

Virtual colonoscopy

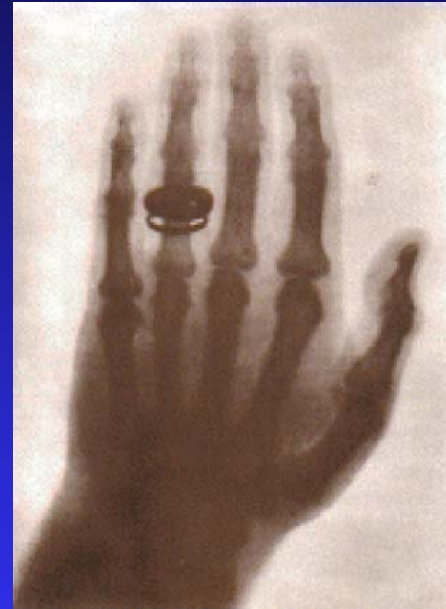
Gábor Blázsovits

Introduction

- Polyp and Colon cancer
- Colonoscopy
- Virtual colonoscopy

Medical imaging technologies

- X – ray
- CT scan
- MRI
- PET
- Sonography



Virtual colonoscopy (VC)

- Preprocessing and Segmentation
- Virtual navigation techniques and Centerline calculation
- Pattern recognition
- Rendering

Preprocessing & Segmentation 1

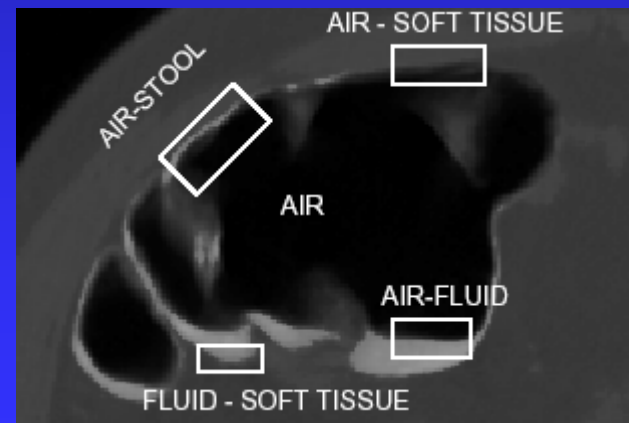
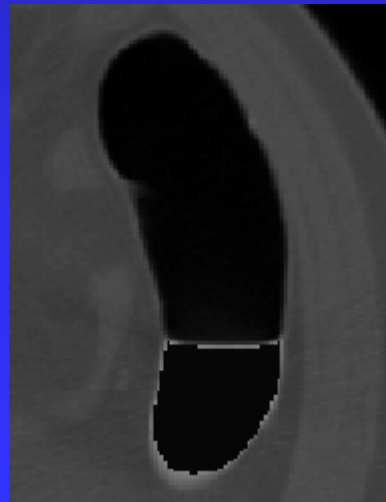
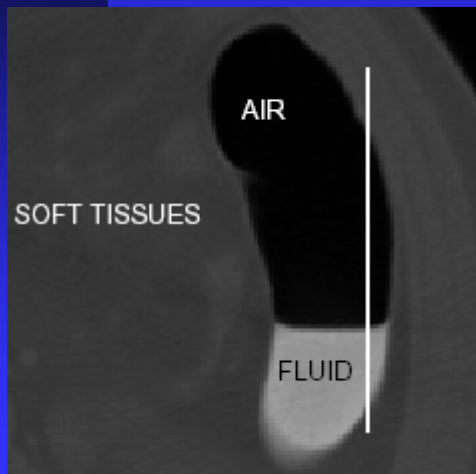
Bowel-cleansing techniques:

- Bowel pre-cleansing
 - effectively clean the residual stool of colon before CT
 - this colon preparation is very uncomfortable
- Post digital bowel cleansing
 - make the VC system friendlier for the patient
 - there is a need for segmentation the residual material out of the colon
 - may not correctly detect bleeding tumor

