University of Stuttgart | ANALYTIC COMPUTING

# Machine Learning (SS 24)

## Assignment 03: Bayes Reasoning


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Submit your solution in ILIAS as a single PDF file.[1] Make sure to list the full names of all participants, matriculation number, study program, and B.Sc. or M.Sc on the first page. Optionally, you can *additionally* upload source files (e.g. PPTX files). If you have any questions, feel free to ask them in the exercise forum in ILIAS. This exercise also includes Python tasks within a Jupyter Notebook. You upload your solutions for them as well. **Submission is open until Monday, 06.05.2024, 12:00 noon.**

[1] Your drawing software probably allows exporting as PDF. An alternative option is to use a PDF printer. If you create multiple PDF files, use a merging tool (like pdfarranger) to combine the PDFs into a single file.

# 1. Coin problem (15 points)

Suppose you have two bags of coins. Bag 1 contains 30 normal coins (heads on one side and tails on the other) and 10 trick coins ( heads on both sides). Bag 2 contains 20 of each kind.

You choose one of the bags at random and, without looking into the bag, choose one of the coins at random. It turns out to be a normal coin. What is the chance that you chose Bag 1 using Bayes's Theorem?

## 2. Medical Diagnosis (20 points)

Imagine a medical scenario where a certain disease, let's call it Disease X, has been affecting a population. You have a patient who presents with symptoms that could indicate either Disease X or Disease Y. You want to determine the probability of the patient having Disease X given their symptoms.

- Disease X is known to affect 2% of the population.
- Disease Y is known to affect 1.5% of the population.
- However, a specific symptom, let's call it Symptom A, is more common in Disease X patients, occurring in 80% of cases, while it only occurs in 10% of Disease Y cases.
- The occurrence of Symptom A in a person not affected by either disease is negligible.

**Questions:**

1. Calculate the probability of a person having Symptom A given that they have Disease X (5 points).
2. Calculate the probability of a person having Symptom A given that they have Disease Y (5 points).
3. Given that a person presents with Symptom A, calculate the probability that they have Disease X (5 points).
4. Given that a person presents with Symptom A, calculate the probability that they have Disease Y (5 points).

## 3. Professor Staab (20 points)

The probability that, on any weekday, the Institute for AI will receive letters addressed to Professor Staab is $\frac{1}{3}$. Professor Staab, who arrives earlier than any of his colleagues, begins the day by collecting his mail. He has told me that there is a 40% chance that he will attend the institute today, and I have noticed that there are no letters in the mailbox. In view of there being no mail in his box, what is the probability that he is attending today?