# Deep Avancé

(overview)

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# Organization

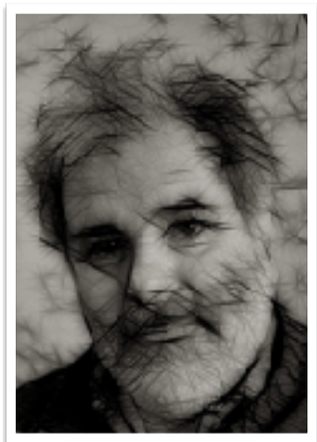
- **Volume**: 30 h (11 x 2h CM&TD + 4 x 2h TP)

- This course is composed of **Two main Topics**:

  - **Image Generative Models**
    (November - December) with **Julien Rabin**

  - Graph-Based Deep Learning
    (January) with **Luc Brun**

julien.rabin



luc.brun

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- **Evaluation**:
  - **Labs reports** (x4)
  - **Final exam** (1h30) *to be announced*

# About me

- Assistant Professor at **ENSICAEN** since 2023
- Member of the **Image Team** at **GREYC** Laboratory
- **Background:**
  - PhD in Object Recognition and Image Matching
  - Assistant Professor at IUT GON MP
- **Research**:
  - image processing & synthesis
  - optimal transportation
  - evaluation of generative models

# About me

- **contact**: julien.rabin [at] ensicaen.fr

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  - **Web Page**: rabin.users.greyc.fr

- **Feeback**:
  - mail
  - online anonymous survey

# About you

- **Sondage 1**:

  « inclure des TD sous forme de notebook à faire sur portable ? »

https://app.wooclap.com/NQOYXD

# Image Generative Models

*Overview*

- **Volume**: **16 h** (6 x 2h CM&TD + 2 x 2h TP)
- **Prerequisite:** optimisation, deep learning, image processing
- **Tools:** python, pytorch, jupyter
- **Three main parts**:
  - **Patch-based** image synthesis
  - **Deep Neural Network** image generation
  - **Applications** and Evaluation of Generative Models

# Image Generative Models

*Motivation*

- **Context**:
  - generative models in SOTA methods
  - at the core of Generative AI (*e.g.* text-to-image)

- **Why focusing on image ?**
  - signal processing and computer vision have many applications in industry
  - (text &) image have seen the first breakthrough for many deep learning techniques (over large datasets)

# Motivational Example

- **Text-to-Image Generation**

  Example with Dall-E 3 (*via* Bing image creator)

