

# Object Recognition for Semantic Image Indexing

Nicolas MAILLOT and Monique THONNAT  
Orion team  
INRIA Sophia Antipolis FRANCE

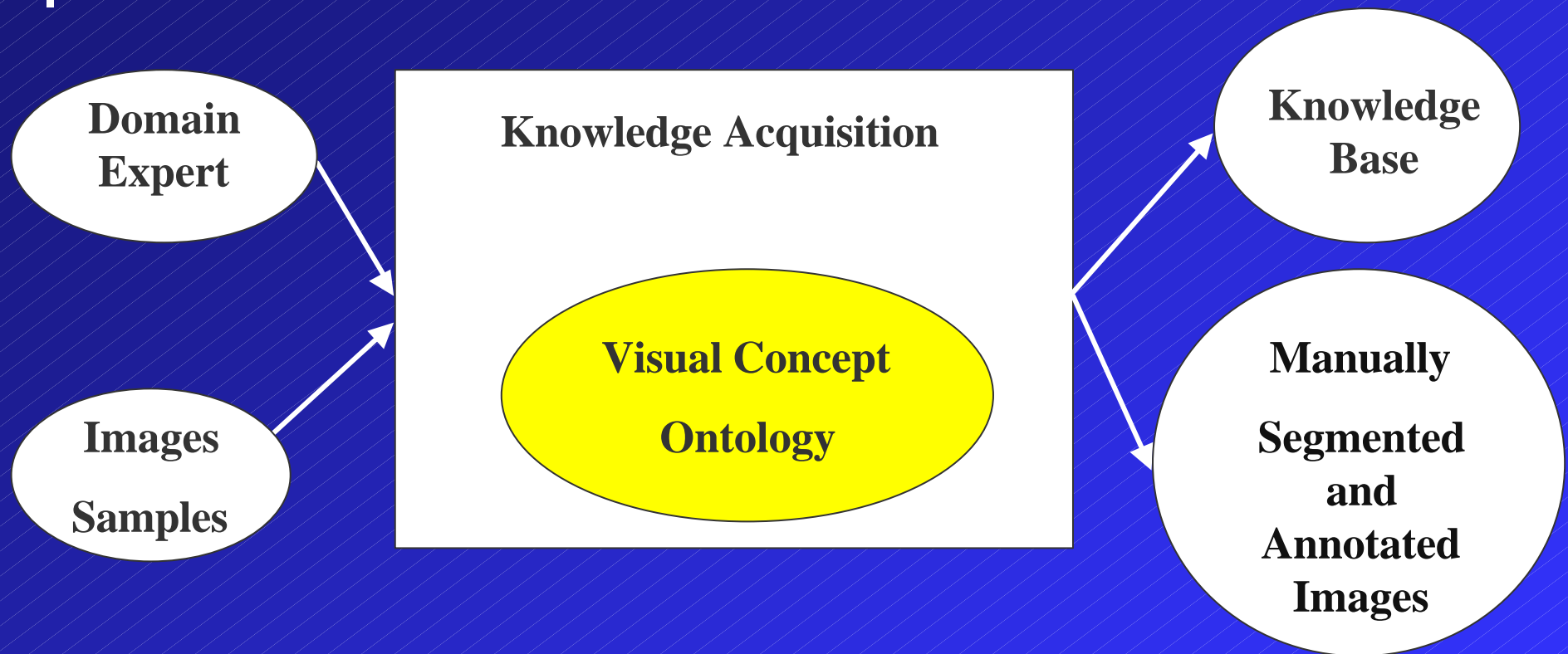
# Talk Overview

- Introduction
- Knowledge Acquisition
- Learning
- Image Indexing
- Retrieval
- Conclusion

# Introduction

- **Goal:** object recognition
  - find the **semantic class** of physical objects observed on images
- **How:**
  - **Knowledge formalization** : hierarchy of object classes described by visual concepts
  - **Machine learning** to match numerical features with semantic concepts
- **Application:**
  - Semantic image **indexing** and **retrieval**

# Phase 1 : Knowledge Acquisition



Knowledge acquisition **guided** by a **visual concept ontology** (i.e. *shape, texture, color*) to describe the objects of the domain.