Preprocessing & Segmentation 2

Digital cleansing:

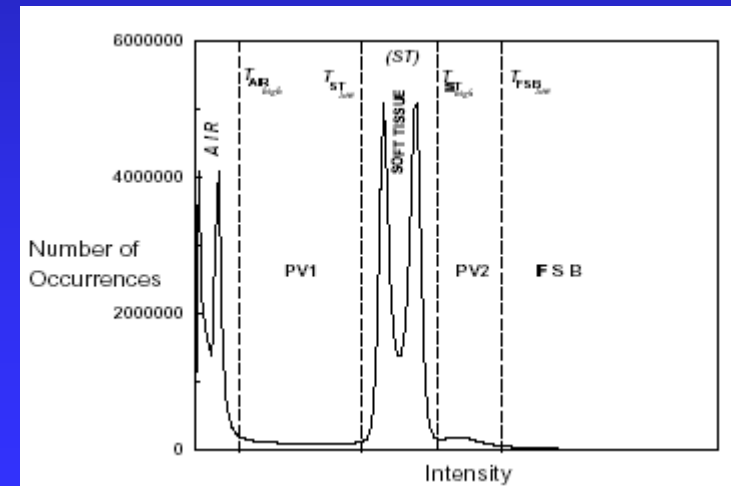
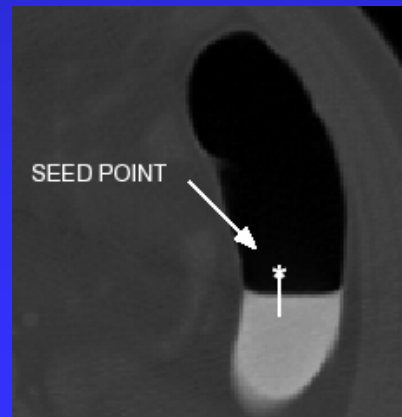
- Segmentation by thresholding
- Segmentation by morphological operations
- Segmentation rays



Digital Cleansing

by segmentation rays 1

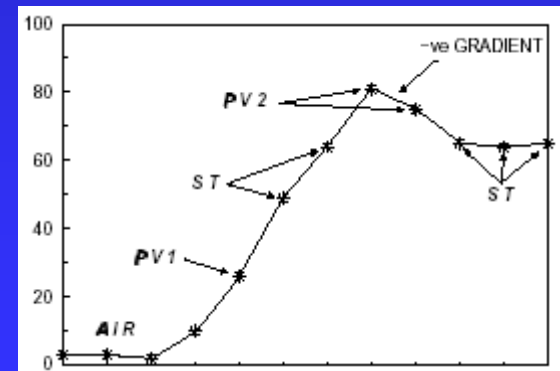
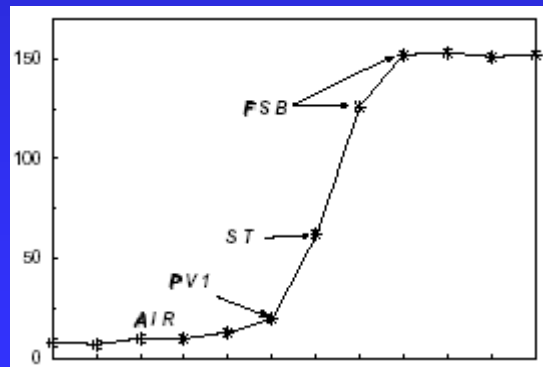
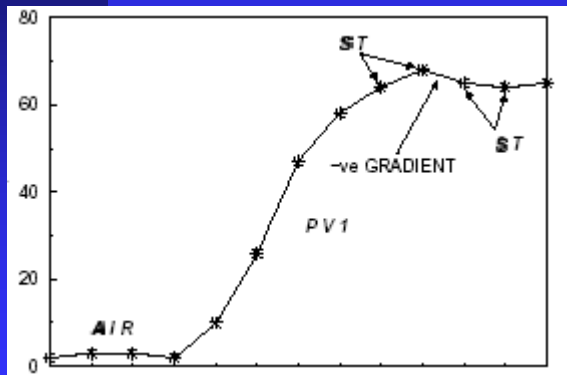
- intensity based classification
 - air, soft tissue (ST), fluid stool bone (FSB)
 - partial volume effect voxels(PVE)
- detecting air boundary by region growing
 - seed point



