Computer-Assisted Diagnosis by Content-Based Image Retrieval – Clinical Use of Retrieval Systems and Databases

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Overview

- CAD
- Challenges
- CBR
- Conclusions

What is Computer-Assisted Diagnosis?

- Application of **computer** programs to **assist** physicians solving **diagnostic** problems
- Computer output as a **second opinion** to assist image interpretation by improving accuracy and consistency of diagnosis, reducing image reading time [Doi-BJR (79)2006]
- Automatic detection (CADe) and analysis (CADx) of certain diseases from medical images
- Originally applied to **detect** lesions in mammography and chest radiography
- Increasing attention in other disciplines

And what is not ?

- CAD is NOT a replacement for human judgment
- In every case the physician is responsible for his final ruling

[Horsch, 2000, Computergestützte Diagnostik für Hautkrebsfrüherkennung, Ösophagustumorstaging und Gastroskopie, Hab.Schrift, TUM]

Categories of CAD

CADe: Abnormality detection

- Used as “second reader” due to
- “Lapse of attention problem”
- Identification of potential regions of interest

Note:

Too many false positives!!

Source: Brown, 1999, **The Evaluation of Computer-Aided Diagnosis Systems: An FDA Perpective**

Computer

Digital Chest Radiography

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http://www.medical.philips.com/main/products/xray/products/radiography/cad_chest/

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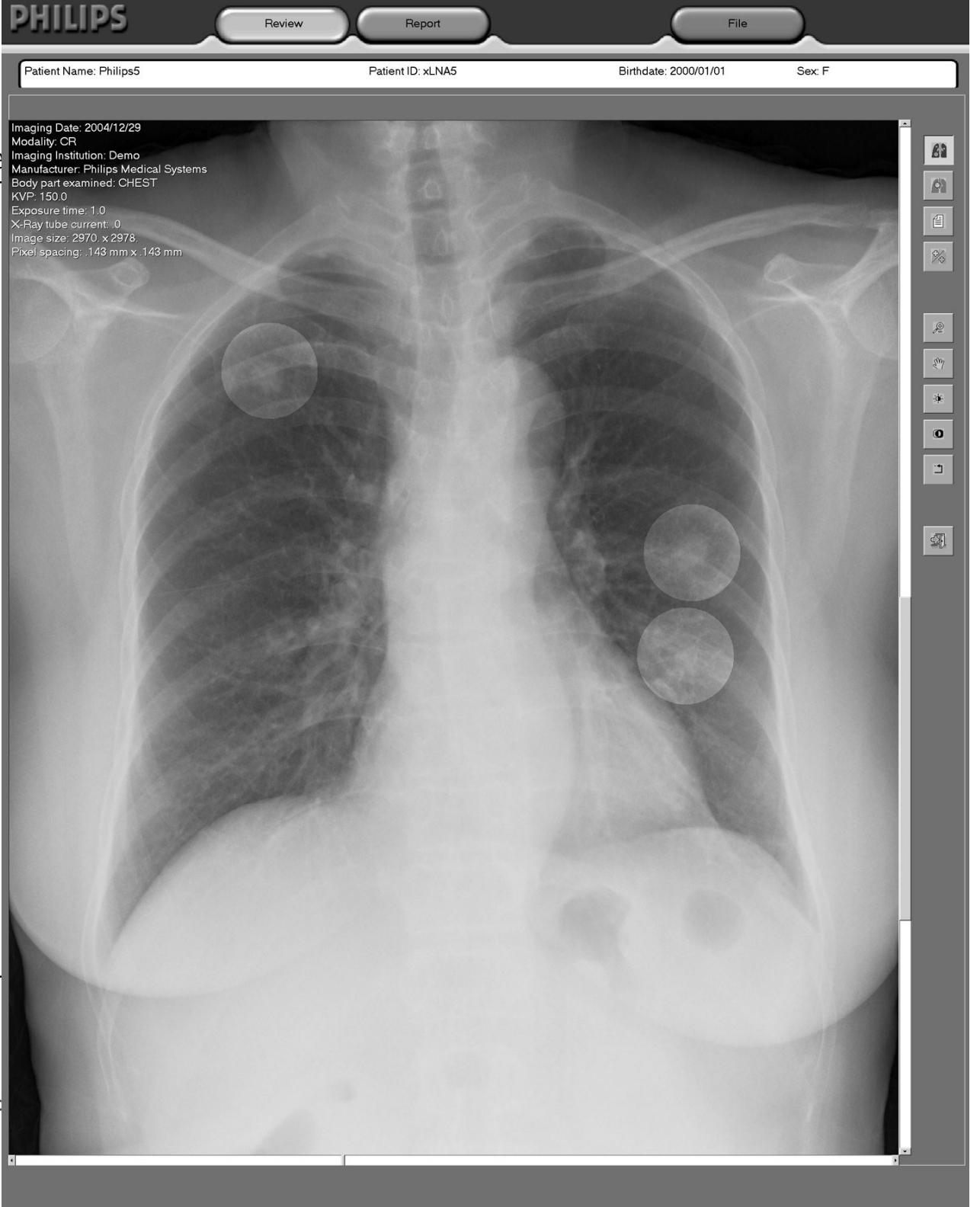
Compute

Digital Chest Radiography



http://www.medical.philips.com/main/products/xray/products/radiography/cad_chest/

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Categories of CAD

1. Abnormality detection (CADe)

2. Diagnosis support by interactive and automatic extraction of features from image data and feature classification (CADx)
   - o asking the “computer's opinion" about a particular region.
   - o Is this a Barret Esophagus?
   - o Is this a benign lesion?
   - → System responds with a probability of disease

Source: Brown, 1999, **The Evaluation of Computer-Aided Diagnosis Systems: An FDA Perpective**