# Phase 1 : Knowledge Acquisition

- Ontological engineering

- **Ontology** : set of concepts and relations useful to describe a domain

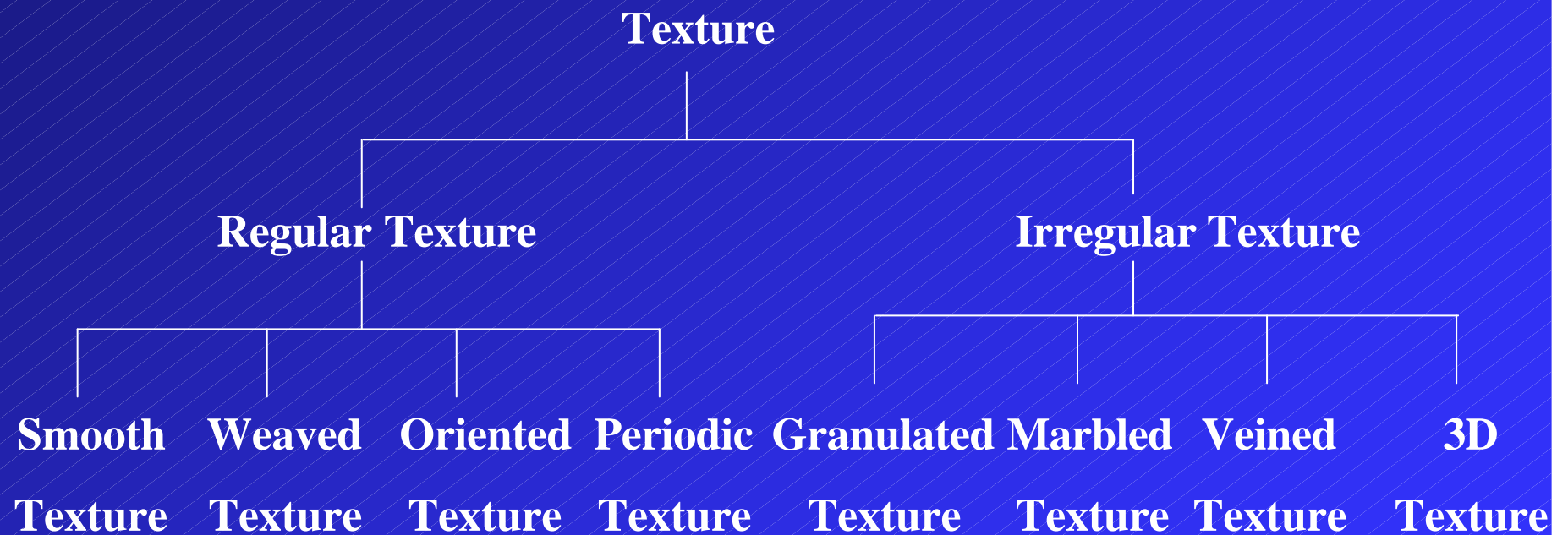
- 103 concepts in our **visual concept ontology**:

- spatio-temporal concepts
    - color concepts
    - texture concepts

➔ Object classes are described by **visual concepts**

# Phase 1 : Knowledge Acquisition

Visual concept ontology content: some **texture concepts**



# Phase 1 : Knowledge Acquisition

## ■ Knowledge Formalization

- **Domain concept tree** : specialization relations
  - Sub-part tree linked to domain concept

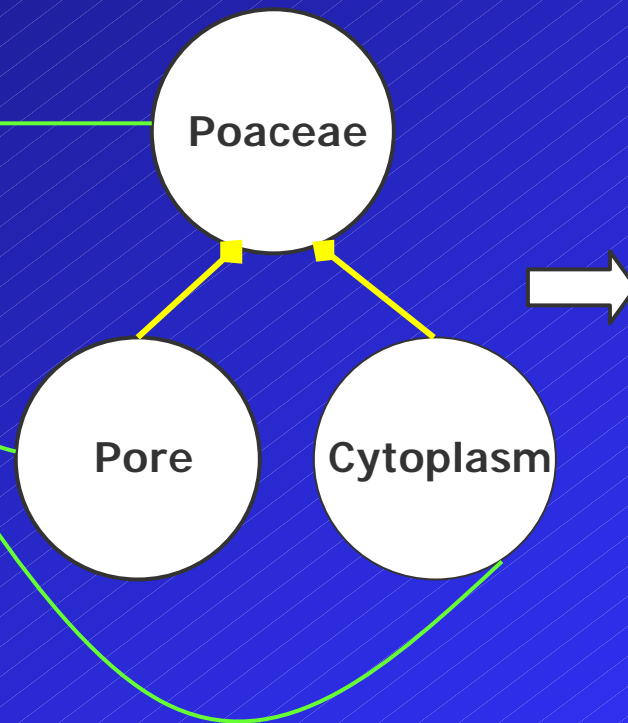
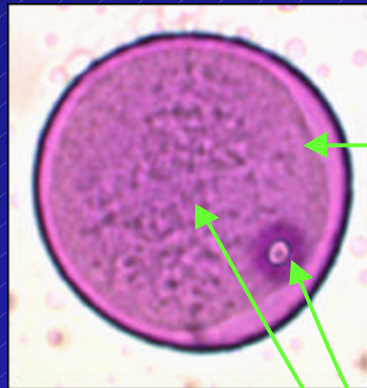


