About the feasibility of use of **Hurst coefficient** in **thermal images** for early **diagnosis of breast diseases**

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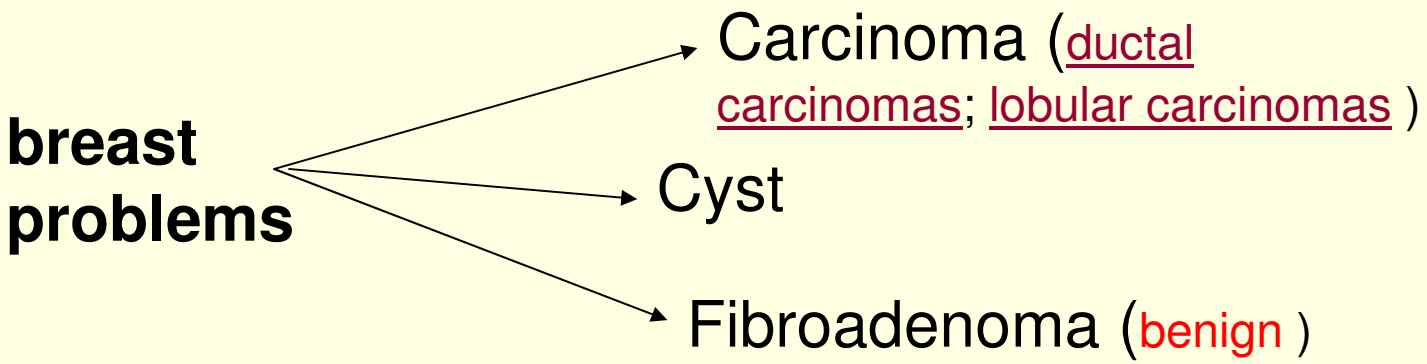
INTRODUCTION

- Women in the USA and Brazil get **breast cancer more than any other type of cancer** except for skin cancer
- **Infrared thermography**, **thermal imaging**, **thermo graphic imaging** to detct a number of new cases of cancer diagnosed
- **Artificial intelligence** (**AI**) +**Digital image processing** = early diagnosis

Breast cancer

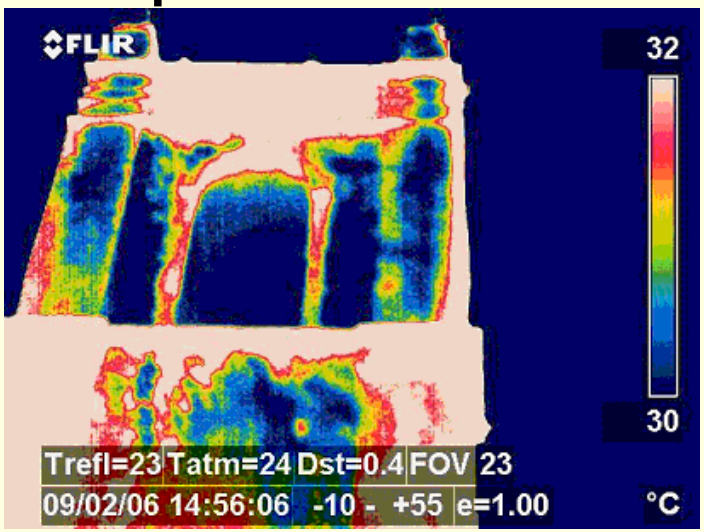


- Worldwide, breast cancer comprises 10.4% of all cancer incidence among women.
- Breast cancer is commonly diagnosed using a "**triple test**": clinical breast examination, mammography, and fine needle aspiration cytology.
- In NE of Brazil each year younger women (< 40) present beast cancers

Infrared thermography

- Temperature measurement presents many **industrial and commercial applications.** It has significant low cost .
- In addition to these , there are a number of uses related to **medical** situations in both human and animal conditions

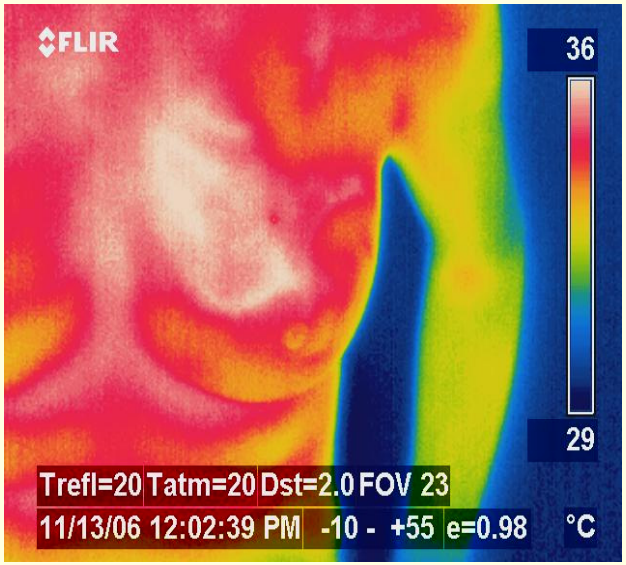
Example: Christian Church of Carmo Olinda - PE



Thermology advantages

- **Thermo graphic imaging** + **triple test** = improve the correction of early diagnosis to **98%.**

- With no physical contact and without pain .



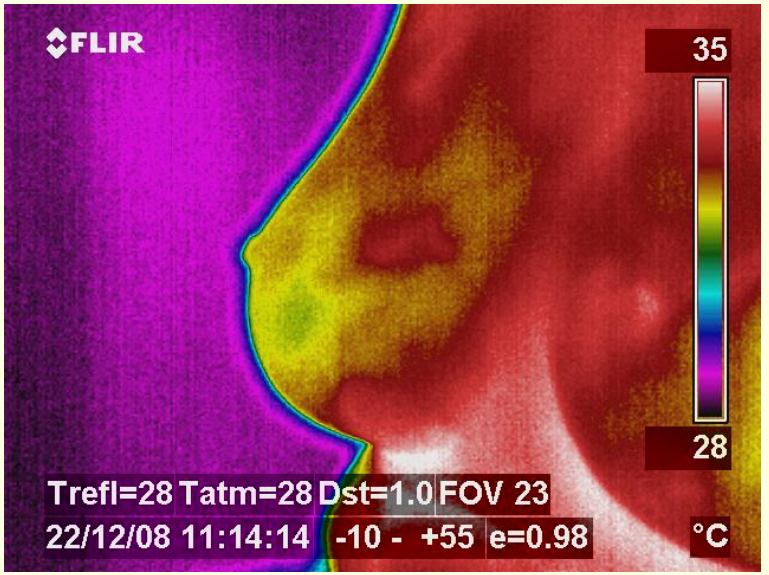
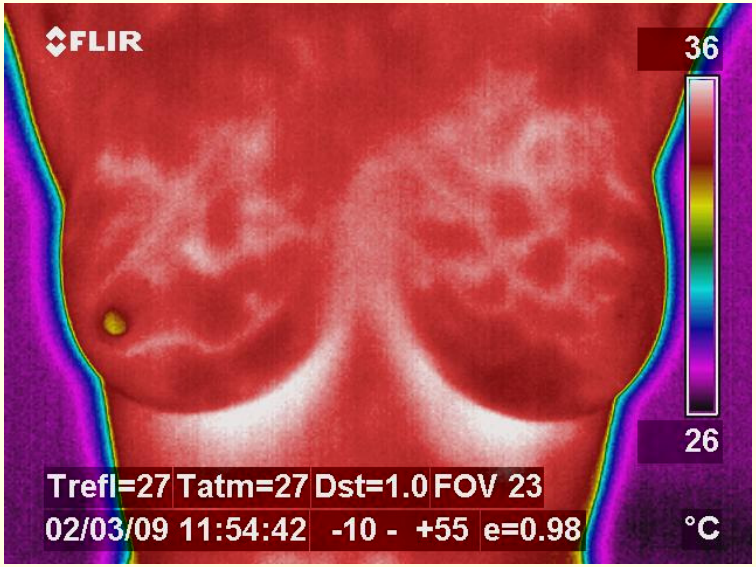


