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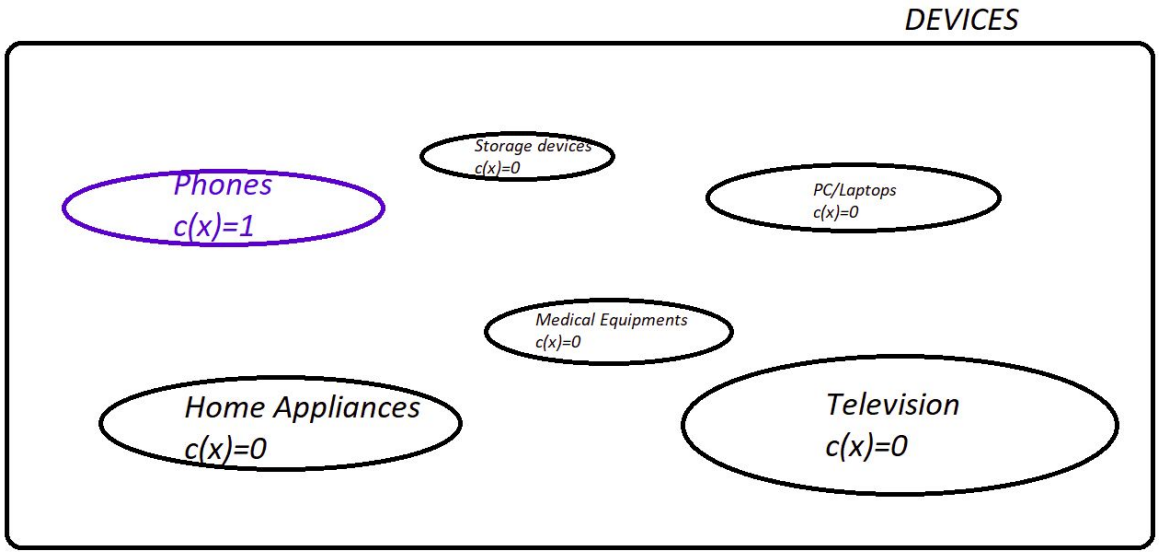
Assignment 3.1

What is concept learning? Explain the basic terms which have been discussed during the lecture (instances, target concept, training examples, hypothesis space, version space). State the learning goal of concept learning. What are the limitations when representing hypotheses as conjunction of constraints?

- We usually, learn general concepts or categories like 'devices', 'car', 'should I buy this item', etc.
- Each such concept can be viewed as describing some subset of objects or events defined over a larger set (e.g. subset of devices that comprises phones).
- On the other hand, each of these concepts can be thought of as **a boolean-valued** function defined over this larger set (e.g. a function defined over all devices, whose value is **true** for phones and **false** for other non-mobile devices).
- So, the problem of automatically inferring the general definition of some concept, given examples labeled as *members* or *non-members* of the concept is commonly referred to as **Concept Learning.**
- **Concept Learning** approximates a boolean-valued function from training examples of its input and output.



Instances (x): The set of items over which the concept is defined is called the set of instances, X (e.g. Thermometer, Weigh scale, Pulse Oxymeter, etc. can be set of instances for the concept 'Medical Equipments').

Target Concept (c): The concept to be learned is called the target concept, c: X $\rightarrow$ {0,1}
(e.g. the 'Medical Equipments').

Training examples (D): The set of training examples, D is a set of instances, x, along with their target concept value c(x).
(e.g. <`Thermometer`,1>, <`Pulse Oxymeter`,1>)

Hypothesis Space (H): It is the set of all possible hypotheses, h, determined by the human designer's choice of a hypothesis representation.
(e.g. `self-administering dialysis equipment`,`Drug-Device combinations (DDCs)`).

Version Space ($VS_{H, D}$):

- A hypothesis h is **consistent** with a set of training examples D of the target concept c iff h(x)=c(x) for each training example <x, c(x)> in D.

$$Consistent(h, D) \equiv (\forall <x, c(x)> \in D: h(x) = c(x))$$

- Version Space ($\mathbf{VS_{H, D}}$) wrt hypothesis space H and training examples D is the subset of hypotheses from H, consistent with all the training examples in D.

$$VS_{H, D} \equiv h \in H | Consistent(h, D)$$

The **goal** of concept learning is to find a hypothesis h: X $\rightarrow$ {0,1}| ***h(x)=c(x)*** $\forall$ x in X.

Limitations of representing hypothesis as the conjunction of constraints:

- The learning task is solved by maintaining two subsets of the version space: set S, the most specific hypotheses in the version space, and set G, the most general hypotheses. Moreover, they are updated with each new example and we must have an efficient procedure for testing whether or not one hypothesis is more general than another and whether or not a hypothesis contains a given instance. The problems are NP-complete if we allow arbitrarily many objects and many attributes in the conjunctive hypotheses.

- The size of the sets S and G can become exponentially unmanageably large.