Reflects the domain taxonomy

- **Class**: a domain concept (aircraft, *pollen grain*) described by **visual concepts** (*pink color and circular shape*)
- Representation by frames with slots

# Phase 1 : Knowledge Acquisition

**Domain knowledge** described using  
*visual concept ontology*



**Poaceae :**

- *Circular Shape*
- *Granulated Texture*
- *Pink Color*

**Pore:**

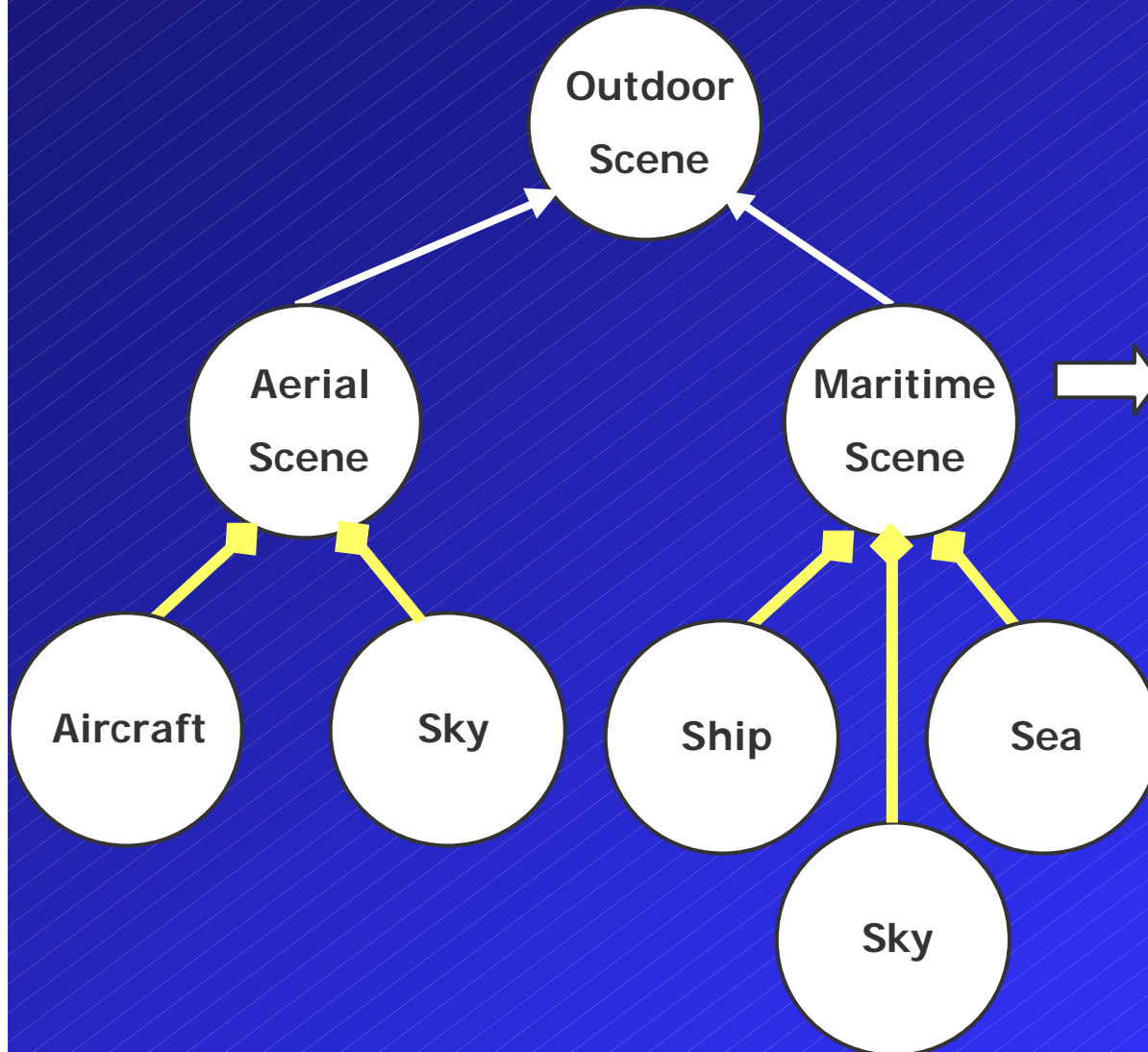
- Subpart of **Poaceae**
- *Elliptic Shape*
- *Small Size*