Image Data Base :

this web-site contains relevant information about patient and their thermo grams for **image analysis**.



http://200.20.11.171/proeng/

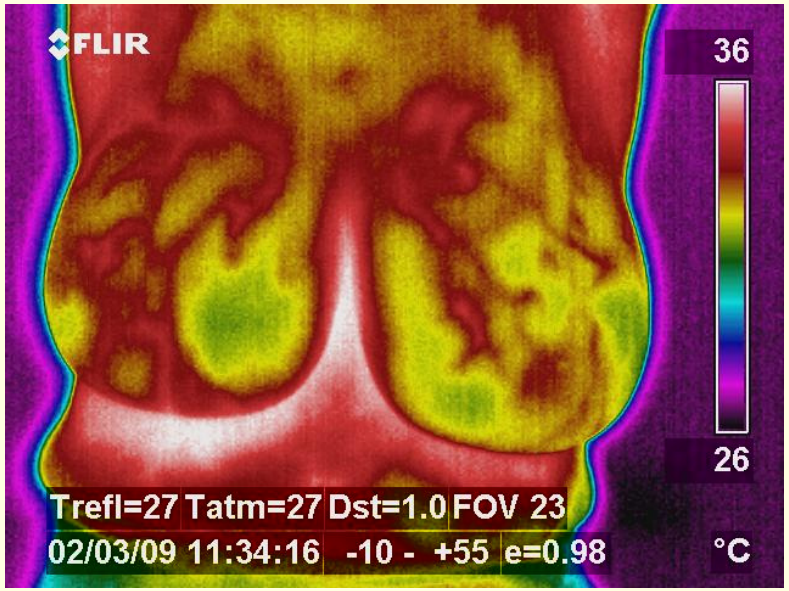
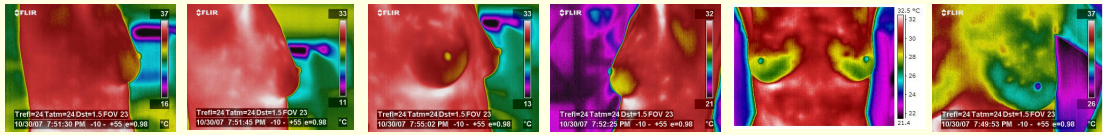


Image Data Base uses:

- Statistic datum;
- Image Registration for public analysis, where there are at least 6 images of each patient in various position;



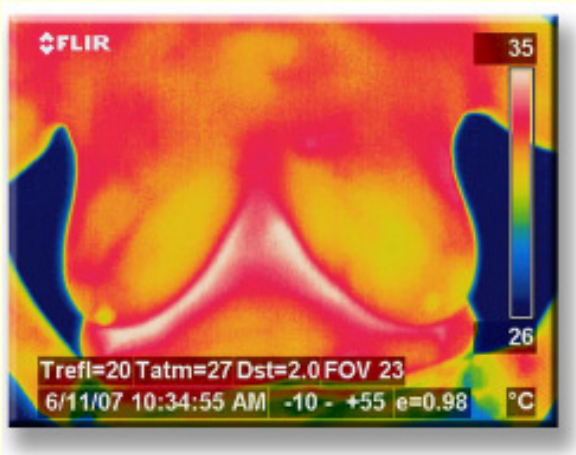
- Automatic diagnosis based on images;
- Reconstruction of 3D breast geometry for mathematical and computational modeling.

Main objective of this paper:

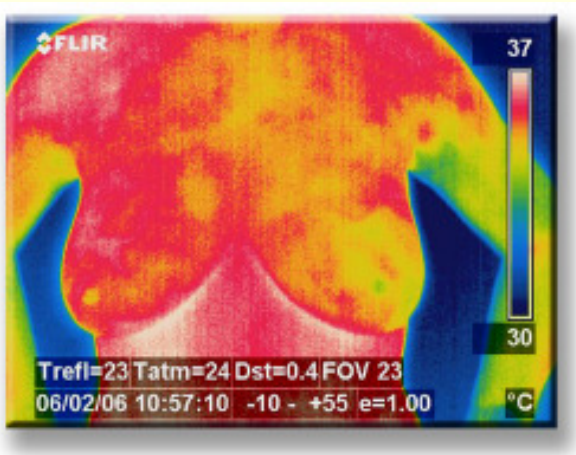
- This paper presents a study on the usability on the fractal measures for diagnoses of breast diseases in early stages.

- It is based on the **fractal dimension characteristic** evaluated by a C# developed algorithm for **Hurst coefficient computation.**

Automatic diagnosis based on image symmetric degree



Patient with normal breast

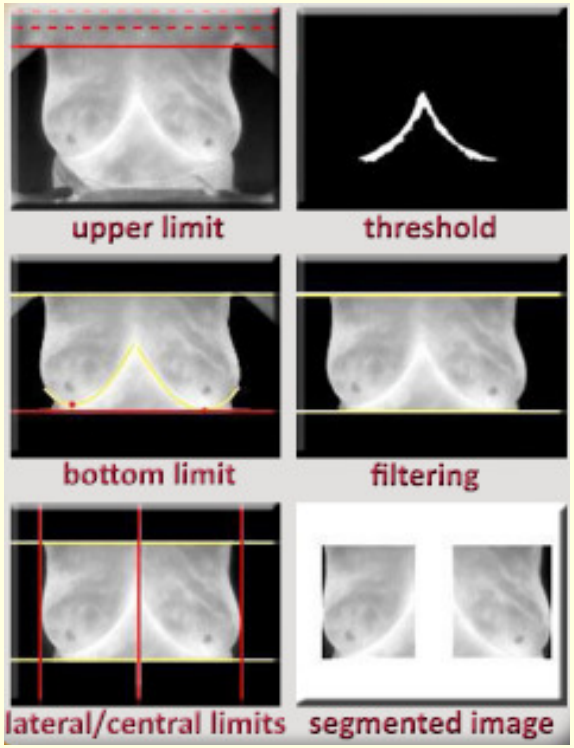


Patient with malign tumor

It is important to note that the **temperature distribution** in healthy breast occurs in a more **symmetrical** manner

First step: image automatic segmentation

Preprocessing Steps



Second step: analyzes the symmetry of the temperature distribution

An algorithm for **Hurst coefficient** computation is used to evaluate the **Fractal Dimension** of square images parts with 6 sizes *wi*: 5,7,9,11,13 and 15 pixels.

