LKEB

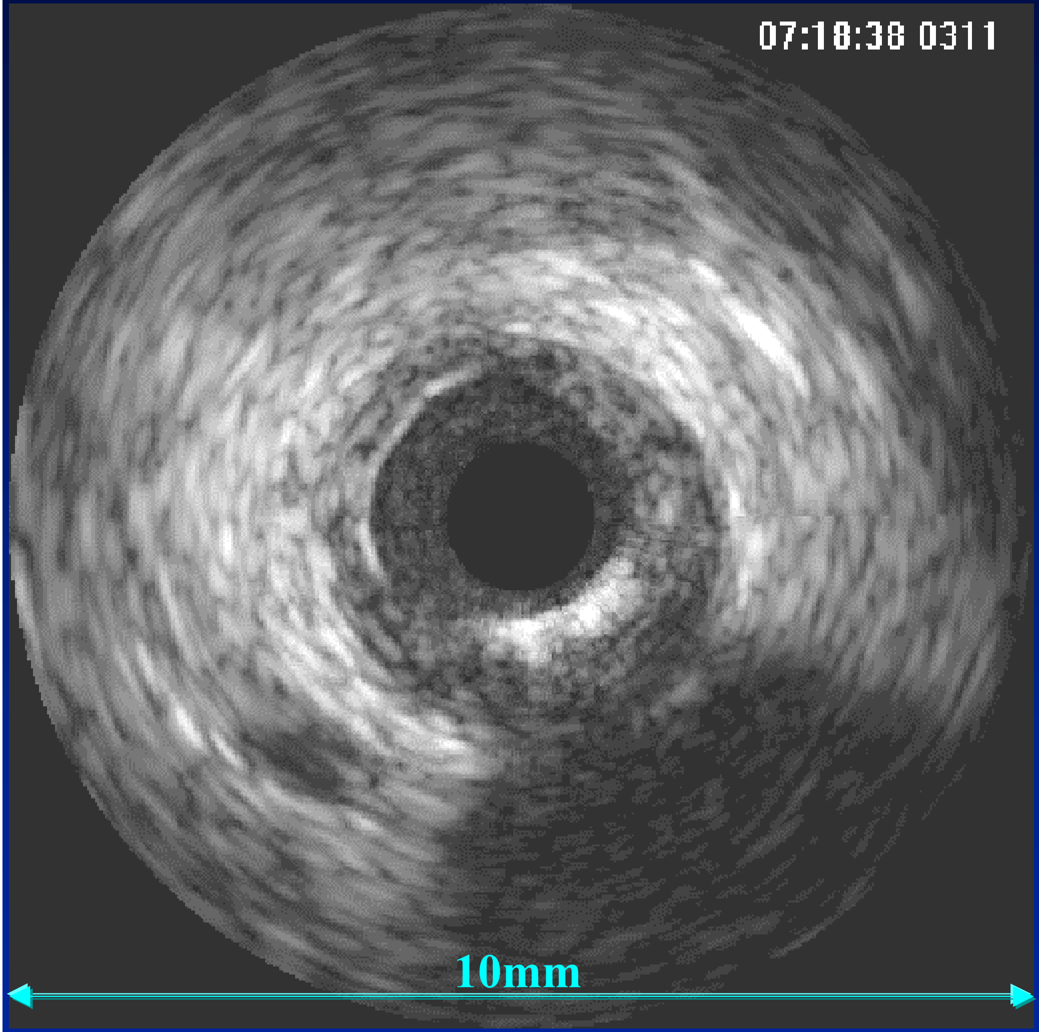
Vision-Soar: Multi-agent image interpretation of medical images

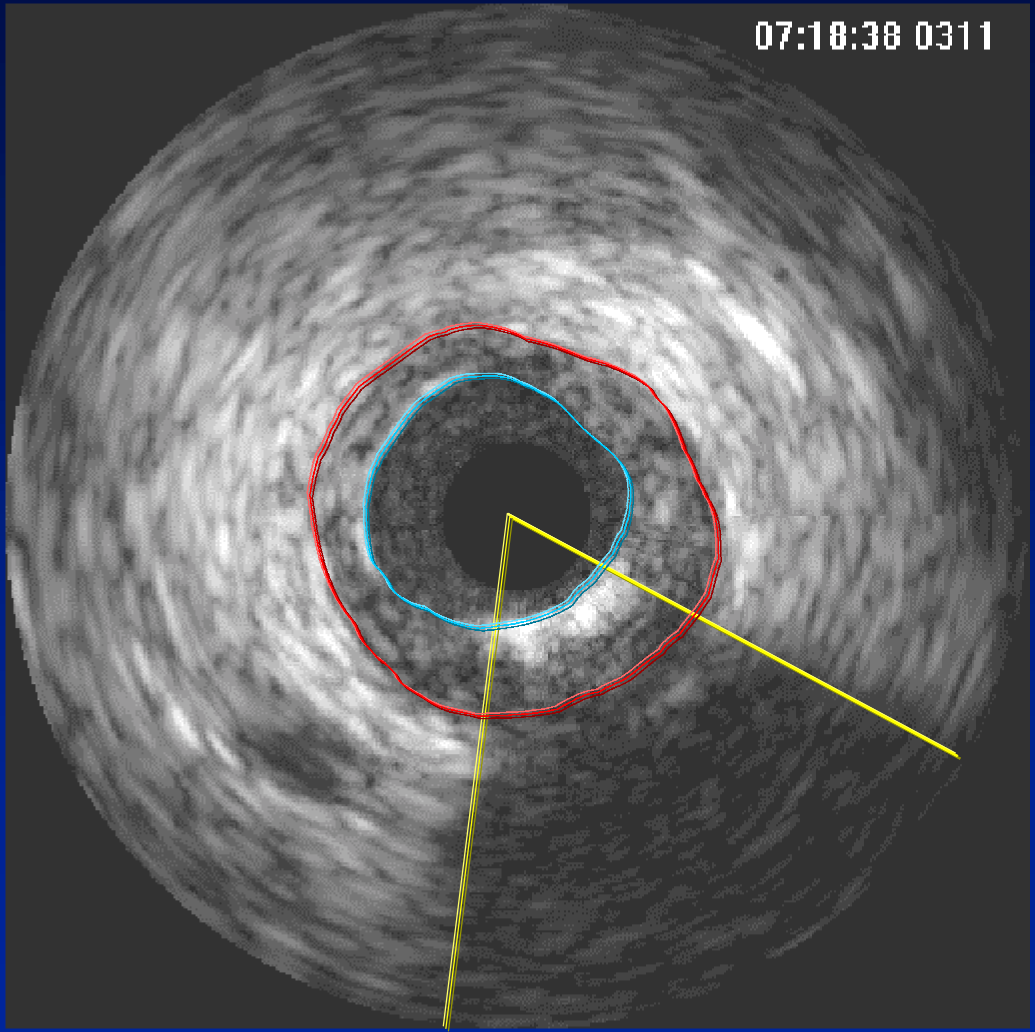
Ernst Bovenkamp

Division of Image Processing, Department of Radiology
Leiden University Medical Center, The Netherlands

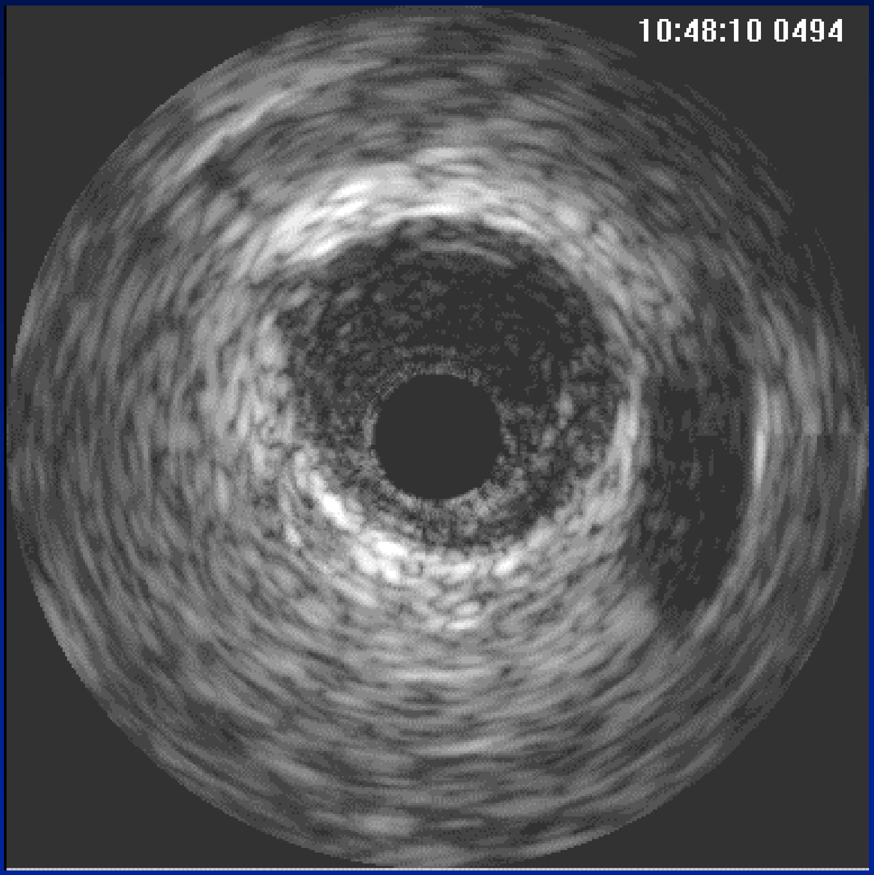
ernst@lkeb.azl.nl

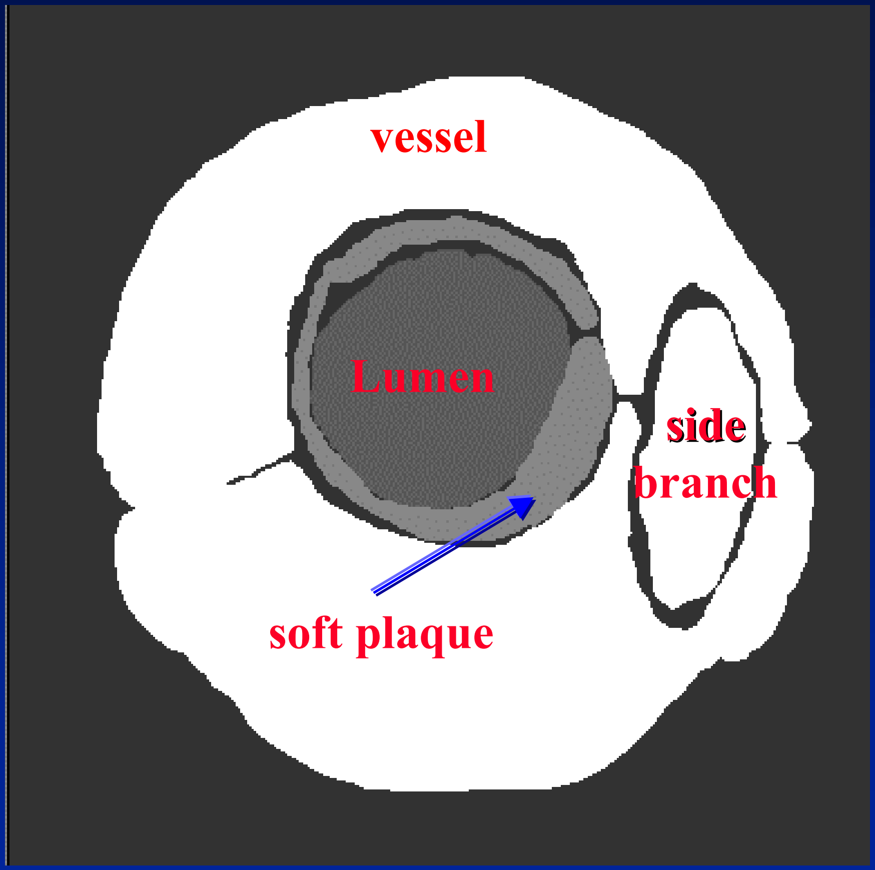
Problem domain (IVUS)


07:18:38 0311
10mm

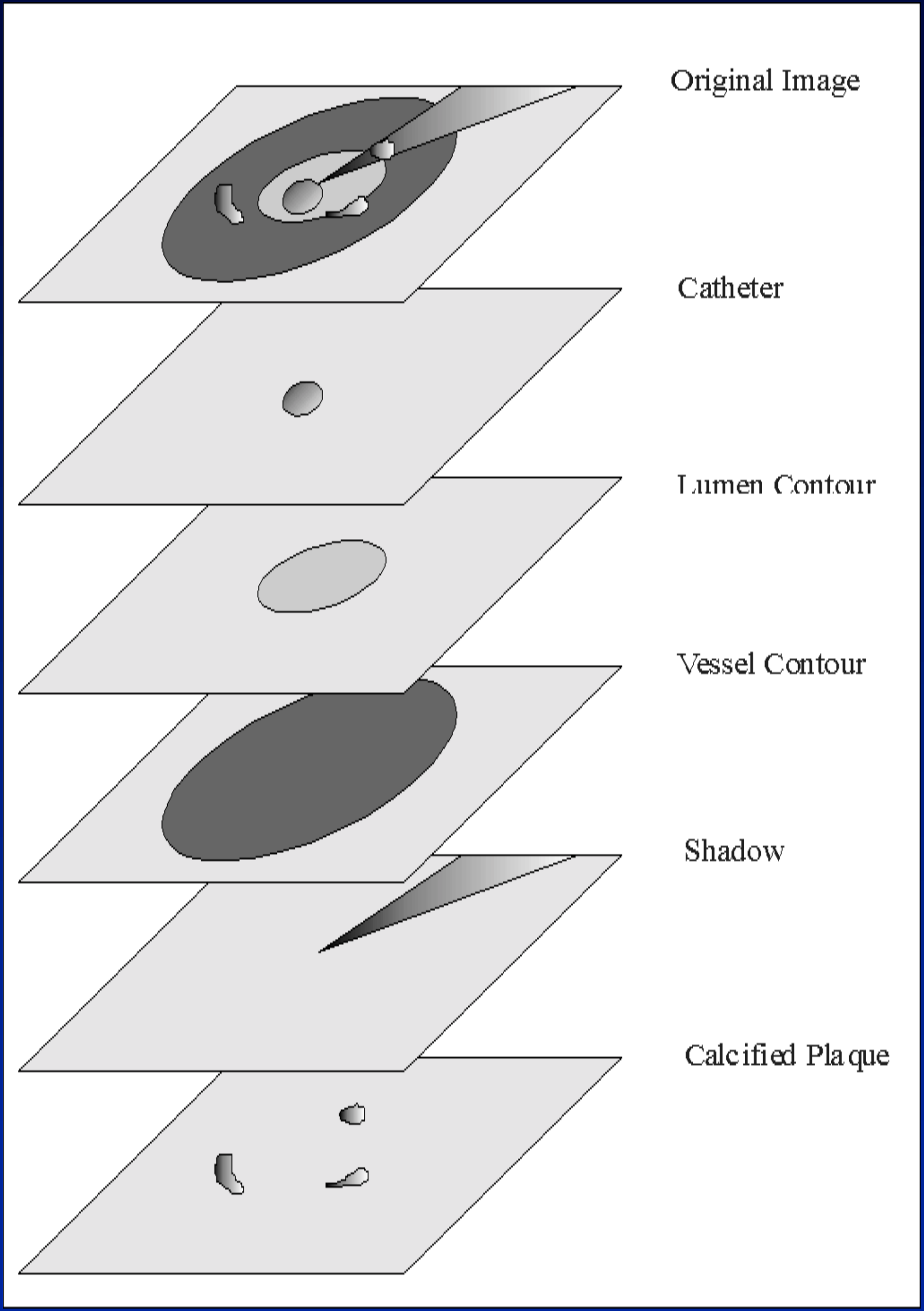

07:18:38 0311

Problem domain (IVUS)


