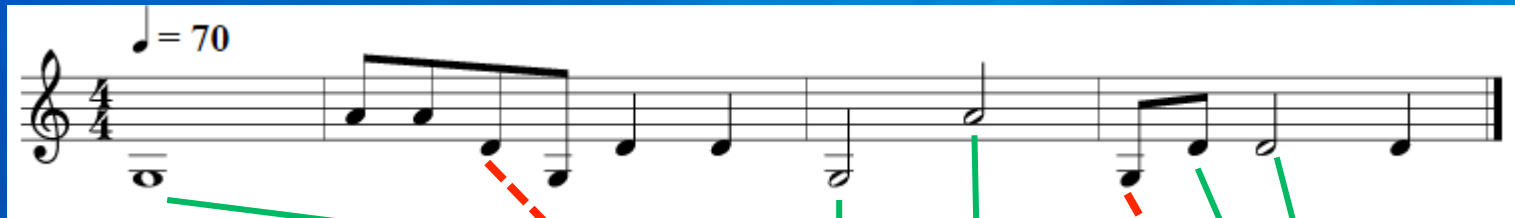# Recent trends and directions in bioacoustic classifiers

Marie A. Roch

1

Traditional Detection & Classification

Detect

Extract features

Classify each event

Whale illustrations American Cetacean Society - Uko Gorter © 2003/2006

Problems with the traditional model

- Individual calls yield limited information
- More recently
  - Groups of calls have higher F-ratios

$$J(w) = \frac{w' S_{\text{between}} w}{w' S_{\text{within}} w} = \frac{w'(\mu_1 - \mu_2)(\mu_1 - \mu_2)' w}{w' \sum_{x \in group_1} (x - \mu_1)(x - \mu_1)' w + w' \sum_{x \in group_2} (x - \mu_2)(x - \mu_2)' w}$$

Problems with the traditional model

- Individual calls yield limited information
- More recently
  - Groups of calls have higher F-ratios

