# FUZZY CLUSTERING FOR SEGMENTATION OF 1ST TRIMESTER ULTRASOUND FETAL IMAGES

GETÚLIO PAULO PEIXOTO IGREJAS

Contents
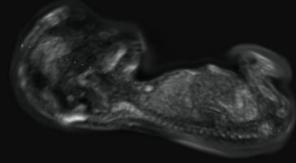
- **Motivation**;
- **Introduction**;
- **Objectives**;
- **Fuzzy Clustering**;
- **FCM & FCM with Spatial Information**;
- **Results**;
- **Conclusions**;

University of Minho
Engineering School
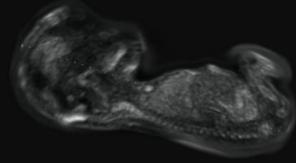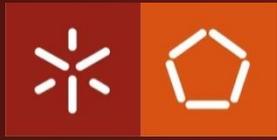
- **Challenge promoted by Dr. José Matos Cruz;**

- **Little work on the subject;**

- **Possibility to give a contribution to the fetal medicine field;**
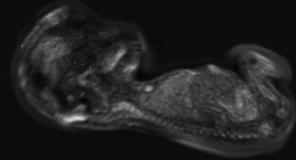
- **Integrated on the PhD work;**
- **Ultrasonography is probably the most widely used pregnancy observation method:**
  - **Is cheap;**
  - **Non-invasive;**
  - **Gives lots of information to obstetricians;**
  - **In case of doubts other methods could be applied (generally more expensive and invasive);**
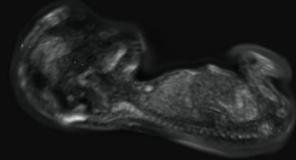
- **Current systems require specialized human intervention for measurements and diagnose;**

- **US image observation combined with measurements represents an important tool to diagnose several problems;**

- **An automatic measurement system and an inference engine could represent an important tool to physicians;**
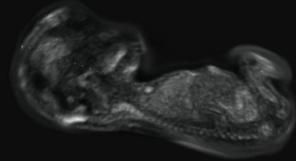
- **Medical organizations recommend 3 US exams (1st at 11th and 14th week);**
- **Three measurements are made:**
  - **Biparietal diameter;**
  - **Crown-rump distance;**
  - **Nuchal translucency size;**
- **These measurements allow to infer the gestational age, the fetal growth rate and some chromosome anomalies;**
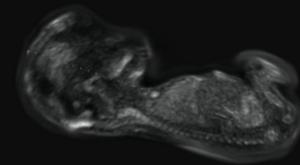
- **Problems with US images:**
  - **Noise presence;**
  - **Contact between relevant structures and other tissues with similar densities;**
 - **Variability of images (even for the same measurement);**
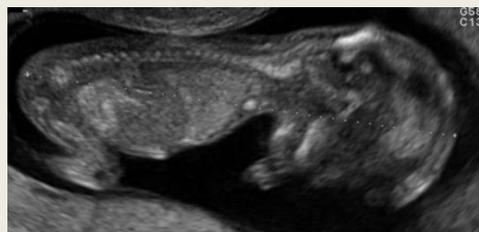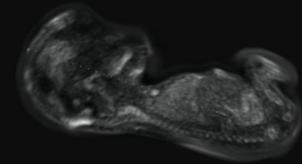
1. **Develop an automatic system, based on 1st trimester ultrasound images, to measure:**
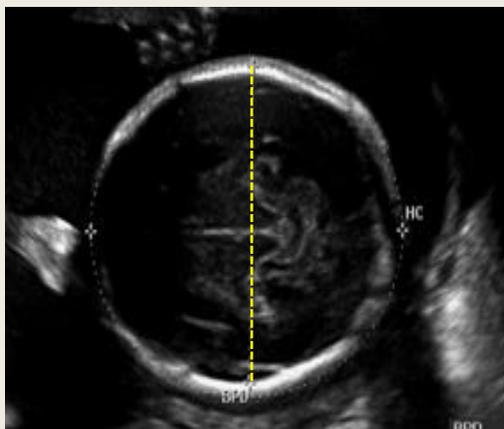
Biparietal Diameter
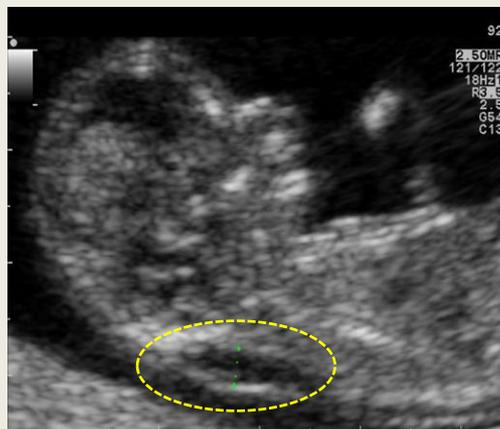
Nuchal Translucency Size
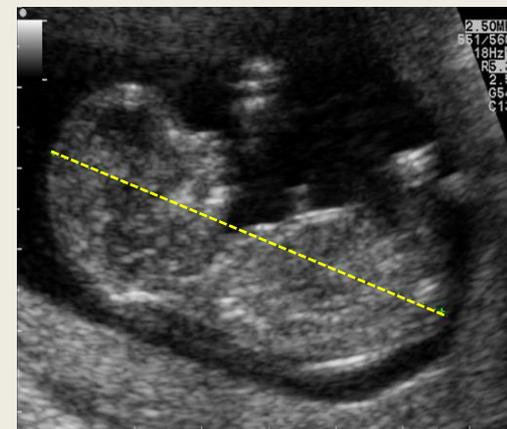
Crown-Rump Distance
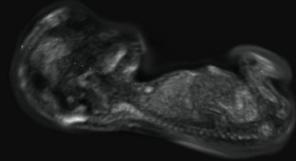
- **Measurement extraction process:**

