

# A Unified Framework for Learning and Processing Perceptual, Relational, and Meta Knowledge



Marc Pickett

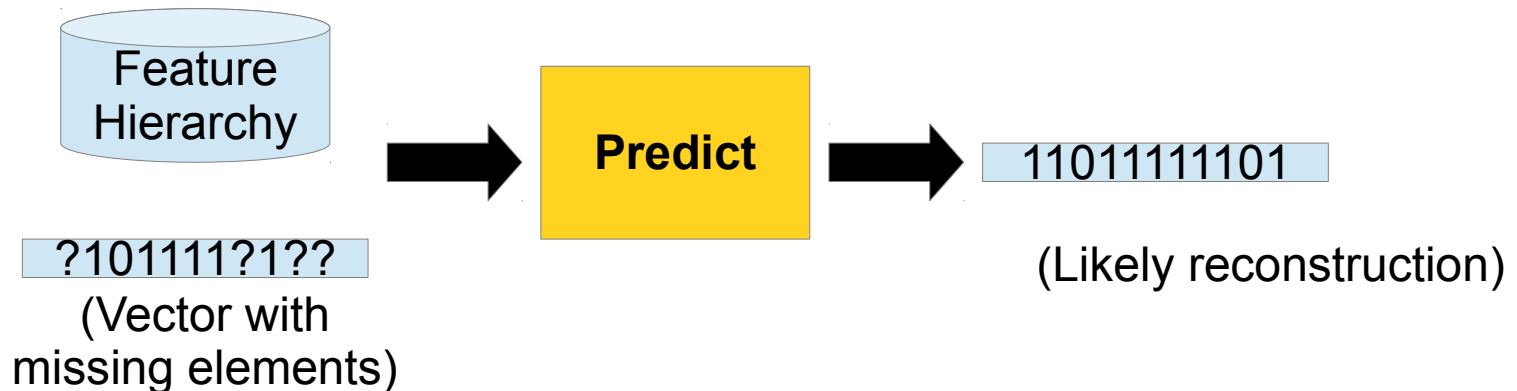
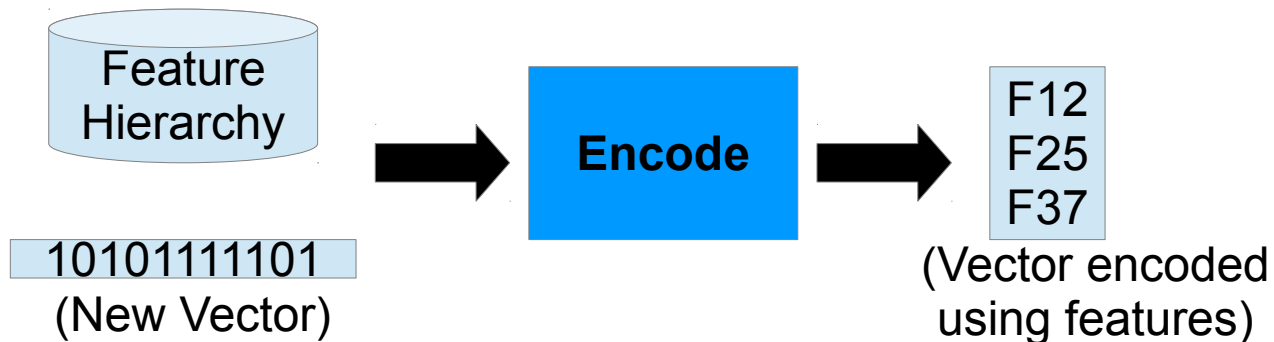
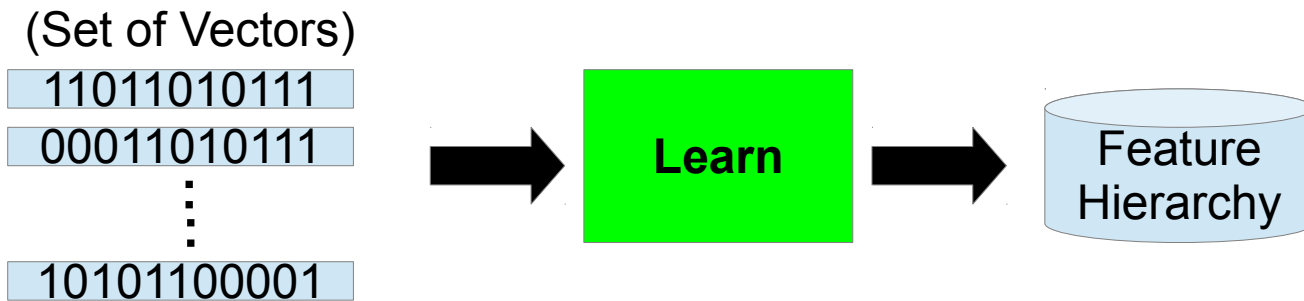
Talk by **Mark Wilson**

