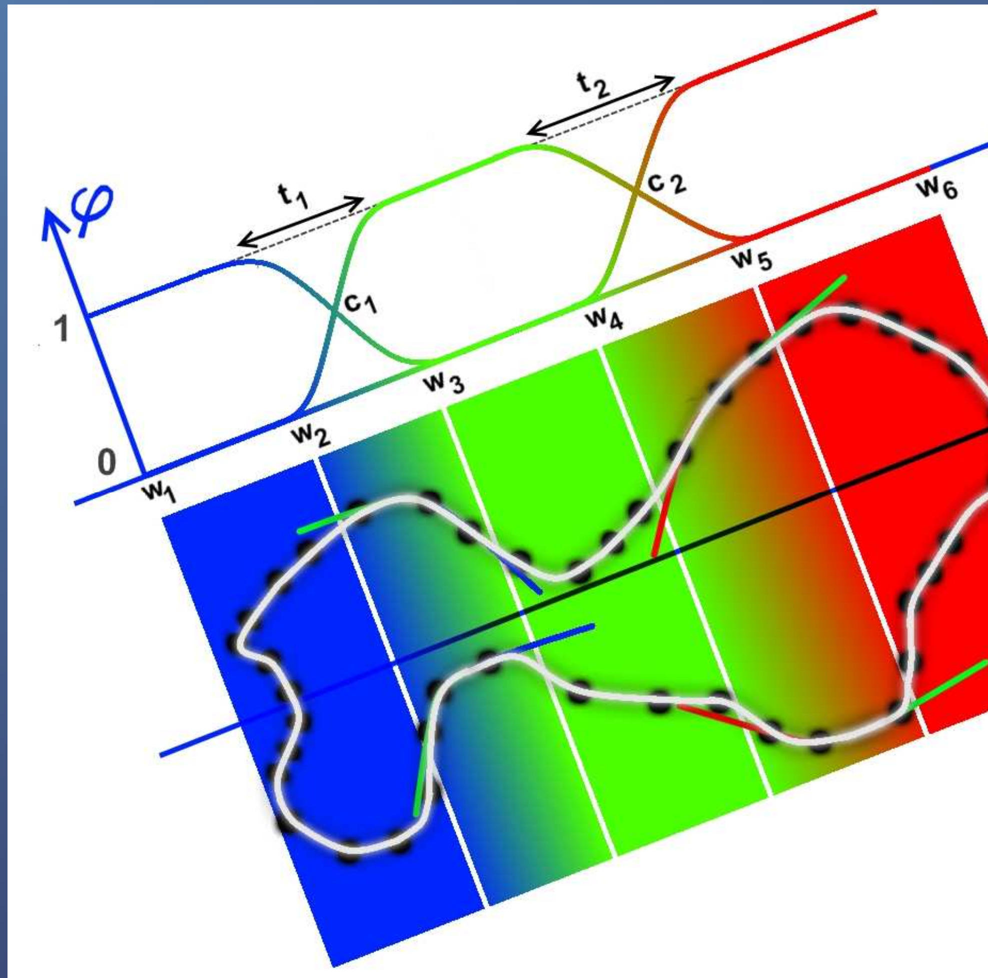
$$P_{i,j} = p_j(x_i), \quad i = 1, \ldots, n, \quad j = 1, \ldots,$$

der to obtain a distance field, where its isovalue defines the femur su
urface 'normals' points are also assigned in the RBF (Carr et al, 2001



•Positive values (outside)

•Negative values (inside)

