TEXTURE ANALYSIS IN QUANTITATIVE OSTEOPOROSIS ASSESSMENT: CHARACTERIZING MICROARCHITECTURE

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Bone Microarchitecture Assessment based on Texture Features

The aim of the proposed texture analysis is to learn **characteristic bone microarchitecture patterns** from high resolution peripheral quantitative computed tomography (**HR-pQCT**). We conduct a pilot study to evaluate if the distribution of the microarchitecture categories can differentiate between osteoporotic and healthy subjects. The categories mimic medical expert observation of distinct patterns in the trabecular bone, but make quantitative measurements possible. The approach could aid treatment decisions by providing more fine-grained differentiation of the effect osteoporosis has on the bone.

1. Segmentation

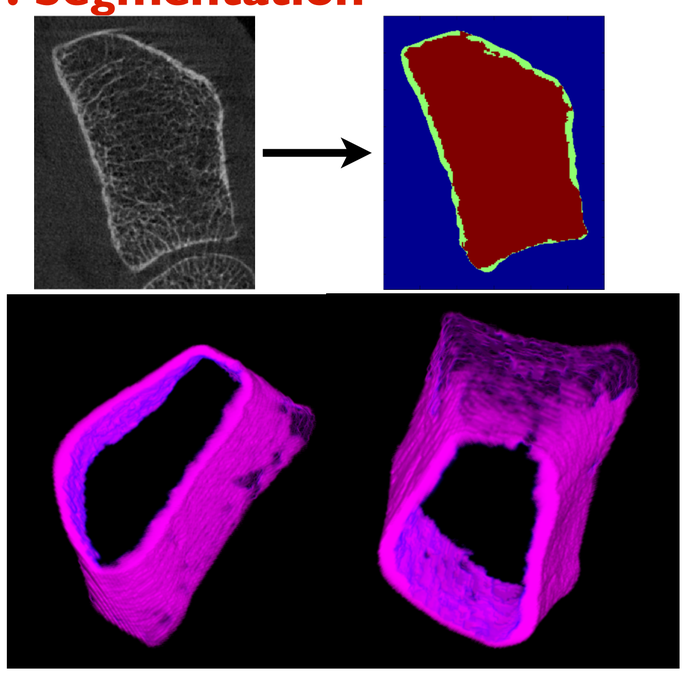

Fig 1: Segmentation of cortical and trabecular bone

2. Feature Extraction

1. **3D Gray-level Co-occurrence Matrix:**
   - between-slice joint probabilities of voxels
2. **Partial Derivatives:**
   - 3D Structure Tensor
   - 3D Hessian Matrix

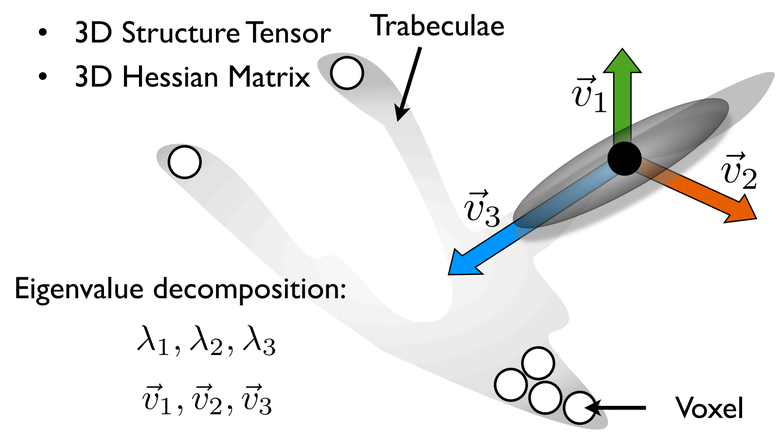

Fig 2: Describing local tubular structure

3. Unsupervised learning

K-Medians Clustering Method

- Learning of consistently detectable bone microarchitecture categories
- proper number of clusters (visual validation)

