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# 3D VOLUME LOCALIZATION USING MINIATURES

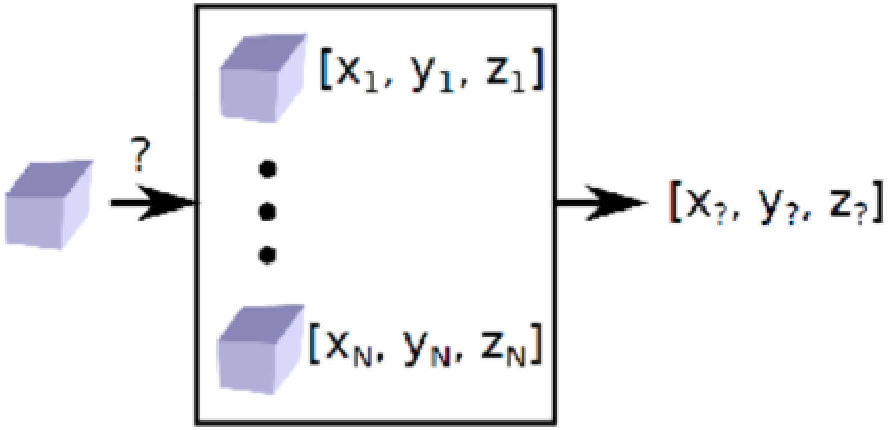
# Agenda

- Problem definition and motivation
- Methods
- Testing environment
- Results

# 3D volume localization

- 3D volume localization problem is a problem of estimating the atlas coordinates of a given sample 3D volume

- Typical approach: compare the sample with the volumes with known coordinates.



# The Methods

Methods used to solve 3D volume localization problem:

- Compare sample volume with the other volumes from the dataset and find the most similar.
  - CBIR problem
  - Collection of histograms

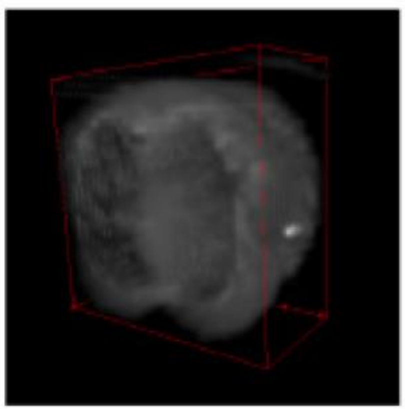
- Estimate the coordinates using classifier regression.

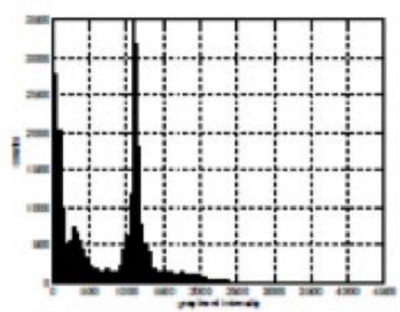
We compared the two approaches.

# Histogram matching

- Different orientation of the volumes

- Proper alignment -> histograms





- Drawback:  loss of spatial intensity distribution information

# Histogram dissimilarity measures

## Bin-to-bin dissimilarity measures:

$$h(L,M) = \frac{\sum_j min(L(j),M(j)))}{\sum_j M(j)}$$

$$L_1(L,M) = \frac{\sum_j abs(L(j)-M(j))}{N}$$

$$L_2(L,M) = \frac{\sum_j (L(j)-M(j))^2}{N}$$

$$\chi^2(L,M) = \frac{\sum_j (L(j)-M(j))^2}{\sum_j L(j)+M(j)}$$

$$\mathrm{Jf}(L,M) = \sum_j \left( L(j) log \frac{2L(j)}{L(j)+M(j)} + M(j) log \frac{2M(j)}{L(j)+M(j)} \right)$$

## Cross-bin dissimilarity measures:

- Earth Movers Distance (EMD)