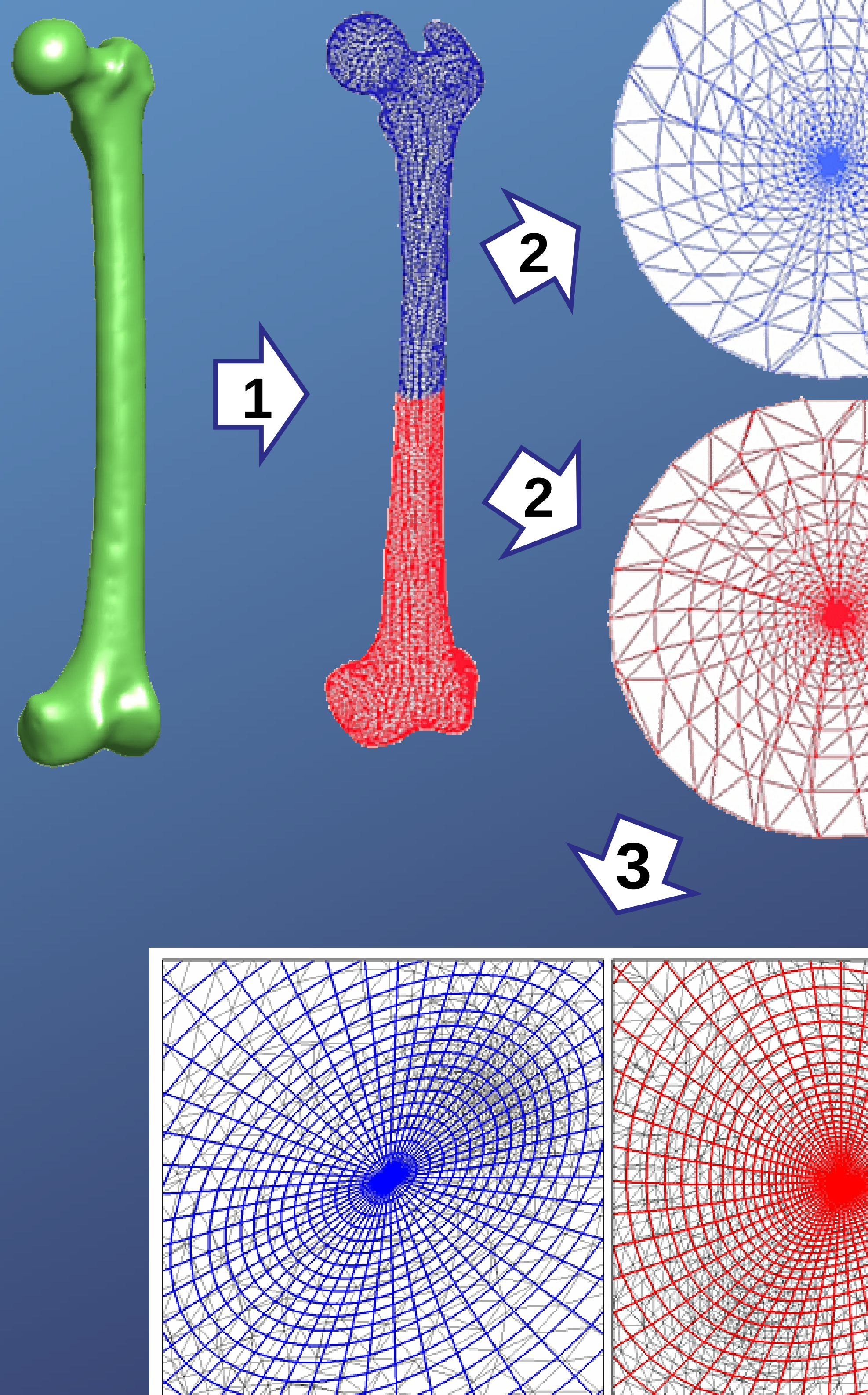


ementented algorithm: The scattered
is subdivided in ***n*** overlapping
ons along a chosen w direction. In
region, the belonging data is fitted by
SF. The final surface is reconstructed
umming the RBFs weighted by
nbership degrees (top).

y applying the marching cubes chnique to the implicit surface, a angular mesh defining the femur is otained.

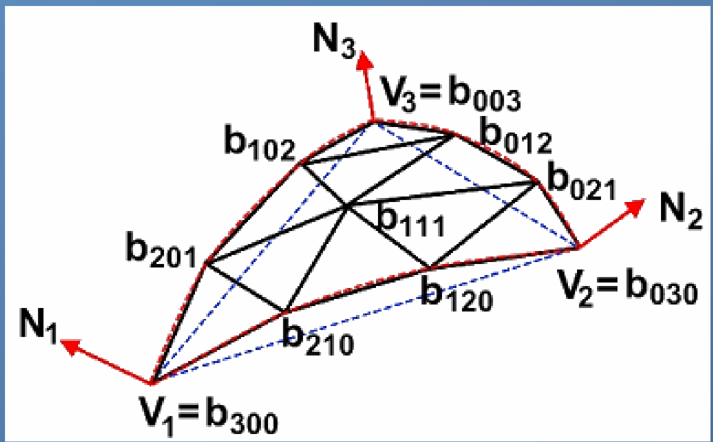
ereafter, the mesh is split in two lfs, where in each one a planar disk rameterization is performed.

ver each planar parameterization, an otimized quadrilateral grid of *m x n* ots is set.



