



**PHOTREK**

# Intelligent Ocular Image Generation Ethics and Equity

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# Who is Photrek?

At *Photrek*, our innovative solutions contribute to the safe integration of *superintelligence* within humanity and the environment. We develop *cyber-governance* capabilities that enlighten the pathway for integrating superintelligence into society and ensuring that human and natural ecosystems thrive together.



## RISK INTELLIGENCE

- Using complex systems models, we integrate relative risk tolerance into the training and assessment of machine learning.



## DAO GOVERNANCE

- We design, simulate and implement robust voting and reputation systems that empower decentralized communities, enabling efficient and fair decision-making.



## ENVIRONMENTAL IMPACT

- We support communities in modeling and assessing the health and property impacts of environmental risks.

# Project Overview

- Built a team of researchers from 5 universities and companies to solve a problem in synthetic image generation
- Developed methodology to generate retinal fundus images with specified disease states
- Currently exploring availability models through Lit Review, discussions with partners like KNUST-RAIL, and SNET/DF Community Feedback

# Presentation Overview

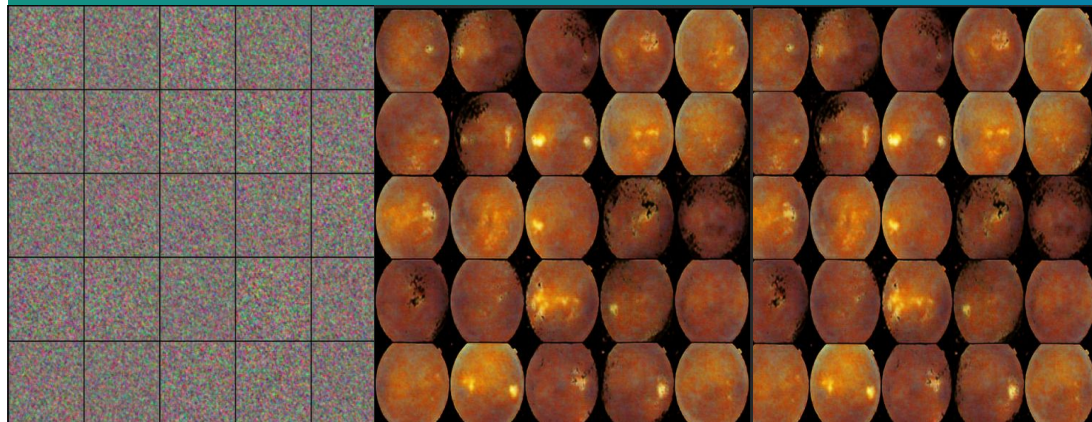
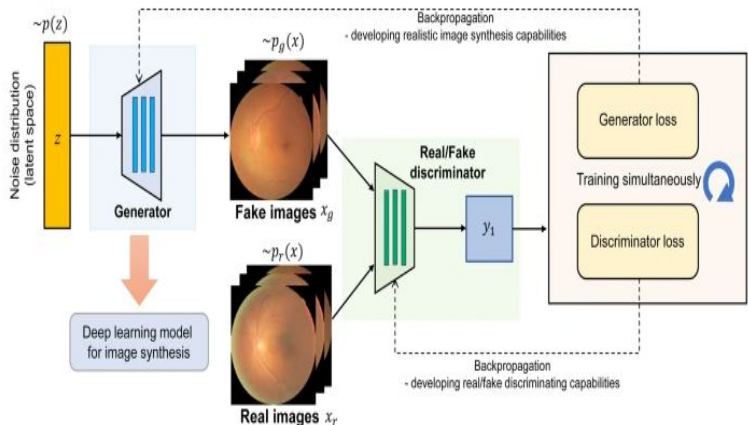
- VAE and GAN Approaches
- Exploring addition of *Coupling* to both models
- Understanding ethics framework
- Developing pricing, incentive, and availability models