NRC/Naval Research Laboratory  
Washington, DC



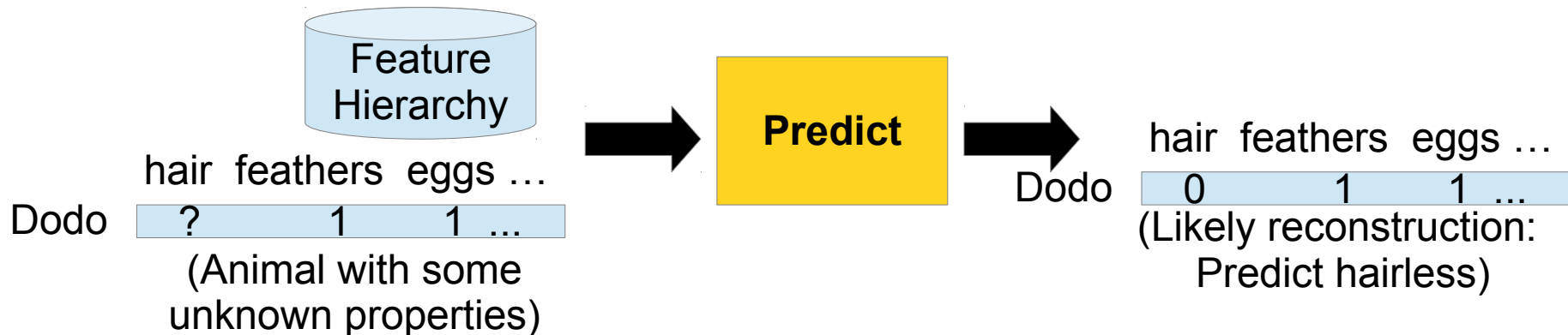
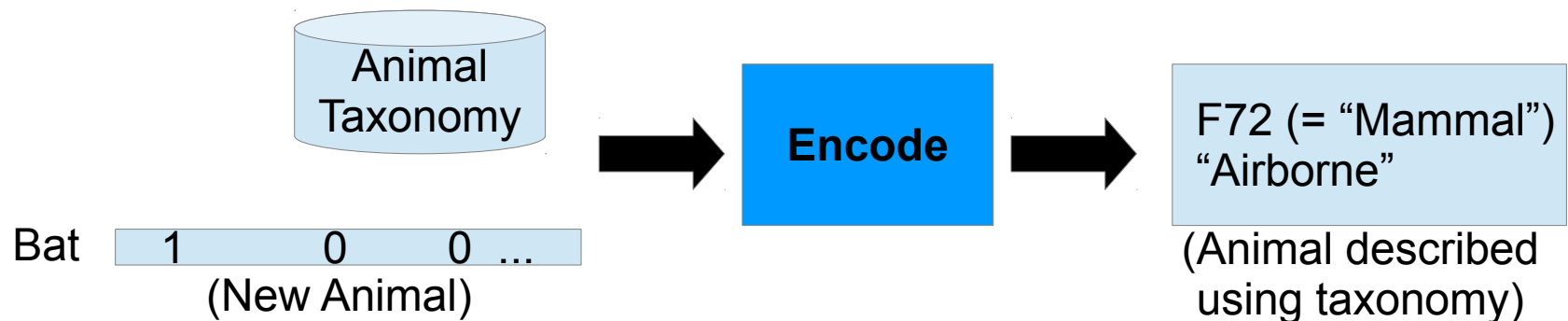
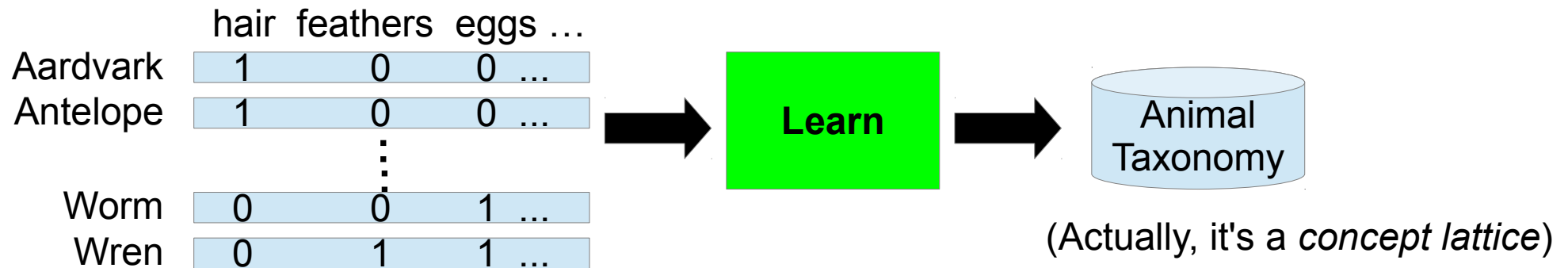
# The “Vector Toolkit”