**Prompt**:

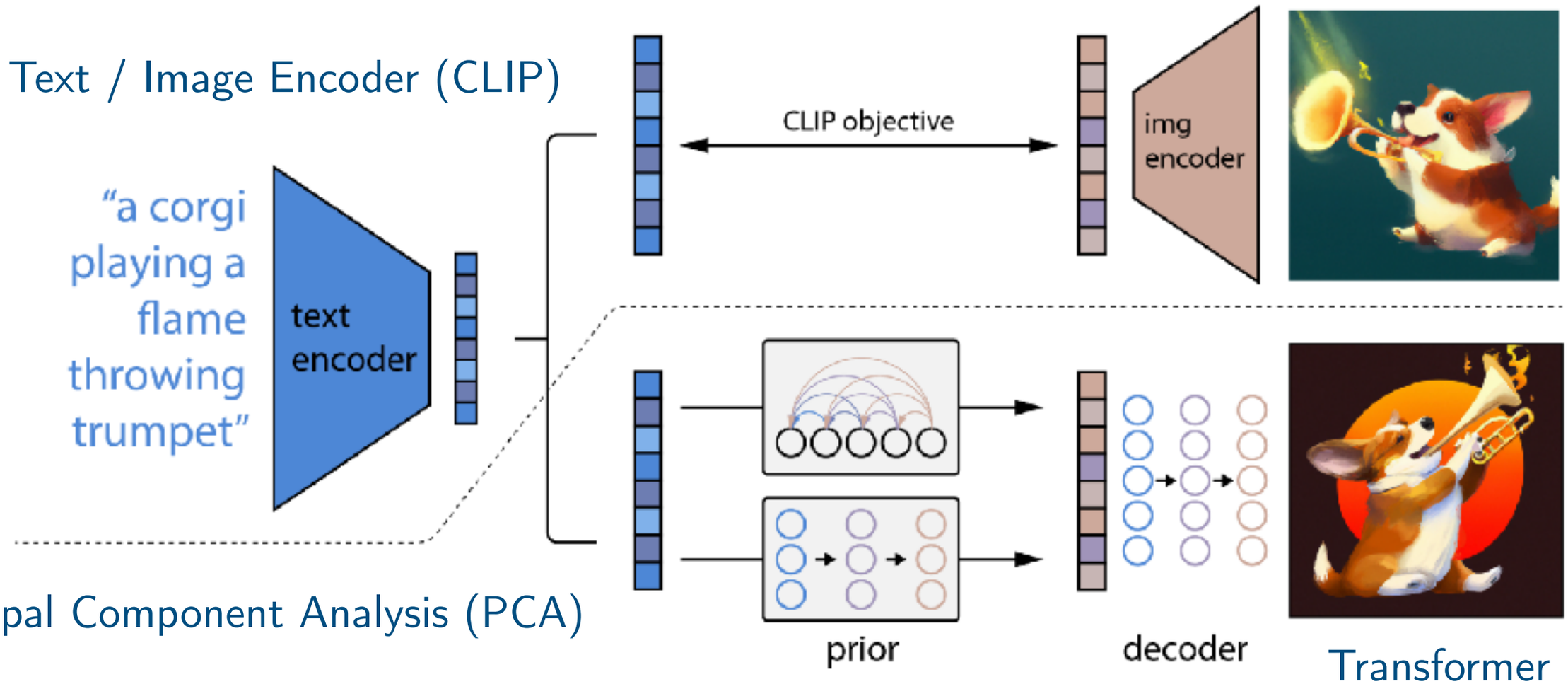
*« A Koala riding a dolphin »*

**Synthesis**:

# Motivational Example

- **Text-to-Image Generation**

  Architecture of Dall-E 2 (unCLIP)

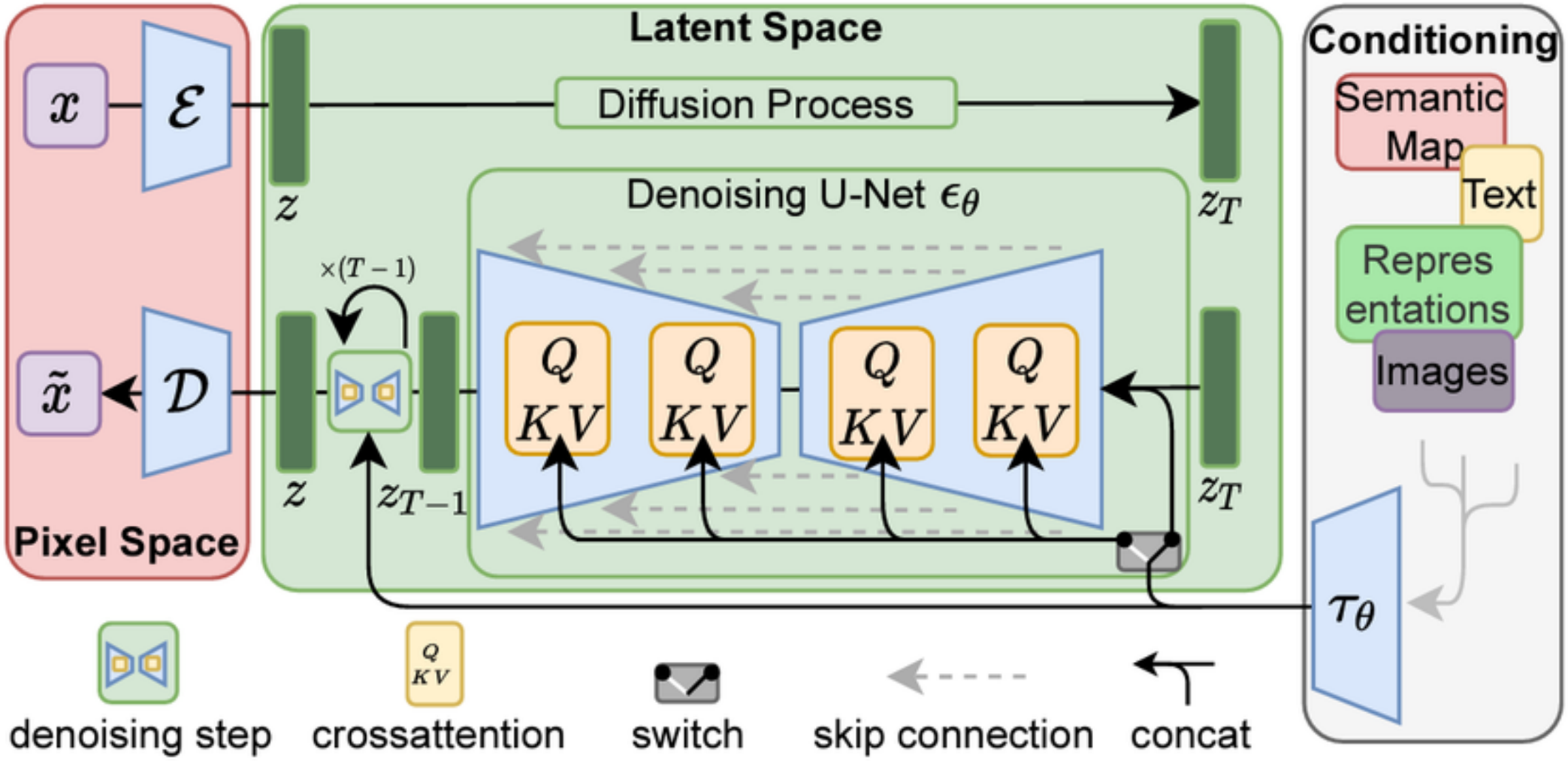





Source: [Ramesh et al '22]

# Motivational Example

- Another **architecture** based on a generative model
- Example of **latent diffusion** [Rombach *et al.*'22]



