0/17 Questions Answered

ECE641-F2020-M

Q1
2 Points

Rules: I understand that this is an open book exam that shall be done within the allotted time of 120 minutes. I can use my notes, previous posted exams and exam solutions, and web resources. However, I will not communicate with any other person other than the official exam proctors during the exam, and I will not seek or accept help from any other persons other than the official proctors.

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Q2 MAP Estimation
36 Points

Consider a sensing sytem with the forward model given by

$$y = Ax + w$$

where $x \sim N(0, R_x)$ and $w \sim N(0, R_w)$ and $A \in \Re^{M \times N}$ where $M < N$.

Q2.1
6 Points

Derive an expression for the forward model $p(y|x)$ and the prior

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Q2.2

6 Points

Is the maximum likelihood estimate (MLE) well defined and unique? If yes, give the MLE. If no, justify your answer.

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Q2.3

6 Points

Are the MMSE estimate and the MAP estimate different? Justify your answer.

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Q2.4

6 Points

Derive a closed form expression for the MAP estimate of x given y.

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Q2.5

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6 Points

Calculate an expression for the gradient descent update using step size $\alpha \geq 0$.

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Q2.6
6 Points

Calculate an expression for the coordinate descent update.

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Q3 Surrogate Functions
35 Points

Consider a problem in which our goal is to minimize a function with the form

$$f(x) = \frac{1}{2}x^t Bx + b^t x$$

where $B \in \Re^{N \times N}$ is a positive definite matrix and $b \in \Re^N$ is a vector.

The goal of this problem will be to find a simplified surrogate function for $f(x)$. Furthermore, assume B is large, and the number of non-zero entries in B is NM_o where $M_o << N$.

Q3.1
7 Points

Derive an expression for the solution of

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$$\hat{x} = \arg\min_x f(x) \ .$$

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Q3.2
7 Points

Within a multiplicative constant, how many operations are required for the solution of part 3.1 above? Why is this computationally difficult?

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Q3.3
7 Points

Derive a surrogate function for $f(x)$ with the form

$$\tilde{f}(x; x') = \frac{\alpha}{2}\|x\|^2 + c^t x$$

where $\alpha \in \Re$ and $c \in \Re^N$ are dependent on the point-of-approximation x'.

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Q3.4
7 Points

Derive the majorization minimization algorithm based on iterative minimization of the surrogate function $\tilde{f}(x; x')$.

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Q3.5
7 Points

How many multiplications are required for each step of the majorization minimization algorithm in part 3.4 above? Why is this computationally efficient?

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Q4 ADMM and PnP
28 Points

Consider the MAP estimation problem with the form

$$\hat{x} = \arg\min_x \{f(x) + h(x)\}$$

where $f(x) = -\log p(y|x)$ is the forward model and $h(x) = -\log p(x)$ is the prior model.

Q4.1
7 Points

Use variable splitting along with the augmented Lagrangian method to derive an algorithm for solving this problem.

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Q4.2
7 Points

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Derive the associated ADMM algorithm for solving this problem. Express your algorithm in terms of the two proximal maps $F(v)$ and $H(v)$, and also give precise expressions for the forms of the two proximal maps.

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Q4.3
7 Points

Give the plug and play algorithm for solving the associated problem

$$x^* = F(x - u)$$
$$x^* = \tilde{H}(x + u)$$

where $\tilde{H}$ is not necessarily a proximal map.

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Q4.4
7 Points

Describe how the function $\tilde{H}$ can be learned using a training algorithm.

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Q5
3 Points

The Chinese general, Sun Tzu, wrote that "Strategy without tactics is the slowest route to victory. Tactics without strategy is the noise before

defeat."

Explain what this means, and give an example of how this advice can be of value in research.

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