For each NxN image this value is computed:

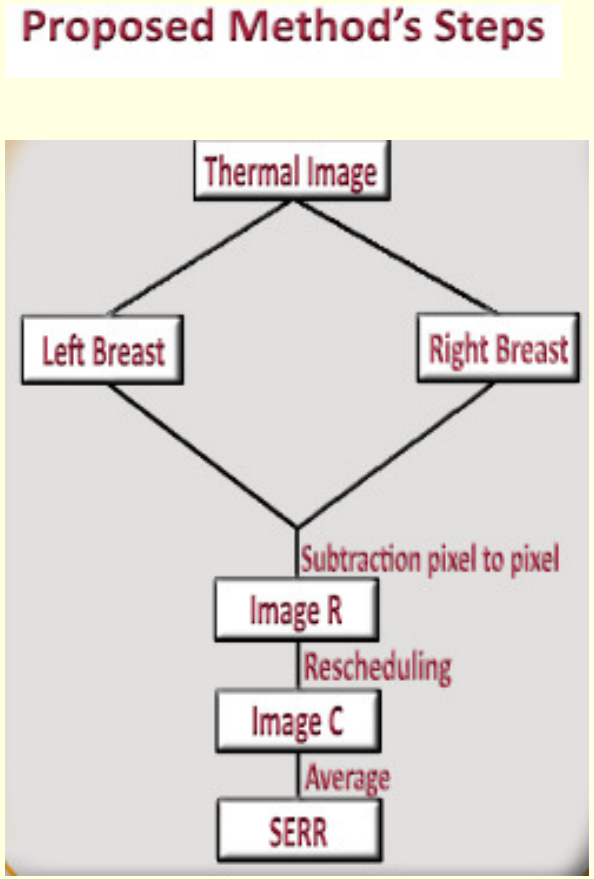
$$\sum (N - (2i + 3))^2$$

times , where i= 1.. 6

These are used to extract 4 features of each breast and 2 features of the subtracted image of both breast (see scheme).

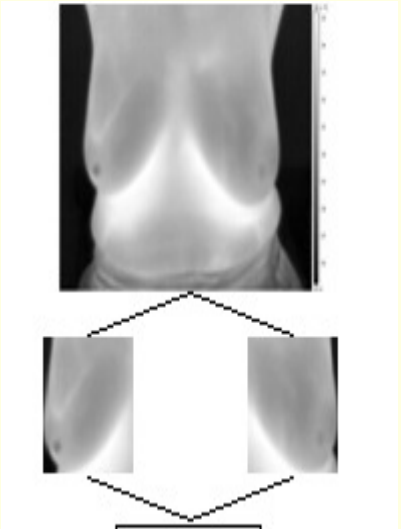
A total of 36 features for each patient are considered.

These correspond to 7 groups for the classification step



Second step: 72 techniques of machine learning are used for diagnose

In this step, we used the software WEKA (http://www.cs.waikato.ac.nz/ml/weka/) and techniques of machine learning, among them: Bayes Logistic Regression, Bayes Net, Complement Naive Bayes, DMNB Text, Naive Bayes, Naive Bayes Multinomial, Naive Bayes Multinomial Updateable, Naive Bayes Simple, Naive Bayes Updateable, Lib Linear, Lib SVM, Logistic, Multilayer Perceptron, RBF Network, Simple Logistic, SMO, Voted Perceptron, IB1, IBK, K Star, LWL, Ada Boost M1, Attribute Selected Classifier, Bagging, Classification Via Clustering, Classification Via Regression, Cost Sensitive Classifier, CV Parameter Selection, Dagging, Decorate, END, Ensemble Selection, Filtered Classifier, Grading, Logit Boost, Meta Cost, Multi Boost AB, Multi Class Classifier, Multi Scheme, Ordinal Class Classifier, Raced Incremental Logit Boost, Random Committee, Random Sub Space, Rotation Forest, Stacking, Stacking C, Threshold Selection Vote, Citation KNN, MI Boost, MISMO, MIW rapper, Simple MI, FLR, Hyper Pipes, VFI, ADTree, BFTree, Decision Stump, FT, J48, J48graft, LADTree, LMT, NBTree, Random Forest, Random, Tree, Rep Tree, Simple Cart, Conjunctive Rule, Decision Table, DTNB, JRip, NNge, OneR, PART, Ridor, ZeroR (Witten and Eibe, 2005). The rules had better results were: Naive Bayes, IB1, Classification Via Regression (CVR), PART.



Conclusions

- Correct classification with the machine learning techniques used.
- The best results (95 % correct) were obtained USING ALL FEACTURES with Naïve Bayes and Lazy IB1 classifiers.
- Next works will consider other two fractal measures to be improve the diagnosis: Lacunarity and Sucolarity

Next parts of the project:

- Continuous population and publication of the databases
- Other features based on texture to evaluate the degree of symmetry
- Numerical modeling
- Experimental comparison