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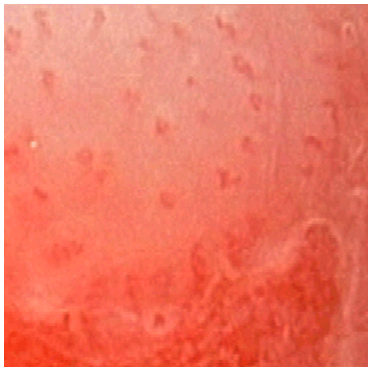
Computer Assisted Endoscopy

(Gastroesophageal Reflux Disease, GERD)



Normal Tissue

Corpus

Cardia

Barrett

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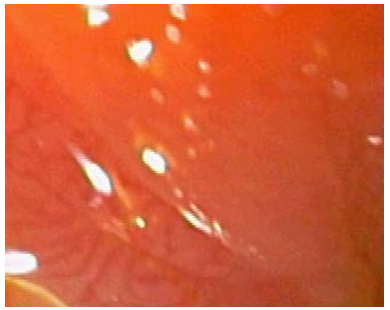
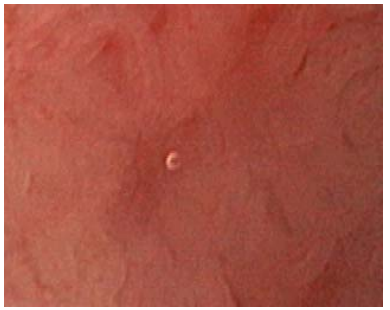
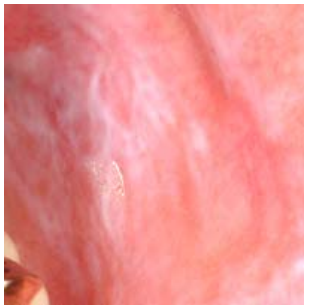
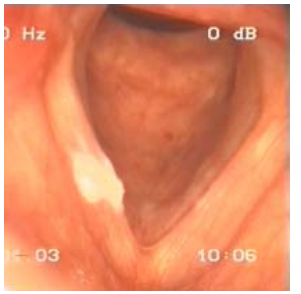
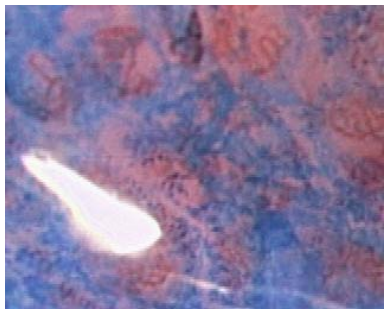
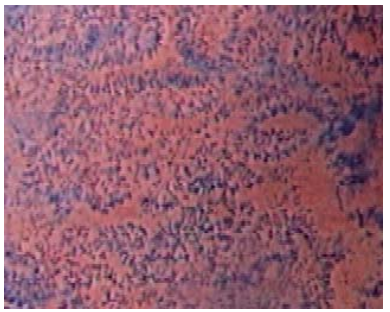
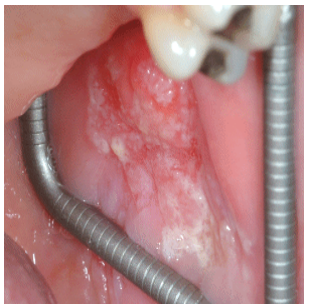
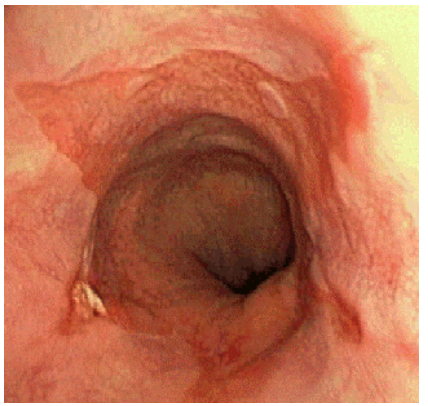
CAD and endoscopy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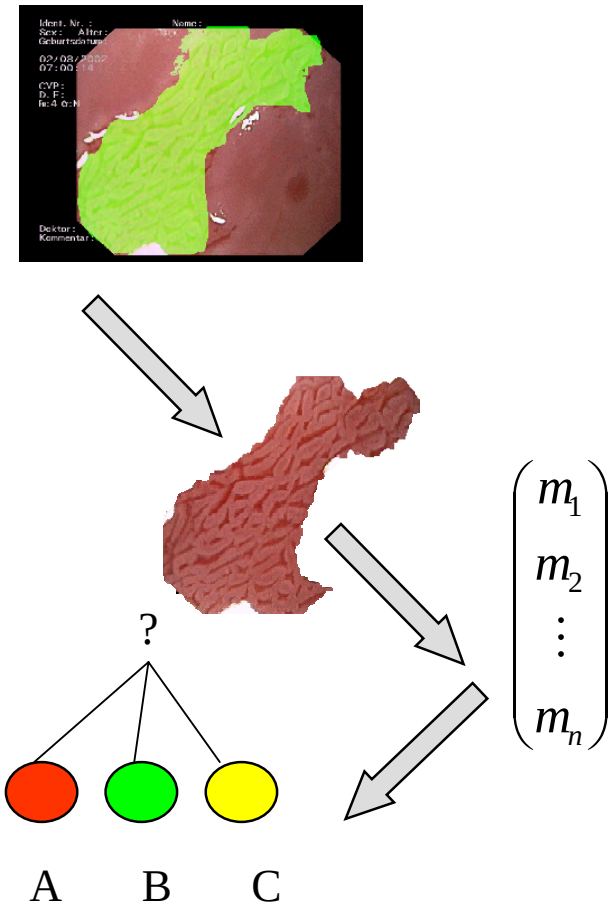
CAD System Overview



CAD systems comprise several steps:

- preprocessing of images or enhancement
- (auto) detection and segmentation of regions of interests (ROI's)
- description of these regions (ROI) by features
- Selection of an adequate feature set
- Classification / pattern recognition
- Presentation and visualisation of results

