

# Humans & Machines collaborating on vision

Pietro Perona  
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NSF Workshop - Frontiers in Vision  
Cambridge, 23 Aug 2011

# *“Collaborative vision” ?*

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# Objectives

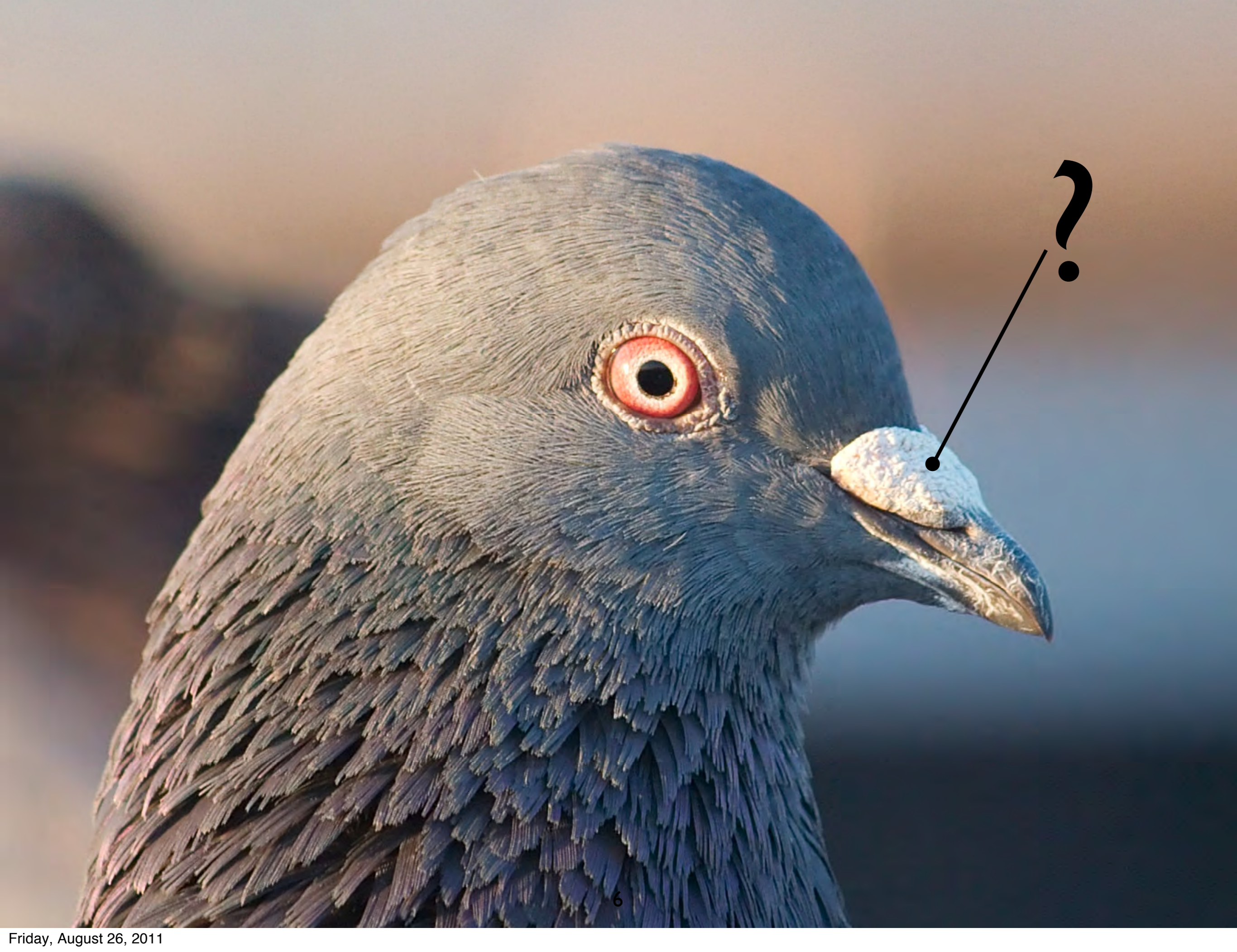
- Sketch new area of research
- Sampler of initial work
- Drawing lessons
- Brainstorm: potential, way forward

# Plan

- Define area (10')
- Presentations (50'): Perona, Geman, Grauman, Berg, Belongie
- Discussion (15')

# Definition







# Cere

From Wikipedia, the free encyclopedia

The **cere** (from the Latin *cera*: wax)<sup>[1]</sup> or **operculum**<sup>[2]</sup> is a soft, fleshy swelling found on the beaks of certain birds. [Hawks](#), [parrots](#), [doves](#), [skuas](#) and [budgerigars](#) are among the birds that have ceres. The word 'cere' is often used synonymously with 'beak', although the two are not identical. The cere plays a role in indicating the reproductive stage of certain [dimorphic](#) birds, and also has a key function in respiration.

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## Physical characteristics [\[edit\]](#)

The cere is located at the top of the beak,<sup>[2][3]</sup> and is often waxy in texture. The colour of the cere may vary from species to species, and also depends on the season.<sup>[4]</sup> The cere contains the [nares](#) (nostrils). The shape of the cere varies from species to species. In falcons, the opening of the nares is roughly circular in shape.<sup>[2]</sup>



The [Rock Pigeon](#), *Columba livia*. The cere is located at the top of the beak, and is a distinctive white-grey colour.

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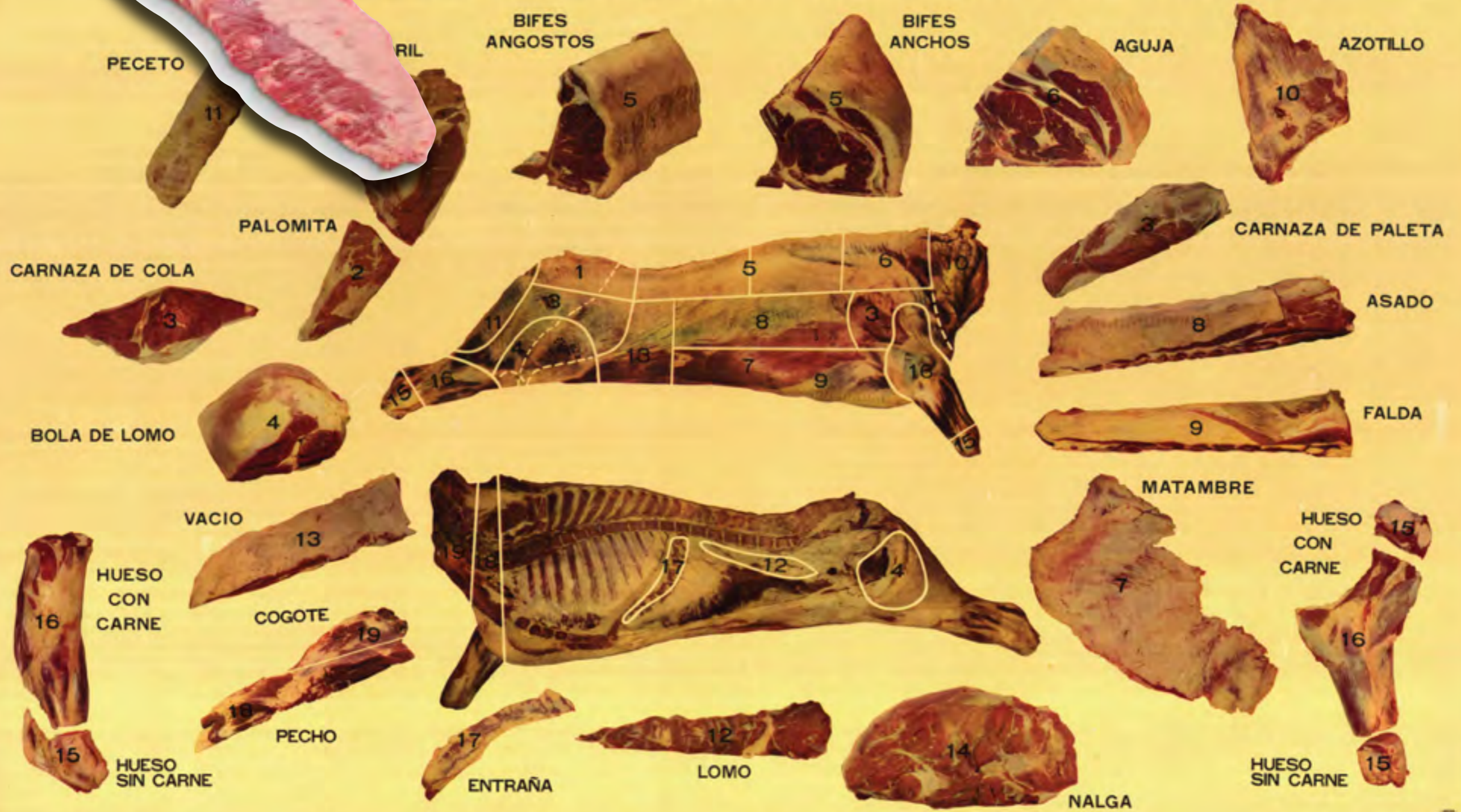


# JUNTA NACIONAL DE CARNES

LEY 11.747

## SECRETARIA DE INDUSTRIA Y COMERCIO

### CLASIFICACION DE LAS PARTES PARA RESES DE NOVILLOS, VACAS, VAQUILLONAS Y NOVILLITOS



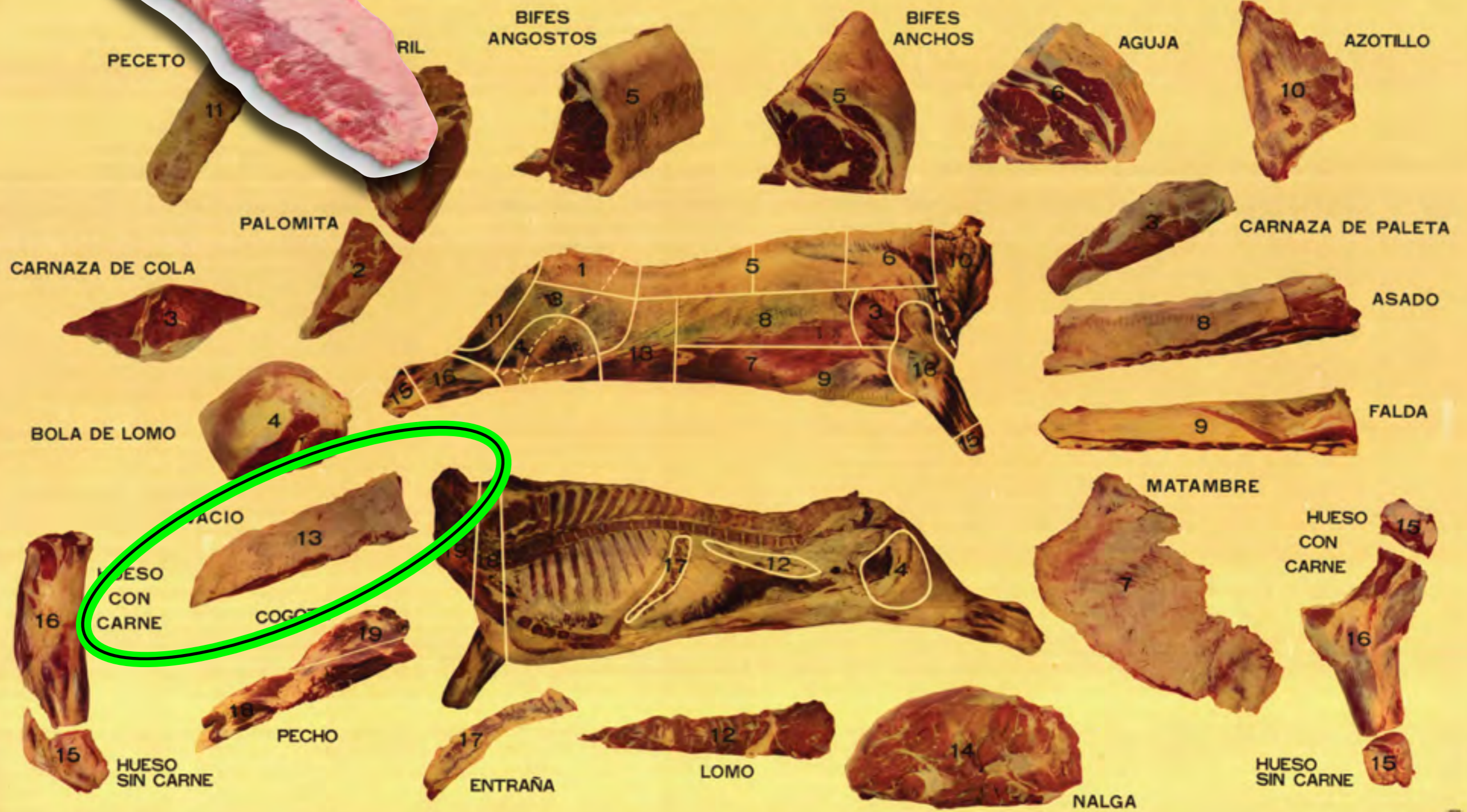
REIMPRESION LAMINA ORIGINAL AÑO 1948 - INSTITUTO DE PROMOCION DE LA CARNE VACUNA ARGENTINA

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# Femur

From Wikipedia, the free encyclopedia

*For the [invertebrate femur](#), see [Arthropod leg](#).*

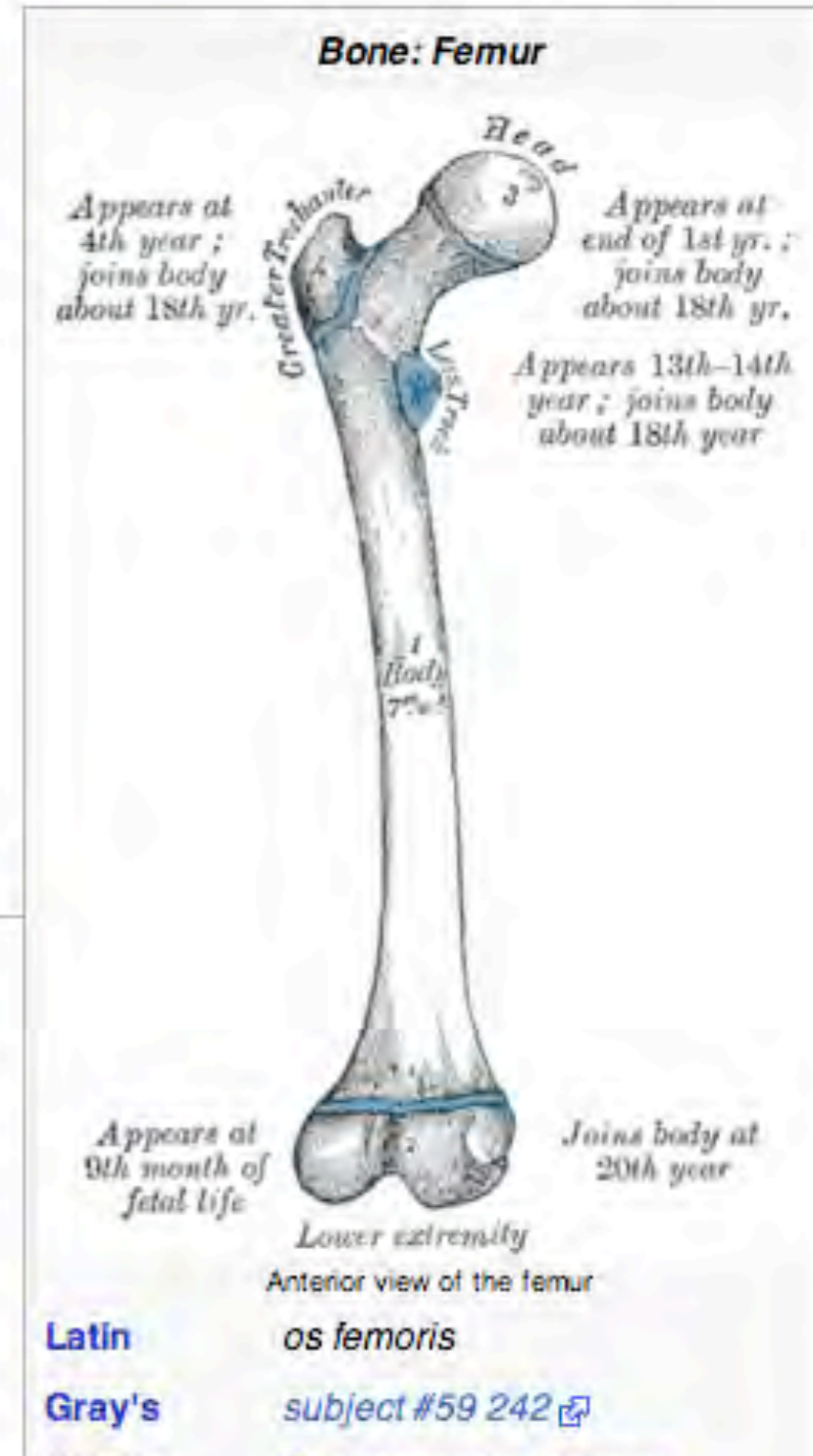
The **femur**, or **thigh bone**, is the most **proximal** (closest to the body) **bone** of the **leg** in **vertebrates** capable of **walking** or **jumping**, such as most **land mammals**, **birds**, many **reptiles** such as **lizards**, and **amphibians** such as **frogs**. In vertebrates with four legs such as **dogs** and **horses**, the femur is found only in the rear legs.

