Knee Segmentation in MRI

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Outline

- Introduction
- Method
  - Bone Segmentation
  - Cartilage Segmentation
- Results
- Conclusion

1.1 Knee MRI - Segment Bone and Cartilage

- Many applications like diagnosis and surgical simulation
- Segmentation into four parts : Femur, Tibia, Femoral cartilage and Tibial cartilage

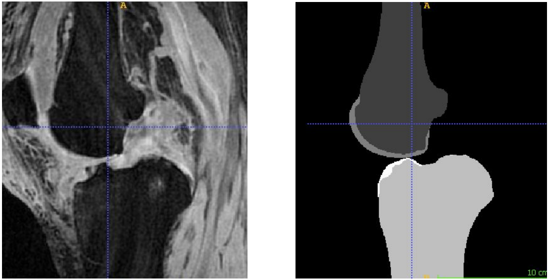

Figure: L : Original MRI Image. R : Ground Truth.

1.2 Challenges

- Variability of shape within image and between images
- Surrounding regions have similar intensities

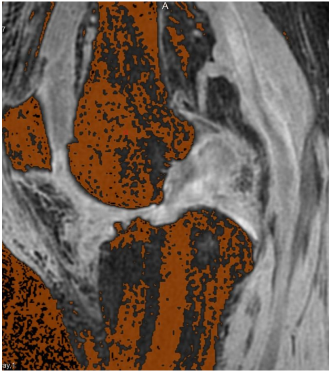

Figure: Basic Region Growing Segmentation Result

2.1 Bone Segmentation

- Geodesic Active Contours Segmentation (Caselles)
- Implemented in the ITK module itk::GeodesicActiveContourLevelSetImageFilter

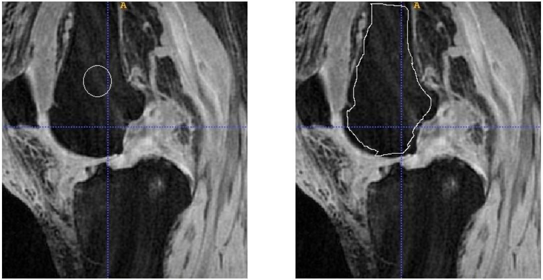

Figure: L : Initial Zero Level Set. R : Final Zero Level Set.

2.1.1 Geodesic Active Contour Segmentation

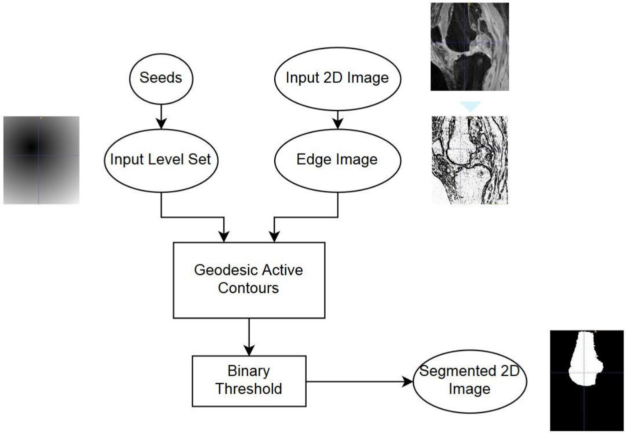

Figure: Geodesic Active Contour Pipeline for Femur bone segmentation

2.1.2 Pixel Variance

- Intensity information not enough
- Texture based Geodesic Active Contours (Lorigo)
- Compute variance at each pixel and use variance image in segmentation

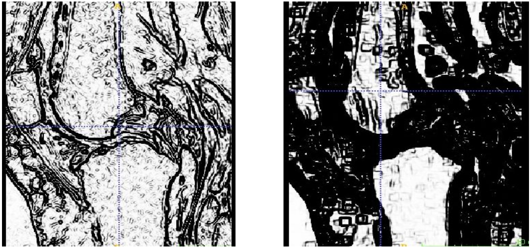

Figure: L : Edge image from intensity. R : Edge image from variance

2.1.3 Logical combination

- Intensity information preserves shape better
- Texture information separates bone from surrounding tissue
- Logical AND of both output

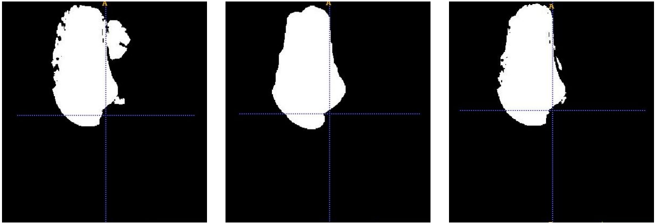

Figure: L-R : Intensity output, Variance output, Logical AND

2.1.4 User input

- Optimal set of parameters found. Input images rescaled to the desired range.
- User needs to provide seed locations
- 3D volume divided into 5 major sections, and seed locations for 3 such sections need to be provided