1000 samples each class

10 sample average of same data
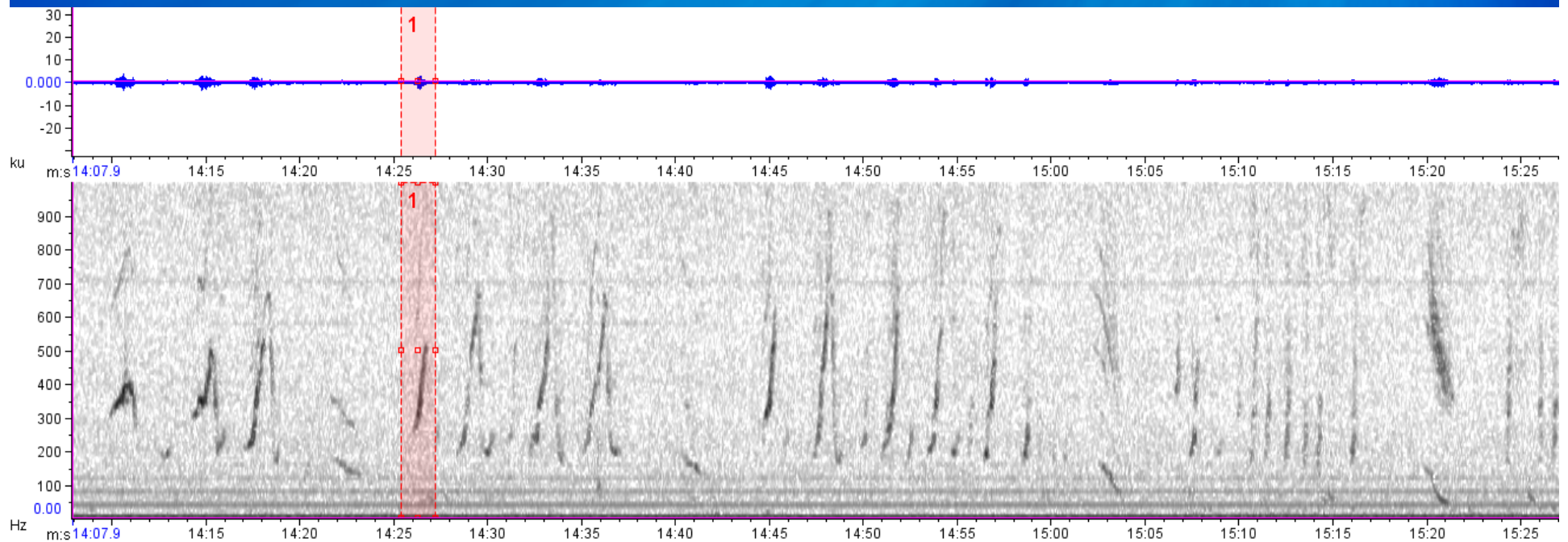
$$\frac{1}{10} \sum_{\text{random } i} x_i$$
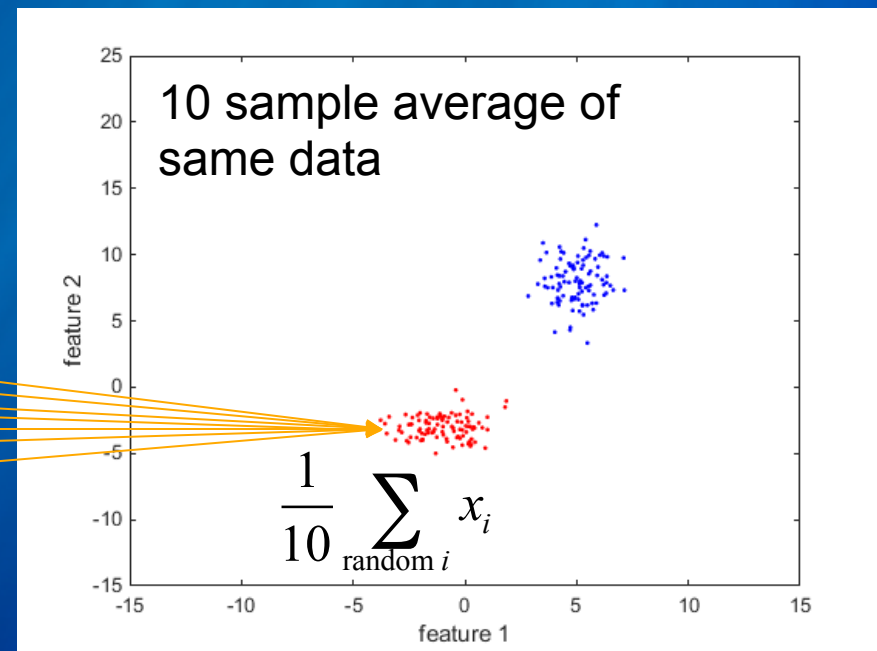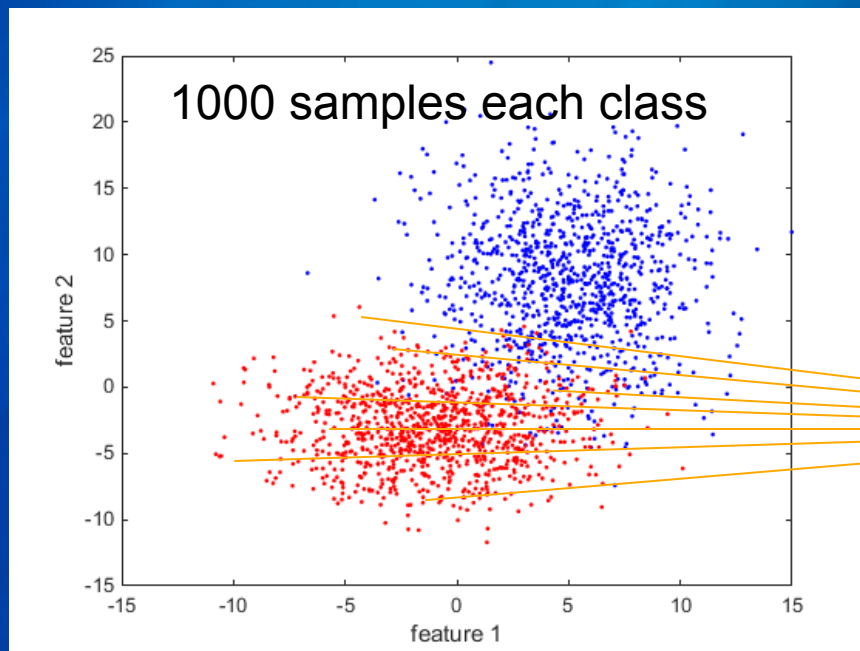
Recent and promising methods