## 3 algorithms on fixed-width vectors



# Vector Toolkit example

## Animal Dataset (from UCI)



# Can Learn Many Feature Hierarchies

Animal Vectors

11011010111  
00011010111  
⋮  
10101100001



Learn



Animal  
Taxonomy

Plant Vectors

1010111  
0011010  
⋮  
1100001



Learn



Plant  
Taxonomy

16x16  
Image Patches



Learn



Visual Feature  
Hierarchy  
For 16x16

32x32  
Image Patches



Learn



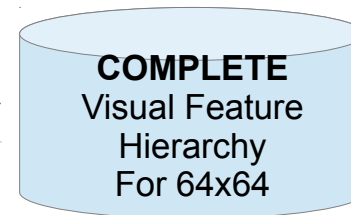
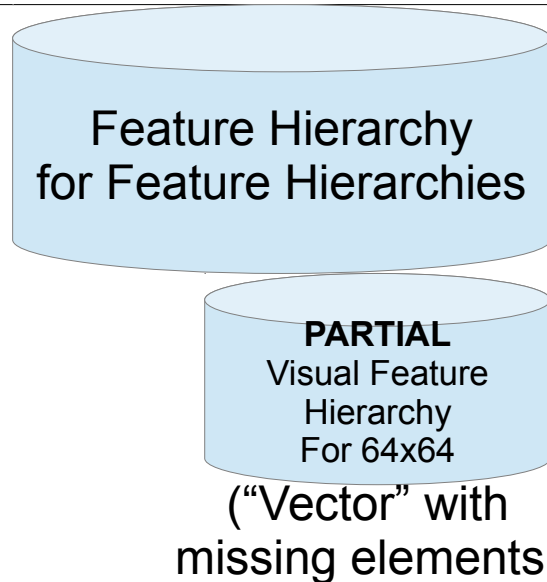
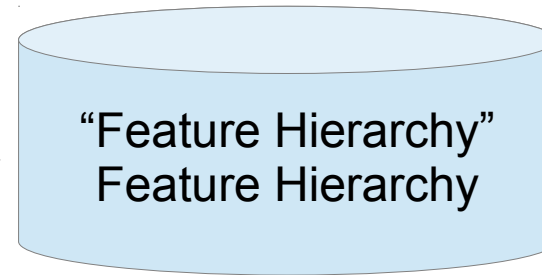
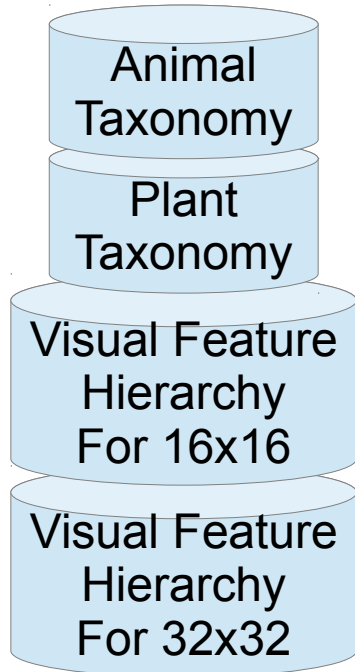
Visual Feature  
Hierarchy  
For 32x32

**How is Animal Taxonomy like Plant Taxonomy?  
Can we generalize knowledge about Image Patches?**

# A “Meta” Feature Hierarchy?

Use the Vector Toolkit...