10:48:10 0494

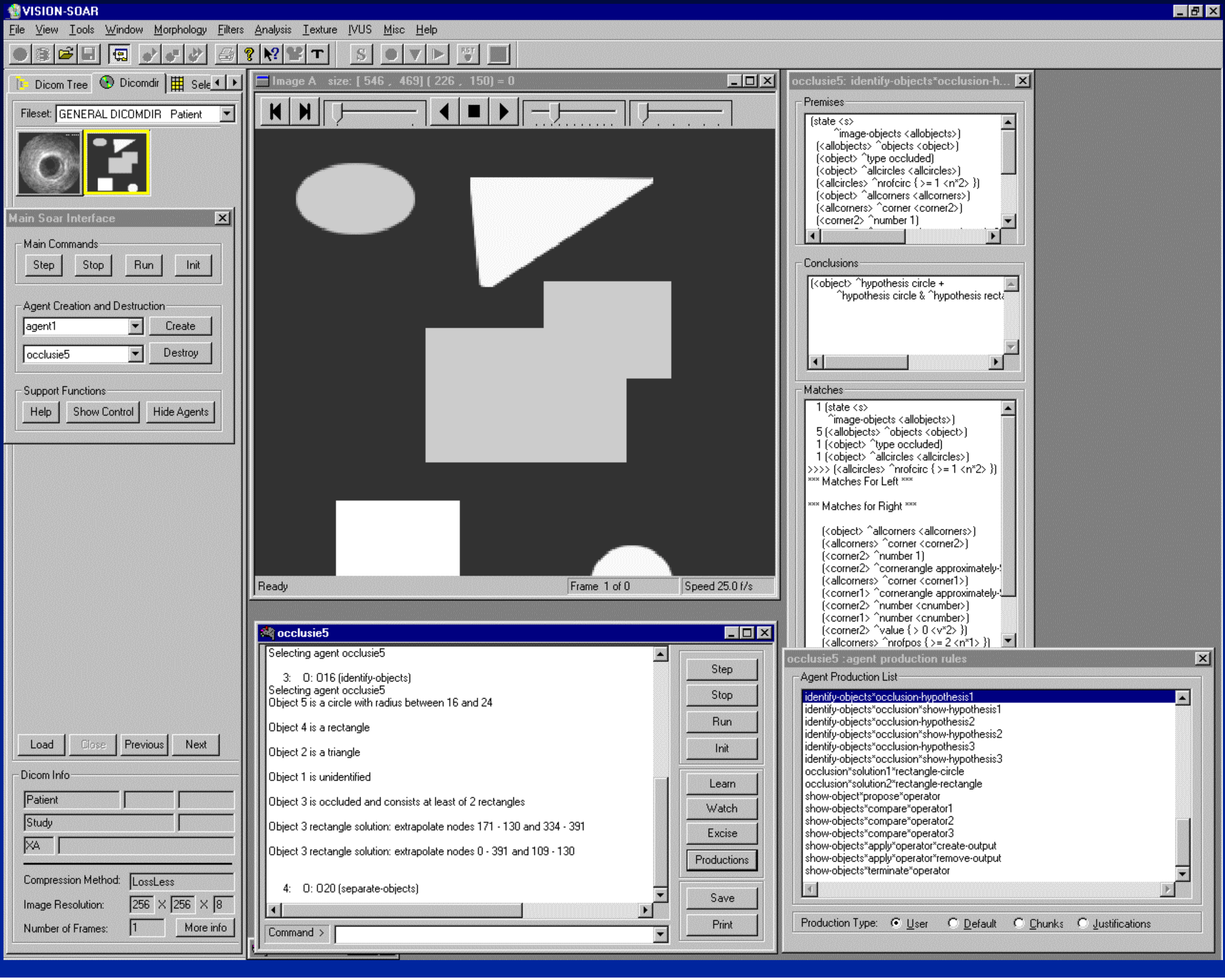

vessel
Lumen
side branch
soft plaque

IVUS Image interpretation


Original Image
Catheter
Lumen Contour
Vessel Contour
Shadow
Calcified Plaque

Some data

- Soar version: 6.2.5
- Agent development: Emacs + SDE 12.0
- Platform: Windows NT
- Software: C++, MDS 6.0


VISION-SOAR
File View Tools Window Morphology Filters Analysis Texture IVUS Misc Help
Dicom Tree
Dicomdir
Sele
Main Soar Interface
Main Commands
Step
Stop
Run
Init
Agent Creation and Destruction
Create
Destroy
Support Functions
Help
Show Control
Hide Agents
Load
Close
Previous
Next
Dicom Info
More info
Image A
occlusie5
Step
Stop
Run
Init
Learn
Watch
Excise
Productions
Save
Print
Command >
occlusie5: identify-objects*occlusion-h...
Premises
Conclusions
Matches
occlusie5 :agent production rules
Agent Production List

Fileset: GENERAL DICOMDIR Patient

agent1

occlusie5

Patient

Study

XA

Compression Method: LossLess

Image Resolution: 256 × 256 × 8

Number of Frames: 1

Image A size: [546 , 469] (226 , 150) = 0

Ready | Frame 1 of 0 | Speed 25.0 f/s

```
Selecting agent occlusie5

   3:    O: O16 (identify-objects)
Selecting agent occlusie5
Object 5 is a circle with radius between 16 and 24

Object 4 is a rectangle

Object 2 is a triangle

Object 1 is unidentified

Object 3 is occluded and consists at least of 2 rectangles

Object 3 rectangle solution: extrapolate nodes 171 - 130 and 334 - 391

Object 3 rectangle solution: extrapolate nodes 0 - 391 and 109 - 130


   4:    O: O20 (separate-objects)
```

Premises

```
(state <s>
      ^image-objects <allobjects>)
  (<allobjects> ^objects <object>)
  (<object> ^type occluded)
  (<object> ^allcircles <allcircles>)
  (<allcircles> ^nrofcirc { >= 1 <n*2> })
  (<object> ^allcorners <allcorners>)
  (<allcorners> ^corner <corner2>)
  (<corner2> ^number 1)
```

Conclusions

```
(<object> ^hypothesis circle +
        ^hypothesis circle & ^hypothesis recta
```

Matches

```
  1 (state <s>
     ^image-objects <allobjects>)
  5 (<allobjects> ^objects <object>)
  1 (<object> ^type occluded)
  1 (<object> ^allcircles <allcircles>)
>>>> (<allcircles> ^nrofcirc { >= 1 <n*2> })
*** Matches For Left ***

*** Matches for Right ***

    (<object> ^allcorners <allcorners>)
    (<allcorners> ^corner <corner2>)
    (<corner2> ^number 1)
    (<corner2> ^cornerangle approximately-
    (<allcorners> ^corner <corner1>)
    (<corner1> ^cornerangle approximately-
    (<corner2> ^number <cnumber>)
    (<corner1> ^number <cnumber>)
    (<corner2> ^value { > 0 <v*2> })
    (<allcorners> ^nrofpos { >= 2 <n*1> })
```

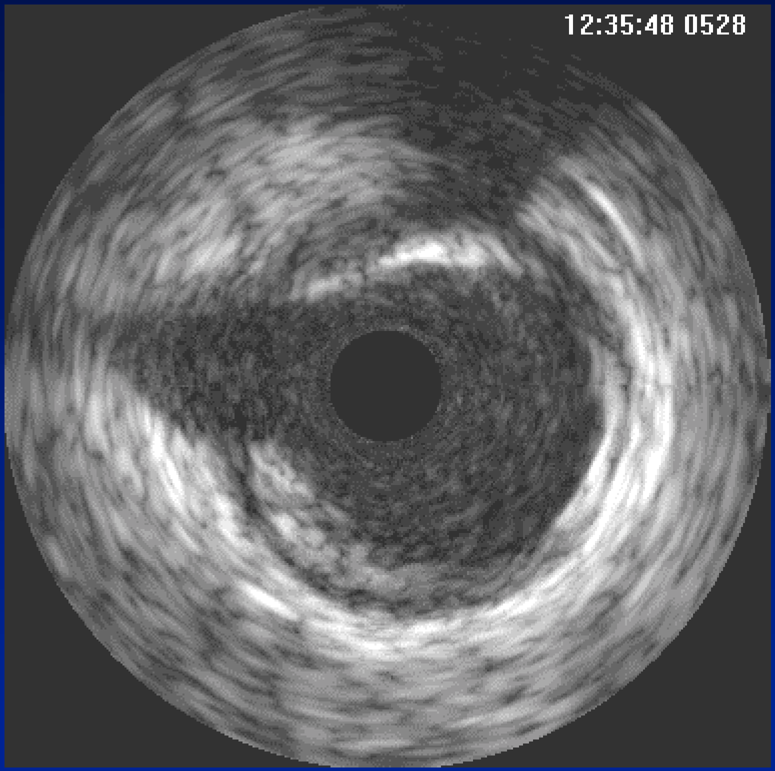
Agent Production List

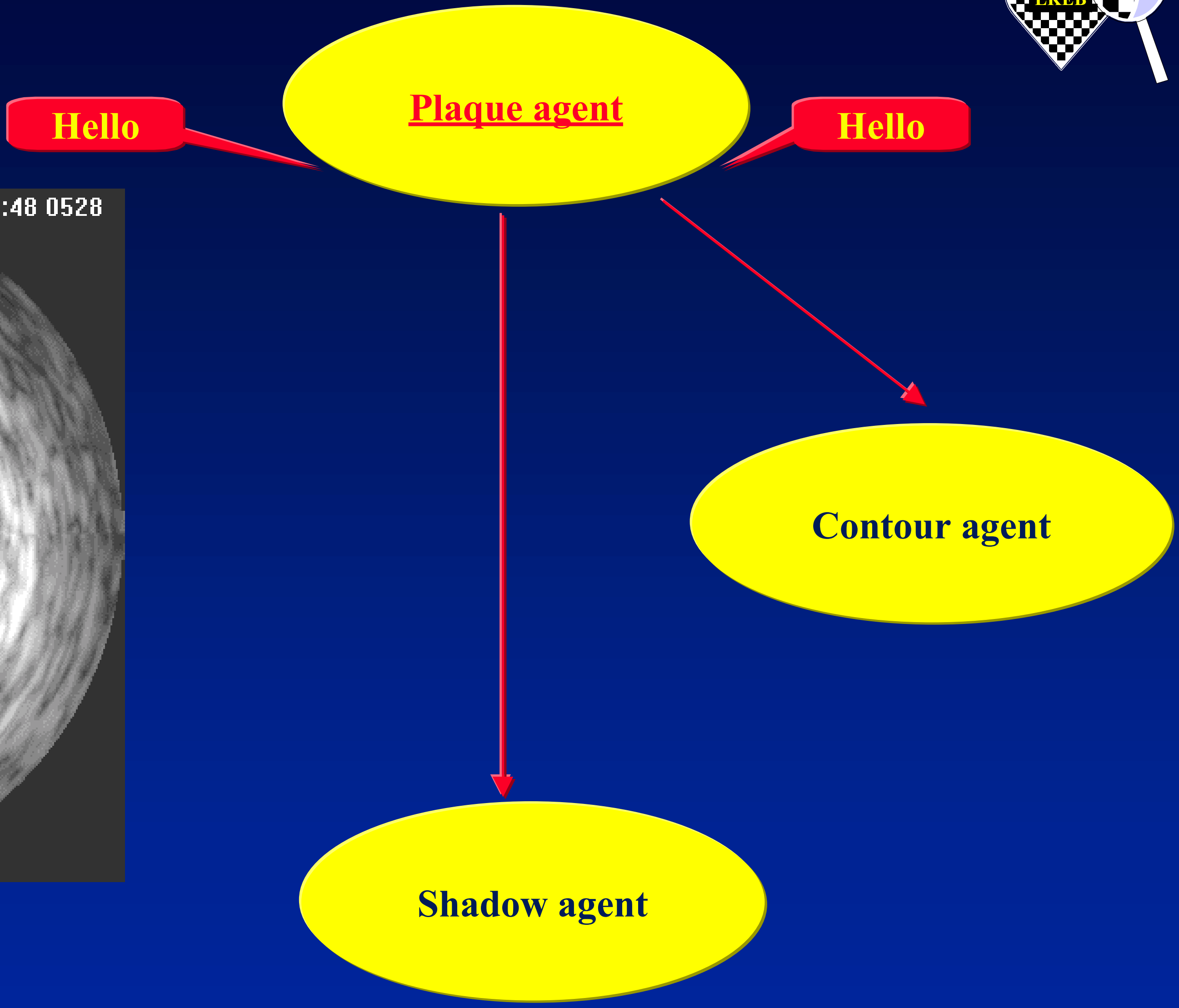
```
identify-objects*occlusion-hypothesis1
identify-objects*occlusion*show-hypothesis1
identify-objects*occlusion-hypothesis2
identify-objects*occlusion*show-hypothesis2
identify-objects*occlusion-hypothesis3
identify-objects*occlusion*show-hypothesis3
occlusion*solution1*rectangle-circle
occlusion*solution2*rectangle-rectangle
show-object*propose*operator
show-objects*compare*operator1
show-objects*compare*operator2
show-objects*compare*operator3
show-objects*apply*operator*create-output
show-objects*apply*operator*remove-output
show-objects*terminate*operator
```

Production Type: ● User ○ Default ○ Chunks ○ Justifications

Agents at work

- Demonstration of communicationprotocol
- Demonstration of imageprocessing actions
- Demonstration build-up of internal models
- Demonstration of exchange of image interpretation information