- Ensemble learning (e.g. random forest)
- Context
- Information theory
- Deep learning
- Multiple lines of evidence

See Holger Klinck's boosting talk Wed 4:40

EricO flickr.com

5

DCLDE 2013 Right whale task
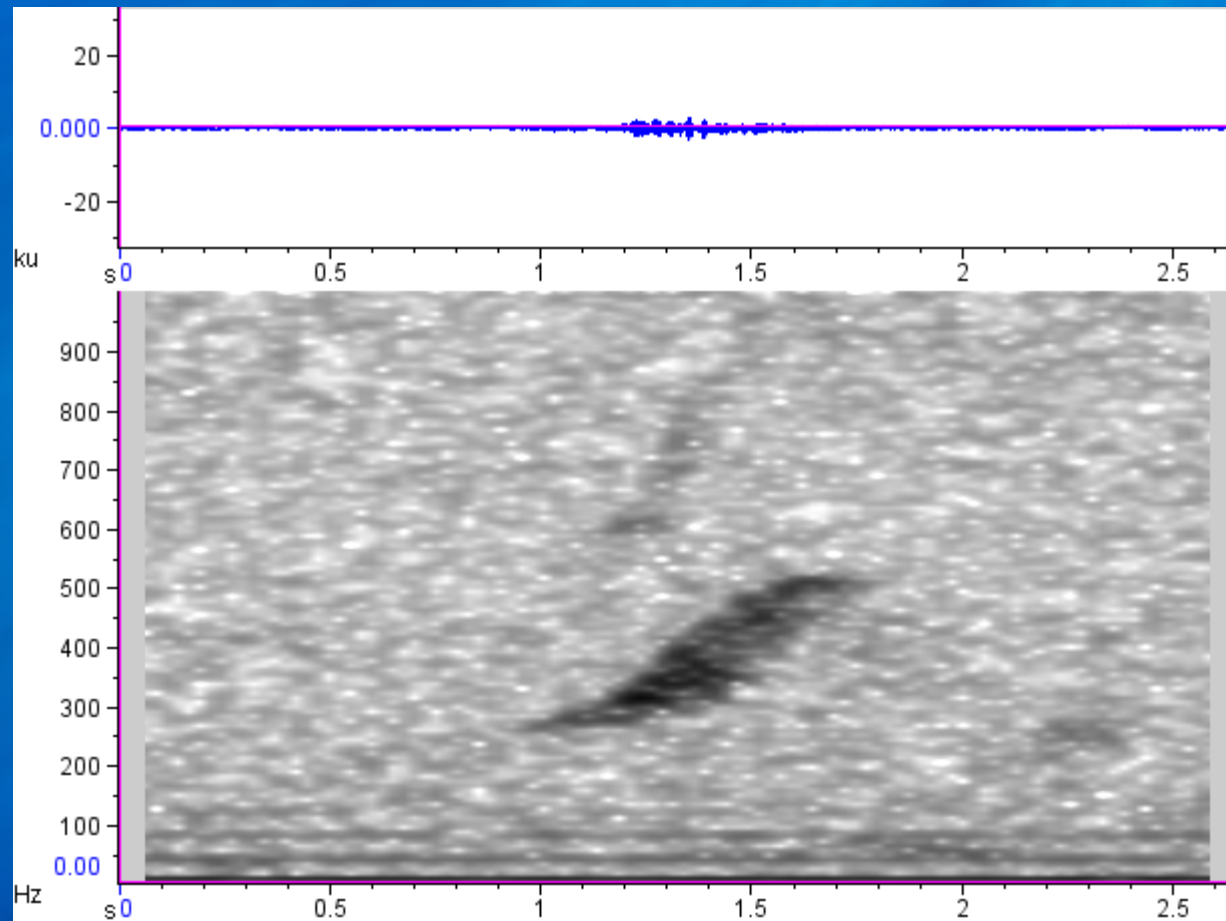

example courtesy Dani Cholewiak NEFSC

DCLDE 2013 Right whale task

example courtesy Dani Cholewiak NEFSC

# Information theory

- Can we look at an acoustic encounter as an event?

- Information theory provides a path
  - Construct probabilistic model of encounter
  - Kullback-Liebler divergence lets us quantify similarity between distributions

