Memory Protocol: Machine Learning 2

Exam date: 5 August 2026

General structure. The exam contained five questions in total, including one multiple-choice question and one programming question. This protocol is based on recollection; the exact wording, point allocation, numerical examples, and multiple-choice options are not fully remembered.

Question 1: Multiple Choice

The multiple-choice items concerned:

- the objective of locally linear embedding (LLE),
- the canonical correlation analysis (CCA) objective,
- statements about the roles of the forward algorithm, the Viterbi algorithm, and the Baum–Welch algorithm.

The exact answer options are not recalled.

Question 2: Applied Machine Learning

A probabilistic model was required for sequences of customer interactions on a website, with an unobserved latent state.

1. Choose a suitable machine-learning method.
2. Describe the relevant hyperparameter(s).
3. Describe the learned parameters.
4. Explain the preprocessing of the interaction sequences.
5. Explain how the learned model and its latent states can be interpreted.
6. Discuss limitations of the model.

The natural model for the stated setting was a hidden Markov model (HMM).

Question 3: LLE and Lagrange Multipliers

1. Explain what the LLE objective optimizes.
2. Consider the constrained optimization problem

$$\min_w \; w^\top C w \qquad \text{subject to} \qquad \mathbf{1}^\top w = 1.$$

   Using Lagrange multipliers, prove the stated solution

$$w^\star = \frac{C^{-1}\mathbf{1}}{\mathbf{1}^\top C^{-1}\mathbf{1}},$$

   assuming the required inverse exists.

3. Prove that the objective value at this solution is

$$(w^\star)^\top C w^\star = \frac{1}{\mathbf{1}^\top C^{-1}\mathbf{1}}.$$

Question 4: Positive-Semidefinite Input–Output Kernel

Let k_1 be a positive-semidefinite kernel on the input space. Define

$$k_2\big((x, y), (x', y')\big) = k_1(x, x')\,\mathbb{I}(y = y').$$

The tasks were:

1. Prove that k_2 is positive semidefinite.
2. Find a feature map associated with k_2 given feature map of k_1.

Question 5: HMM Programming

An HMM was represented by

$$A \in \mathbb{R}^{h\times h}, \qquad B \in \mathbb{R}^{h\times d}, \qquad \pi \in \mathbb{R}^{h},$$

where A is the transition matrix, B is the emission matrix, and π is the initial-state distribution.

The programming tasks were:

1. Validate A, B, and π:
   - check the required dimensions;
   - check that every row of A and B sums to one;
   - check that the entries of π sum to one.
2. Implement the forward algorithm using the recursion formula supplied in the exam.
3. Simulate an observation sequence from the HMM.