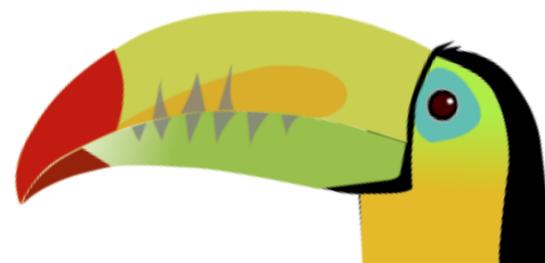


Visipedia Tool Ecosystem for Dataset Curation and Annotation

Serge Belongie



Outline

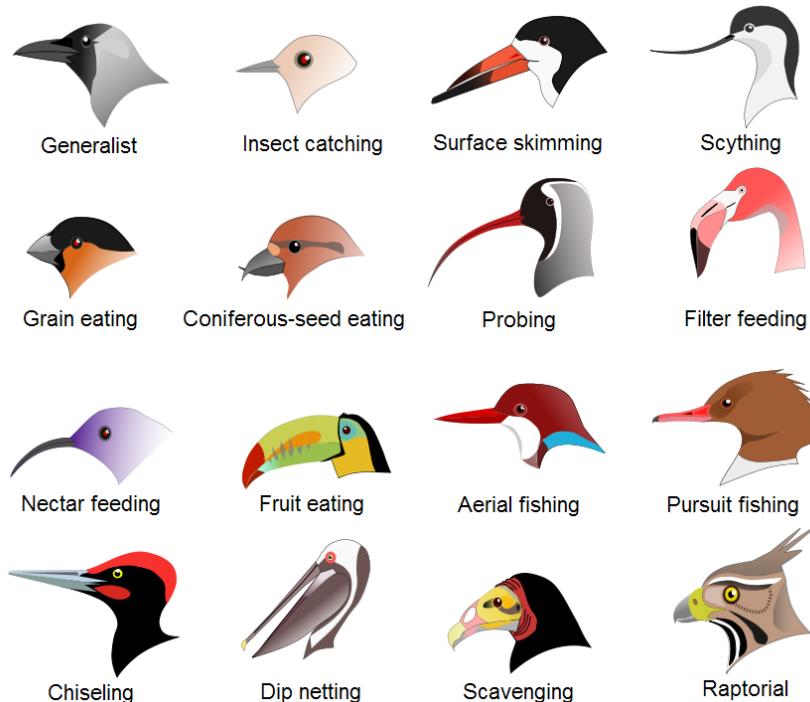
- Visipedia Project Overview
- Related Work
- Bird Datasets
- ViBE: Visipedia Back End
- Future Work

Outline

- **Visipedia Project Overview**
- Related Work
- Bird Datasets
- ViBE: Visipedia Back End
- Future Work

What Is Visipedia?

- A user-generated encyclopedia of visual knowledge
- An effort to associate articles with large quantities of well-organized, intuitive visual concepts



Motivation

- People will willingly label or organize certain images if:
 - They are interested in a particular subject matter
 - They have the appropriate expertise



Ring-tailed lemur



Thruxtion Jackaroo

A DUBIOUSLY ACCURATE 233 YEAR HISTORY OF CYCLING

posted by Saris - September 4, 2013 - 5pm EDT



While we're not particularly certain about some of the claims in this bicycle family tree (e.g. freeride bikes spawned downhill bikes, which gave birth to 29ers?), we're certain you'll appreciate the artwork. You can head to their [website](#) to buy your own copy and laugh at the implication that big wheels evolved into recumbents for only \$22.

THE EVOLUTION OF BICYCLES

COMMENTS

Ben - 09/04/13 - 5:44pm

This is so completely out of order. Why the hell would you pay 22 dollars for a poster that doesn't make any sense?

Gillis - 09/04/13 - 6:00pm

I like how the track bike sits in between the randonneur and touring bikes. And a modern looking TT bike some how comes before Boardman's Lotus, which both come after fixie's.

This is junk.

Walter - 09/04/13 - 6:09pm

So triathlon bikes gave birth to fixies and early eighties long wheel base recumbents came from modern high racers. These folks are creationists.

NotAMachinist - 09/04/13 - 6:20pm

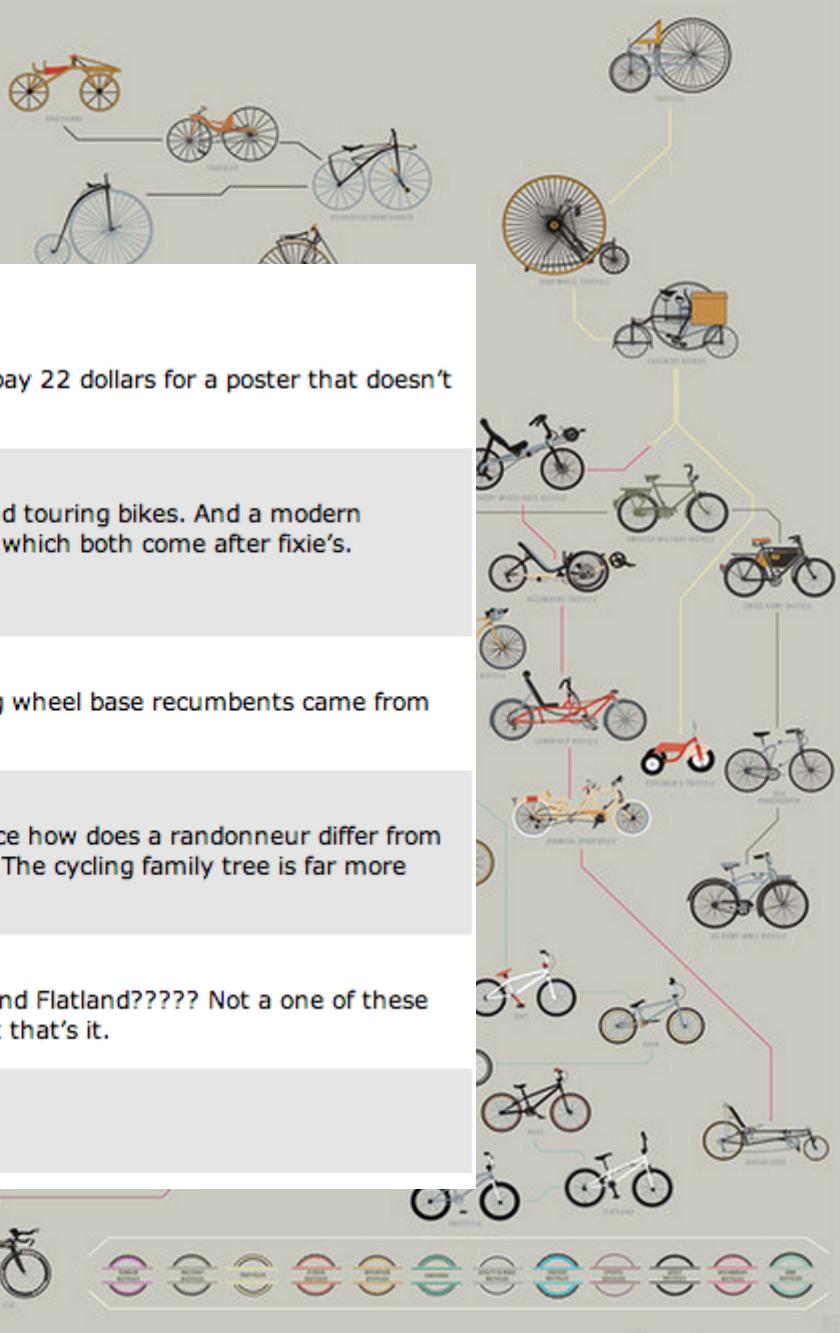
It's sort of cool looking until you really look at it. For instance how does a randonneur differ from a touring or trekking bike? How did cyclocross spawn BMX? The cycling family tree is far more incestuous.

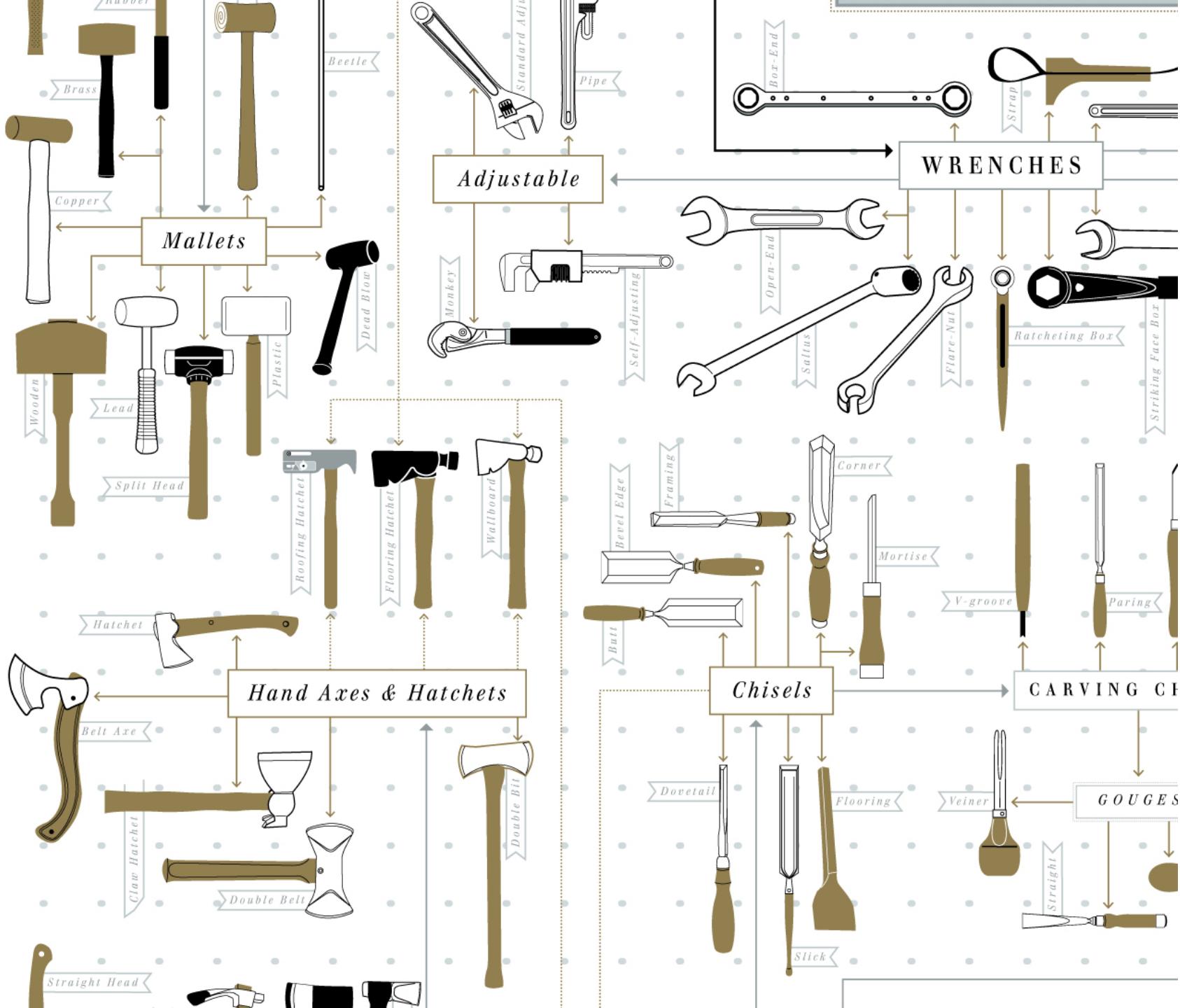
Joe - 09/04/13 - 6:22pm

Cyclocross to 20" Dirt, Street, Park to Racing to Freestyle and Flatland????? Not a one of these is right....the whole chart is a nice piece of wallpaper art but that's it.

Keith D - 09/04/13 - 6:46pm

It's pretty much rubbish.

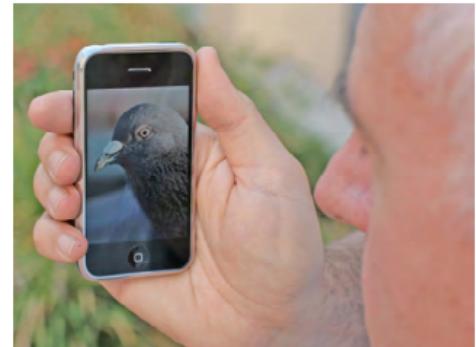




Motivation

- Construct comprehensive, intuitive knowledge base of visual objects
- Provide better text-to-image search and image-to-article search

The screenshot shows a Wikipedia article page for the Rock Dove. At the top, there's a navigation bar with links for Article, Talk, Read, Edit, View history, and Search. Below the title 'Rock Dove' and its subtitle 'From Wikipedia, the free encyclopedia', there's a note: "'Rock Pigeon' redirects here. For other uses, see [Rock Pigeon \(disambiguation\)](#)'. The main text describes the Rock Dove (*Columba livia*) or Rock Pigeon, noting it's a member of the Columbidae family. It mentions the domestic pigeon and feral populations. The habitat section discusses various open environments, mentioning cliffs and rock ledges. A sidebar on the right contains a large image of a Rock Dove, its scientific name 'Adult *C. l. intermedia* in India', a conservation status chart showing 'Least Concern' (LC), and a link to 'Scientific classification'. At the bottom left, there's a 'Contents' box with sections for Taxonomy and naming, Subspecies, and Description.

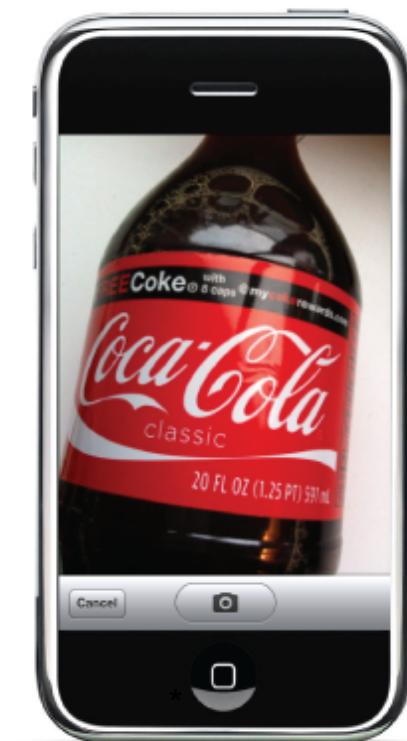
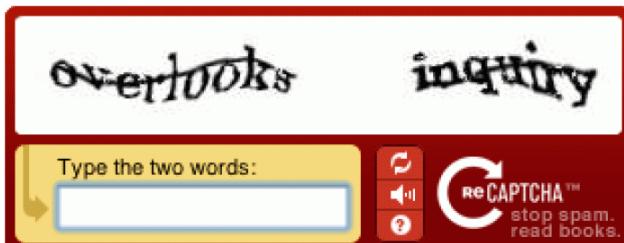


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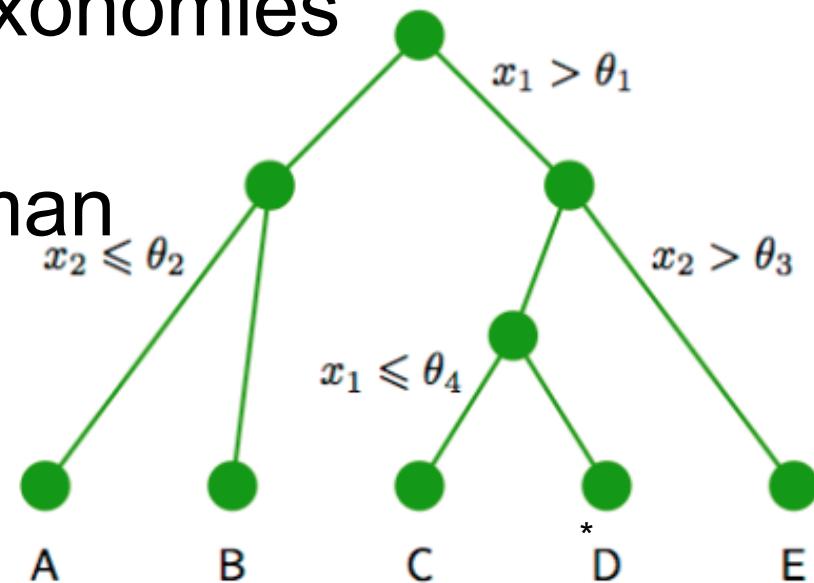
Related Work: Systems

- {Leaf,Dog,Bird}snap [Belhumeur et al.]
- Oxford Flowers [Nilsback & Zisserman]
- STONEFLY9 [Martínez-Muñoz et al.]
- omoby [IQEngines.com]
- 20 Questions game [20q.net]
- ReCAPTCHA [von Ahn et al.]
- Wikimedia Commons



Related Work: Methods

- Relevance Feedback
- Active Learning
- Expert Systems
- Decision Trees
- Feature Sharing & Taxonomies
- Parts & Attributes
- Crowdsourcing & Human Computation



Motivation: Computer Vision Perspective

- Need for more training data
 - Beyond the capacity of any one research group
 - Better quality control
- Need for more realistic data
 - Let people define what tasks are important
 - Study tightly-related categories

Dealing With a Large Number of Related Classes

- Standard classification methods fail because:
 - Few training examples per class available
 - Variation between classes is small
 - Variation within a class is often still high



Brewer's Sparrow



Vesper Sparrow



(A) Easy for Humans



Chair? Airplane? ...