  See Yun Trinh's talk Monday 4:00

Kullback-Liebler Encounter Divergence

Risso's dolphin
Pacific white-sided dolphin

Pacific white-sided

Risso's
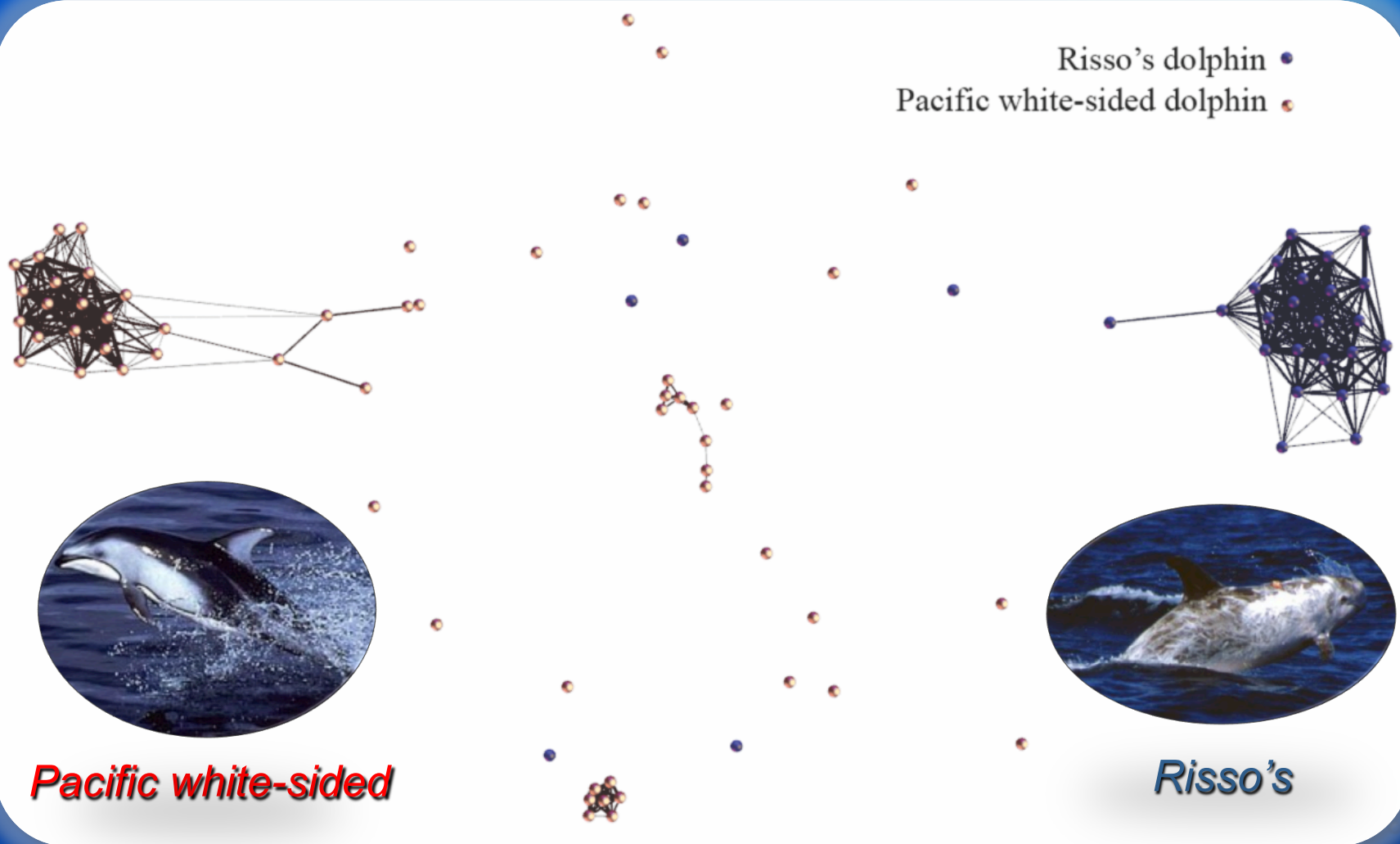
Deep Learning

- Recent form of neural net
  (review in *Nature* LeCun, Bengio & Hinton 2015 521 436-444)

- Key usage concepts
  - Large training sets
  - Use for classification and/or feature extraction

