DENOISING DIFFUSION

Original Paper

- Title: Denoising Diffusion Probabilistic Models
- Authors: Jonathan Ho, Ajay Jain, Pieter Abbeel
- Conference: NeurIPS 2020
- Link: https://arxiv.org/abs/2006.11239

This paper introduced the foundational approach where a forward diffusion process gradually adds Gaussian noise, and a learned reverse process denoises the sample step by step.

Here are reliable sources that explain the **mathematical foundations** and reasoning behind DDPMs:

1. **Ho et al. (2020) – Section 2 and 3:**
    - Defines the forward (q) and reverse (p) Markov processes.
    - Derives the variational lower bound (ELBO) used to train the model.
    - Link: https://arxiv.org/abs/2006.11239
2. **Kingma et al. (2021) – *Variational Diffusion Models***
    - Extends and provides deeper analysis of the variational inference used in diffusion models.
    - Link: https://arxiv.org/abs/2107.00630

3. **Sohl-Dickstein et al. (2015) – *Deep Unsupervised Learning using Nonequilibrium Thermodynamics***

    - Early inspiration behind diffusion processes, with detailed derivation of the forward and reverse processes in a thermodynamic framework.

    - Link: https://arxiv.org/abs/1503.03585

4. **Stanford CS236 (2023) – Lecture Notes on Diffusion Models**

    - Provides intuitive and mathematical explanations with code examples.

    - Link: https://cs236.stanford.edu/

5. **Hugging Face Diffusion Course – Chapter 2 & 3**

    - Offers a rigorous, open-source, and interactive explanation of denoising diffusion with Python code.

    - Link: https://huggingface.co/learn/diffusion-course/chapter2

🛠️ Hands-on Implementations

- **"Denoising Diffusion Model Implementation from Scratch"** by Jasmeet on Medium
  Covers the theory, noise scheduling, and a full PyTorch build in about a 13-minute read.
  → https://medium.com/@sjasmeet135/denoising-diffusion-model-implementation-from-scratch-b0a1fc6ef5d8 github.com+15lilianweng.github.io+15medium.com+15medium.comarxiv.org+13medium.com+13scribd.com+13

- **"In-Depth Guide to Denoising Diffusion Probabilistic Models (DDPM)"** on LearnOpenCV

Walks through the math, forward/reverse processes, loss derivation, and code on a flowers dataset.
→ https://learnopencv.com/denoising-diffusion-probabilistic-models/ www2.cs.uh.edu+15learnopencv.com+15learnopencv.com+15

🧩 Conceptual Overviews

- **"What are Diffusion Models?"** by Lilian Weng (Lil'Log)
  A beautifully structured guide linking diffusion processes to thermodynamics, covering key papers like Sohl-Dickstein et al. (2015) and DDPM (2020).
  → https://lilianweng.github.io/posts/2021-07-11-diffusion-models/ tree.rocks+11lilianweng.github.io+11linkedin.com+11

- **"Step-by-Step visual introduction to Diffusion Models"** by Kemal Piro on Medium
  Offers visual explanations of the U-Net architecture, timestep embeddings, forward/reverse diffusion, and scheduling.
  → https://medium.com/@kemalpiro/step-by-step-visual-introduction-to-diffusion-models-235942d2f15c medium.com+3medium.com+3medium.com+3

🔍 Math-Focused Walkthroughs

- **"How diffusion models work: the math from scratch"** by AI Summer
  A rigorous breakdown of DDPM math: Gaussian forward chains, noise schedules, reverse denoising, and Langevin dynamics.
  → https://theaisummer.com/diffusion-models/ reddit.com+15theaisummer.com+15donaldlab.cs.duke.edu+15arxiv.org+3medium.com+3youtube.com+3

📚 Additional Resources

- **“Denoising Diffusion Probabilistic Models”** by Eleventh Hour Enthusiast on Medium
  Reviews the forward and reverse processes, KL-divergence training, and unifies score-matching and likelihood perspectives.
  → https://medium.com/@EleventhHourEnthusiast/denoising-diffusion-probabilistic-models-63b4fd3a3b67 theaisummer.com+15medium.com+15youtube.com+15