12:35:48 0528



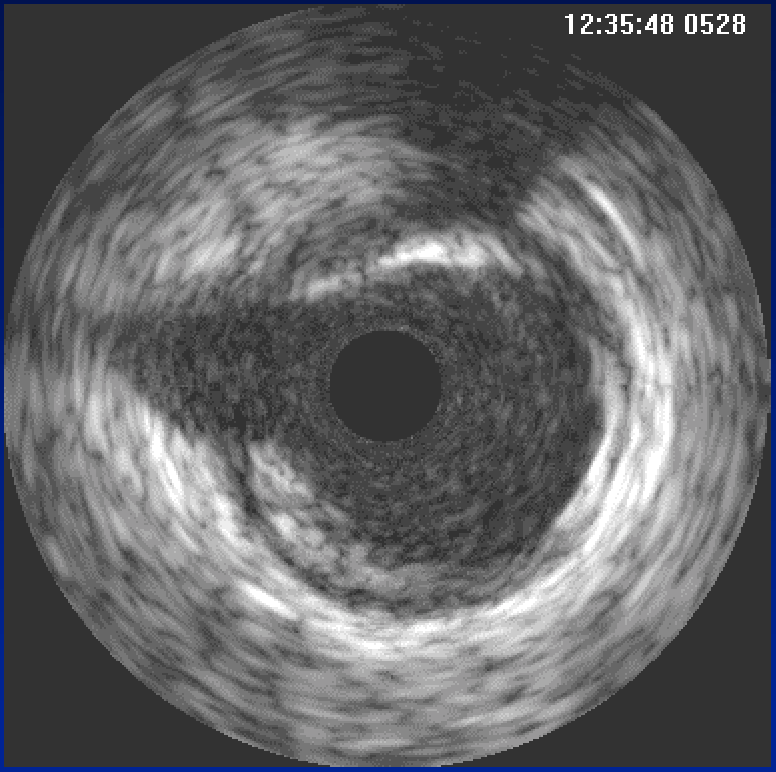
Hello

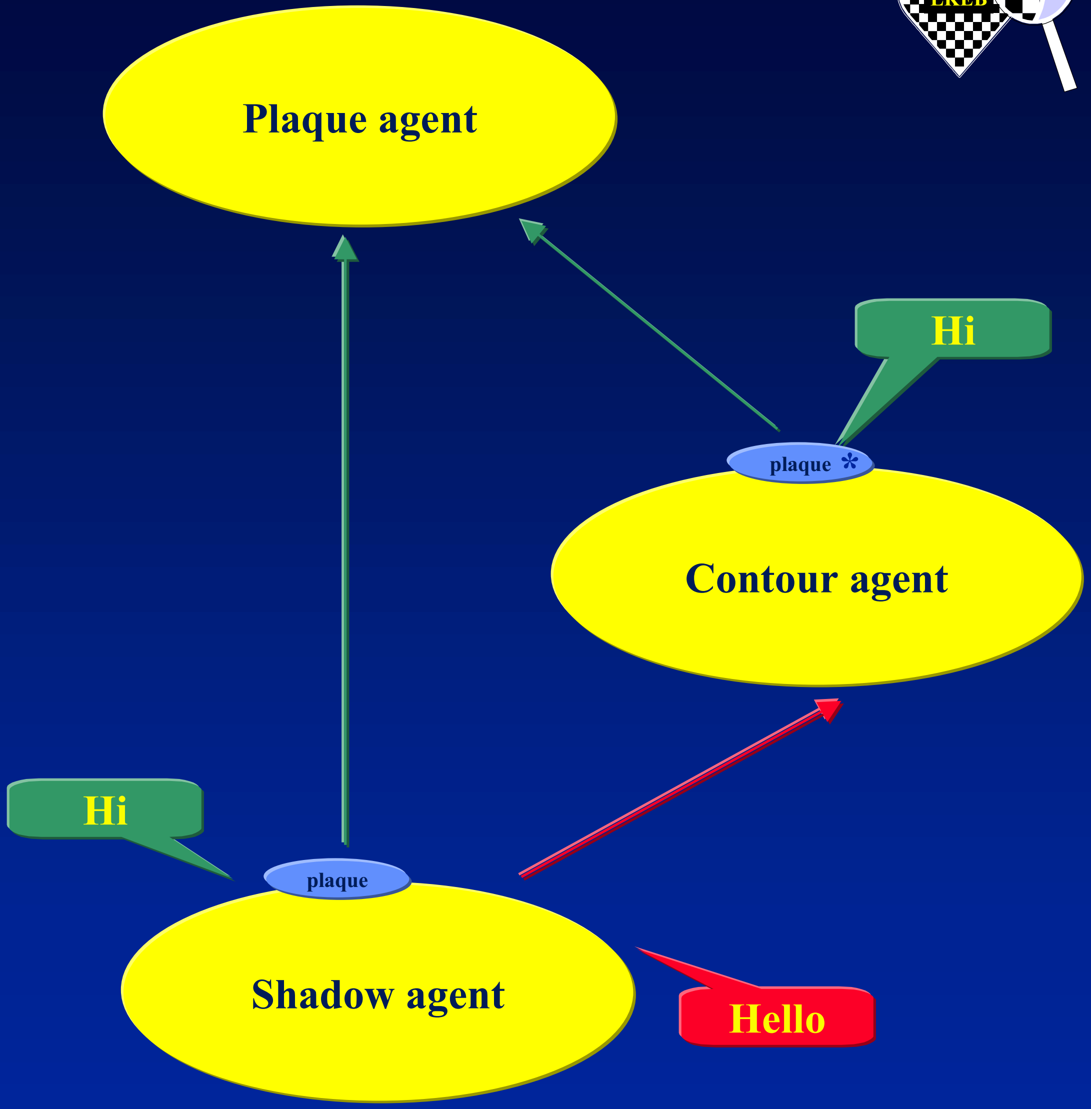
Plaque agent

Hello

Contour agent

Shadow agent


12:35:48 0528



Plaque agent

Hi

plaque *

Contour agent

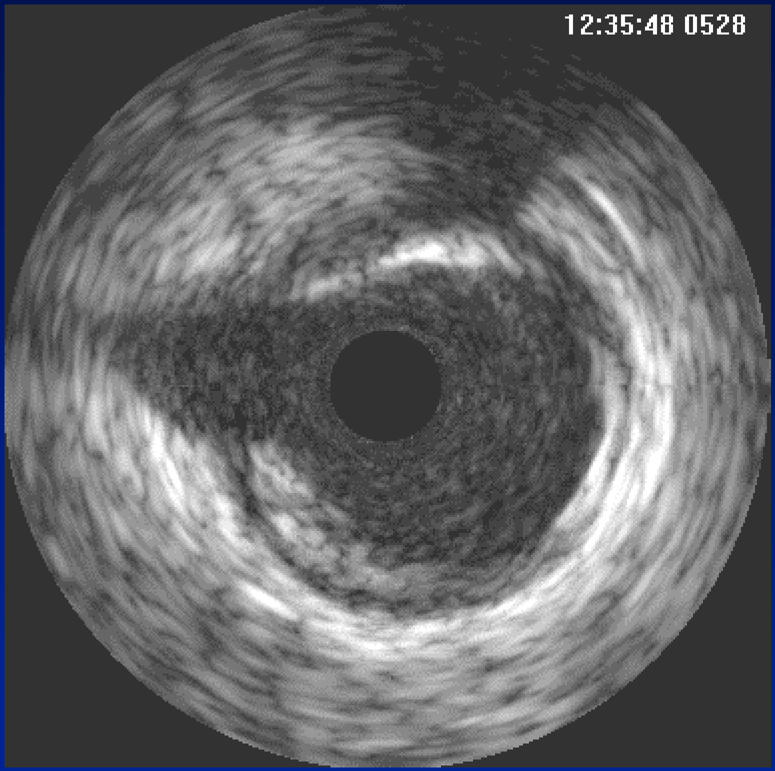
Hi

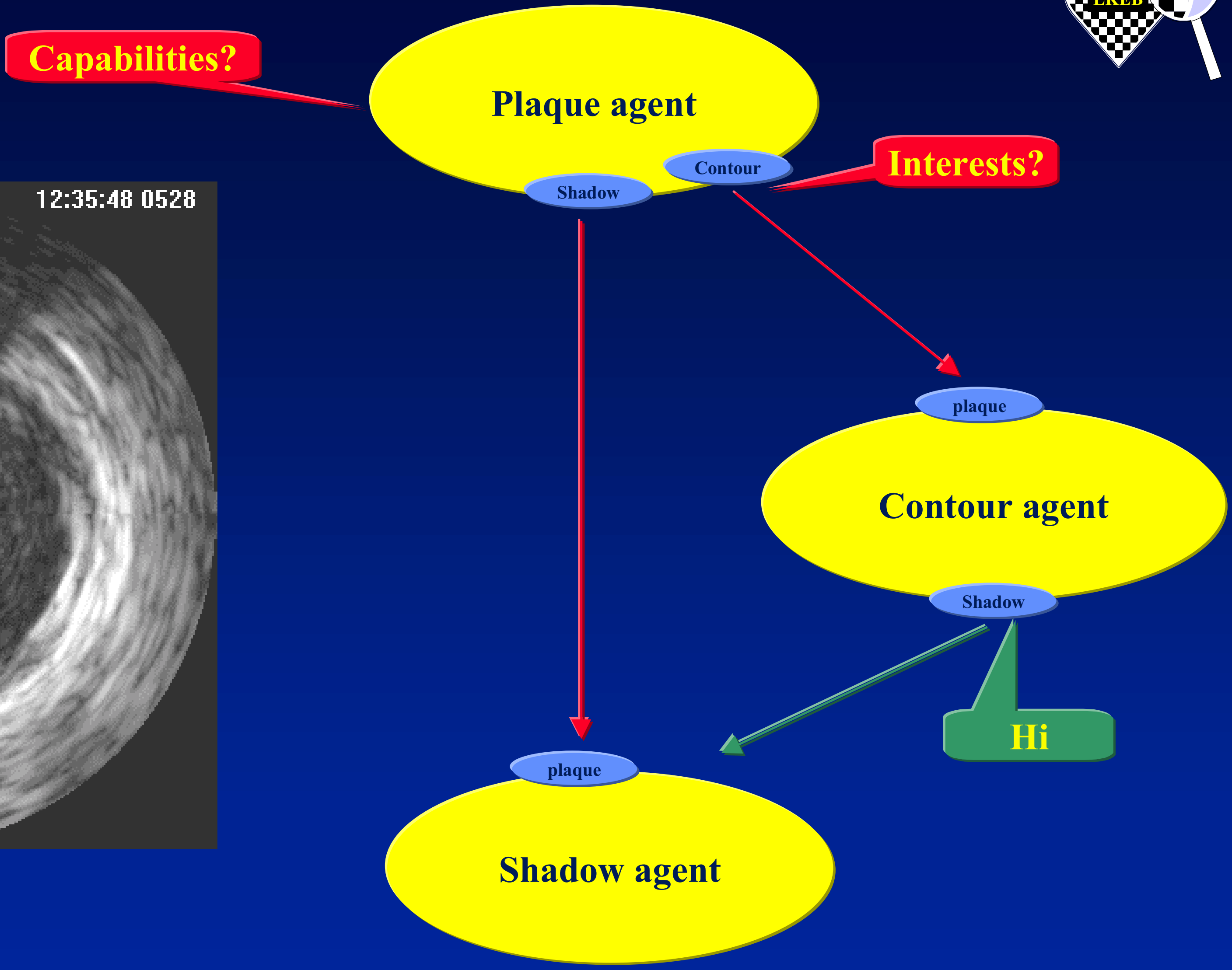
plaque

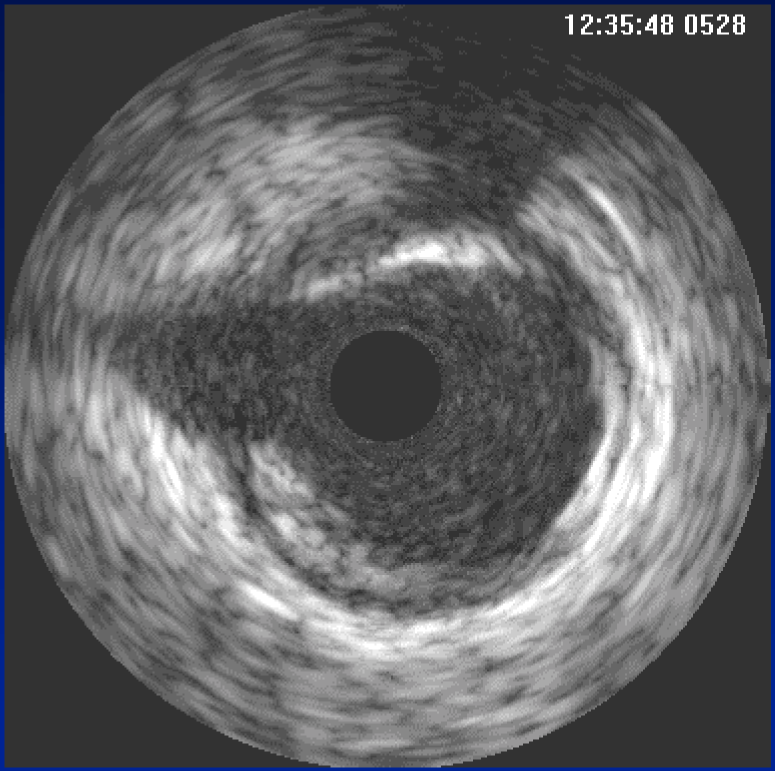
Shadow agent

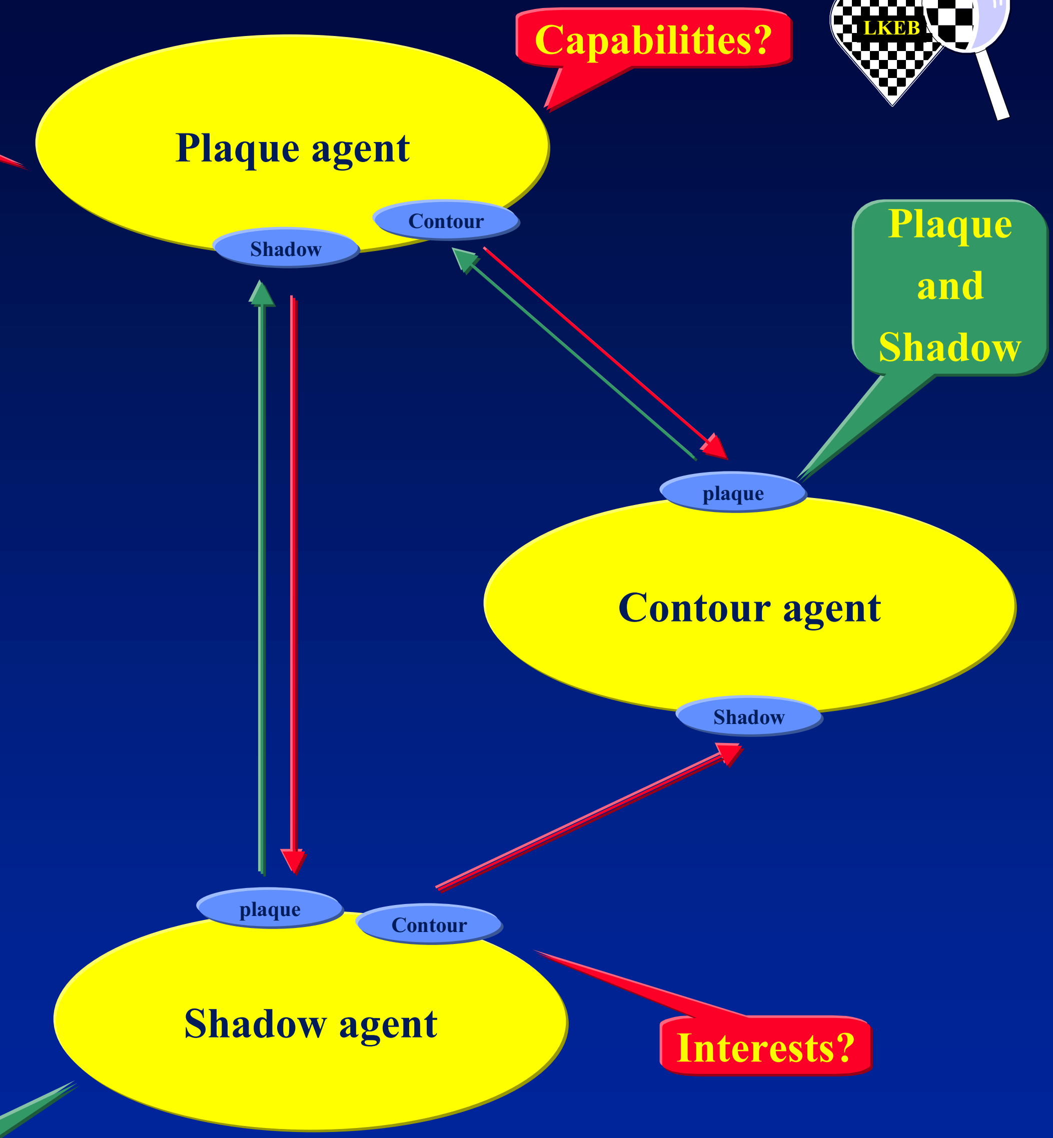
Hello

LKEB


12:35:48 0528


Capabilities?
Plaque agent
Shadow
Contour
Interests?
plaque
Contour agent
Shadow
Hi
plaque
Shadow agent


12:35:48 0528


Plaque agent
Shadow
Contour
Contour agent
plaque
Shadow
Shadow agent
plaque
Contour

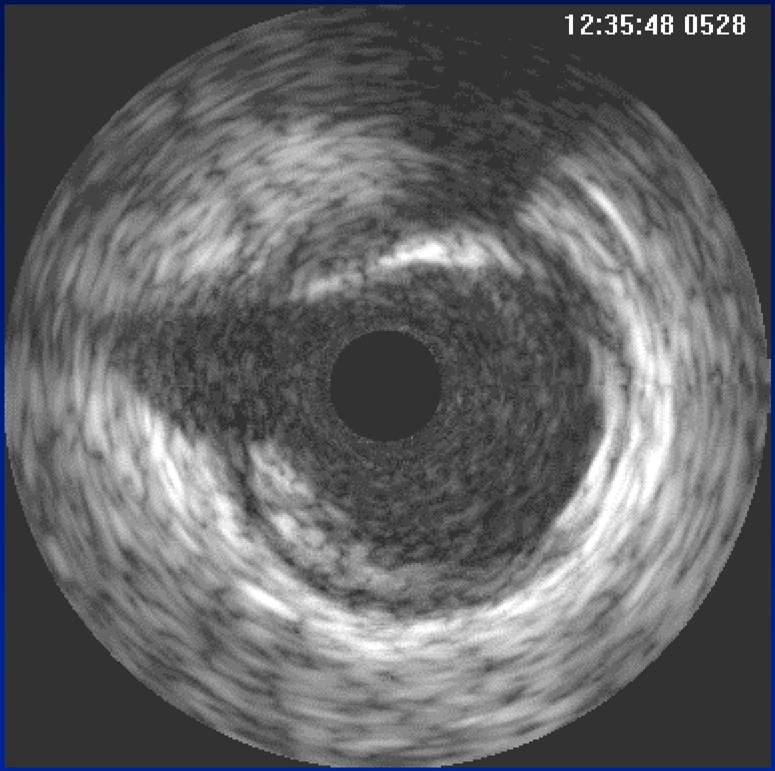
Interests?