- Highly successful in a wide variety of fields

- Bioacoustics:
  - Halkias et al. (2013) *JASA* 134(5)
  - See Jeremy Karnowski's talk Monday 4:40

Deep Learning

- Layers of restricted Boltzman machines

Hidden data

$$output(node) = f\left(\sum_{i=1}^{N} w_i x_i + w_0\right)$$

Visible data
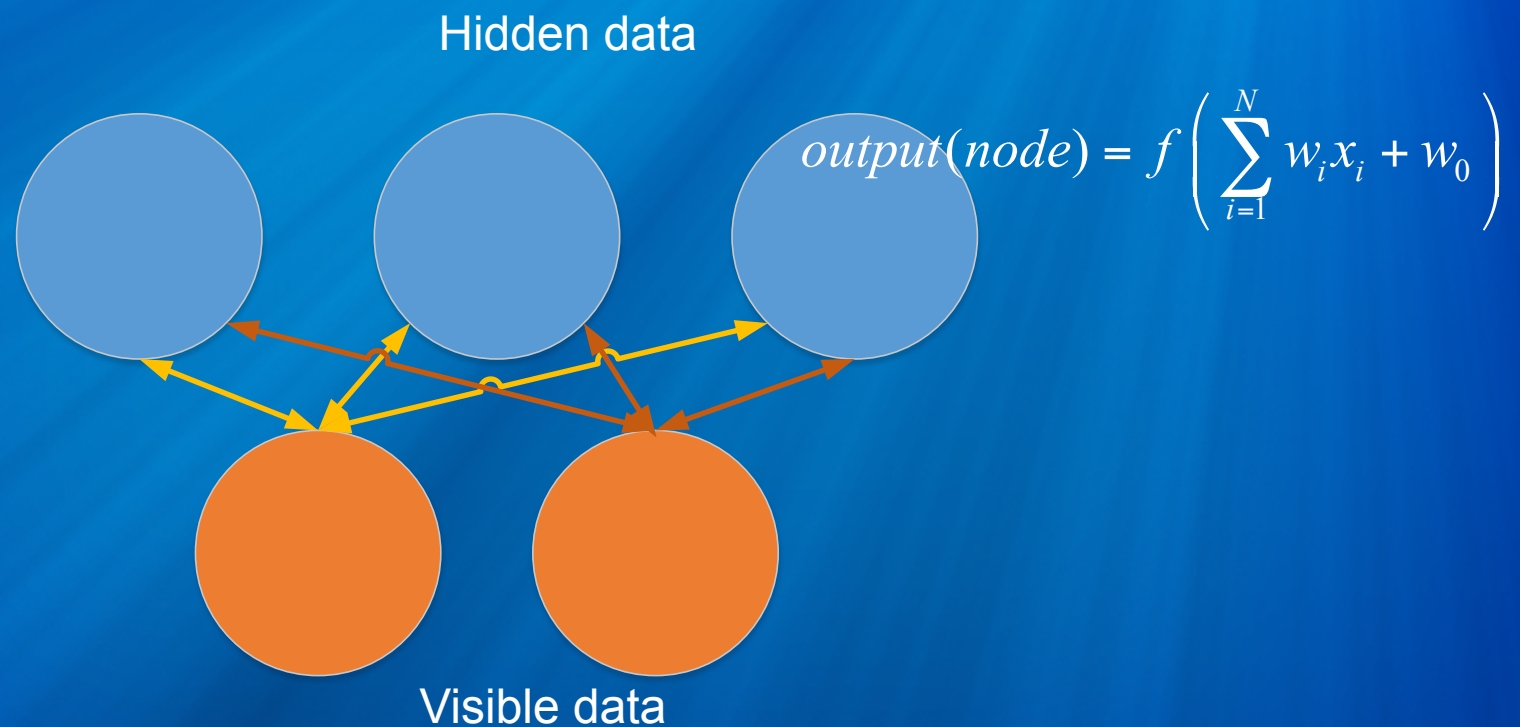
- Stacked and learned one at a time