Digital Cleansing

by segmentation rays 2

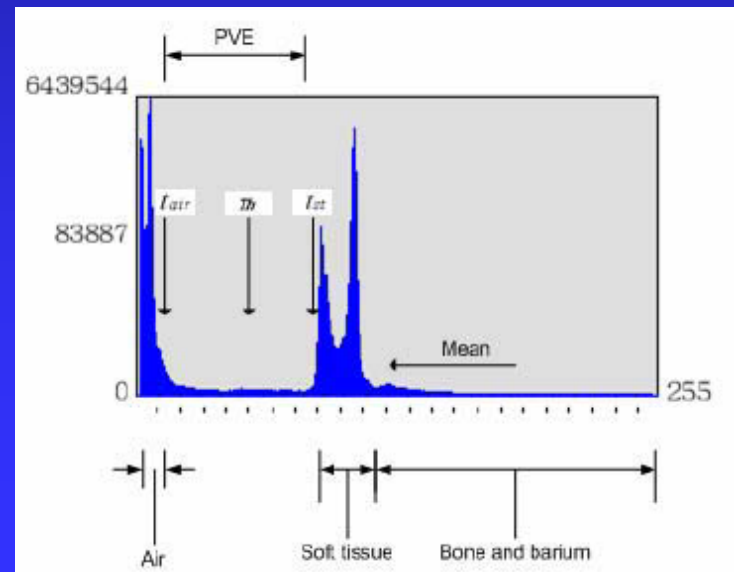
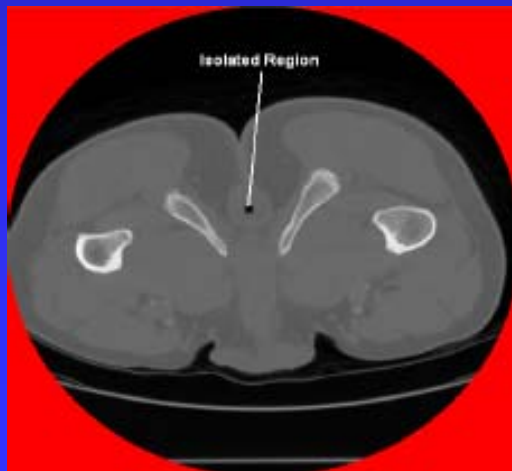
- starting points for segmentation rays
- detecting and characterizing the intersections:
 - AIR – ST, AIR – Fluid, AIR - Stool
- cleaning the image



Preprocessing & Segmentation 3

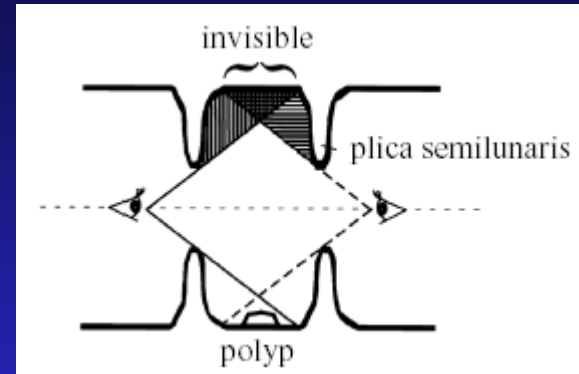
Automatic segmentation of the colon wall:

- thresholding
- seed point for region growing
- 3D region growing



Navigation techniques

- planed navigation
 - off line movie
- free navigation
 - the user controls the camera movement at every step
- guided navigation
 - predefined path (center line)
 - user control mode