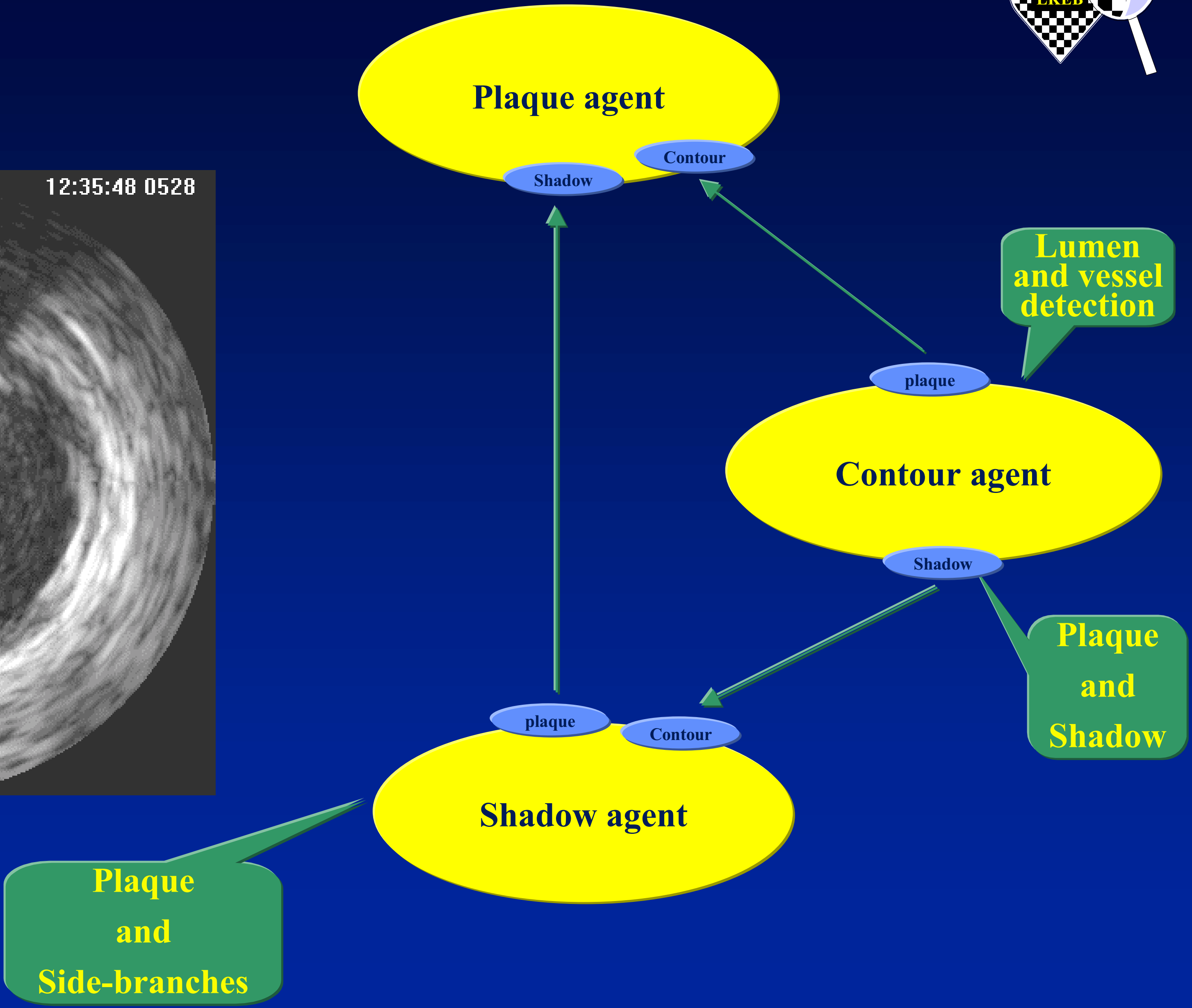
Capabilities?

Plaque
and
Shadow

Interests?

Shadow
detection





Plaque agent

Shadow

Contour

Lumen and vessel detection

plaque

Contour agent

Shadow

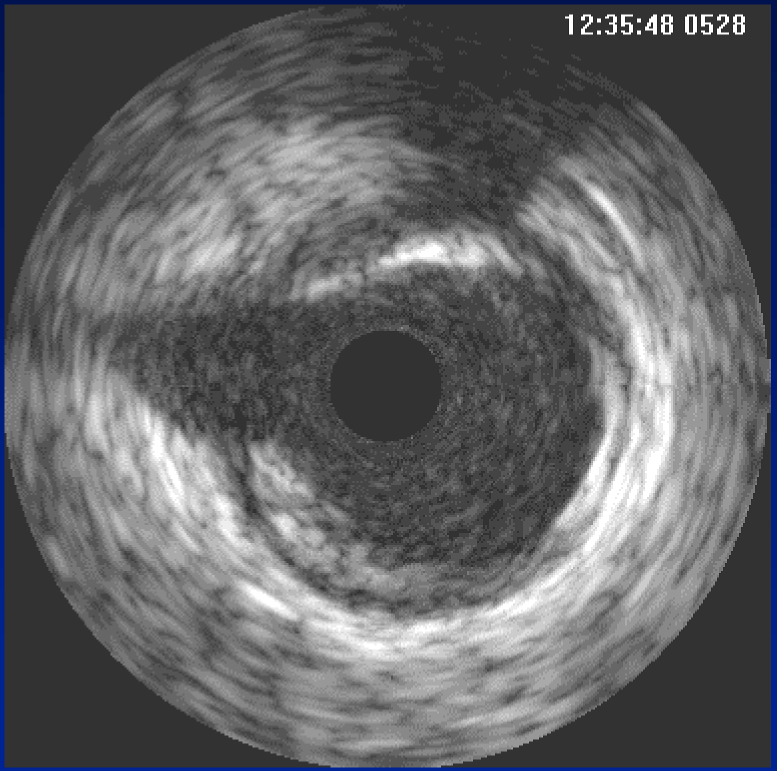
Plaque and Shadow

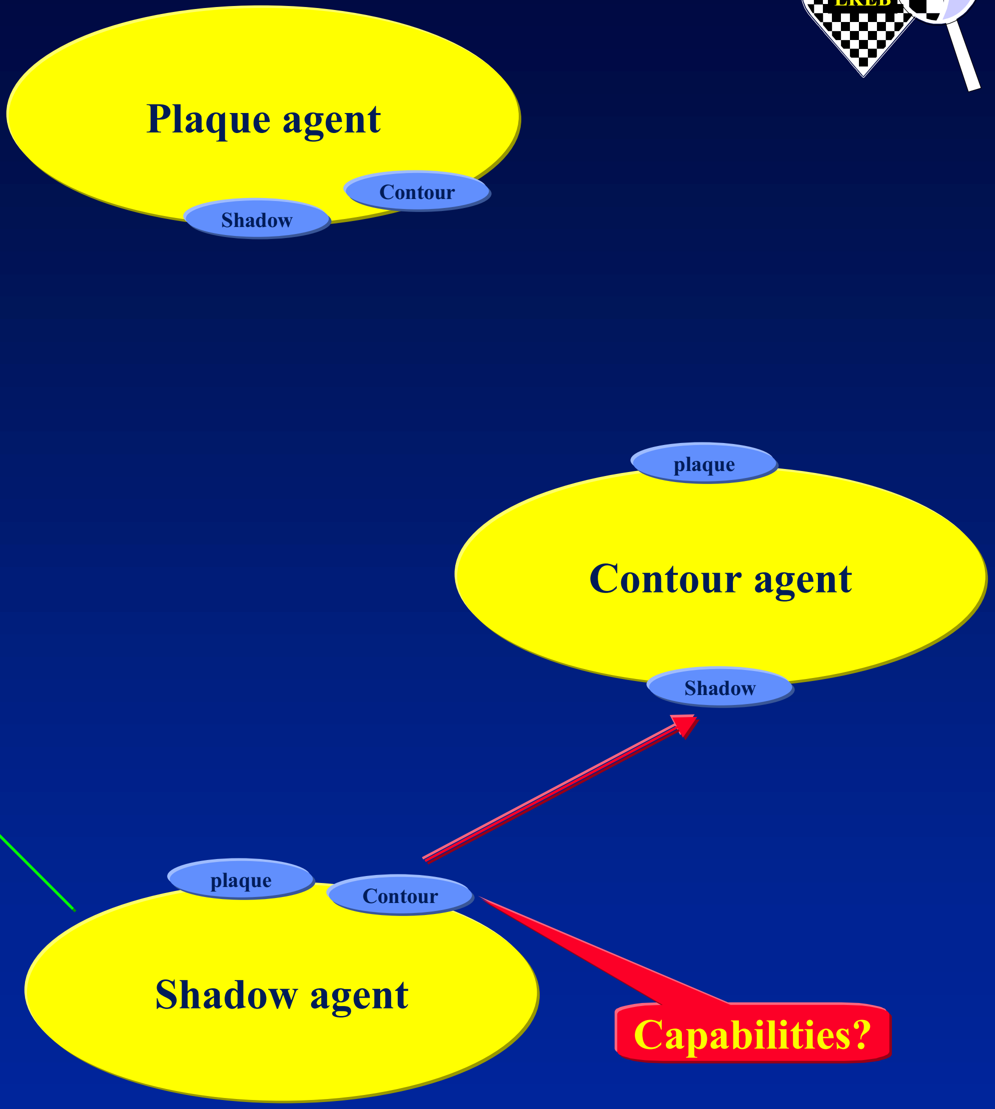
plaque

Contour

Shadow agent

Plaque and Side-branches


12:35:48 0528



Plaque agent

Shadow

Contour

plaque

Contour agent

Shadow

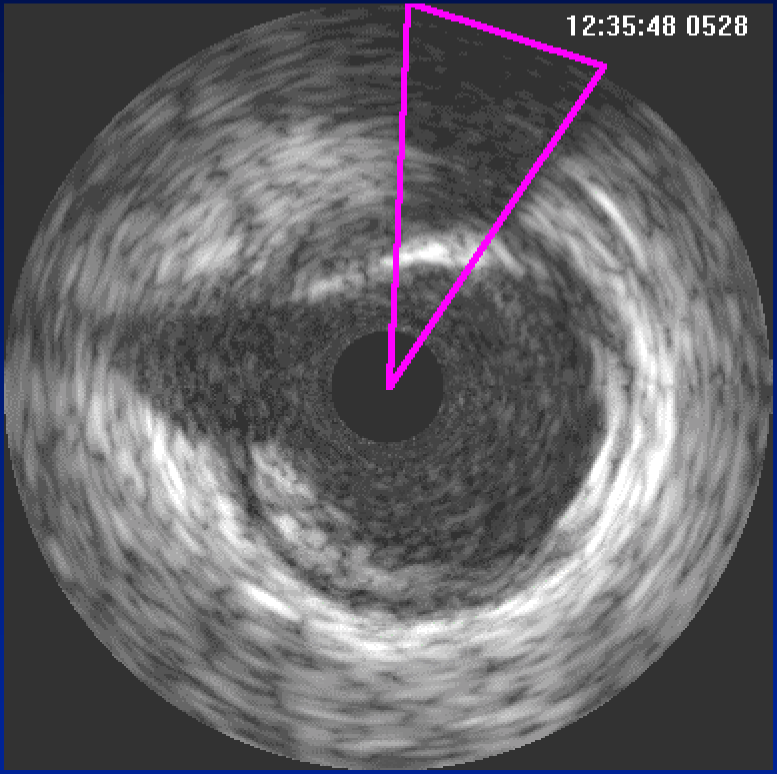
plaque

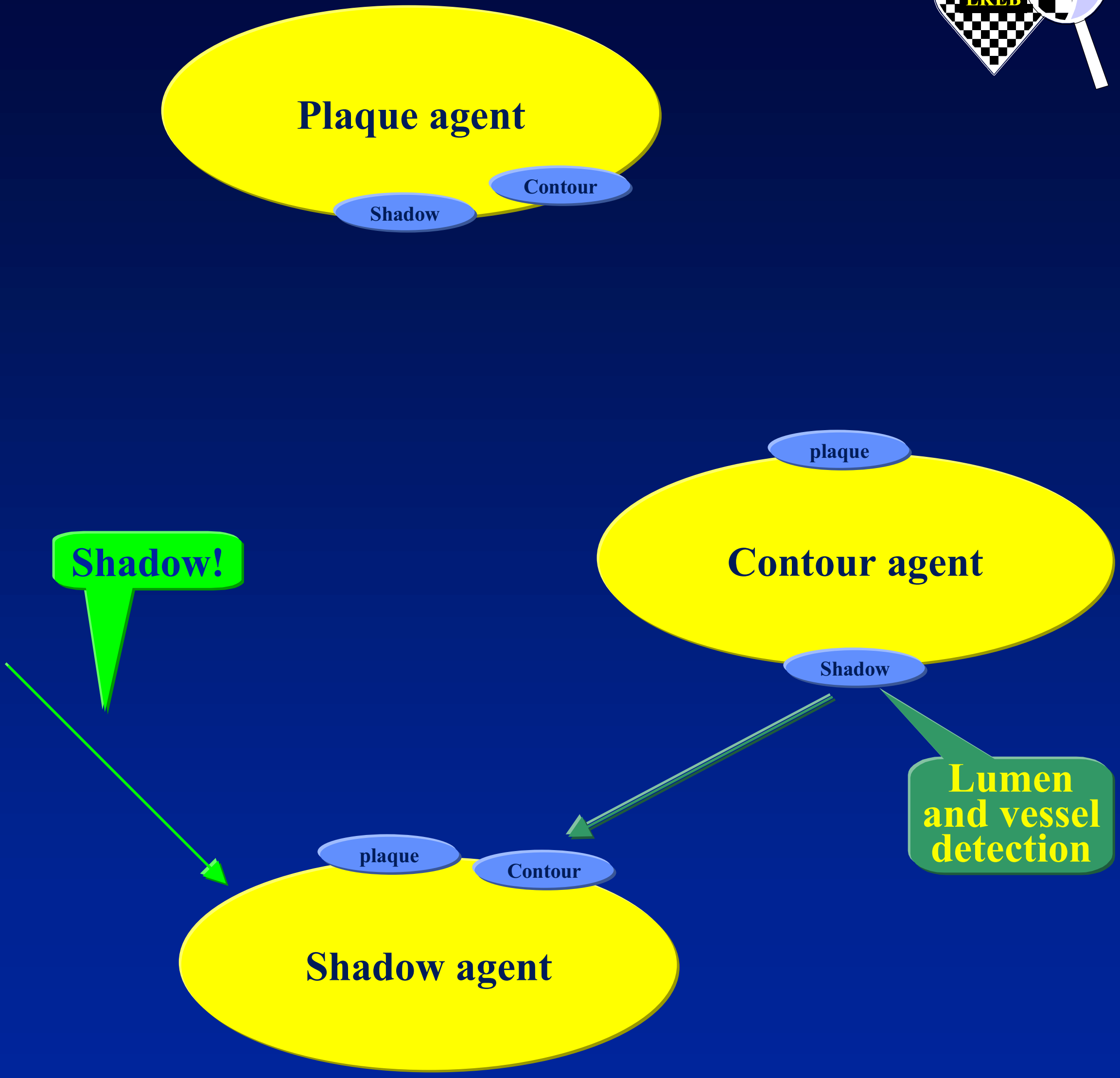
Contour

Shadow agent

Shadow?

Capabilities?




Plaque agent

Shadow

Contour

plaque

Contour agent

Shadow

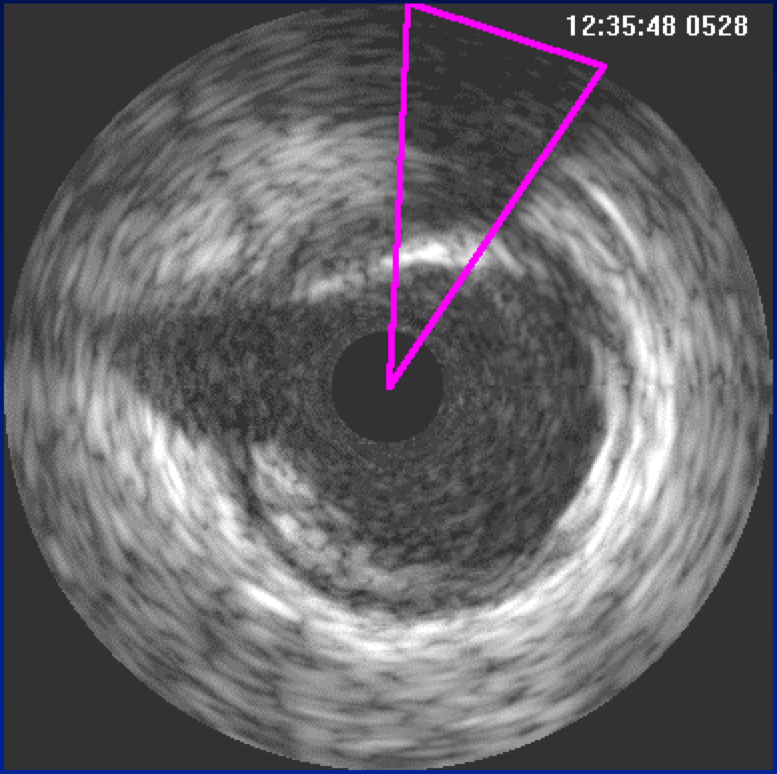
Shadow!