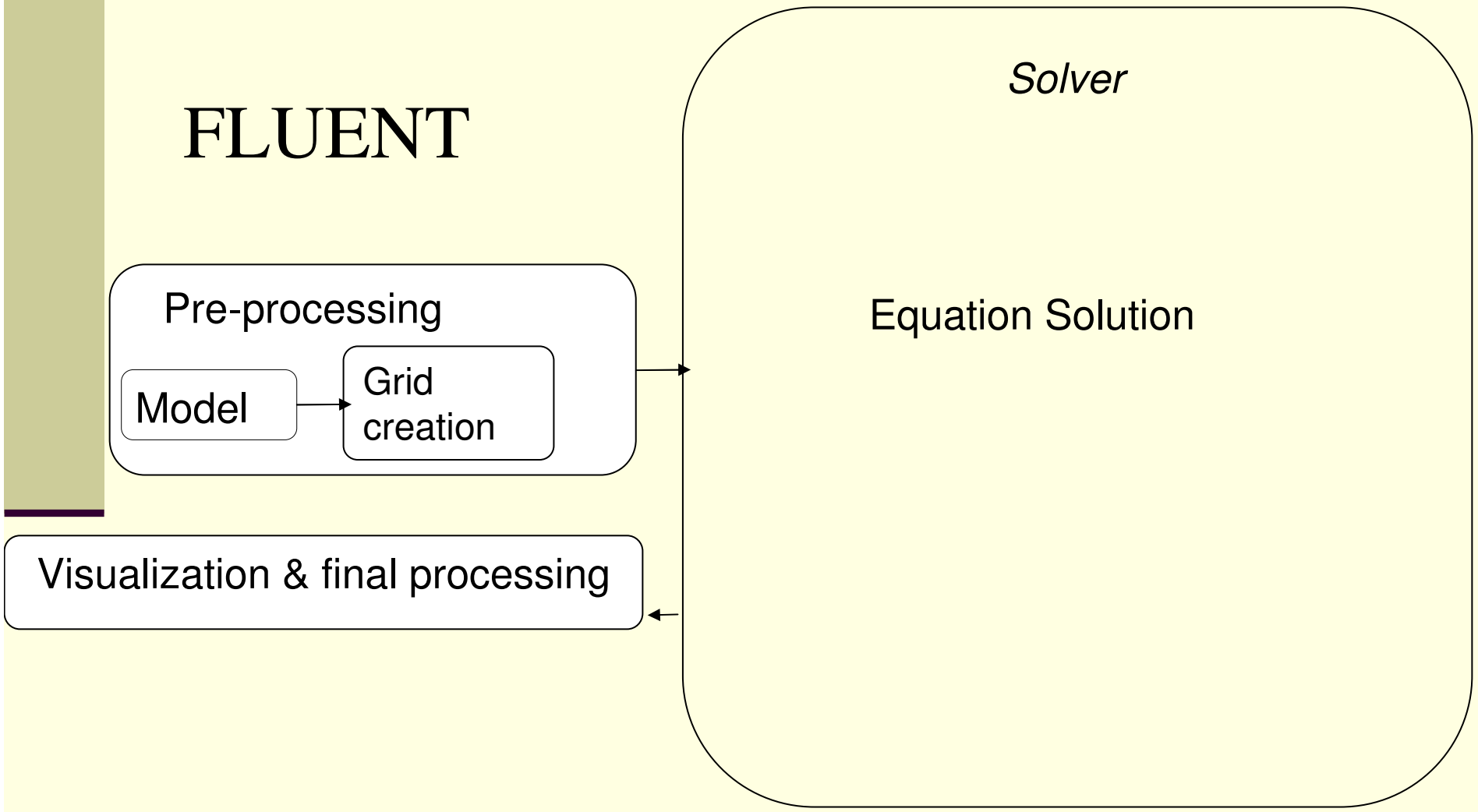
Math. model

Heat Equation

$$\rho c \frac{\partial T}{\partial t} = k_t \nabla^2 T + Q_p + Q_m + Q_e$$

$$Q_p = \omega \rho_s c_s \left(T_a - T_v \right)$$

Computational Model

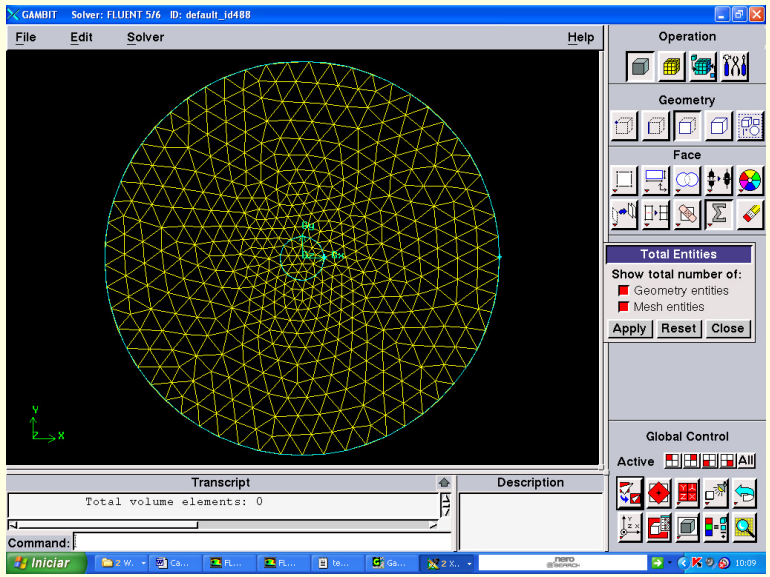


Thermophisical Proprieties

tissue	*k (W/m°C)*	*ρ (kg/m³)*	*c (J/kg°C)*	*ω (s⁻¹)*	*Q_m(W/m³)*
Normal - (Glandular)	0,480	1080	3000	0,00018	450
Tumor Malign	0,480	1080	3500	0,009 (c)	5790

Numerical studies

- Bidimensional



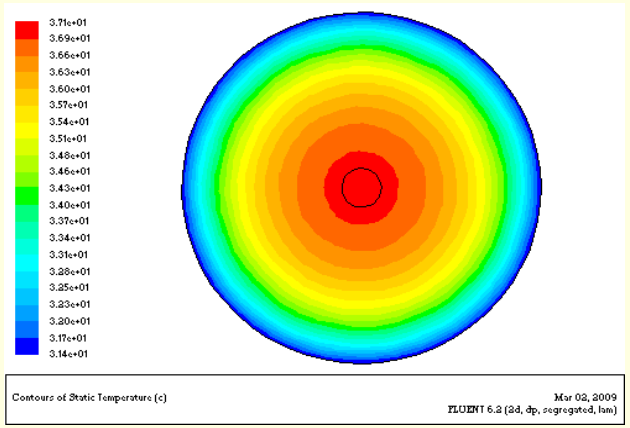
mesh	nodes	Temperatures (º C)
1	355	37,144
2	478	37,145
3	942	37,147