Deep Network Recognizing digits
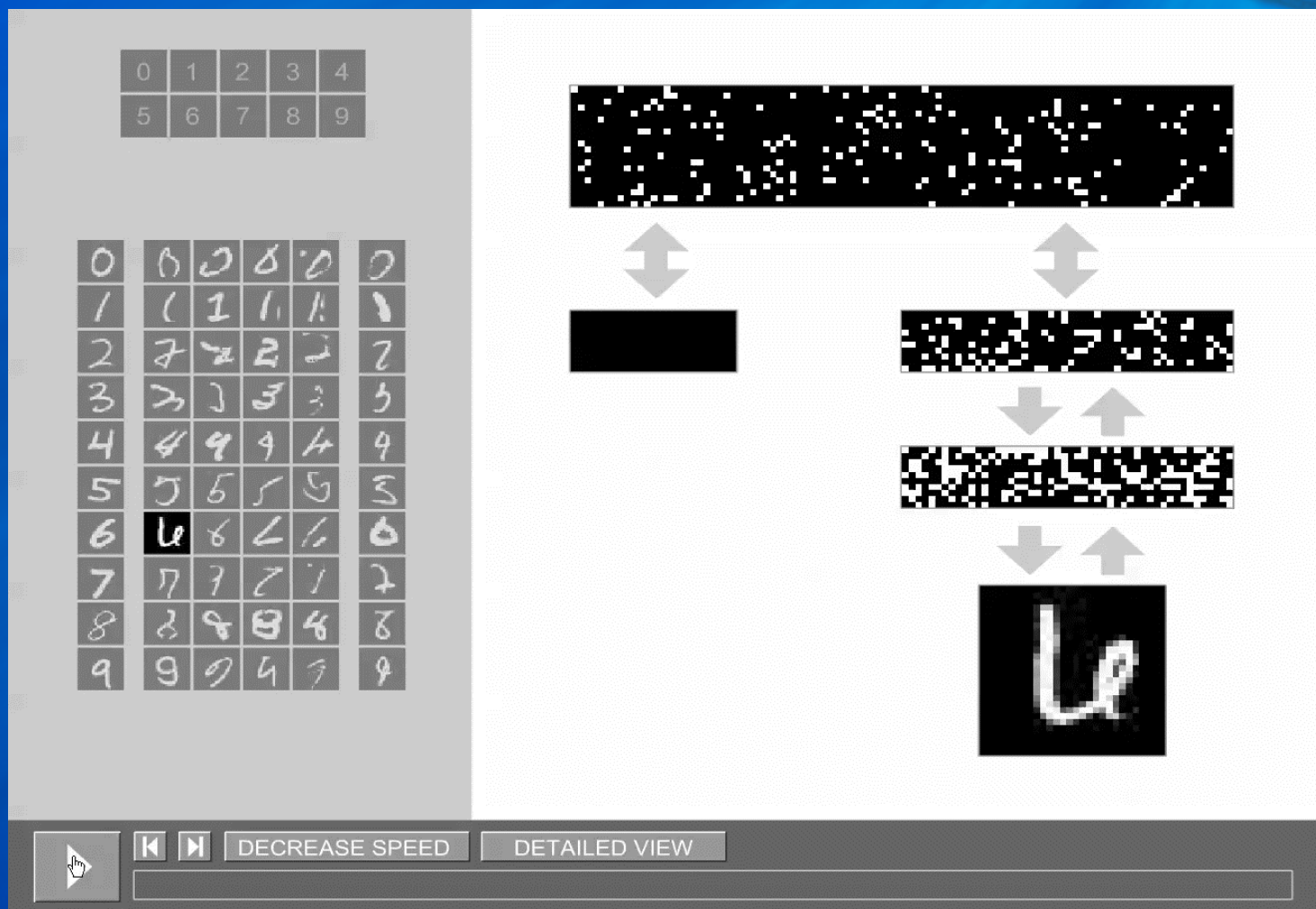
demo by Geoff Hinton