**Subpart Tree**

N. Maillot and M. Thonnat



# Phase 1 : Knowledge Acquisition



## Sky :

- *Blue or White*
- *Smooth Texture*

## Sea:

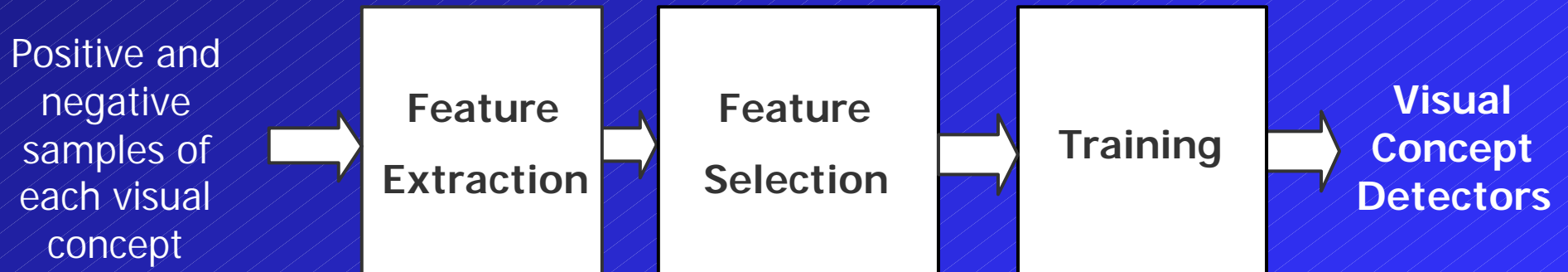
- *Blue*
- *Random Texture*

## Aircraft:

- *Polygonal Shape*

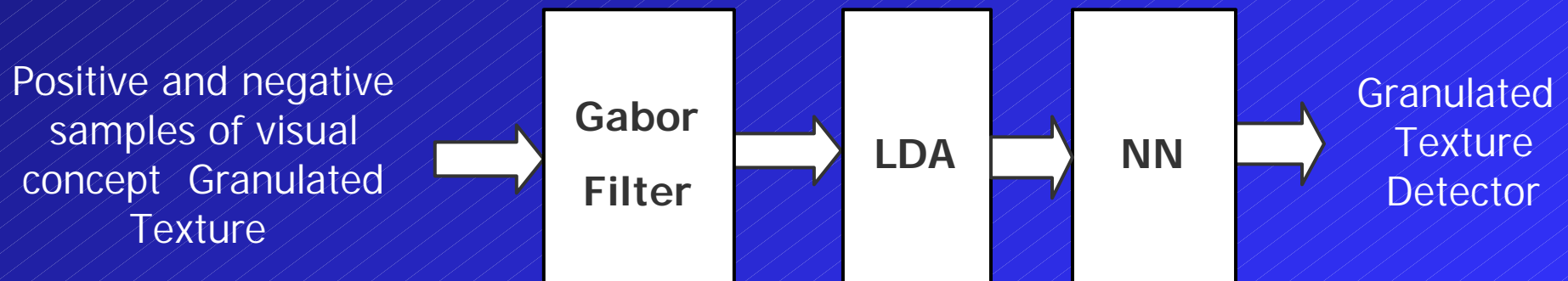
## Phase 2 : Learning

**Goal:** training a set of detectors (e.g. Multi Layer Neural Networks, SVM) to the detection of visual concepts used during knowledge acquisition phase.