(B) Hard for Humans



Finch? Bunting?...

(C) Easy for Humans



Yellow Belly? Blue Belly? ...

Plants vs Birds



2d

Doesn't move

Okay to pluck from tree

Mostly single color

Very few parts

Adequately described by boundary

Relatively easy to segment



3d

Moves

Not okay to pluck from tree

Many colors

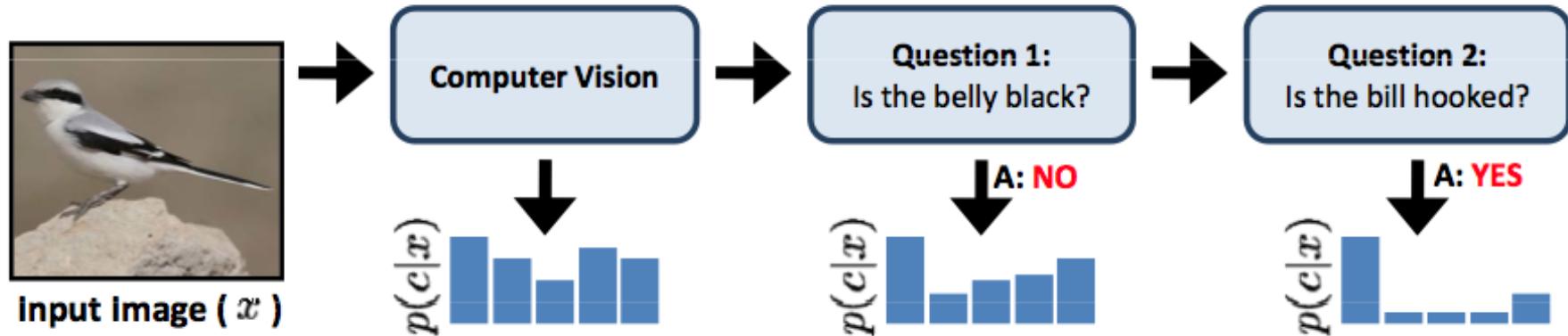
Many parts

Not well described by boundary

Hard to segment

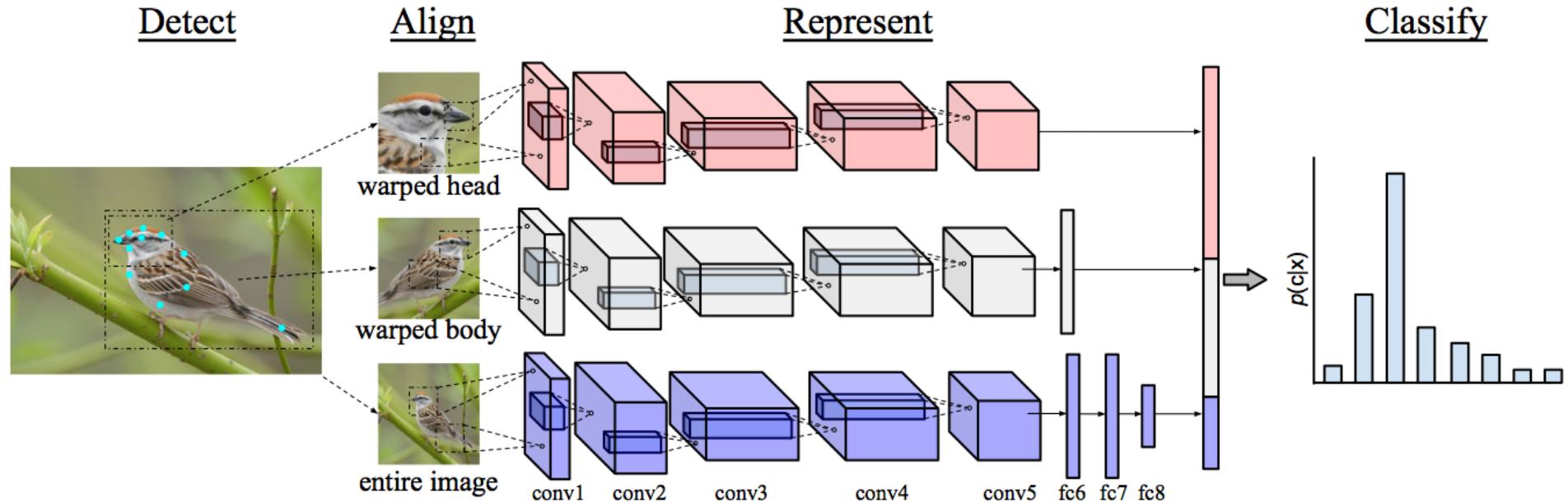
slide credit: Neeraj Kumar

Visual 20 Questions



- “Computer Vision” module = Vedaldi’s *VLFeat*
- VQ Geometric Blur, color/gray SIFT spatial pyramid
- Multiple Kernel Learning
- Per-Class 1-vs-All SVM
- 15 training examples per bird species
- Choose question to maximize expected Information Gain

Pose Normalized Deep ConvNets



[Van Horn, Branson, Perona, Belongie BMVC 2014]

Algorithm 1 Visual 20 Questions Game

- 1: $U^0 \leftarrow \emptyset$
- 2: **for** $t = 1$ to 20 **do**
- 3: $j(t) = \max_k I(c; u_k | x, U^{t-1})$
- 4: Ask user question $u_{j(t)}$, and $U^t \leftarrow U^{t-1} \cup u_{j(t)}$.
- 5: **end for**
- 6: Return class $c^* = \max_c p(c|x, U^t)$

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Birds-200 Dataset



6033 images over 200 bird species

Image Harvesting

- Flickr: text search on species name
- MTurk: presence/absence and bounding boxes



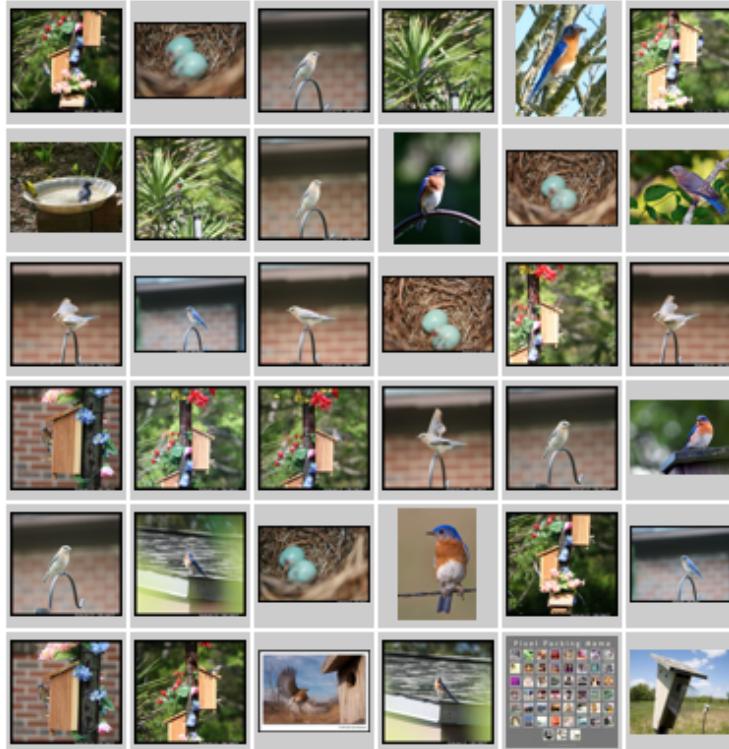
Illustrations of Eastern Bluebird



Click to select images below which you think contain Eastern Bluebird.
Remember that the color of the bird in a photo is sometimes slightly different from the illustrations.

[Click here to view detailed instructions.](#) Please read at least once.

[Select all](#) [Select none](#) Select images by clicking on them so that a green border appears.



[Select all](#) [Select none](#) Select images by clicking on them so that a green border appears.

[Click here to provide feedback on this HIT.](#) (Will expand this section to show a form.)

Tick this box if you are particularly interested in birds and consider yourself an expert on Eastern Bluebird (this will **not** affect your payment).

The human annotation process

- Modeling various aspects of annotation:
 - *Worker competency* – accuracy in labeling
 - *Worker expertise* – better at labeling some things than others, based on their strengths
 - *Worker bias* – how one weighs errors
 - *Task difficulty* – ambiguous images are universally hard to label
 - *True label* – the ground truth label value
- We leverage the "Multidimensional Wisdom of Crowds" [Welinder et al. 2010]

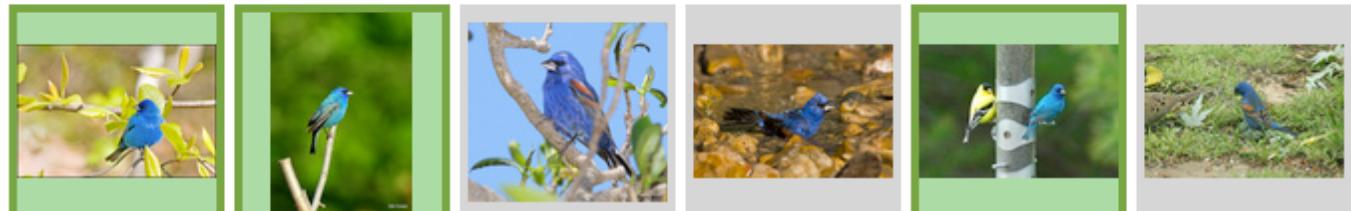
Types of annotator errors

Task: Find the Indigo Bunting

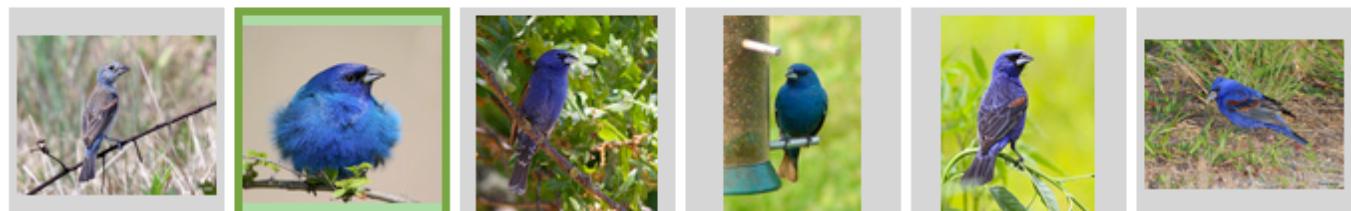
Indigo Bunting



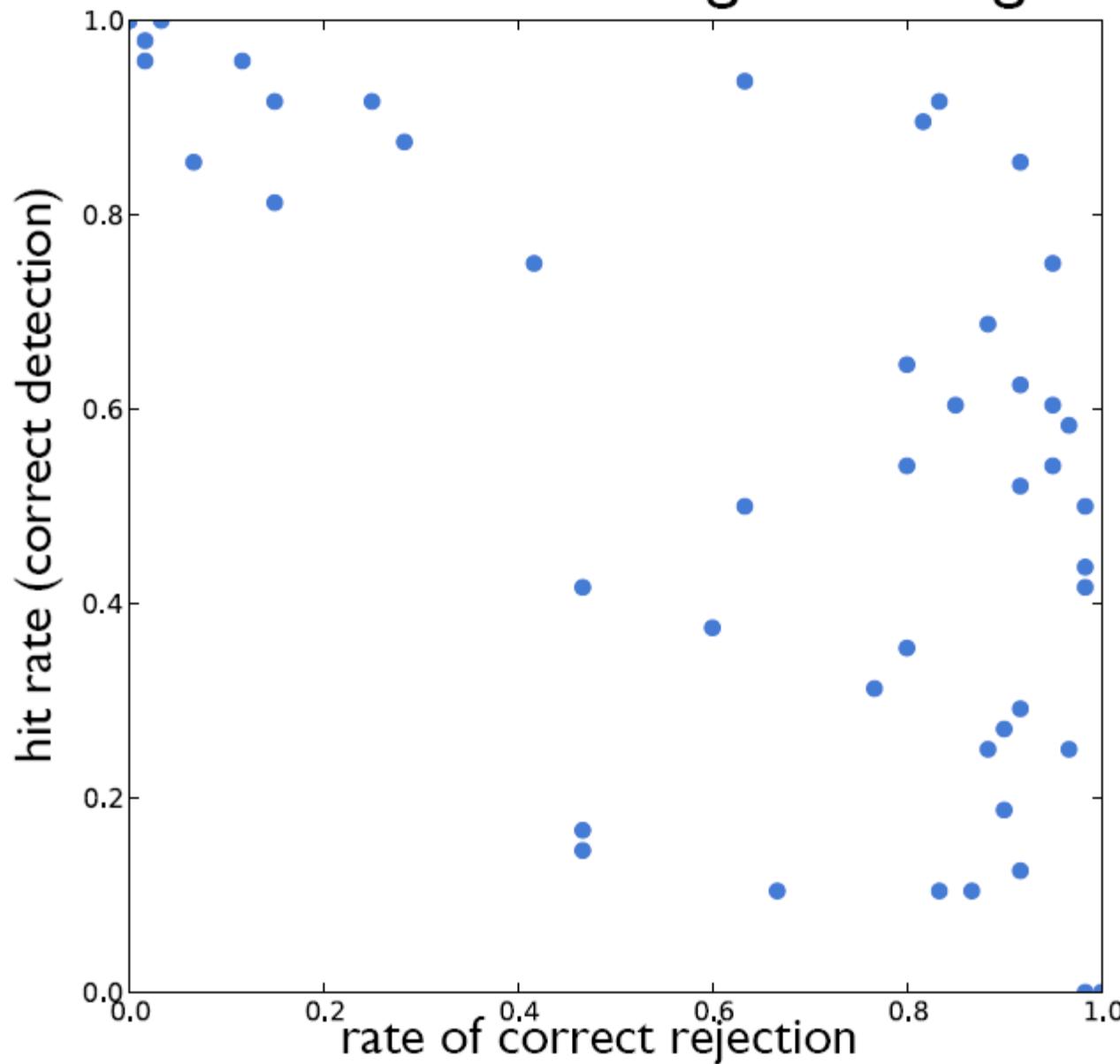
Select images by clicking on them so that a green border appears.