Multiple lines of evidence

- We typically look for specific call types
- Can we merge multiple information sources?
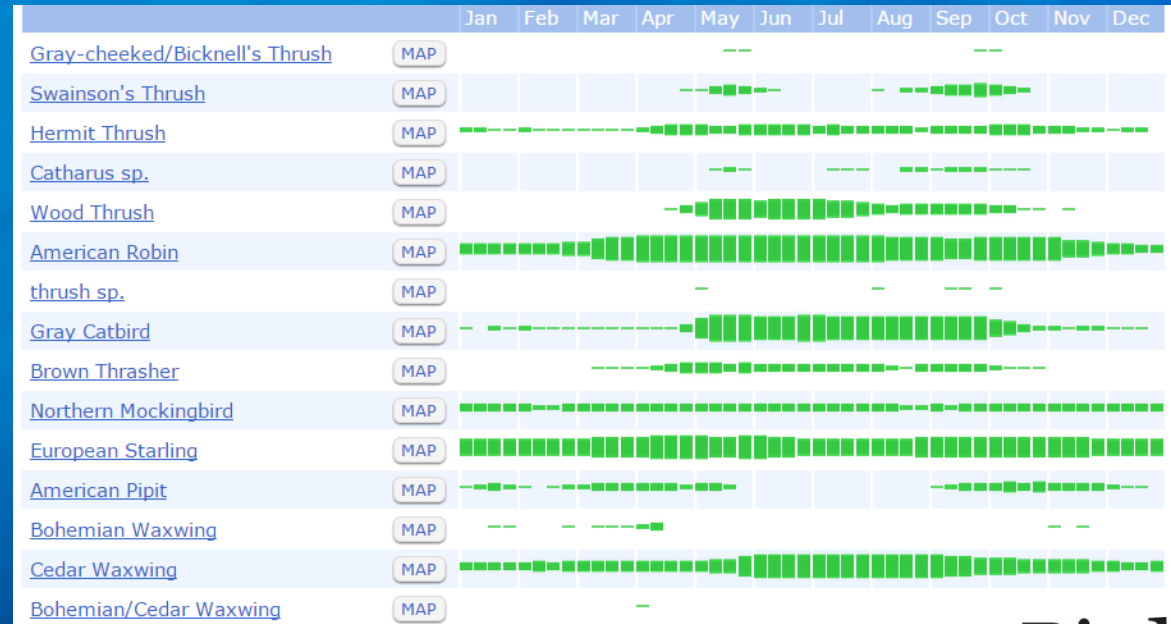 - whistles and echolocation clicks
  - habitat (location, time, environment)
  - depth
  - number of calling animals
  - etc.