An example: the EndoCAD - system

- Is a member of the CADx technology family of the Fraunhofer IIS
- The technology platform is applicable to different application fields such as
  - dermatoscopy (DermaCAD®),
  - mammography (mammoCAD®)
  - and endoscopy (EndoCAD®)

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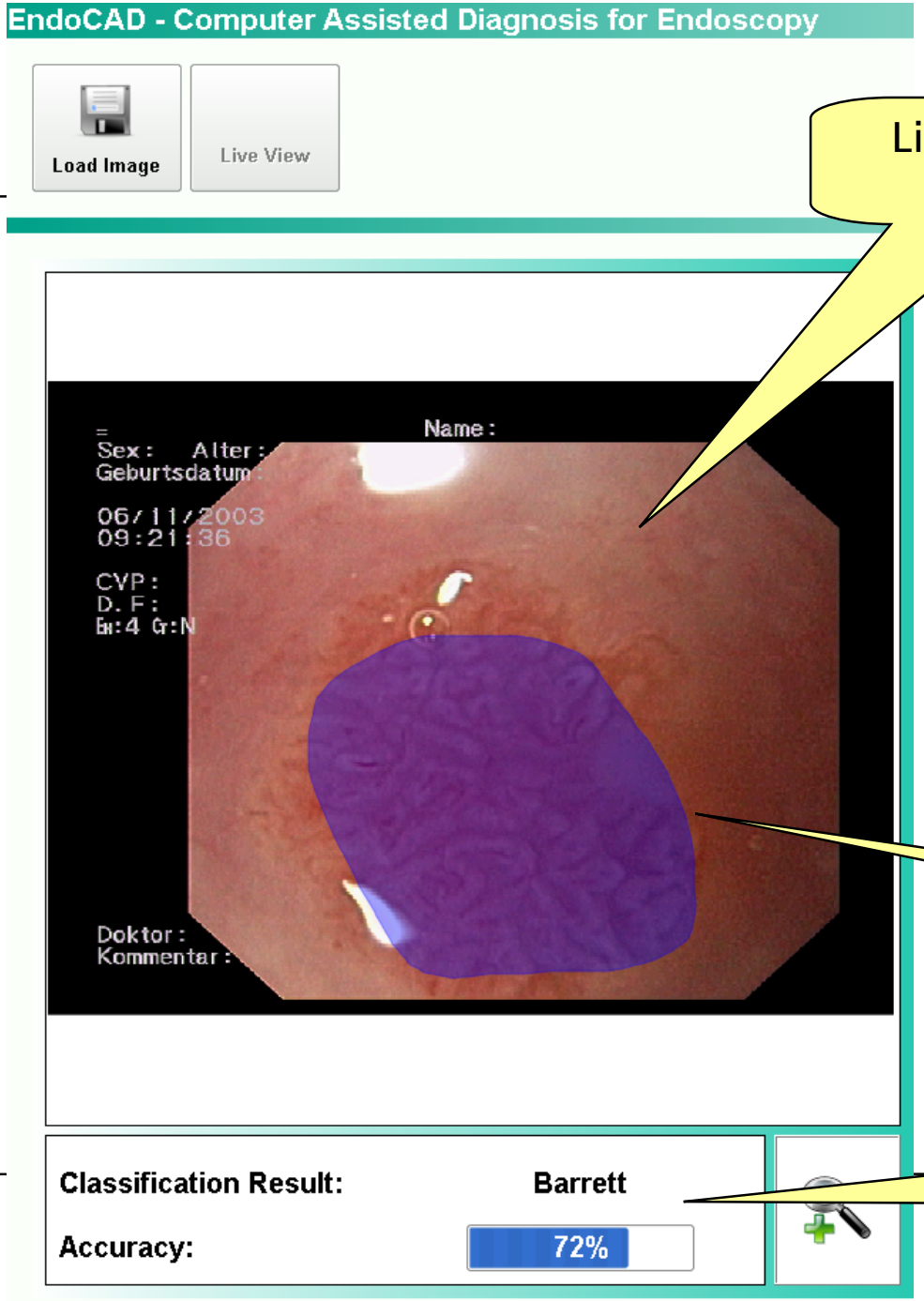

Live image from camera

- HMI is optimized for intuitive interaction via touch-screen
- Can be enhanced using **"live-wire"** technology
- Characterization of different tissue types using a set of textural, morphological, color and functional parameters

Manual delineation via touchscreen

Accuarcy / Probability of result

Challenges of CAD

- Input : Image (or other data)
- Output: Detection / Classification Result
- Detection → Too Many False Positives
- Classification → Many CAD Systems are better than experienced physicians, but not accepted
- Systems are not transparent

→ Black Box „Phenomena“

Plausibility

- Describe findings in images with well-known and accepted ontologies
  - Mammography → BIRADS
  - Dermatology → ABCD
- no commonly accepted description language for all fields

→ Ontology–free image description

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Overview

- CAD
- Challenges
- CBR – Case-based reasoning
  & Evidence based medicine
- Conclusions

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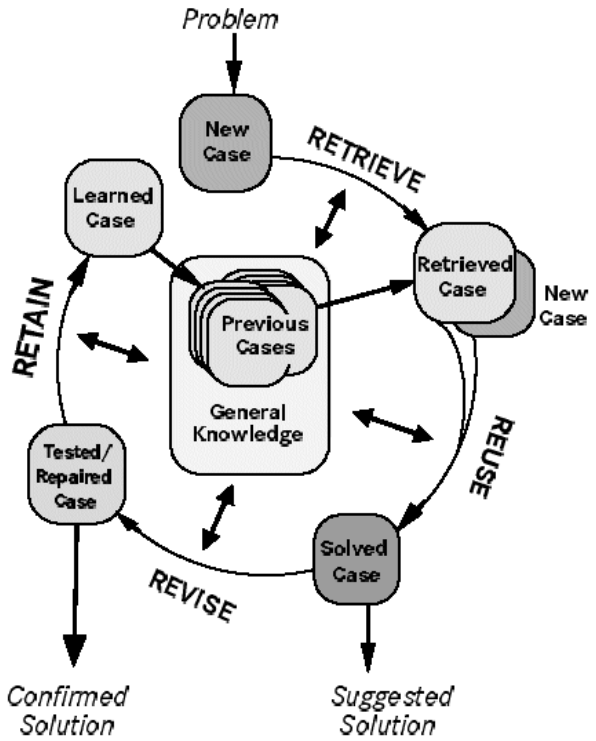
CBR System Overview (R4-Paradigm)