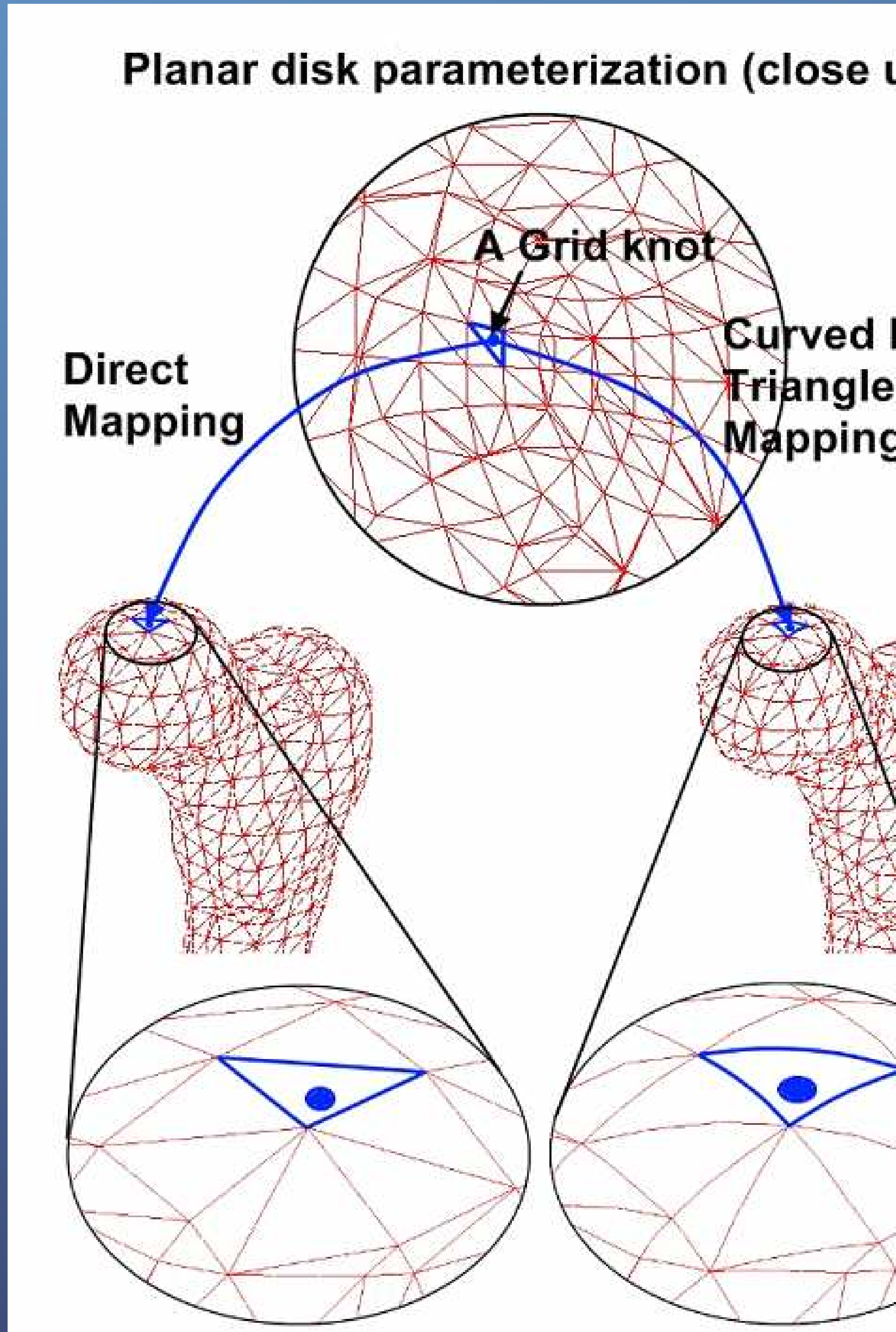
ed Point-Normal triangles (Vlachos 2001) mapping:

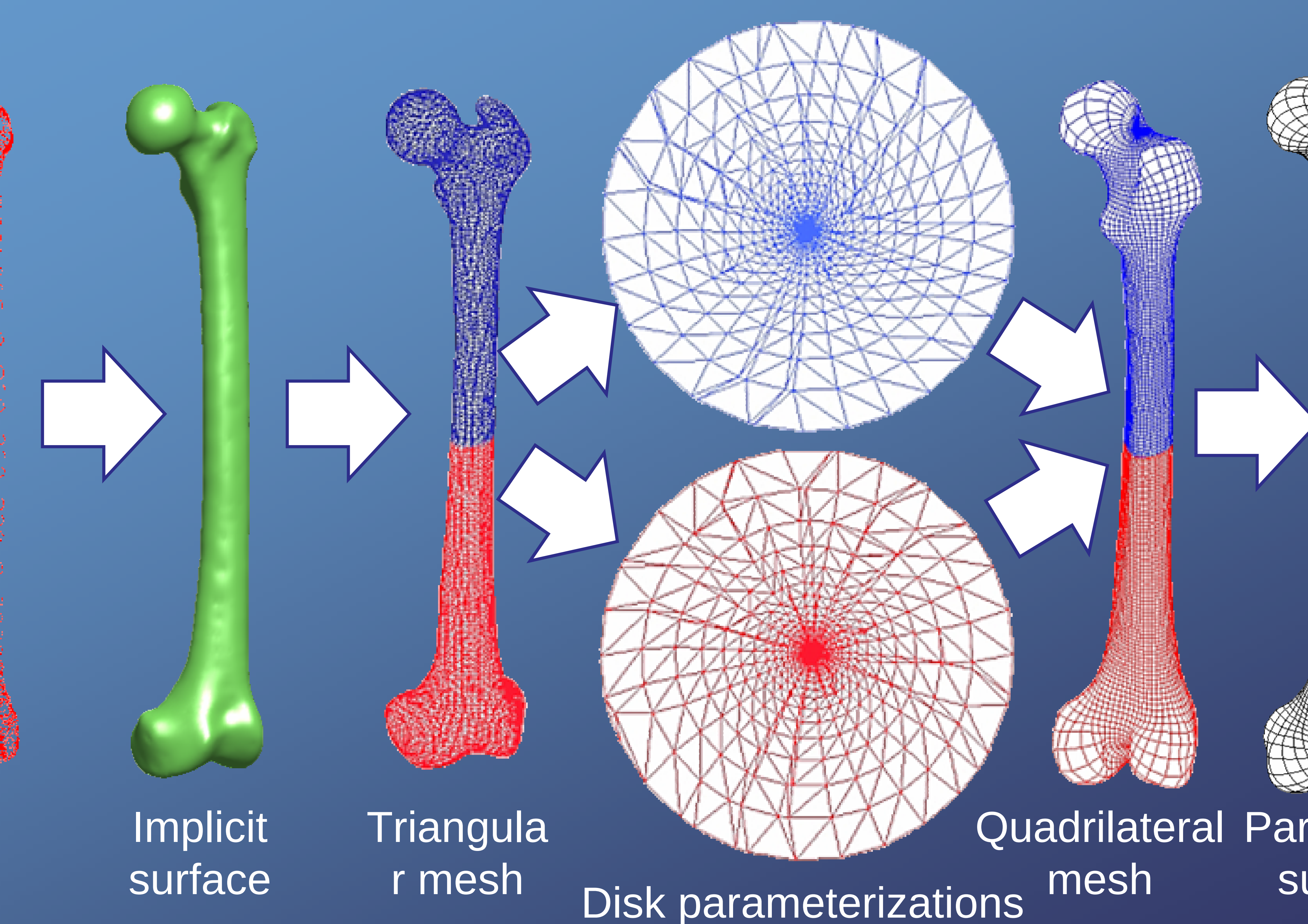
s methodology the local surface ture in each mesh face is taking onsideration by recurring to the nation of the normals at each e of the face.