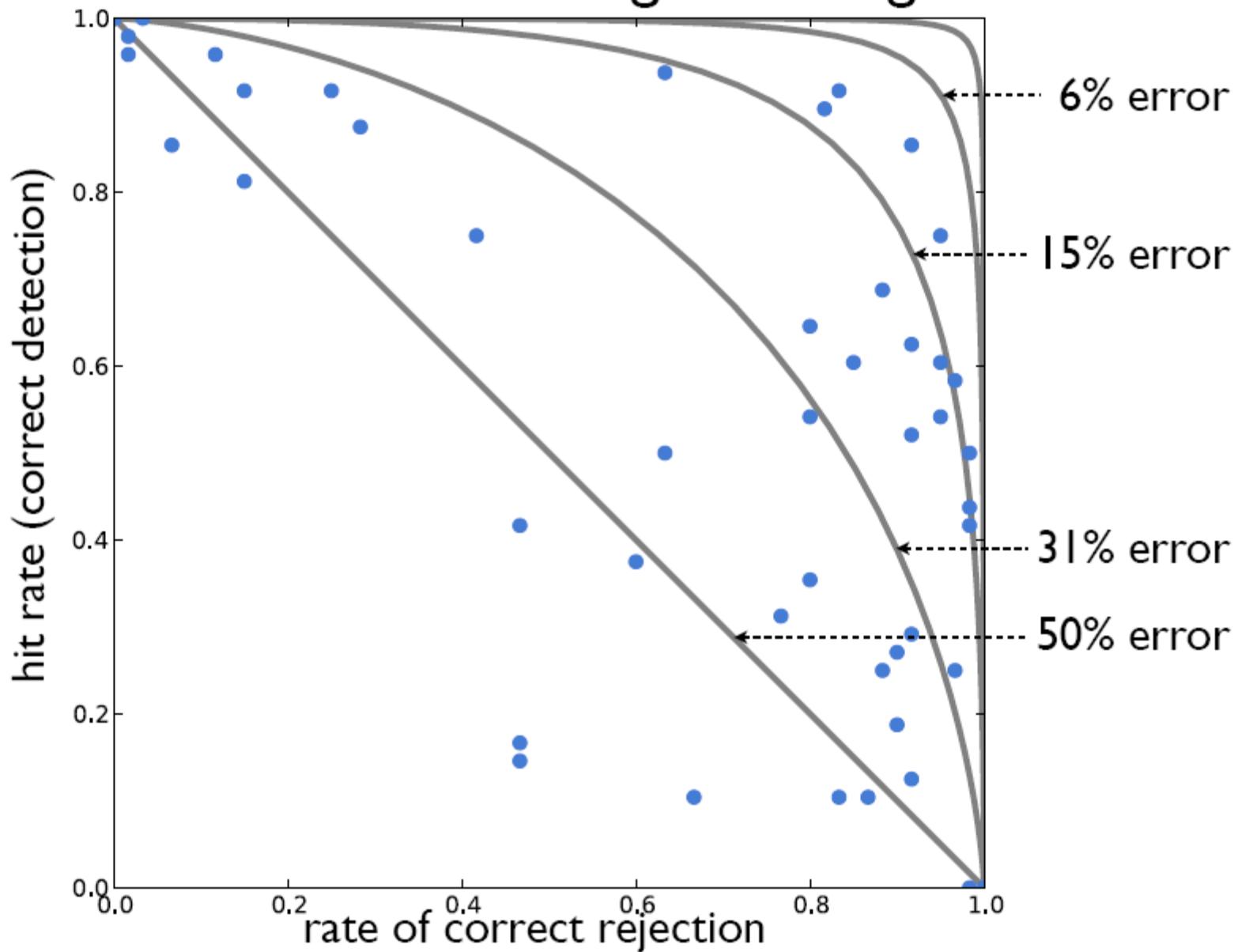
Blue Grosbeak



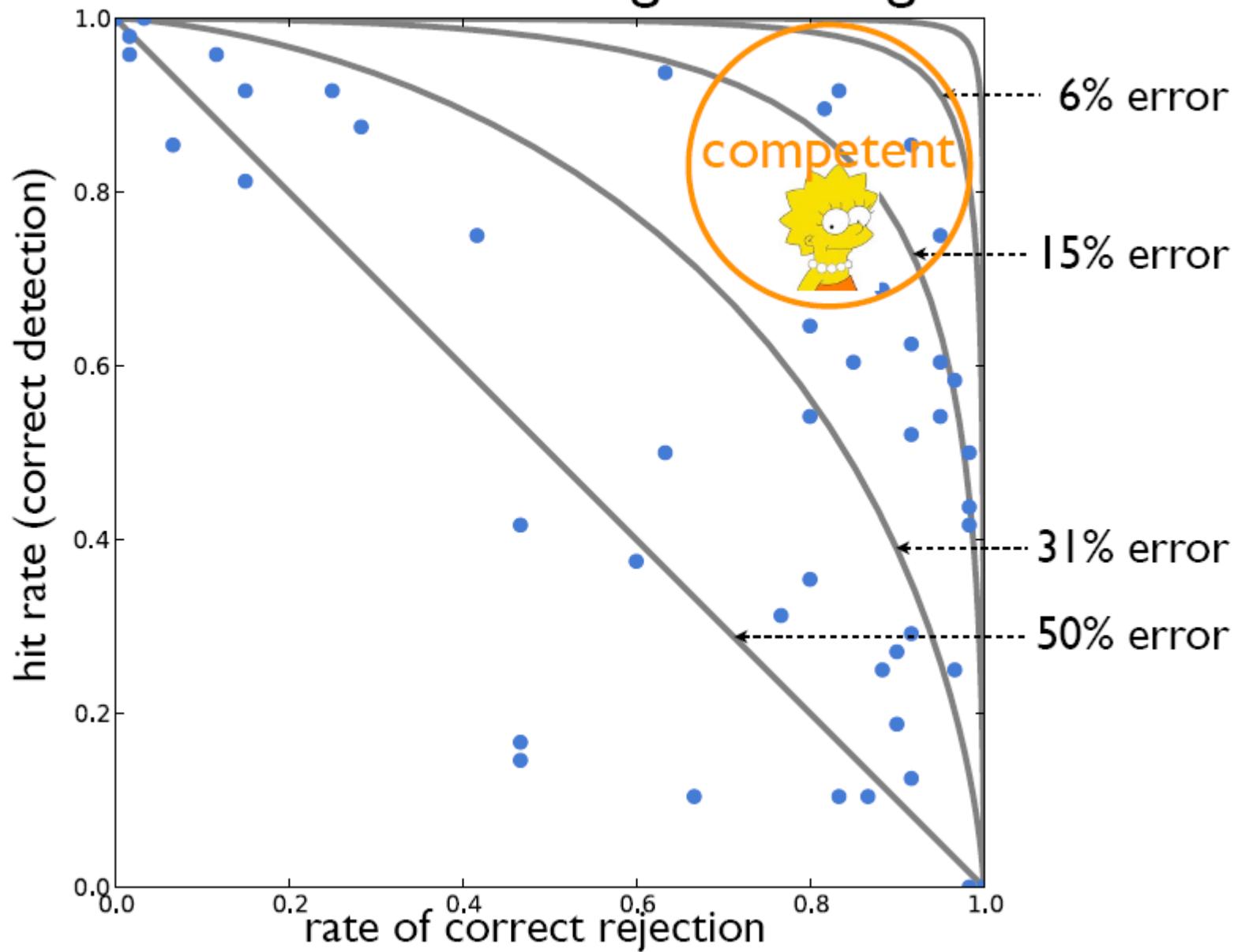
Task: Find the Indigo Bunting



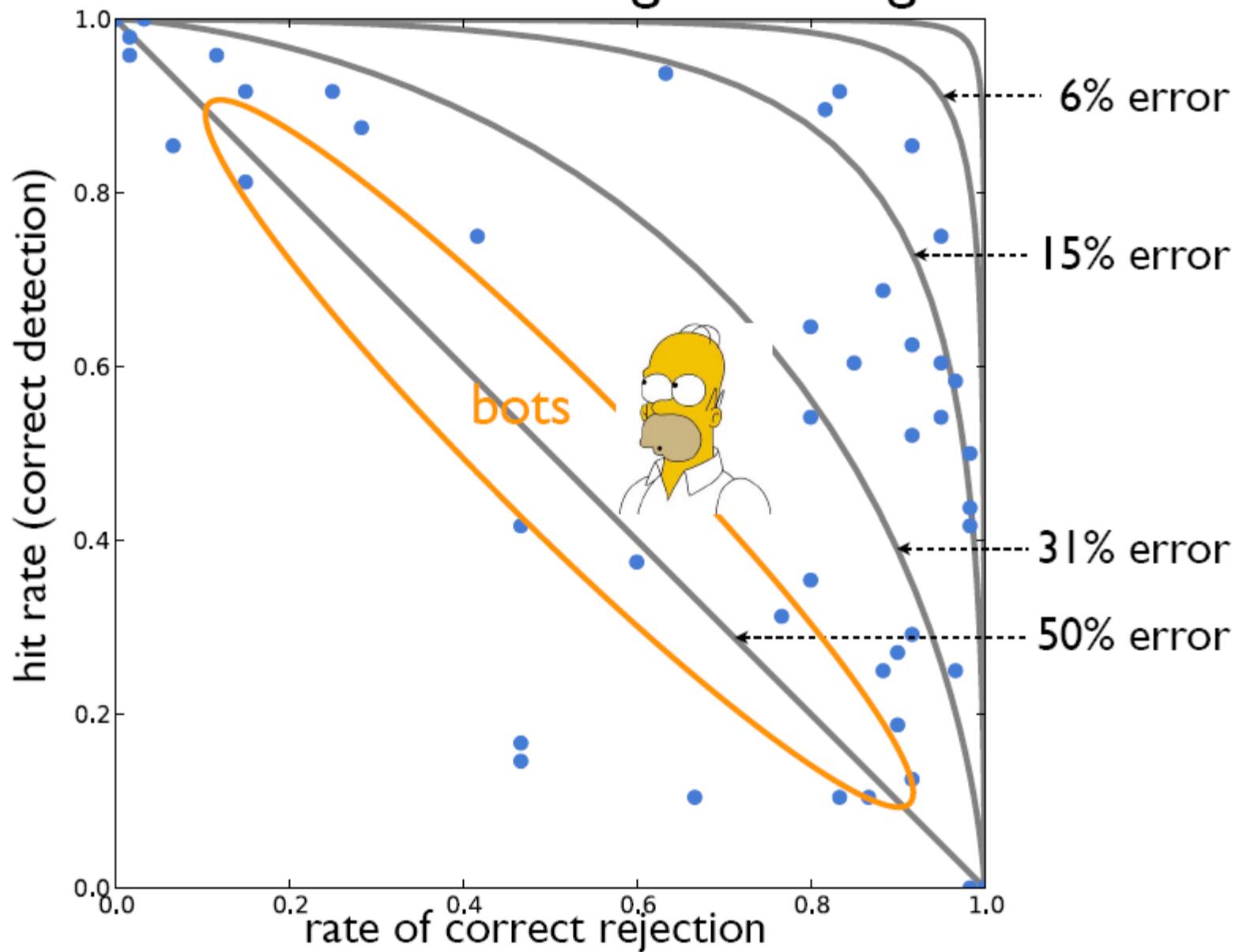
Task: Find the Indigo Bunting



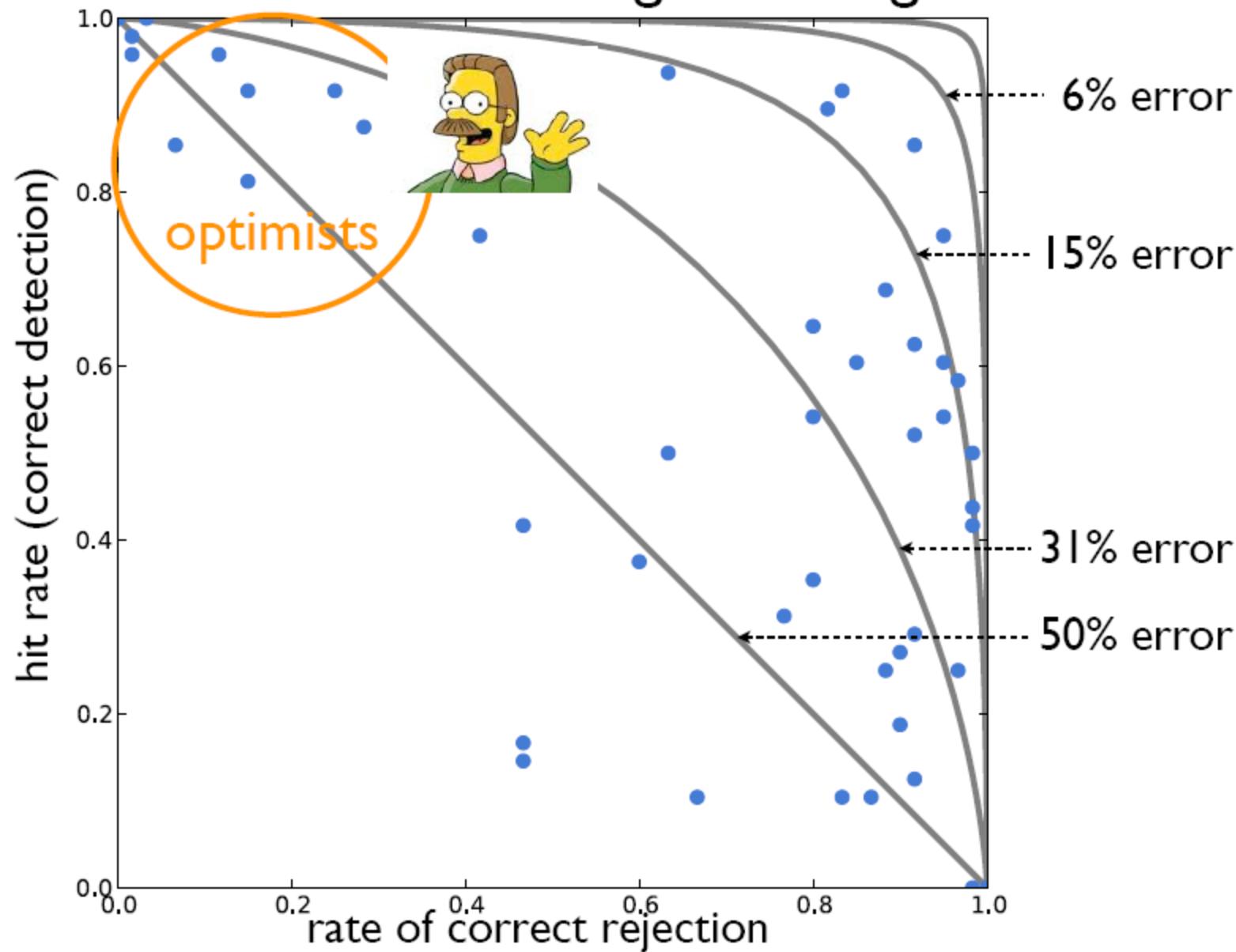
Task: Find the Indigo Bunting



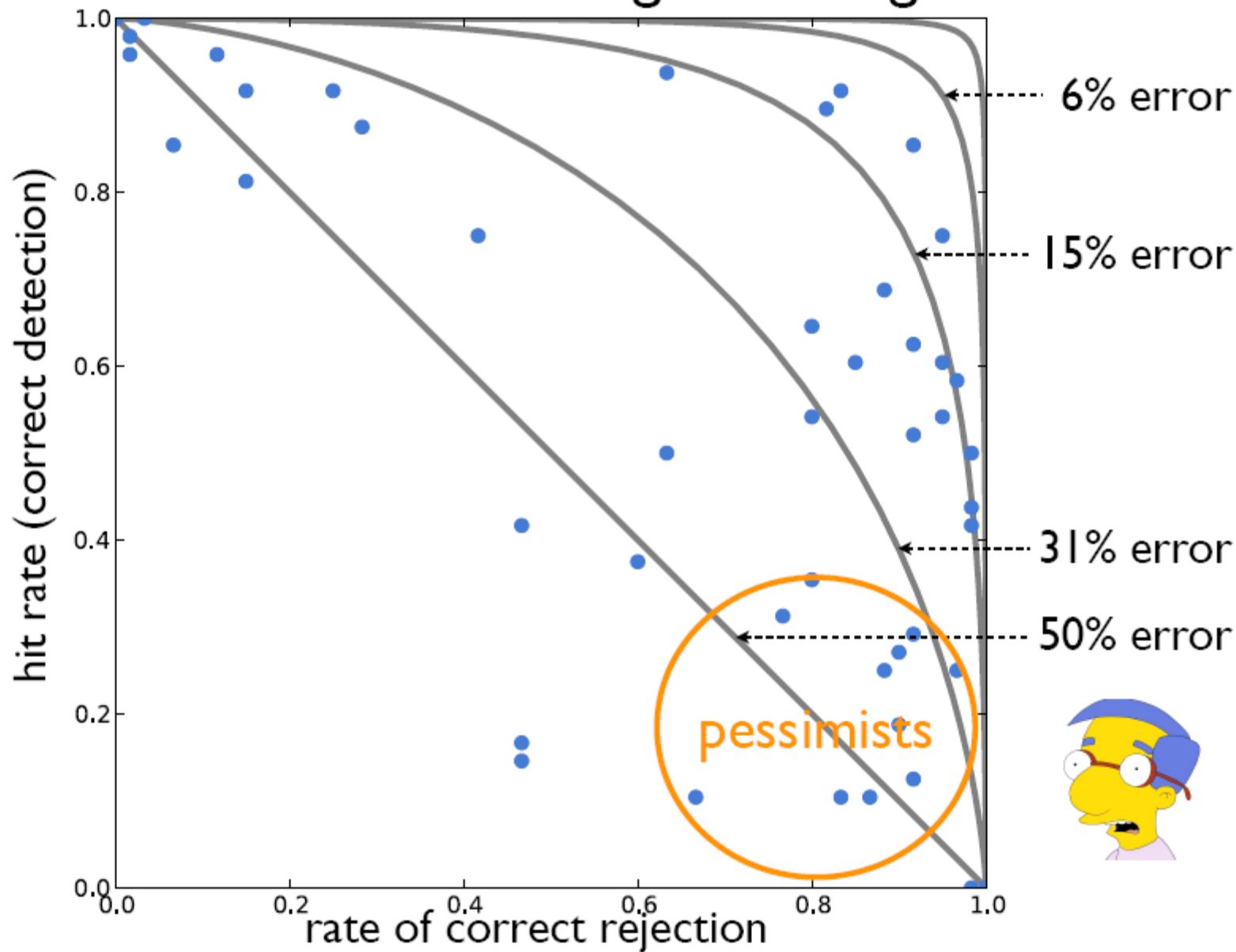
Task: Find the Indigo Bunting



Task: Find the Indigo Bunting



Task: Find the Indigo Bunting



Task: Find the Indigo Bunting