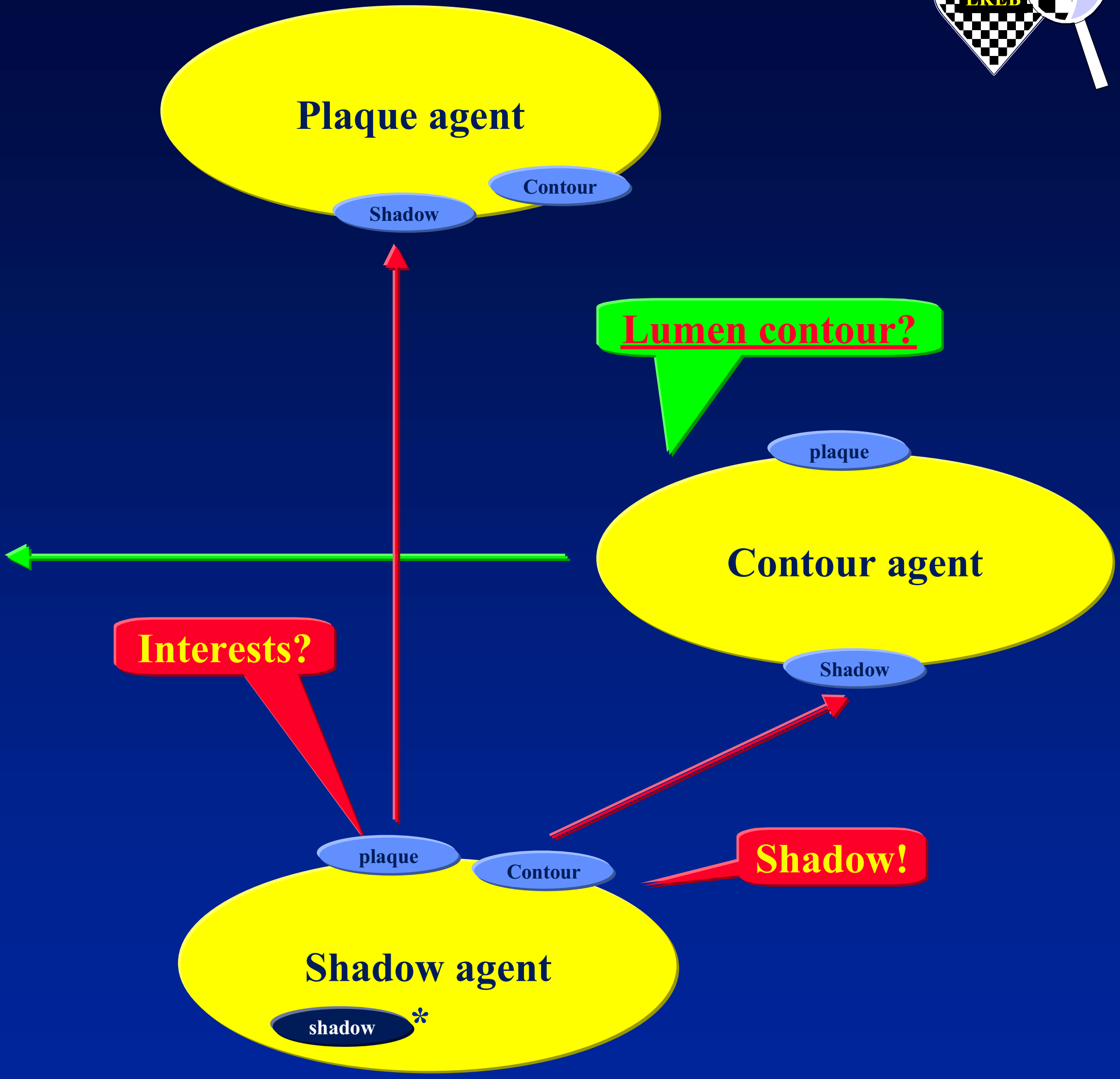
Lumen and vessel detection

plaque

Contour

Shadow agent





Plaque agent

Shadow

Contour

Lumen contour?

plaque

Contour agent

Shadow

Interests?

plaque

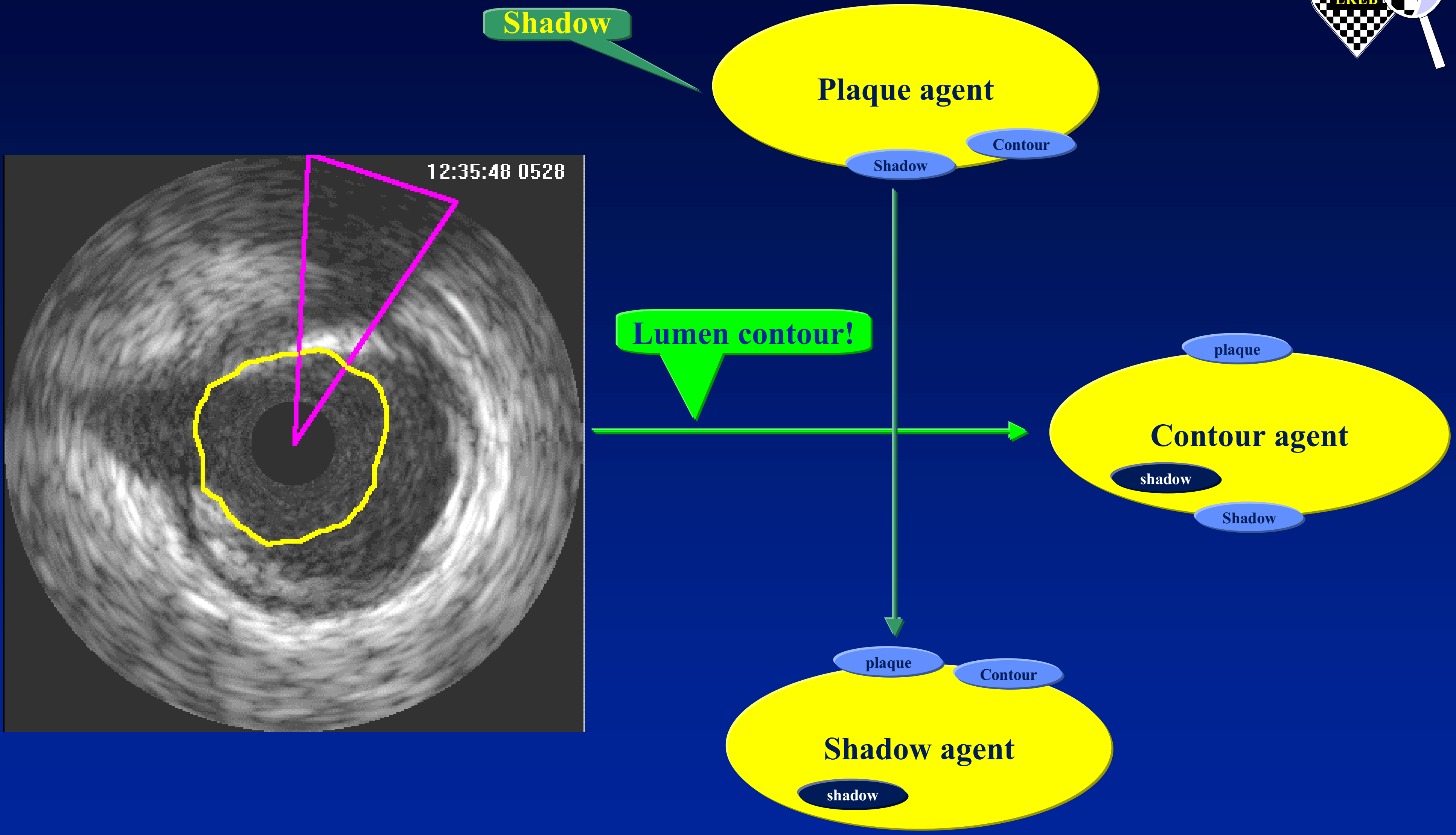
Contour

Shadow!

Shadow agent

shadow*

LKEB



Shadow

Plaque agent

Contour

Shadow

Lumen contour!

plaque

Contour agent

shadow

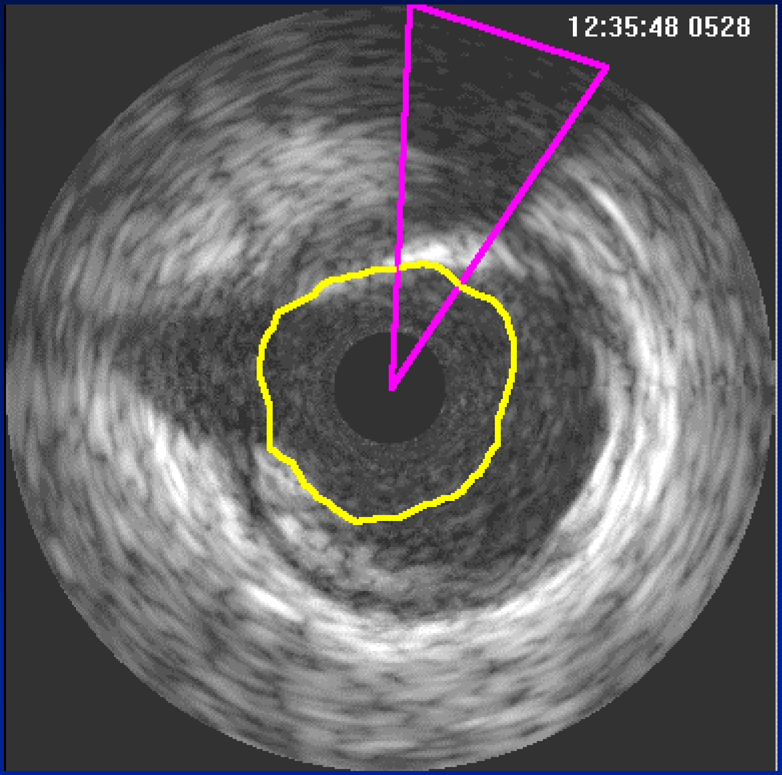
Shadow

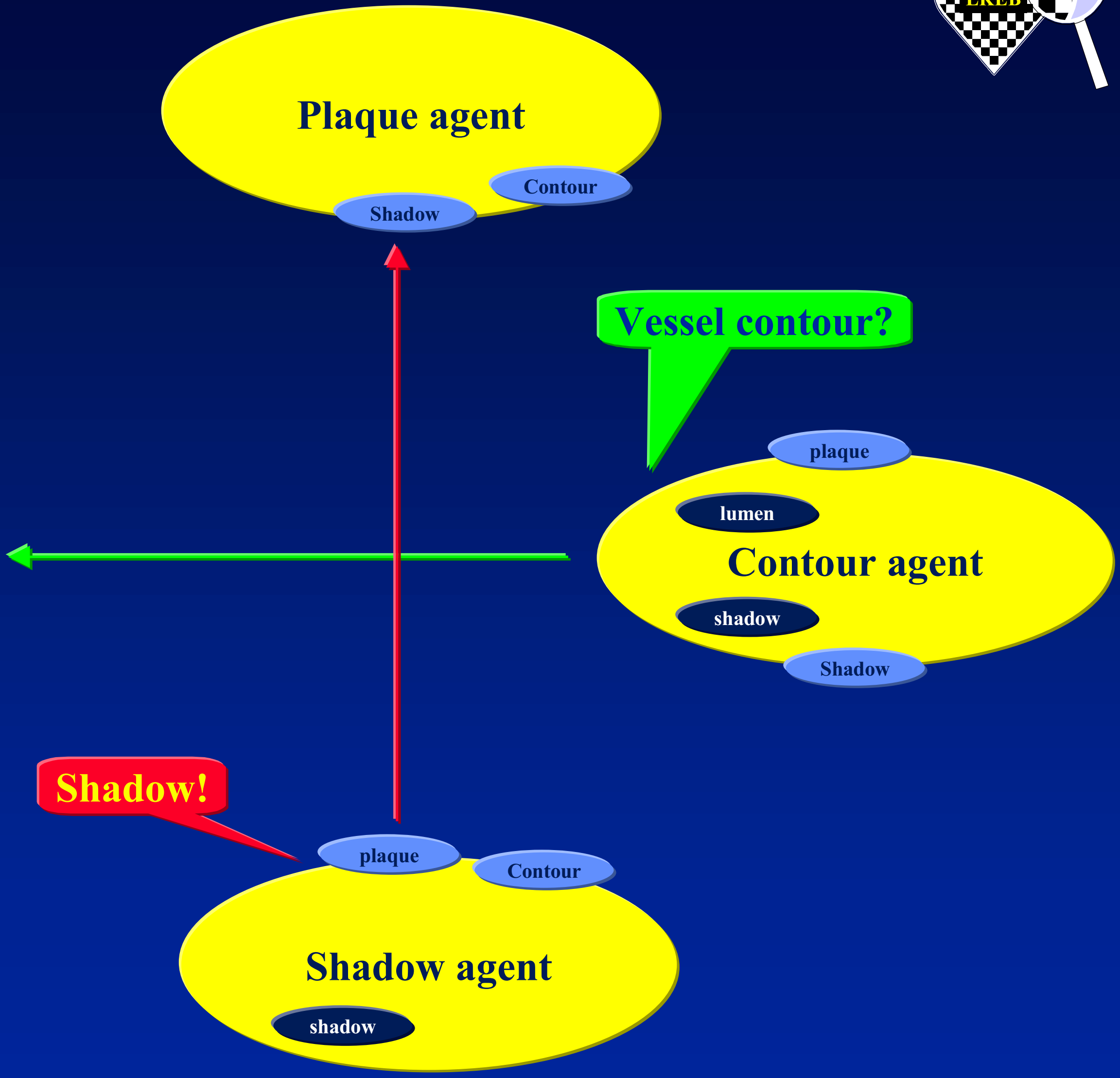
plaque

Contour

Shadow agent

shadow





Plaque agent

Shadow

Contour

Vessel contour?

plaque

lumen

Contour agent

shadow

Shadow

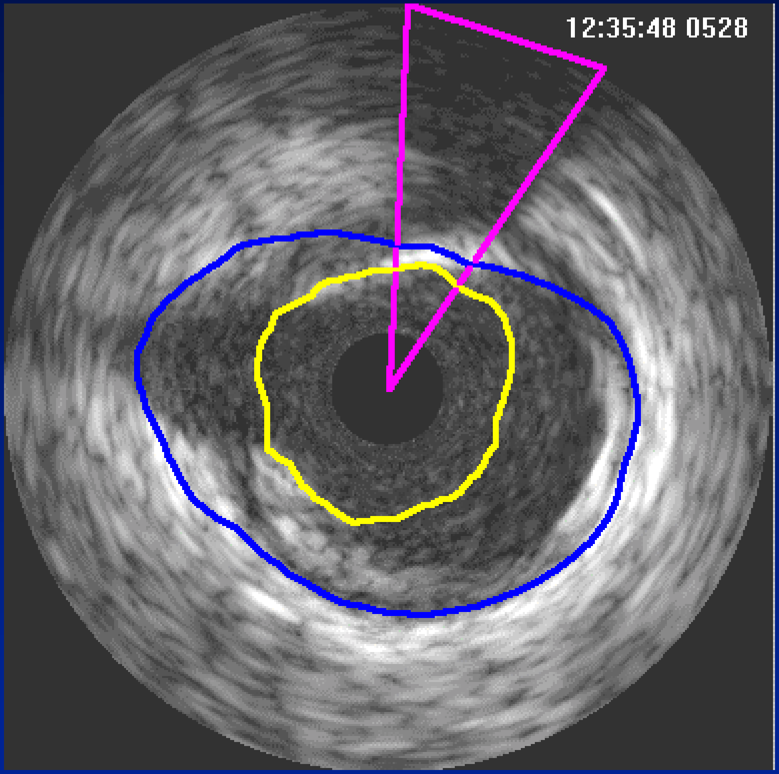
Shadow!