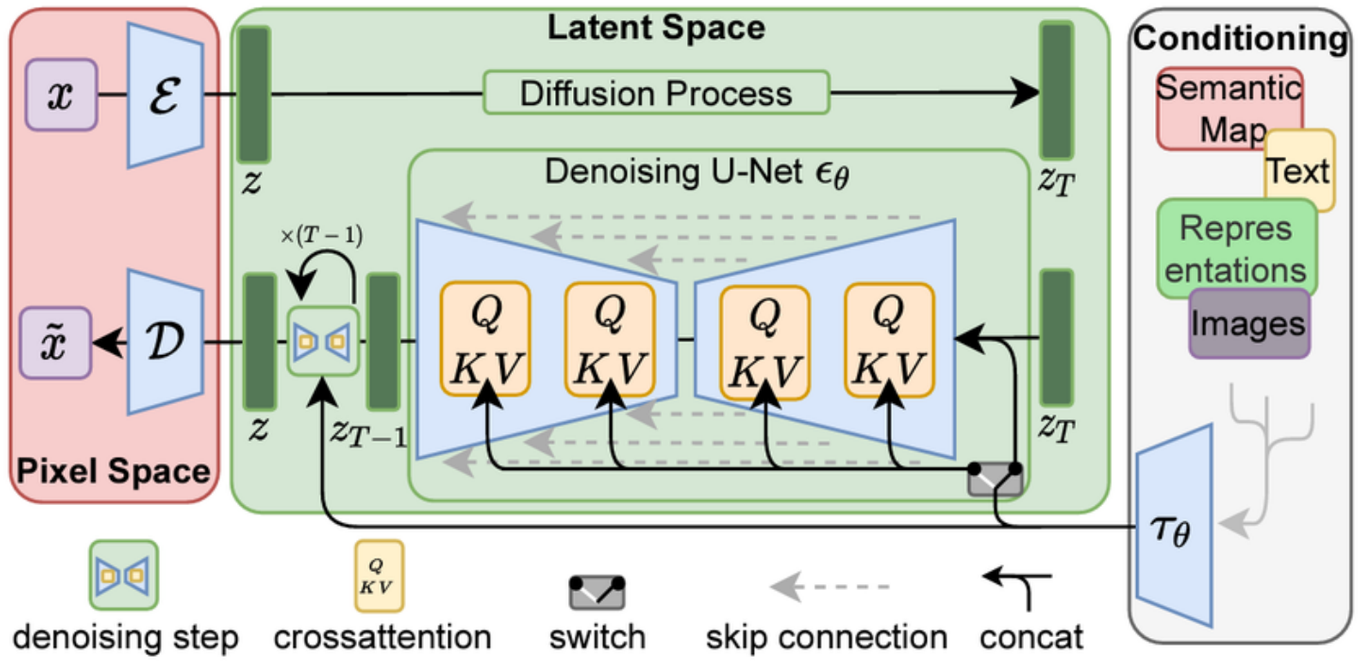
# Motivational Example

Latent representation

Vector Quantization (VQ)

Variational Auto-Encoder (VAE)

Self-Attention




Cross-Attention

Adversarial Loss (GAN)

FID

U-NET

Text Embedding

Perceptual Loss

Diffusion Model

# Questions

- How to define a generative model for image ?
- What is the best embedding for image (and text) ?
- How to evaluate the performance of a model ?
- How to train a model with limited data ?
- How to use a generative model for image processing ?
- How to design a generative model for text (NLP) ?
- ...

# Part I: patch-based image synthesis & processing

*(Tentative Program)*

- **Objectives**:
  - review some techniques (SOTA before deep learning) that are used in image generation
  - practice on "small scale" problems
- **Outline**:
  - quick review of neighbourhood-based image filtering
  - application to image restauration
  - acceleration of patch matching
  - application to inpainting, texture synthesis & image stylisation

# Part II: **deep representation** for image synthesis & processing

*(Tentative Program)*

- **Objective**:
  - review some deep learning techniques that are used in image processing
  - again, practice on "small scale" problems
- **Outline**:
  - unsupervised deep representation
  - application to image restoration
  - supervised deep representation for texture synthesis
  - definition of the perceptual loss
  - application to style transfert

# Part III: deep generative networks for images

*(Tentative Program)*

- **Objective**:
  - review SOTA methods for **unsupervised learning**
  - again, practice on small datasets
- **Outline:**
  - Auto-Encoder (AE)
  - Variational Auto-Encoder (VAE)
  - Generative Adversarial Network (GAN)
  - Flow-based Models (realNVP, GLOW)
  - Denoising Diffusion Probabilistic Model (DDPM), score energy-based models
  - Auto-regressive Model (PixelCNN, Transformers)

# Part IV: **Applications** & **Evaluation** of generative models

*(Tentative Program)*

- **Objective**:
  - review applications and limitations
- **Outline**:
  - Semi-supervised training (conditional generation)
  - VQ-GAN, latent-diffusion
  - Applications to image processing and editing
  - Text & Image Embedding (CLIP)
  - FID & Precision Recall
  - Overfitting and Memorization
  - Membership Attacks, Data Poisoning