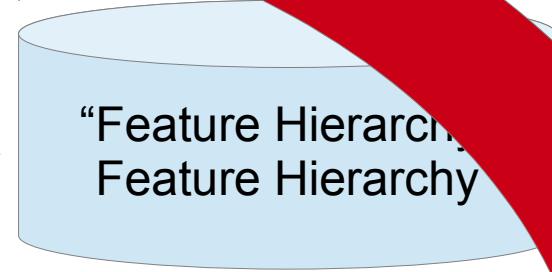
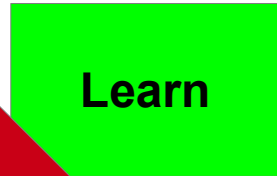
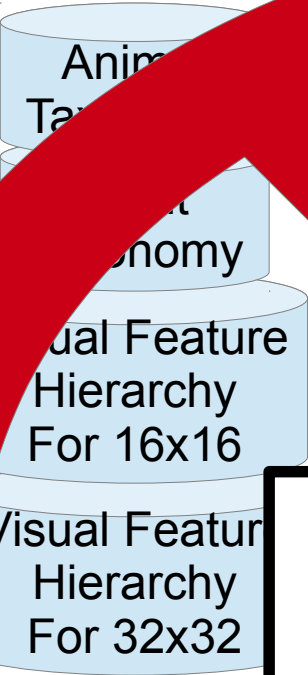
(Input “Vectors”)



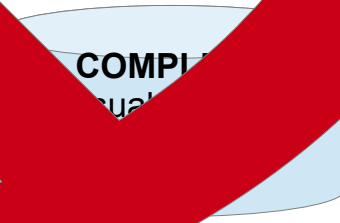
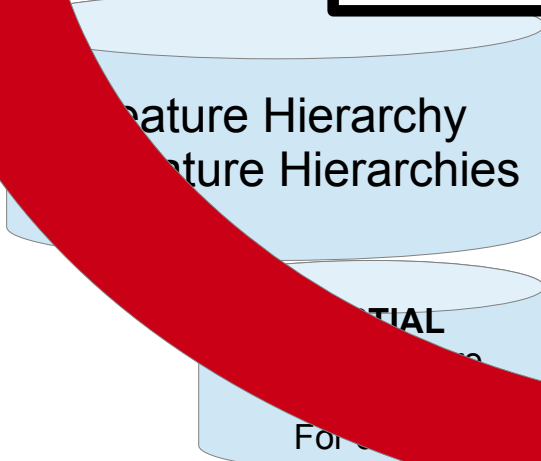
# A "Meta" Feature Hierarchy?

(Input "Vectors")

Toolkit...



Vector Toolkit requires **vectors**  
Feature Hierarchies are **structures**



("Vector" with missing elements)

# Transform Feature-Hierarchies into Vectors



Transform Feature-Hierarchy into vector such that:

**Partial Overlap in vectors iff Partial *Structural* Overlap in Feature-Hierarchies**

E.g., if there is a large partial isomorphism between animal taxonomy and plant taxonomy, then their vector representations will have many common elements (and vice versa).

Other approaches (Plate's HRRs, Socher's autoencoders, Bag of Words) lack this property.

**(See paper for details of Vectorize.)**

# Simple Demo

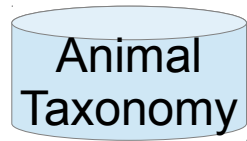
## Process Finds Structure Similarity in (Object-level) Feature-Hierarchies

Animal Vectors

11011010111  
00011010111  
⋮  
10101100001



**Learn**



**Vectorize**



(Animal Tax. as Vector)

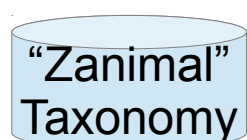
1001110...11011

“Zanimal” Vectors

11011010111  
00011010111  
⋮  
10101100001



**Learn**



**Vectorize**



(Zanimal Tax. Vector)

0100110...11001



**Learn**



111011010111  
000111010111  
⋮  
101011001001

Congressional voting Vectors (from UCI)



**Learn**



**Vectorize**



(Congress F.H. Vector)