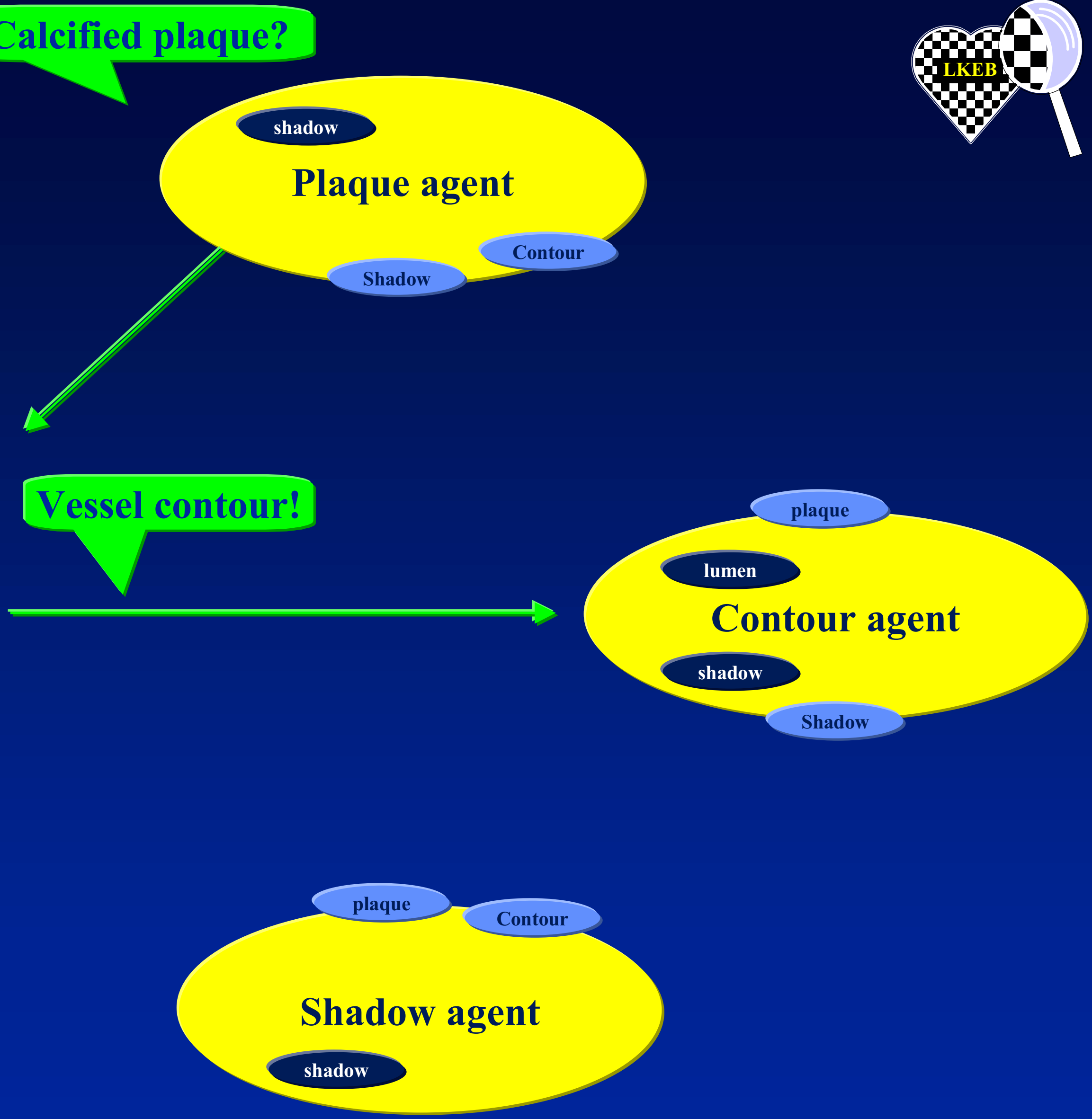
plaque

Contour

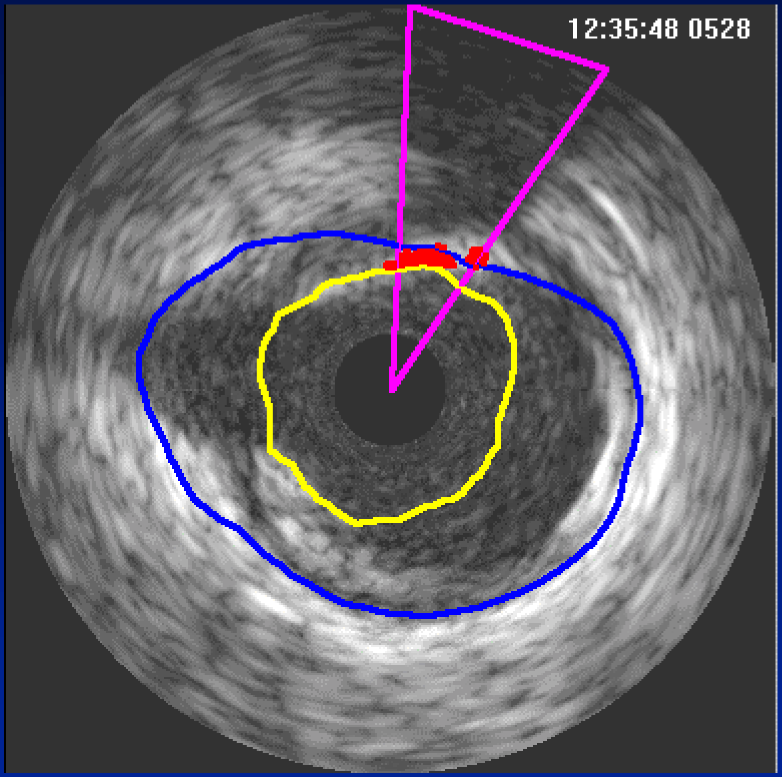
Shadow agent

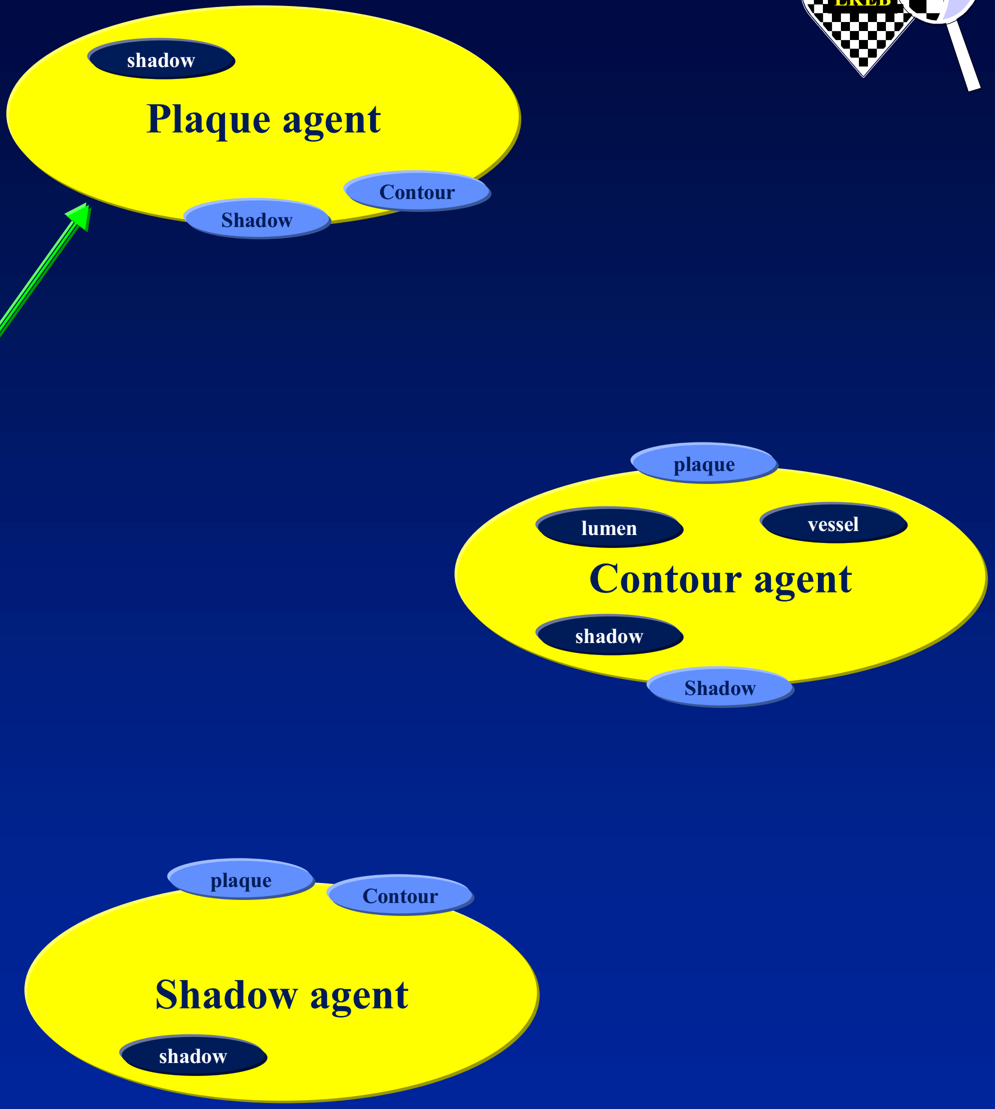
shadow


12:35:48 0528


Calcified plaque?
shadow
Plaque agent
Contour
Shadow
Vessel contour!
plaque
lumen
Contour agent
shadow
Shadow
plaque
Contour
Shadow agent
shadow

Calcified plaque!





Plaque agent

shadow

Shadow

Contour

Contour agent

plaque

lumen

vessel

shadow

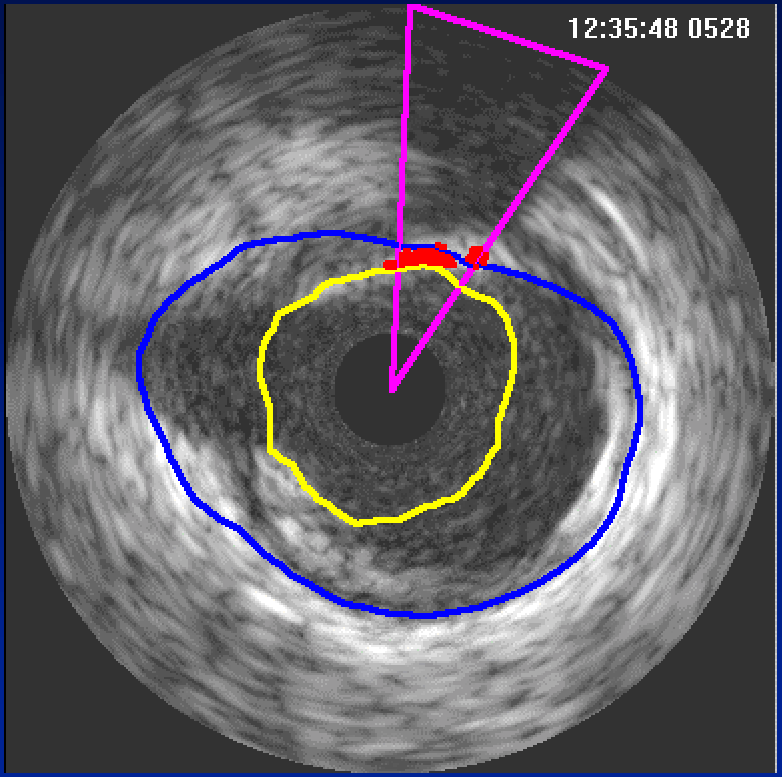
Shadow

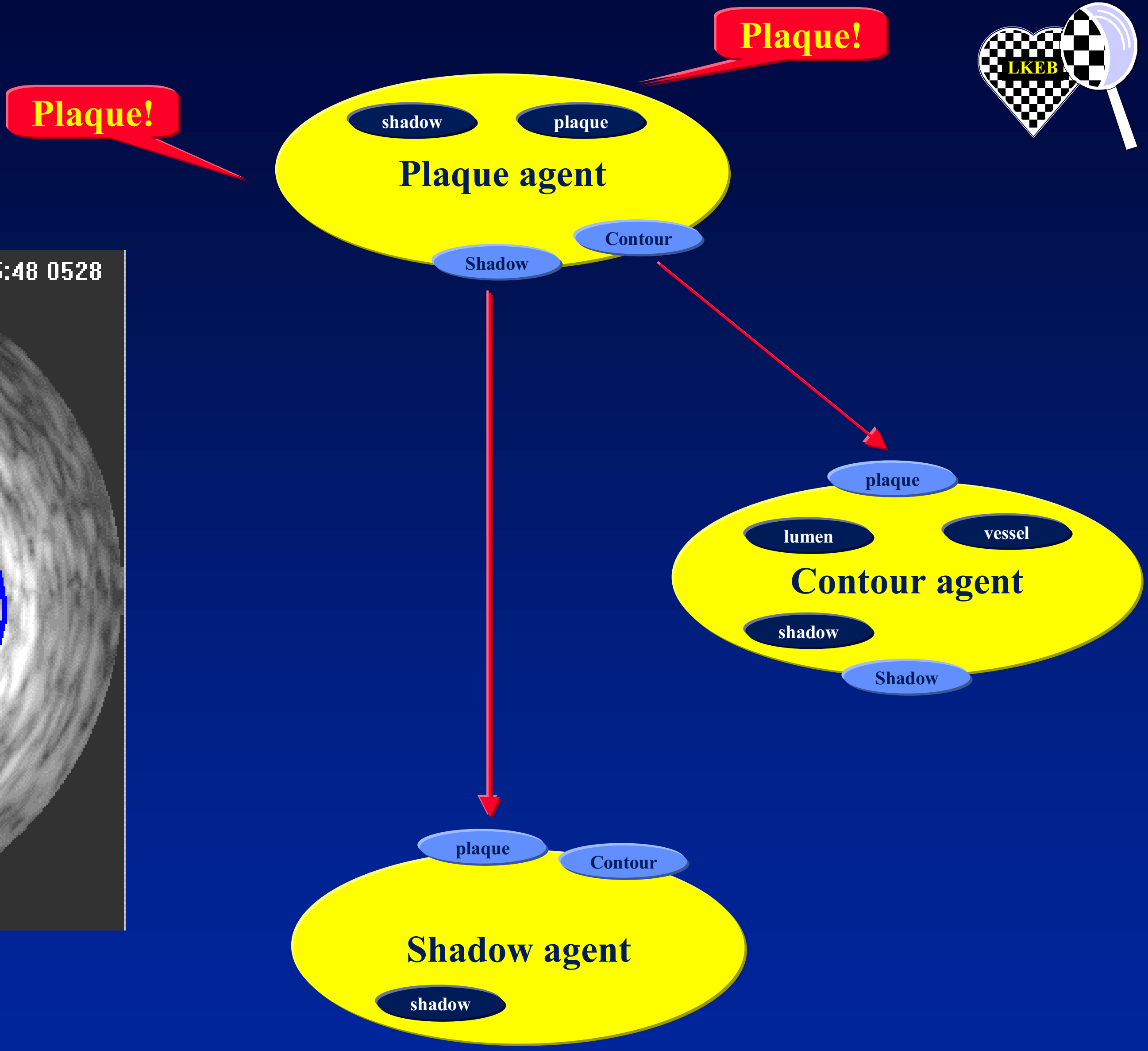
Shadow agent

plaque

Contour

shadow





Plaque!

Plaque!