## Contents [\[hide\]](#)

- 1 Human anatomy
- 2 Evolutionary variation
- 3 Etymology
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## Human anatomy [\[edit\]](#)

In **human anatomy**, the femur is the **longest** and largest bone. Along with the **temporal bone** of the **skull**, it is one of the two strongest bones in the body. The average adult male femur is 48 centimeters (18.9 in) in length and 2.34 cm (0.92 in) in diameter and can support up to 30 times the weight of an adult.<sup>[1]</sup> It forms part of the **hip** (at the **acetabulum**) and part of the **knee**, which is located above. There are four eminences, or protuberances, in the human femur: the **head**, the **greater trochanter**, the **lesser trochanter**, and the **lower extremity**. They appear at various times from just before birth to about age 14. Initially, they are joined to the main body of the femur with **cartilage**, which gradually



**Latin**   *os femoris*  
**Gray's**   *subject #59 242* [\[↗\]](#)



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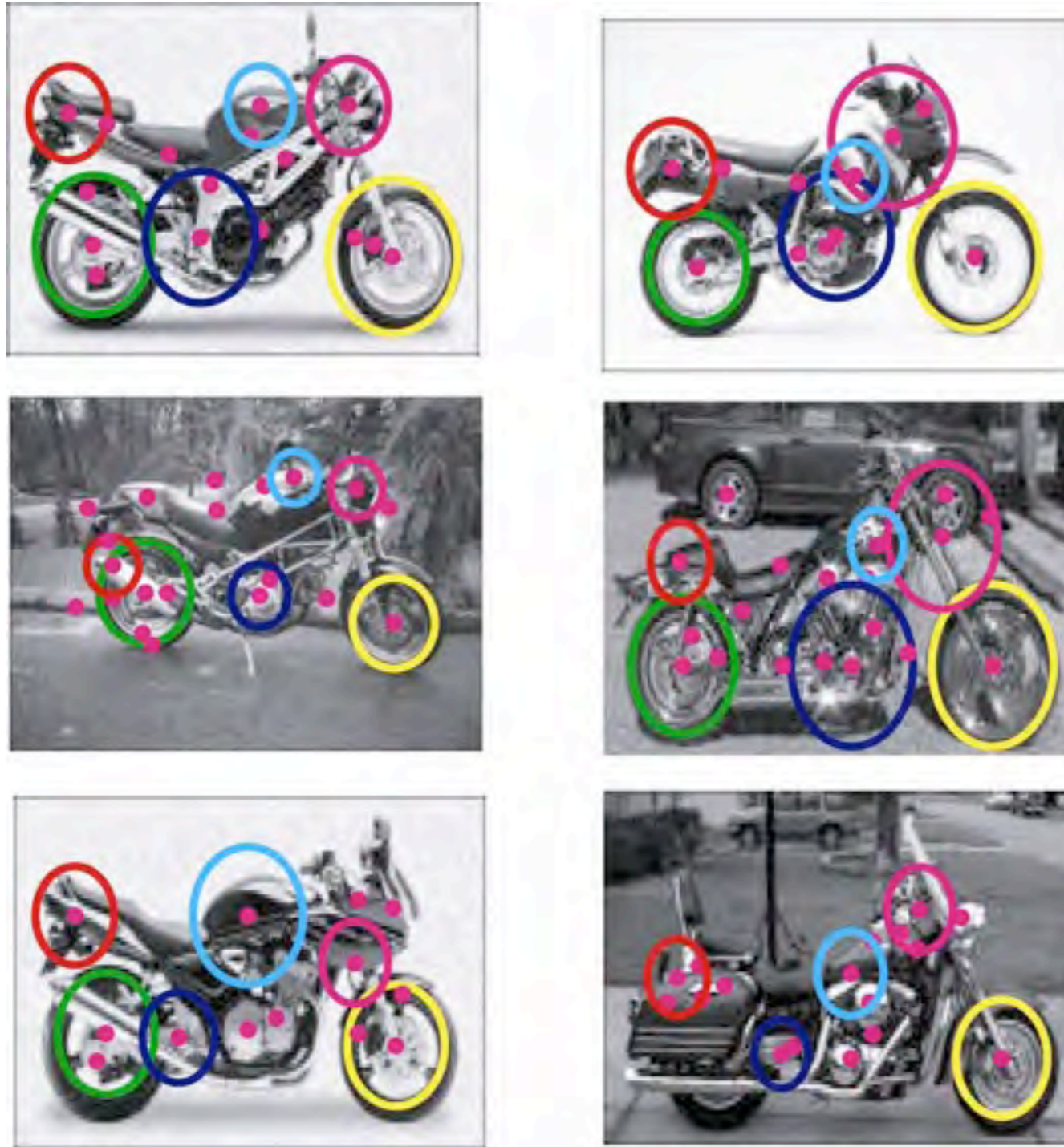
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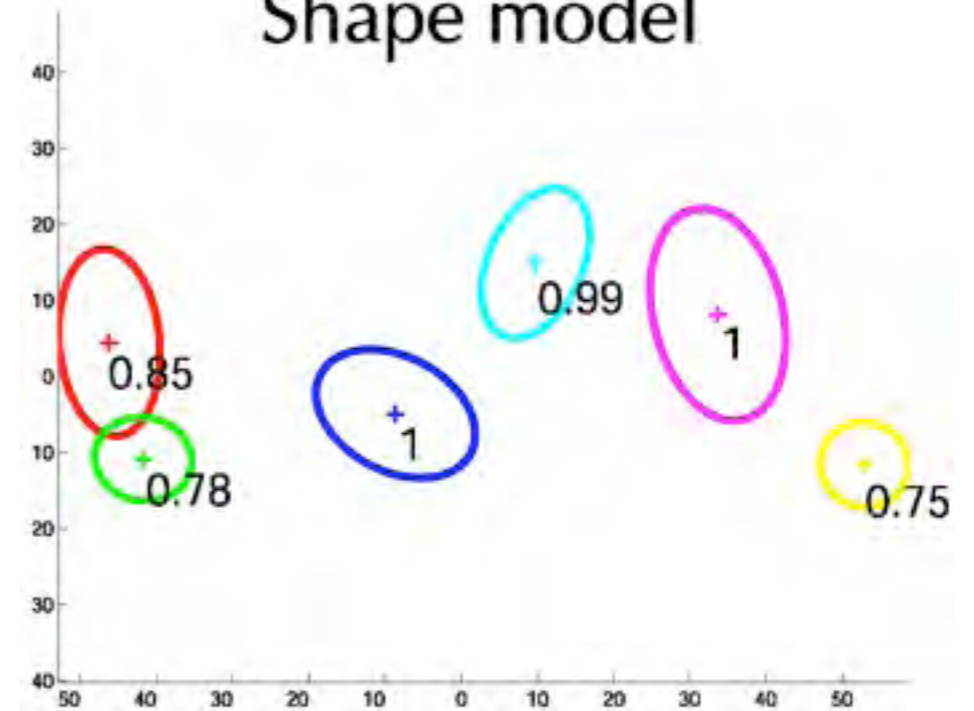
# Lessons:

- *Visual queries*
  - Easy for humans
  - Difficult for machines
- Much information is available on line
- Pictures are *digital dark matter*
- Experts not providing visual knowledge

# Unsupervised learning?



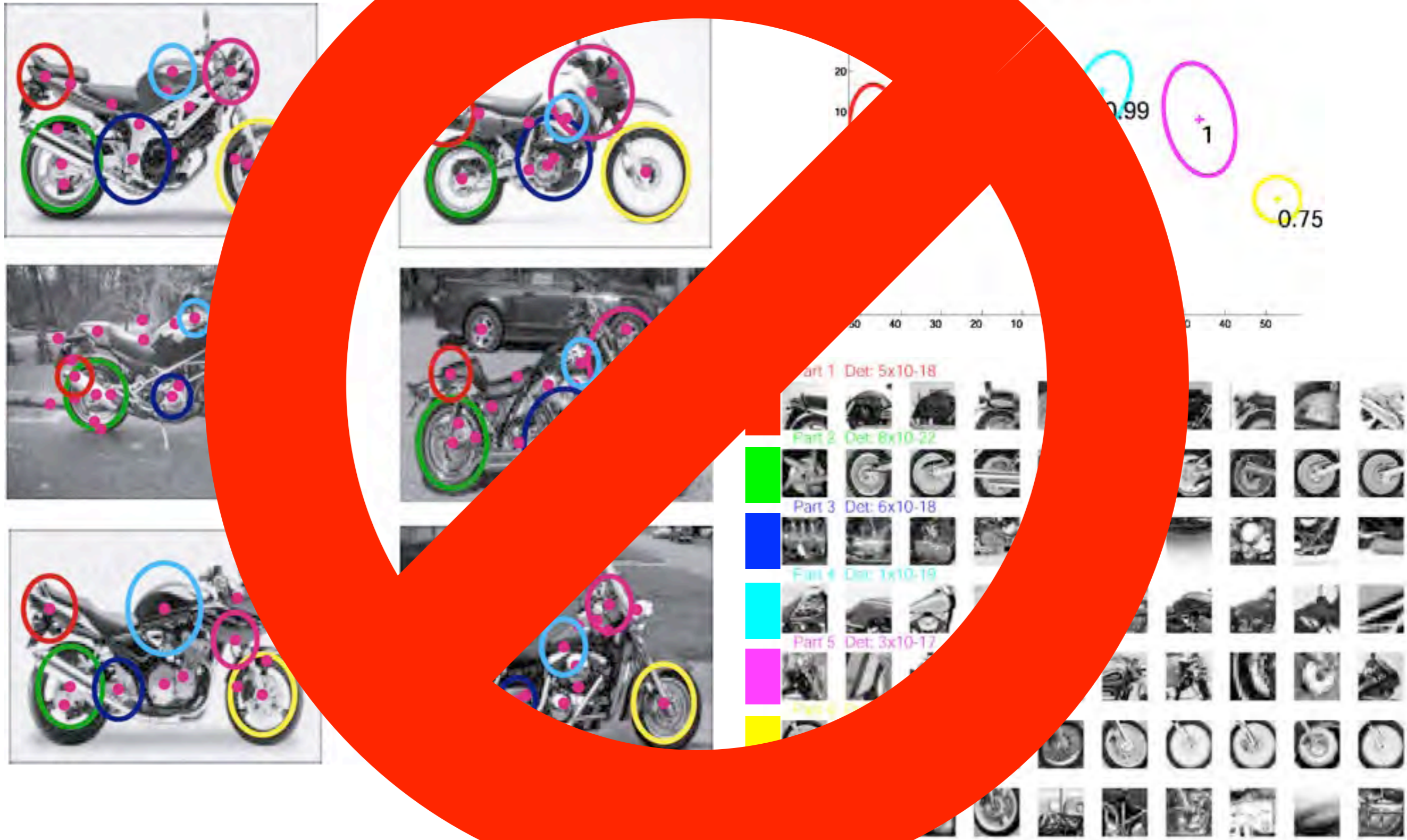
Shape model



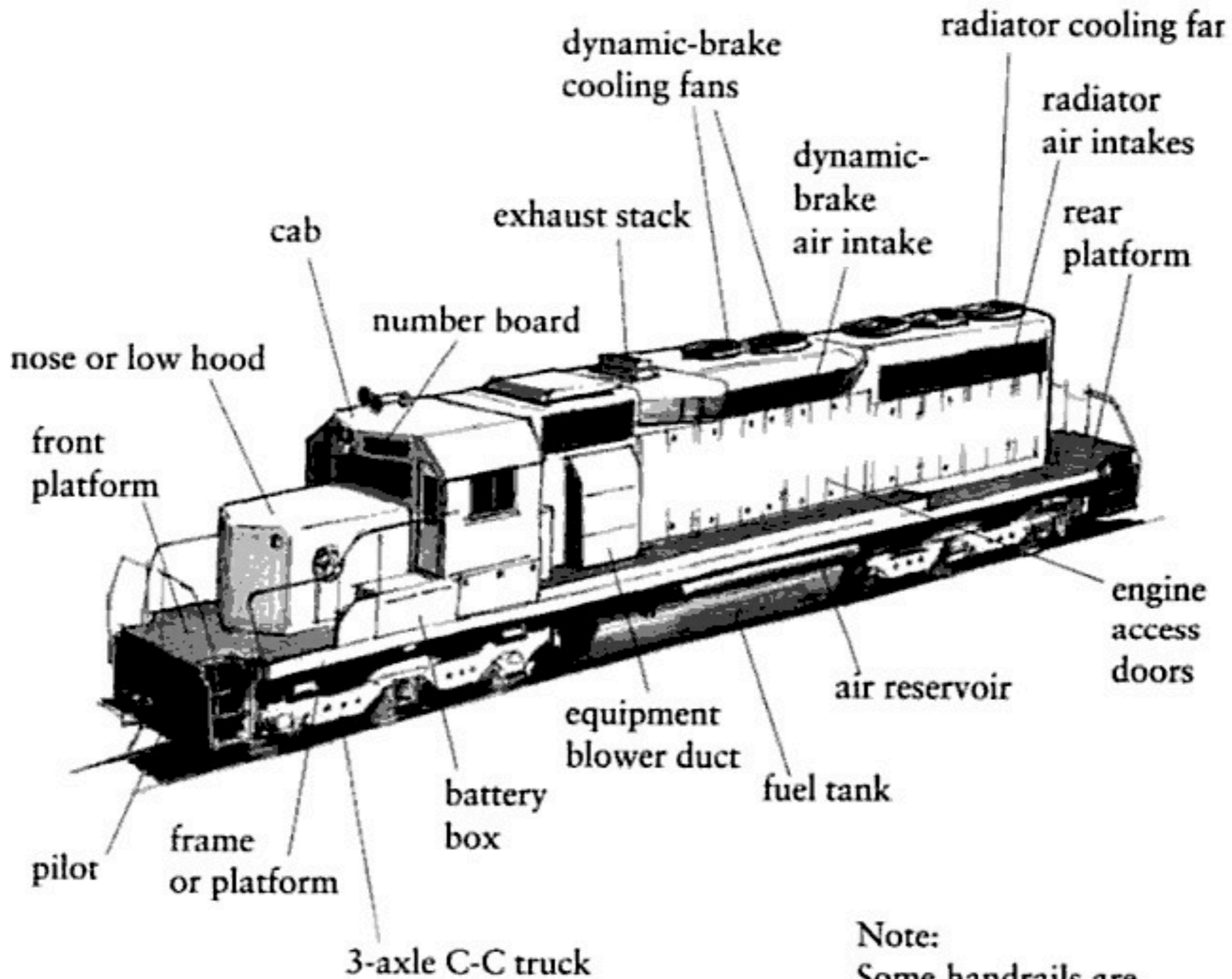
[Fergus et al., CVPR03]