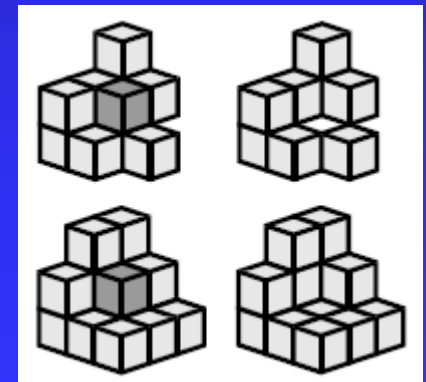
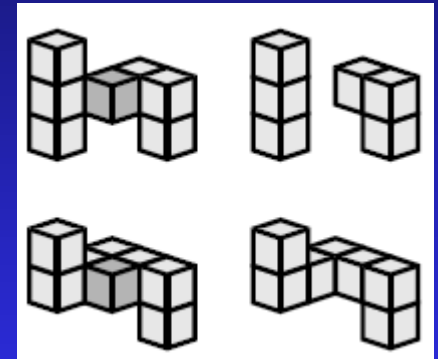
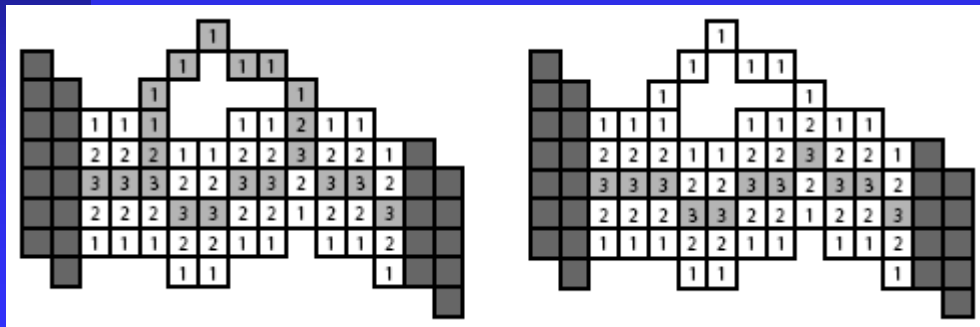


Centerline calculation

- Manual extraction
- Topological thinning
- Distance mapping
 - Distance-field based skeletons
 - Hierarchical subdivision and DFB field
(DFB – Distance From Boundary)

3D Topological thinning

- We don't need all skeletal branches
- Surface voxel tracing
- Connectivity test
- Hole detection
- Removing extraneous loops



Distance-field based skeletons

First step:

- compute the DFB field
- convert the volumetric DFB field into 3D directed weight graph
- build a minimum-cost spanning (MCS) tree from the weight graph using the Dijkstra's alg.

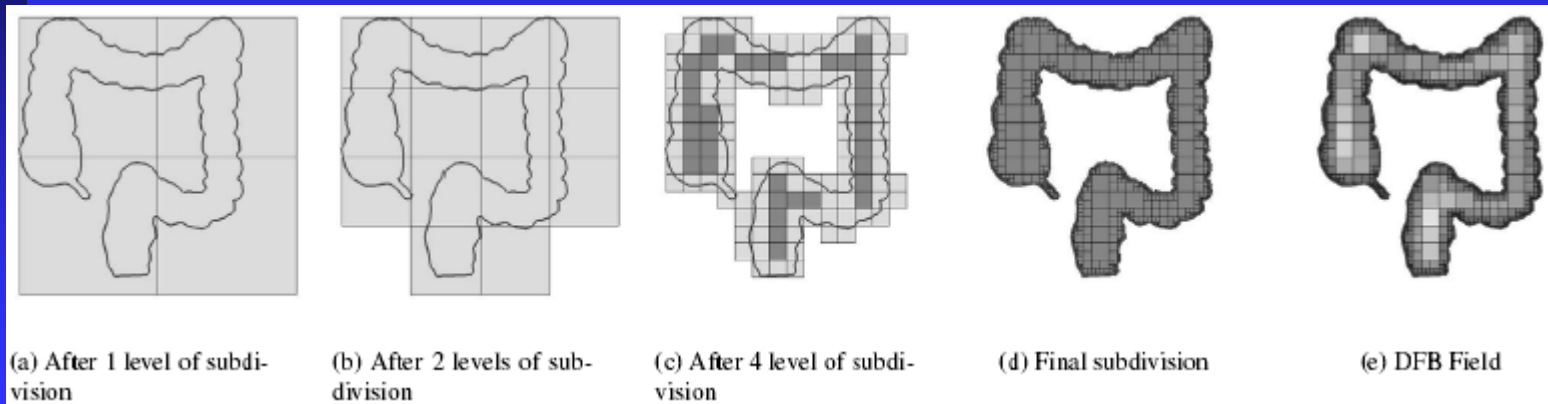
Second step:

- extract the main centerline
- detect all the branches attached to the main centerline



Hierarchical subdivision and DFB field 1

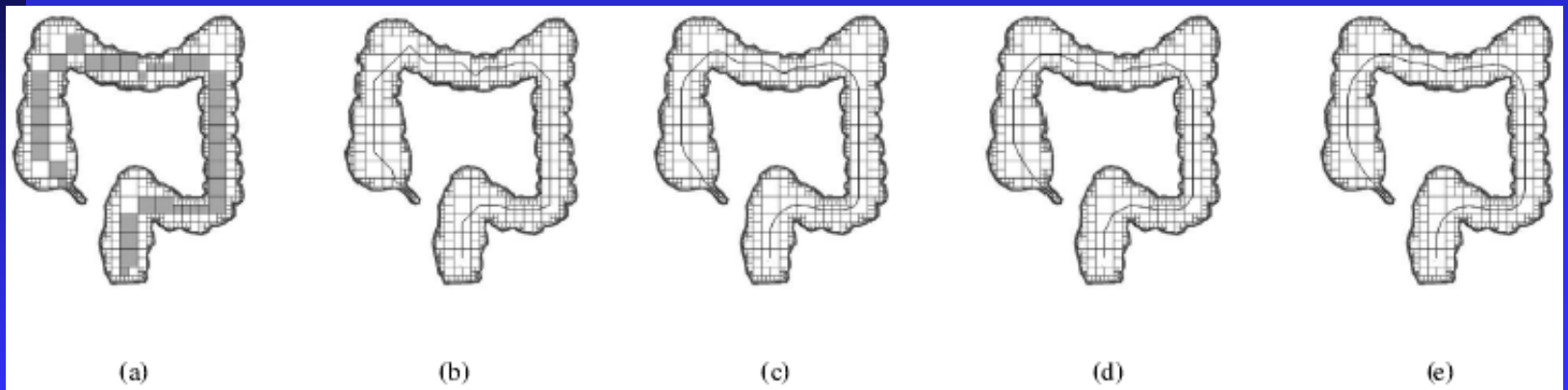
- Subdivide the object
- Compute the DFB field
- Compute the central path
 - create a graph $w(a,b)=1/dfb(a) + 1/dfb(b)$
 - use Dijkstra's alg. to compute the shortest path