# Weighting the coordinates

- Inter-histogram dissimilarities.
- Candidates for the result: 10 most similar volumes.
- Result - weighted averaging:

$$[x_{est}, y_{est}, z_{est}] = \sum_{i=1}^{10} w_i [x_i y_i z_i]$$

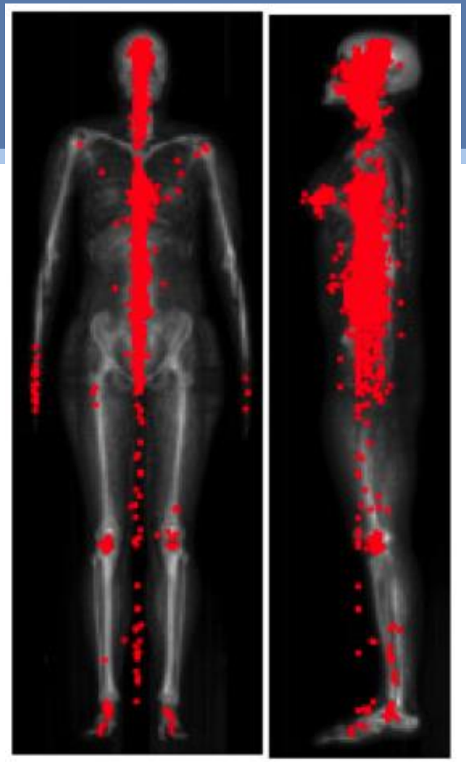
$$\text{where } w_i = e^{-\lambda i} \text{ and } \lambda = max\left(\frac{d_i - mean(d_i)}{var(d_i)}\right)$$

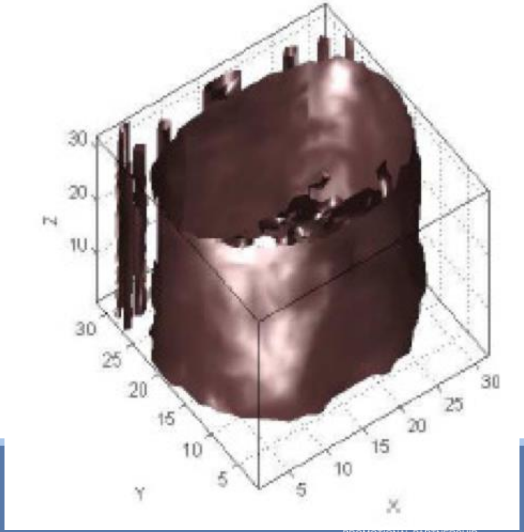
# Classifier regression

- Image features -> carry out the regression
- Classifier scores are used to interpolate coordinates
- Typical features used:
  - mean,
  - standard deviation,
  - median,
  - volume,
  - centroid,
  - central moments,
  - …

# Testing environment

- Dataset consisting of 3926 volumes
- Each volumes: 32 × 32 × 32
  image cube.
- Voxel intensities: ranging from
  0 to 4095
- Volumes resembling different regions of the body with different orientation



