ETH
Eidgenössische Technische Hochschule Zürich
Swiss Federal Institute of Technology Zurich

Dr. Francis Colas
Institute of Robotics and Intelligent Systems
Autonomous Systems Lab

ETH Zürich
CLA E 26
Tannenstraße 3
8092 Zürich Switzerland

fcolas@mavt.ethz.ch
www.asl.ethz.ch

Information Processing in Robotics

Exercise Sheet 1

Topic: Introduction to Learning and Probabilistic Reasoning

Exercise 1: Learning

Find at least 5 examples of machine learning techniques that have not been discussed in the class. Describe them briefly and point out what they try to learn (classification, regression...), how they learn it (supervised, unsupervised...), and what assumption they make (Gaussian noise, linearly separable...).

Exercise 2: Bayes' rule

The aim of this exercise is to familiarize with Bayes' rule and implement it into a ROS service.

(a) With just the sum and product rule, demonstrate the simple form of Bayes' theorem:

$$P(A|B) = \frac{P(B|A)P(A)}{P(B)},$$

and the generic inference equation:

$$P(S|K) = \frac{\sum_F P(S,F,K)}{\sum_{S,F} P(S,F,K)}.$$

(b) Given an actual value b for variable B, what are:

- $P(A)$ (the prior),
- $P(b|A)$ (the likelihood function),
- $P(b)$ (the evidence),
- $P(A|b)$ (the posterior)?

Which of those are probability distribution (over which variable), functions (on which support), scalars?

(c) Give an expression of $P(b)$ given the prior and the likelihood.

(d) Deduce an algorithm that computes the posterior as a function of the prior and the likelihood.

(e) Implement this algorithm as a ROS service. The signature of the service can be:

```
float64[] prior
float64[] likelihood
---
float64[] posterior
```

Exercise 3: Playing around with Bayes' rule

The aim of this exercise is to play with the ROS service in order to better understand Bayes rule and the result of inference.

(a) First example in the lecture: $P(D) = (0.6, 0.4)$, $P(S|D = \texttt{True}) = (0.8, 0.2)$, $P(S|D = \texttt{False}) = (0.1, 0.9)$. Given that the sensor returned `False`, what is the likelihood? Invoke the service above to compute the posterior. What if the sensor returns `True`?

(b) In the naive fusion example in the class: $P(D,S,T) = P(D)P(S|D)P(T|D)$, which variables are independent? conditionally independent?

(c) In this case, compute the fusion result $P(D|S,T)$ based on our service. (Recall: $S = \texttt{True}$, $T = \texttt{True}$, $P(T|D = \texttt{True}) = (0.95, 0.05)$, $P(T|D = \texttt{False}) = (0.05, 0.95)$.)

(d) Given a prior $(0.6, 0.4)$ and likelihood $(0.7, 0.3)$ compute the posterior. Use this posterior as a new prior for the same likelihood and compare the results. If you iterate a few times, what happens, what is the interpretation from a probabilistic point-of-view?