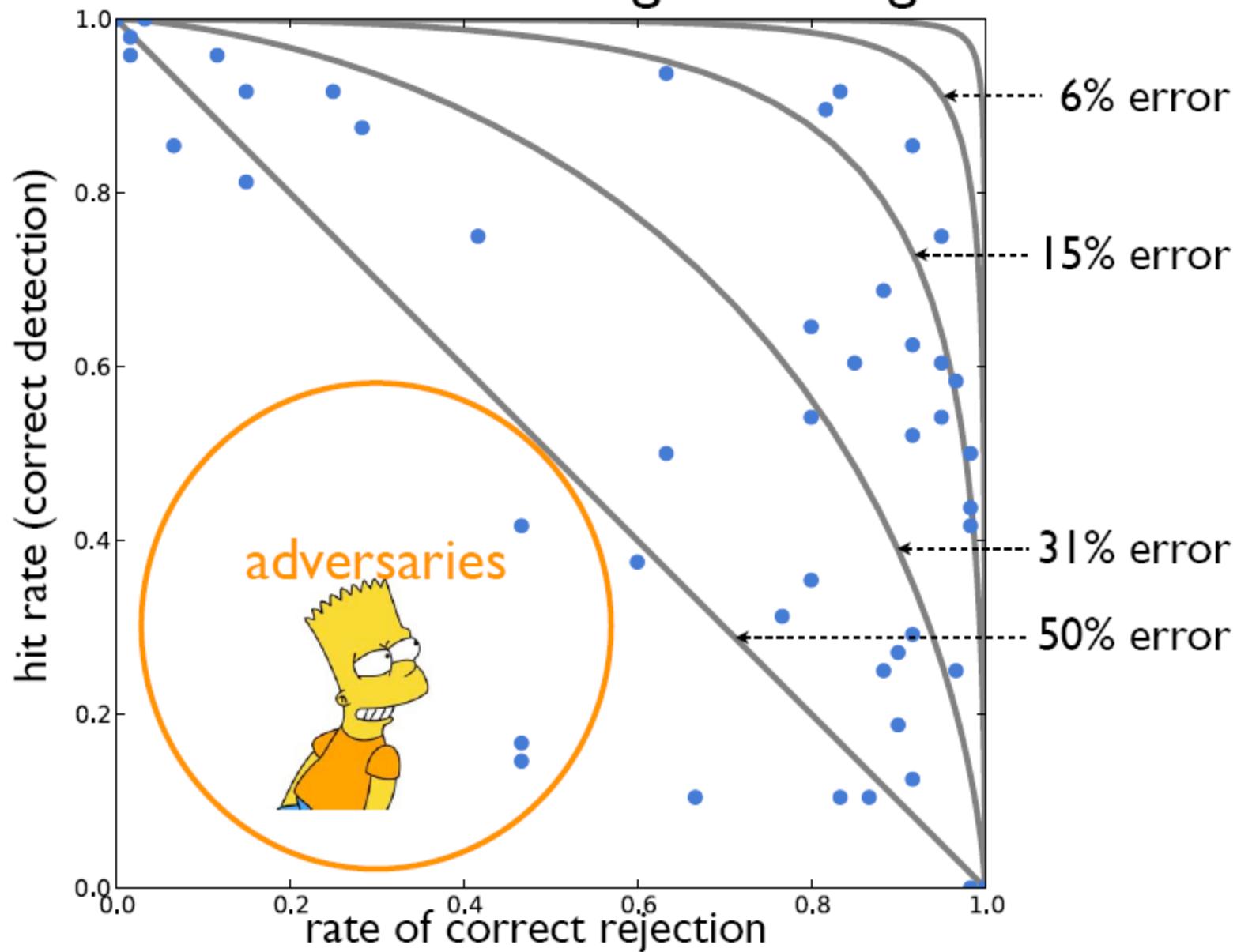
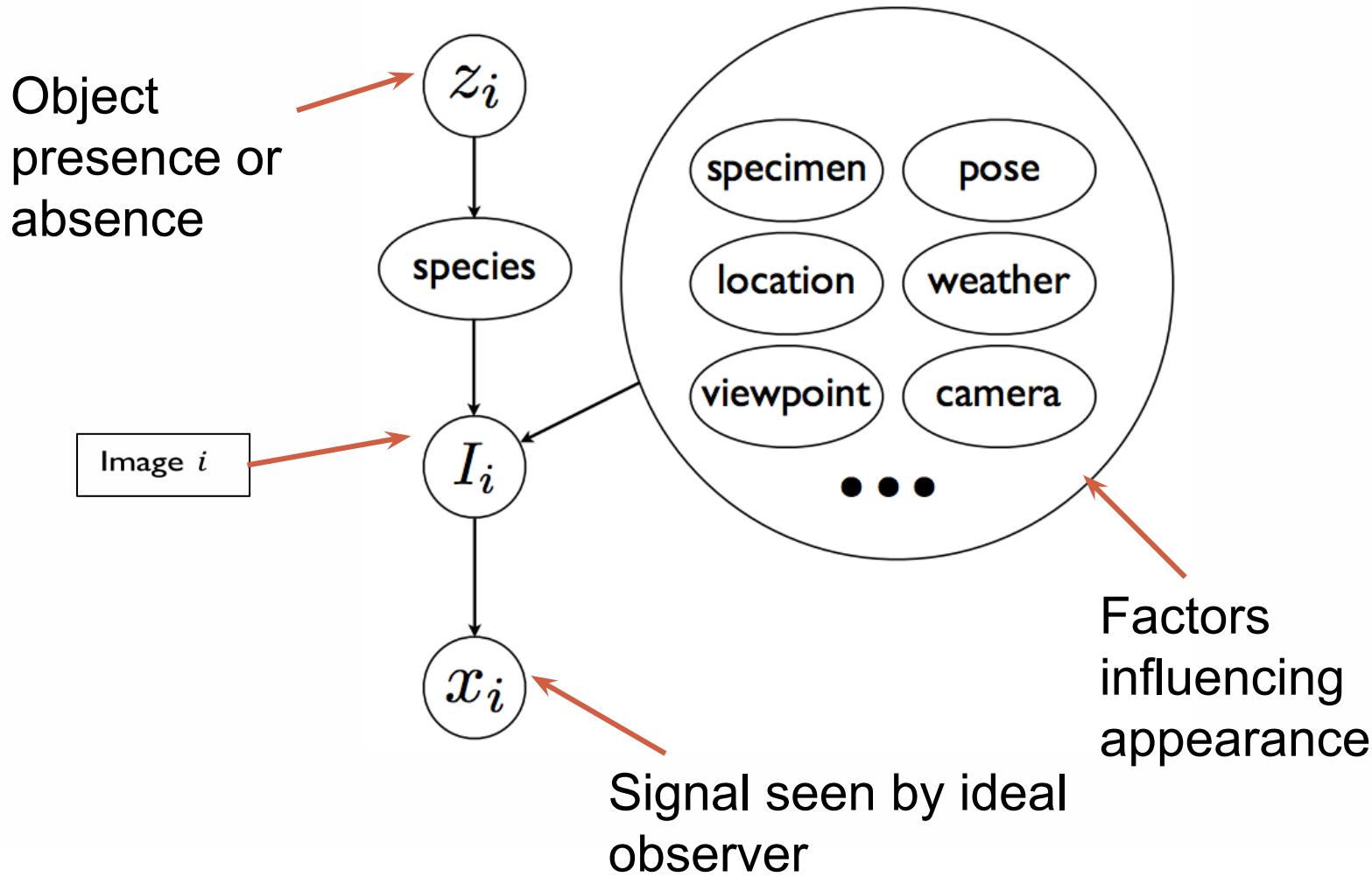


Image formation process



Entire annotation process

$$p(\mathcal{L}, x, w, \tau) = \prod_{j=1}^M p(\tau_j | \gamma) p(w_j | \alpha) \prod_{i=1}^N \left(p(x_i | \theta_z, \beta) \prod_{j \in \mathcal{J}_i} p(l_{ij} | x_i, w_j, \tau_j) \right)$$

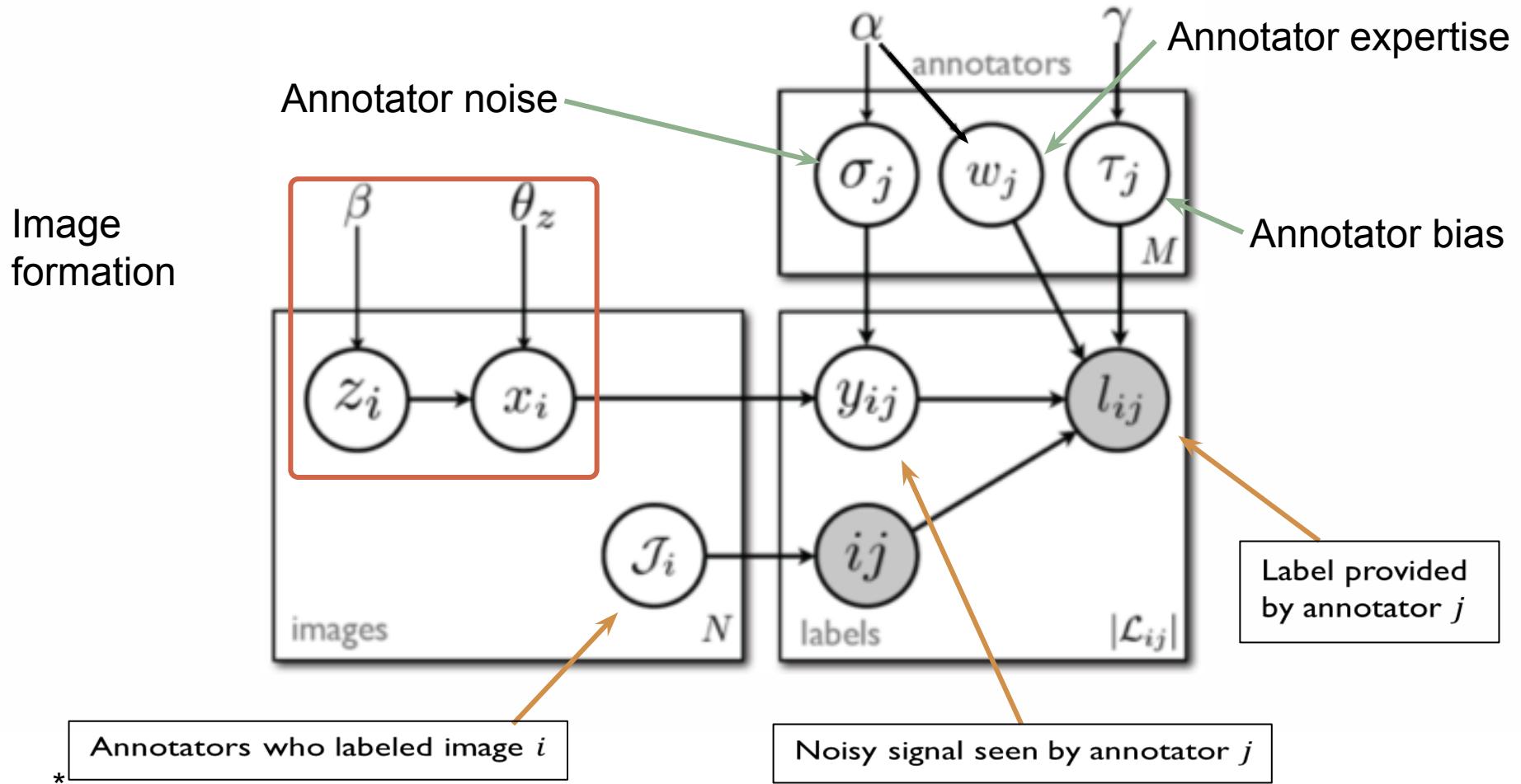
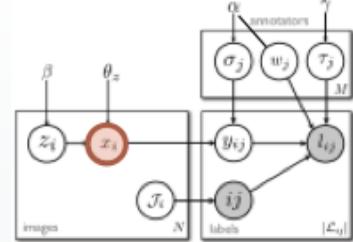
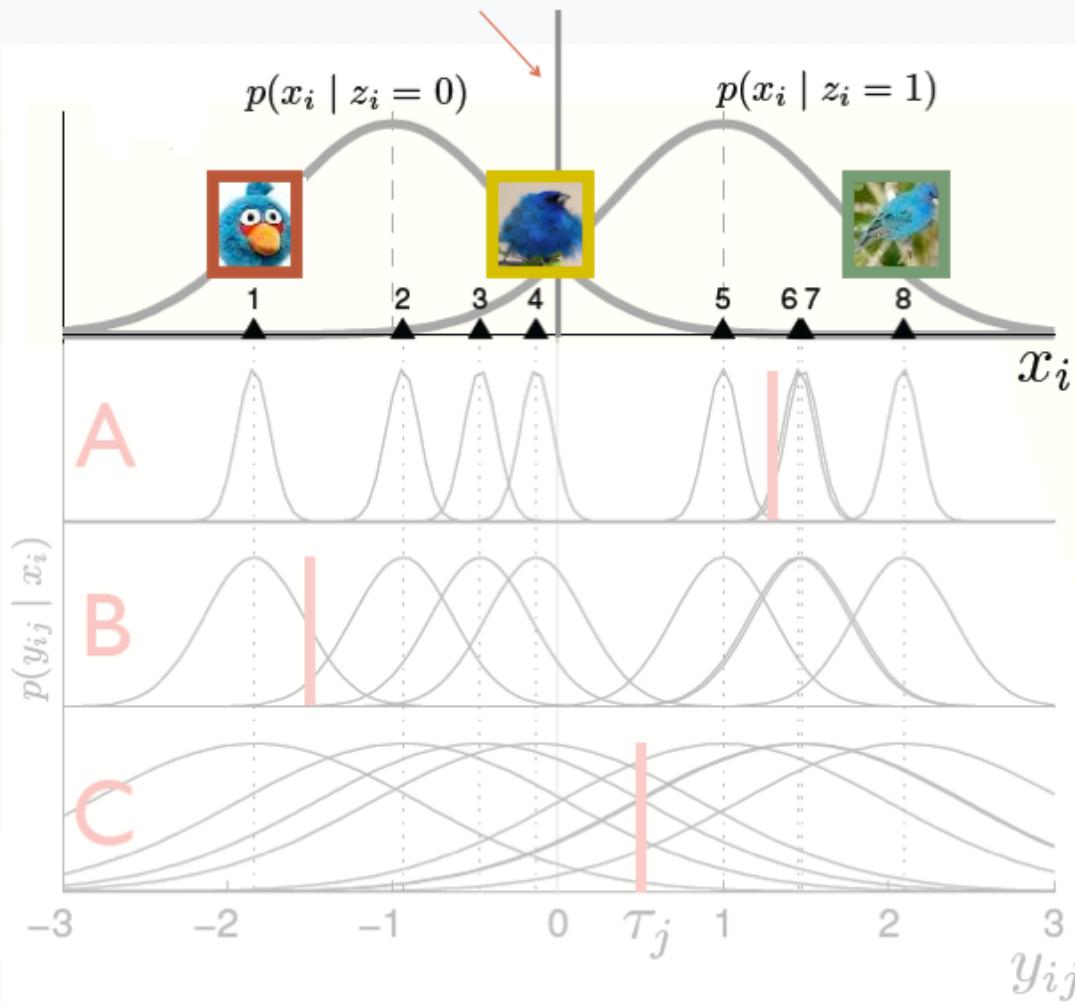