- Triangular grid
- 478 nodes
- 868 elements
- 1345 faces

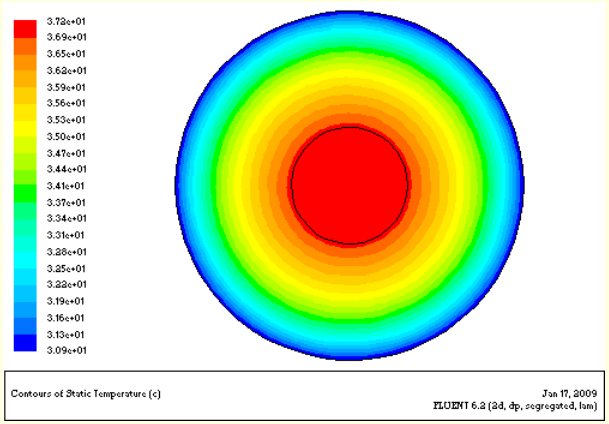
Node size influence

BIDIMENSIONAL

Case1



Case 2

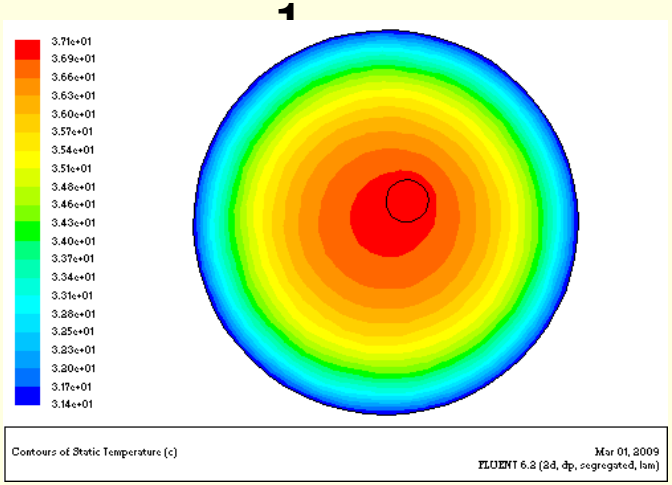


Case	radius (cm)	Temperature (º C)
1	1	36,69
2	3	37,14

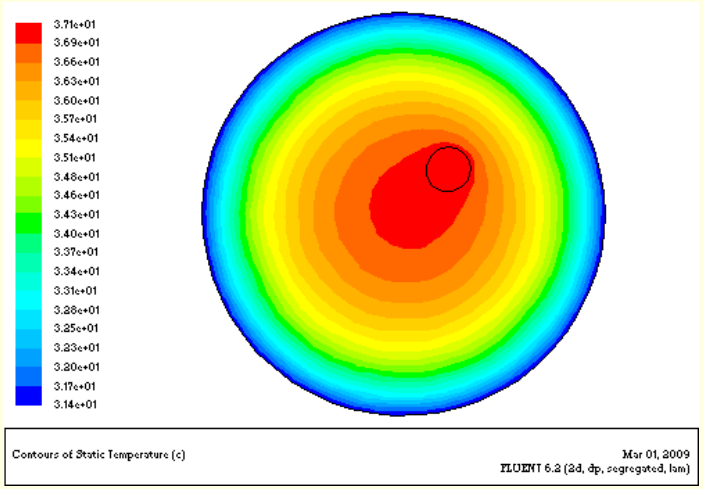
BIDIMENSIONAL

Position

Case 1



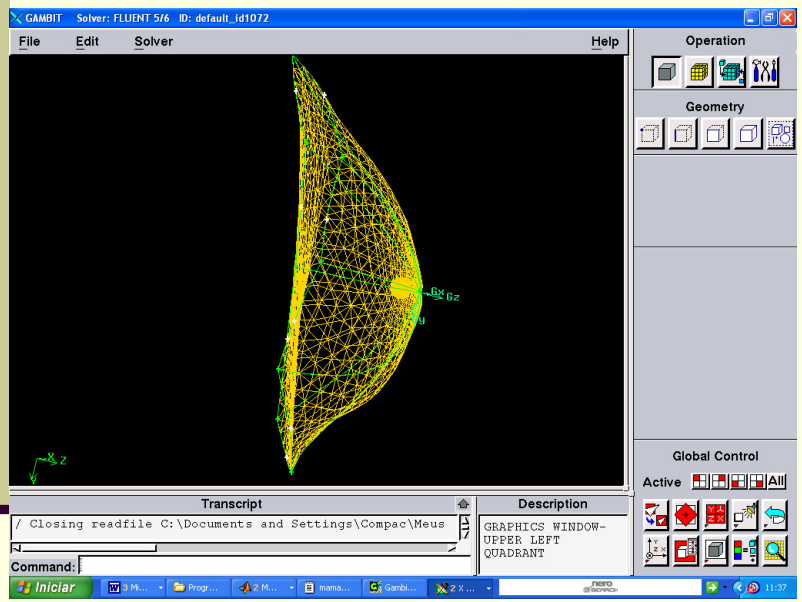
Case



Case	Position	Temperature(º C)
1	(1cm,1cm)	36,74
2	(2cm,2cm)	36,77

Numerical studies

- Tridimensional

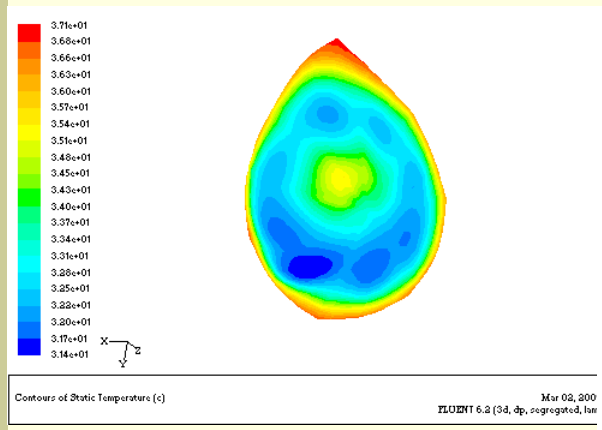


mesh	nodes	Temperature (ºC)	Processing time (min)
1	17334	36,37	8
2	23670	36,41	11
3	34068	36,43	16

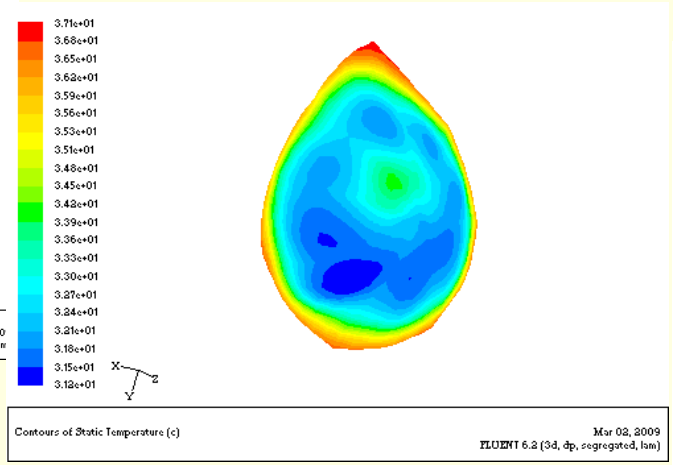
- Tetradric grid
- 23670 nodes
- 277317 elements
- 138023 faces