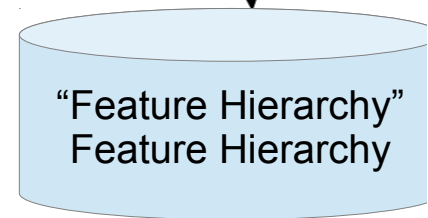
1100000...01001

1100000...01001

1001110...11011

0100110...11001

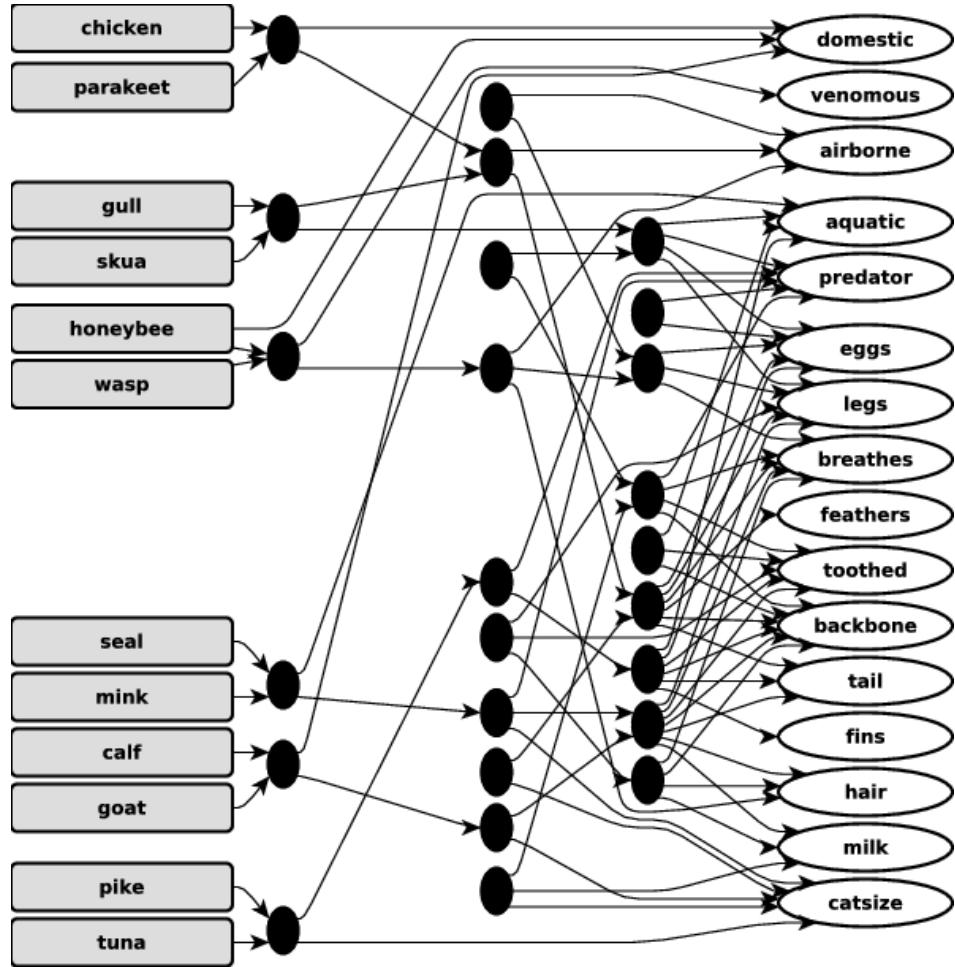
(Fongress, Zongress, and Fanimal F.H. Vectors)



