MGM Practice Problems-I

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1 Basic Information

- Exams are a good opportunity to do a revision and restructuring of your knowledge.
- It is indeed essential to remember important definitions.
- By knowing and remembering many things, your lookup time is reduced, and you progress well.
- Apart from assignments, these problem sets give you some idea of the concepts that you must learn or revise.

2 Basic Definitions

Define the following:

1. Maximum likelihood estimation
2. Normal distribution
3. Binomial distribution
4. Uniform distribution
5. Poisson Distribution
6. Independent random variables
7. Law of total probability
8. MAP estimate
9. Biased and unbiased estimator
10. Random sample
11. Central limit theorem
12. Law of large numbers
13. Consistent estimator
14. Expectation of continuous and discrete random variables
15. Variance
16. CDF
17. Joint distribution

18. Covariance
19. Correlation
20. Marginal distribution
21. Conditional Expectation
22. Markov inequality
23. Chebychev inequality
24. Difference between classical and Bayesian inference
25. Prior and Posterior distribution
26. KL divergence
27. Why KL divergence is not a metric?
28. Wasserstein distance
29. Is Wasserstein divergence a distance?
30. JS divergence
31. f divergence
32. Convex set
33. Two examples of convex sets
34. Convex combination
35. Operations that preserve convexity
36. Convex function
37. Conjugate function
38. Write optimization problem in standard form.
39. Write Lagrangian function for optimization problem in standard form.
40. What is Slater's condition.
41. Where is Slater's condition used in class?
42. What is duality gap?
43. For an optimization problem with all functions convex, show that $\inf \sup = \sup \inf$
44. First order condition for convexity
45. Define Hessian
46. Second order definition for convexity
47. Infimum and Supremum
48. Open Sets and Closed sets
49. Lower semicontinuity (LSC)
50. Upper semicontinuity (USC)

51. Metric space
52. Define directional derivative. How do we define directional derivative when gradient is known?
53. In which theorem LSC is used?
54. In which theorem closed set is used?
55. Define topological space.
56. Given an example of topological space other than trivial ones, empty and full set.
57. Compact Sets
58. How are compact sets useful?
59. Give examples of sets that are not compact.
60. Define extreme value theorem.
61. How do we characterize compact sets in $\mathbb{R}^n$?
62. Lipschitz continuity
63. Where is Lipschitz continuity used in class?
64. Is classifier loss used in WGAN?
65. Write briefly how gradient penalty helps in improved WGAN.
66. Sigmoid activation
67. ReLU activation
68. Softmax activation
69. Label smoothing
70. Define a feed forward process for a neural network with input layer size of 4, hidden layer size of 3, another hidden layer size of 4, followed by a final sigmoid activation.
71. Inception score (google search)
72. CIFAR10 dataset (google search)
73. Draw architecture diagram of GAN.
74. Draw architecture diagram of Conditional GAN.
75. Mode collapse in GAN (do google search, if not covered in class)

3 Descriptive Questions

1. Show that dual function is always a lower bound to primal optimal p^*
2. Derive KL divergence from f divergence
3. Show that sample mean is an unbiased estimator of true mean.
4. Show that minimizing KL divergence is equivalent to MLE estimation.
5. Derive GAN framework starting from f divergence.

6. Write full GAN algorithm.
7. Derive WGAN from KR duality. Write full proof.
8. Write full WGAN algorithm.
9. Derive gradient penalty formulation of WGAN.
10. Write full improved GAN algorithm.
11. Write a generator and discriminator module python code for Vanilla GAN.
12. For a fixed Generator, derive expression for optimal discriminator.
13. Show that for vanilla GAN, optimality is achieved when real distribution becomes equal to generated distribution and in that case optimal value is $-\log\ 4$.
14. Describe conditional GAN. What are the uses of conditional GAN?
15. Describe progressive GAN.
16. Describe pix2pix idea.