ROI detection for Virtual Colonoscopy

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Introduction

- Polyp and colon cancer
- Colonoscopy and virtual colonoscopy (VC)
- VC with computer aided detection (CAD)

The goal of the project

- Explore the area
  - Virtual colonoscopy
  - Computer aided polyp detection
- Find a new method for ROI detection
- Implementation

Virtual colonoscopy

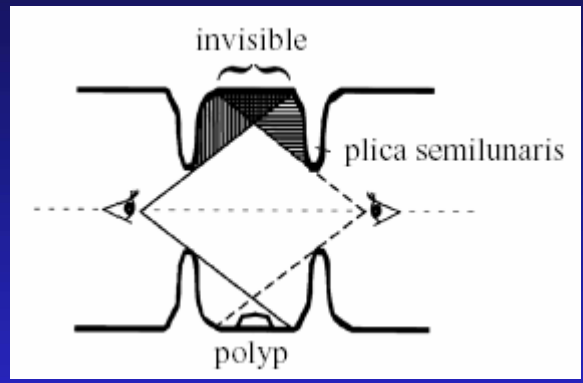
- Preprocessing and segmentation
- Virtual navigation techniques and centerline calculation
- Rendering

Preprocessing & segmentation

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

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)

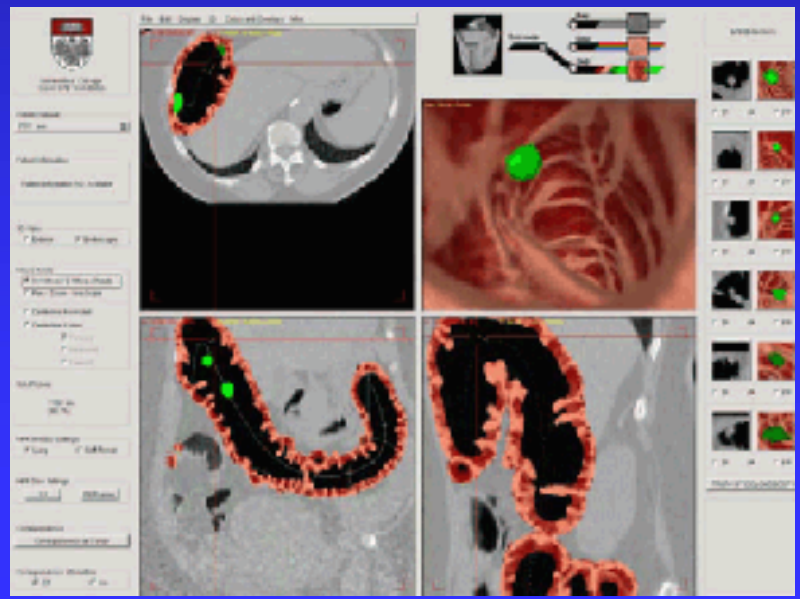
Surface vs. Volume rendering

- Pre-segmentation
- Great number of triangles
- Sharp edges

- No pre-segmentation
- Fast preprocessing
- More realistic colon image

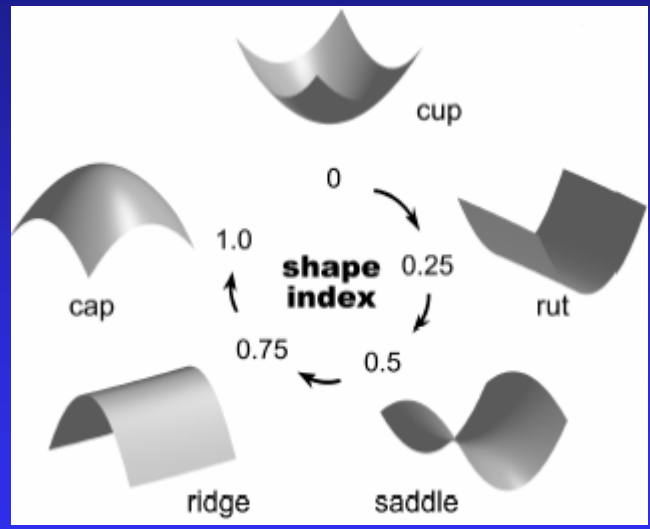
Computer aided polyp detection

- Colon wall segmentation
- ROI identification
- Feature derivation from the ROI
- Feature based classification