# Unsupervised Learning?

Shape model



[Fergus et al., CVPR05]



## THE PARTS OF A LOCOMOTIVE

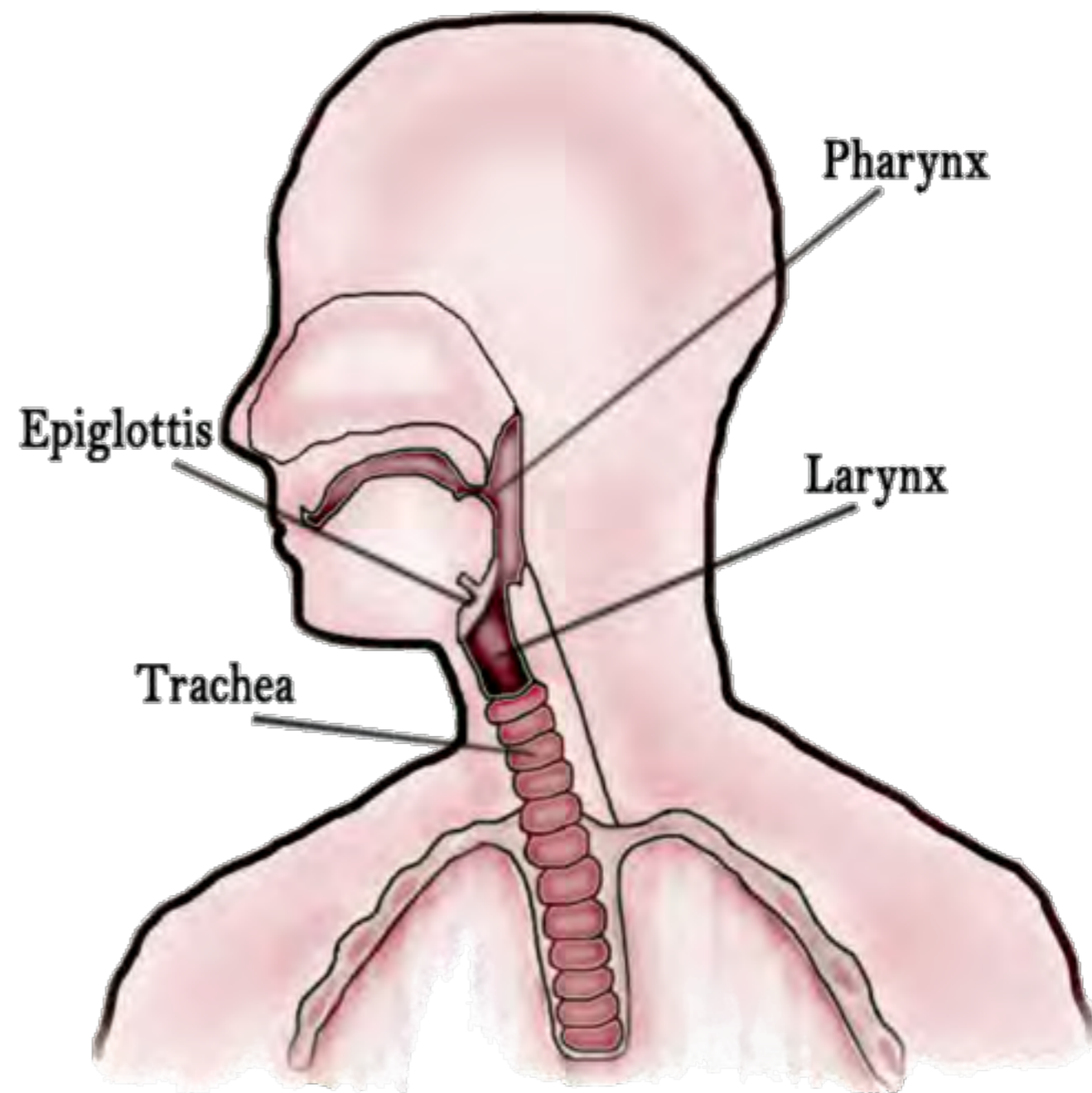




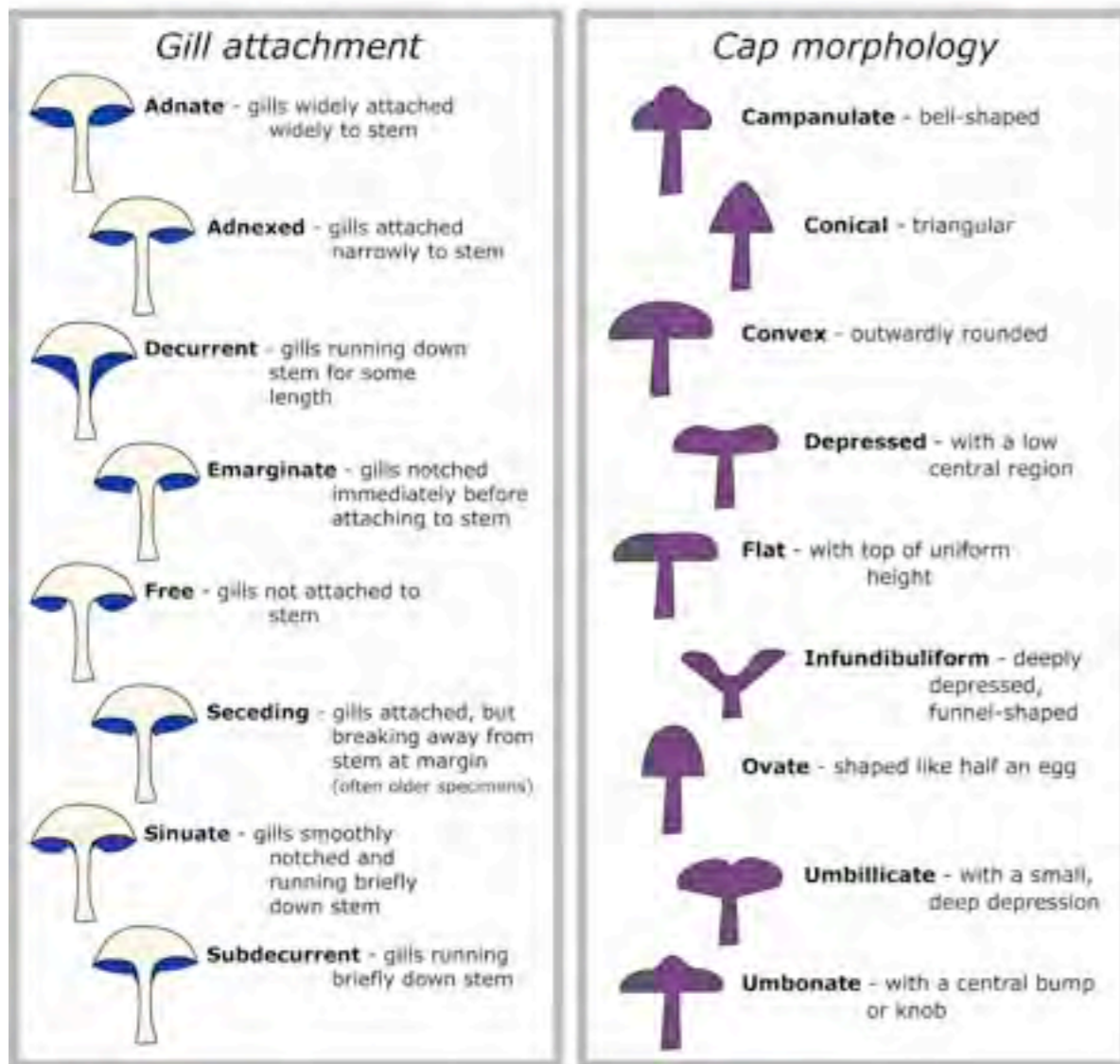
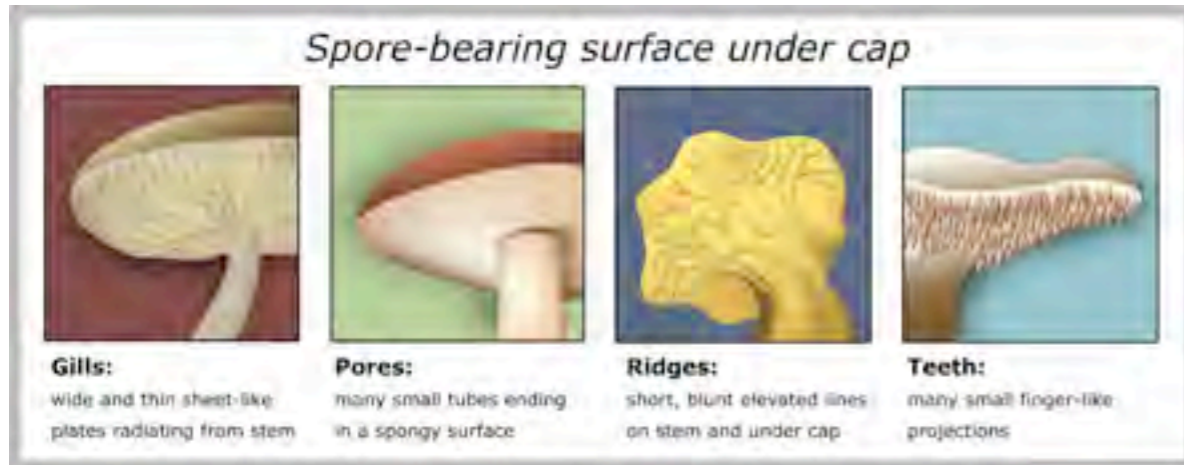
Throat



