# Advancing Video Motion Learning
## with Deep Features and Physics-Based Priors

박사포럼 at KCC 2024

2024-06-27

Woobin Im (임우빈) iwbn.github.io

Advisor: Prof. Sung-Eui Yoon

SGVR Lab

KAIST School of Computing

# About Me

임우빈 (Im, Woobin)
KAIST SGVR Lab.

- **Research Interest**
  - Video, optical flow, dynamic NeRF, generative models
- **Education**
  - KAIST, Ph.D., Computer Science / 2018-current
    - Advisor: Professor Sung-Eui Yoon
  - KAIST, M.S., Computer Science / 2016-2018
    - Advisor: Professor Hyun Seung Yang
  - Yonsei University, B.S., Computer Science / 2012-2016
- **Work**
  - CLOVA, NAVER Cloud Corp. (internship) / 2023.02-2023.08

# Content

**Research Summary**

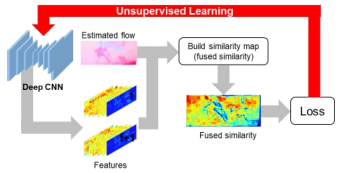
**Research Details**

**Summary & Verdict**

# Research Summary

# Advancing Video Motion Learning

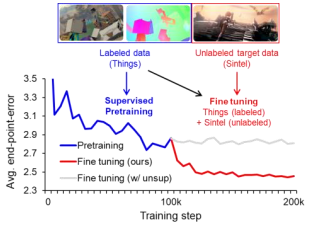
## 2D Motion: Optical Flow




**Woobin Im**, Tae-Kyun Kim, Sung-Eui Yoon

***[Unsupervised] SimFlow*, ECCV 2020**

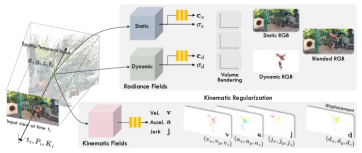
Finalist at Qualcomm Innovation Fellowship Korea (QIFK)




**Woobin Im**, Sebin Lee, Sung-Eui Yoon

***[Semi-supervised] Flow Supervisor*, ECCV 2022**

## 3D Motion: Dynamic NeRF



**Woobin Im**, et al.

***KinematicFields*, Under Review, 2024**

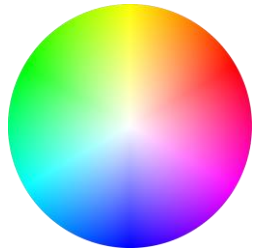
Work done during NAVER internship

# 2D Motion in video

**Optical Flow: Pixel-level motion** in consecutive frames

Optical Flow Datasets

Learn



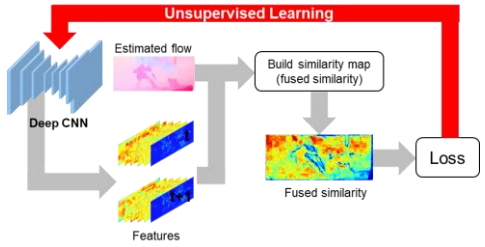
**Color wheel**

Woobin Im, Sebin Lee, Sung-Eui Yoon, *Flow Supervisor*, ECCV 2022

# 2D Motion in video

- **Un- / Semi-supervised Learning** (optical flow)
  - **Woobin Im** et al., **Unsupervised Learning** of Optical Flow with Deep Feature Similarity, ECCV 2020
  - **Woobin Im** et al., **Semi-Supervised Learning** of Optical Flow by Flow Supervisor, ECCV 2022

→ Uncovering 2D motion in a video

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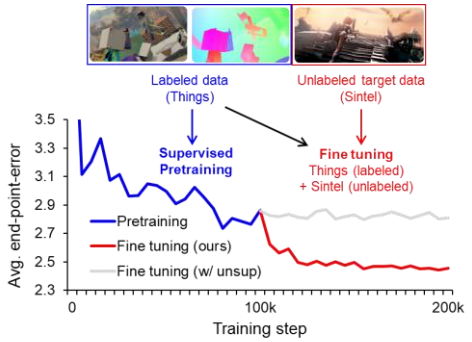



**Woobin Im**, Sebin Lee, Sung-Eui Yoon

***[Semi-supervised] Flow Supervisor*, ECCV 2022**

# 3D Motion in video

**Kinematic Fields: Physical Field** representing motion in 3D space

**Monocular** 2D Video

Learn

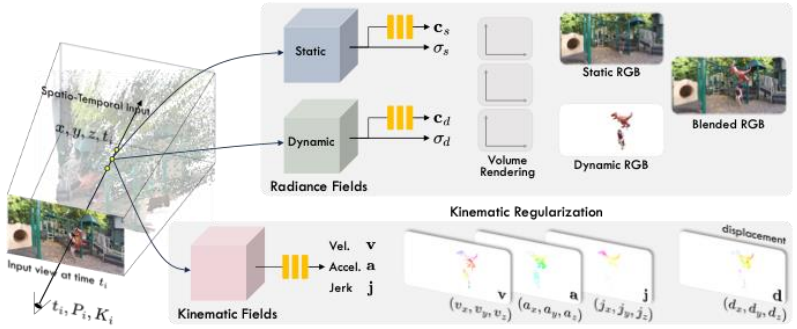
Radiance Field (novel view synthesis), Kinematic Field (3D motion)

Woobin Im et al., “Regularizing Dynamic Radiance Fields with Kinematic Fields”, under review

# 3D Motion in video

- **Dynamic Radiance Fields**
  - **Woobin Im** et al., “Regularizing Dynamic Radiance Fields with Kinematic Fields”, under review