nt P belonging to the curved PN gle face is given by the triangular er cubic patch:

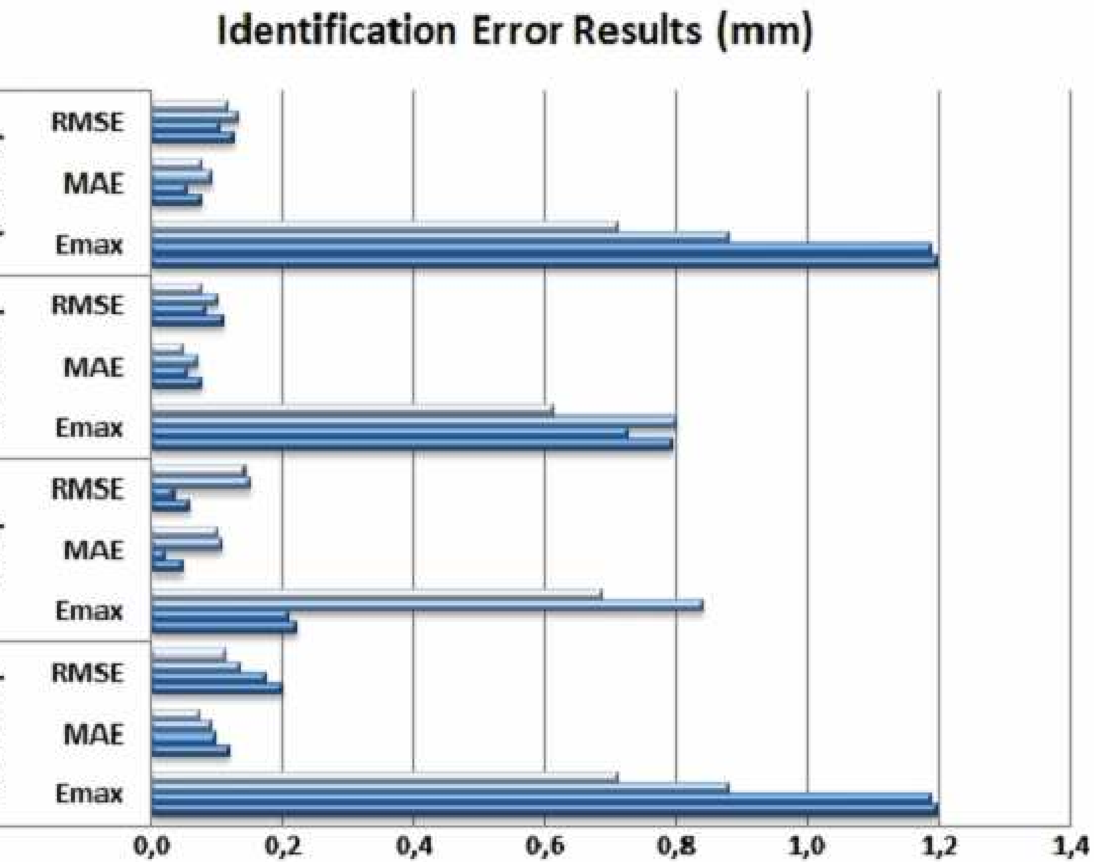
$$= \sum_{i+j+k=3} b_{ijk} \frac{3!}{i!\,j!\,k!} w^i u^j v^k, \quad w = 1 - u - v$$