Size influence

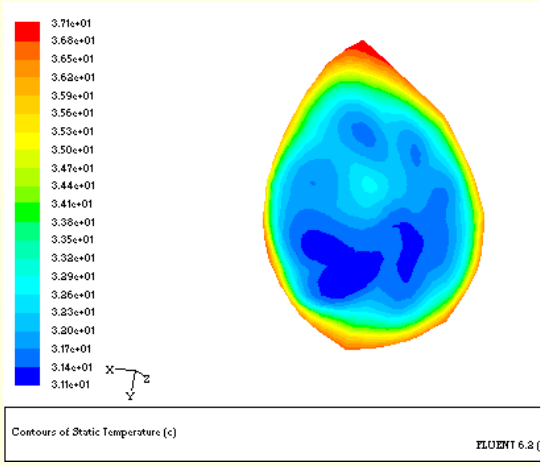
Case 1



Case 2



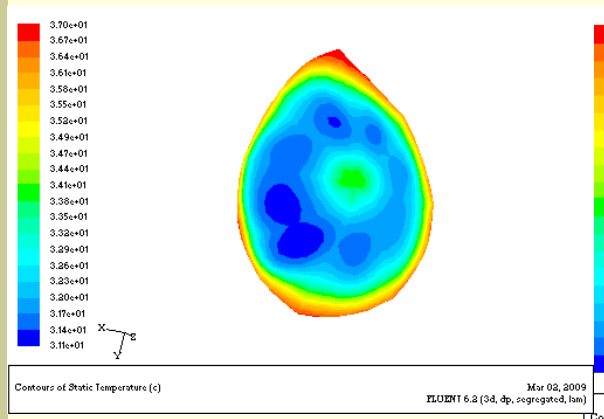
Case 3



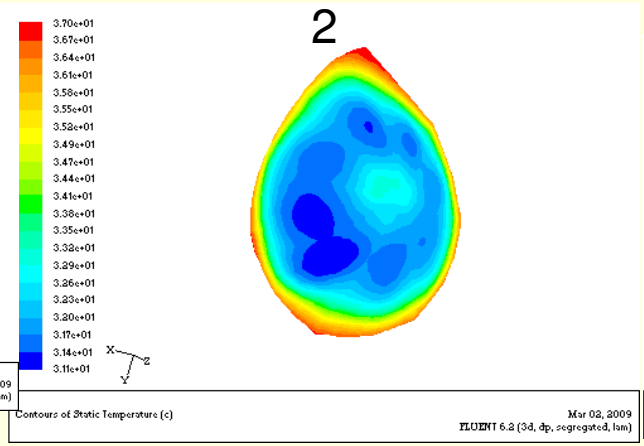
Case	radius	Temperature (º C)
1	2,0 cm	34,65
2	1,5 cm	32,71
3	1,0 cm	31,72

Position influence

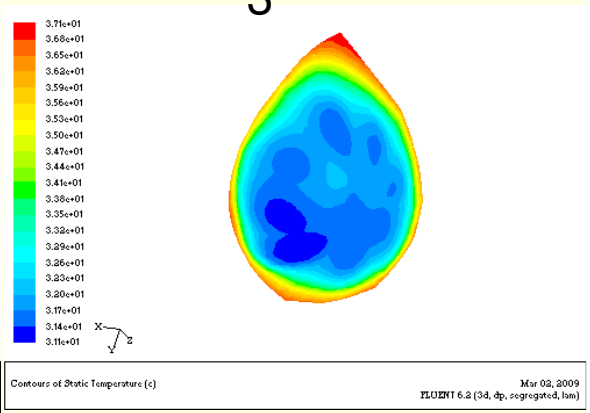
Case 1



Case 2

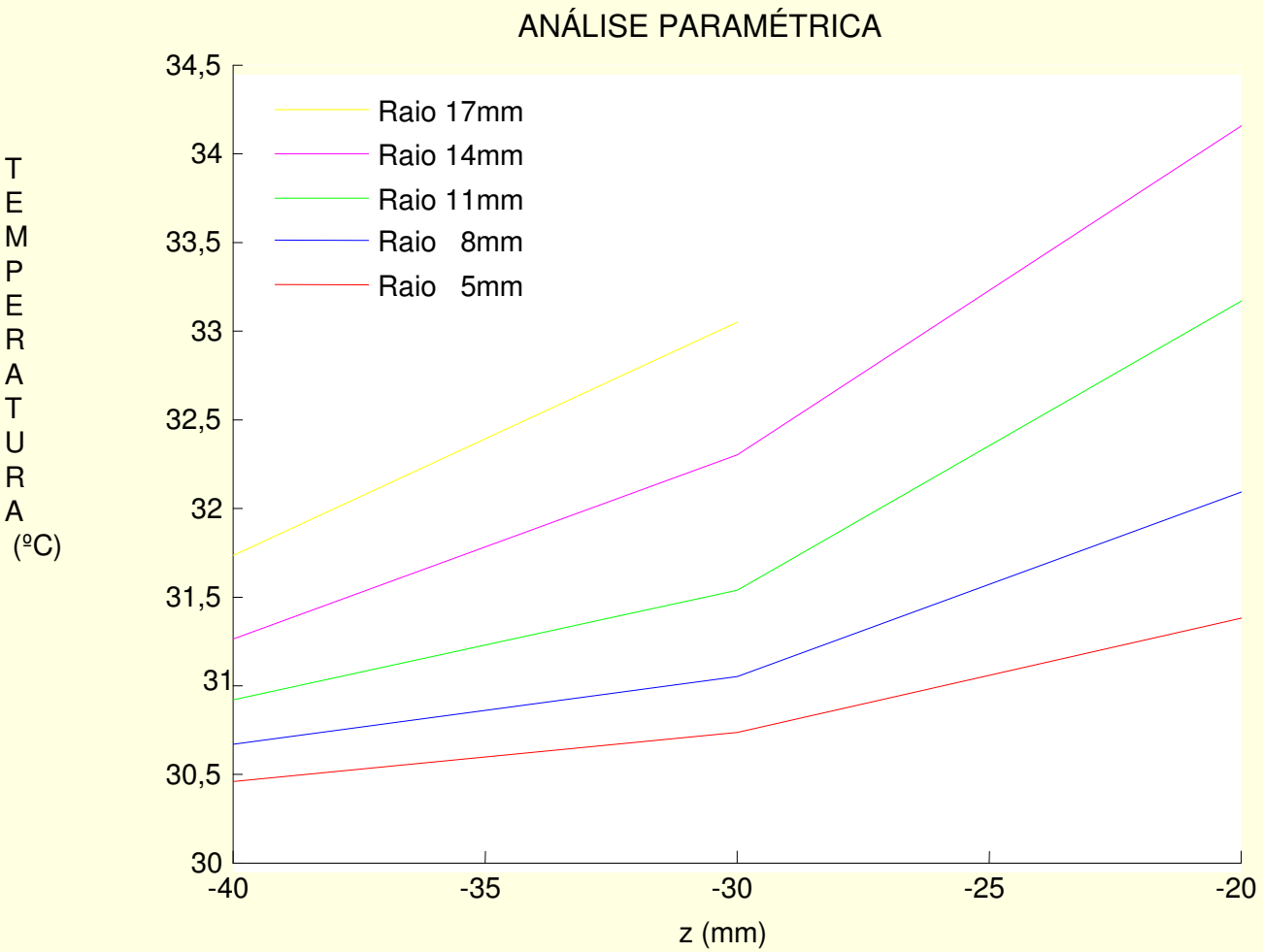


Case 3



Case	Position	Temperature(º C)
1	(0 cm,0 cm, -1,5 cm)	34,16
2	(0 cm,0 cm, -2,0 cm)	32,99
3	(0 cm,0 cm, -3,0 cm)	31,72