→ **Unsupervised learning** 3D motion in a video + Rendering



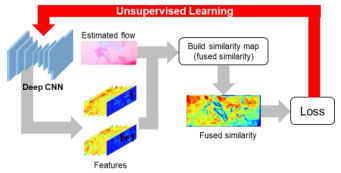

**Woobin Im**, et al.

***KinematicFields*, Under Review, 2024**

Work done during NAVER internship

# Advancing Video Motion Learning

## Un-/Semi-Supervised Learning *2D* motion in a video

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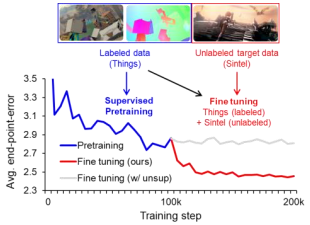
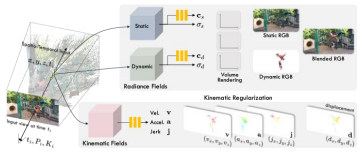



**Woobin Im**, Sebin Lee, Sung-Eui Yoon

***[Semi-supervised] Flow Supervisor*, ECCV 2022**

## Unsupervised learning *3D* motion in a video



**Woobin Im**, et al.

***KinematicFields*, Under Review, 2024**

Work done during NAVER internship

# More Things

- **Award**
  - Naver Ph.D Fellowship Award, 2022.
  - Finalist at Qualcomm Innovation Fellowship Korea (QIFK), 2020.
  - Outstanding Teaching Assistant Award (우수조교상), KAIST, 2019.

- **특허**
  - 광학 흐름 추정을 위한 딥 유사도 기반 비지도 학습의 컴퓨터 시스템 및 그의 방법
    [KR] [US App]
  - 트리플릿 기반의 손실함수를 활용한 순서가 있는 분류문제를 위한 딥러닝 모델 학습 방법 및 장치
    [US App] [KR App]

# HPC

High Performance Computing

NAVER NSML

AWS Compute

Brain Cloud

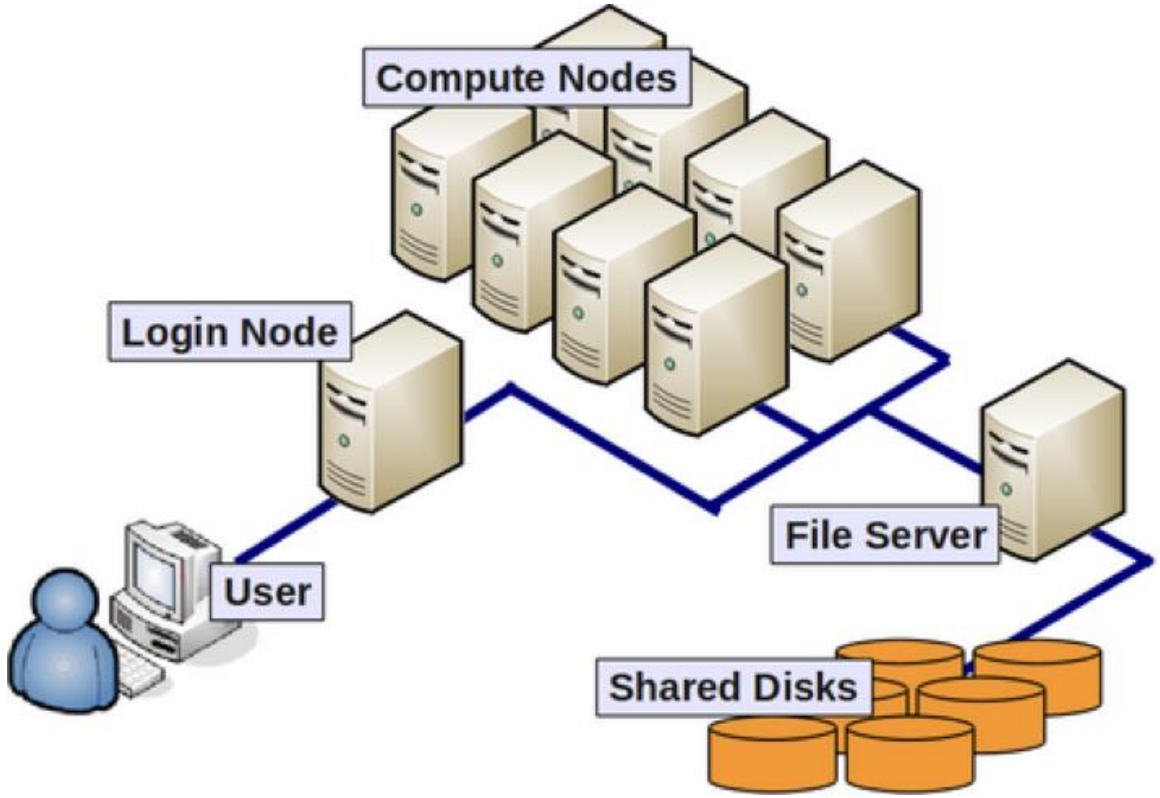



그림 출처: https://hbctraining.github.io/Intro-to-shell-flipped/lessons/08_HPC_intro_and_terms.html

