IIT Jodhpur

Biological Vision and Applications
Module 03-07: Hierarchical Bayesian Model

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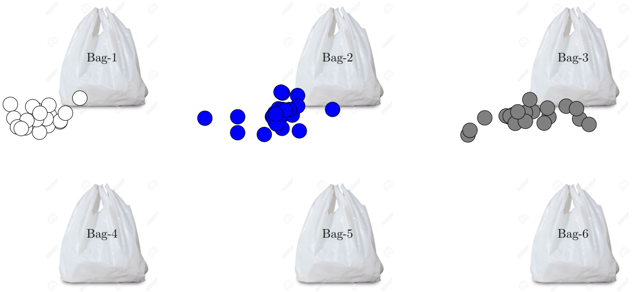
An example

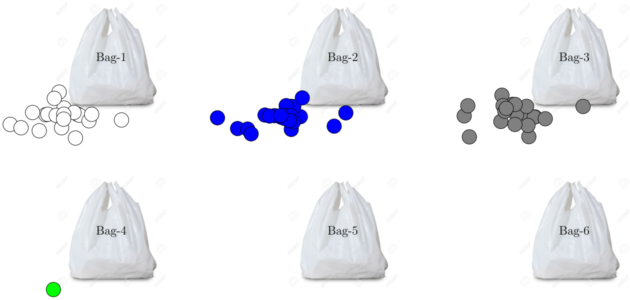
Prior belief: The bags can have marbles of any color or mix



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

An example

… Contd.

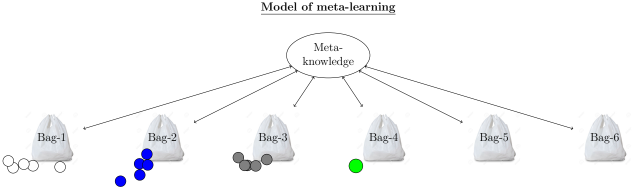


- What do we infer about bag 4 from this new observation?

This is the very basis of transfer learning

Specific knowledge and Generic knowledge

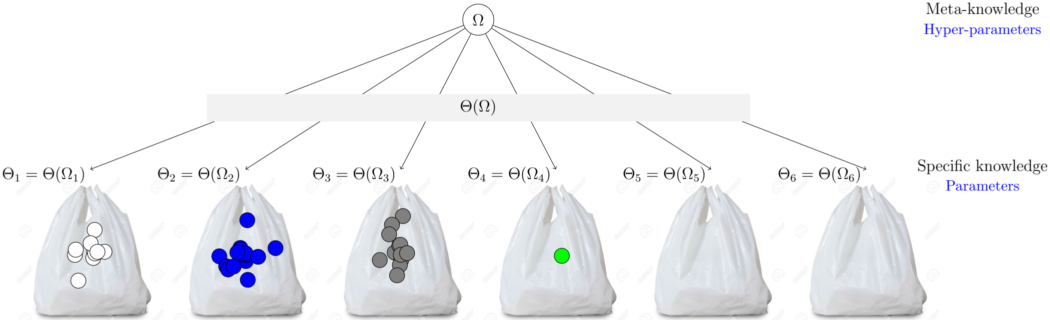
- Specific Knowledge: When we sample marbles from a particular bag, we gain knowledge about the content of that bag
- Generic (Meta) Knowledge: When we sample marbles from several bags, we gain knowledge about all bags ... even for those which are not sampled



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

Modeling the problem

Hierarchical Bayesian Model



Modeling the problem

contd ...

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

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

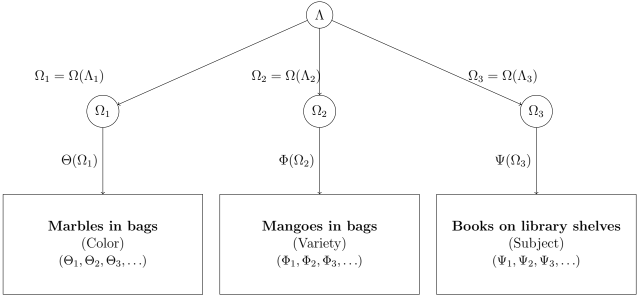
Example of Dirichlet Distribution

What is really happening?

- When we have no observations, we have some priors on Ω
  - This determines priors (constraints) for Θ_i's
- As we observe i-th bag, we learn (update) Θ_i
  - As we "observe" Θ_i, we learn (update) Ω
- As we update Ω, values of all Θ_i are updated

- Hyper-parameters Ω are learned together with the model parameters Θ_i's
- Hyper-parameters Ω links the model parameters Θ_i's
- An observation for one bag serves as an observation for the other bags too

Progressive generalization of knowledge



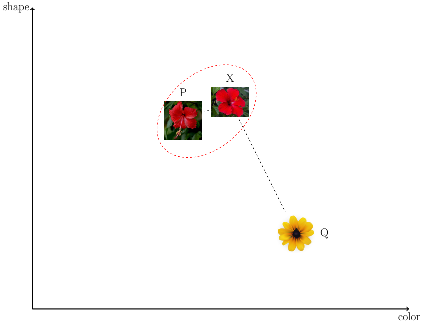
- It is possible to model generic knowlege with even higher abstraction (level) of knowledge, and so on ...
- The entire knowledge-base gets linked
  - Generalization from one problem to another will be efficient for similar problems

Feature Learning

Which feature do you choose ?

Which category X belongs to?

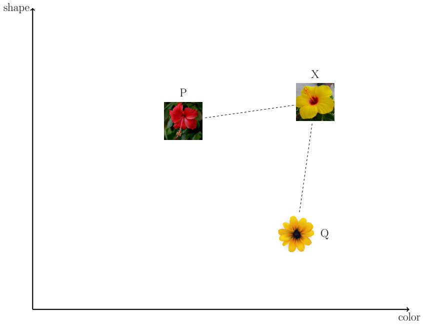
P and Q are rare flowers, you have one sample for each



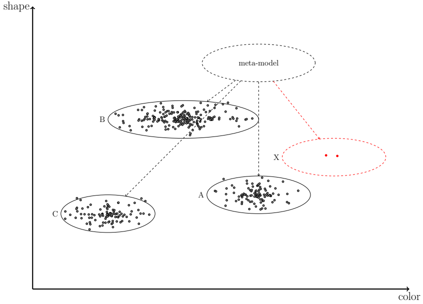
Pretty simple !

Which category X belongs to?

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



Meta-learning from abundant classes

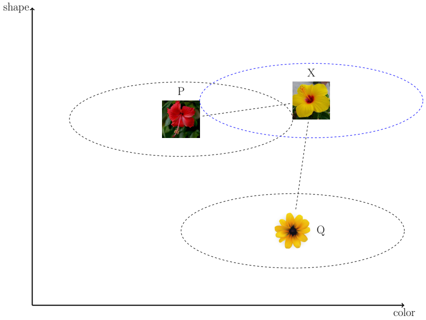


Meta-learn visual model for objects from abundant classes:

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

Source: Shape Bias

Quiz

Quiz 03-07

End of Module 03-07