

Semi-Automatic Segmentation of the Patellar Cartilage in MRI

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Problem Statement

Application: Segmentation of patellar cartilage in MR images for extraction of quantitative data like volume, thickness, etc.

Problem: Manual segmentation is cumbersome. Automatic segmentation procedures often fail to process special cases and tend to “know better than the user”. Many of them also require a lengthy training period.

Solution: User-friendly, robust system consisting of an adequate user interface and tools for sub-pixel accurate edge tracing, semi-automatic contour completion and propagation, and correction of segmentation results at any time.

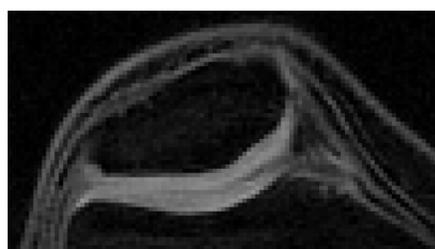
Key Features of the Presented System

Semi-automatic Approach: Support the user as much as possible, give the user as much control as necessary.

Sub-pixel Accuracy throughout data preprocessing, segmentation, and volumetric measurements

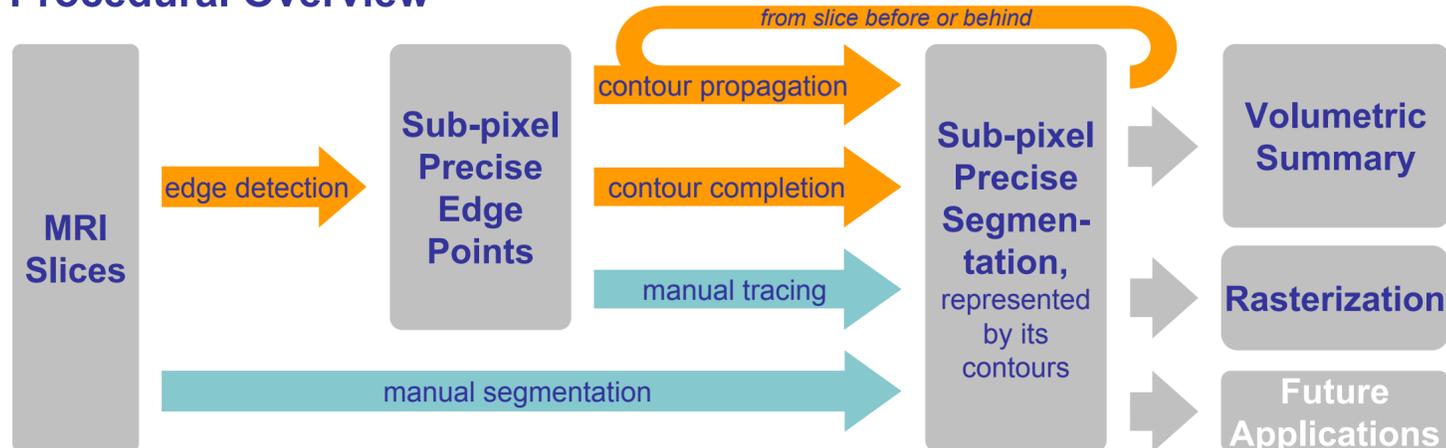
Improved Usability in user interaction, visualization, image file handling and data output—no external tools required

Flexible Visualization: independently adjustable display range, display mode (outlined/filled), opacity, and color for original image and segmentation



Very little contrast between the patellar (above) and femoral (below) cartilages in this MR image of the knee. Most automatic segmentation procedures will fail in such cases.