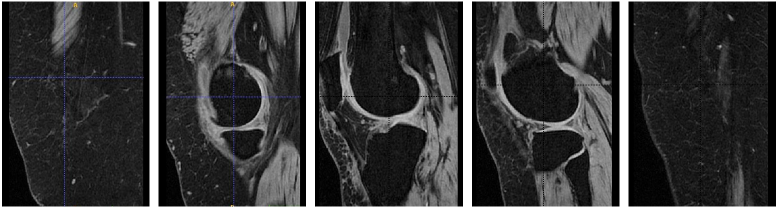

Figure: L-R : 5 major sections in knee 3D volume

2.2 Cartilage Segmentation

- Cartilage consists of cells with different molecular compositions
- Using of texture-analysis techniques can help to distinguish the cartilage areas from their neighbouring regions
- Possible statistical measures based on the co-occurrence matrix: Contrast, Homogeneity, Energy, Correlation

2.2.1 Correlation

- Correlation: Measures the joint probability occurrence of the specified pixel pairs

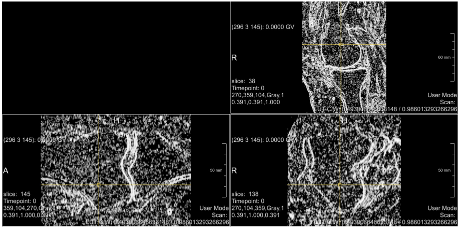

Figure: Textural filtering using correlation measure

2.2.2 Region Growing Segmentation

- Region Growing: Choosing the suitable seeds with the direction of growing specified (MevisLab)

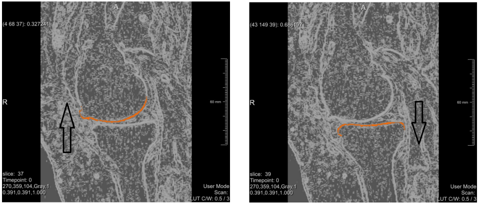

Figure: Cartilage segmentation using RG. L : Femoral R : Tibial

2.2.3 Morphological Operations

- Applying some morphological (closing) and logical (AND with XOR) operations, both cartilage regions combined

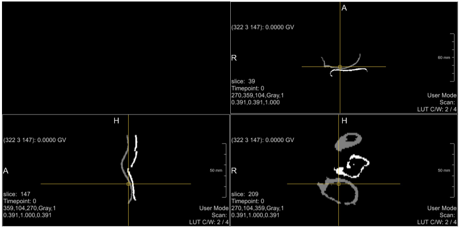

Figure: Combining femoral and tibial cartilage segmentation results

3.1 Results - Qualitative

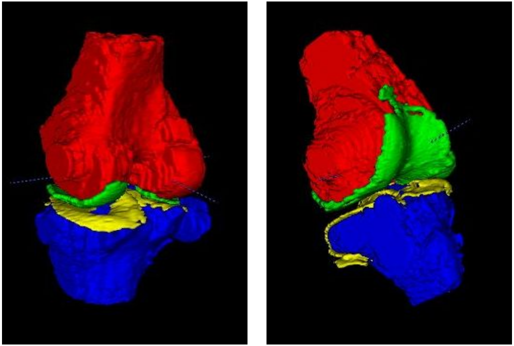

Figure: Final segmentation output. L : Image-061 R : Image-063

3.2 Results - Quantitative

- Use evaluation code from SKI 10.
- Bone score from average and RMS surface distances and cartilage score from overlap and volume errors

Image	Bone Score	Cartilage Score	Average Score
Image-061	31.90	39.90	35.90
Image-062	21.00	32.40	26.70
Image-063	28.90	50.60	39.80
Image-064	22.00	25.00	23.50
Average	25.95	36.98	31.48

4 Conclusions

- Bone Segmentation using Geodesic Active Contours with Intensity and Variance
- Cartilage Segmentation using Region Growing with Pixel correlation
- Focus on reducing user input
- Good results
- Use of both ITK and MevisLab

References

- V. Caselles, R. Kimmel, and G. Sapiro. *Geodesic active contours*. International Journal on Computer Vision, 22(1):6197, 1997.
- L. M. Lorigo, O. Faugeras, W. E. L. Grimson, R. Keriven, R. Kikinis. *Segmentation of bone in clinical knee MRI using texture-based geodesic active contours*. Medical Image Computing and Computer-Assisted Intervention MICCAI'98, Volume 1496, pp 1195-1204, 1998.
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- https://itk.org/Doxygen/html/Examples_2Segmentation_2GeodesicActiveContourImageFilter_8cxx-example.html

Thank You