# Generative Adversarial Networks (GANs)

## Revolutionizing Fundus Imaging with Generative Adversarial Networks - Unlocking the Power of Synthetic Imaging

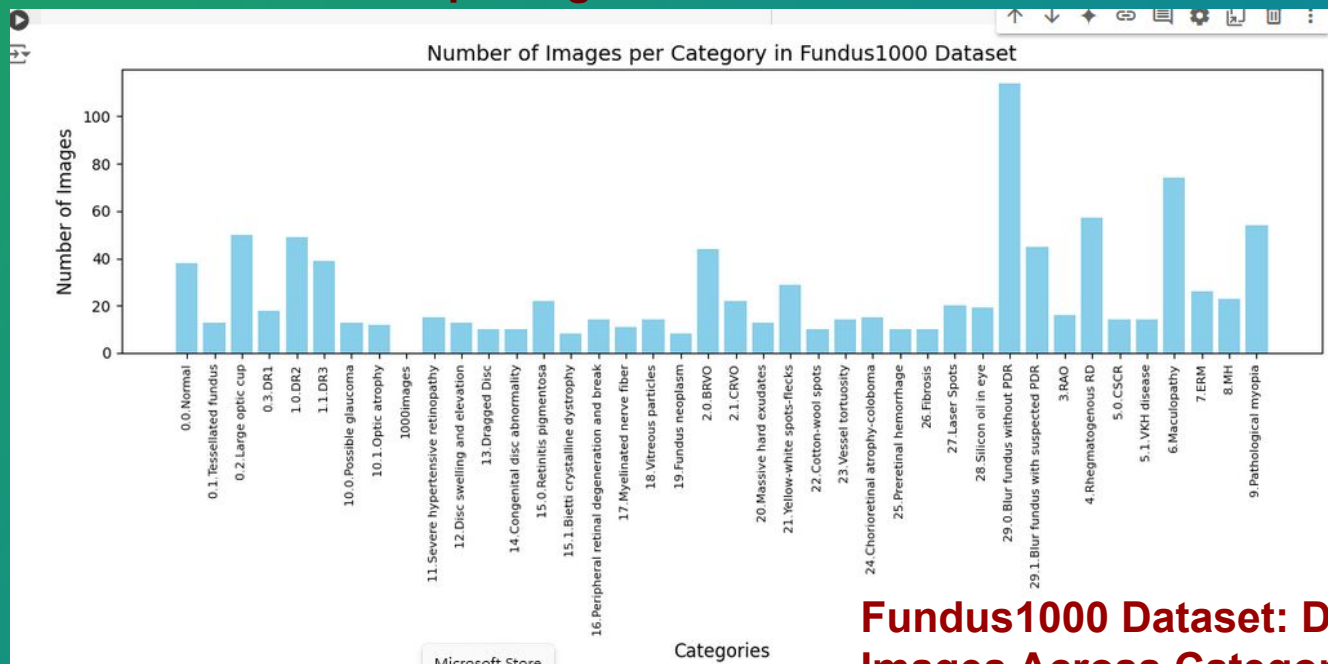
Fig. 1



Bringing the future of ophthalmology into focus

# Generative Adversarial Networks (GANs)

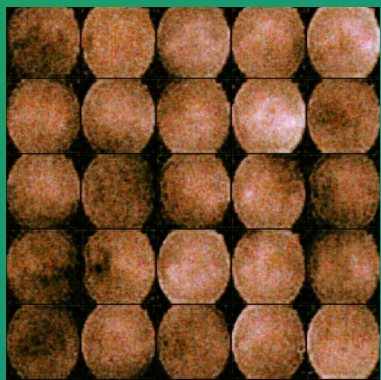
## Exploring the Dataset Behind GANs



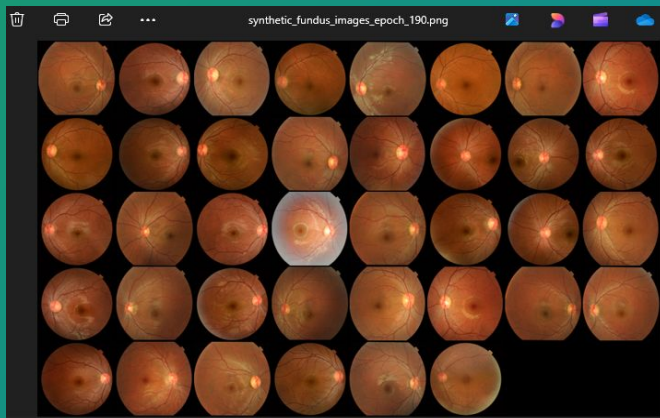
