Paper 1.

Introduction → Problem - Medical data are limited
- Rare disease are scare
- Patient privacy must be protected
- AI systems require large datasets for traning

→ Generative AI
↳ is a type of AI
↳ That can create a content
instead of only analyzing existing data

→ Synthethic Data ↝ generated Data that mimic real-world data

→ Type - Physic - Informed models
↳ Genarate data using physical laws & scientific knowledge
ex. Blood simulation
Radiation does simulation

Model as a Dataset
↳ Model ที่ถูกฝึกมาแล้ว
↓
เก็บ Weight

- Statistical Models
↳ Learns patterns directly from data
→ 3 type → VAE (Variational Autoencoder)
- fast
- Efficient
- Lower image quality

Compressed data into a lower-dimensional space and reconstruct it

→ GAN (Generative Adversarial Network)
Utilize a dual-network where a generator create sample and a discriminator evaluates them driving quality through adversarial traning
- Produce realistic images
- can suffer Mode Collapse

→ DDPM (Diffusion Model)
- Highest image quality
- slowest ↝ Induced noise into an image sample and learn to reverse the process to produce high quality

AI Trilemma → must balance 3 factors

1. Quality
2. Diversity
3. Speed

⊗ Improving one often reduced another

ex. DDPM → high quality but slow

VAE → fast but lower quality

Medical Application

- Data Augmentation → create additional training data
- Denoising → Removing noise from medical images
- MRI Sequence Generation
- Inpainting → Adding or Removing specific image regions

How Are Generated Image Evaluated

When Ground Truth Exists

- SSIM
- PSNR

When Ground Truth does not exist

- Inception
- FID ⤳ Lower FID = Better Image Quality

Human Evaluation

↳ Human Turing Test → Read image

→ AI generated image?

Advantages of Synthetic Data

- Larger datasets
- Greater diversity
- Improved fairness
- Better privacy protection

Challenges and limitations

- Bias → ข้อมูลที่ได้อาจมี Bias ทำให้ AI ติด Bias, → ขยาย Bias (Amplify bias) → potriat bias
- Data leakage
- Patient Privacy & [Data Copying] → AI อาจจะจำได้แม่น จน Copy ภาพจนไม่จริงนัก แก้โดยการต้องใส่ใหม่,
- Lack of clinical Validation

Future Directions

- Better evaluation frameworks
- Responsible AI development
- Clinical implementation