temperature x radius

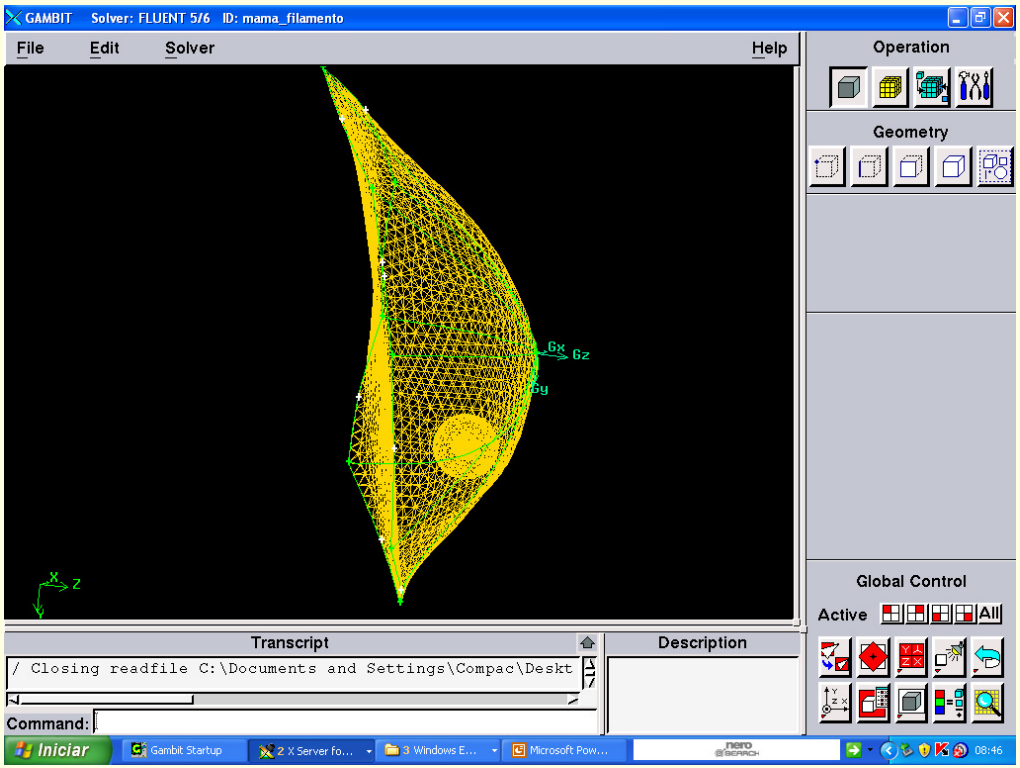


Experiments with a phantom

Thermo physic proprieties

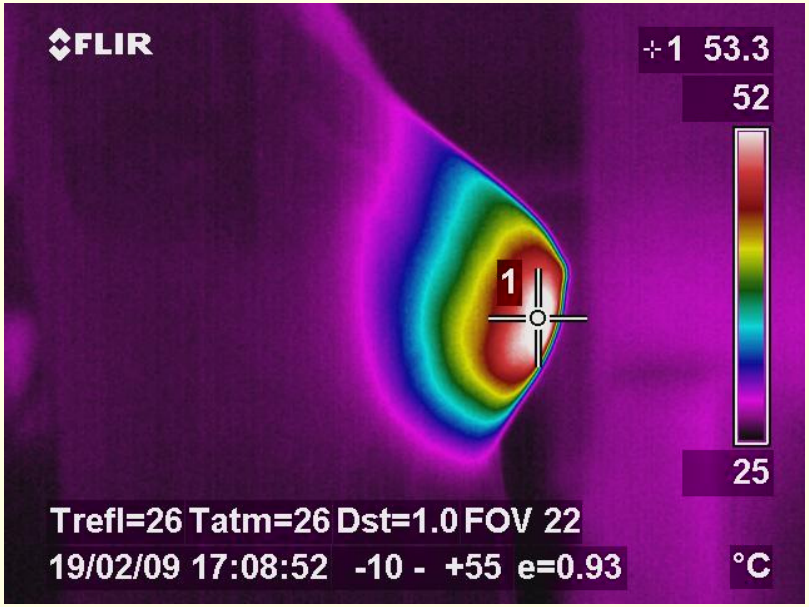
Material	*k (W/m°C)*	*ρ (kg/m³)*	*c (J/kg°C)*
Silicone	0,21	970	65,68
Tungsten	132	174	19250
Air	0,0242	1006,43	1,225