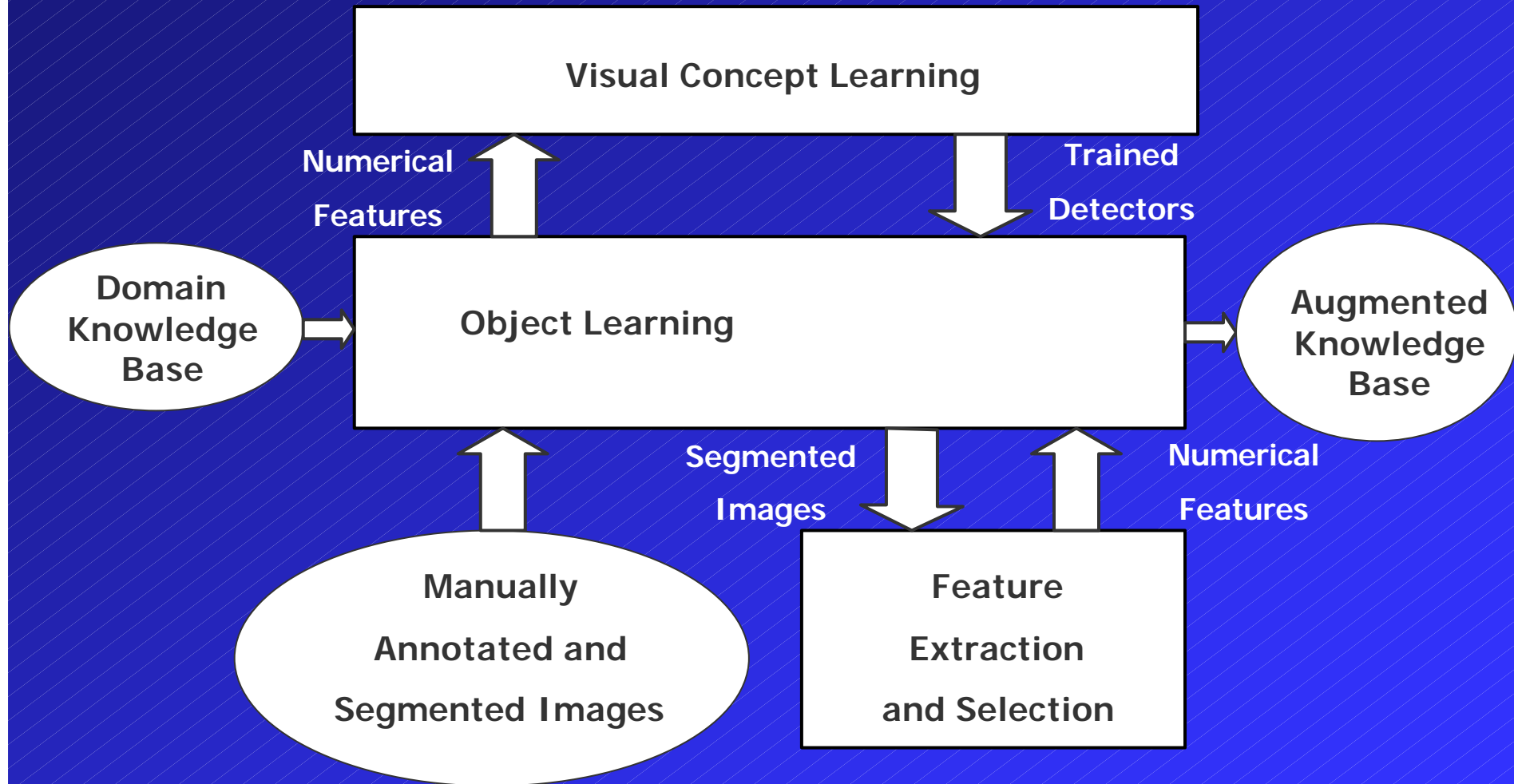
## Phase 2 : Learning

Example : Learn the visual concept Granulated Texture



Visual concept detectors are used to augment the knowledge base

# Phase 2 : Learning



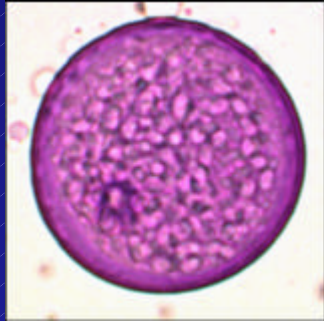
## Phase 3 : Image Indexing

### Algorithm: Hierarchical exploration of object classes

- For each class of the class hierarchy from root class
- **Detection** in the segmented image of the visual concepts used to describe the class
- **Local matching** between each visual concept of the class and visual concepts detected in the image
- Recursion on sub-parts
- **Global Matching** (object/class)
- If compatibility then consider sub-classes  
else Back-track