**Fundus1000 Dataset: Distribution of Images Across Categories**

# Generative Adversarial Networks (GANs)

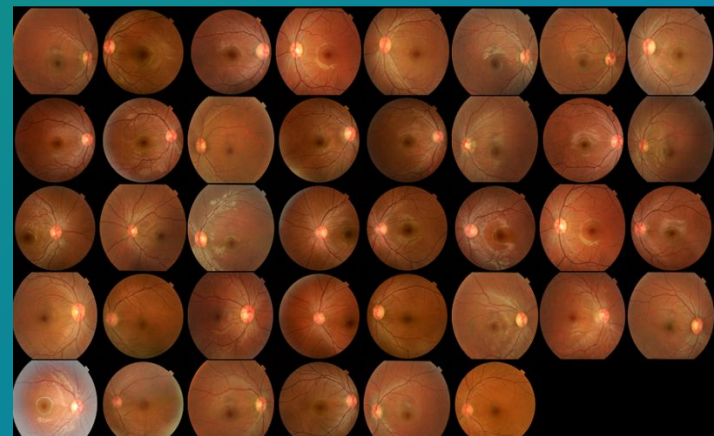
GANs are like digital artists trained to imitate real-world patterns.



Synthetic Image at  
5th epoch



Synthetic Image at 190th epoch

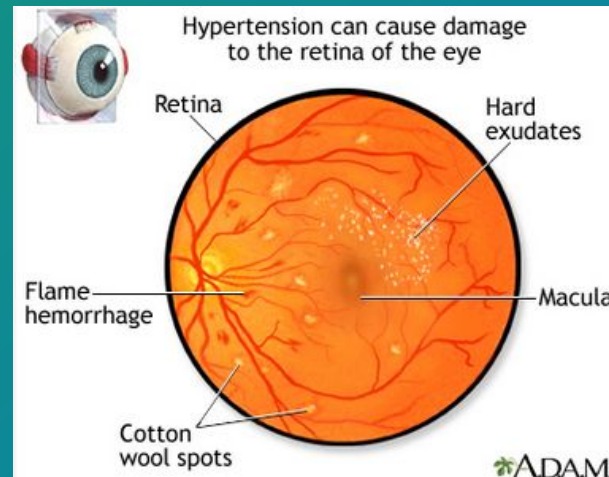
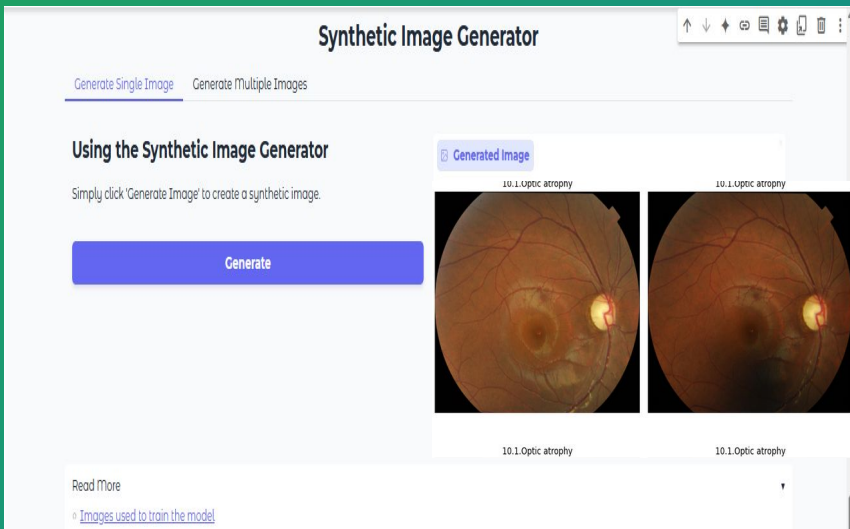