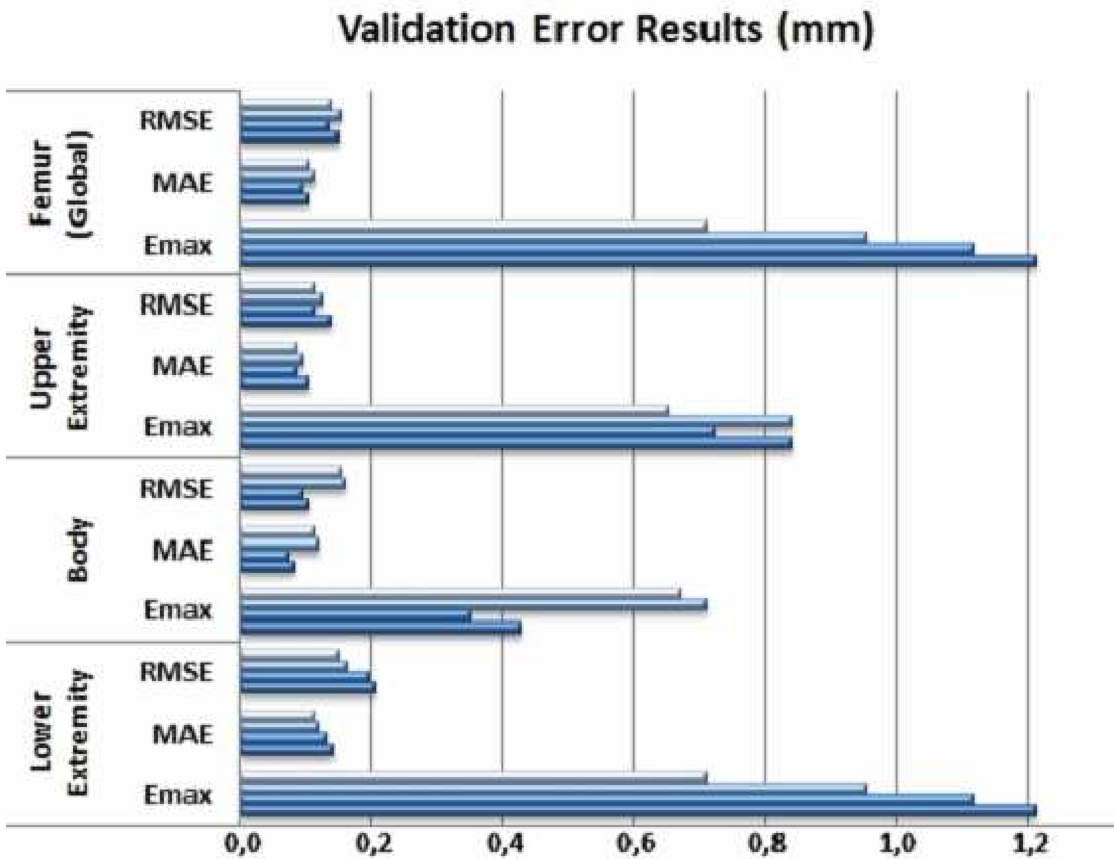

Implicit surface
Triangula r mesh
Disk parameterizations
Quadrilateral mesh

terms of implicit reconstruction, the maximum error
lowed is 0.1mm.
arametric reconstruction time is about ~1 minute.

#surface points	#RBF centers	Imp rec
20k	4081	86.
40k	6374	87.
60k	8367	90.
80k	10153	101
100k	12291	112



	Lower Extremity			Body			Upper Extremity			Femur (Global)		
Map	Emax	MAE	RMSE	Emax	MAE	RMSE	Emax	MAE	RMSE	Emax	MAE	RMSE
G1	0,710	0,073	0,113	0,687	0,101	0,142	0,613	0,048	0,075	0,710	0,078	0,118
C0	0,880	0,091	0,137	0,840	0,108	0,148	0,803	0,070	0,102	0,880	0,092	0,133
G1	1,189	0,098	0,176	0,209	0,023	0,034	0,725	0,054	0,084	1,189	0,053	0,106
C0	1,200	0,122	0,199	0,223	0,047	0,057	0,795	0,076	0,111	1,200	0,075	0,127



		Lower Extremity			Body			Upper Extremity			Femur (Globa		
Grid	Map	Emax	MAE	RMSE	Emax	MAE	RMSE	Emax	MAE	RMSE	Emax	MAE	RM
Opt 50x100	G1	0,709	0,113	0,150	0,671	0,115	0,152	0,652	0,085	0,114	0,709	0,105	0,1
	C0	0,954	0,121	0,163	0,710	0,121	0,159	0,840	0,096	0,128	0,954	0,113	0,1
Uni 50x202	G1	1,119	0,132	0,196	0,352	0,074	0,095	0,722	0,086	0,116	1,119	0,094	0,1
	C0	1,215	0,144	0,207	0,429	0,083	0,106	0,840	0,104	0,139	1,215	0,106	0,1

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