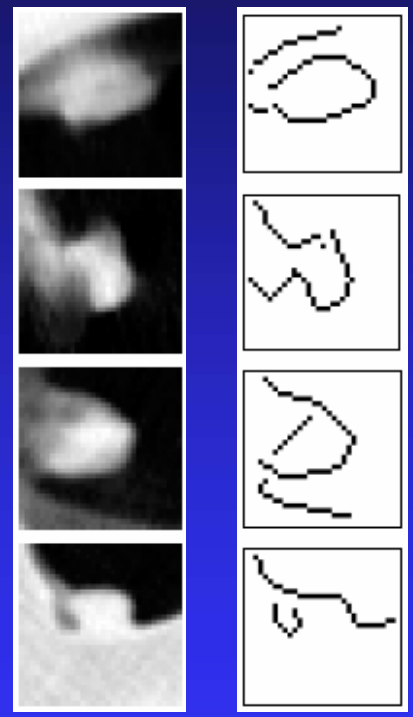
ROI identification

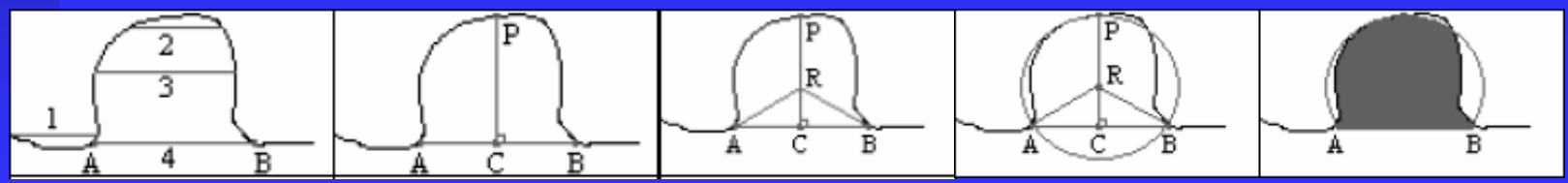
- Curvature estimation:
  - Kernel-based convolution methods
  - Surface patch fitting methods
- Curvature and 3D shape combination



Feature derivation form the ROI

- Polyp segmentation
  - 2D methods
  - 3D methods
- Feature extraction
  - Shape
  - Curvature
  - Geometric features





Feature based classification

CAD system has two phases:

- Training phase
- Application phase

Classifiers:

- Support Vector Machines (SVM)
- Neural Networks (NN)

ROI detection by concave parts of the boundary

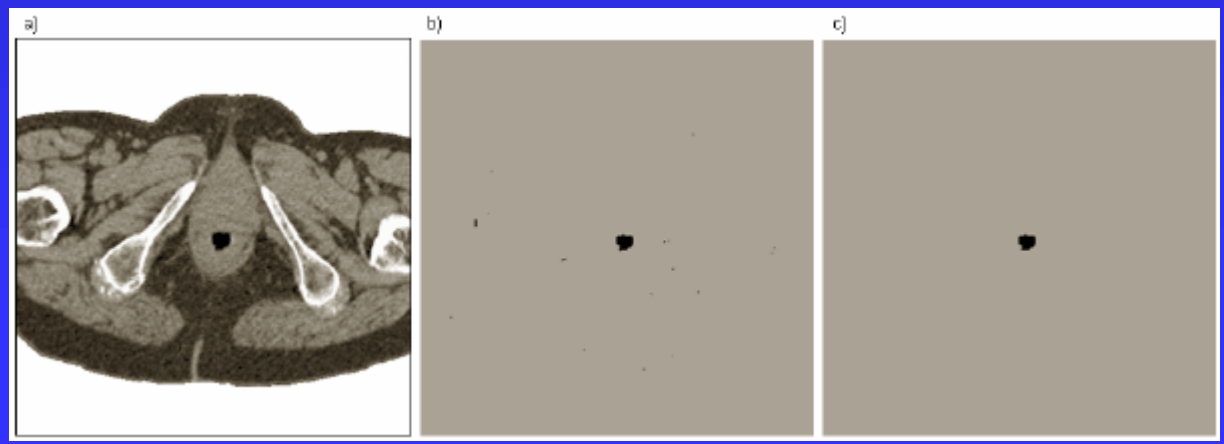
- Automatic segmentation of the colon wall
- Searching for concave parts of the boundary
- ROI identification on the slices
- Searching for 3D ROI