Image difficulty

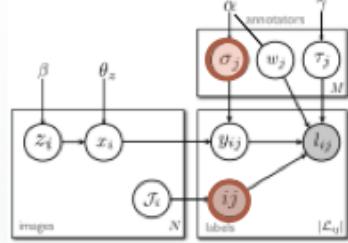


Ground truth decision plane at $x_i = 0$



[Welinder et al., 2010]

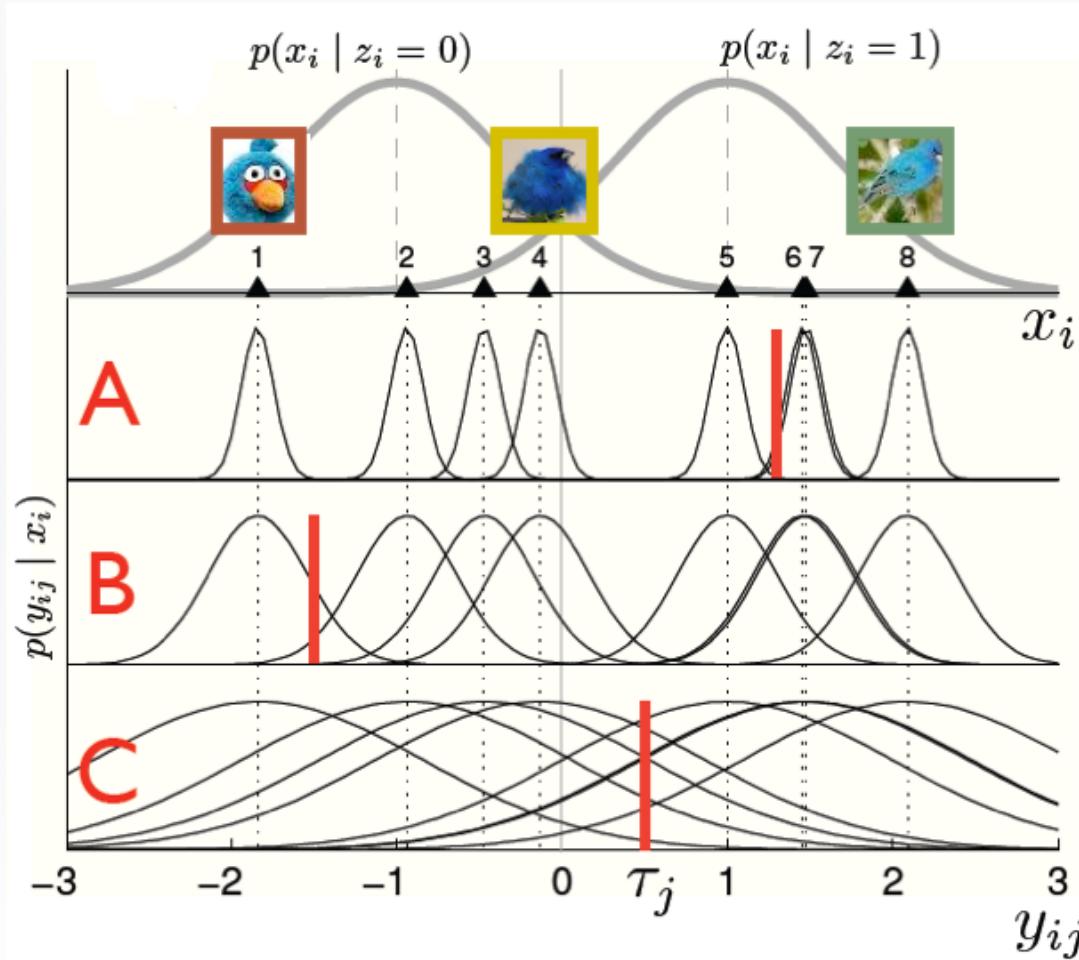
Annotator competence



High competence

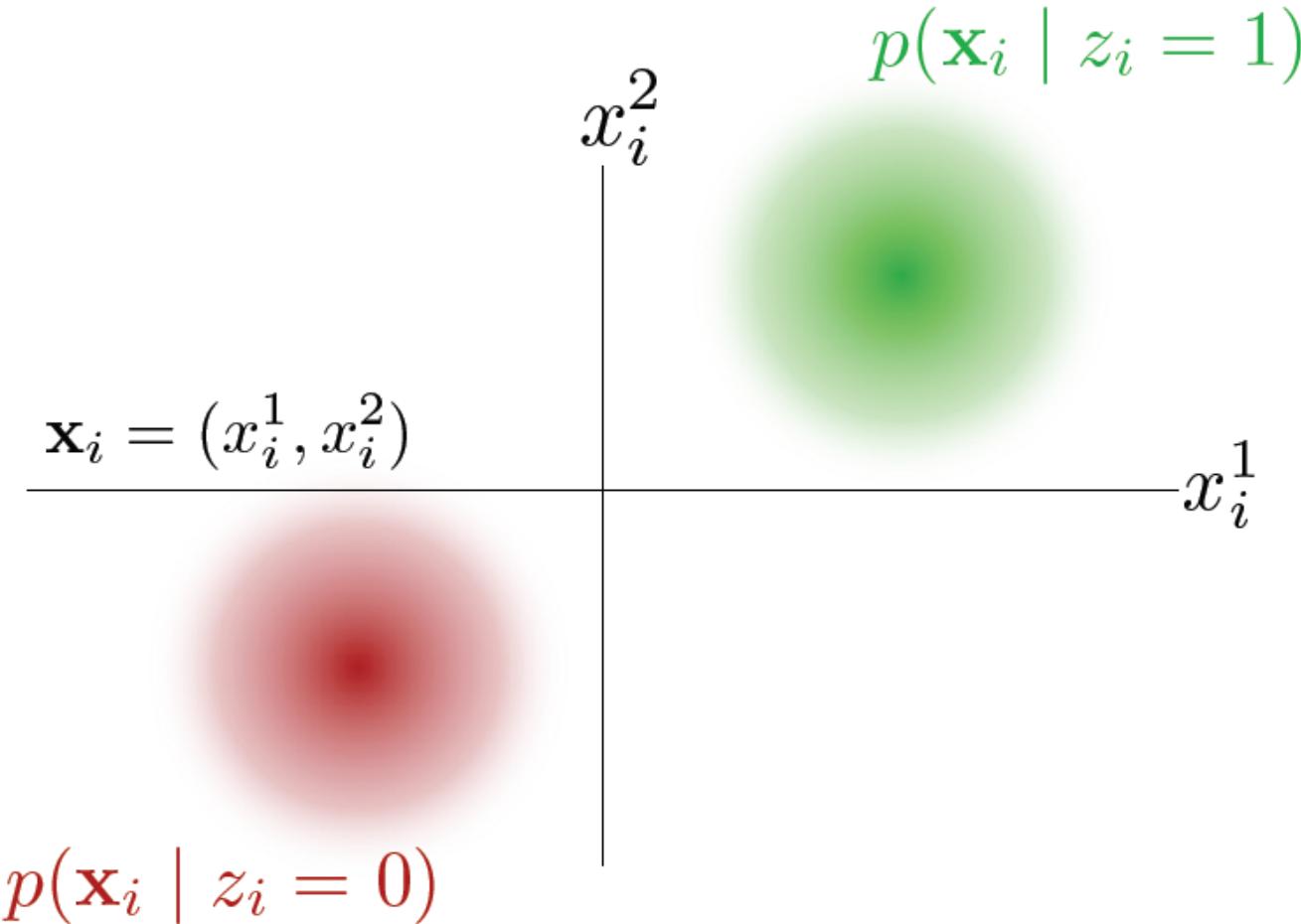
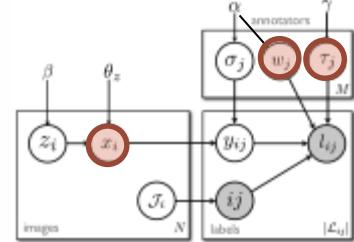


Low competence

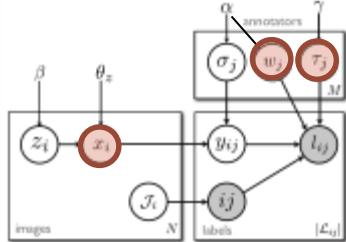
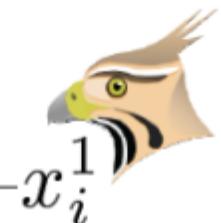


[Welinder et al., 2010]

Multidimensional ability of annotators



Multidimensional ability of annotators

 x_i^2 $p(\mathbf{x}_i \mid z_i = 1)$ 

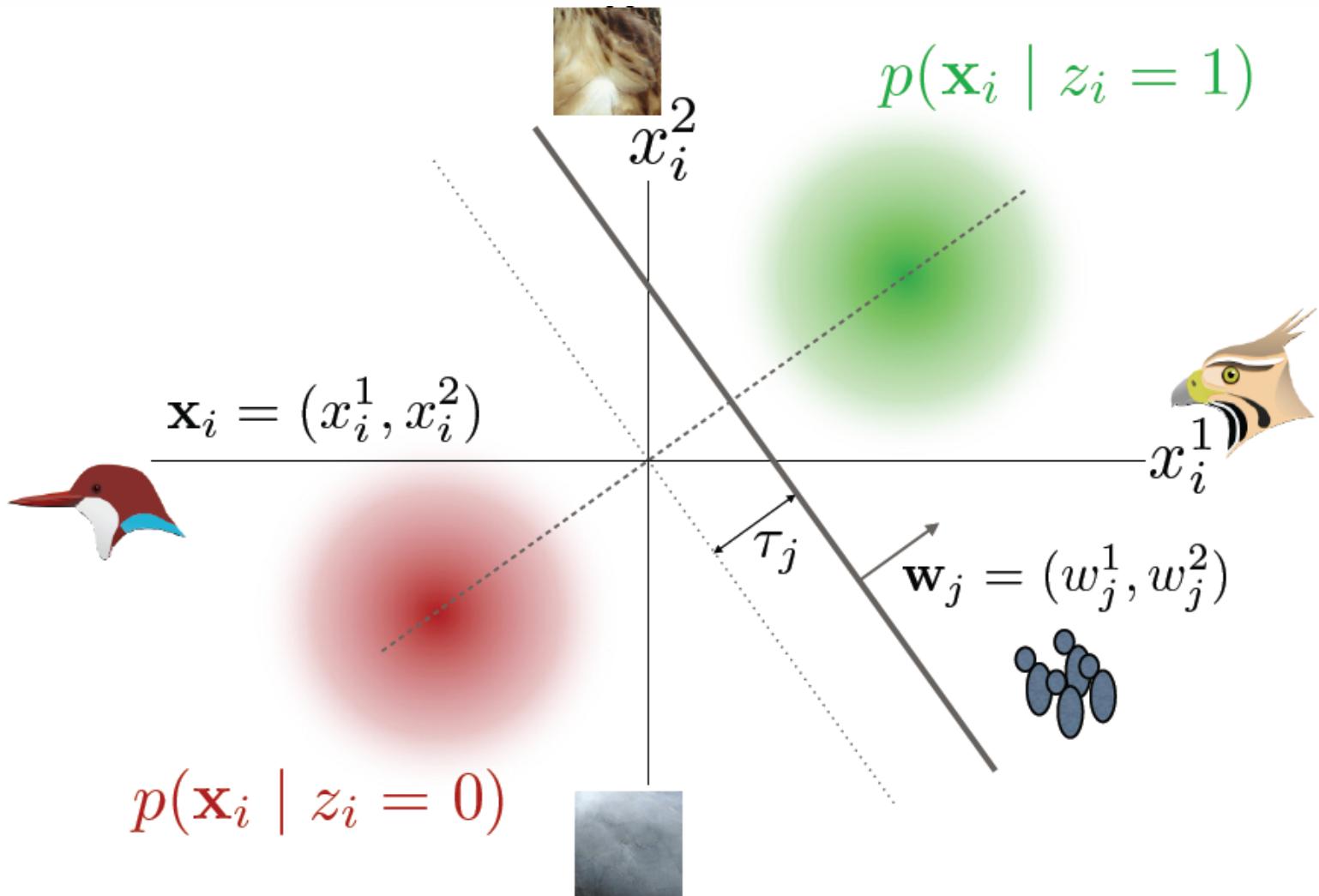
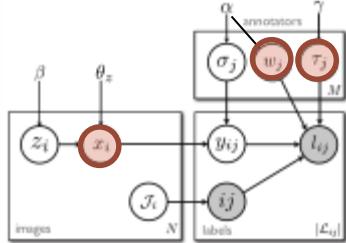
$$\mathbf{x}_i = (x_i^1, x_i^2)$$