The Case-Based Reasoning Process Model according to Aamodt and Plaza

Assumption: "similar problems have similar solutions"

Given a new Problem …

… retrieve similar and known problems and related solutions from database

… reuse the retrieved information to find a solution for the given problem

… revise the solution using additional information (e.g. biopsy)

… retain solution into database

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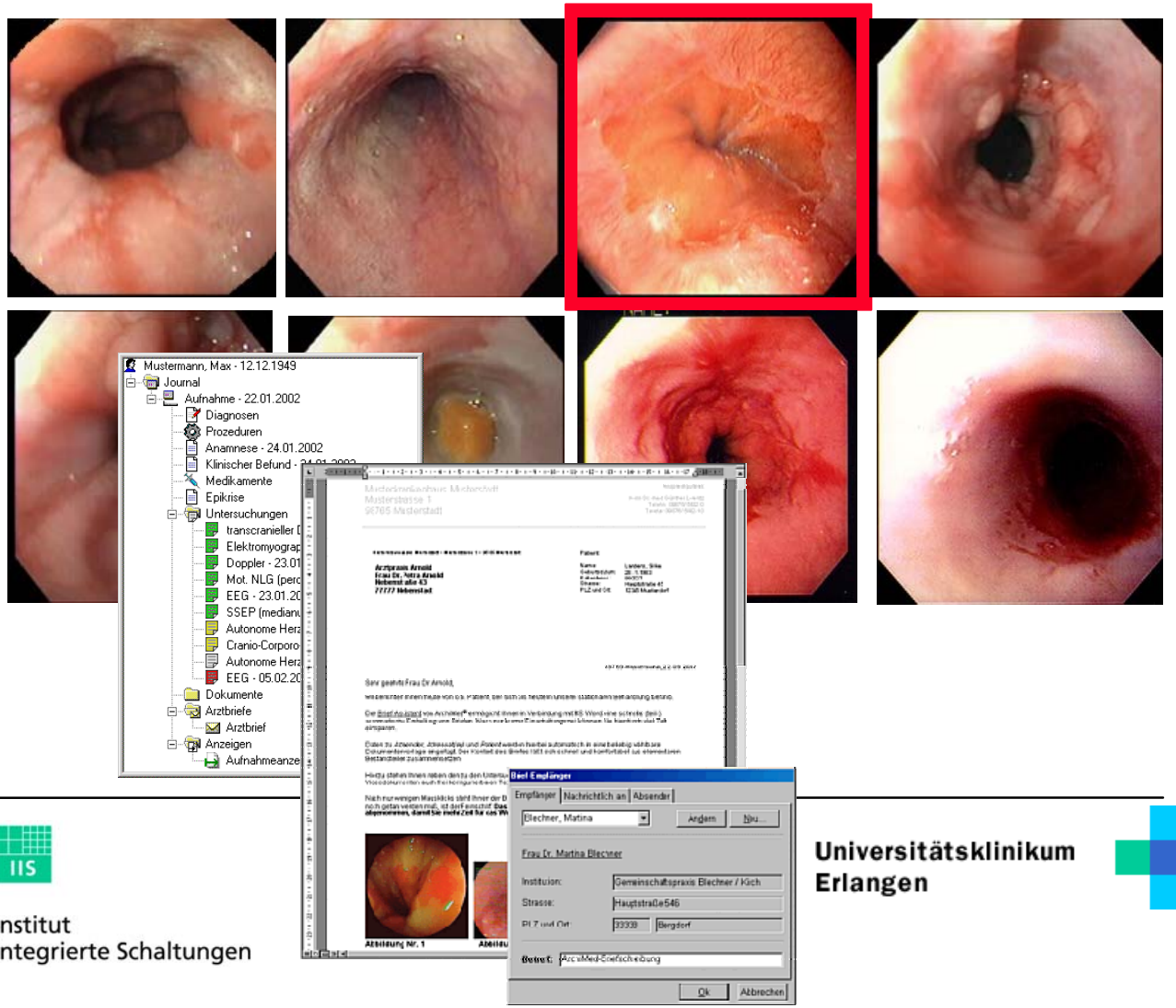
Overview

- CAD
- CADe and CADx
- CBR ------- and CBIR
- Conclusions

Case Based Reasoning (CBR)



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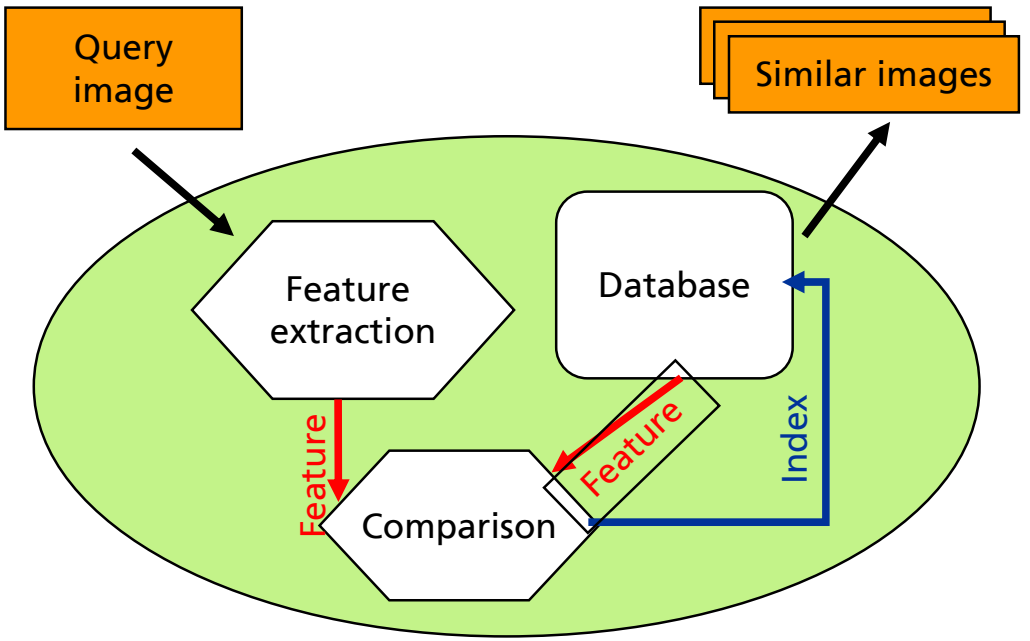
CBIR - Content based Image retrieval