Throat

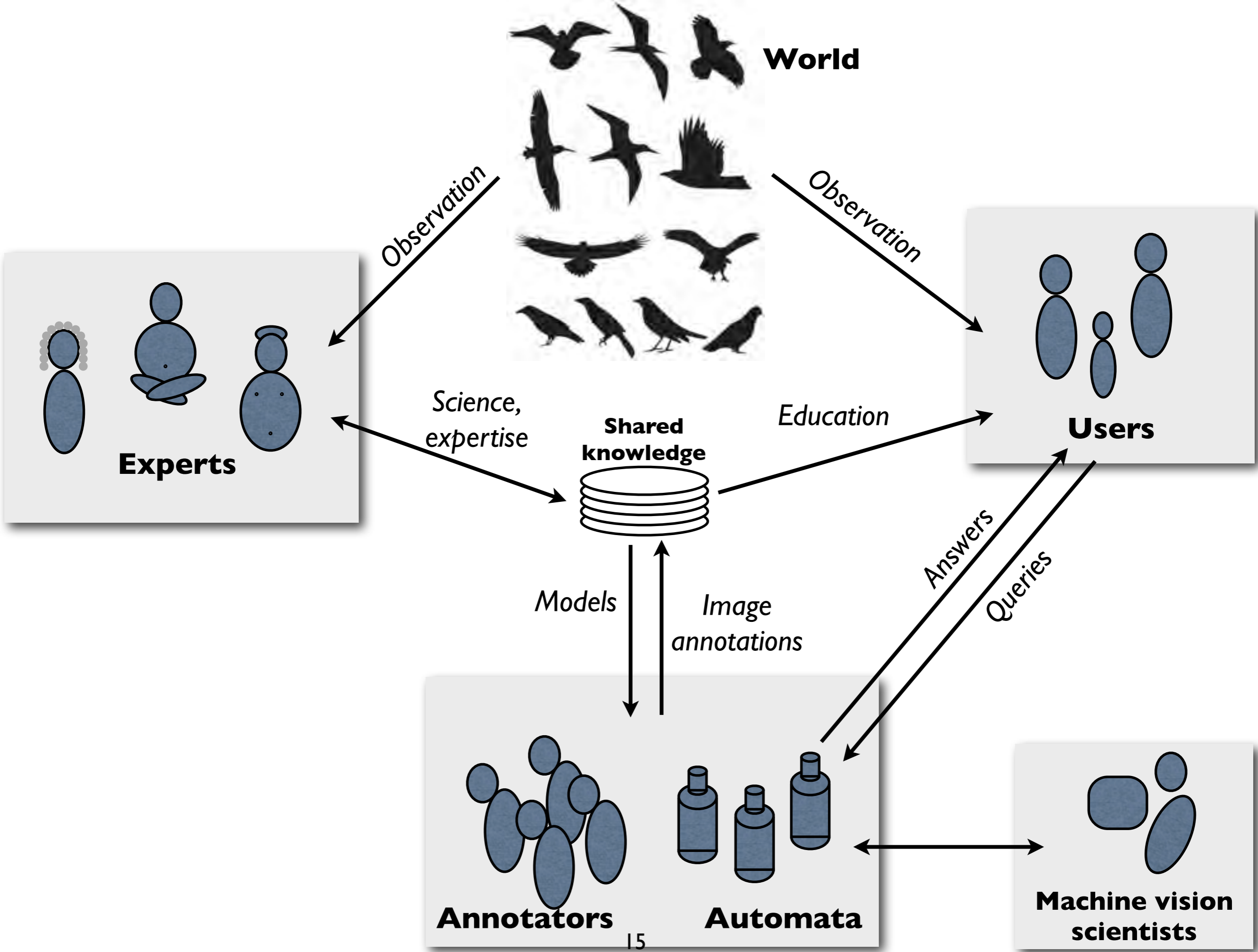


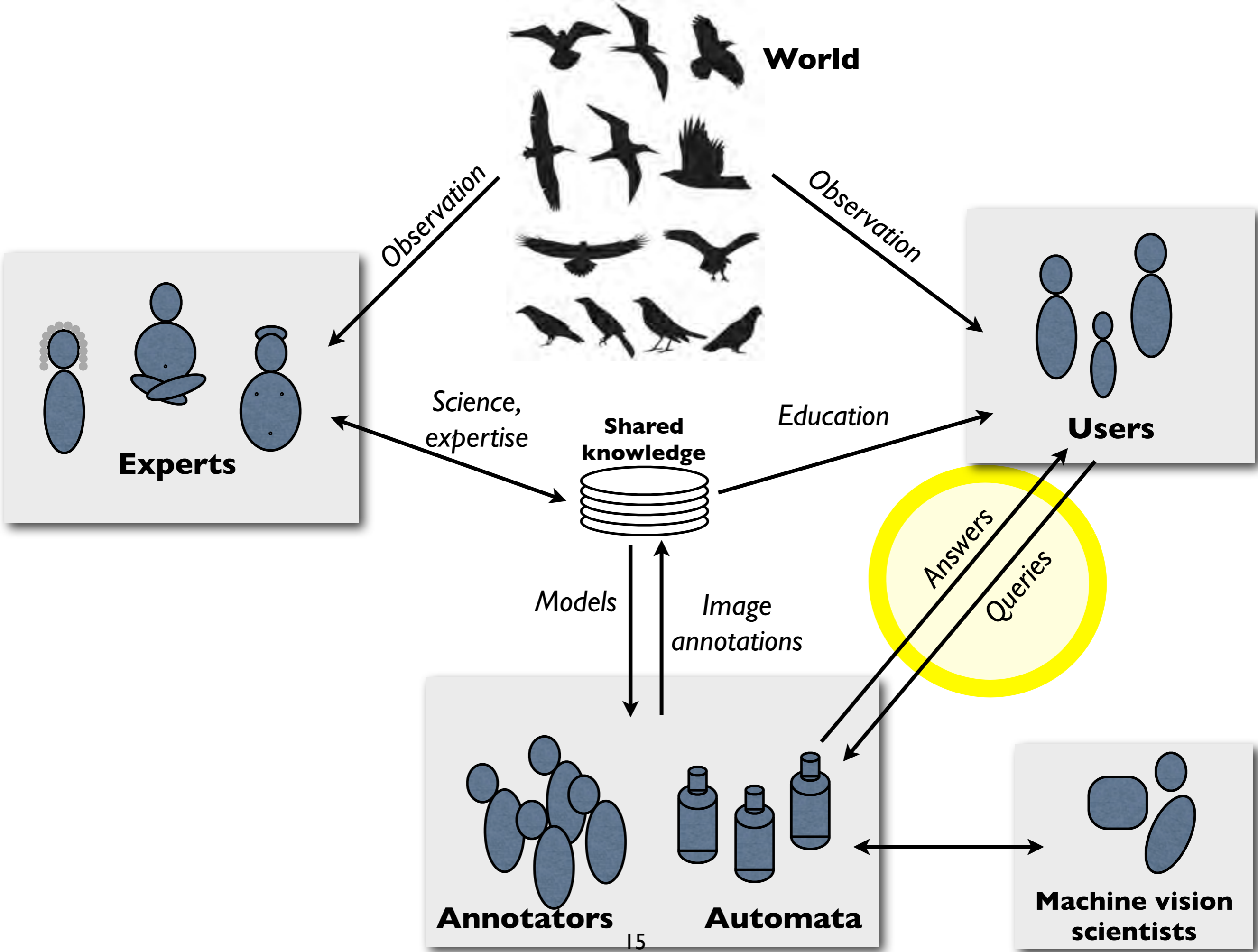
# Visual knowledge

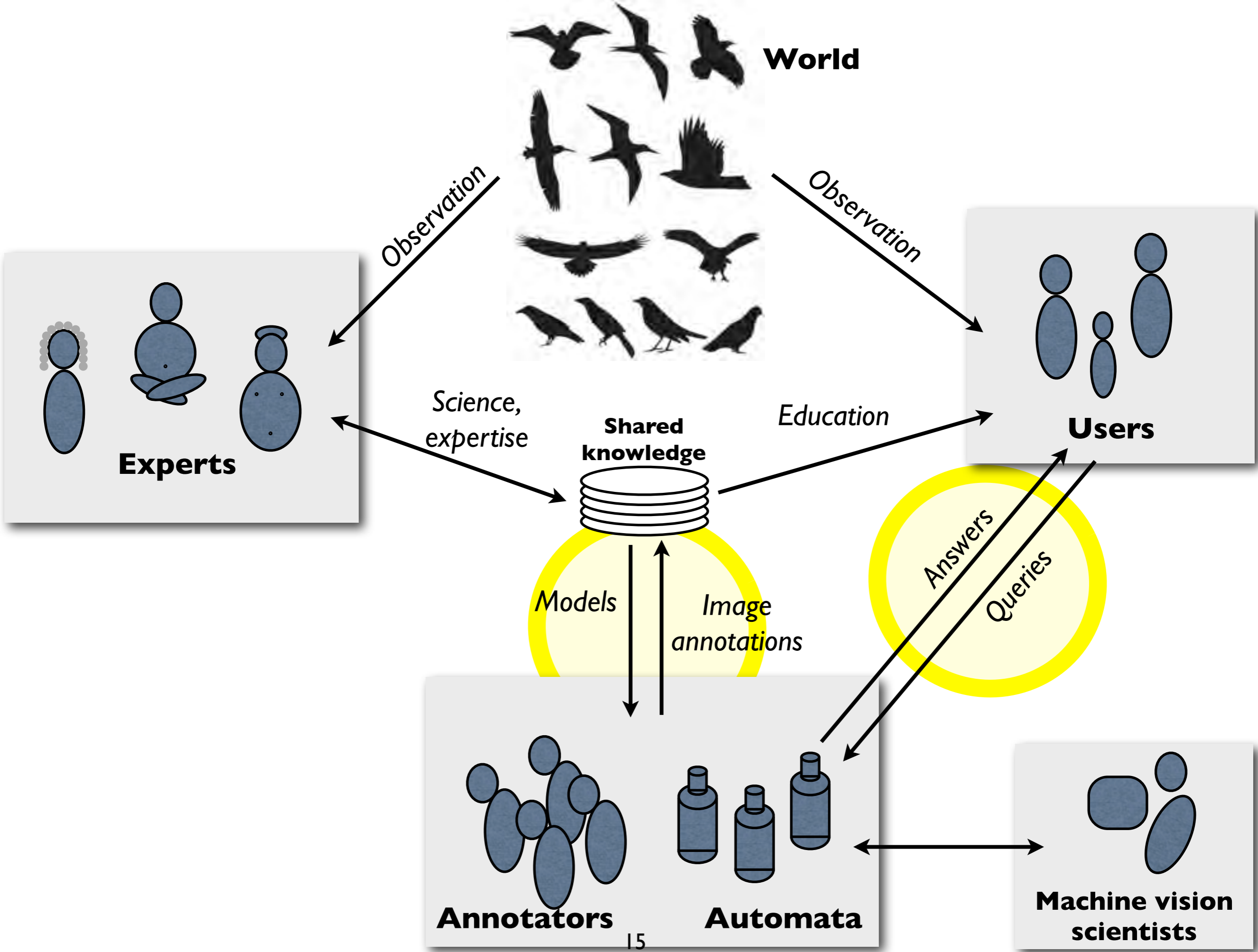


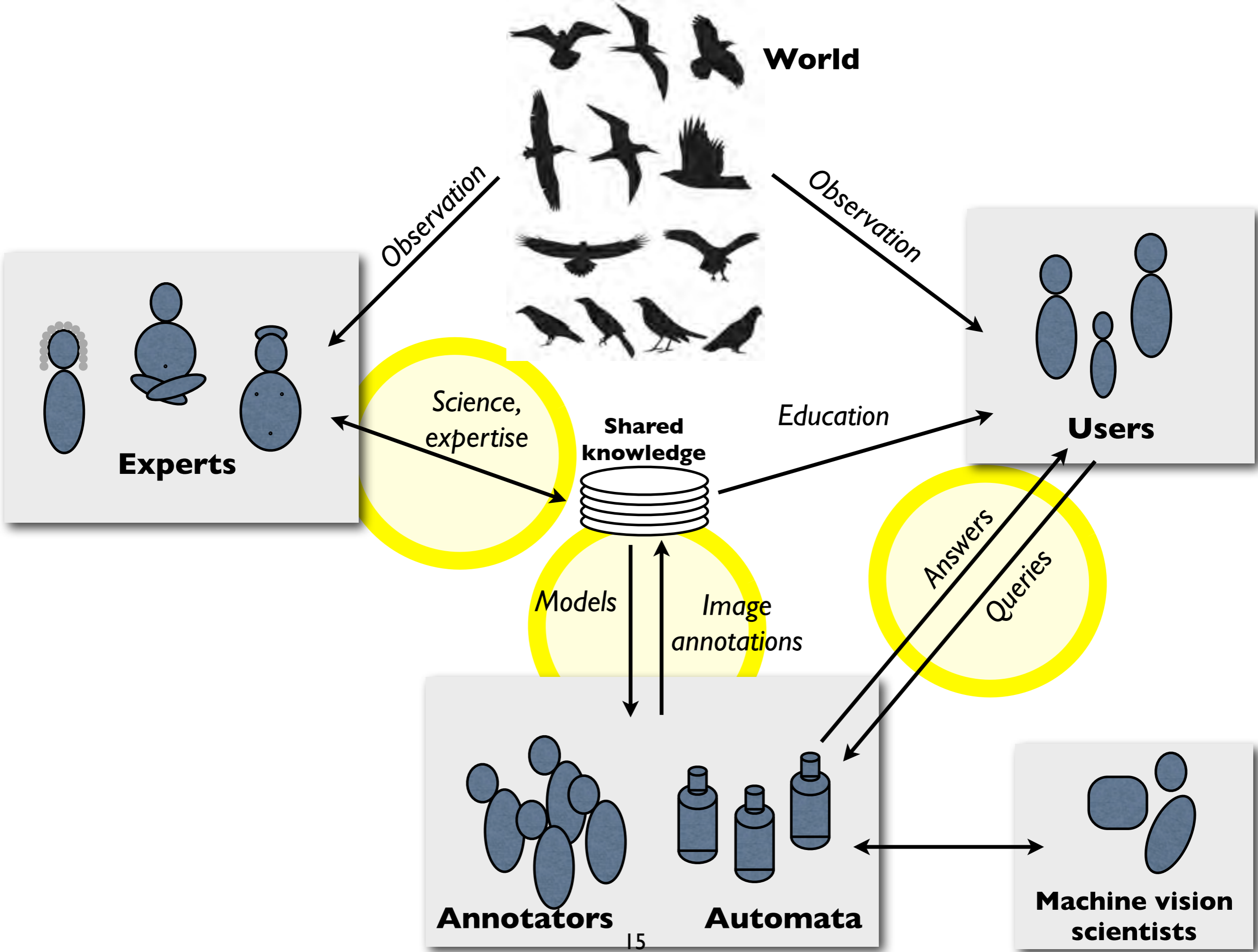
Categorical (experts)