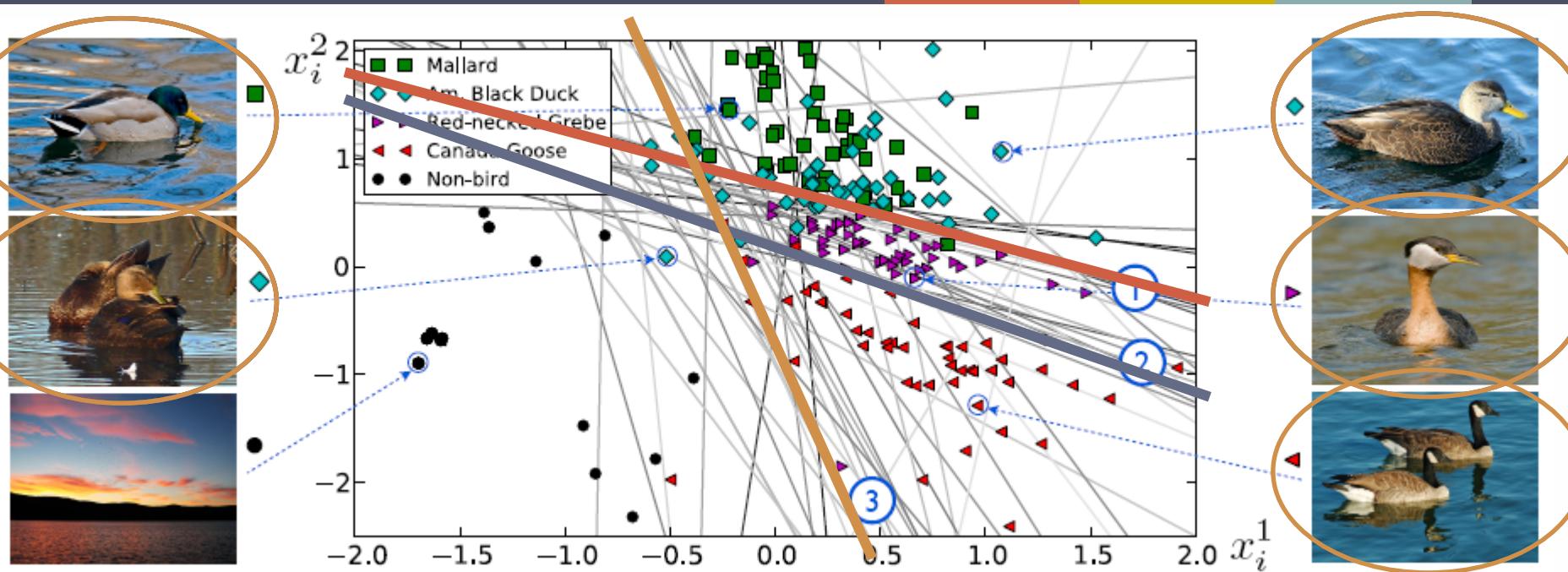
$$p(\mathbf{x}_i \mid z_i = 0)$$



Multidimensional ability of annotators



Worker “schools of thought”



Ducks ■ ◆

Ducks and grebes ■ ◆ ▲

Ducks, grebes, and geese ■ ◆ ▲ ▲ ▲

Discussion: quality management

- Models can capture multidimensionality of annotation process
- How well does this generalize to continuous annotations?

Different tasks require different reviewing strategies.

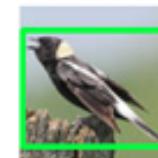
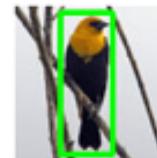
Predicting quality accurately can reduce the number of labels needed.



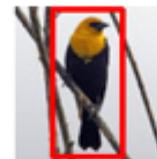
Photo by Chippewabear

Please draw a rectangle around the bird in the image. The rectangle should be fit around the bird tightly.

Good Rectangles:



Bad Rectangles:



Tick any of the boxes below if they are true about the image.

- Bird is **truncated**
- Bird is **occluded**
- There is **more than one bird**
- There is **no bird** in the image

1/5

◀ Previous

Next ▶

✓ Submit

Please provide feedback in the box below if you have comments:

Attribute Labeling

- Attributes from whatbird.com
- 25 visual attributes → 288 binary attributes
 - similar to “dichotomous key” in biology
- MTurk interface
 - *{guessing, probably, definitely}*
- 3-5x redundancy factor



You will be asked to answer a series of questions based on identifying visual features from the bird image on the left. Closely follow the specific instructions for each question. Holding the mouse over each selectable option for 1 second will provide additional instructions or examples.



What is the **pattern of the breast** of the bird? 1/12

Select one. If the breast isn't visible, make your best guess, then select "Guessing".

A small illustration of a bird, possibly a sparrow, shown from the side. A large, solid red patch is highlighted on its breast area.

Solid Multi-Colored Striped Spotted

◀ Go Back ▶ Guessing ▶ Probably ▶ Definitely

You will be asked to answer a series of questions based on identifying visual features from the bird image on the left. Closely follow the specific instructions for each question. Holding the mouse over each selectable option for 1 second will provide additional instructions or examples.



What is the **color of the crown?**

1/12

Select at least one. If the crown isn't visible, make your best guess, then select "Guessing". If the color is a mixture of two colors, select both (e.g., for blue-green select blue and green). If the crown has two distinct colors, select both (e.g., for yellow with black stripes, select yellow and black).



White



Black



Grey



Buff



Brown



Rufous



Red



Pink



Orange



Yellow



Green



Olive



Blue



Purple



Shiny /
Iridescent

◀ Go Back

▶ Guessing

▶ Probably

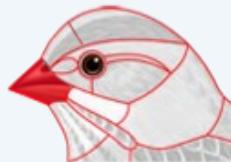
▶ Definitely

You will be asked to answer a series of questions based on identifying visual features from the bird image on the left. Closely follow the specific instructions for each question. Holding the mouse over each selectable option for 1 second will provide additional instructions or examples.



What is the **shape of the bill/beak?**

1/12



Select one. If the beak isn't visible, make your best guess, then select "Guessing".



All-purpose



Cone



Curved (up or down)



Dagger



Hooked



Hooked Seabird



Needle



Spatulate



Specialized

◀ Go Back

▶ Guessing

▶ Probably

▶ Definitely

You will be asked to answer a series of questions based on identifying visual features from the bird image on the left. Closely follow the specific instructions for each question. Holding the mouse over each selectable option for 1 second will provide additional instructions or examples.



What is the **color of the wings** of the bird? 1/12

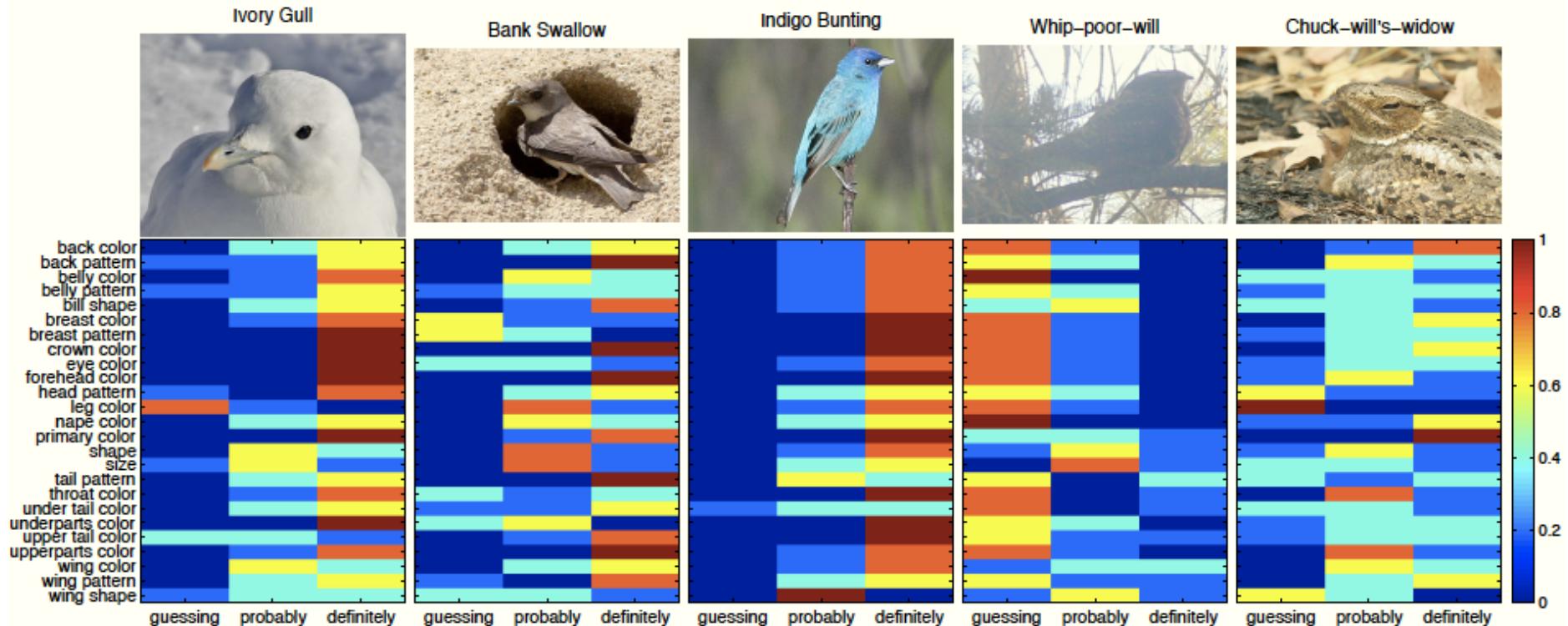
Select at least one. If the wings aren't visible, make your best guess, then select "Guessing". If the color is a mixture of two colors, select both (e.g., for blue-green select blue and green). If the wings have two distinct colors, select both (e.g., for yellow with black stripes, select yellow and black).

 A red silhouette of a bird in flight, showing its wings and tail.

				
White	Black	Grey	Buff	Brown
				
Rufous	Red	Pink	Orange	Yellow
				
Green	Olive	Blue	Purple	Shiny / Iridescent

◀ Go Back ▶ Guessing ▶ Probably ▶ Definitely

MTurker Label Certainty



MTurker Feedback

- “These hits were fun. Will you be posting more of them anytime soon? Thanks!”
- “These are Beautiful birds and I am enjoying this hit collection”
- “I really enjoy doing your hits, they are fun and interesting. Thanks.”
- “Love doing these because I'm a bird watcher.”
- “the birds are so cute..hope u can send more kind of birds”
- “I haven't really studied birds, but doing these HITs has made me realize just how beautiful they are. It has also made me aware of the many different types of birds. Thank you”
- “I REALLY LOVE THE COLOR OF THE BIRDS.”
- “Thank you for providing this job. The fact that the images are beautiful to look at make it a lot more enjoyable to do!”
- “Enjoyable to do.”
- *Hourly Wage ≈ \$1.25*

*

CCUB NABirds 700

Try out on a new dataset for fine-grained recognition, featuring 550 of North America's most common birds. The full dataset will be available in the fall. Join the competition today and download the "taster" dataset!

<http://birds.cornell.edu/nabirds>

CCUB NABirds includes:

- More than 700 visual categories, organized taxonomically
- Photos curated in collaboration with domain experts
- Data organized in a researcher-friendly, widely-used PASCAL VOC format

For more information contact: Ryan Farrell (farrell@eecs.berkeley.edu)



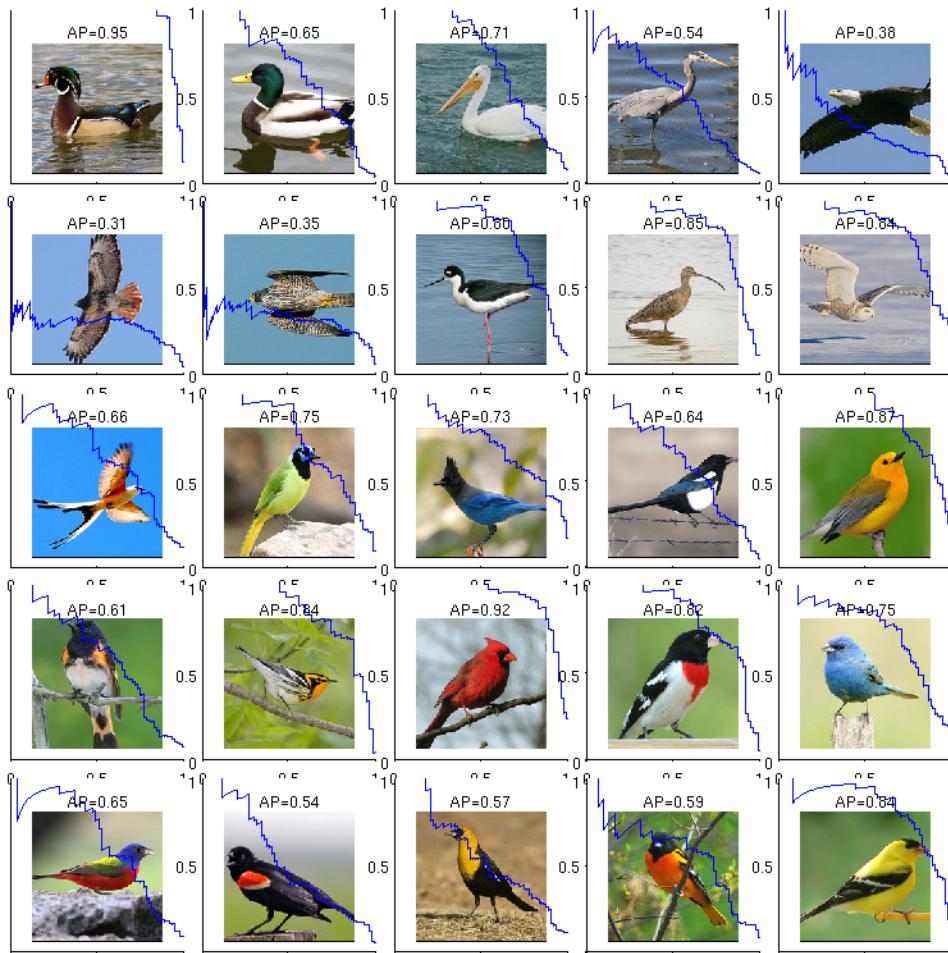
CCUB Taster25



"Bitter" Taster

"Sweet" Taster

CCUB Taster25 Results

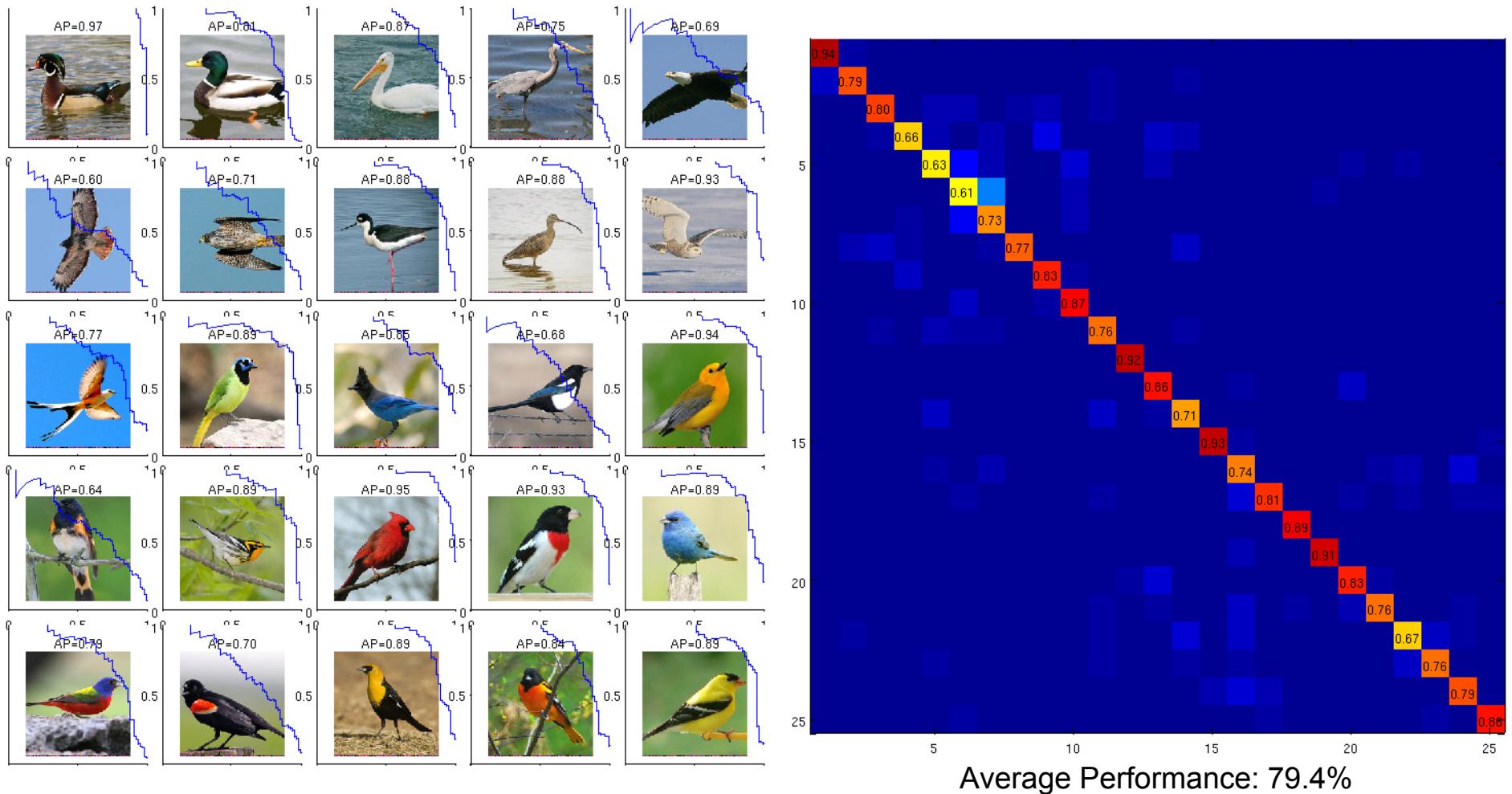


Baseline Performance:
The winning ILSVRC '11
approach of Florent Perronnin
and Jorge Sanchez.

