Diffusion Models in Generative AI

Course title – Intitulé du cours	Diffusion Models in Generative AI
Level / Semester – Niveau /semestre	M2, Semester 2
School – Composante	Ecole d'Economie de Toulouse
Teacher – Enseignant responsable	Julien Chhor
Other teacher(s) – Autre(s) enseignant(s)	
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Other teacher(s) – Autre(s) enseignant(s)	
Lecture Hours – Volume Horaire CM	15h
TA Hours – Volume horaire TD	
TP Hours – Volume horaire TP	
Course Language – Langue du cours	English
TA and/or TP Language – Langue des TD et/ou TP	

Teaching staff contacts – Coordonnées de l'équipe pédagogique :

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Course Objectives – Objectifs du cours :

Diffusion models have emerged as one of the most significant AI breakthroughs in recent years. They are widely used in generative AI applications, excelling in tasks such as ultra-realistic image generation, medical data reconstruction, and scientific modeling and optimization. A notable demonstration of their cutting-edge capabilities is their role in enabling image generators like DALL·E. This course will explore the theory and practical implementation of diffusion models, providing an overview of the latest advancements and techniques in this rapidly evolving field.

The course will address the following aspects of diffusion models

- Continuous time diffusion models (forward and backward stochastic differential equations)
- Score-based generative models and score matching techniques
- Classifier guidance and classifier-free guidance
- Acceleration techniques:
    - Denoising diffusion implicit models (DDIM)
    - Distillation,
    - Latent Diffusion Models (LDM)
- Neural network architectures used in diffusion model training
- Energy-based models

References

Coste, S. (2023, March). *Diffusion models*. Available at https://scoste.fr/posts/diffusion/
Weng, Lilian. (Jul 2021). What are diffusion models? Lil'Log. https://lilianweng.github.io/posts/2021-07-11-diffusion-models/.
Luo, Calvin. "Understanding diffusion models: A unified perspective." *arXiv preprint arXiv:2208.11970* (2022).

Prerequisites – Pré requis :

It is recommended to have followed the beginning of the course "Stochastic Control and applications" on the construction of Brownian motion and continuous martingales, Itô's calculus and stochastic integral.

Practical information about the sessions – Modalités pratiques de gestion du cours :

Grading system – Modalités d'évaluation :

Final exam or project, coding homework.

Bibliography/references – Bibliographie/références :

Coste, S. (2023, March). *Diffusion models*. Available at https://scoste.fr/posts/diffusion/

Weng, Lilian. (Jul 2021). What are diffusion models? Lil'Log. https://lilianweng.github.io/posts/2021-07-11-diffusion-models/.

Luo, Calvin. "Understanding diffusion models: A unified perspective." *arXiv preprint arXiv:2208.11970* (2022).

Session planning – Planification des séances

Distance learning – *Enseignement à distance :*