Final Synthetic Image generated

**Advancing Synthetic Fundus Image Generation for Ophthalmology**

# Generative Adversarial Networks (GANs)

## Using GANs to Generate Realistic Fundus Images for Medical Diagnostics



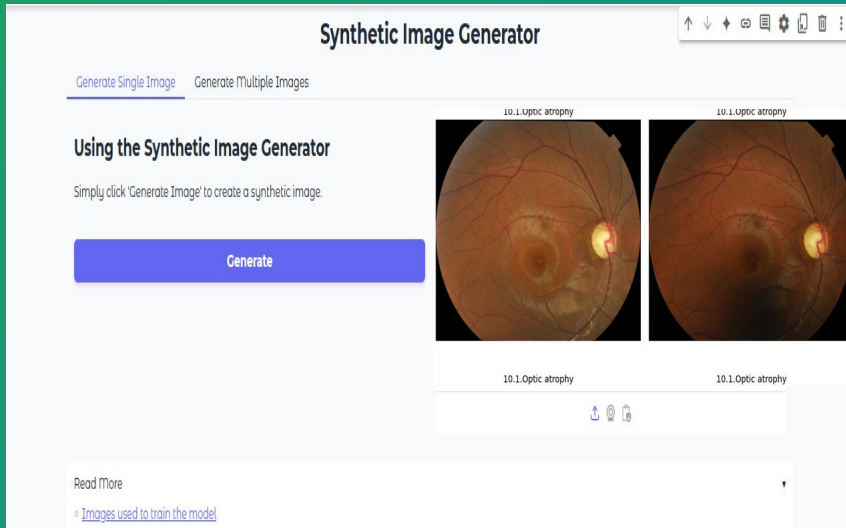
Globally, 285 million people live with visual impairment. GAN-generated synthetic images are transforming diagnosis and care for millions.



# Generative Adversarial Networks (GANs)

Using GANs to Generate Realistic Fundus Images for Medical Diagnostics

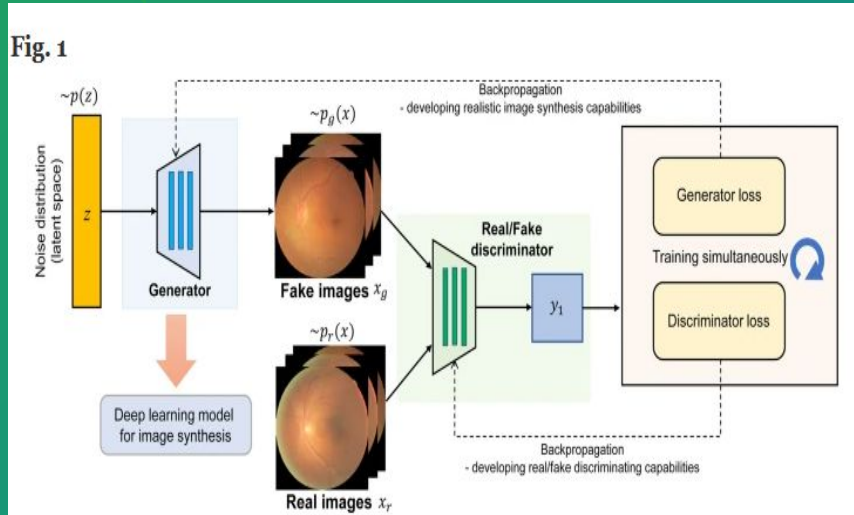
Identify Fake and Real Image



SSIM: 0.987 MSE:0.003

These synthetic images are not just pixels; they are pathways to better healthcare