Colon wall segmentation

- Get a seed point
- 3D floodfill with 6-neighbourhood
- Thresholding
- Get the boundary for next computation

Automatic seed point selection

- Take the last slice
- With the combination of the floodfill and thresholding we get the rectum point
- Noise was removed by morphologic close operation



Concave points and boundary parts

Def. *For each concave point of the boundary exists a line defined by two points from its neighborhood, the oriented distance between them is positive.*

Def. *Concave boundary parts are defined by near concave points of the boundary.*

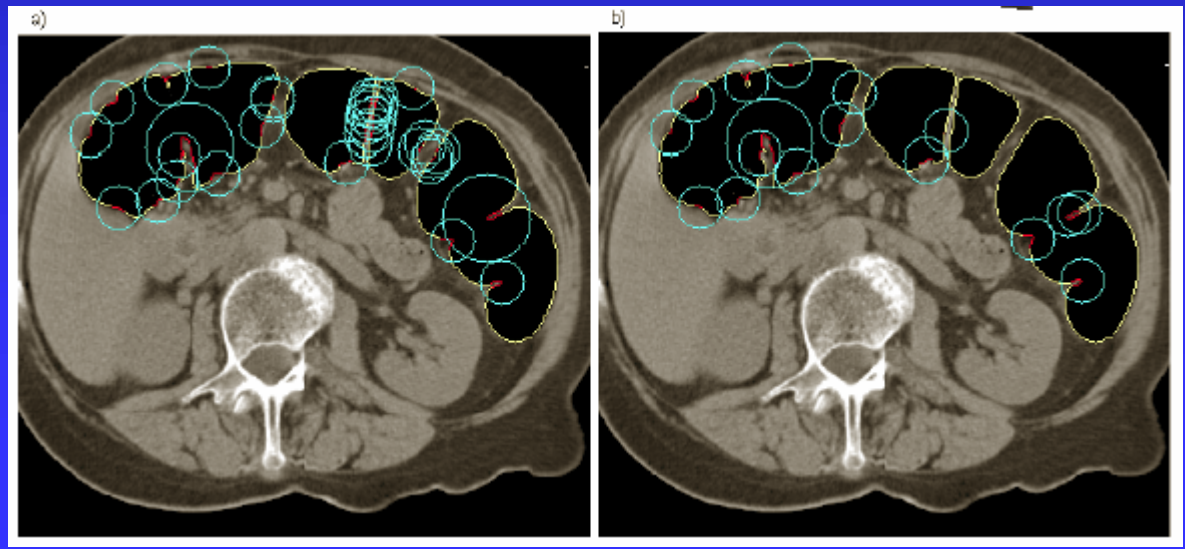
Searching for concave points

$$p : ax + by + c = 0 .$$

$$d(X_0, p) = \frac{ax_0 + by_0 + c}{\sqrt{a^2 + b^2}},$$

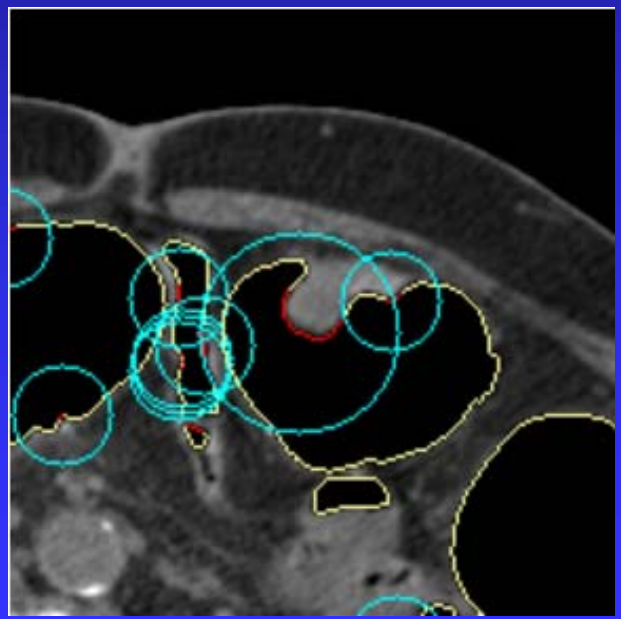
$sign(d(\mathrm{X}_0, p)) > 0 .$

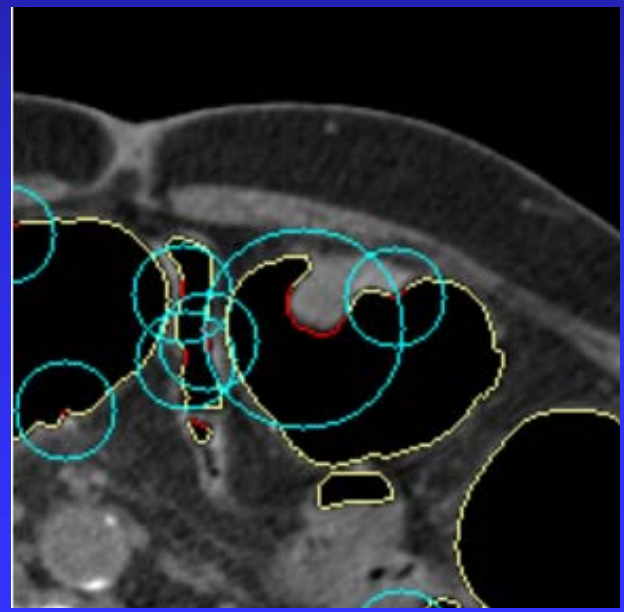
$sign(d(\mathrm{X}_0, p)) > 1 .$



ROI detection on the slices

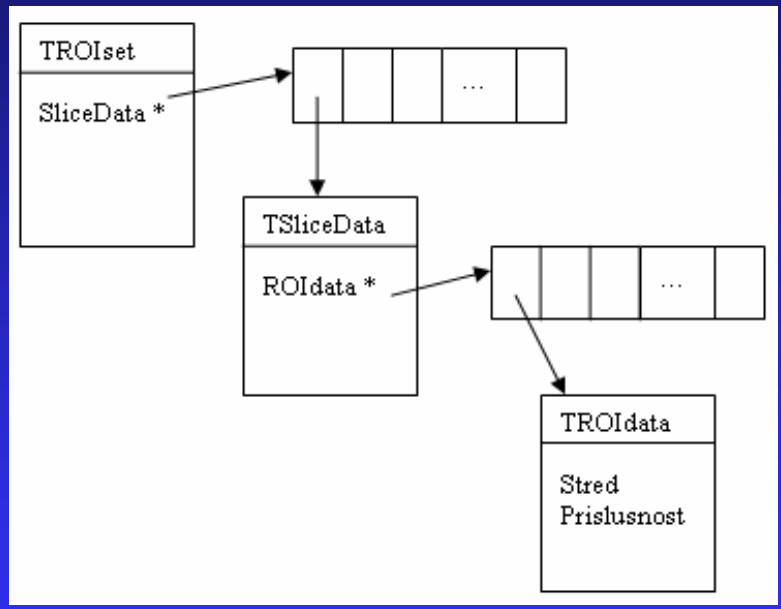
- We merge the concave parts of the boundary to get continuous regions (ROIs)





3D ROI detection

- For each ROI we search the surrounding slices to expand it to 3D
- We uses a specific data structure to speed up the process