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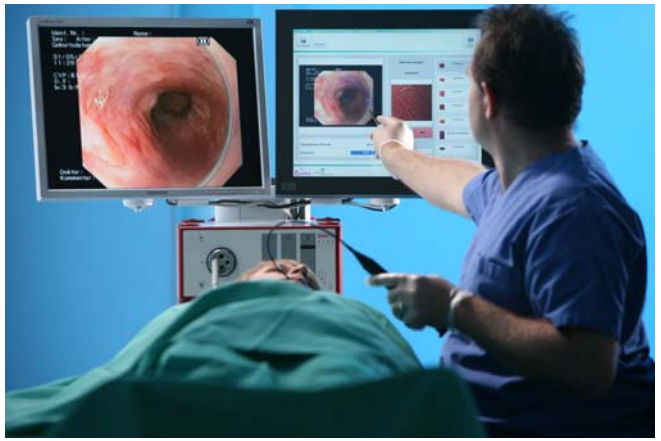
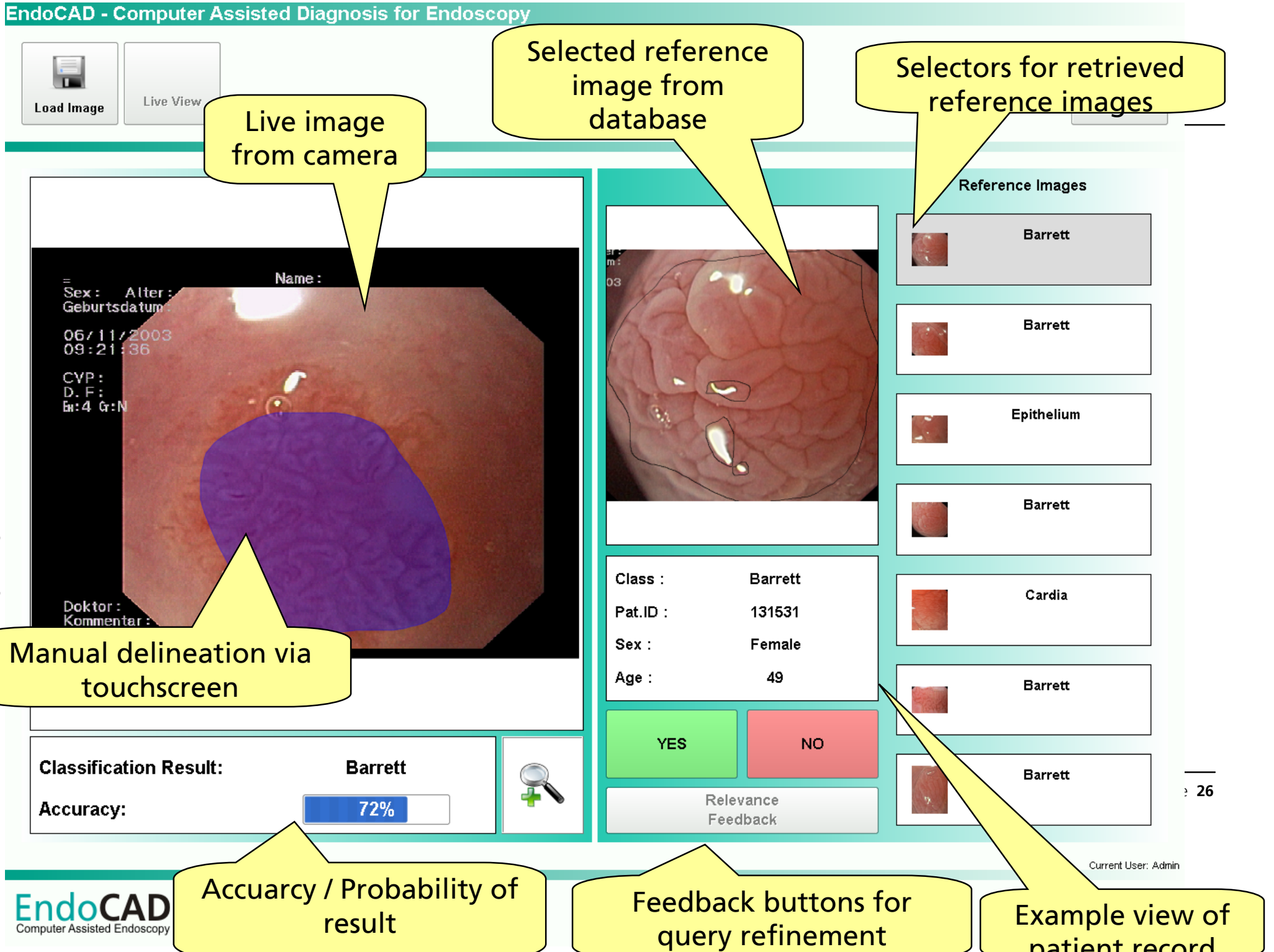
Back to the EndoCAD System