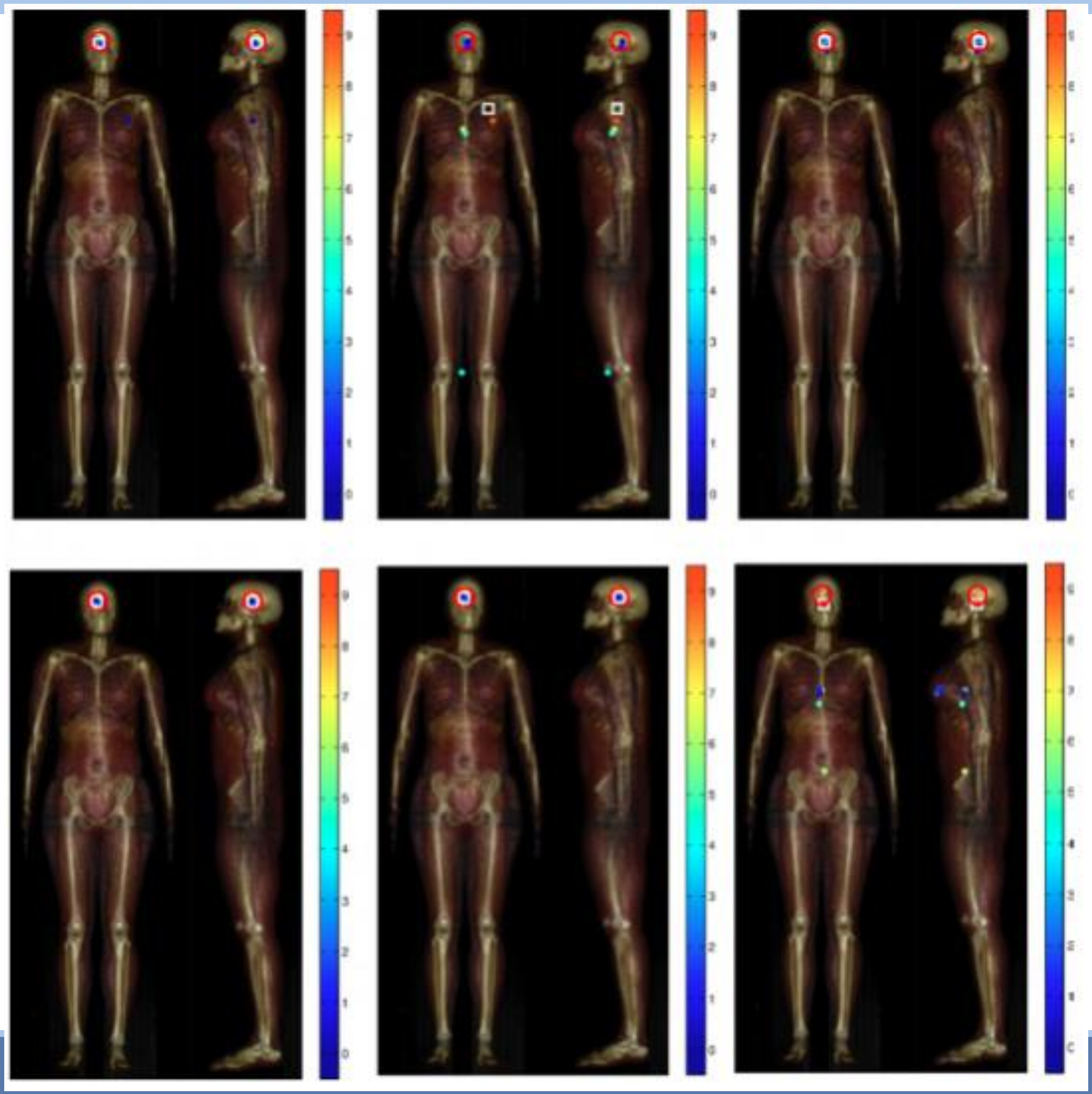


# Results - histograms

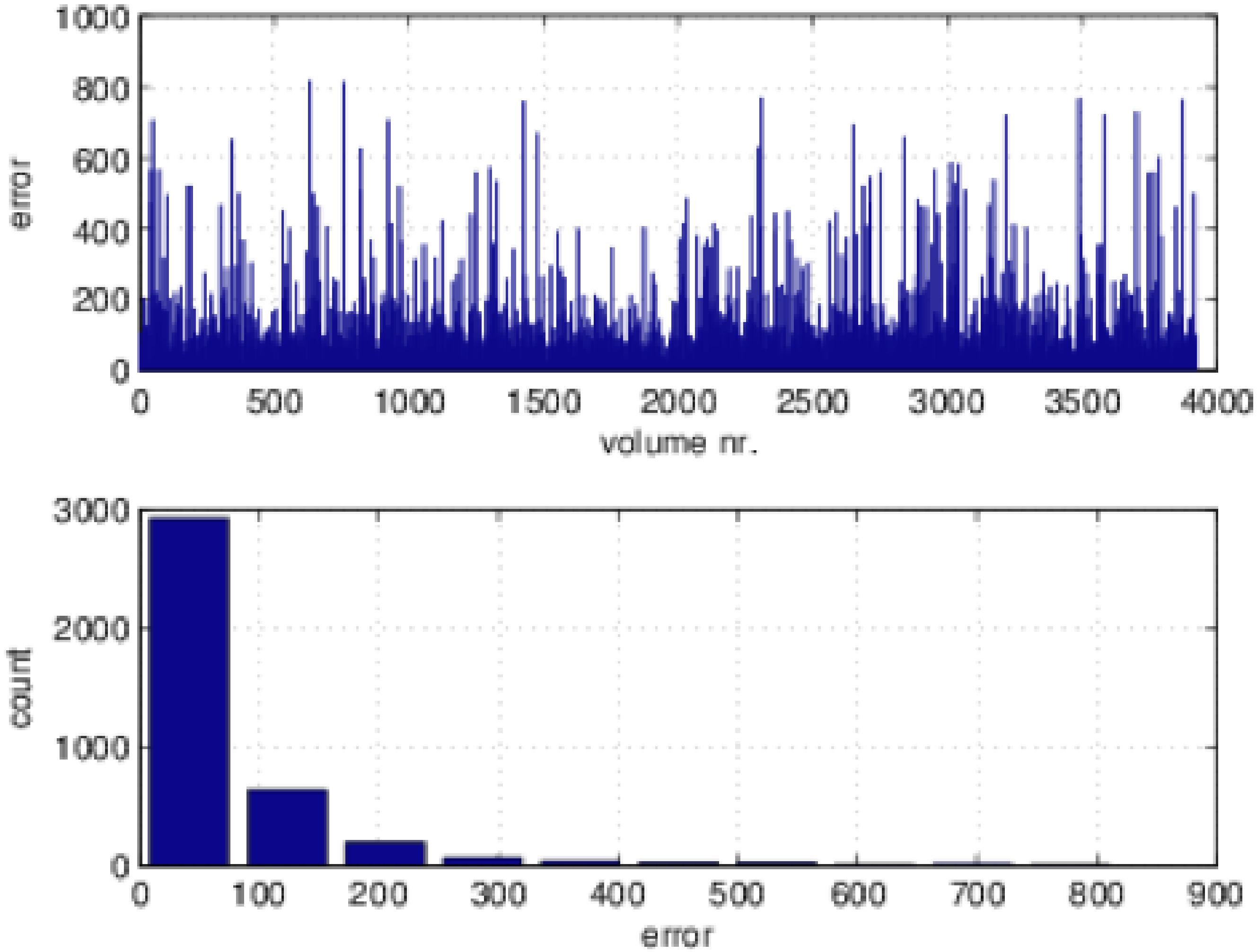
- Histogram comparison: quite precise
- A cross-bin dissimilarity is preferred
- EMD: best both in terms of accuracy and robustness, but it is slow

| Dissimilarity measure | h | $L_1$ | $L_2$ | $\chi^2$ | Jf | EMD |
|---|---|---|---|---|---|---|
| Estimated position error | 16.5792 | 3.7436 | 129.8316 | 1.3632 | 1.2895 | **1.2466** |

# Results - histograms



# Results - classifier regression



# Summary

- We tested two approaches: histograms classifier regression
  - EMD was used for histograms
  - 10-NN and Random Ferns was used for regression
- Classification regression using 10-NN proved to be slightly less precise but significantly faster
- Random Ferns best performance: voxel volumes and 3D patches.

# Questions

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