Control parameters

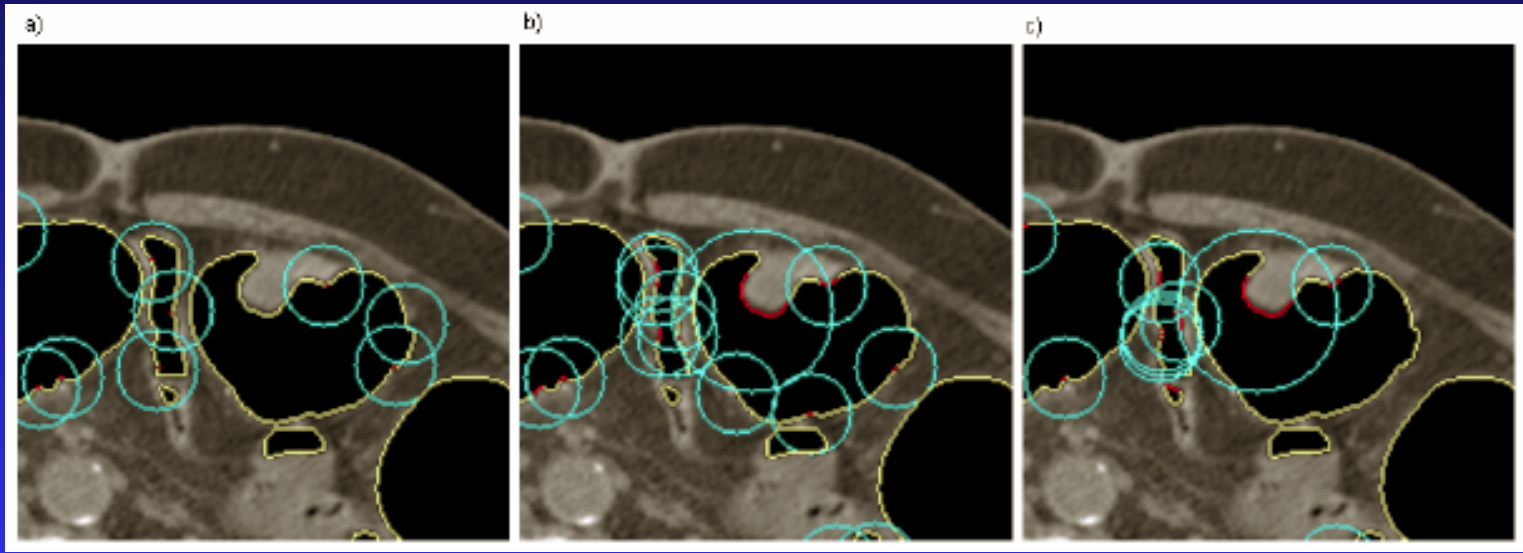
Mean – size of the mean mask

Concave – size of the mask for concave point computation

Region – threshold value for ROI detection

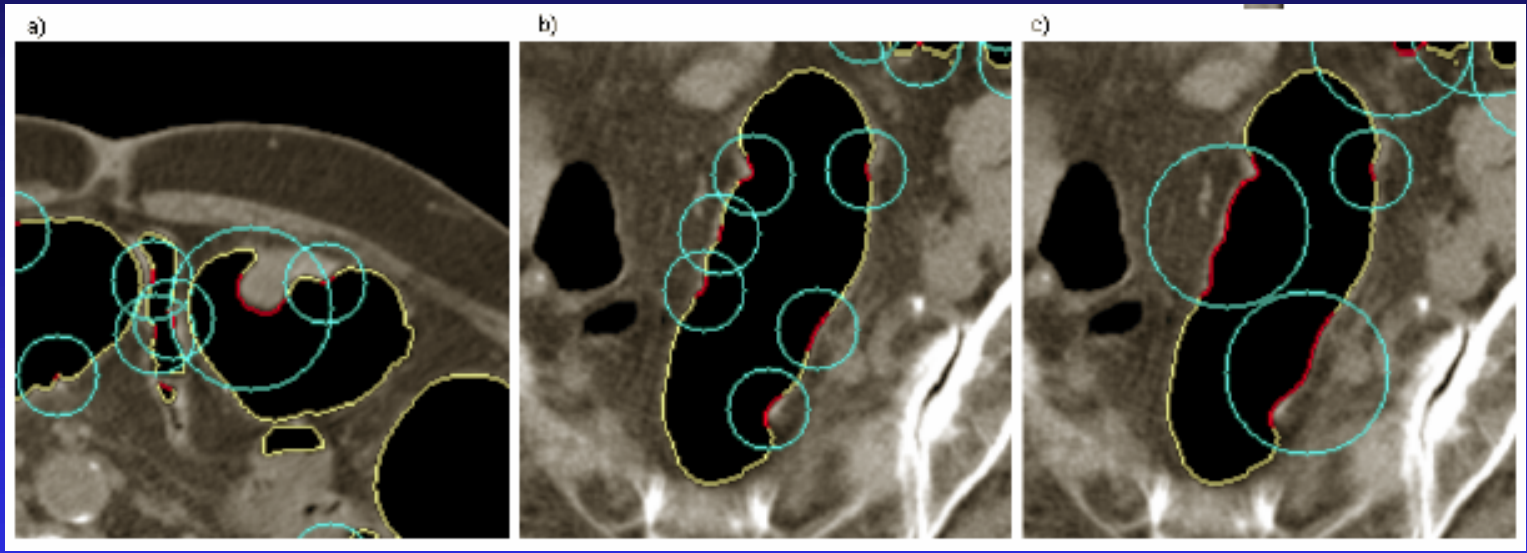
3DROI – threshold value for 3D ROI detection