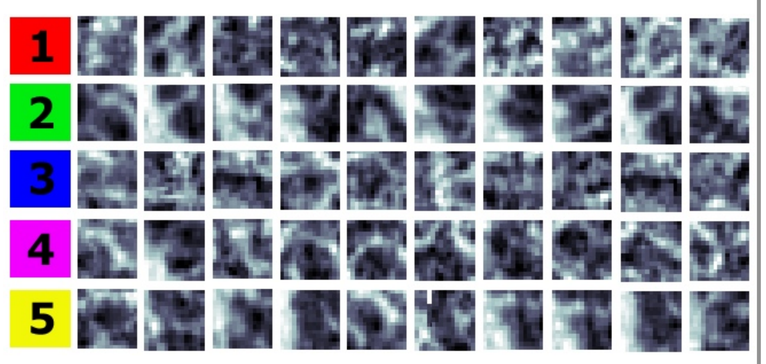

Fig 3: 5 microarchitecture classes learnt from the data. The patches show the 10 nearest neighbors of each cluster centroid in the feature space.

Results

Objective: Evaluation of novel trabecular bone classes and their capability to differentiate between ***healthy*** and ***osteoporotic*** subjects.

Data: 3 healthy and 3 osteoporotic HR-pQCT female bone scans of distal radius with 82 µm in-vivo resolution

Questions:

- Does texture patterns result in repeatable clustering?
- Which texture classes are captured by the procedure?
- Can we differentiate between healthy and osteoporotic subjects?

Differentiation

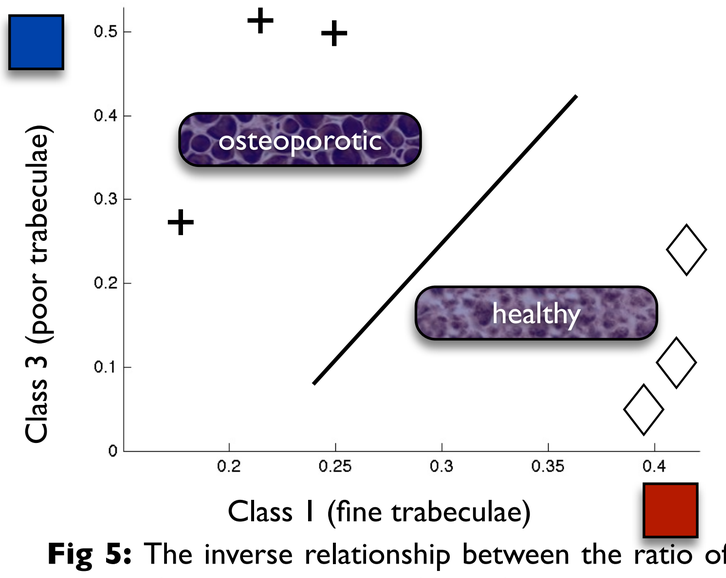

Fig 5: The inverse relationship between the ratio of the very poor in trabeculae area (Class3) and the fine trabecular area (Class1) and its correlation to osteoporotic versus healthy subjects indicates a potential differentiating power of the histogram features.

Repeatability validation

Leave-one-out validation:

- Dice coefficient between corresponding categories

Cluster	Mean
Class 1 (red)	0.752
Class 2 (green)	0.628
Class 3 (blue)	0.874
Class 4 (magenta)	0.791
Class 5 (yellow)	0.744