Plaque agent

shadow

plaque

Shadow

Contour

Contour agent

plaque

lumen

vessel

shadow

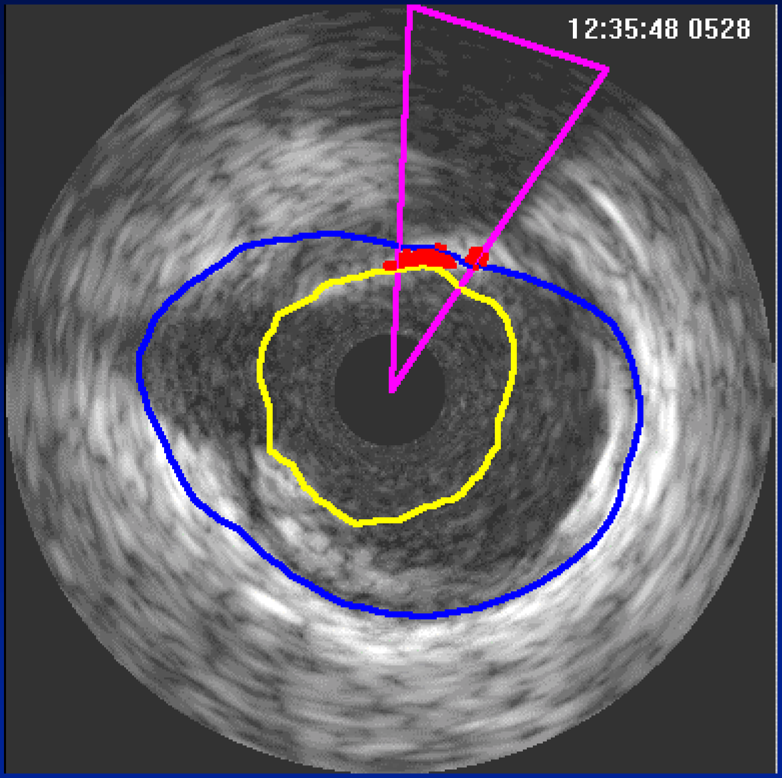
Shadow

Shadow agent

plaque

Contour

shadow

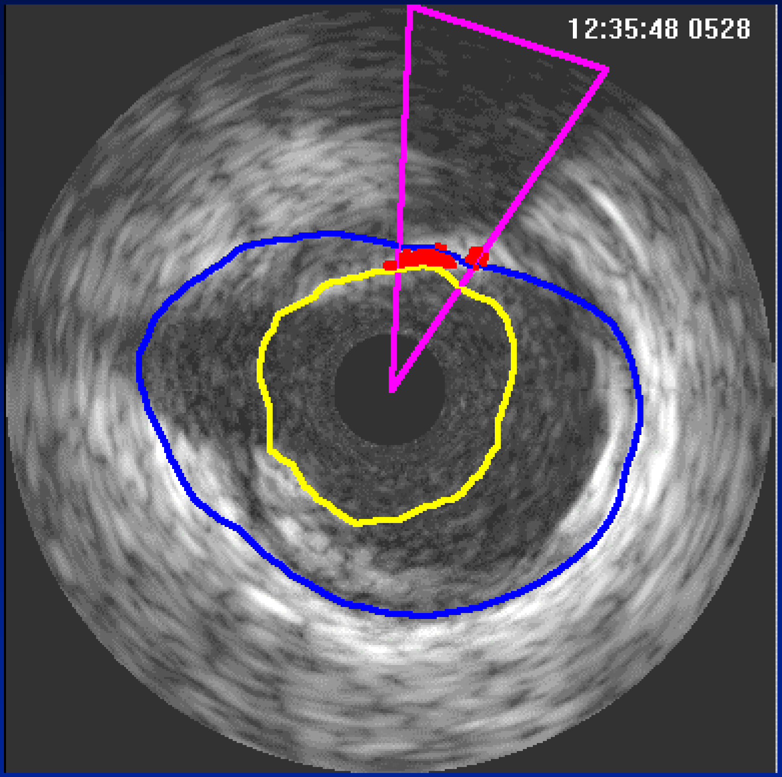


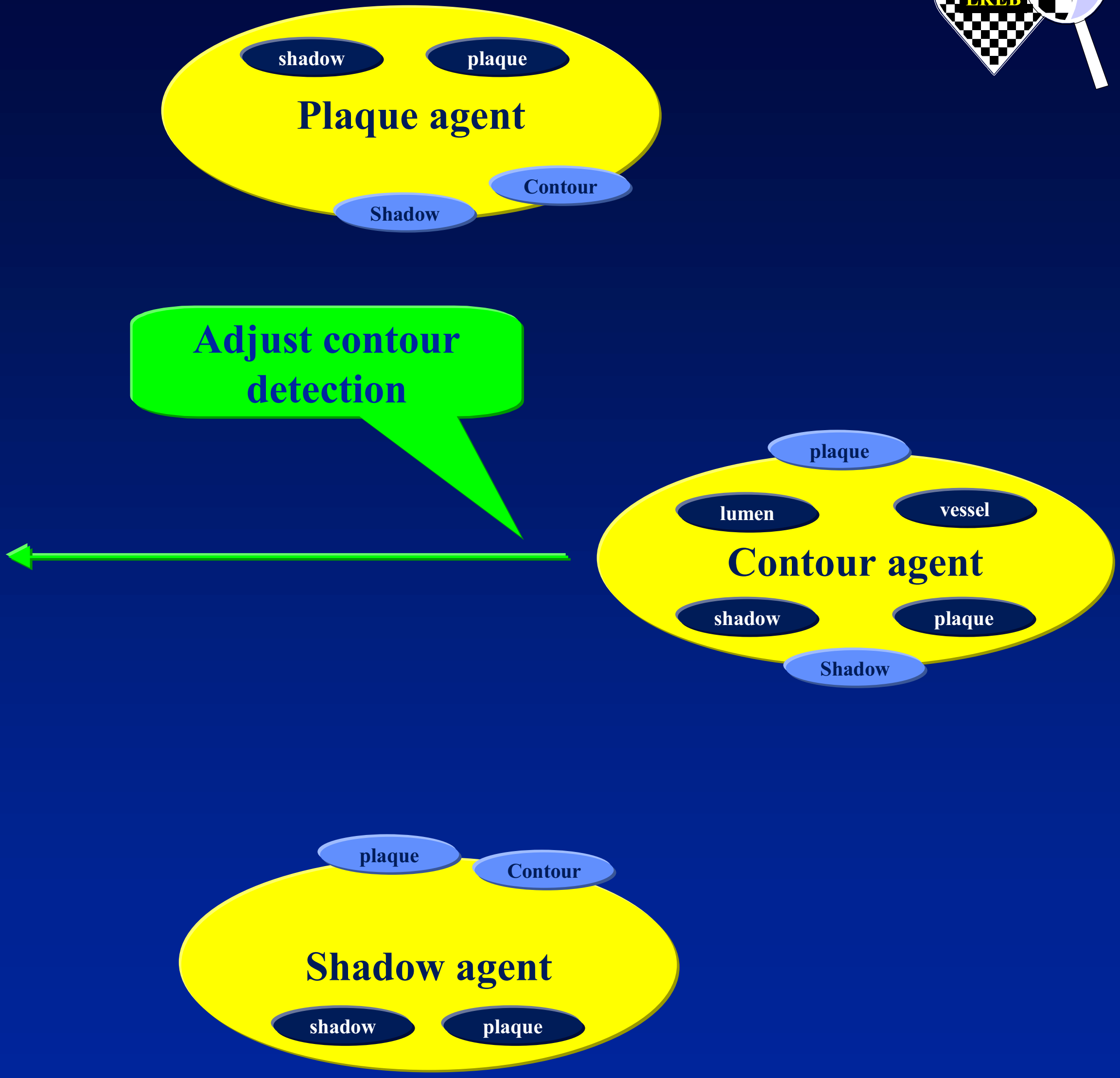
shadow
plaque
Plaque agent
Contour
Shadow

plaque
lumen
vessel
Contour agent
shadow
plaque
Shadow

plaque
Contour
Shadow agent
shadow
plaque

Shadow confirmed by plaque





Plaque agent

shadow
plaque
Contour
Shadow

Adjust contour detection

Contour agent

plaque
lumen
vessel
shadow
plaque
Shadow

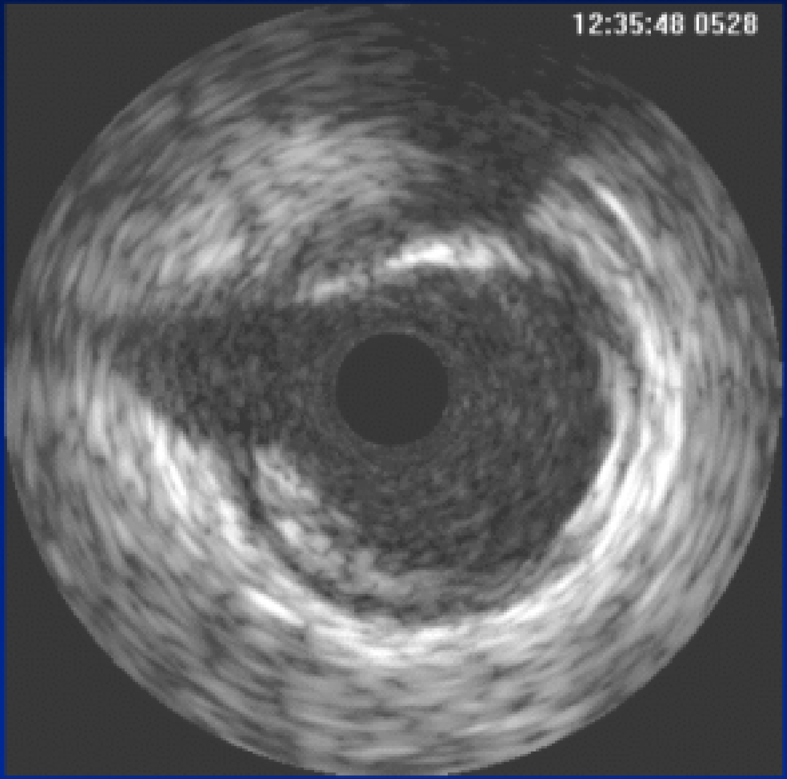
Shadow agent

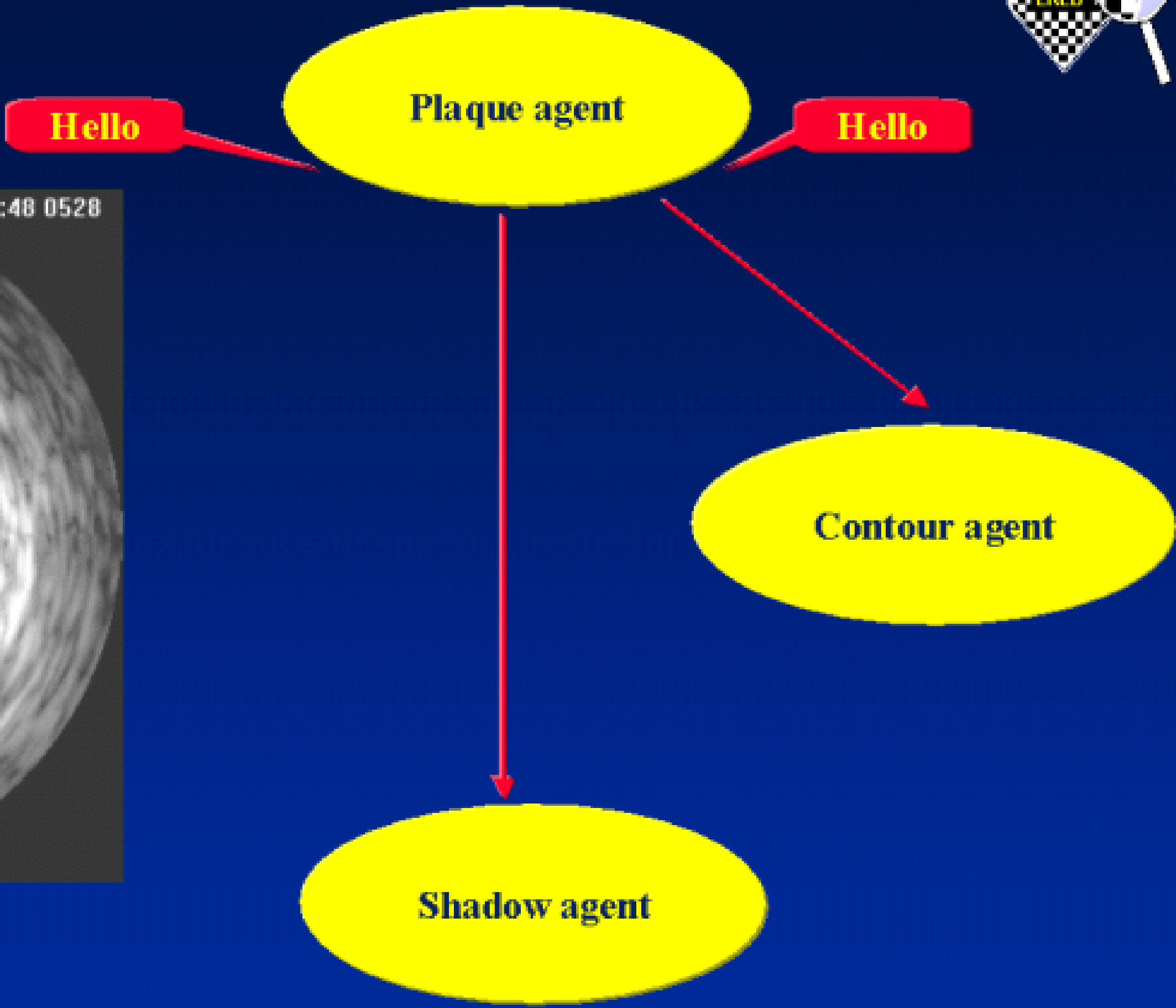
plaque
Contour
shadow
plaque

Animation

Future work

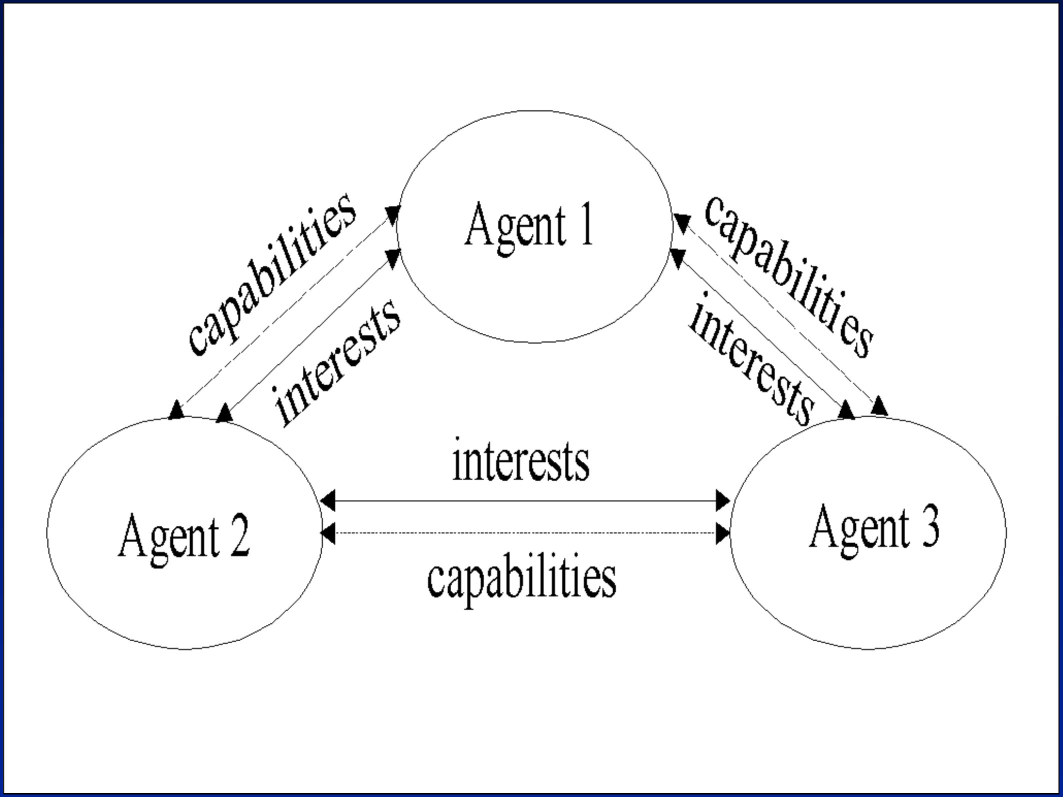
- Agent behavior: learning, emergent behavior, timing issues.
- Agent internal models: allowing an agent its personal views on the world and other agents.
- Specialized vs general agent issues.
- Agent communication: outdated information, conflicting information, etc.