Estimation of the control parameters



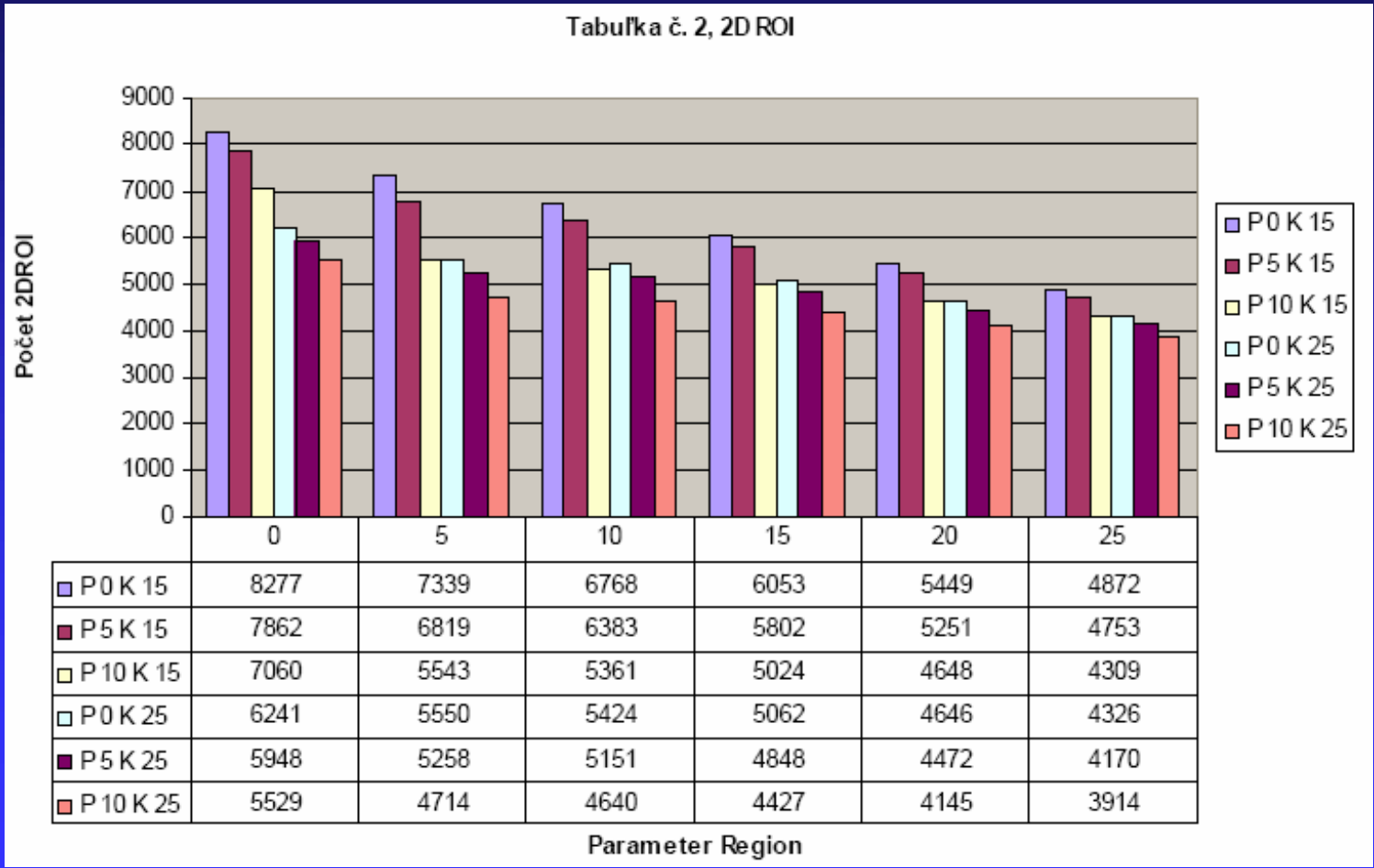
a) concave = 5 b) concave = 15 c) concave = 25