Cluster comparison: healthy vs. osteoporotic

Differentiation

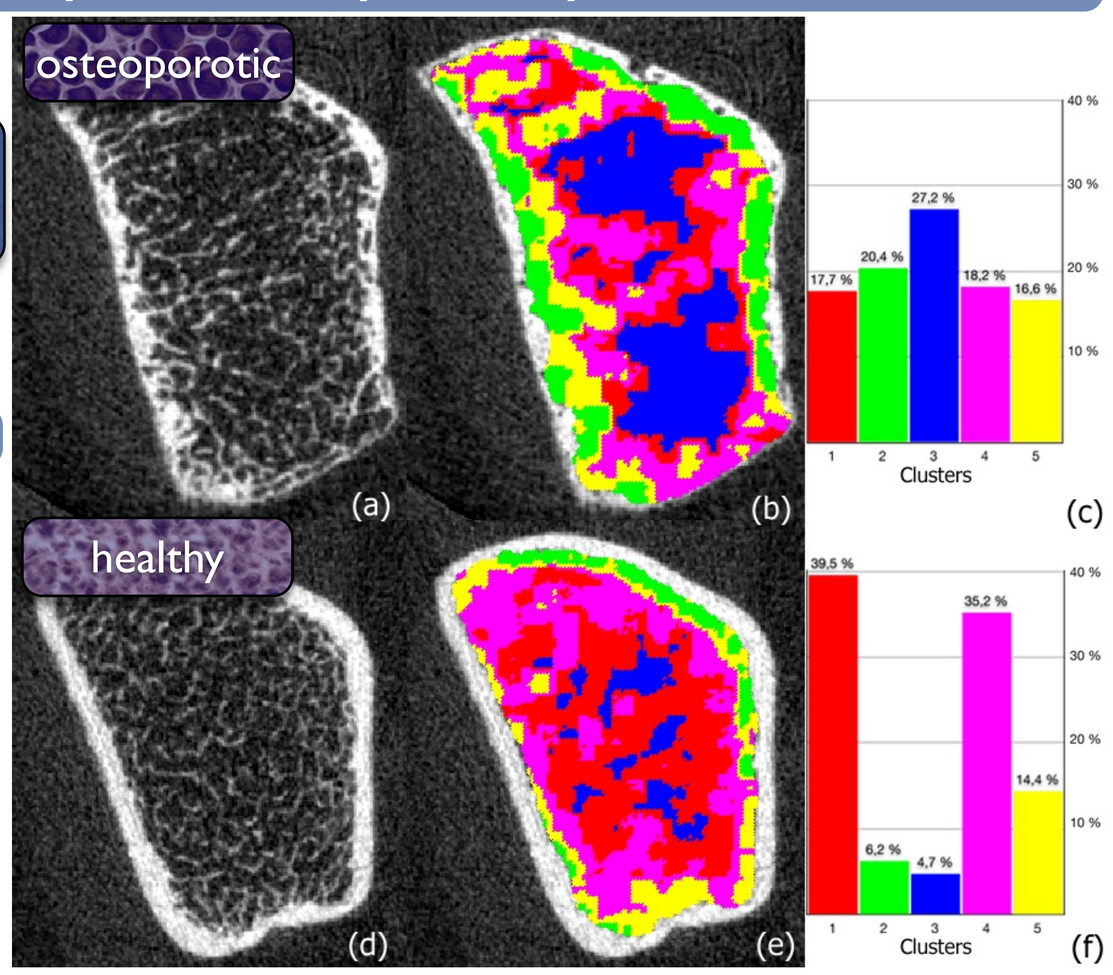

Fig 4: The texture class images b,e show differences in the distribution of texture classes, corresponding to the visible microstructural differences in the texture patterns of a, d. The Histograms vary also between the osteoporotic and healthy subjects.

Conclusion

Investigation of differentiation between osteoporotic and healthy subjects according to their 3D texture features in HR-pQCT data.

Results indicate that the approach is applicable:

- We can quantitatively define and classify microstructural patterns of trabecular bone and their spatial distribution.
- The experiments indicates that the frequency of the class occurrences is a good indicator when differentiating

References

C. Graeff, et al "Monitoring teriparatide-associated changes in vertebral microstructure by high-resolution CT in vivo: results from the EUROFORS study," Journal of Bone and Mineral Research, vol. 22, no. 9, pp. 1426–1433, 2007.

Y. Sato,et al, "Three-dimensional multi-scale line filter for segmentation and visualization of curvilinear structures in medical images," Medical Image Analysis, vol. 2, no. 2, pp. 143–168, 1998.

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