12:35:48 0528


Hello
Plaque agent
Hello
Contour agent
Shadow agent

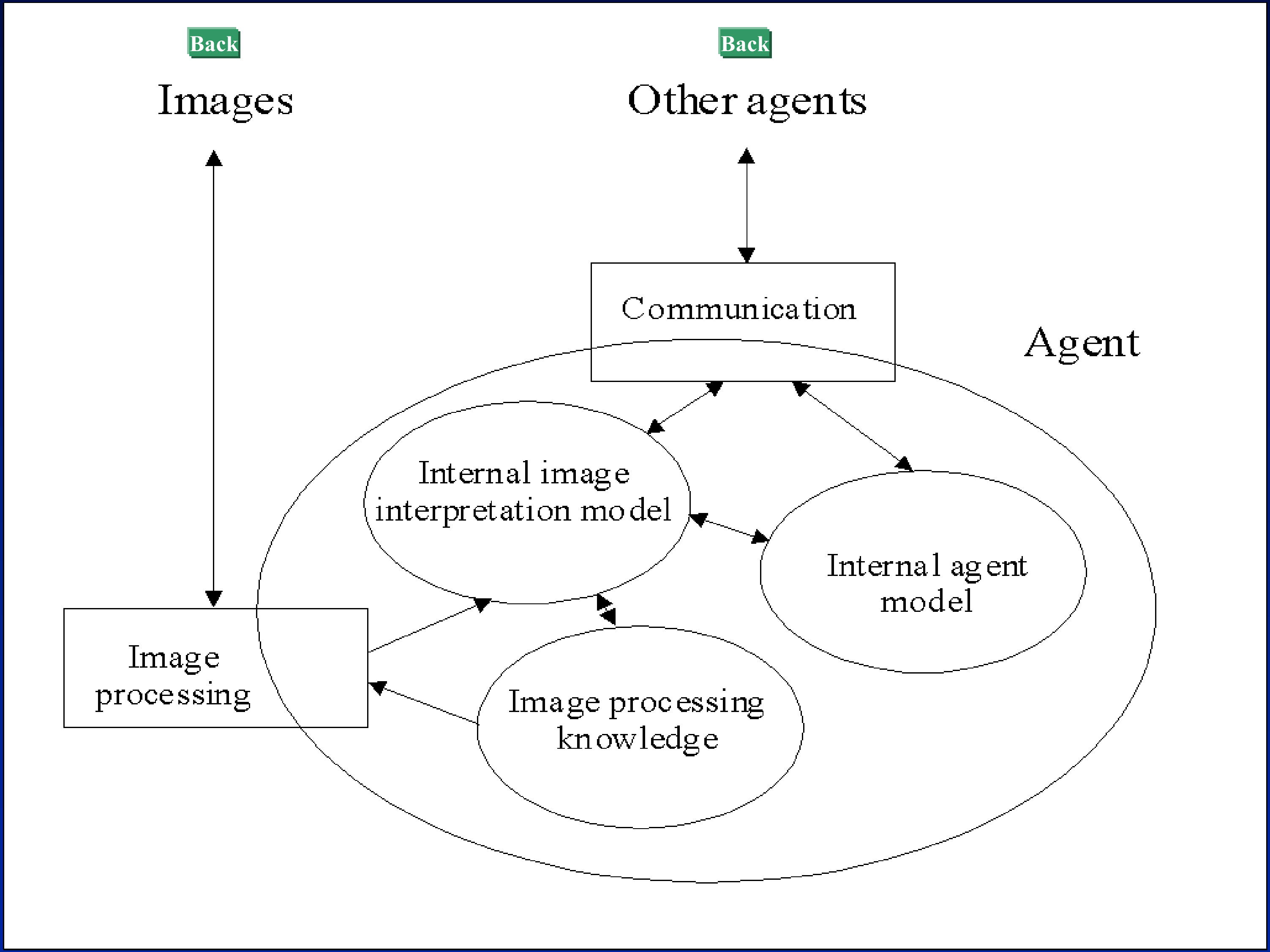
Back

Agent communication: initialization


Agent 1
capabilities
interests
capabilities
interests
Agent 2
interests
capabilities
Agent 3

Back

Agent Internal model



Back

Back

Images

Other agents

Communication

Agent

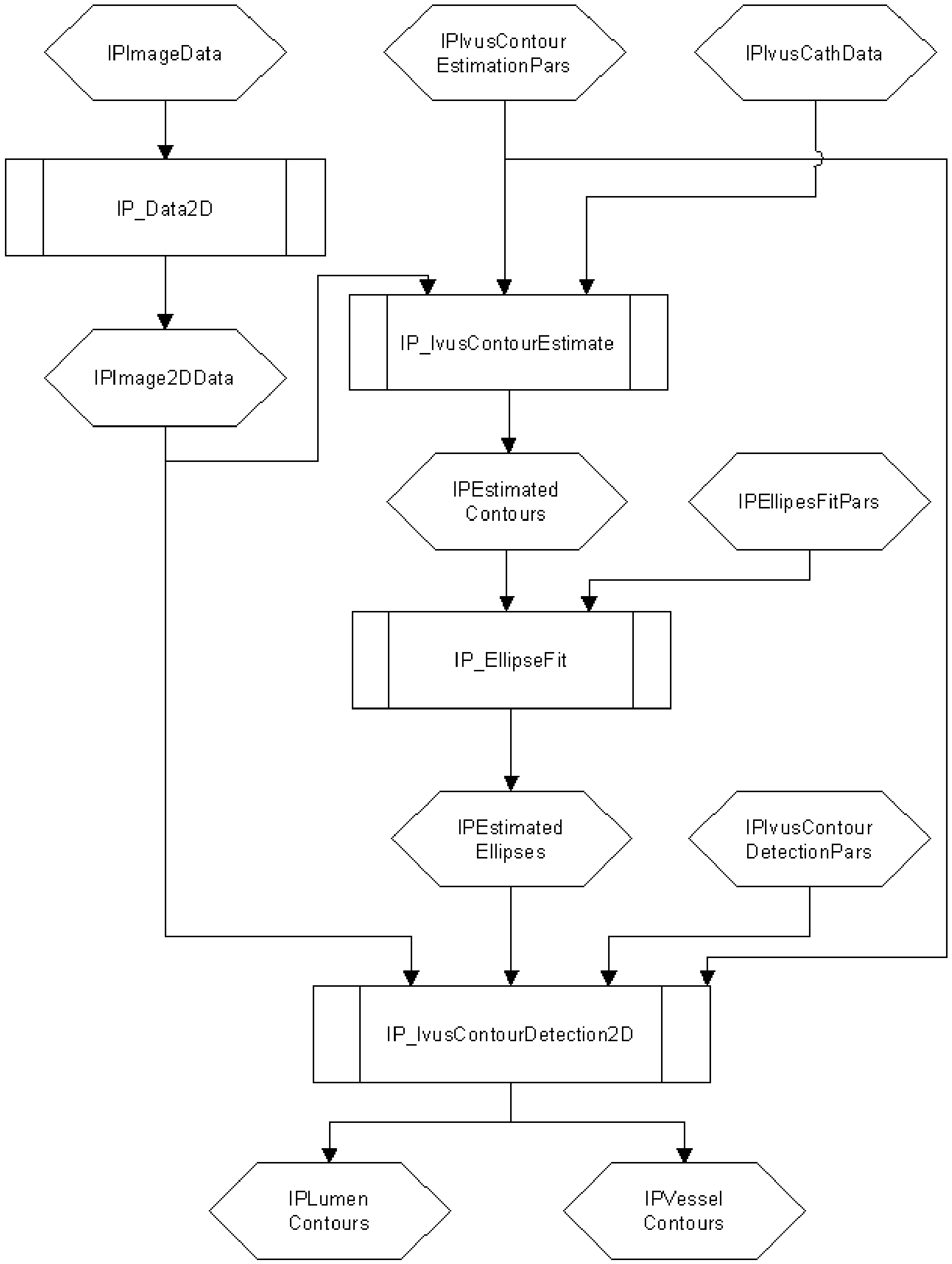
Internal image interpretation model

Internal agent model

Image processing

Image processing knowledge

Agent IP: encoding of a cascade of image processing operations



IPImageData

IPIvusContour EstimationPars

IPIvusCathData

IP_Data2D

IPImage2DData

IP_IvusContourEstimate

IPEstimated Contours

IPEllipesFitPars

IP_EllipseFit

IPEstimated Ellipses

IPIvusContour DetectionPars

IP_IvusContourDetection2D

IPLumen Contours

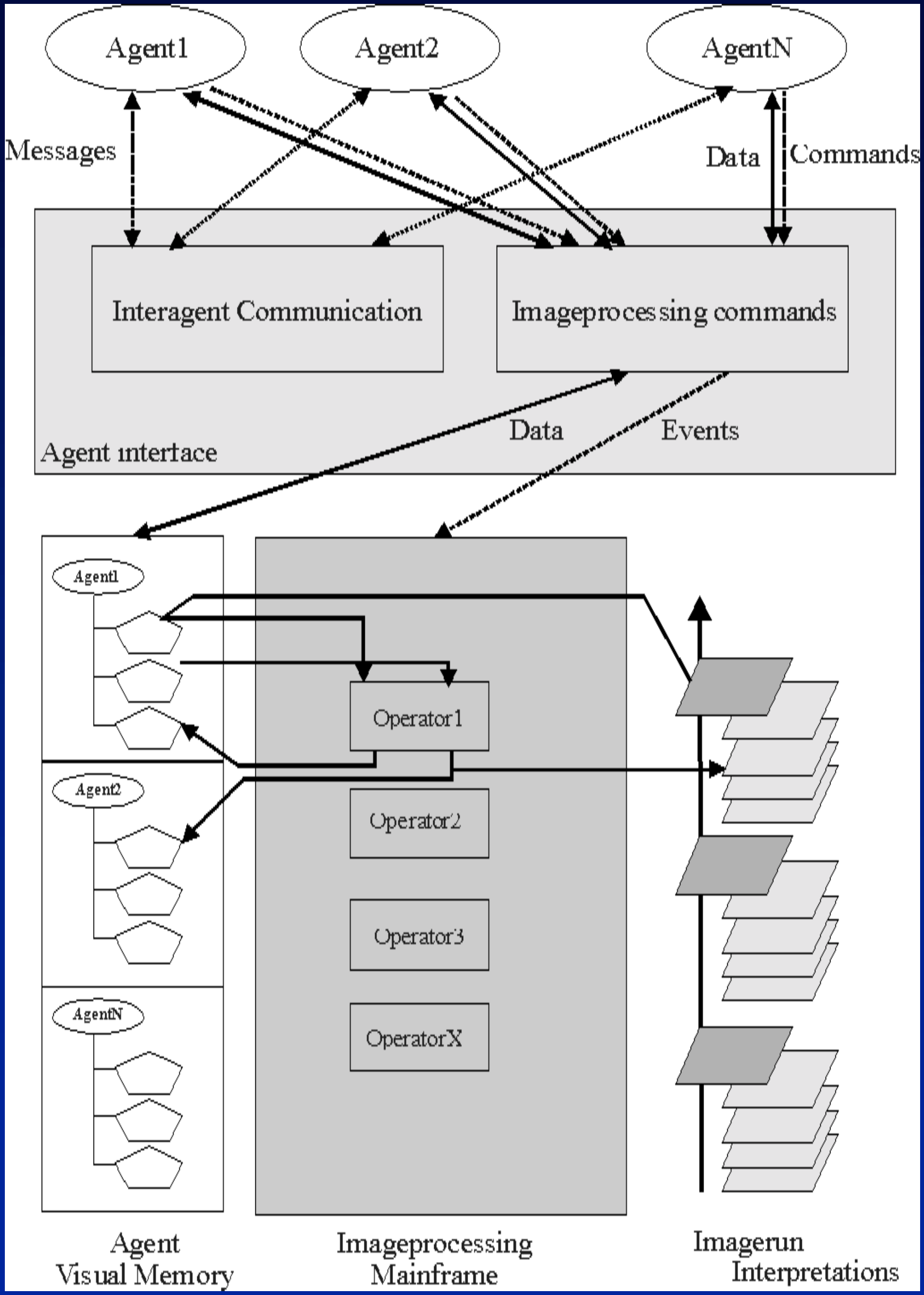
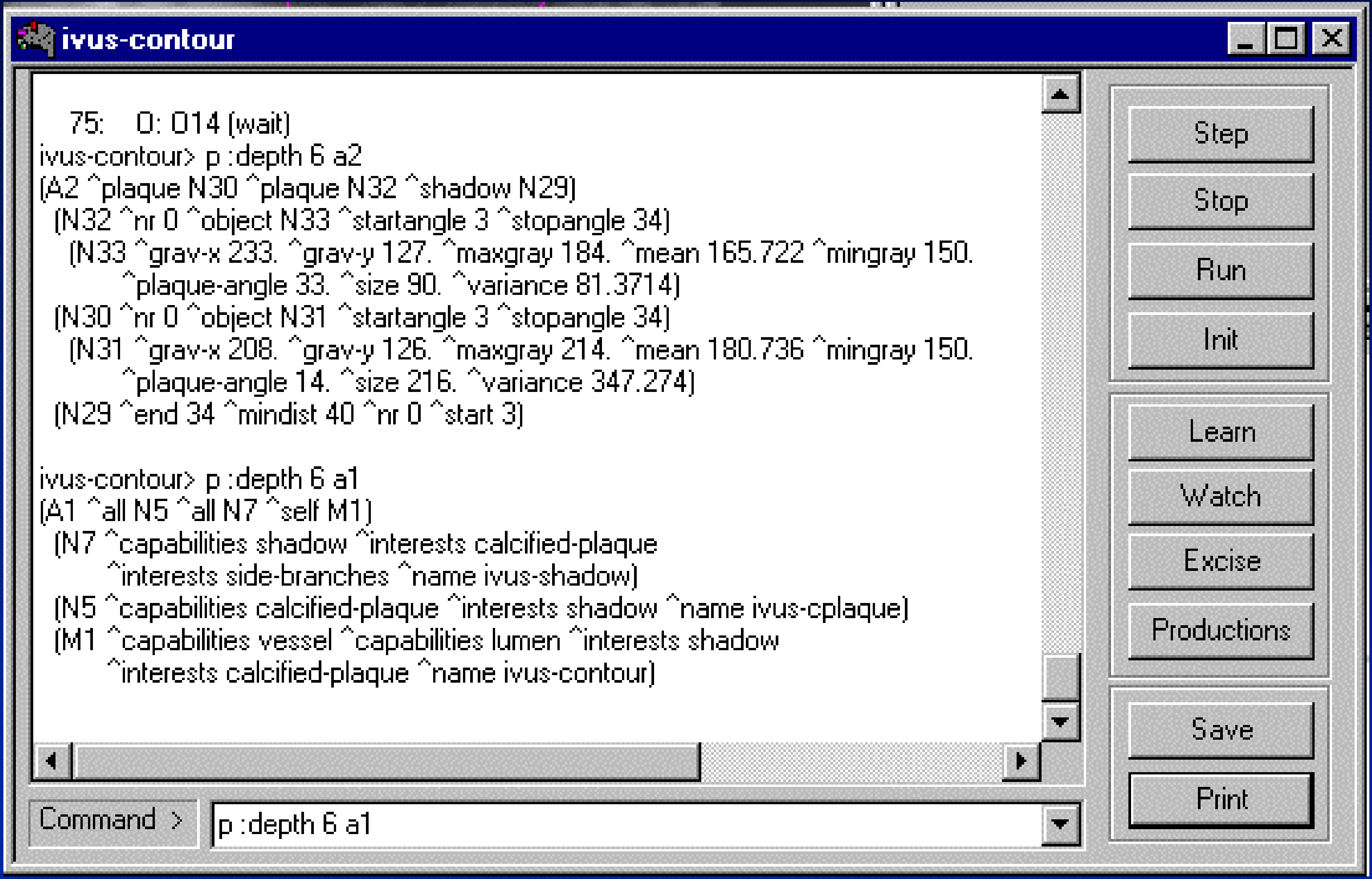
IPVessel Contours

IvusContourDetection
Operator Structure

Ernst Bovenkamp
LKEB, 25/2/2000

Back to agent demo

Soar agent interfaces


Agent1
Agent2
AgentN
Messages
Data
Commands
Interagent Communication
Imageprocessing commands
Data
Events
Agent interface
Agent1
Agent2
AgentN
Operator1
Operator2
Operator3
OperatorX
Agent
Visual Memory
Imageprocessing
Mainframe
Imagerun
Interpretations