Procedural Overview



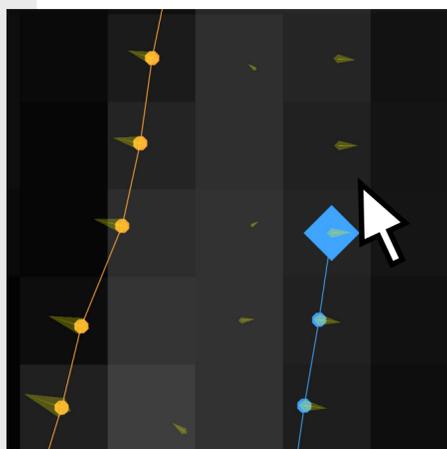
Edge Detection

Edge Detection is done slice-by-slice as a preprocessing step:

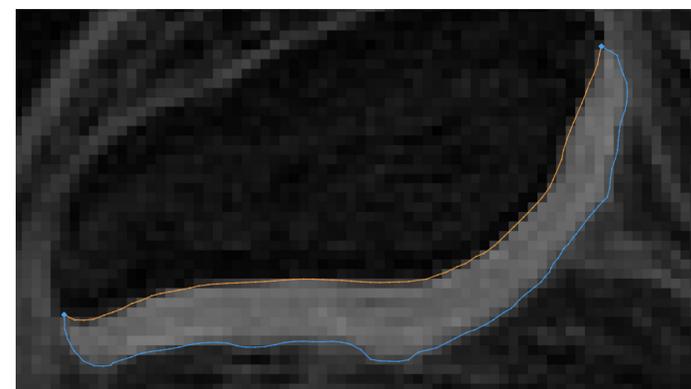
Gradient Computation using the Sobel operator

2D Facet Model [2] to determine the sub-pixel maxima of the gradient image

Labeling of these edge points with local orientation and magnitude of the gradient image



Edge point based manual tracing of the cartilage surface (blue). The yellow wedges indicate orientation and sharpness of the edge points found in the preprocessing step. The mouse cursor is moving upward in this situation, the cartilage bone interface (orange) has already been extracted.



Complete segmentation of the patellar cartilage, visualized for one slice. The cartilage bone interface (orange) has been semi-automatically propagated from the slice before; user interaction was limited to input of endpoints (blue diamond shapes). The cartilage surface (blue) was extracted by manually tracing the previously computed edge points.

User Interaction

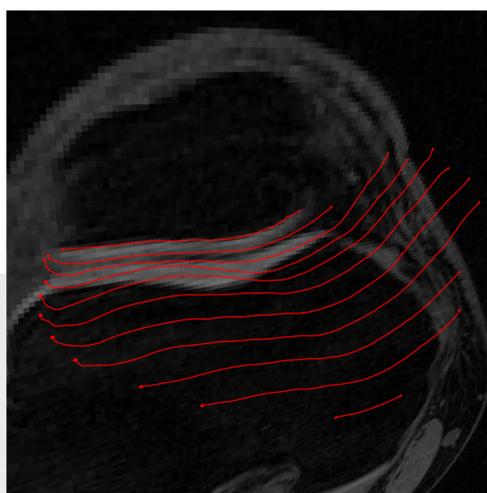
Manual Segmentation: contour follows mouse

Manual Tracing: contour follows edge points

Contour Completion/Propagation: two endpoints connected automatically based on edge points/segmentation results from adjacent slice

Correction simply by redrawing at any time

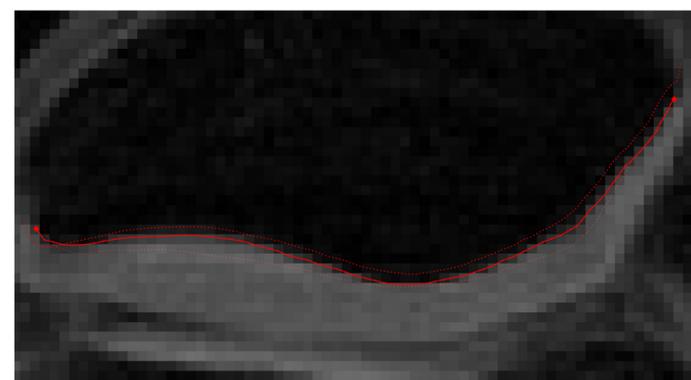
Perspective visualization of the extracted cartilage bone interface throughout slices.



Visualization

Unified Projection Matrix for smooth transitions between orthographic and perspective view

Free Scrolling, Rotation, and Smooth Zooming by dragging with the mouse



Segmentation result from adjacent slices superimposed onto the current slice for review/support of segmentation of the current slice. Display of the extracted cartilage bone interface of the slice before (dotted, bright) and behind (dotted, weak) using an orthographic projection.