# ML research environment for SGVR Lab, KAIST

# GPU Cluster Service

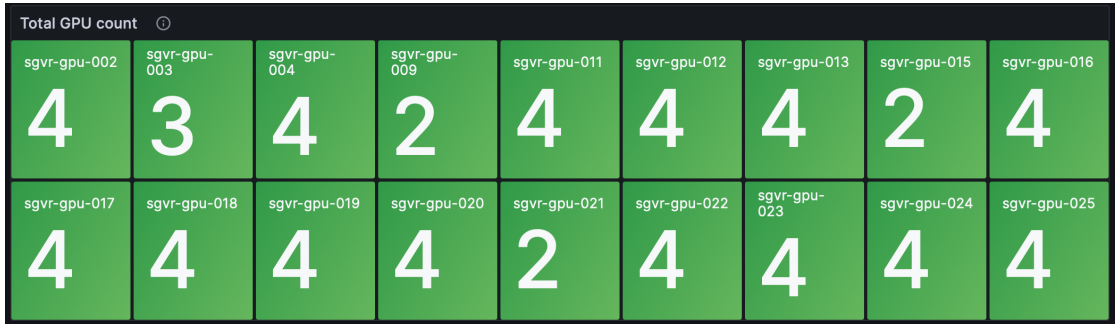
https://sgvr.kaist.ac.kr/ml-research-environment/

- **My role in this project**

  → **Leader and main developer**

- **GPU Cluster**
  - **Elastic** GPU allocation
  - **Kubernetes** + **Docker** based
  - NFS > **200TB, 10Gbps** network
  - Provide **CLI and Web based tools**

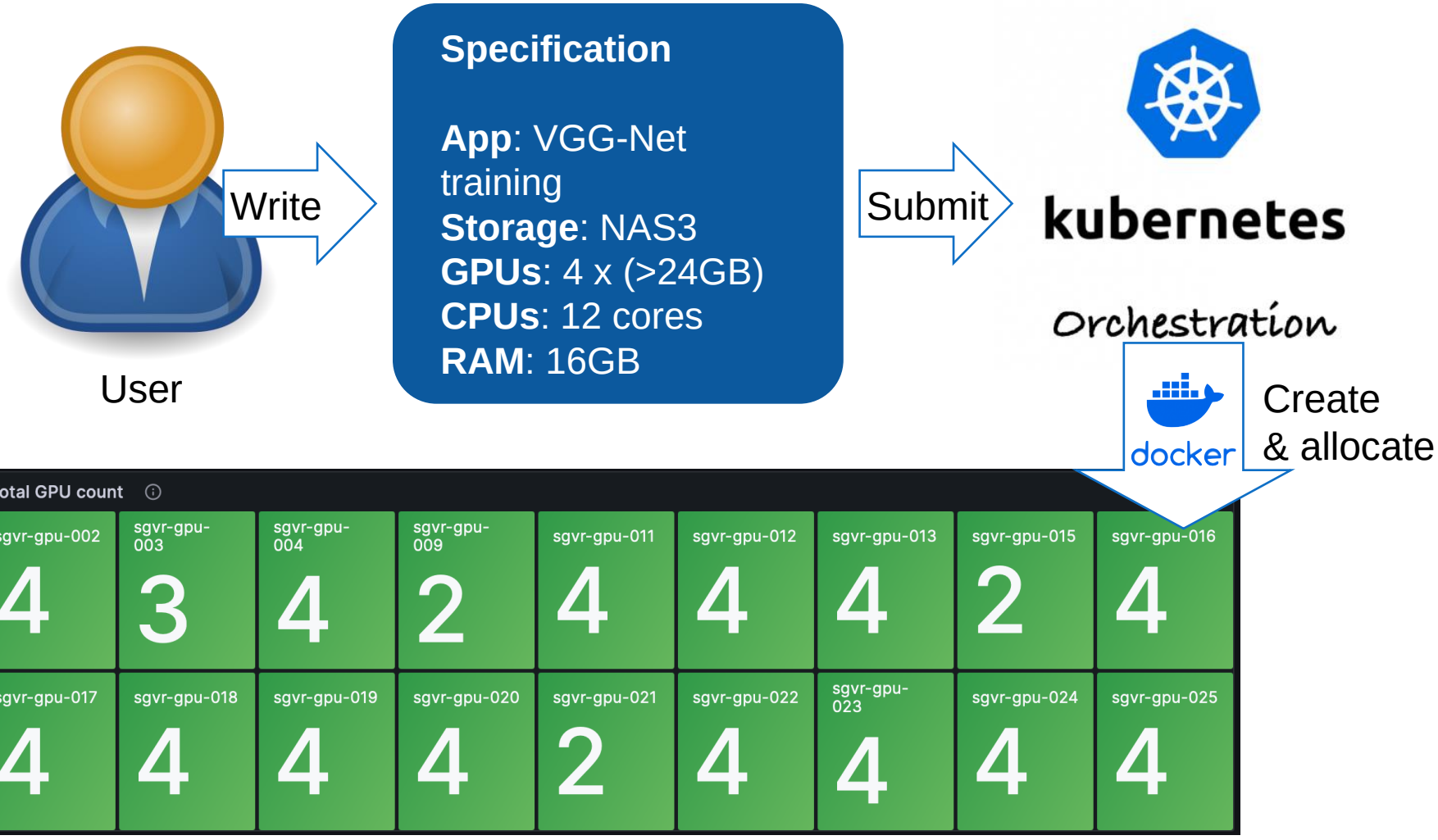
Jobs (utilization) running on our cluster