- Characterization of different types of tissues by a set of textural, morphological, color and functional features
- Using these features a content based comparison of images is possible
- We need a metric between features and a classifier
- This allows retrieval of images from a database which are similar by image contents ("query by example", NO implicit keyword search)

CBIR

- With annotated and pathological validated images, diagnosis can be supported using case-based-reasoning (CBR) technology.
- Provision of similar reference cases in real time using an image database or an atlas (online lookup).
- Together with the reference cases all relevant patient history data could be retrieved and displayed during the examination process (in collaboration with the host archiving system)


EndoCAD - Computer Assisted Diagnosis for Endoscopy
Load Image
Live View
Live image from camera
Selected reference image from database
Selectors for retrieved reference images
Reference Images
Barrett
Barrett
Epithelium
Barrett
Cardia
Barrett
Barrett
Name :
Sex : Alter :
Geburtsdatum :
06/11/2003
09:21:36
CVP :
D. F :
Bm:4 Gr:N
Doktor :
Kommentar :
Manual delineation via touchscreen
Class : Barrett
Pat.ID : 131531
Sex : Female
Age : 49
YES
NO
Relevance Feedback
Classification Result: Barrett
Accuracy: 72%
Accuarcy / Probability of result
Feedback buttons for query refinement
Example view of patient record
Current User: Admin
EndoCAD
Computer Assisted Endoscopy
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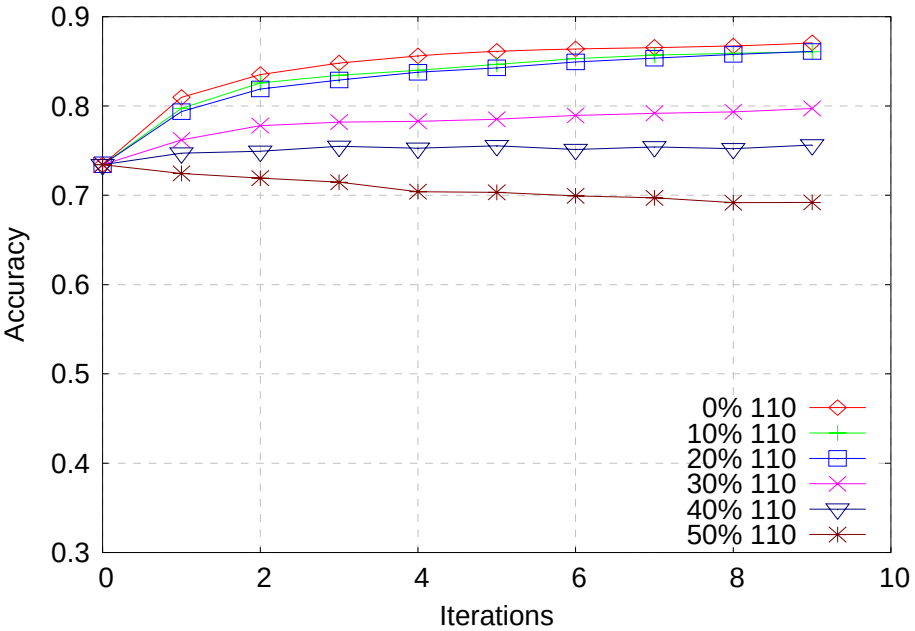
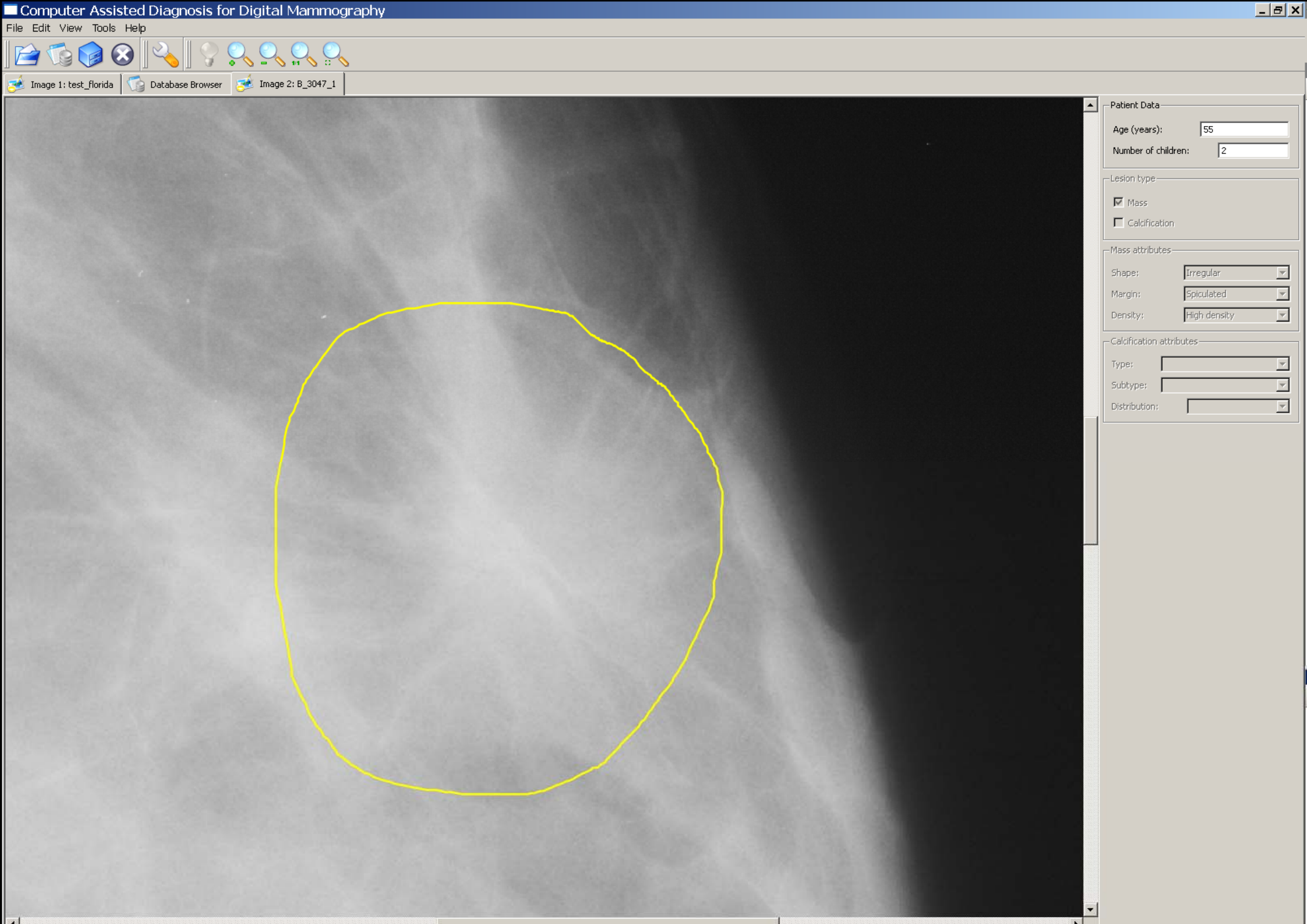
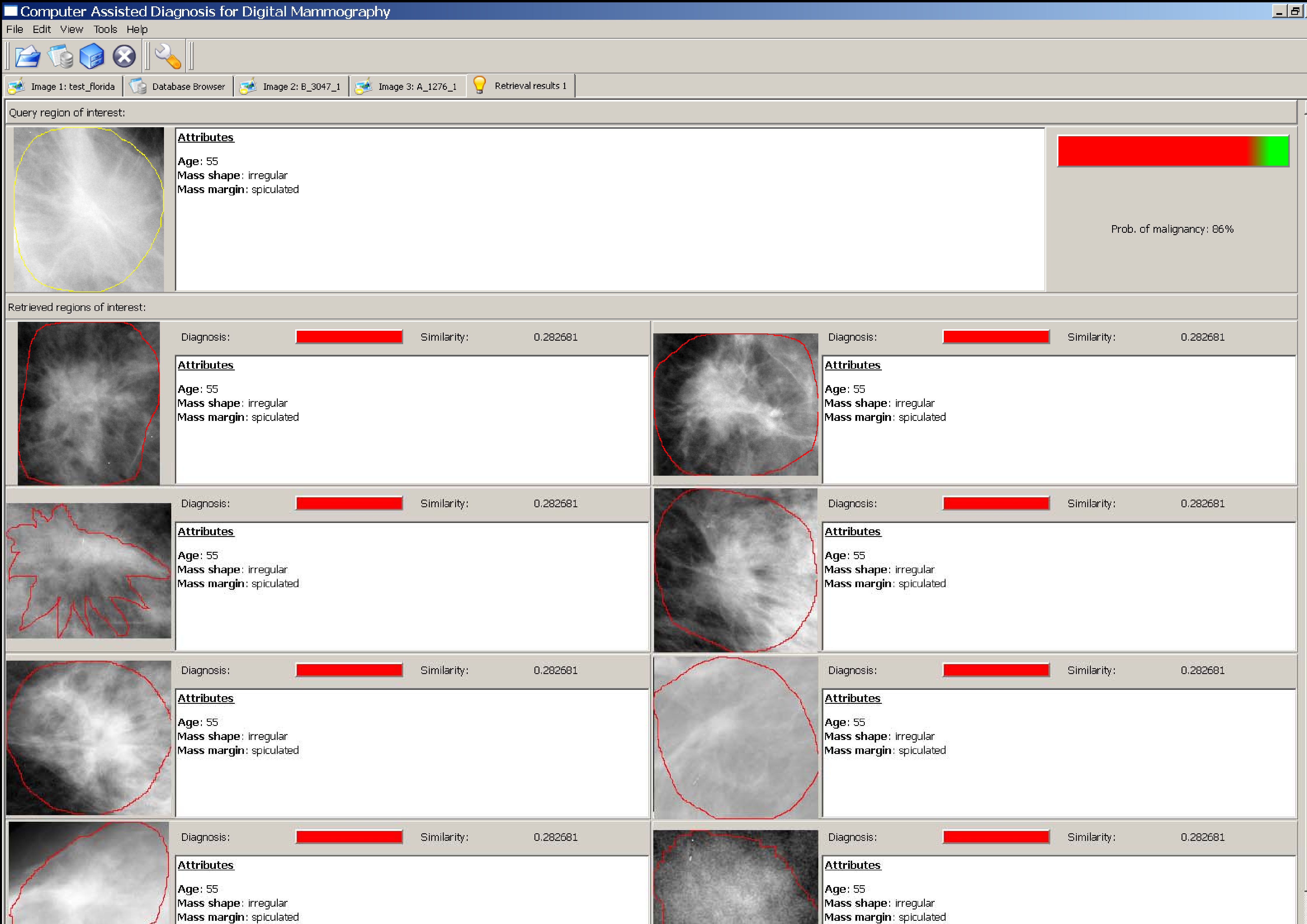
Interactive Query Refinement

