Machine Learning 2020-21
Makeup Exam

12 February 2021

Name: . . . .

Question 1: $\boxed{\text{2 points}}$ Solve the following constrained optimization problem:

$$\max_{x,y} \; y - x^2$$
$$\text{s.t. } y + 2x = 1.$$

Indicate the optimal values of x, y and the objective.

Question 2: $\boxed{\text{2 points}}$ Describe the three basic learning paradigms in machine learning (i.e. the three types of learning), and explain how they differ from each other.

Question 3: $\boxed{\text{1 point}}$ Name three techniques for unsupervised learning and briefly describe how each technique works.

Question 4: $\boxed{\text{1 point}}$ Describe three differences between linear regression and logistic regression.

Question 5: $\boxed{\text{1 point}}$ Name three differences between feedforward neural networks and convolutional neural networks.

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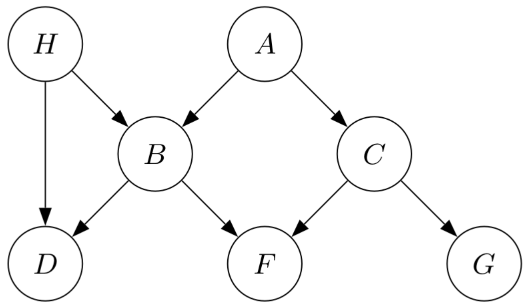
Question 6: $\boxed{\text{3 point}}$ Consider the Bayesian network in the following figure



1. Write down the corresponding factorization of the joint probability distribution.
2. Are the following independence statements true or false? Justify your answer.
   (a) $H \perp C$
   (b) $H \perp C|F$
   (c) $D \perp G|A$
   (d) $A \perp H|F$
   (e) $A \perp D|B$
3. Draw a possible factor graph that can represent the same probability distribution. Indicate for each factor which function it represents.

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Question 7: $\boxed{\text{2 point}}$ In discounted Markov decision processes, the action-value function Q^π associated with a deterministic policy $\pi : \mathcal{X} \to \mathcal{A}$ is defined as $Q^\pi(x,a) = \mathbb{E}_\pi\left[\sum_{t=0}^{\infty} \gamma^t r_t \middle| x_0 = x, a_0 = a\right]$ for all states $x \in \mathcal{X}$ and actions $a \in \mathcal{A}$. Using this notation, give the definition of an optimal policy π^* and the optimal action-value function Q^*. Additionally, explain the relationship between Q^* and the optimal value function V^*.

Question 8: $\boxed{\text{1 point}}$ For a discounted MDP $(\mathcal{X}, \mathcal{A}, P, \gamma, r)$, define the Bellman optimality operator T^* that maps functions in $\mathbb{R}^{\mathcal{X}}$ to functions in $\mathbb{R}^{\mathcal{X}}$. Specifically, for a function $f : \mathcal{X} \to \mathbb{R}$, how is the function $g = T^* f$ defined?

Question 9: $\boxed{\text{2 points}}$ The LSTD algorithm takes as input a sequence of observations $(x_t, a_t, r_t)_{t=1}^T$ and solves the equation $\frac{1}{T}\sum_{t=1}^{T} \delta_t(\theta_T)\phi(x_t) = 0$, where $\phi : \mathcal{X} \to \mathbb{R}^d$ is a feature map and $\delta_t(\theta) = r_t + \gamma\theta\phi(x_{t+1}) - \phi(x_t)$ is the t-th temporal difference associated with θ. Derive the expression of θ_T that solves the above equation!