

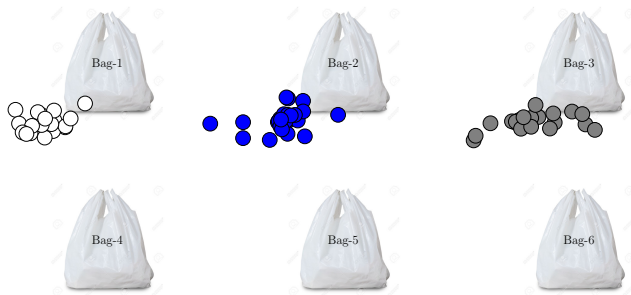
# Biological Vision and Applications

## Module 03-07: Hierarchical Bayesian Model

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# An example

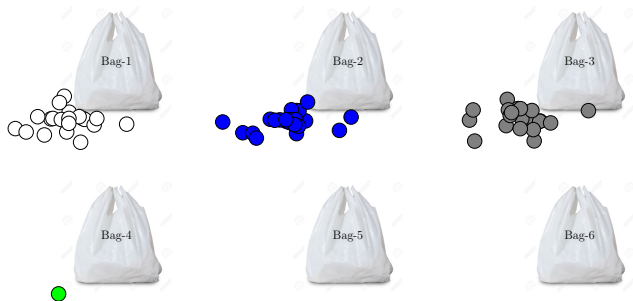
Prior belief: The bags can have marbles of any color or mix



- What do we learn from these observations?
- Can we predict something about bags 4 – 6 that are yet to be sampled?

# An example

... Contd.

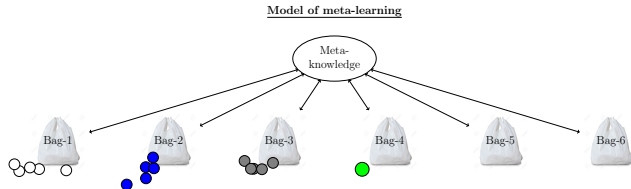


- What do we infer about bag 4 from this new observation?

This is the very basis of transfer learning

# Specific knowledge and Generic knowledge

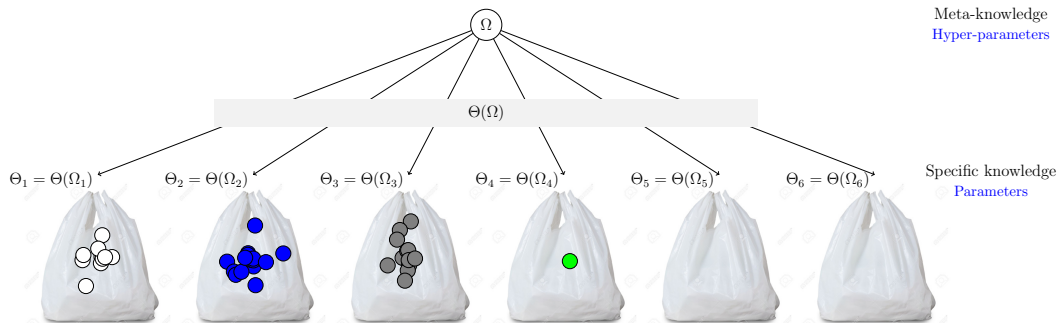
- **Specific Knowledge:** When we sample marbles from a particular bag, we gain knowledge about the content of that bag
- **Generic (Meta) Knowledge:** When we sample marbles from several bags, we gain knowledge about all bags ... even for those which are not sampled



This is an instance of **inductive reasoning** or **inductive generalization**

# Modeling the problem

## Hierarchical Bayesian Model



# Modeling the problem

contd ...

- Let  $\Theta_i$  represent the model parameters for bag  $i$ 
  - ▶  $\Theta_i = (\theta_{i1}, \theta_{i2}, \dots)$ ,  $\theta_{ij}$ : probability of a marble to be of color  $j$ 
    - ▶  $0 \leq \theta_{ij} \leq 1$ ,  $\sum_j \theta_{ij} = 1$
  - ▶ Parameters  $\theta_{ij}$ 's can be individually learned using Bayesian inferencing
- $\Theta_i$ s are modeled as probabilistic functions of some hyper-parameters  $\Omega$  in HBM
- A common approach is to use Dirichlet distribution

$$\text{Dirichlet distribution: } P_{\alpha}(x) = \frac{1}{B(\alpha)} \prod_{i=1}^k x_i^{(\alpha_i+1)}, \quad \text{where } B(\alpha) = \frac{\prod_{i=1}^k \Gamma(\alpha_i)}{\Gamma(\sum_{i=1}^k \alpha_i)}$$