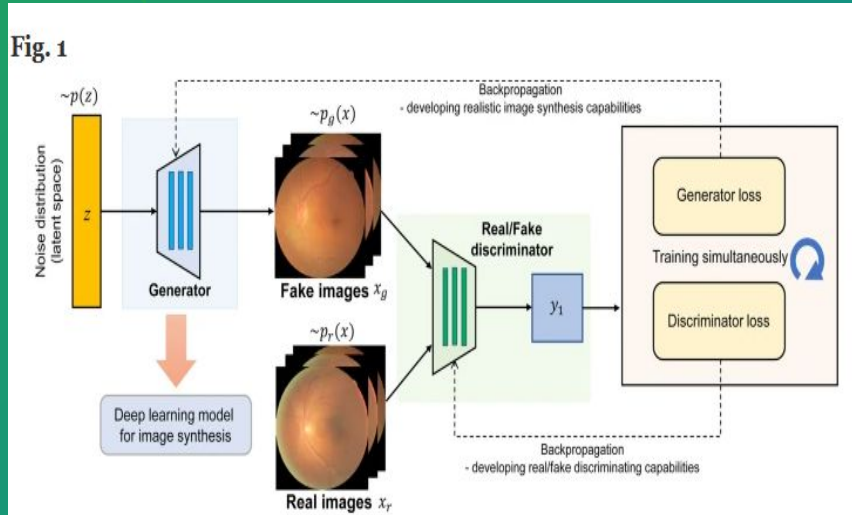
# Improving the GANs: Coupled GANs



- We combine coupling principles with the GAN framework.
- Focus: Enhancing tail behavior in data distributions.
- We use coupled probabilities in the generator and/or discriminator.

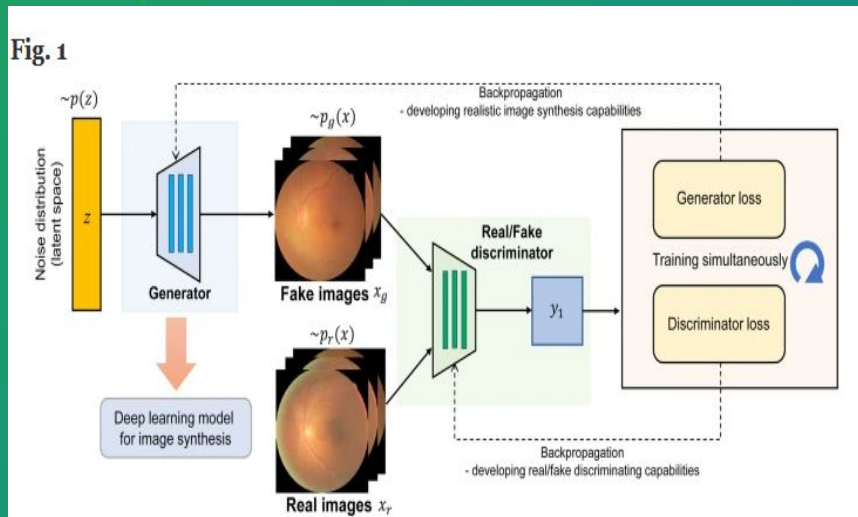
Good results with coupled VAE, but VAE are not adequate for complex medical data.

# Improving the GANs: Coupled GANs



- Generator: Sample latent variables  $z$  from a coupled distribution  $Q(z)$ .
- Incorporate  $Q(z)$  in the loss function.
- Goal: Improve anomaly detection for rare pathological features (e.g., tumors).
- Approach may have increased training complexity.