- Dense SIFT and Color Descriptors
- Aggregated using Fisher vectors [Perronnin, et al. ECCV 10]
- Linear SVMs with SGD
- Same parameters used in ILSVRC

Using the winning ILSVRC '11 approach by [F. Perronnin, et al.],
training on 25 images/category

CCUB Taster25 Results



Using the winning ILSVRC '11 approach by [F. Perronnin, et al.],
training on 50 images/category



CCUB NABirds 700

Try out on a new dataset for fine-grained recognition, featuring 550 of North America's most common birds. The full dataset will be available in the fall. Join the competition today and download the "taster" dataset!

<http://birds.cornell.edu/nabirds>

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Vibe Demo

<http://visipedia.org>

<http://vibe.visipedia.org>

Visipedia Backend

Storage and collaboration infrastructure to support visual search applications.

Storage

Cloud storage and access for your image datasets and annotations.

Organize

Build a hierarchical representation of your domain and use it to organize your images.

Collaborate

Divide and conquer your data collection and curation tasks by sharing your data with collaborators.

Annotate

Use our annotation templates to create your custom annotation tasks.

Deploy

Integrate Vibe storage functionality into your app or website for easy image upload and annotation by your users.

Analyze

Hook Vibe into your classification pipeline to analyze how images are being classified.



NAB 700 Taxonomy

- › Ducks, Geese, and Swans :
- › Grouse, Quail, and Allies :
- › Loons :
- › Grebes :
- › Flamingos :
- › Shearwaters, Petrels, Albatross, and Allies :
- › Storks :
- › Frigatebirds, Boobies, Cormorants, Darters, a
- › Pelicans, Herons, Ibises, and Allies :
- › Hawks, Kites, Eagles, and Allies :
- › Caracaras and Falcons :
- › Cranes and Rails :
- › Plovers, Sandpipers, and Allies :
- › Skuas and Alcids :
- › Gulls, Terns, and Allies :
- › Pigeons and Doves :
- › Parrots :
- › Cuckoos :
- › Owls :
- › Nightjars :
- › Swifts and Hummingbirds :
- › Trogons and Quetzals :
- › Kingfishers and Allies :
- › Woodpeckers :
- › Perching Birds :

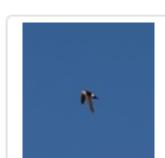
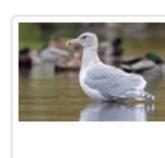
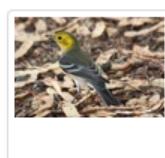
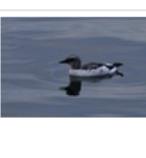
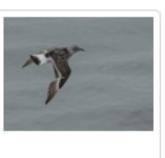
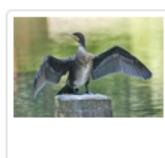
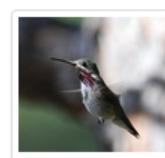
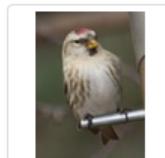
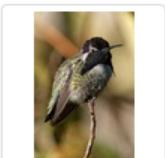
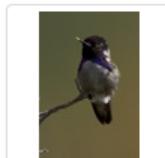
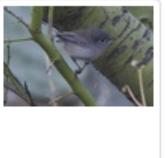
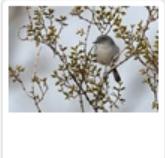
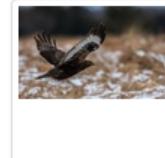
NAB 700 Taxonomy

100722 total

Go To ▾

Order By ▾

Size ▾

 Descendant Content[Add Content](#)[Clear Selection](#)[Selection Operations](#)[Bucket Operations](#)

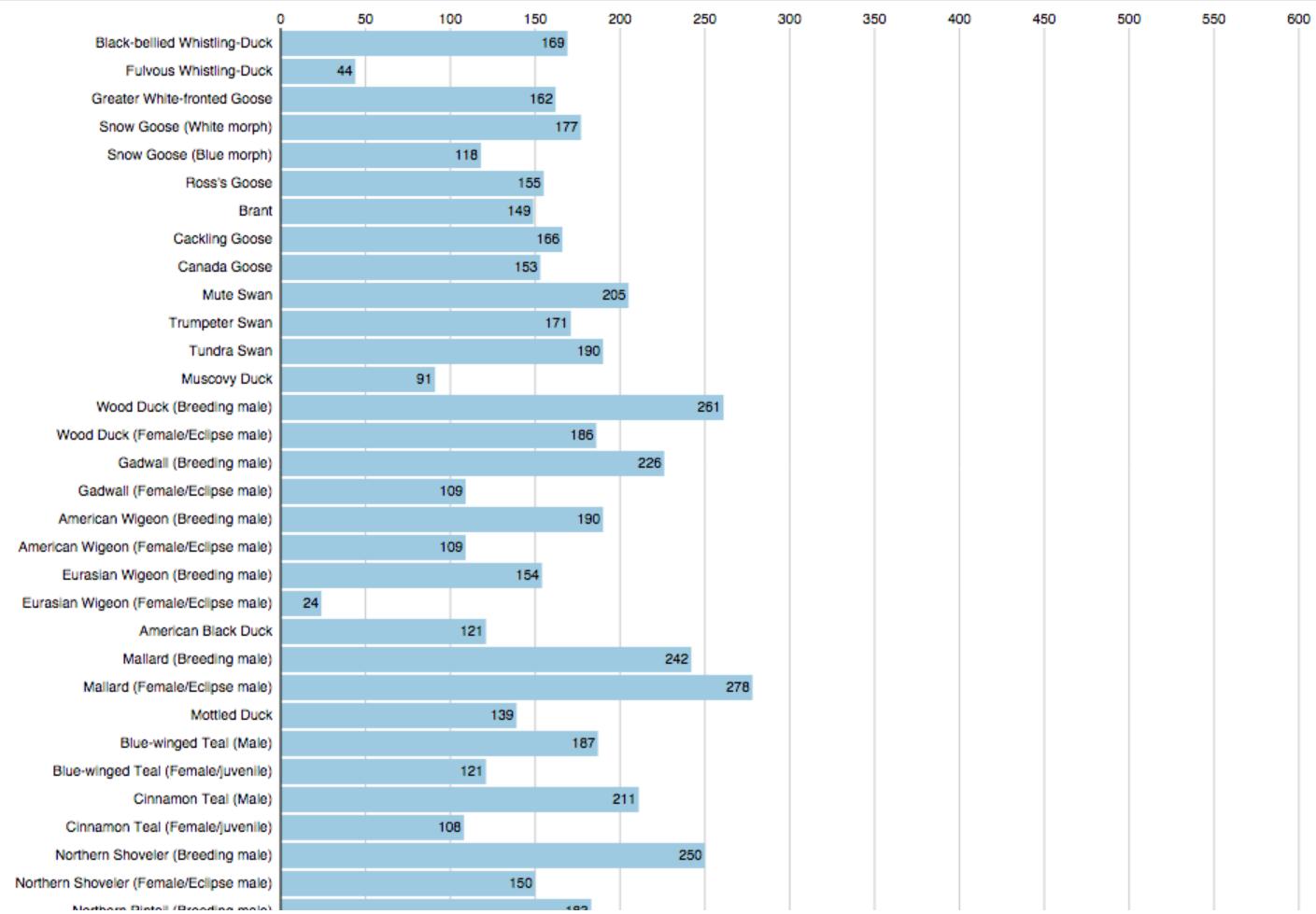
Click on the ♦ next to a bucket to add it here for quick drag and drop

Total Nodes: 1674

Total Leaves: 929

 Threshold

Sort Order: Original Order



[Start Bird Photo ID](#)

Merlin is equipped with computer vision to identify birds in images. Thanks to help from the community who shared and annotated images, Merlin has been trained to identify [125 species](#). At this stage, Merlin well-suited to handle high-quality images taken with DSLR cameras. Results may not be as good for images taken on iPhones and other mobile devices, however, we encourage you to see how Merlin does with lower-quality images! All images uploaded to this test interface will be used help improve the system in the future. We appreciate your [feedback](#) as Merlin development continues.

Select your photo.

Browse

Or drag and drop your file into this box.

1. Upload one image at a time.
2. Upload a jpeg or png image.
3. Image must be less than 10 MB.

Did you take this photo?

Yes

No

Crop the bird by clicking and dragging a box.

Next



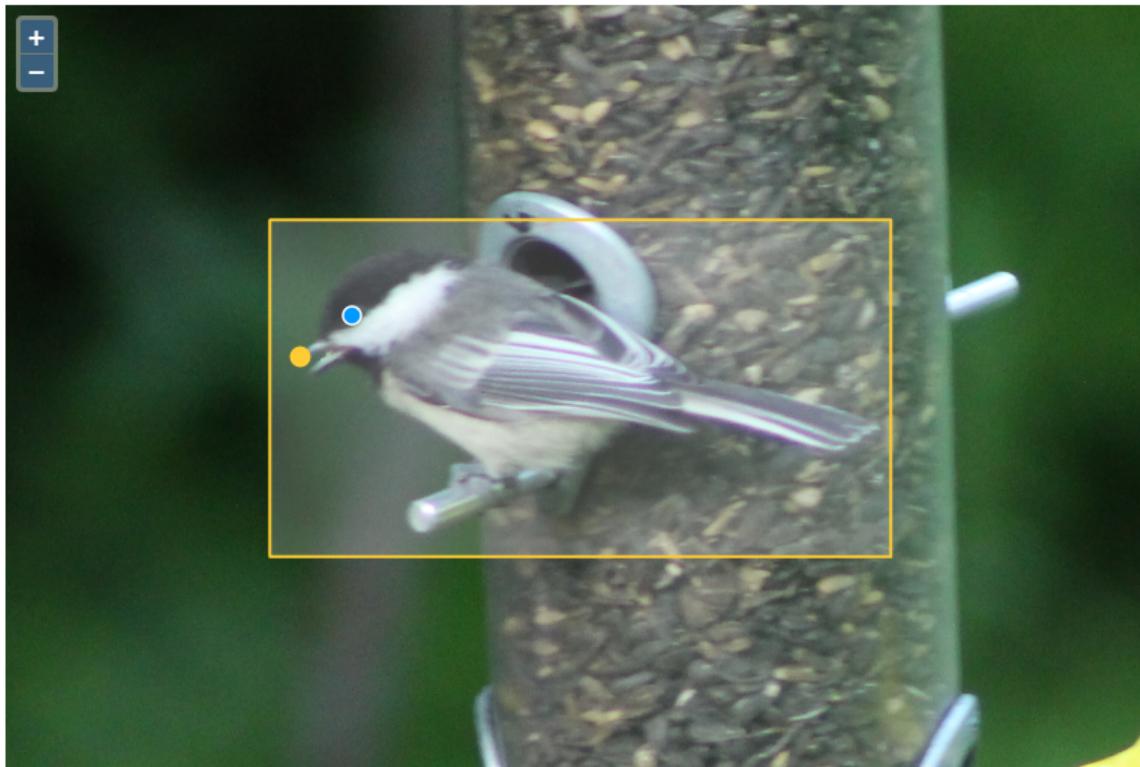
Click on the bill tip.

Next



Click on the eye. If both eyes are visible, click on the side of the head that is more visible.

Next



Where did you see the bird?

1. Search or click on the map to place a marker where the photo was taken.
2. Then, click Next to confirm the location.

Next

Search by City and State or Zip Code



When did you see the bird?

August  6 

[Next](#)

Creating list of possible birds...





Dryden, NY, USA

Aug 6

Black-capped Chickadee



Christopher L. Wood



Christopher L. Wood



Christopher L. Wood

This Is My Bird

Can't find your bird?

