

# Knee Cartilage Segmentation

ENGN 2500 – Medical Imaging Analysis  
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# Introduction

- Osteoarthritis – one of the main health issues among elderly population.
- One of its main effects is the degradation of articular cartilage.
- MRI is the leading imaging modality to quantify knee cartilage and detect deterioration.
- Segmentation of the cartilage tissue is an important step in this process.



# Clustering Method

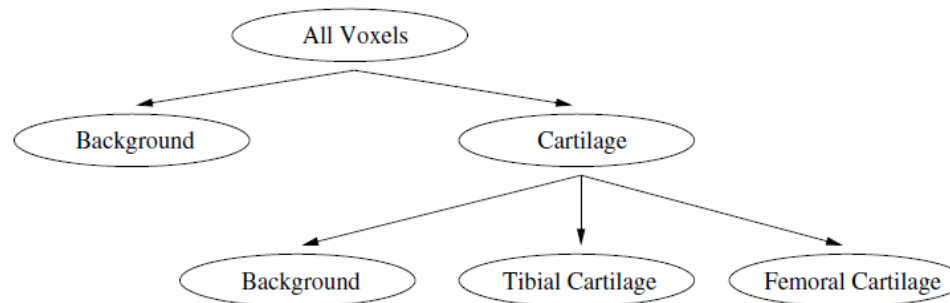
- **Voxel Classification**

- Folkesson, J., Dam, E. B., Olsen, O. F., Pettersen, P. C., and Christiansen, C., “Automatic segmentation of the articular cartilage in knee mri using a hierarchical multi-class classification scheme,” in 8th Int. Conf. Med. Image Comput. Comput.-Assist. Intervention (MICCAI’05), Palm Springs, CA, 2005, pp. 327–334.

- **Approximate k-Nearest Neighbor classifier is used for classification.**

- Similar to kNN algorithms but trades off some precision for computation speed.
- kNN algorithm finds the nearest k neighbors to a query point over a given feature space.
- Euclidian distance is used to compute the distance of each feature parameter.

# Classification Schemes



Hierarchical Classification

- 3 different classification schemes used are, direct partitioning into the three classes, multi-class classification and hierarchical classification

# Feature Selection

- The features used are mainly related to the pixel intensity and geometry of the cartilage.
- Selected features for each voxel as given in the paper:
  - position in the image (x, y, z coordinates)
  - raw and Gaussian smoothed (on 3 different scales) intensities of the voxels
  - 1<sup>st</sup>, 2<sup>nd</sup> and 3<sup>rd</sup> order Gaussian derivatives of the Gaussian smoothed values
  - eigenvalues of the Hessian matrix, which describes the local curvature the voxel. Thin curved disc shape of the cartilage is exploited with this feature.
  - eigenvalues and eigenvectors of the structure tensor matrix which is used to detect thin structures

# Current Progress

- The Approximate Nearest Neighbor (ANN) library used by the authors
- MATLAB wrapper for the ANN Library
- Initial experimentation of the classification scheme over 2-D images with basic features.
  - Features used
    - Pixel Intensity
    - X coordinate of the pixel
    - Y coordinate of the pixel

# Learning Set



Consecutive Sagittal Slides from the same MRI data set

# Test Image & Results



a)



b)



c)

Consecutive Sagittal Slide from the same MRI data set showing the (a) input test image and obtained cartilage segmentations with (b)  $k = 5$  and (c)  $k = 10$

# Updated Project Timeline

- Week 1-2: Using Approximate Nearest Neighbor (ANN) library, and Implementing 2-D Cartilage Segmentation with basic Features

-- Progress Presentation

- Week 3: Implementation of Hierarchical classification scheme with extended features (28 + 52 for hierarchical scheme)
- Week 4: Extending classification to 3-D data set and comparison of segmentation results with other known methods (e.g. GraphCut).

# References

- Folkesson, J, Olsen, O. F., Pettersen, P. C., Dam, E. B., and Christiansen, C., “Combining binary classifiers for automatic cartilage segmentation in knee mri,” in ICCV 1st Int. Workshop: Comput. Vision Biomed. Imag. Appl., 2005, pp. 230–239.
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- S. Arya, D. Mount, N. Netanyahu, R. Silverman, and A. Wu, “An optimal algorithm for approximate nearest neighbor searching in fixed dimensions,” ACM-SIAM. Discrete Algorithms, no. 5, pp. 573–582, 1994.
- Shim, H., Chang, S., Tao, C., Wang, J.-H., Kwoh, C. K., and Bae, K. T., “Knee cartilage: Efficient and reproducible segmentation on high-spatial-resolution MR images with the semiautomated graph-cut method,” Radiology 251(2), 548–556 (2009).
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