# Improving the GANs: Coupled GANs

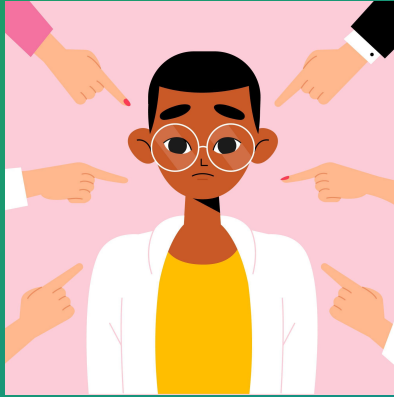


## Next Steps

- Compare standard GAN vs. Coupled GAN on diversity and quality of images.
- Analyze impact of coupling parameters on performance.
- Evaluate usefulness of coupling approach in anomaly detection and other tasks.



# Ethics and Equity: Problem Statement



AI systems, while innovative, often inherit biases from historical data, leading to unequal treatment of marginalized groups

promoting inclusivity in AI development, mitigating bias, and establishing clear ethical guidelines.



# Ethics and Equity: KNUST-RAIL

- RAIL - Responsible Artificial Intelligence Lab
- RAIL is hosted at the Kwame Nkrumah University of Science and Technology (KNUST) in Ghana. It seeks to be the first step in establishing a sustainable approach to nurturing local talent to engage in multidisciplinary, responsible AI development, research and innovation with focus on women to respond to capacity requirements of public and private sector.

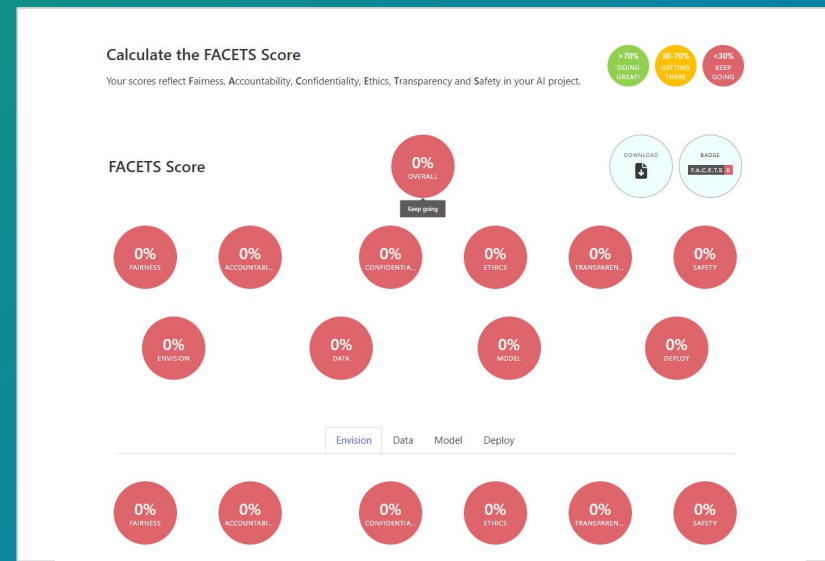
# Ethics and Equity: Proposed Model

While there are some existing responsible AI toolkits like the IBM's AI Fairness 360, Google's What-if Tool, and Fairlearn, help developers test for fairness, transparency and accountability in AI systems, they each handle a separate component of the evaluation components.

## Rail FACETS Framework

Fairness, Accountability, Confidentiality, *Ethics*, Transparency, and Safety.

- 4 Stages - Envision, Data, Model, and Deploy
- The scores are shared along with a Badge and a report.



# Ethics and Equity: Availability

- Typical generative AI pricing models
  - *token based* (user consumption model)
  - *subscription based* (hides costs from consumers...think of gym membership)
  - *value based* (efficiencies and improvements)
- How do you incentivize innovation? Who pays and who benefits?
- Liability- who incurs risk when images used/misused?
- How do you measure customer value and build into pricing? (e.g. few API calls but immense value)



# Ethics and Equity: Availability

Bias? Fairness? Sustainability?  
Explainability? Transparency?

DF Community Feedback