Estimation of the control parameters



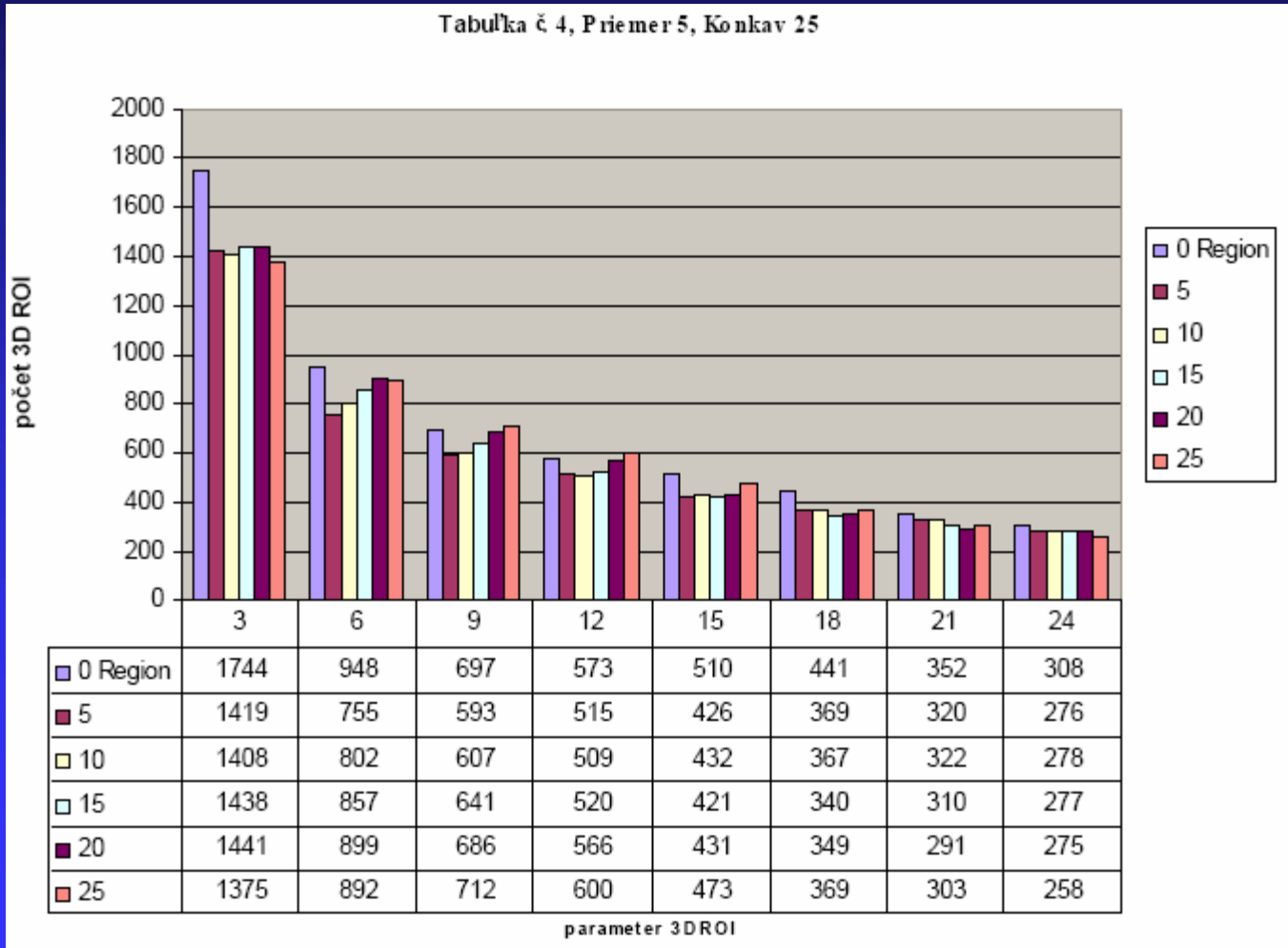
a) region = 5 b) region = 10 c) region = 20

Results, 2D ROI



	0	5	10	15	20	25
P 0 K 15	8277	7339	6768	6053	5449	4872
P 5 K 15	7862	6819	6383	5802	5251	4753
P 10 K 15	7060	5543	5361	5024	4648	4309
P 0 K 25	6241	5550	5424	5062	4646	4326
P 5 K 25	5948	5258	5151	4848	4472	4170
P 10 K 25	5529	4714	4640	4427	4145	3914

Results, 3D ROI



	3	6	9	12	15	18	21	24
0 Region	1744	948	697	573	510	441	352	308
5	1419	755	593	515	426	369	320	276
10	1408	802	607	509	432	367	322	278
15	1438	857	641	520	421	340	310	277
20	1441	899	686	566	431	349	291	275
25	1375	892	712	600	473	369	303	258

Future work

- Polyp feature derivation from ROI
- Feature based classification of polyp candidates
- Create a complete system for polyp detection