Nodes and available GPUs

# GPU Cluster Service

https://sgvr.kaist.ac.kr/ml-research-environment/




**GPU Cluster (multiple nodes x GPUs)**

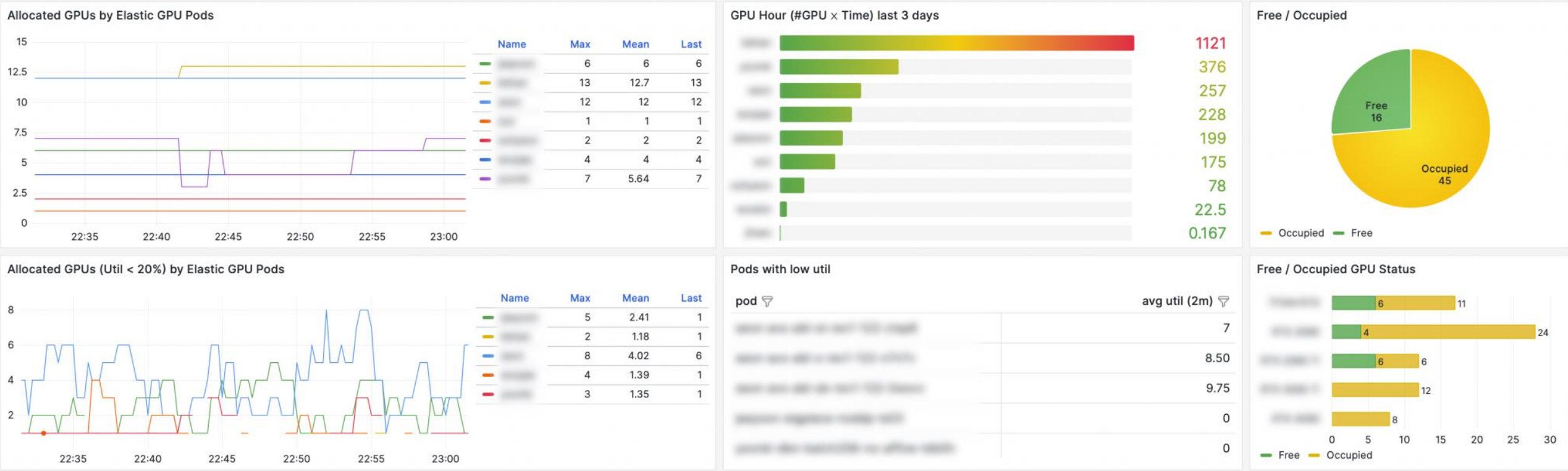
# GPU Cluster Service (Monitoring)