14 Task-oriented (practitioners)









**Some progress...**

# DUCKS

Mallard



American Black Duck



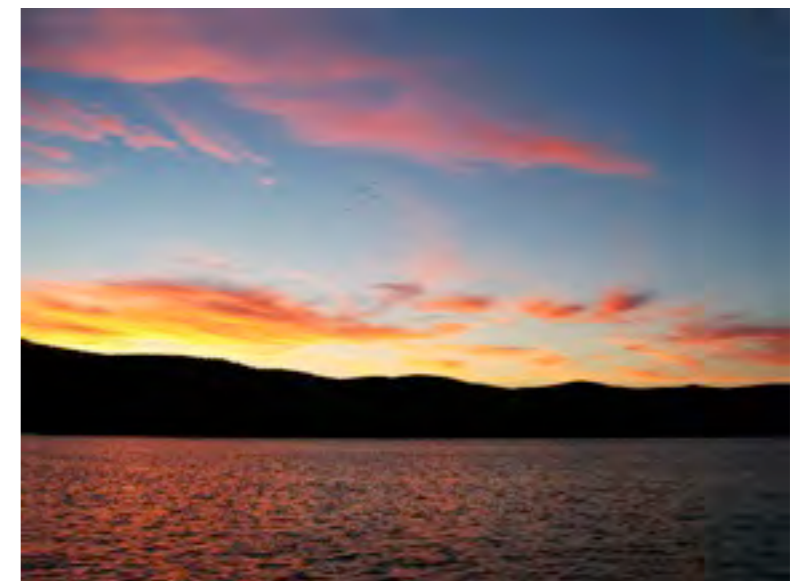
Canada Goose



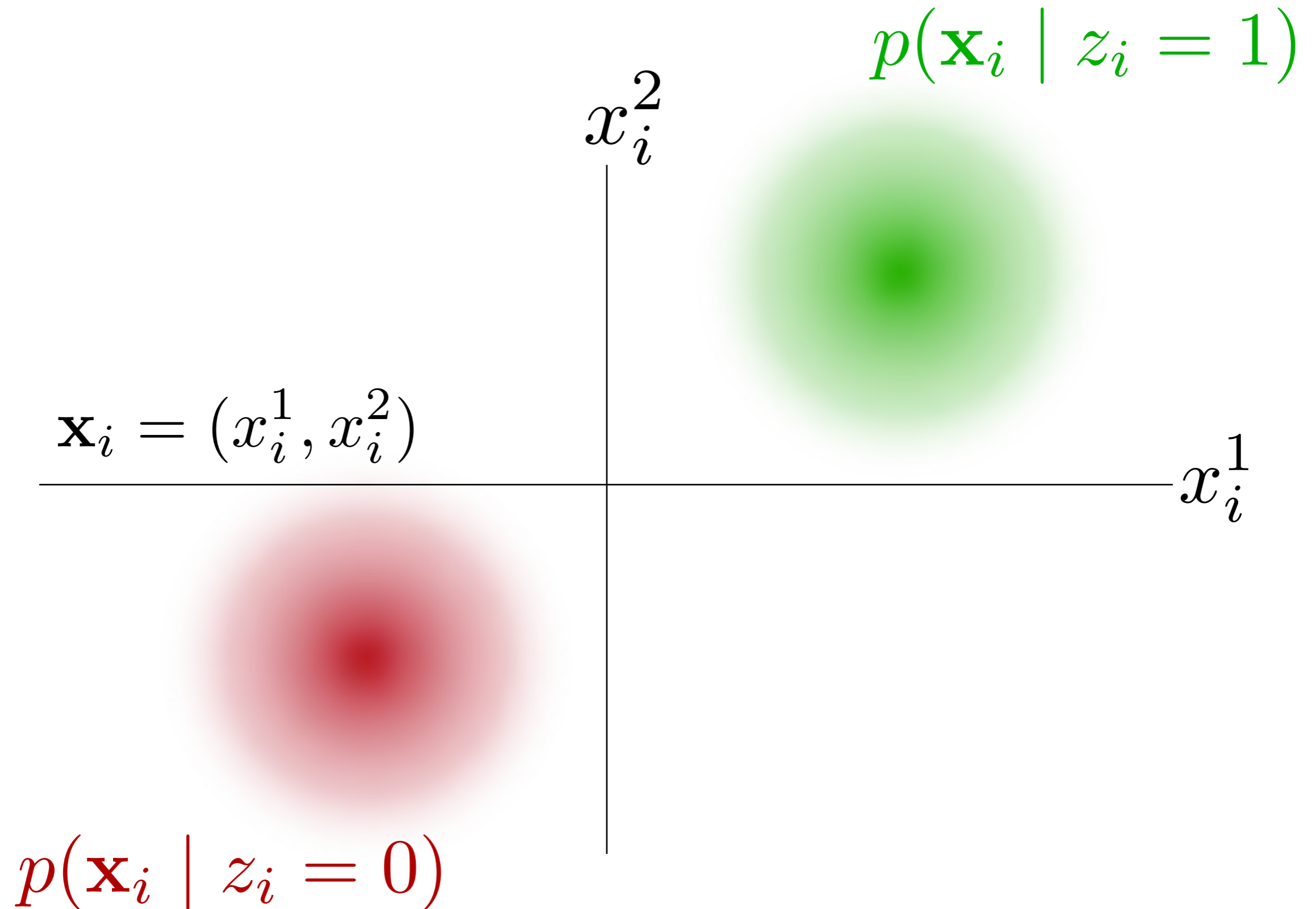
Red Necked Grebe



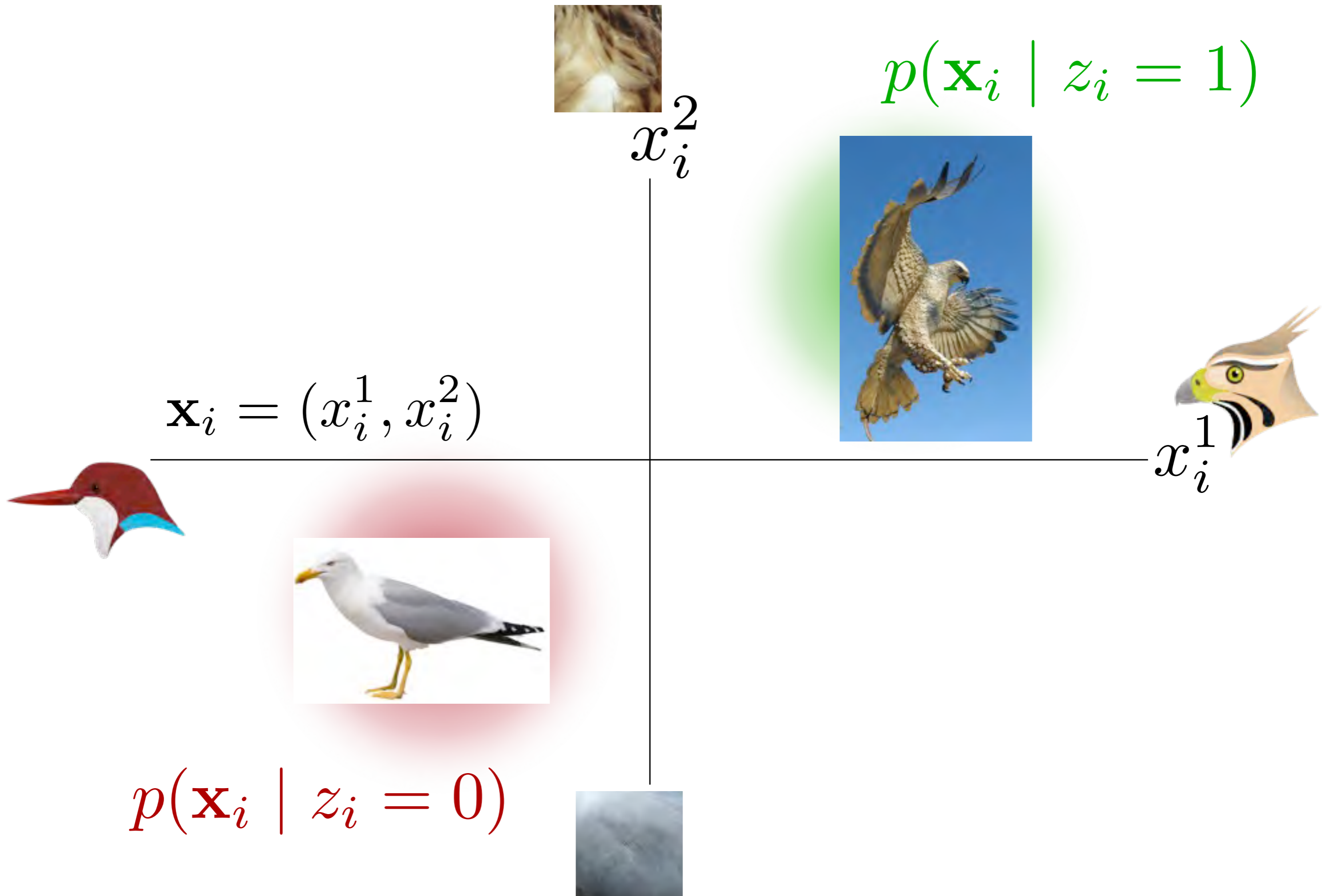
Clutter



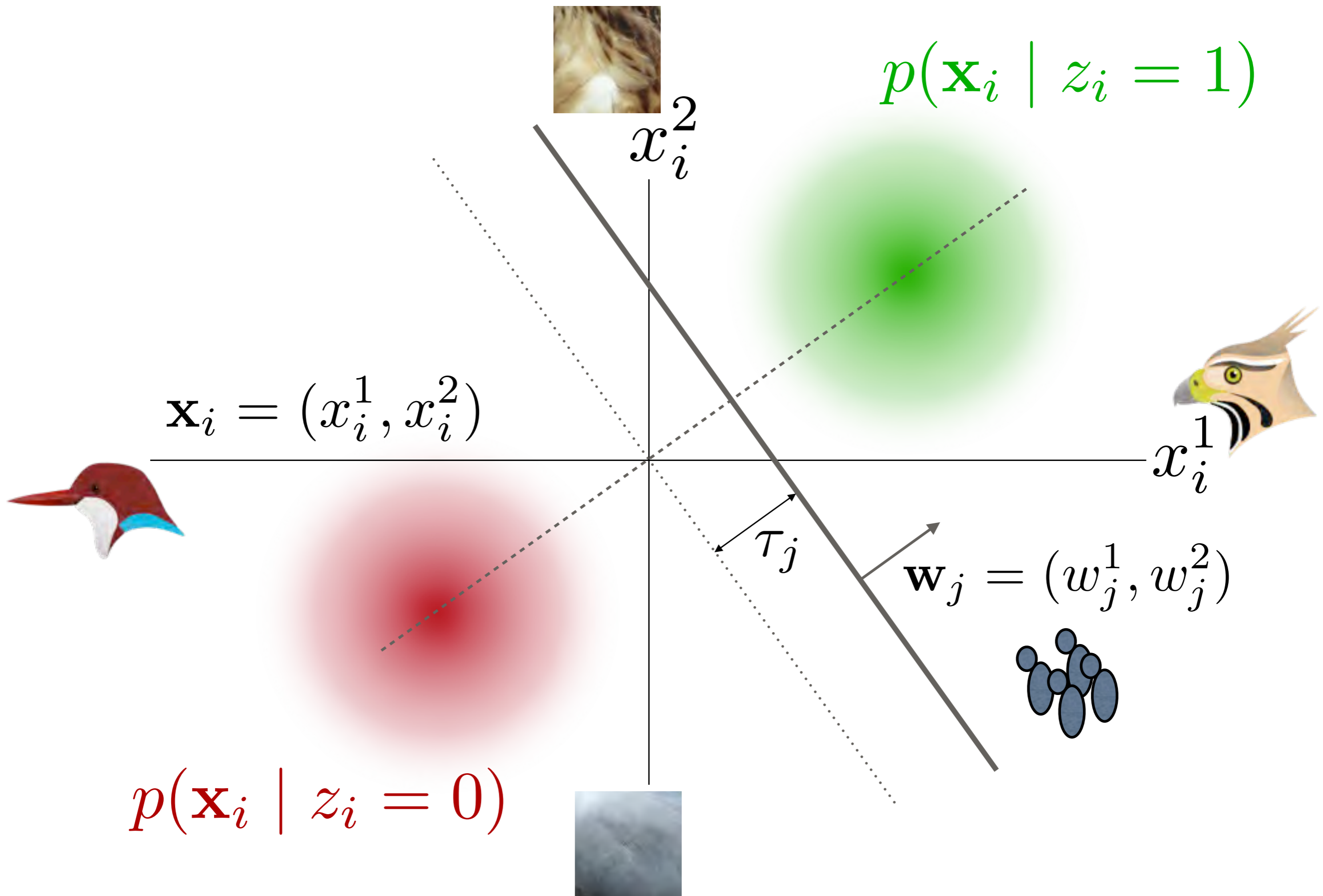
# Multidimensional signals and annotators



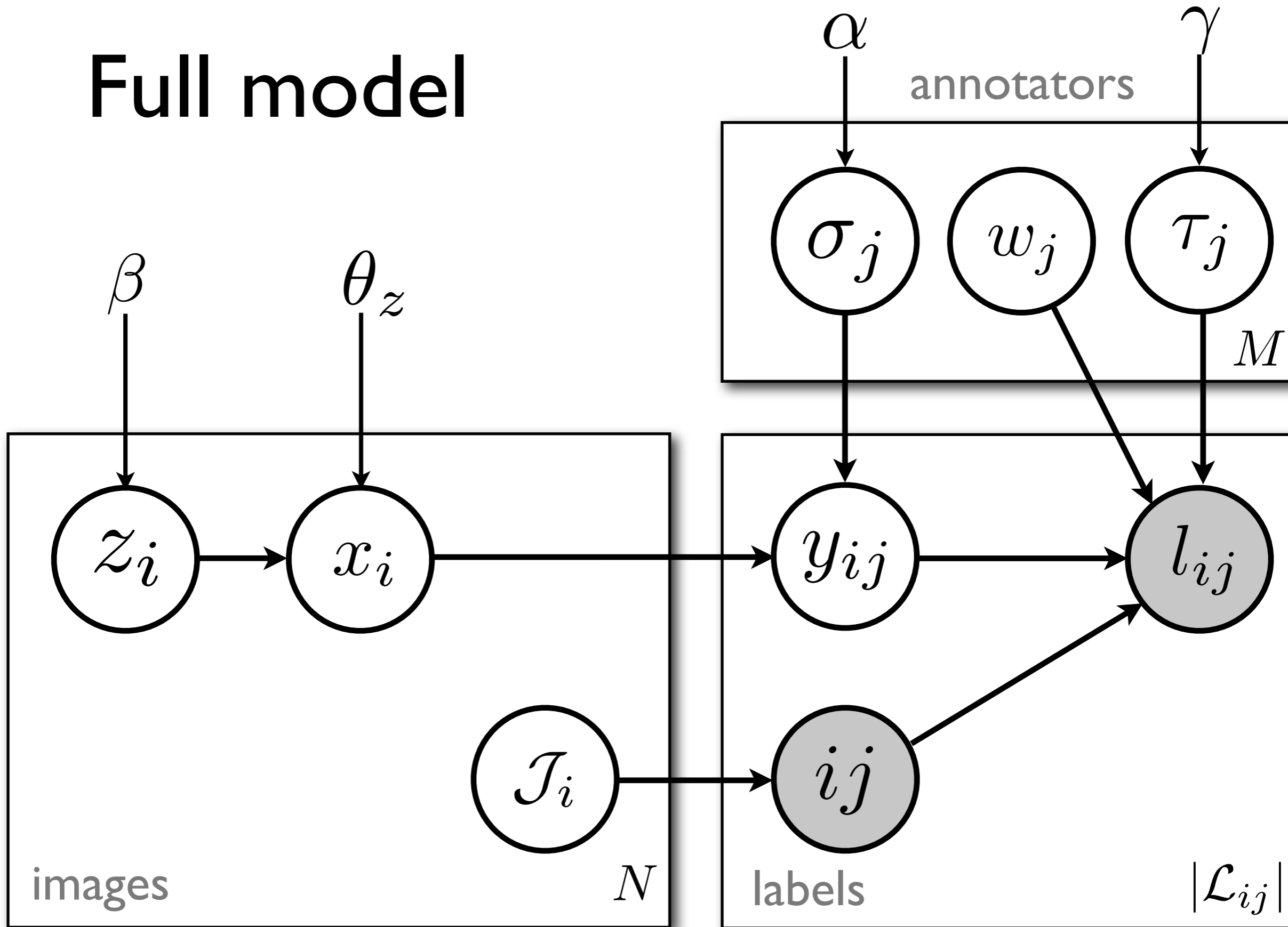
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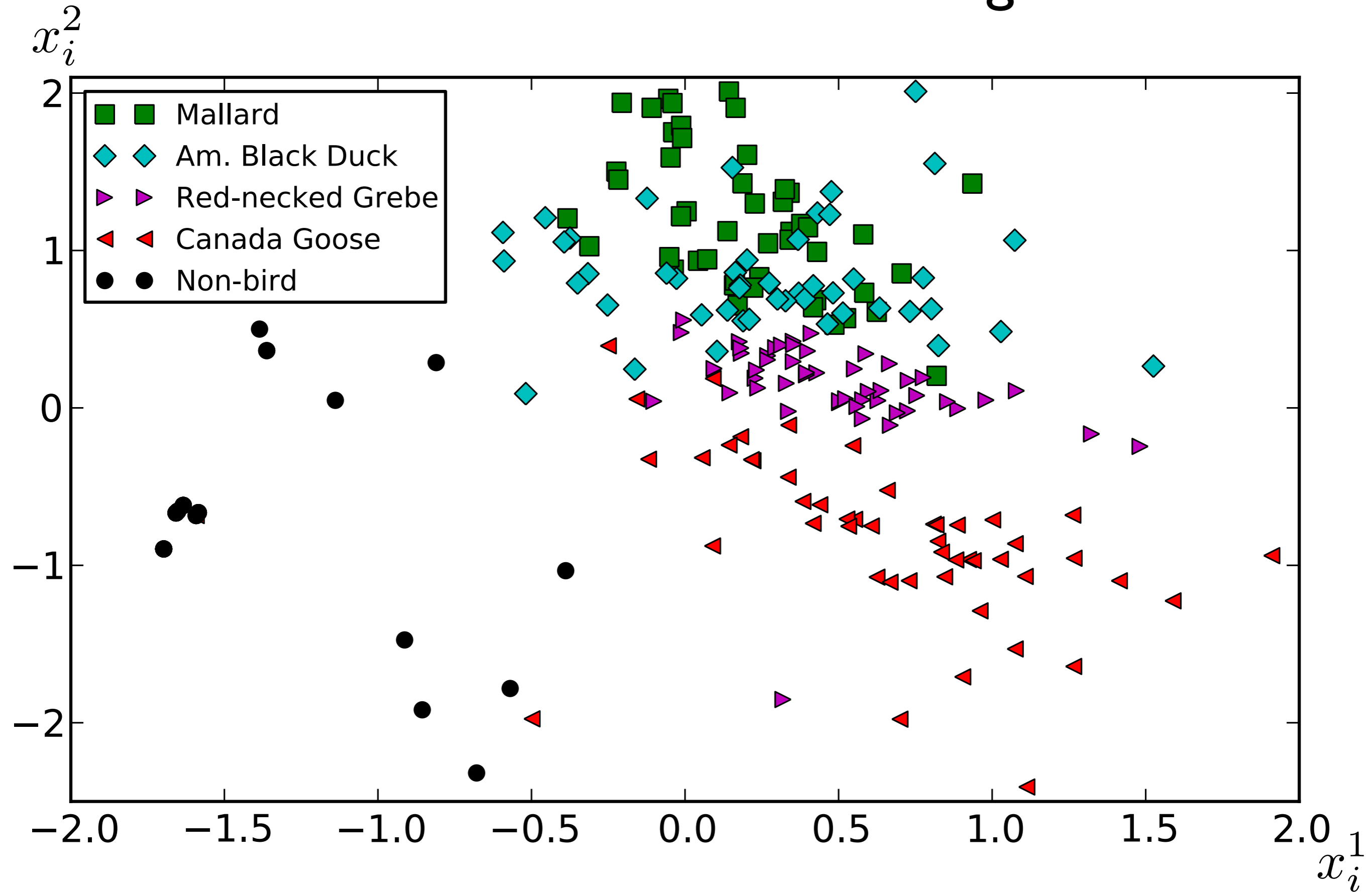