| Images | → | Image Enhancement & Filtering | → | Segmentation & Features Extraction | → | Measurements Extraction |

University of Minho
Engineering School
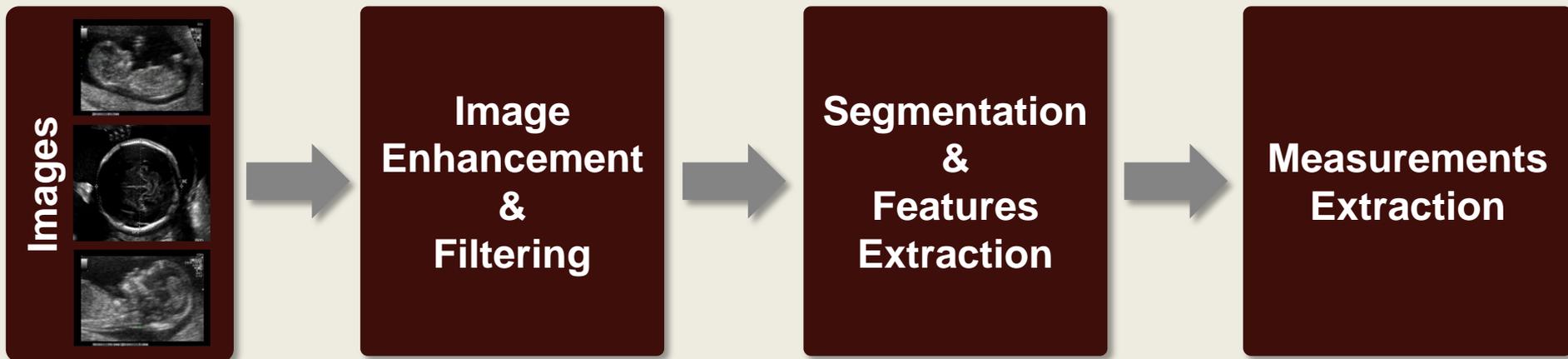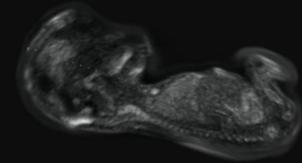
2. Build an expert system to diagnose chromosome anomalies and evaluate fetal growth;

Measurements → **Fuzzy Inference System** → **Anomalies Evaluation & Fetal Growth Evaluation**
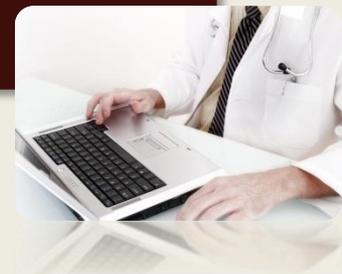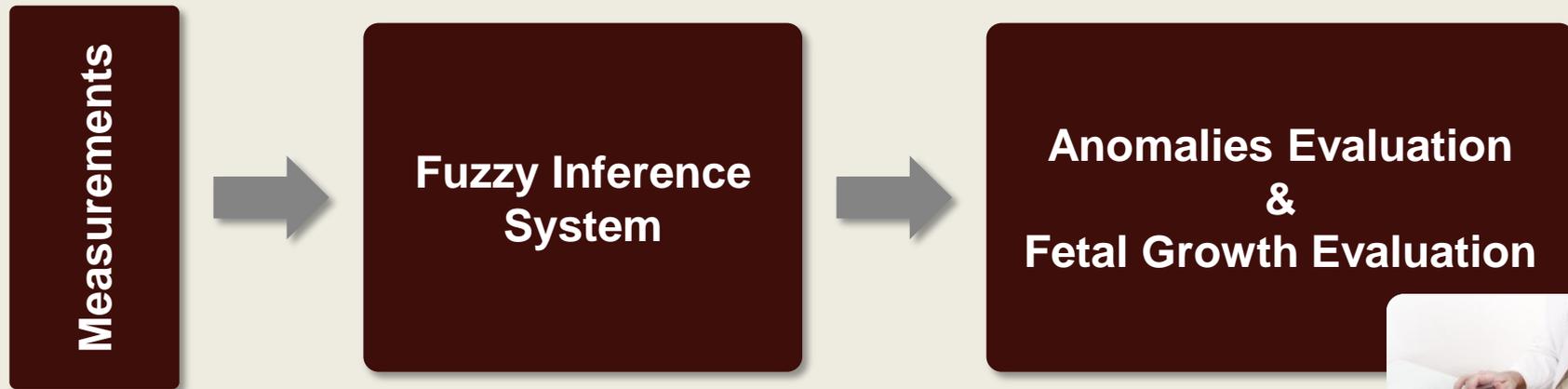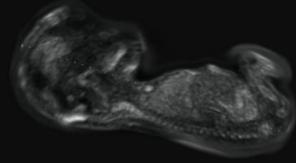
- **Clustering is the process to group data elements according to a similarity criteria - segmentation;**