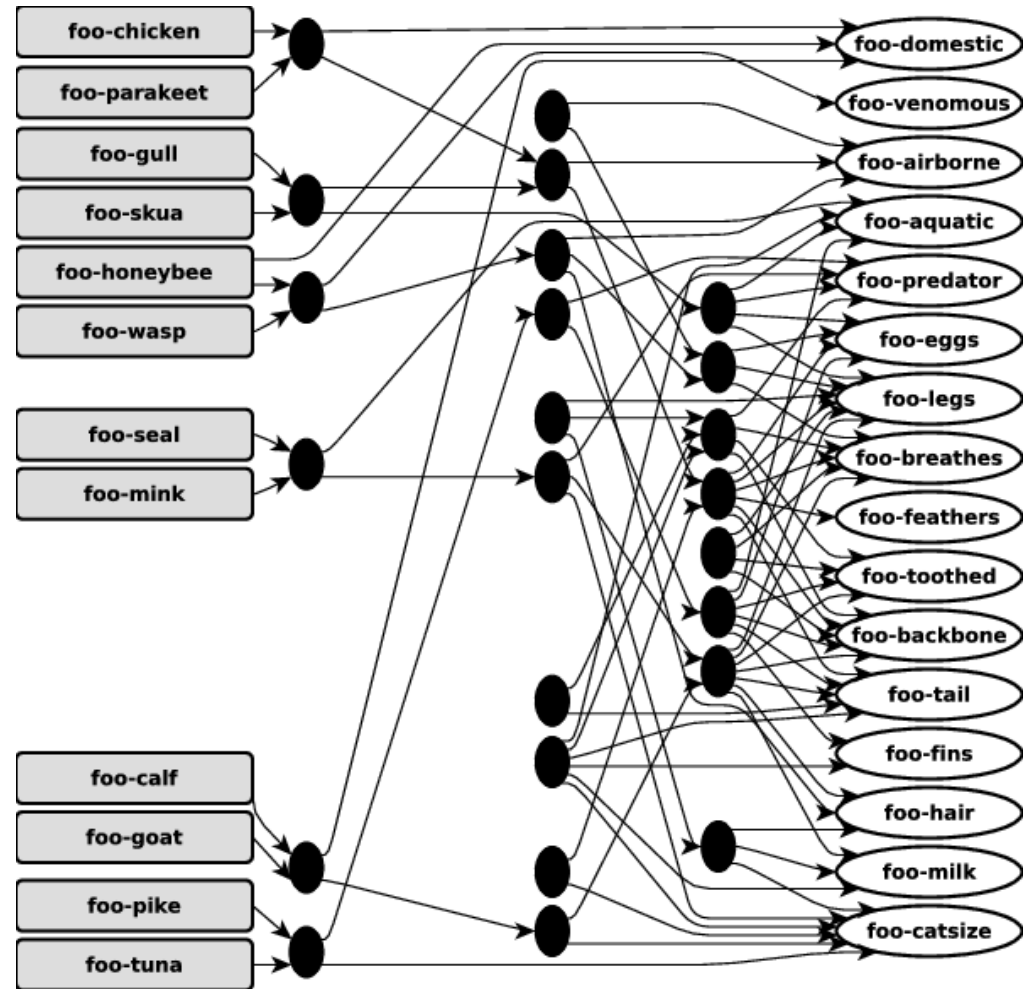


# Simple Demo

## A Peek Under The Hood



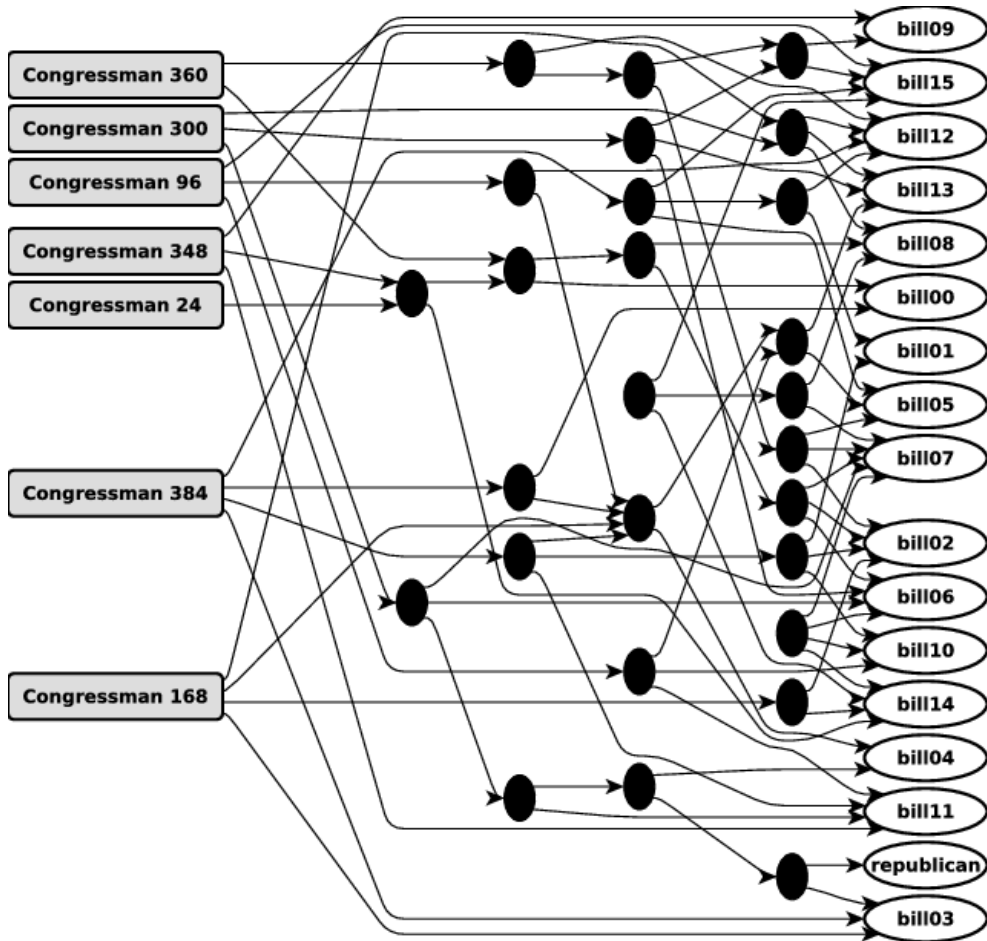
Actual Animal Taxonomy (partial)