https://sgvr.kaist.ac.kr/ml-research-environment/

Grafana

Monitoring

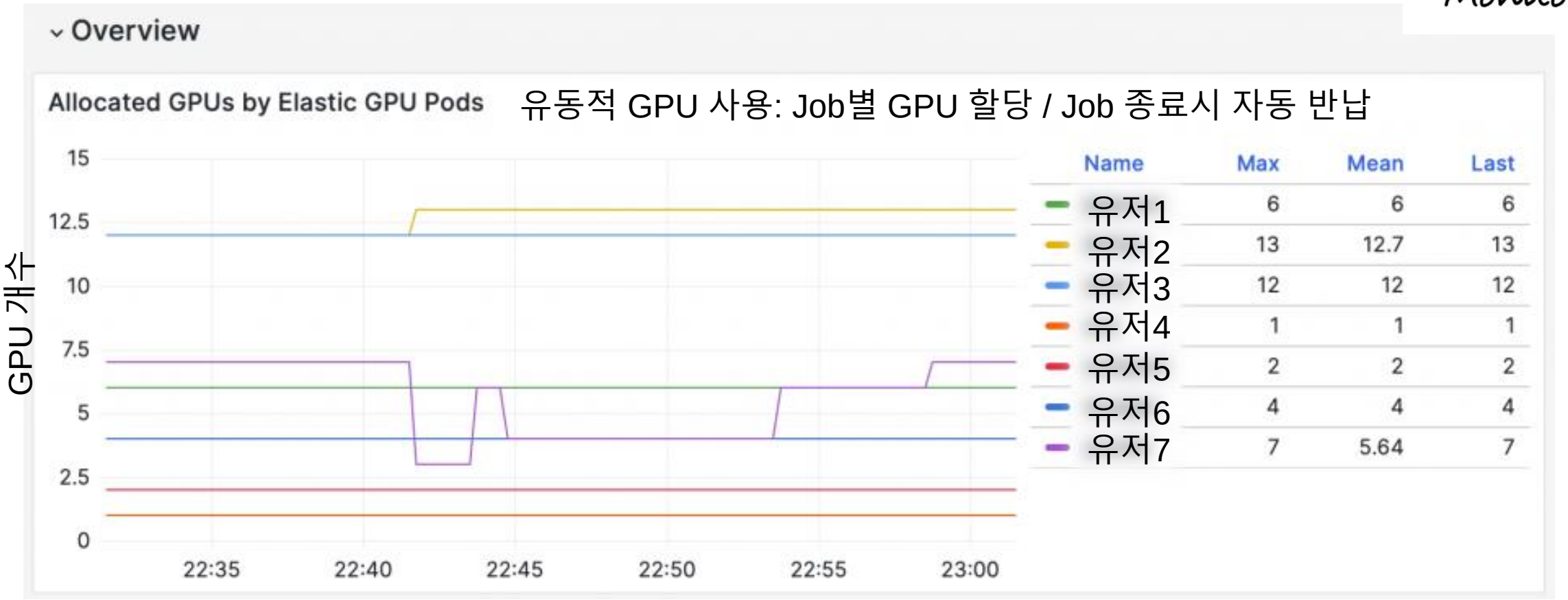
Overview



# GPU Cluster Service (Monitoring)

https://sgvr.kaist.ac.kr/ml-research-environment/

Grafana Monitoring



# GPU Cluster Service (Monitoring)

https://sgvr.kaist.ac.kr/ml-research-environment/

Grafana

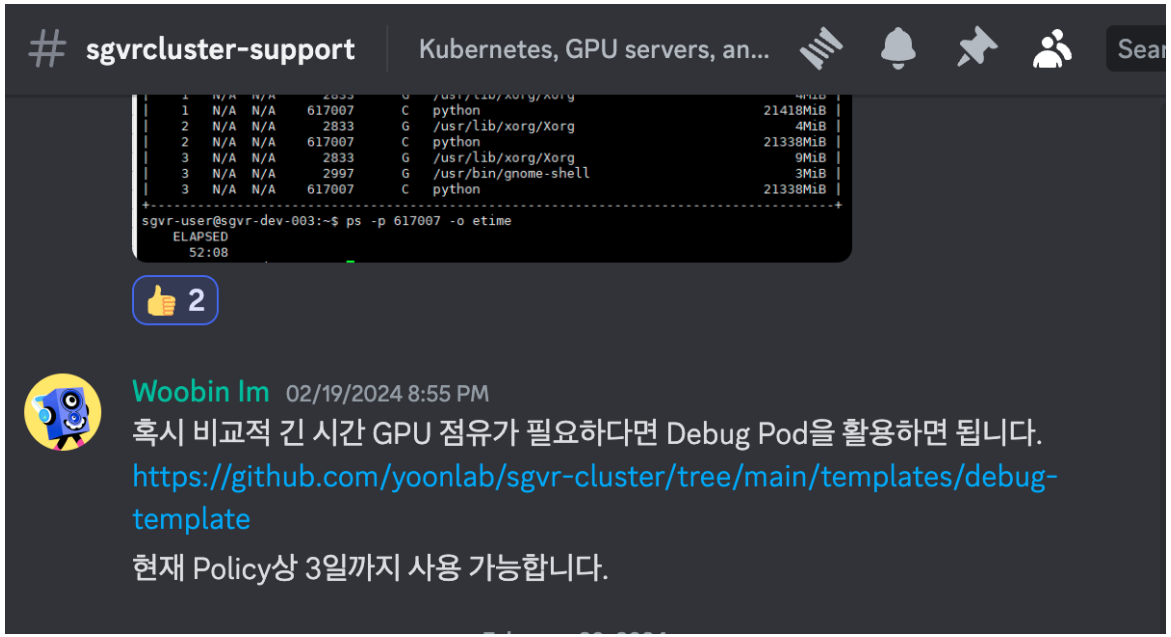
Monitoring

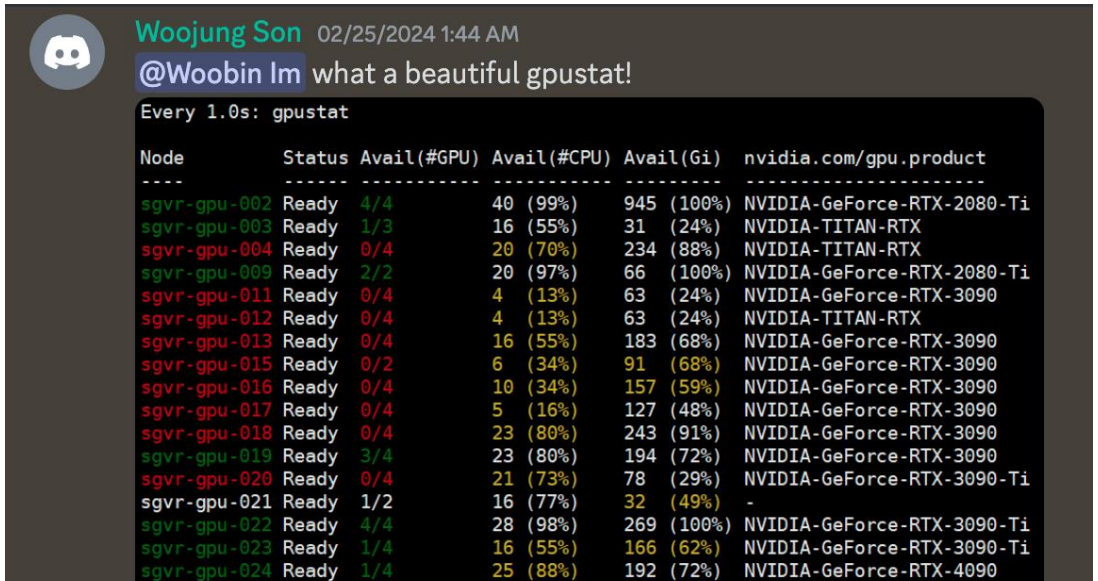
1121 GPU hours / 3 days
by one user!