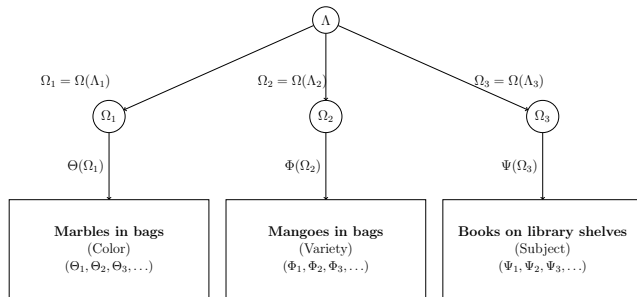
Example of Dirichlet Distribution

# What is really happening?

- When we have no observations, we have some priors on  $\Omega$ 
  - ▶ This determines priors (constraints) for  $\Theta_i$ 's
- As we observe  $i$ -th bag, we learn (update)  $\Theta_i$ 
  - ▶ As we “observe”  $\Theta_i$ , we learn (update)  $\Omega$
- As we update  $\Omega$ , values of all  $\Theta_i$  are updated

- Hyper-parameters  $\Omega$  are learned together with the model parameters  $\Theta_i$ 's
- Hyper-parameters  $\Omega$  links the model parameters  $\Theta_i$ 's
- An observation for one bag serves as an observation for the other bags too

# Progressive generalization of knowledge



- It is possible to model generic knowledge with even higher abstraction (level) of knowledge, and so on ...
- The entire knowledge-base gets linked
  - ▶ Generalization from one problem to another will be efficient for similar problems



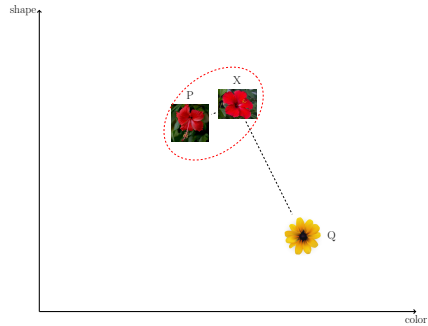
# Feature Learning

Which feature do you choose ?



# Which category X belongs to?

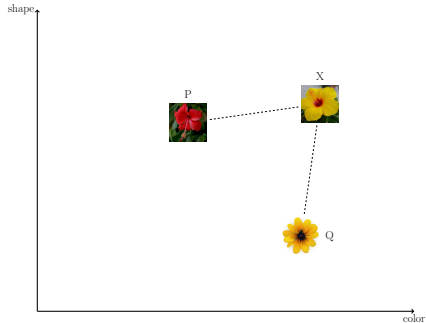
P and Q are rare flowers, you have one sample for each



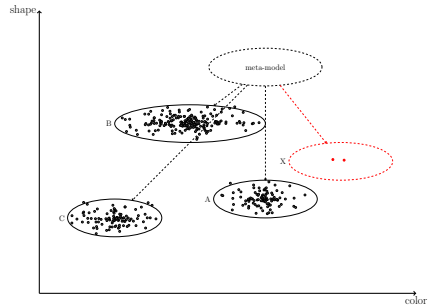
*Pretty simple !*

# Which category X belongs to?

P and Q are rare flowers, you have one sample for each



# Meta-learning from abundant classes

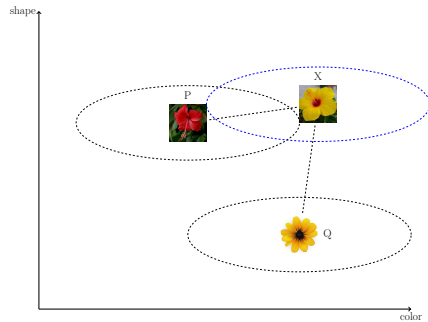


Meta-learn visual model for objects from abundant classes:

Object features have more spread in color than shape

Use the meta-model to create models for new (and rare) classes

# Create models for rare classes from meta-model



X belongs to class P

We put more emphasis on shape than color

# Shape bias

That is exactly how a child learns to distinguish objects by their shapes

 <p>In this example, we have a variety of cups, spoons, and plates that vary in color, material, size, and design. You may start with comparable objects mixed up like this or placed in a large container.</p> <p>1</p>	 <p>"This is a white paper plate. We will put the plates in this area."</p>  <p>"This is a blue plastic cup. We will put the other cups near this cup."</p> <p>One by one, organize all the objects by their shapes as you describe them. Talk about the objects' colors, sizes, materials, and other attributes. Ask your baby where the objects belong. For example, select the large red plate and ask your baby, "What does this go next to?" or "Where are the other plates?"</p> <p>2</p>
 <p>At the end of the activity, the objects should be sorted into categories. When doing these activities, your focus should be on teaching your baby that shapes provide important information about how categories are formed. The ability to categorize by shape helps infants and children learn words.</p> <p>3</p>	 <p>A more advanced activity that you can try with children who are at least 12 months old is to give your child objects that could be sorted by color or by shape and ask your child to organize them. You may want to demonstrate how to sort them both ways many times before checking to see if your child will sort them. Please don't be concerned if your baby plays with the toys and does no sorting. Another way to check if your baby has a strong shape bias is to check if your baby can recognize written words by their shapes.</p> <p>4</p>

Source: Shape Bias

Quiz 03-07

End of Module 03-07