# Full model

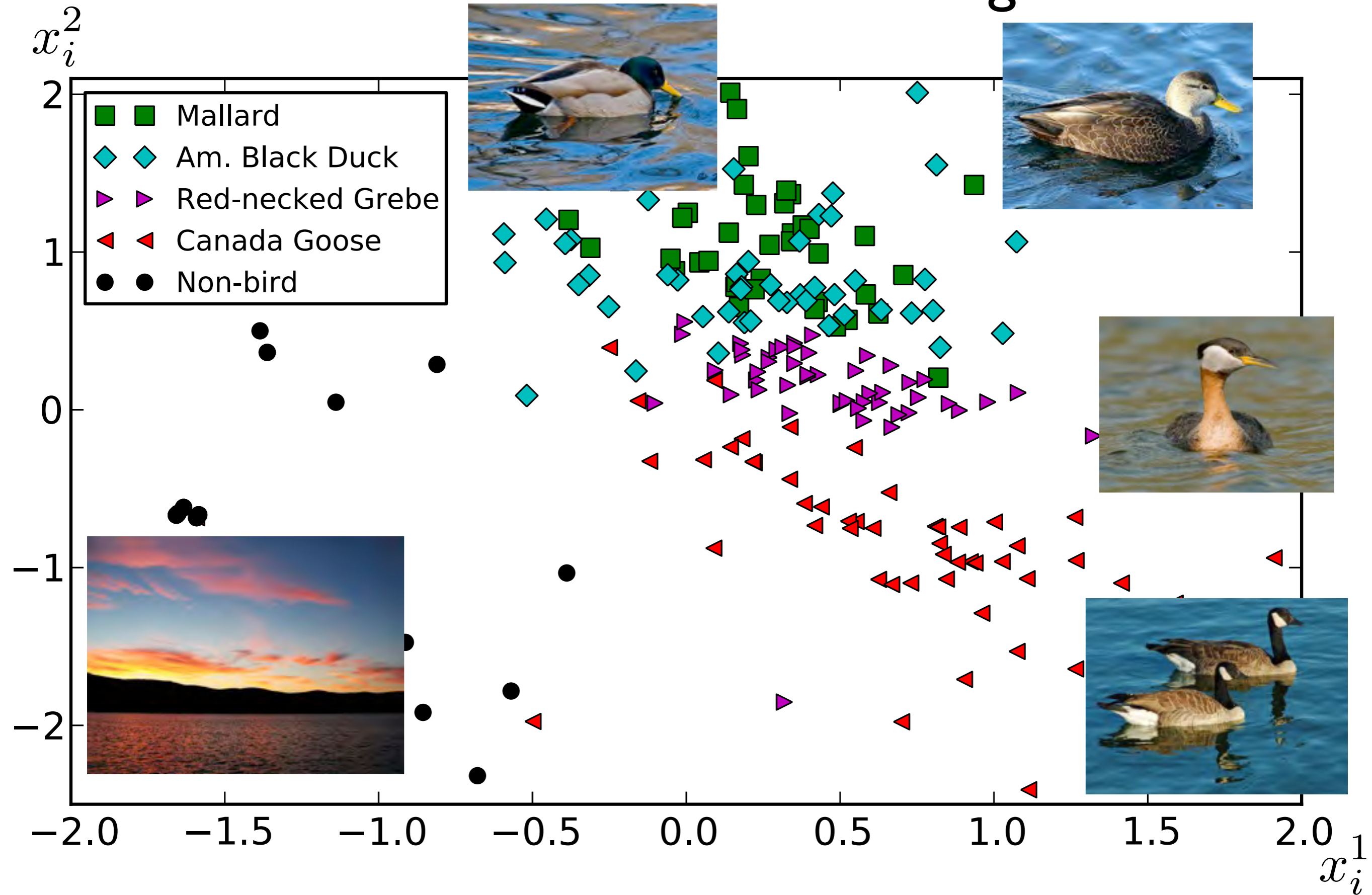


[Welinder et al., NIPS2010]

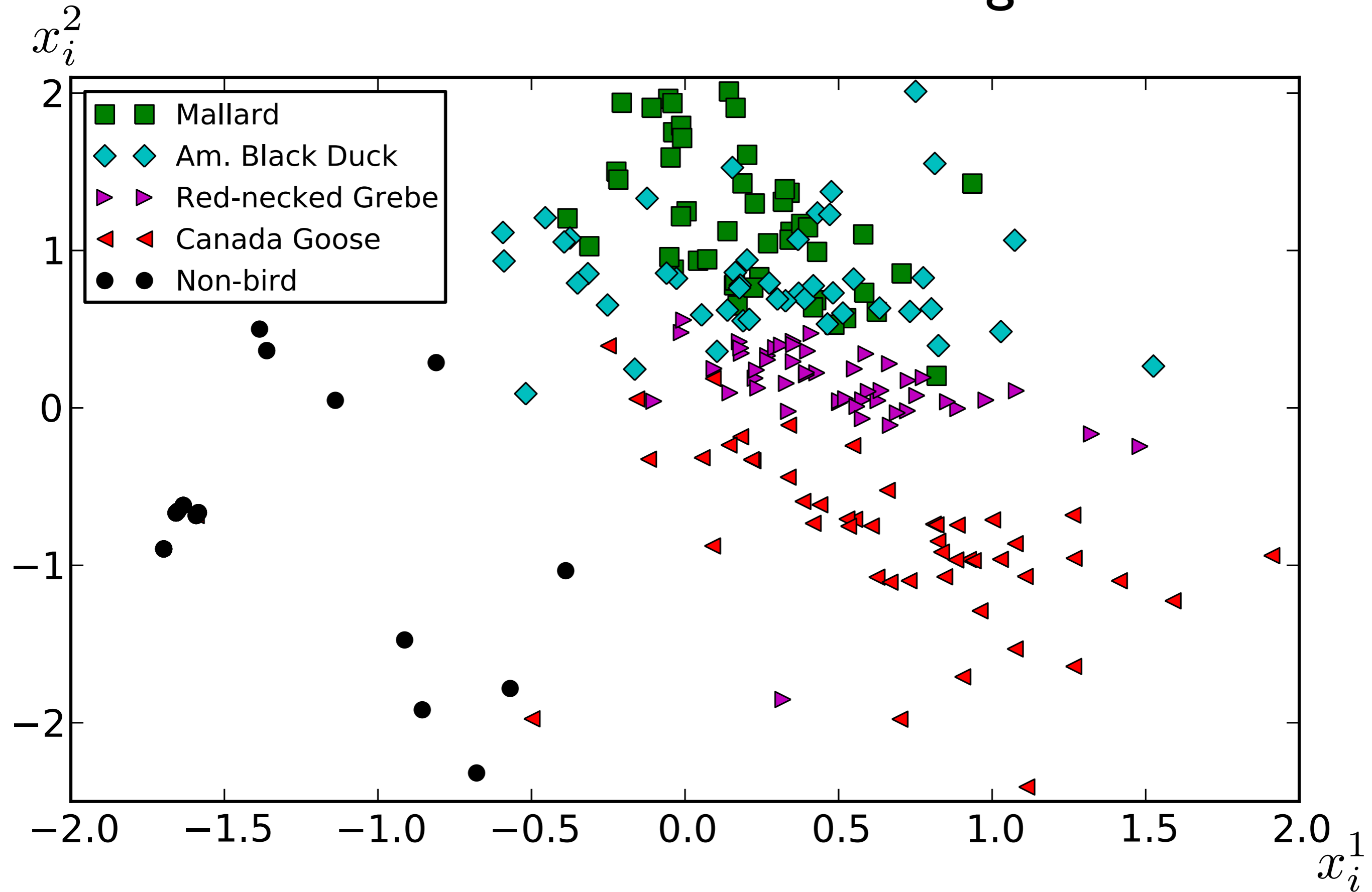
# Is there a duck in the image?