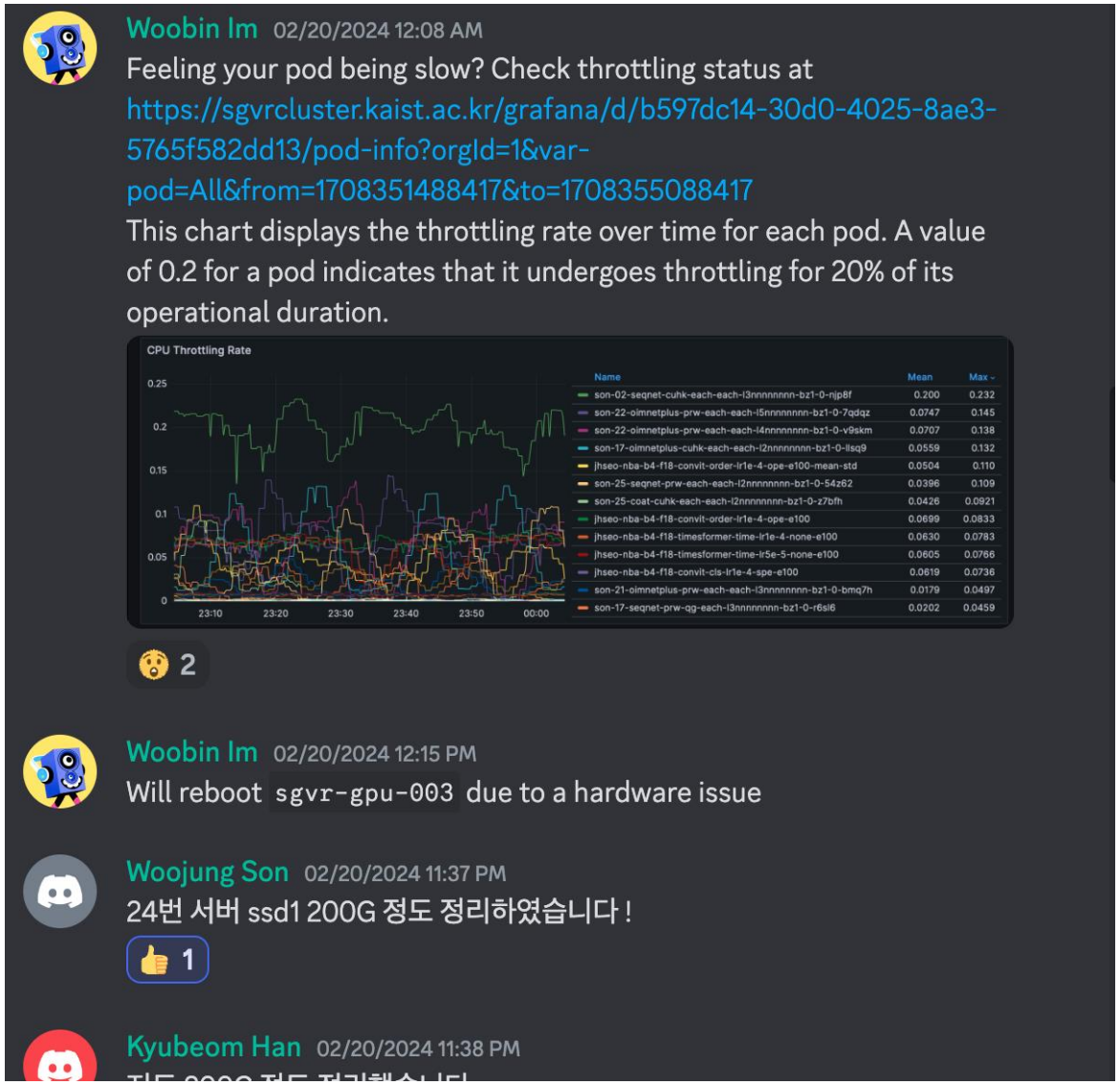
*Feat. SIGGRAPH deadline…*
*Note: we are not Google*