Merlin considers the 400 most familiar species in North America. The bird you're seeing might not be in our database yet. [Browse species.](#)

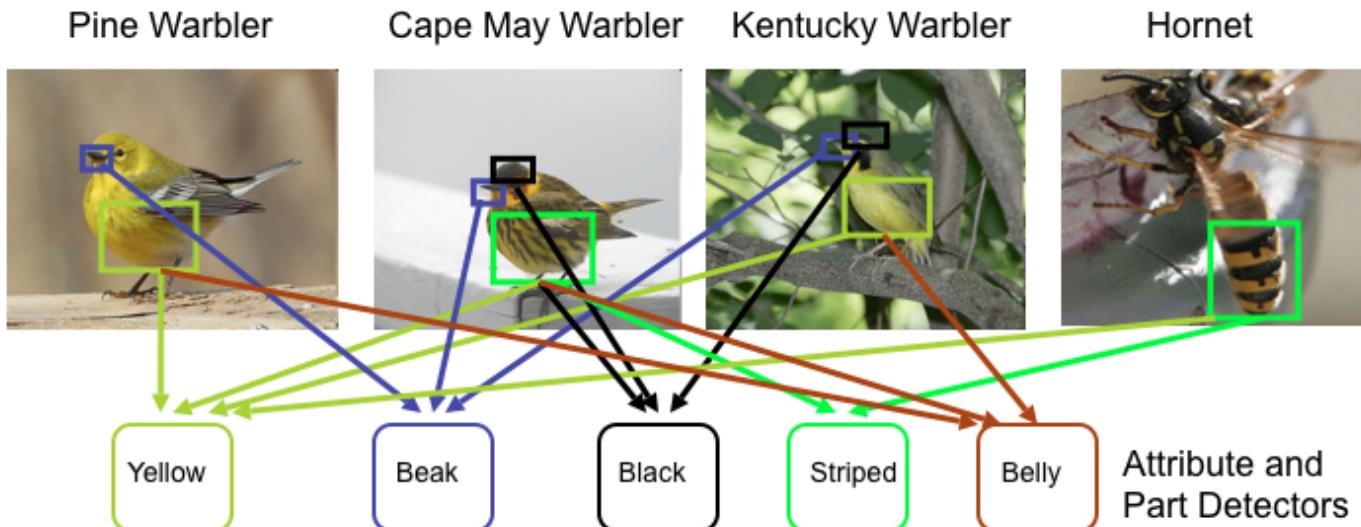
ID Another Bird

Outline

- Visipedia Project Overview
- Related Work
- Bird Datasets
- ViBE: Visipedia Back End
- **Future Work**

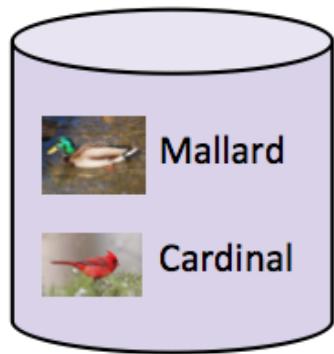
Future Work

- Beyond Birds
- Attribute Induction
- Relevance Feedback

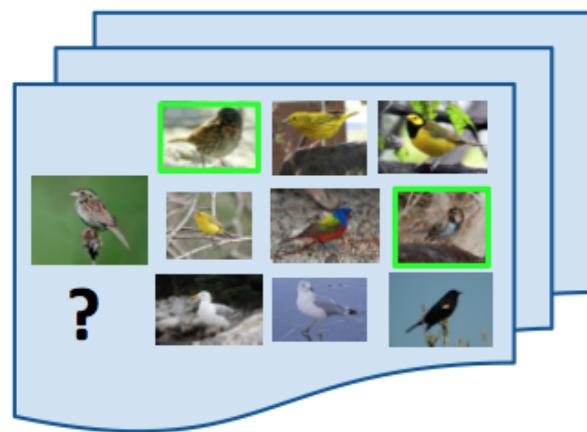


TRAIN TIME

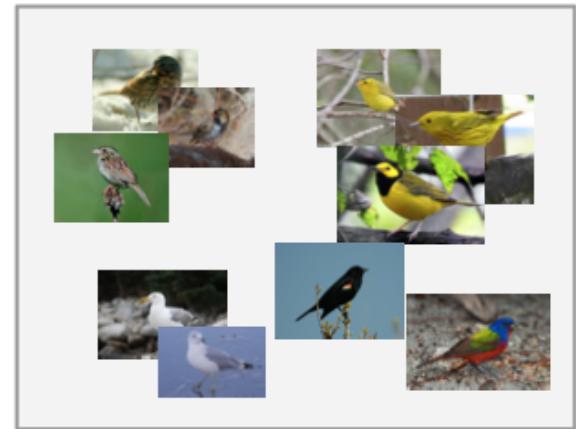
1) Image Database w/ Class Labels



2) Collect Similarity Comparisons



3) Learn Perceptual Embedding

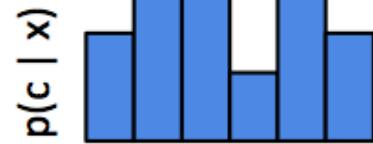


TEST TIME

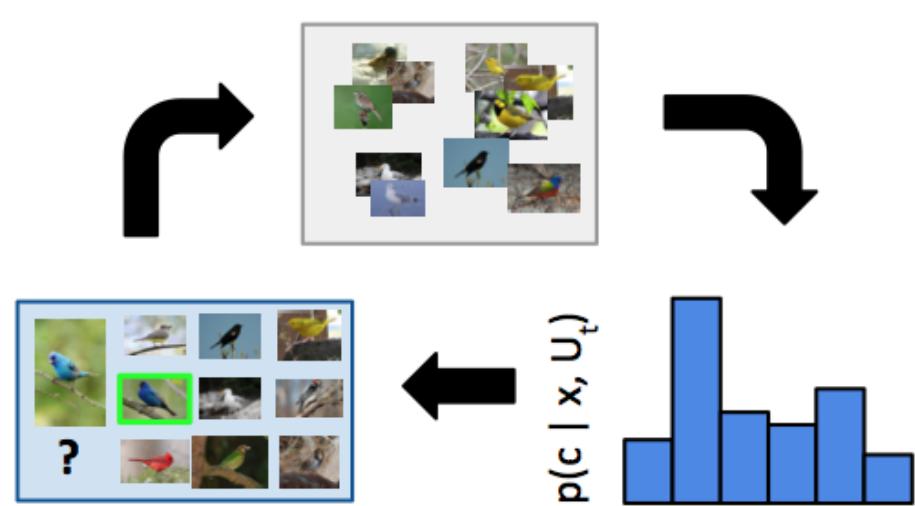
1) Query Image



2) Computer Vision



3) Human-in-the-Loop Categorization





Click on the birds to the right that are clearly **dissimilar** species from the bird above.

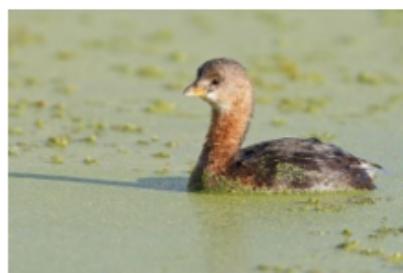
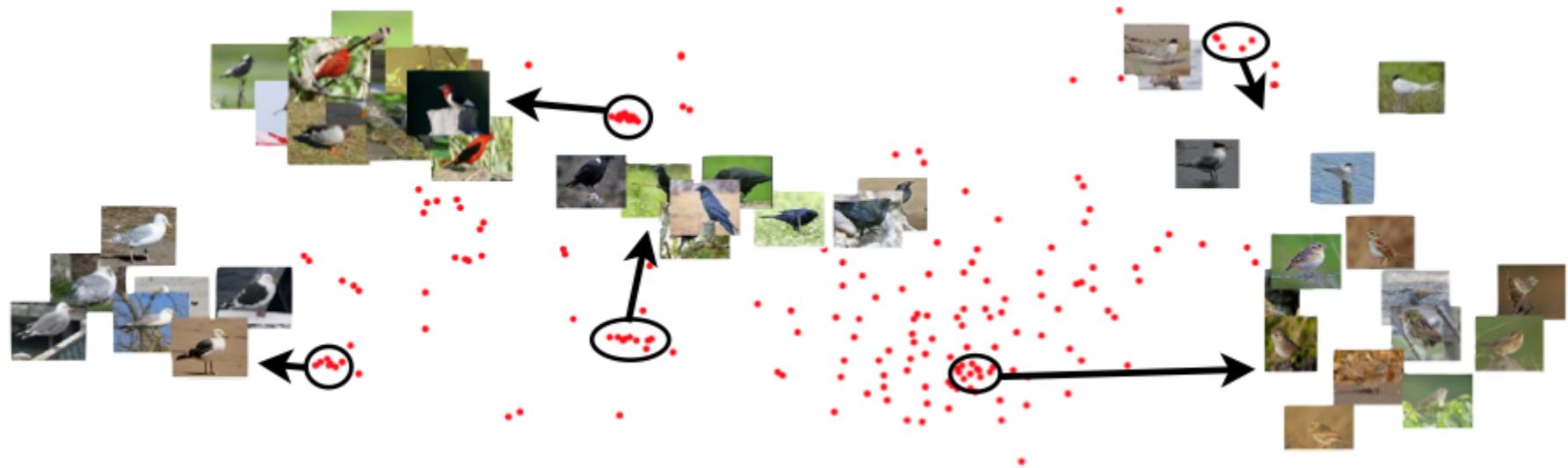
Instructions



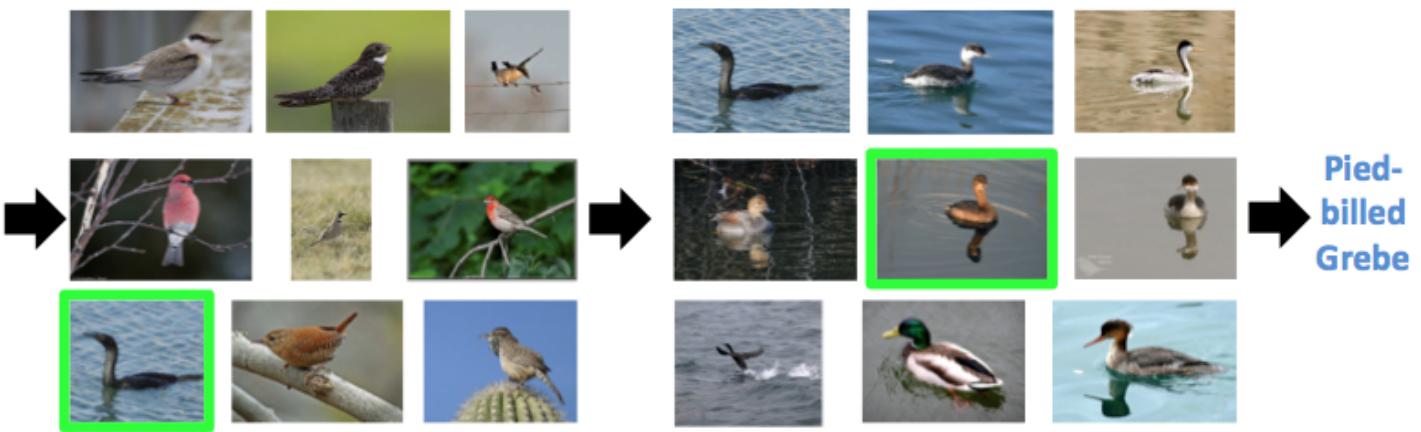
$$\mathcal{T}^k = \{(i, j, l) | x_i \text{ is more similar to } x_j \text{ than } x_l\}$$

$$\|\mathbf{z}_i - \mathbf{z}_j\|_2 < \|\mathbf{z}_i - \mathbf{z}_l\|_2 \iff s(i, j) > s(i, l)$$

Perceptual Embedding



Query Image



Thank You

- Caltech: Steve Branson, Grant Van Horn, Pietro Perona
- UCSD: Catherine Wah
- Cornell: Jessie Barry, Miyoko Chu
- BYU: Ryan Farrell
- Google Focused Research Award



visipedia.org

Extra Slides

Computational Pathology

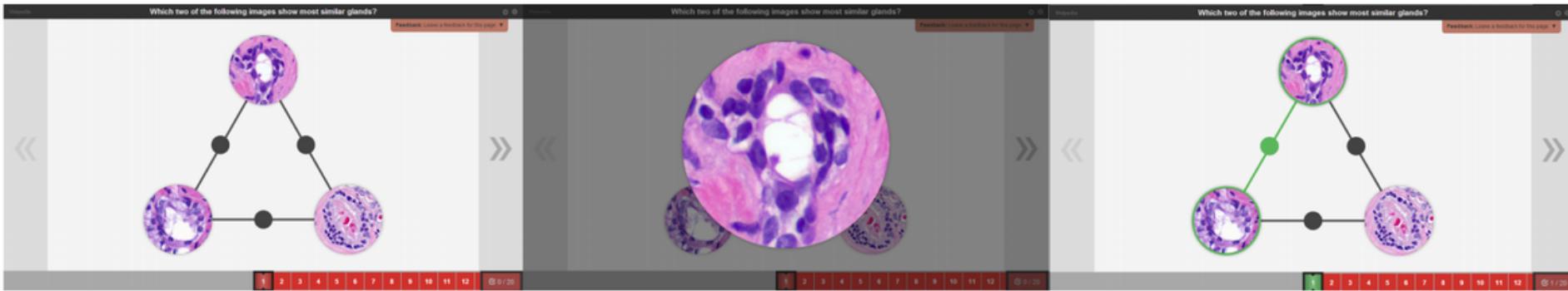


Figure 1.4. In our crowdsourcing framework, workers are asked which pair images in a triplet look most similar. Given a large collection of such relative measurements, we can learn a similarity function on image patches that captures human perception. Left: triplet depicting three regions of interest from a slide image. Middle: zoomed-in regions. Right: the chosen pair (clicked by the worker) is indicated in green.

CD44

20 total

Go To ▾ Order By ▾ Size ▾ Descendant

Add Content

Content

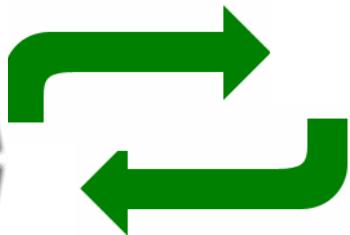
Clear Selection Selection Operations Bucket Operations

Tissue + **Prostate** + **Stain** + **CD44** + **NABirds** +

Click on the ♦ next to a bucket to add it here for quick drag and drop

Populating Visipedia

- Populate Wikipedia articles with more visual data using large quantities of unlabeled data on the web



World wide web



Visipedia

Attribute-Based Classification

- Train classifiers on attributes instead of objects
- Attributes are shared by different object classes
- Attributes provide the ingredients necessary to recognize each object class

otter

black:	yes
white:	no
brown:	yes
stripes:	no
water:	yes
eats fish:	yes



polar bear

black:	no
white:	yes
brown:	no
stripes:	no
water:	yes
eats fish:	yes



zebra

black:	yes
white:	yes
brown:	no
stripes:	yes
water:	no
eats fish:	no



Lampert et al. 2009

Farhadi et al. 2009

Attribute-Based Classification

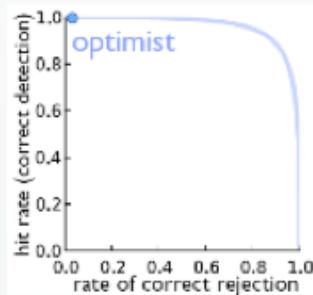
- Number of attributes is less than number of classes
- Attribute classification tasks might be easier
- Makes it easier to incorporate human knowledge

Brewer's Sparrow
Spizella breweri

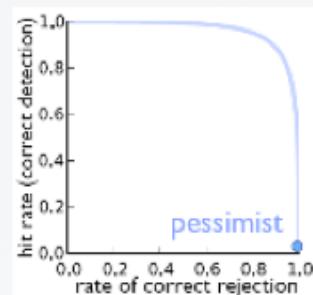
Order PASSERIFORMES	Family Sparrows (Emberizidae)	Code 4 BRSP	Code 6 SPIBRE	ITIS 179440
BODY		HEAD		
				
<ul style="list-style-type: none">■ Length Range: 14 cm (5.5 in)■ Weight: 14 g (0.5 oz)■ Size: Small (5 - 9 in)■ Color Primary: Brown, Gray■ Underparts: Pale Gray■ Upperparts: Gray-brown with black streaking.■ Back Pattern: Striped or streaked■ Belly Pattern: Solid■ Breast Pattern: Solid		<ul style="list-style-type: none">■ Bill Shape: Cone■ Eye Color: Dark hazel or blackish brown at all ages.■ Head Pattern: Eyeline, Striped, Streaked, Eyering, Malar or malar stripe■ Crown Color: Gray-brown with fine black streaking.■ Forehead Color: Gray-brown with fine black streaking.■ Nape Color: Gray-brown with fine black streaking.■ Throat Color: White with gray wash.■ Cere color: No Data		
FLIGHT				

Annotator bias

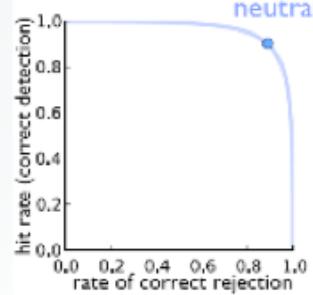
A



B



C



$$p(x_i | z_i = 0)$$

1

$$p(x_i | z_i = 1)$$

2

5

6

7

8

A

B

C

$$p(x_i | z_i = 0)$$

1

$$p(x_i | z_i = 1)$$

2

5

6

7

8

x_i

y_{ij}