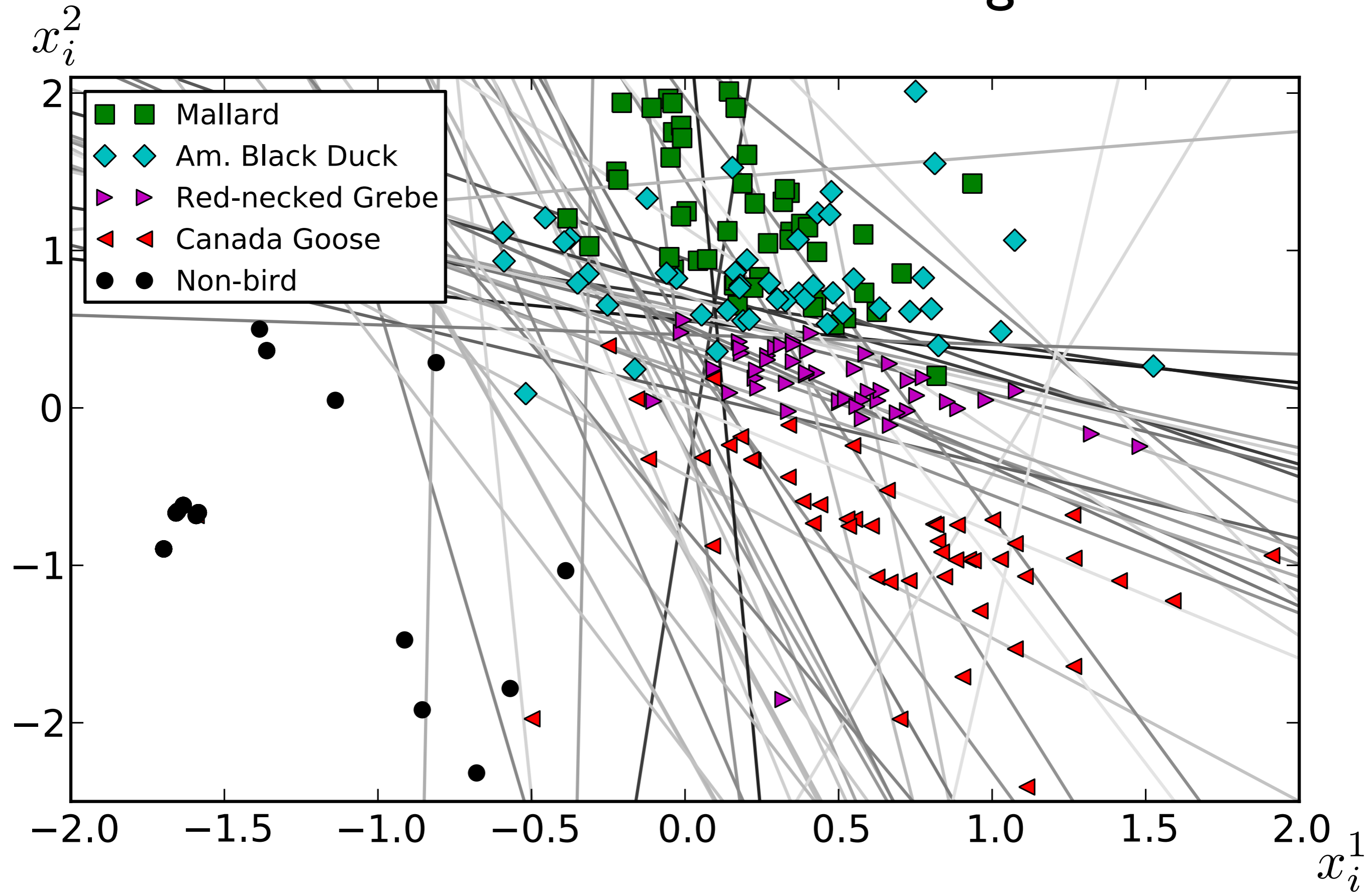
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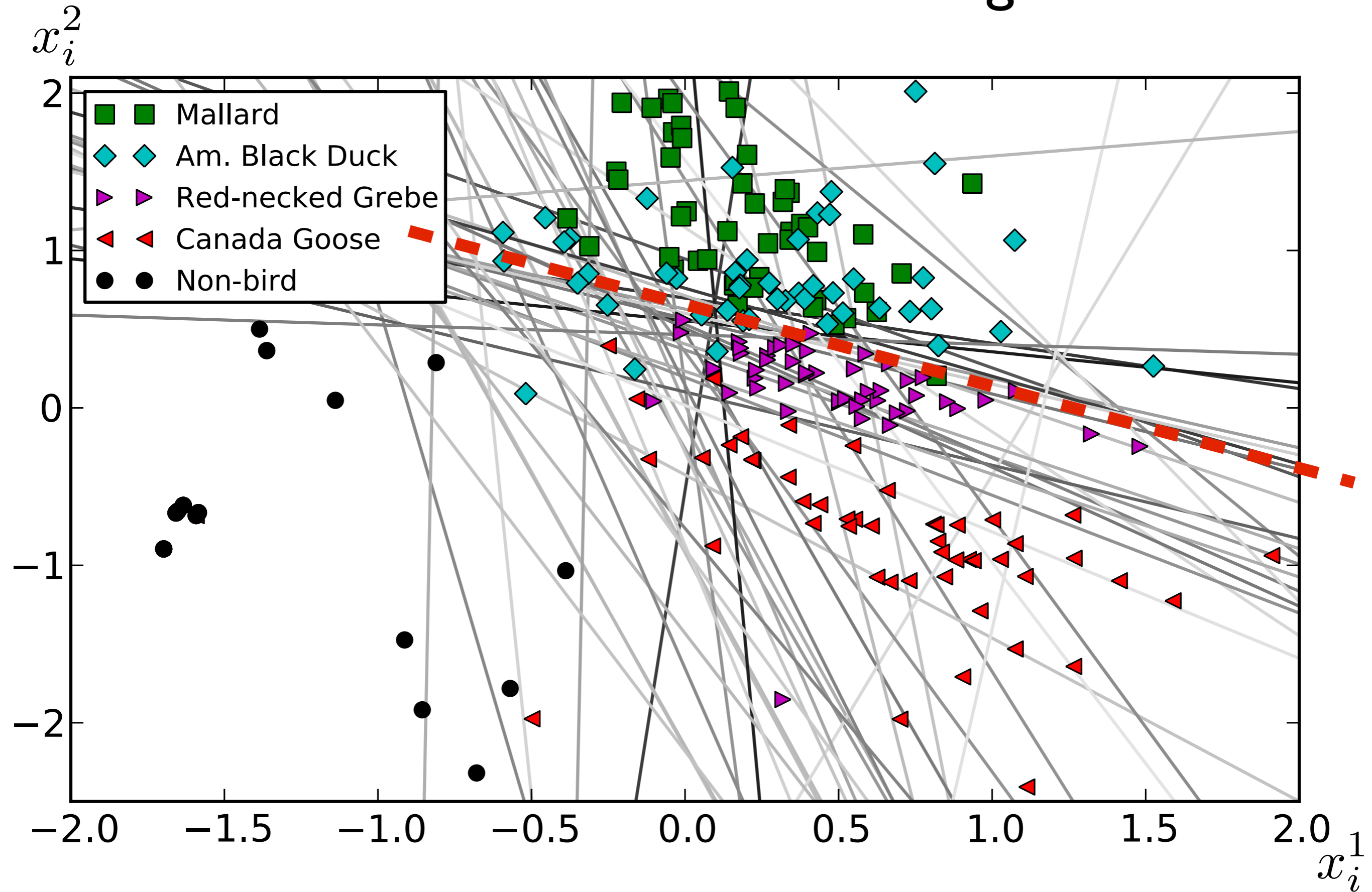
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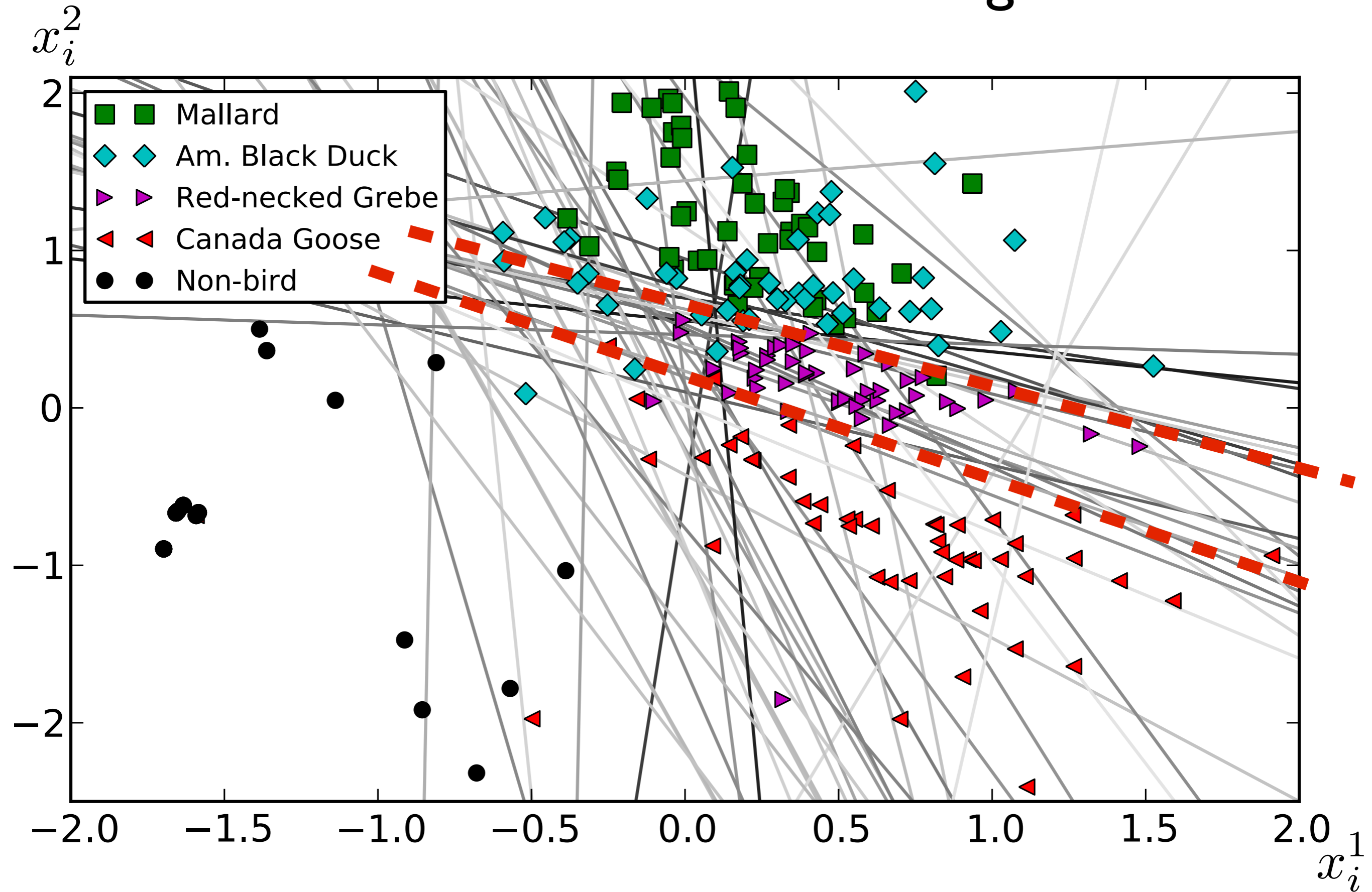
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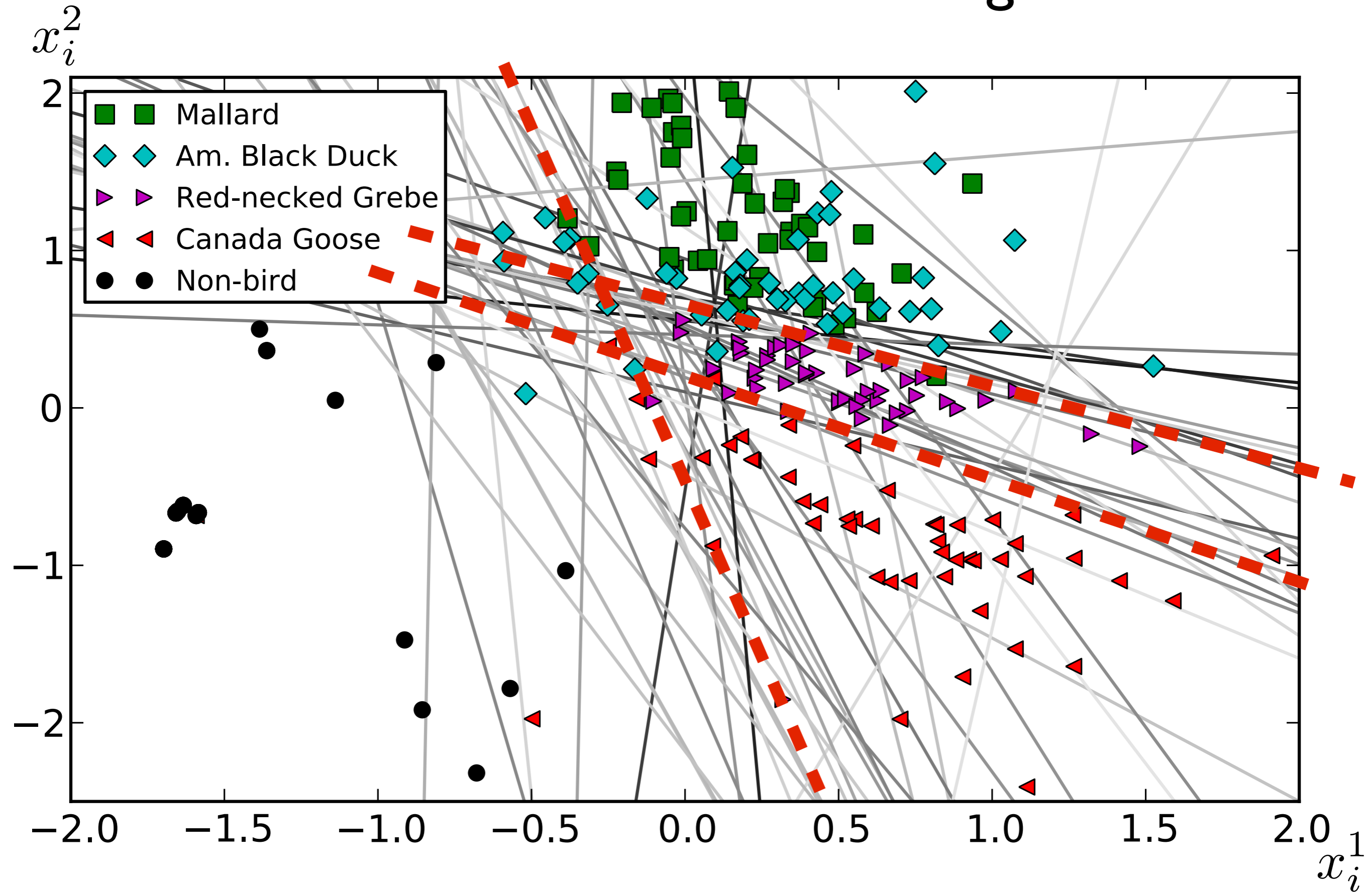
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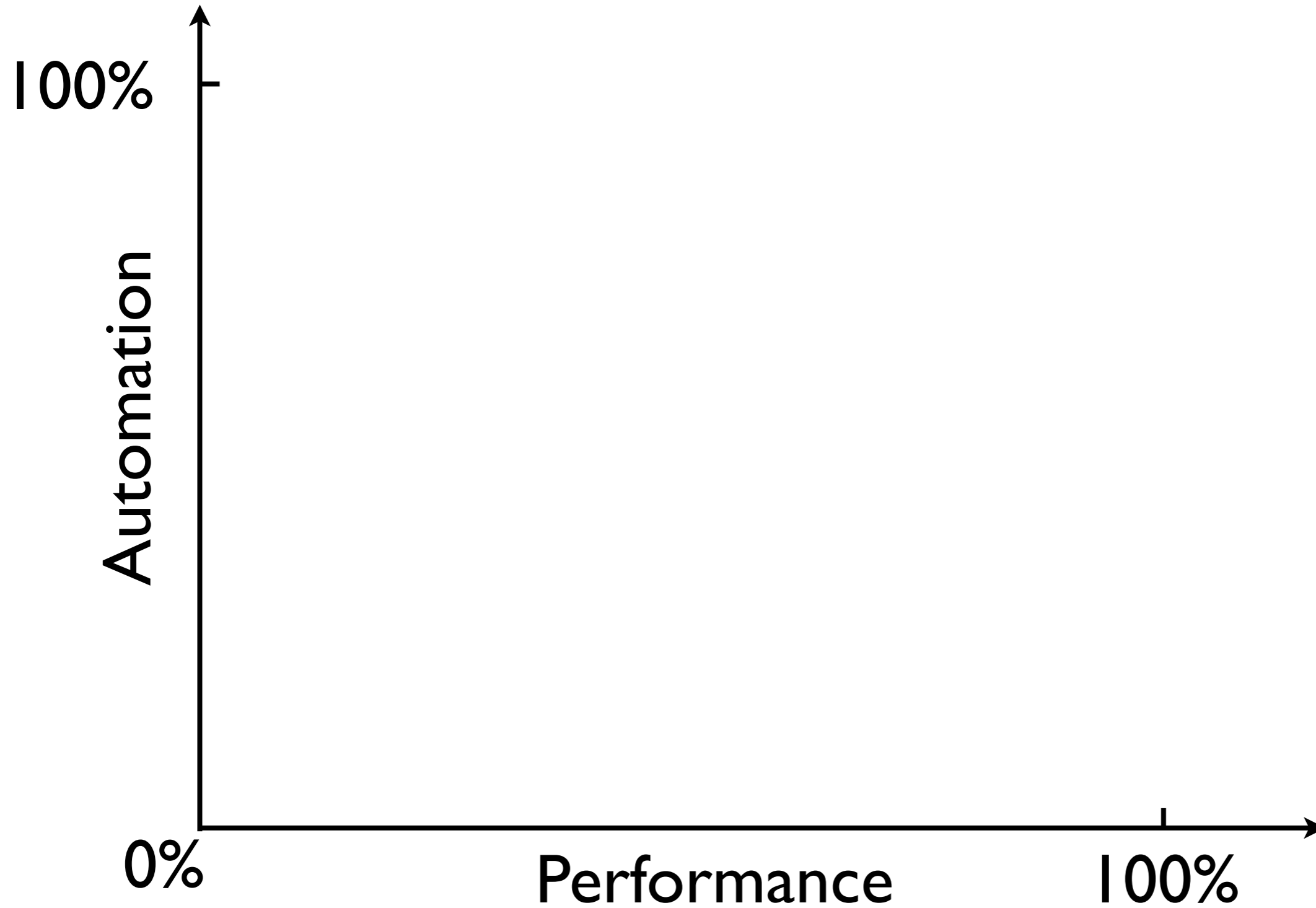


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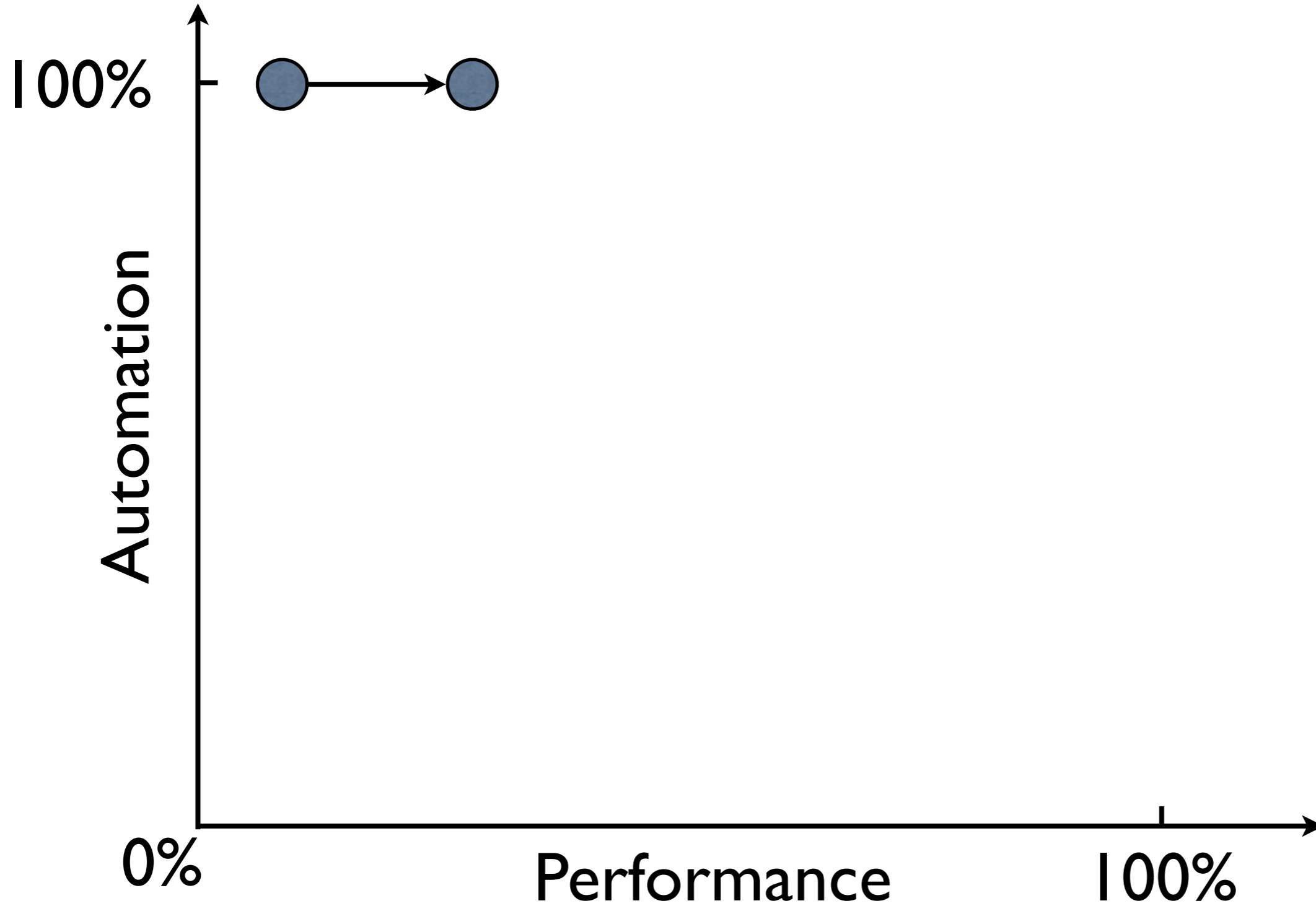