# User Community (Discord)

https://sgvr.kaist.ac.kr/ml-research-environment/

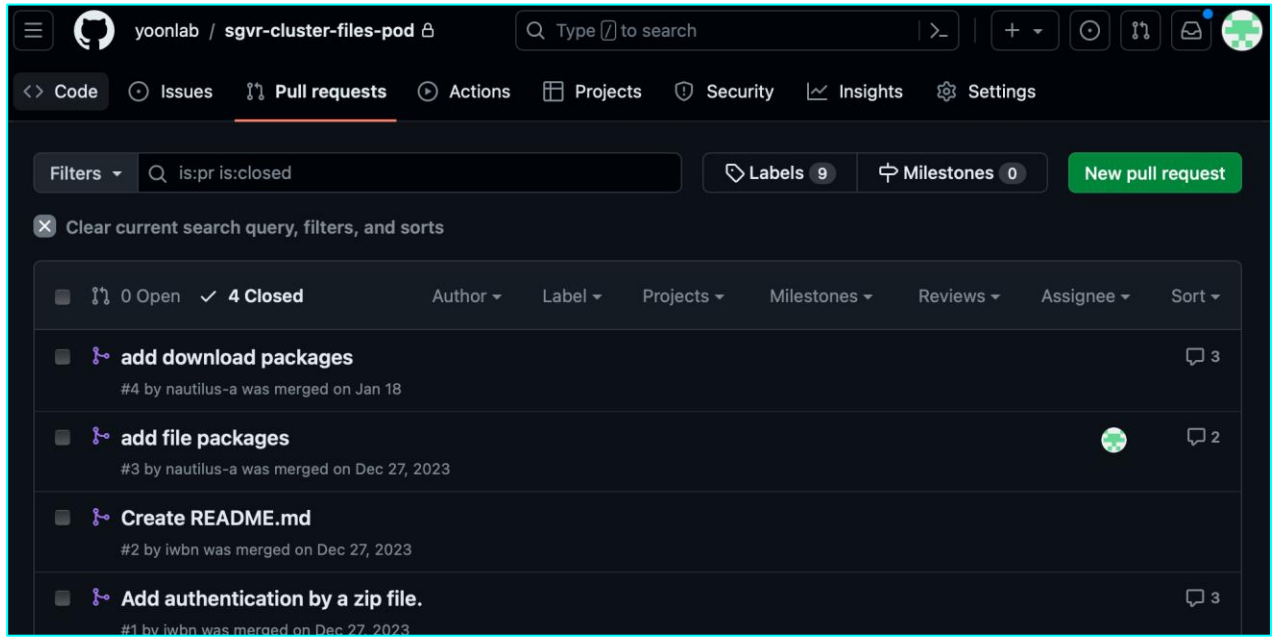


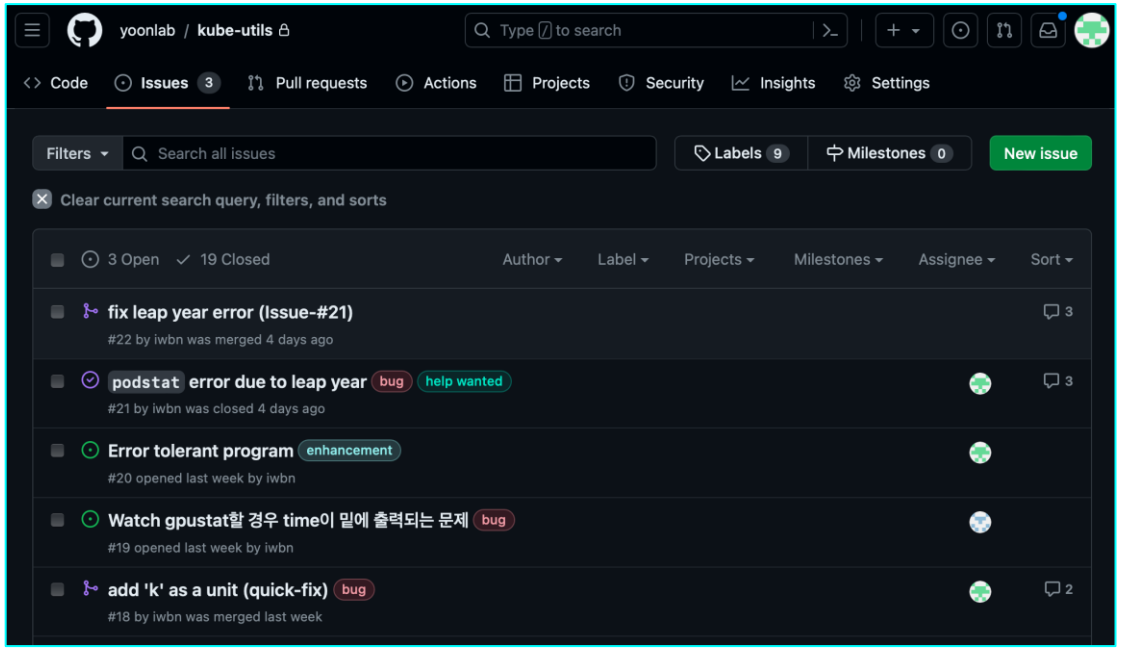



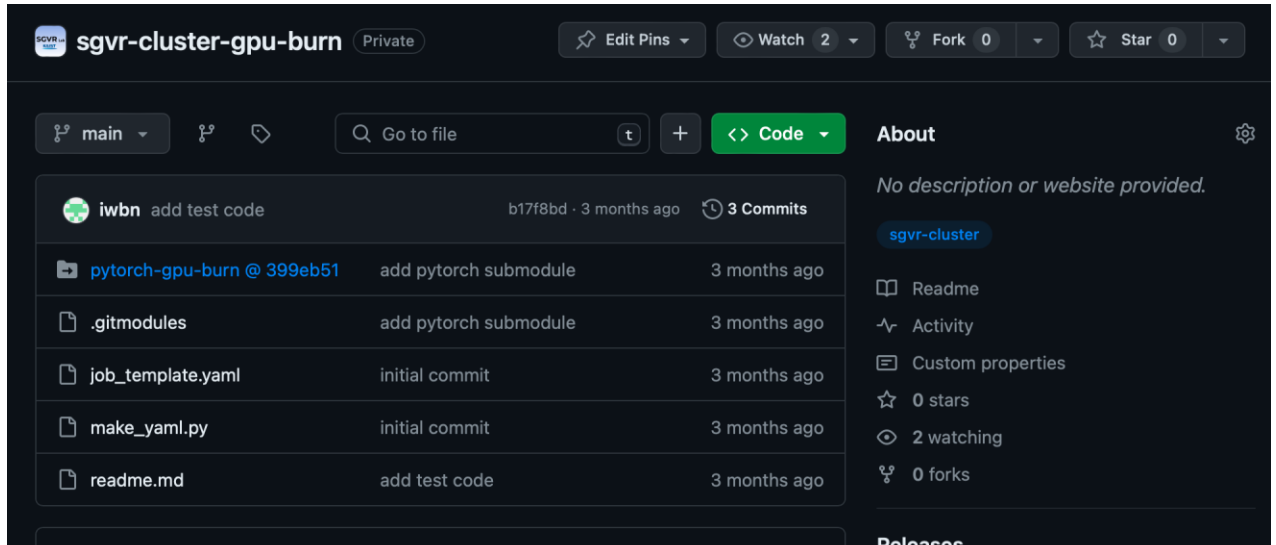



# Open-Source Community

https://sgvr.kaist.ac.kr/ml-research-environment/



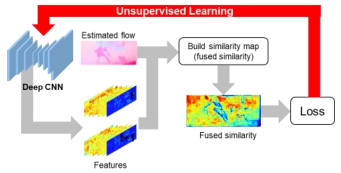




Related code repos
are **open-sourced** within our lab!