Hierarchical subdivision and DFB field 2

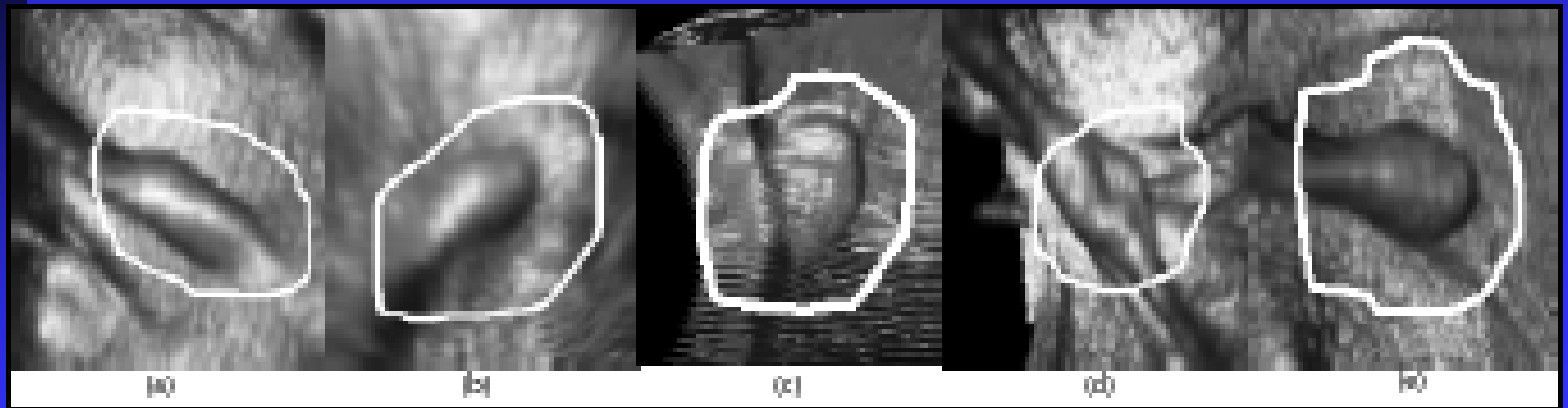
A better path is obtained using smoothing heuristics:

- interpolate the linear path segments with splines (b,c)
- replacing the part of the original path inside a block by a straight line segment joining the points of intersection (d), this may be followed by spline interpolation (e)



Pattern recognition 1

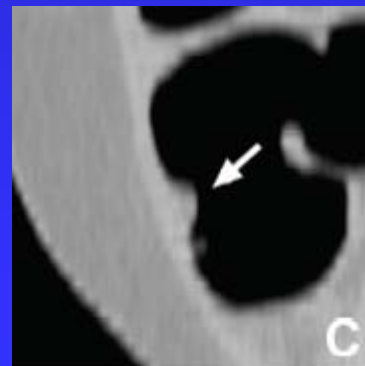
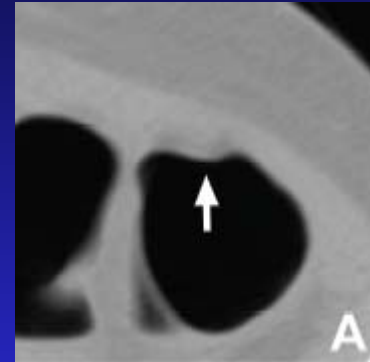
- the shape of a polyp is similar to a hemisphere
- a-c) examples of polyps
- d-e) examples of healthy tissue that have similar shapes



Pattern recognition 2

Characterizing features:

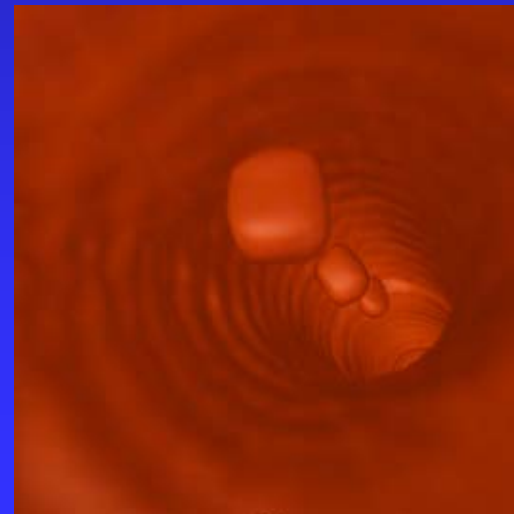
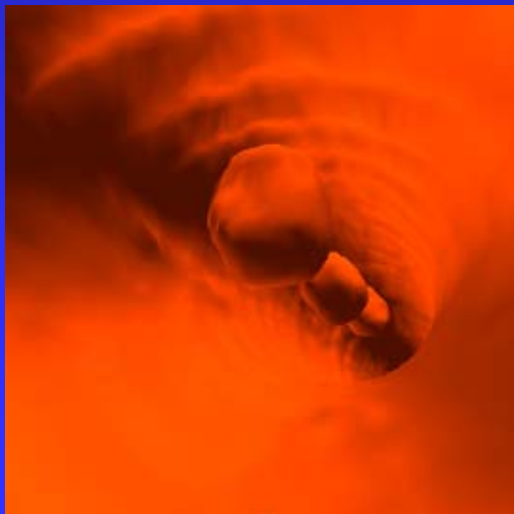
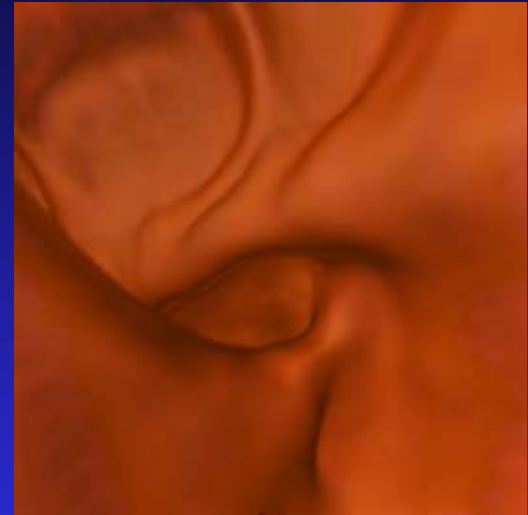
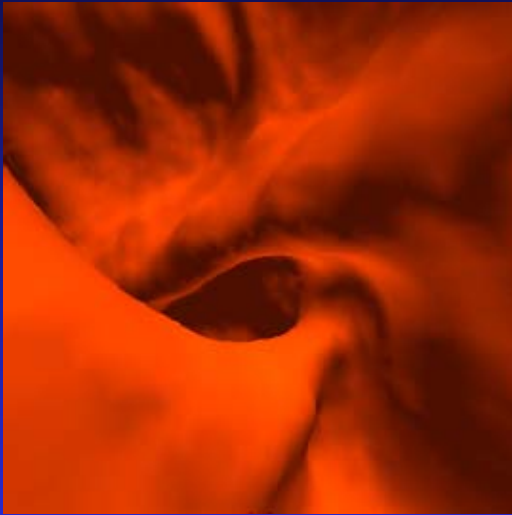
- Shape
- Curvature
- Intersecting normal vectors
- Geometric features