**Concluding...**

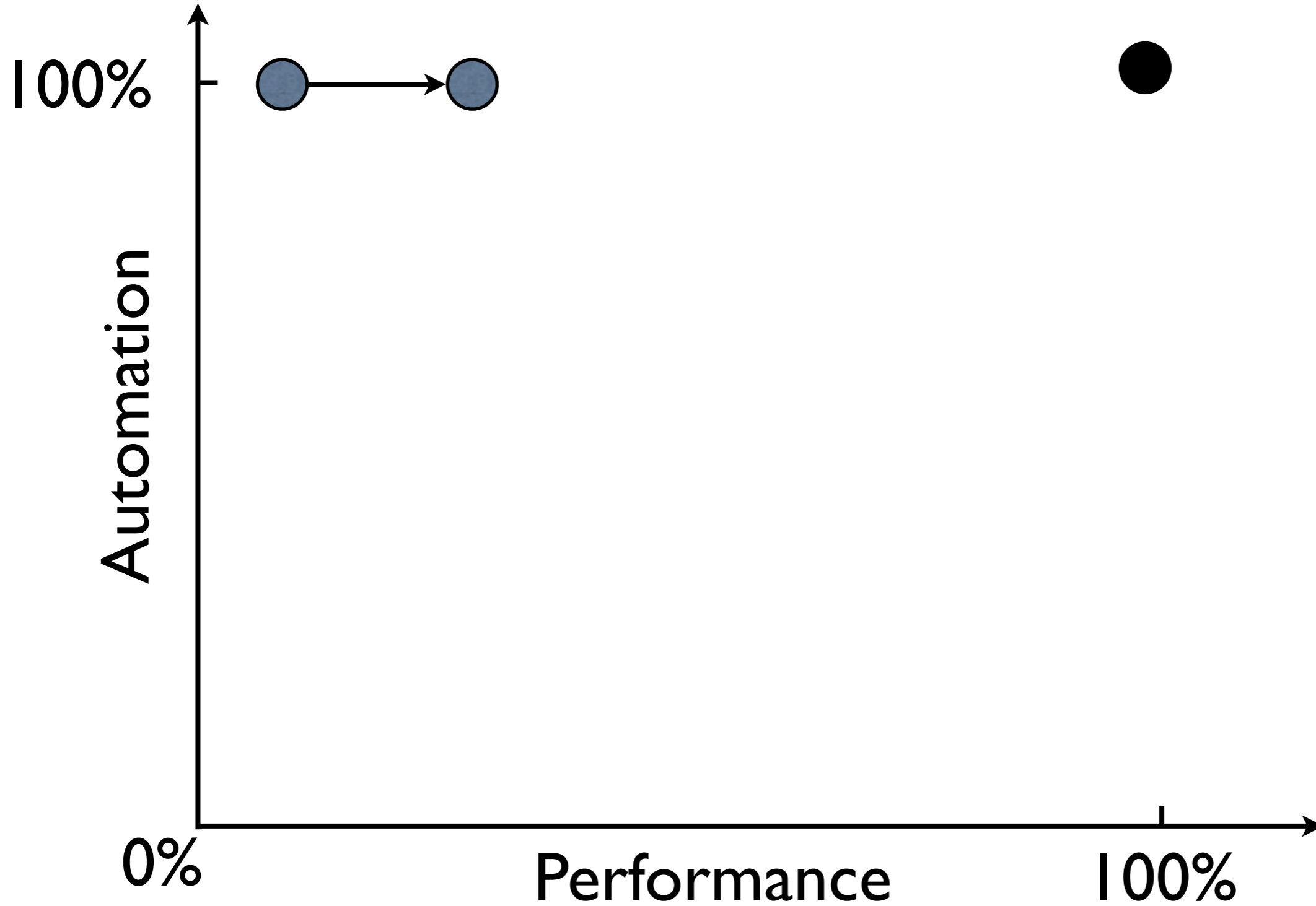
# Collaborative vision



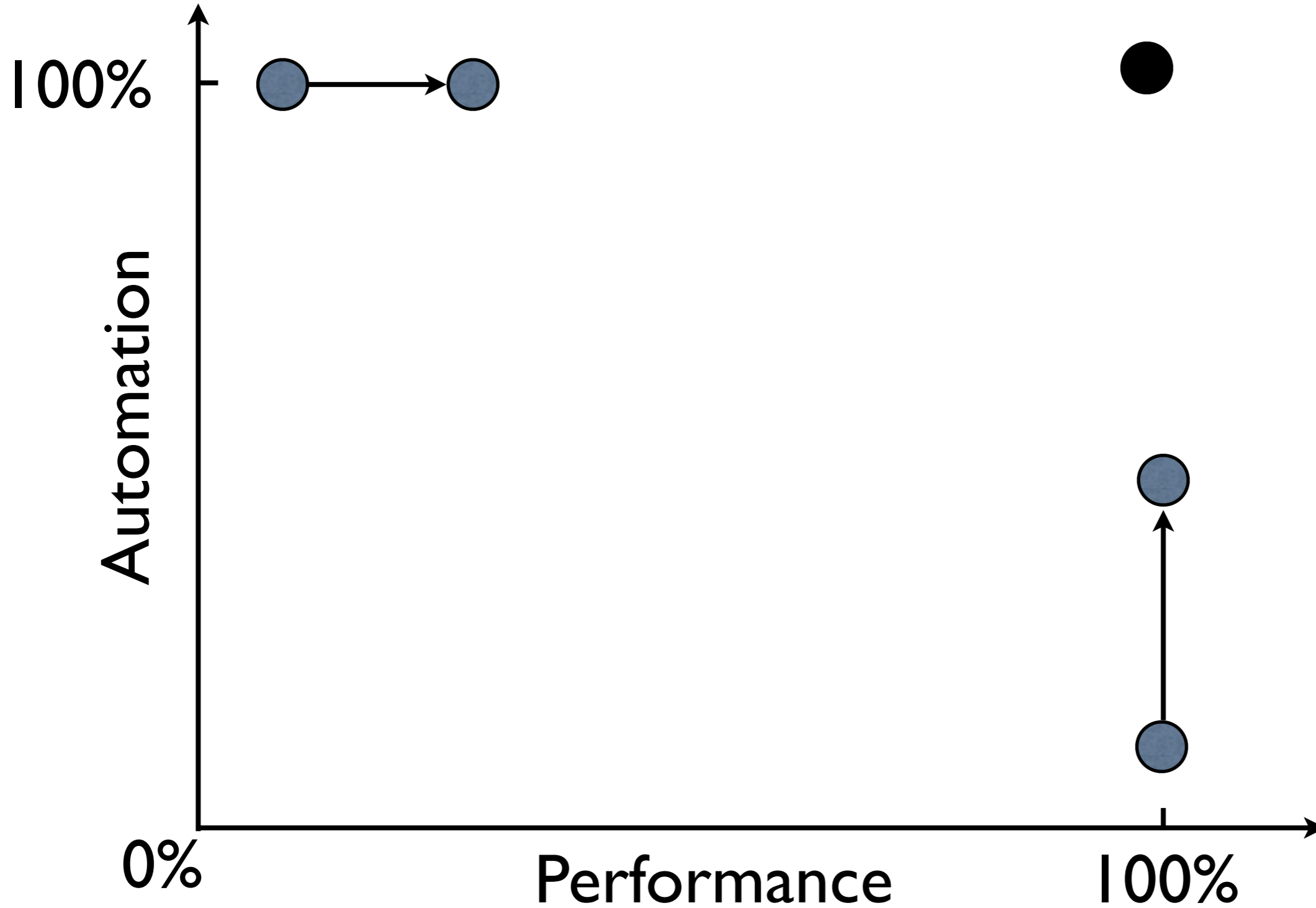
# Collaborative vision



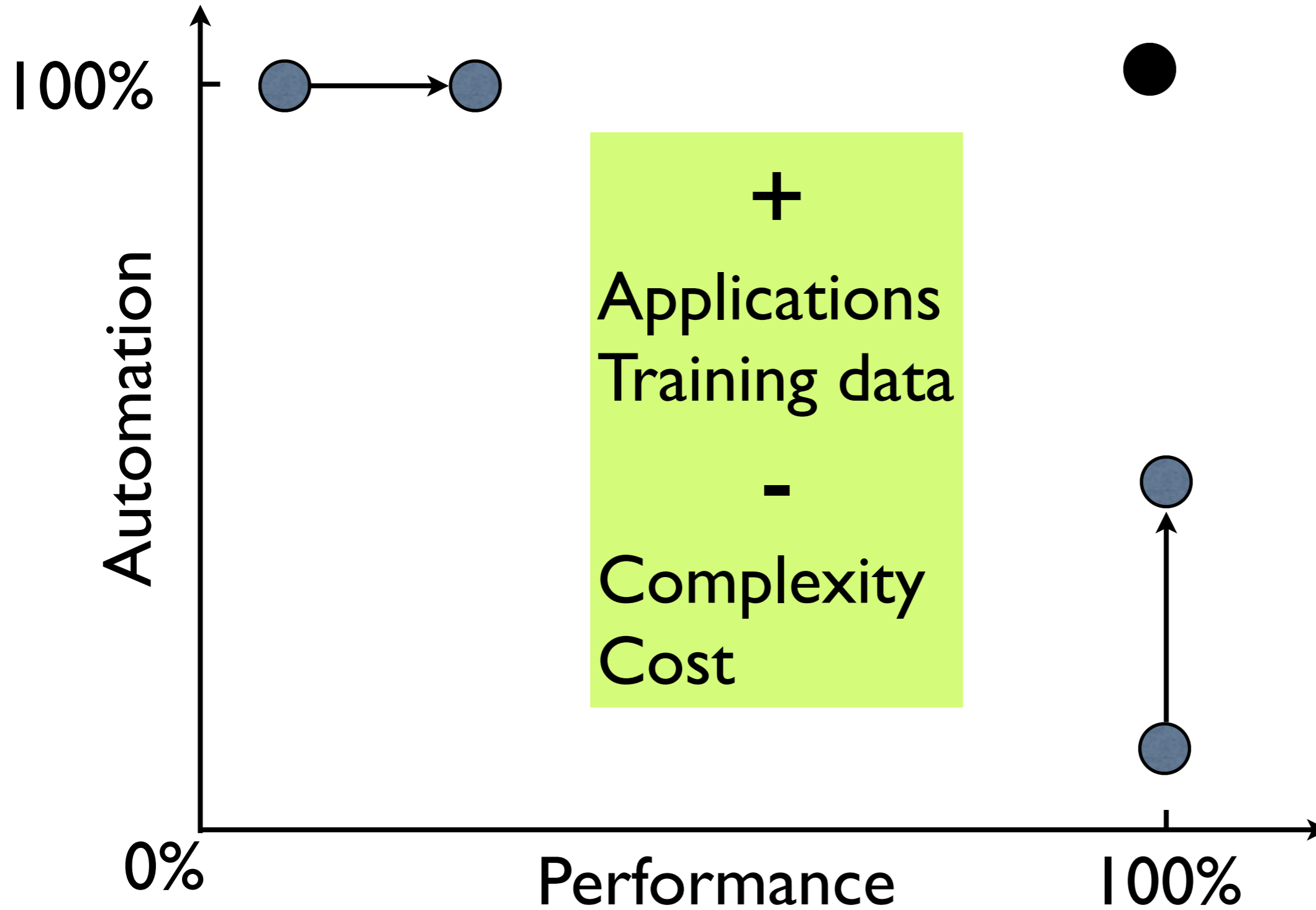
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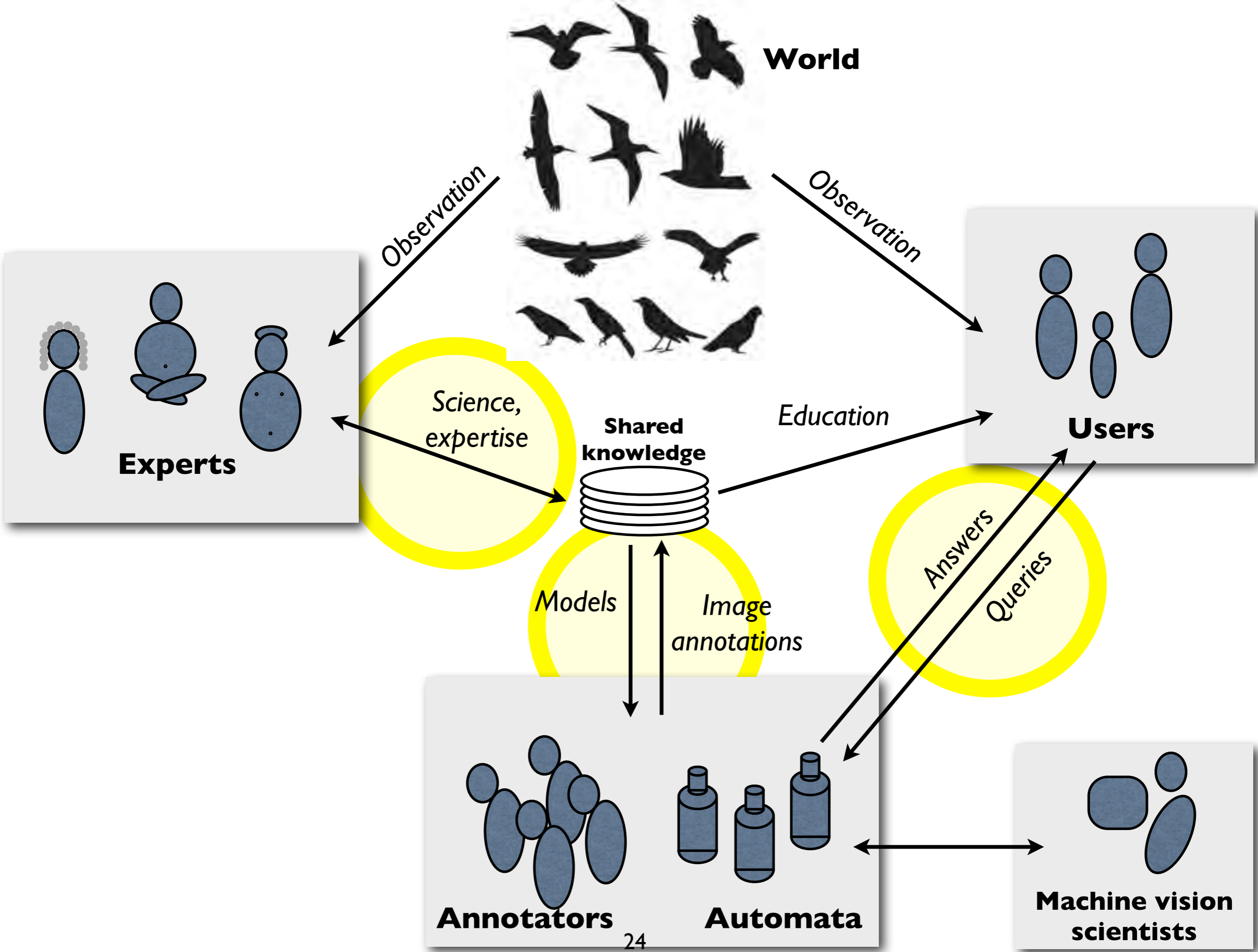


# Collaborative vision



# Collaborative vision





# New research directions

- Incremental learning
- Models of human vision, decision, attention
- Systems composed of machines and humans
- Performance bounds (humans, machines)
- Representations (human-machine-friendly)
- Extracting visual knowledge from experts