Experiments with a phantom

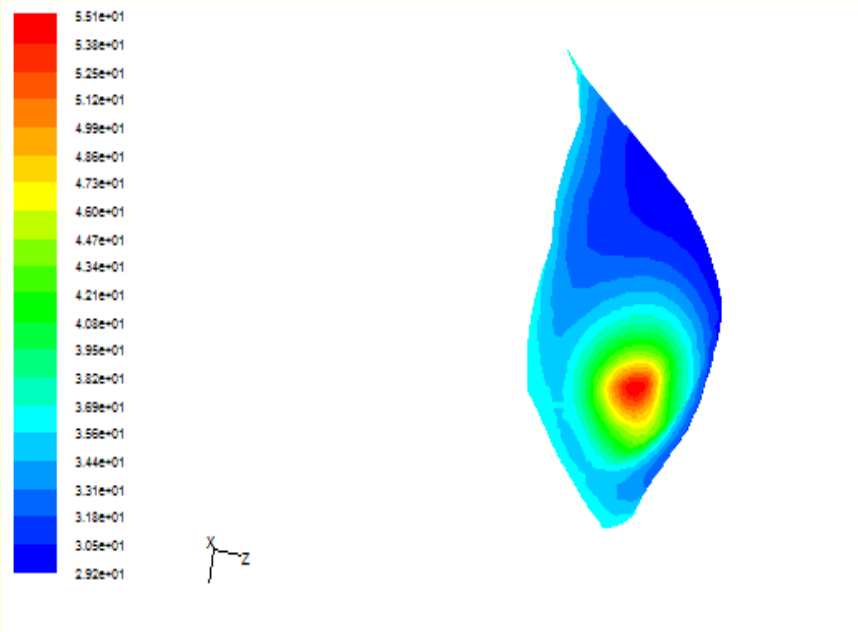


- Tetraedric
- 7855 nodes
- 42481 elements
- 85970 faces

Experiments with a phantom x numerical experiments



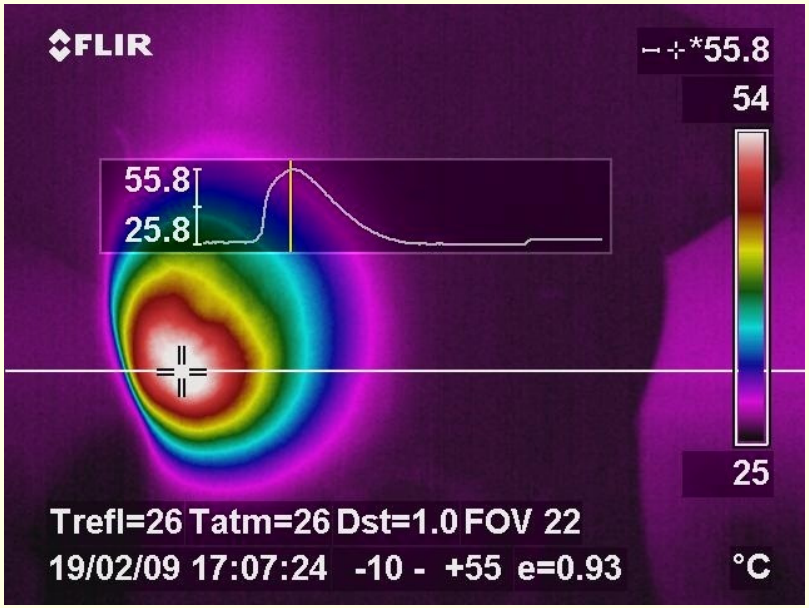
maximum temperature 53,3 ºC



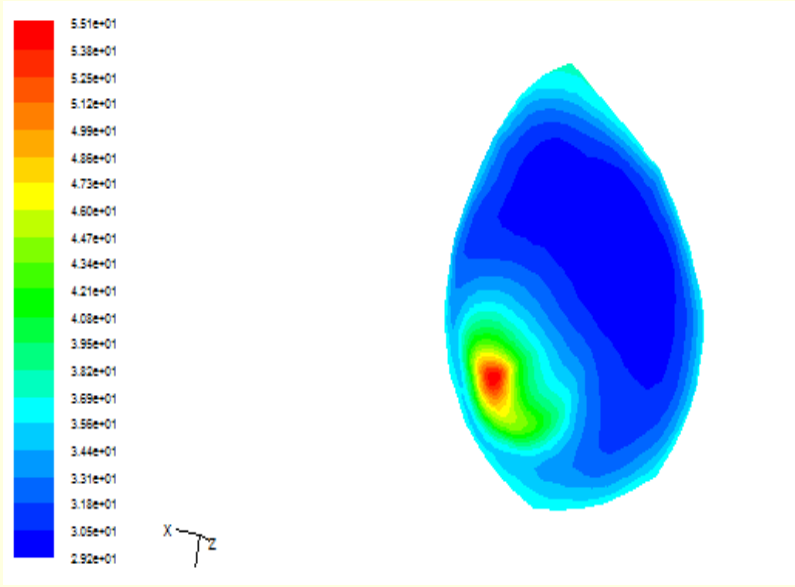
maximum temperature 55,1 ºC

Erro = 3,26%

Experiments with a phantom x numerical experiments



maximum temperature 55,8 ºC



maximum temperature 55,1 ºC

Erro = 1,25%

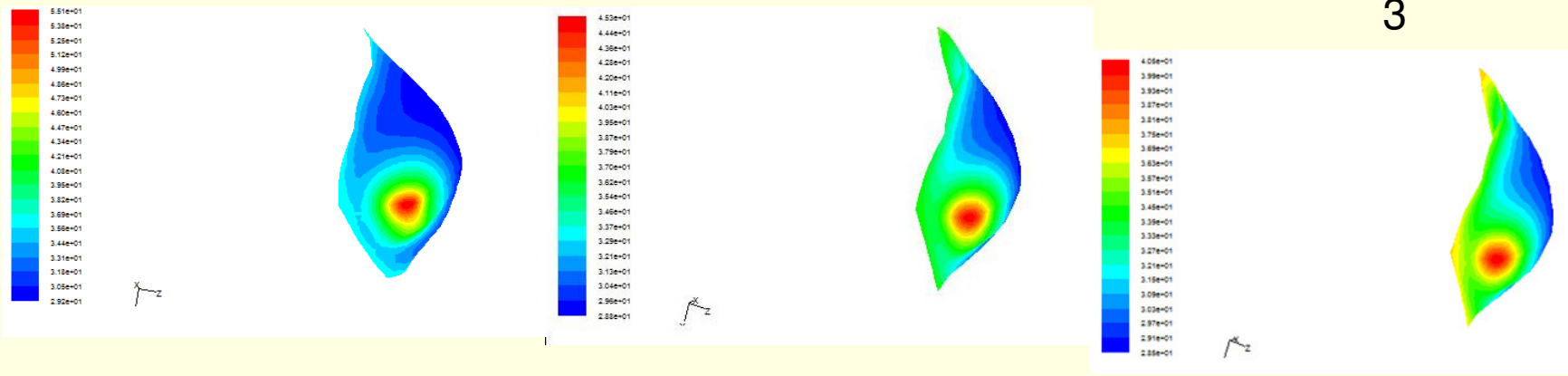
Numerical experiments

Position

Case 1

Case 2

Case 3

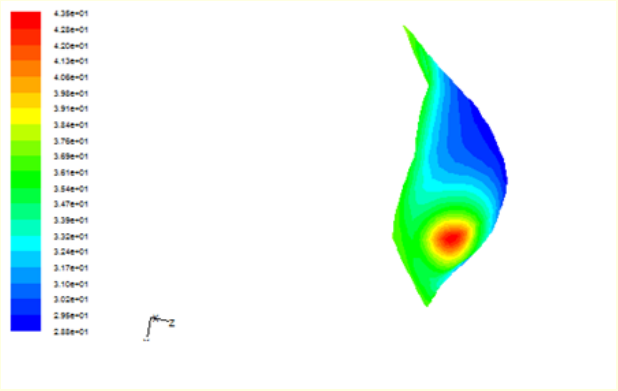


Case	Position	maximum temperature (ºC)
1	(2cm,4cm,-3cm)	55,11
2	(2cm,4cm,-4cm)	45,26
3	(2cm,4cm,-5cm)	40,46

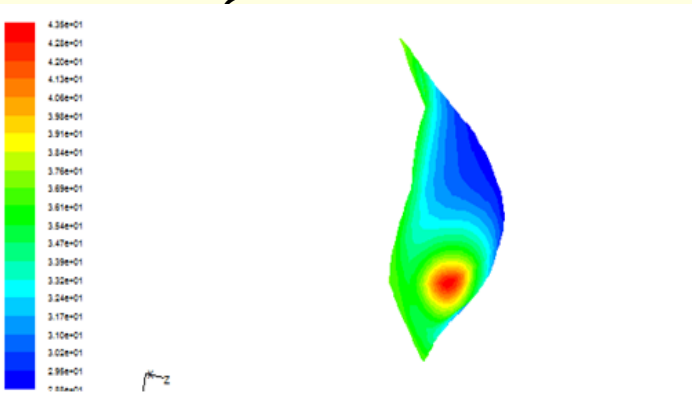
Numerical experiments

size

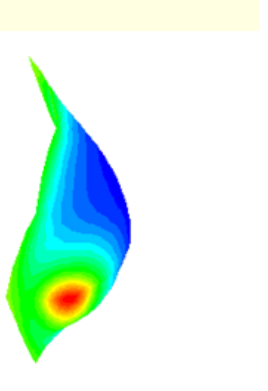
Case 1



Case 2



Case 3



Case	radius	Temperature(° C)
1	1,3 cm	45,26
2	1,5 cm	43,4
3	1,8 cm	43,0

Acknowledgements

- CAPES - Projeto PE021/2008 PROENG.
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