- **Two types of clustering:**
  - **Hard clustering;**
  - **Soft clustering;**

- **Fuzzy clustering assigns a membership value to each element in every cluster (Fuzzy Partition);**
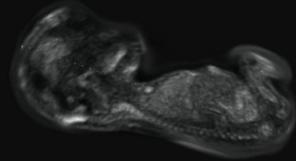
- **Most common Fuzzy Clustering algorithm is Fuzzy C-means (Bezdek, 1981);**
- **It minimizes the cost function:**

$$J_m = \sum_{k=1}^{N} \sum_{j=1}^{C} \left(\mu_{jk} \right)^m \left\| x_k - c_j \right\|^2$$

- **The result is a partition matrix *U* with all the μ_{jk} (membership values) and the c_j (cluster centers) that minimizes the distance;**
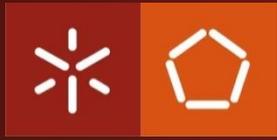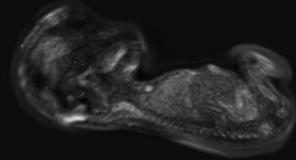
- **The FCM with Spatial Information introduces the calculation of the partition matrix based on the spatial distance and on the gray-level:**

$$F_{ij}^{S} = e^{\left(\frac{-\max\left(\left|x_j - x_i\right|, \left|y_j - y_i\right|\right)}{\lambda_S} \right)}$$

$$F_{ij}^{G} = e^{\left(\frac{-\left\|g\left(x_j, y_j\right) - g\left(x_i, y_i\right)\right\|^2}{\lambda_G \times \sigma_i^{G^2}} \right)}$$

$$F_{ij} = \begin{cases} F_{ij}^{S} \times F_{ij}^{G}, & j \neq i \\ 0, & j = i \end{cases}$$

- **Based on the F_{ij} feature matrix new membership values and cluster centers are calculated;**
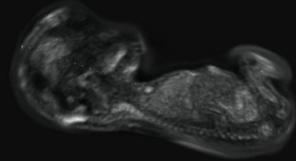
Original Image
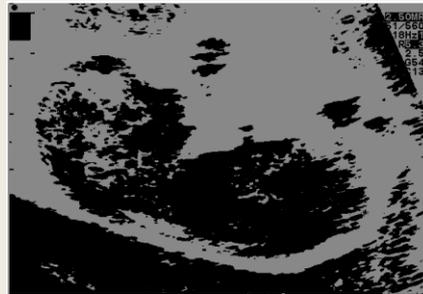
K-means

Active Contour
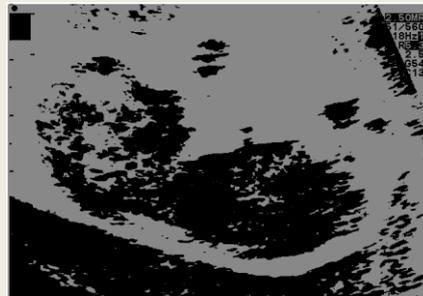
Fuzzy C-means


Fuzzy C-means with Spatial Info

Conclusions
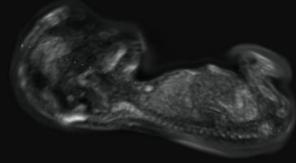
- **Fuzzy clustering approaches present similar or better results than other relevant strategies;**

- **FCM with Spatial Information is less sensible to noise than common FCM;**

- **Combined strategies could improve results;**
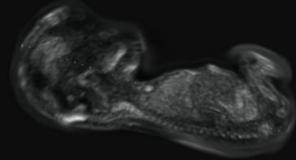
- **Prof. Doutor Carlos Alberto Caridade Monteiro e Couto, Dept. of Industrial Electronics of the Engineering school of University of Minho;**

- **Prof. Doutor Paulo Alexandre Cardoso Salgado, Dept. of Engineering of School of Sciences and Technology of University of Trás-os-Montes e Alto Douro;**

University of Minho
Engineering School
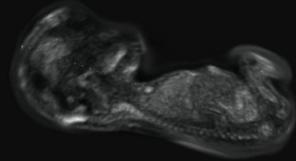
- **Dr. José Matos Cruz, Fetal Medicine and Pre-natal diagnose Unit of São Marcos Hospital, Braga, Portugal;**

THANK FOR YOUR ATTENTION

&

HAPPY BIRTHDAY ENGINEERING

SCHOOL