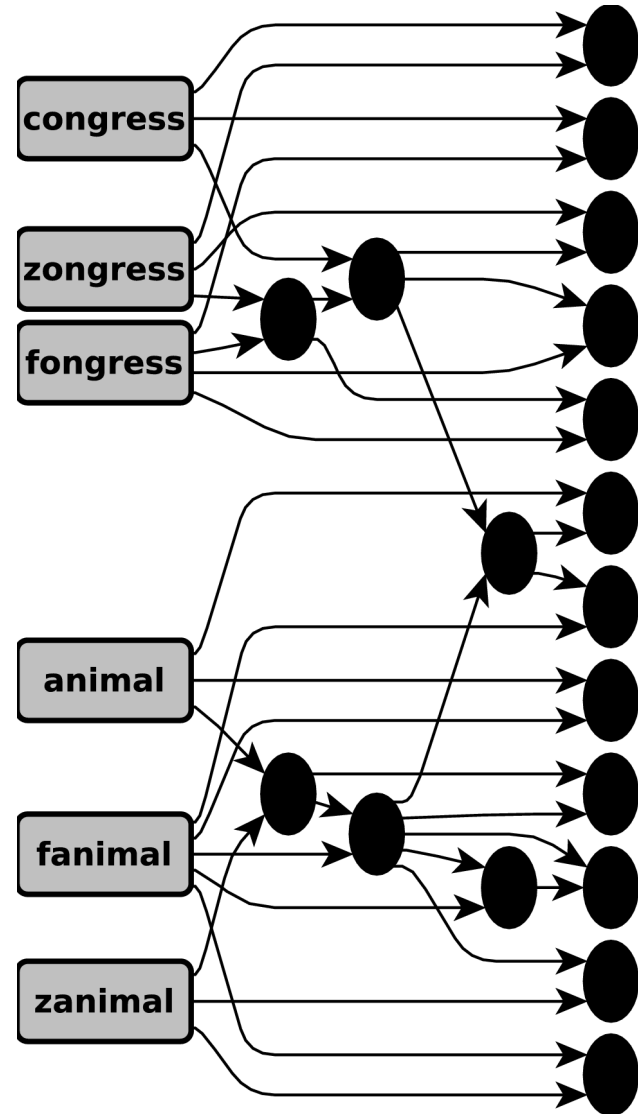
Actual Fanimal Taxonomy (partial)

# Simple Demo

## A Peek Under The Hood



Actual Congress Feature Hierarchy  
(partial)



The "Meta" Feature-Hierarchy (partial)

# Discussion

## Next Steps: Potential Uses of “Meta” Feature Hierarchies

- Transfer between domains
  - Learn about 64x64 image patches if 32x32 and 16x16 are already learned
  - Use **Encode** and **Predict** to make inferences for new domains
- Discover translation invariance in images
  - Feature hierarchy for top-left of image is structurally similar to bottom-right