[M2] Probabilistic generative models

EXAMEN : 24/10/2024, 14h00-16h00

Part 1: Basic Principles and Models

1. Explain what probabilistic generative models are and provide two examples where they can be applied effectively.

2. How do latent variables function in the context of generative models like VAEs? Describe their role and significance.

3. Differentiate between discriminative and generative models using specific examples for each.

4. Discuss the concept and mathematical formulation of a Bayesian network. How do Bayesian networks facilitate probabilistic inference?

Part 2: Deep Learning in Generative Models

5. What are Variational Autoencoders (VAEs)? Discuss their architecture and how they differ from traditional autoencoders.

6. Explain the reparameterization trick in VAEs and its importance in the training process.

7. Generative Adversarial Networks (GANs) introduce a novel training methodology. Sketch this training paradigm and discuss its components: generator and discriminator.

8. In practical terms, how are VAEs applied to image generation? Provide a conceptual overview and discuss potential limitations.

Part 3: Applications and Advanced Techniques

9. Describe how GANs can be used for enhancing image resolution, including a brief outline of the process involved.

10. Discuss the principle of 'Diffusion' in diffusion models and provide an example where diffusion models offer advantages over other types of generative models.

11. Probabilistic Diffusion Models utilize a specific iterative process to generate data. Explain this process with an example.

Part 4: Transformers and Advanced LLMs

12. How have transformer models influenced the development of probabilistic generative models? Provide an overview of key innovations.

13. Discuss the role of sparse attention mechanisms in transformers like GPT-4 and their implications on computational efficiency.

14. Detail how reinforcement learning from human feedback (RLHF) is integrated into training protocols for models like GPT-4.

Part 5: Multimodal and Novel Applications

15. Multimodal Large Language Models (M-LLMs) are gaining prominence. Discuss their architecture and how they manage different data types effectively.

16. Using OpenAI's CLIP as an example, explain how combining textual and visual data can enhance model performance in real-world applications.

Part 6: Ethical and Practical Considerations

17. What are the potential ethical issues associated with using generative models in public domains?

18. Discuss the challenges in training stable and effective GANs, including issues related to mode collapse.

19. Considerations for model deployment: What are some key factors to consider when deploying generative models in a production environment?

20. Future Directions: Speculate on potential future developments in the field of probabilistic generative models and how they might impact AI research.