- Possibility to refine image queries
- Images can be marked as “relevant” or “irrelevant” (yes/no-buttons) to direct the next query to the users likings
- Experimental results with endoscopic images have shown that even with a significant amount of wrong user decisions the accuracy still grows for query iterations (graph)



Relevance feedback (prelim. Results from endoscopy)


Computer Assisted Diagnosis for Digital Mammography
File Edit View Tools Help
Image 1: test_florida
Database Browser
Image 2: B_3047_1
Patient Data
Age (years): 55
Number of children: 2
Lesion type
Mass
Calcification
Mass attributes
Shape: Irregular
Margin: Spiculated
Density: High density
Calcification attributes
Type:
Subtype:
Distribution:


Computer Assisted Diagnosis for Digital Mammography
File Edit View Tools Help
Image 1: test_florida
Database Browser
Image 2: B_3047_1
Image 3: A_1276_1
Retrieval results 1
Query region of interest:
Attributes
Age: 55
Mass shape: irregular
Mass margin: spiculated
Prob. of malignancy: 86%
Retrieved regions of interest:
Diagnosis:
Similarity:
0.282681
Attributes
Age: 55
Mass shape: irregular
Mass margin: spiculated
Diagnosis:
Similarity:
0.282681
Attributes
Age: 55
Mass shape: irregular
Mass margin: spiculated
Diagnosis:
Similarity:
0.282681
Attributes
Age: 55
Mass shape: irregular
Mass margin: spiculated
Diagnosis:
Similarity:
0.282681
Attributes
Age: 55
Mass shape: irregular
Mass margin: spiculated
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Similarity:
0.282681
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Mass margin: spiculated
Diagnosis:
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Attributes
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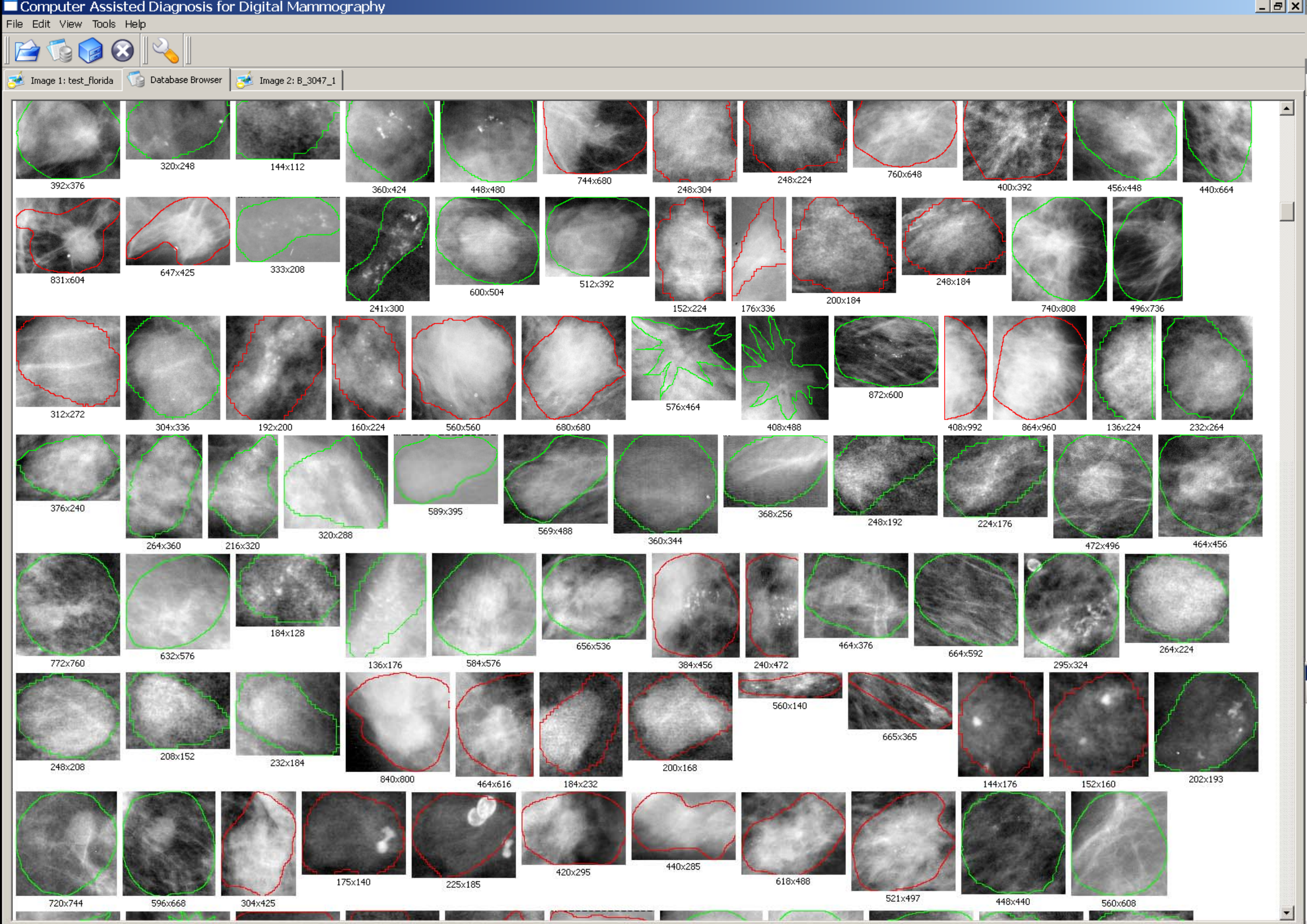
Mass margin: spiculated


Computer Assisted Diagnosis for Digital Mammography
File Edit View Tools Help
Image 1: test_florida
Database Browser
Image 2: B_3047_1
392x376
320x248
144x112
360x424
448x480
744x680
248x304
248x224
760x648
400x392
456x448
440x664
831x604
647x425
333x208
241x300
600x504
512x392
152x224
176x336
200x184
248x184
740x808
496x736
312x272
304x336
192x200
160x224
560x560
680x680
576x464
408x488
872x600
408x992
864x960
136x224
232x264
376x240
264x360
216x320
320x288
589x395
569x488
360x344
368x256
248x192
224x176
472x496
464x456
772x760
632x576
184x128
136x176
584x576
656x536
384x456
240x472
464x376
664x592
295x324
264x224
248x208
208x152
232x184
840x800
464x616
184x232
200x168
560x140
665x365
144x176
152x160
202x193
720x744
596x668
304x425
175x140
225x185
420x295
440x285
618x488
521x497
448x440
560x608

Overview

- CAD
- Challenges
- CBR
- Conclusions

Resume

In all medical disciplines

- An increased need of CAD can be observed
- Acceptance depends on plausibility
- CBR is a non-verbal description of images
- Use machine learning approaches
- Use large-scale data reference image bases
- Need for annotated reference data bases!!!