Surface vs. Volume rendering 1

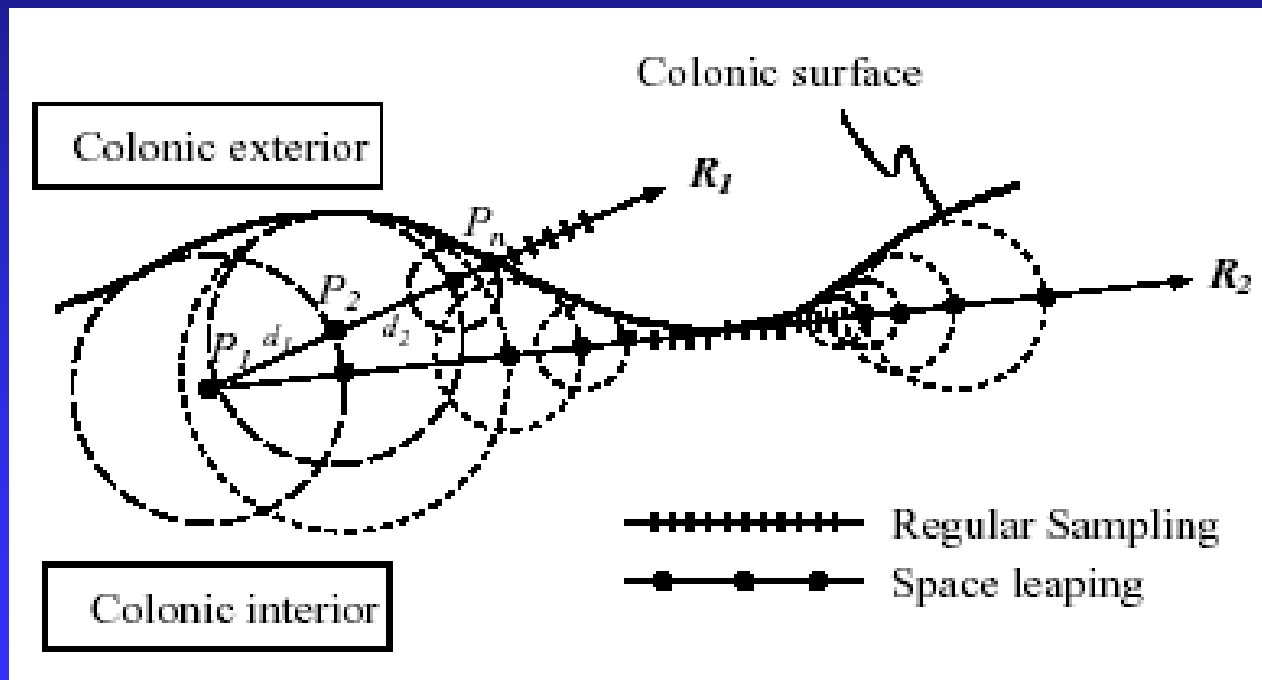
- Pre-segmentation
- Great number of triangles
- Sharp edges
- No pre-segmentation
- Fast preprocessing
- More realistic colon image

Surface vs. Volume rendering 2



Volume rendering

- Potential-Field-Assisted ray casting



Examples

Future work

1. Stage

- Preprocessing
- Segmentation
- Centerline calculation and Navigation
- Rendering

2. Stage

- Automatic polyp detection

References:

- 1) S. Lakare, M. Wan, M. Sato, A. Kaufman. 3D digital cleansing using segmentation rays
- 2) S. B. Göktürk, C. Tomasi. A new 3D pattern recognition technique with application to computer aided colonoscopy. CVPR'01 IEEE. 0-7695-1272-0/01.
- 3) C. Ko, J. Jang. Interactive polyp biopsy based on automatic segmentation of virtual colonoscopy. BIBE'04 IEEE. 0-7695-2173-8/04
- 4) M. J. Potel. Imaging in medicine – Here's looking into you, kid. 0272-1716/98 IEEE.
- 5) M. Wan, F. Dachille, A. Kaufman. Distance-field based skeletons for virtual navigation. 2001 IEEE Visualization.
- 6) P. Chaudhuri, R. Khandekar, D. Sethi, P. Kalra. An efficient central path algorithm for virtual navigation. CGI'04 IEEE. 1530-1052/04
- 7) R. J. T. Sadler, P. F. Whelan. Colon centerline calculation for CT colonography using optimized 3D topological thinning.
- 8) S. You, L. Hong, M. Wan, K. Junyaprasert, A. Kaufman, S. Murahhi, Y. Zhou, M. Wax, Z. Liang. Interactive volume rendering for virtual colonoscopy. IEEE Visualization '97. 1070-2385/97
- 9) M. Wan, Q. Tang, A. Kaufman, Z. Liang, M. Wax. Volume rendering based interactive navigation within the human colon. 0-7803-5897-x/99 IEEE
- 10) R. Shahidi, B. Lorensen, R. Kikinis, J. Flynn, A. Kaufman, S. Napel. Surface rendering versus volume rendering in medical imaging: Techniques and applications. IEEE VIS'96 1070-2385/96
- 11) ...