13

Example: PAM of migrating birds

Classify species

Night flight calls hard to classify; many candidates
(>300 potential species in Upstate NY)

e-Bird visual sightings as a "weighting factor"

Transmit to lab
(Wi-Fi, cell phone)

Target signal?
yes/no

		Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Gray-cheeked/Bicknell's Thrush	MAP					—				—			
Swainson's Thrush	MAP				— —			—	— — —	—			
Hermit Thrush	MAP	— —	—	— —	— —	— —	—	—	—	—	—	—	—
Catharus sp.	MAP				—		— — —	—				
Wood Thrush	MAP				— —	—	—	—	—	—			
American Robin	MAP	—	— —	— —	—	—	—	—	—	—	—	—	
thrush sp.	MAP				—			—	— —	—		
Gray Catbird	MAP		— —		—	—	—	—	—	—		
Brown Thrasher	MAP			— —	—	—	—	—	— —			
Northern Mockingbird	MAP	— —	—	— —	—	—	—	—	—	— —	—	—	
European Starling	MAP	—	— —	—	—	—	—	—	—	—	—	—	—
American Pipit	MAP	— —	—	— —	—	—	—	—	—	—		
Bohemian Waxwing	MAP	— —	—	— — —	—				— —		
Cedar Waxwing	MAP	—	— —	—	—	—	—	—	—	—	—	—	—
Bohemian/Cedar Waxwing	MAP			—								

eBird

ROBIN
Field Unit

Significantly increases classification accuracy

courtesy Holger Klinck
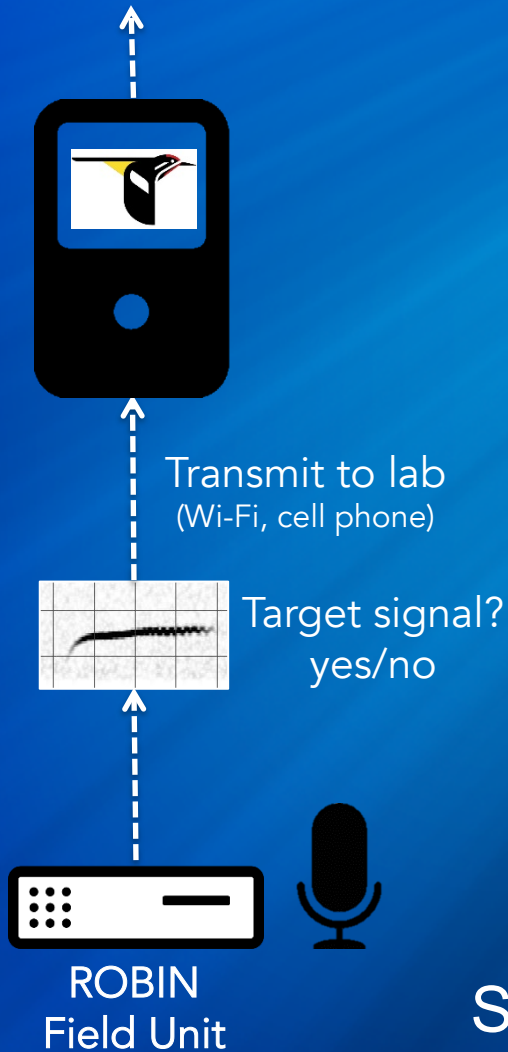
Where do we go from here?

- Develop methods to extract better features
  - Automatically?
  - Alternatives? (e.g. Leroy Emmanuelle's subspace analysis earlier today)

- Incorporation of context and multiple lines of evidence

- Move beyond predicting species…
  - Can we use learning to discover information about behavior, species assemblies, etc.?

¡Muchas gracias!

Michael Weise & Dana Belden

Members of the following labs:
SDSU Audio Processing Lab
SIO Behavioral Acoustic Ecology Lab (Simone Baumann-Pickering)
SIO Marine Bioacoustics Lab (Ana Širović)
SIO Whale Acoustics Lab (John Hildebrand)