# Phase 3 : Object Recognition for Image Indexing

Object to Recognize



Automatic Segmentation

Feature Extraction

Circular Shape Detector

Granulated Texture Detector

Pink Hue Detector

Current Class :

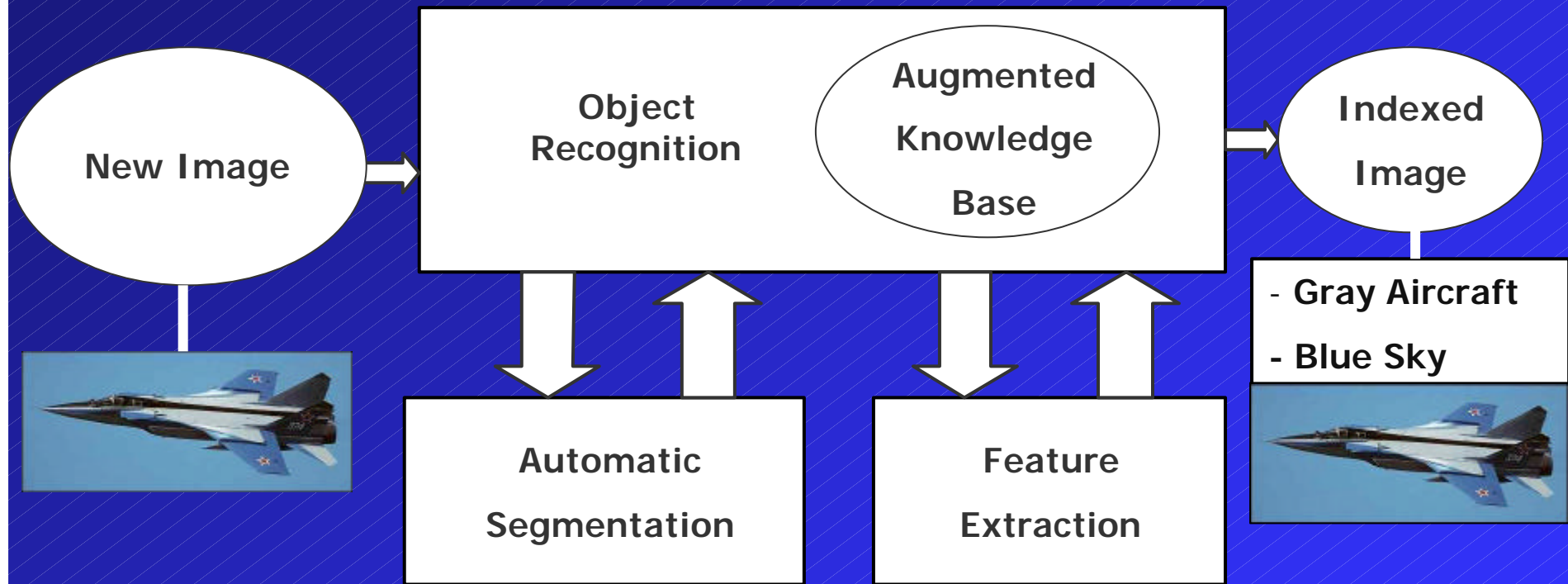
**Poaceae :**

- *Circular Shape*
- *Granulated Texture*
- *Pink Hue*

X

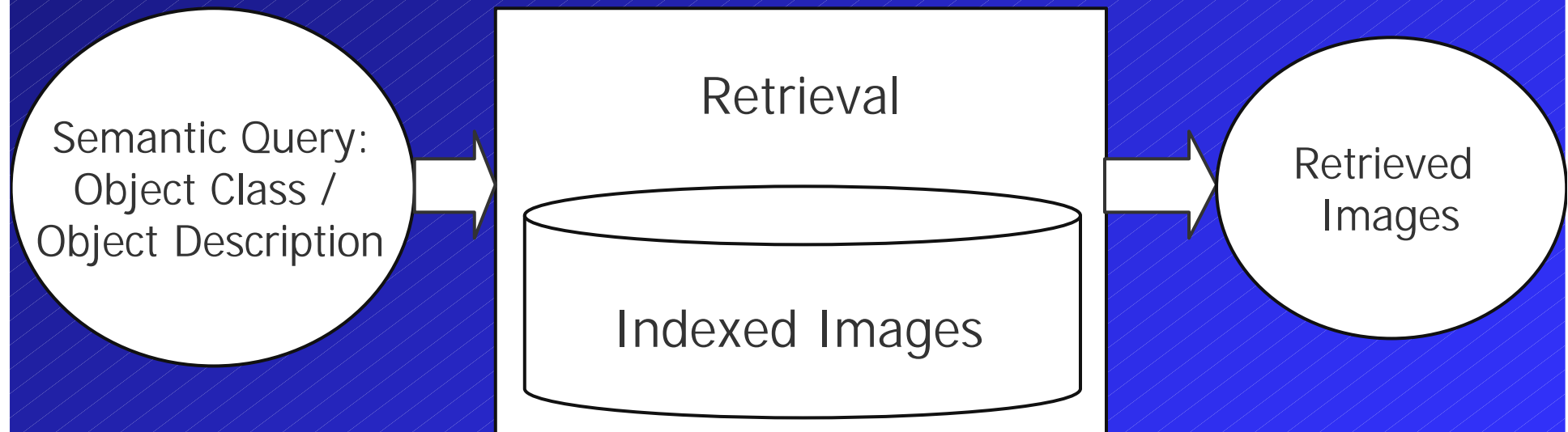
Confidence Value

# Phase 3 : Object Recognition for Image Indexing



## Phase 4 : Retrieval

Query by concept (opposed to query by example):



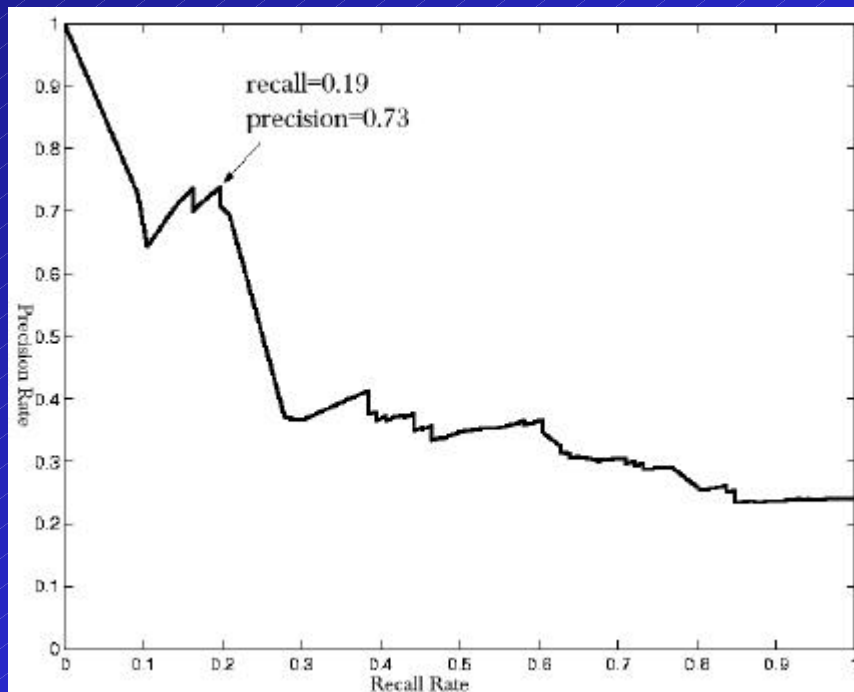
- Example of semantic queries : "Aircraft ", "Gray Aircraft and Blue Sky"



## Phase 4 : Retrieval

- Results on application aircraft/ship retrieval
- Training Set : 60 aircraft images, 30 ship images
- Precision / Recall Curve obtained on 7000 images

Precision Rate



Recall Rate

Precision = 73%

Recall = 19%

# Conclusion and Future Works

Approach : semantic object recognition

- **a priori knowledge** : classes described by visual concepts
- **supervised machine learning** techniques to recognize visual concepts

Application to image indexing and retrieval

- Automatic image indexing
- Semantic query

Future works

- **Weakly-supervised** visual concept learning
- Learning for image segmentation