# Summary & Future Work

# Advancing Video Motion Learning

## 2D Motion: Optical Flow

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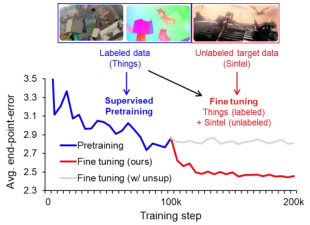


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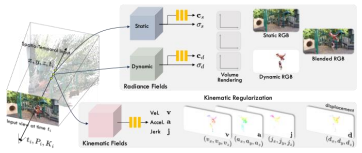
## 3D Motion: Dynamic NeRF



**Woobin Im**, et al.

***KinematicFields*, Under Review, 2024**

Work done during NAVER internship

kubernetes

# **Wide Research Area** through **Collaboration**

- **Metric Learning**
  - **Woobin Im** et al., Scale-Varying Triplet Ranking with Classification Loss for Facial Age Estimation, ACCV 2018
  - Sungeun Hong, **Woobin Im** et al., CBVMR: Content-Based Video-Music Retrieval Using Soft Intra-Modal Structure Constraint, ICMR 2018
  - Abhilasha Nanda, **Woobin Im** et al., Combined Center Dispersion Loss Function for Deep Facial Expression Recognition, PRL 2020

- **Domain Adaptation**
  - Sungeun Hong, **Woobin Im** et al., SSPP-DAN: Deep Domain Adaptation Network for Face Recognition with Single Sample Per Person, ICIP 2017
  - Gwangbeen Park and **Woobin Im**, Image-text multi-modal representation learning by adversarial backpropagation,
    ArXiv 2016

# Wide Research Area through Collaboration

- **Generative Models**
  - Jumin Lee, Sebin Lee, Changho Jo, **Woobin Im**, Ju-hyeong Seon, Sung-eui Yoon, SemCity: Semantic Scene Generation with Triplane Diffusion, Accepted to **CVPR'24**
  - Changho Jo, **Woobin Im**, and Sung-Eui Yoon, In-N-Out: Towards Good Initialization for Inpainting and Outpainting, **BMVC 2021**

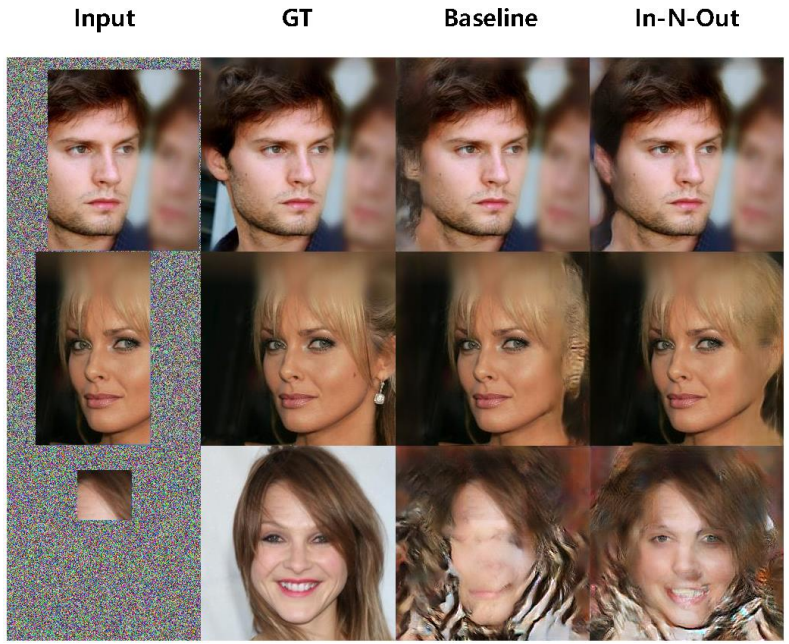



Figure from **In-N-Out**

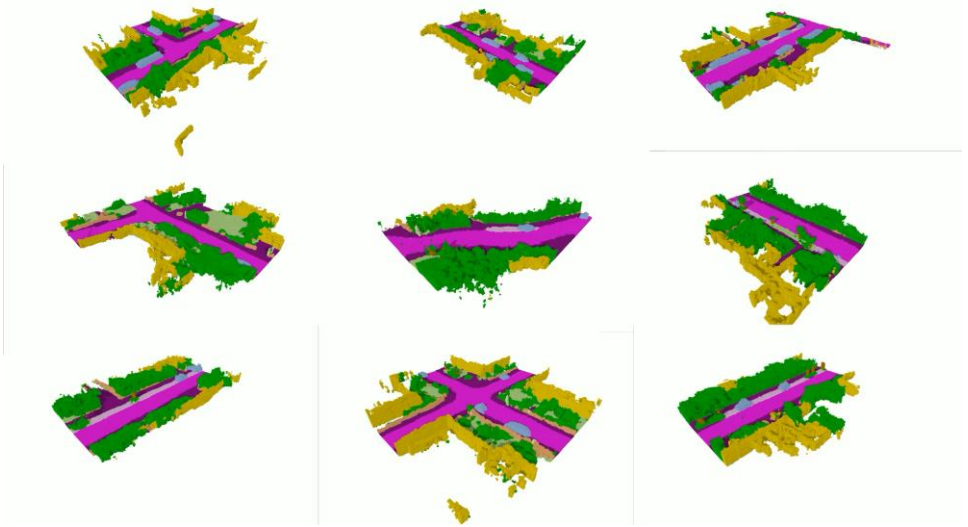
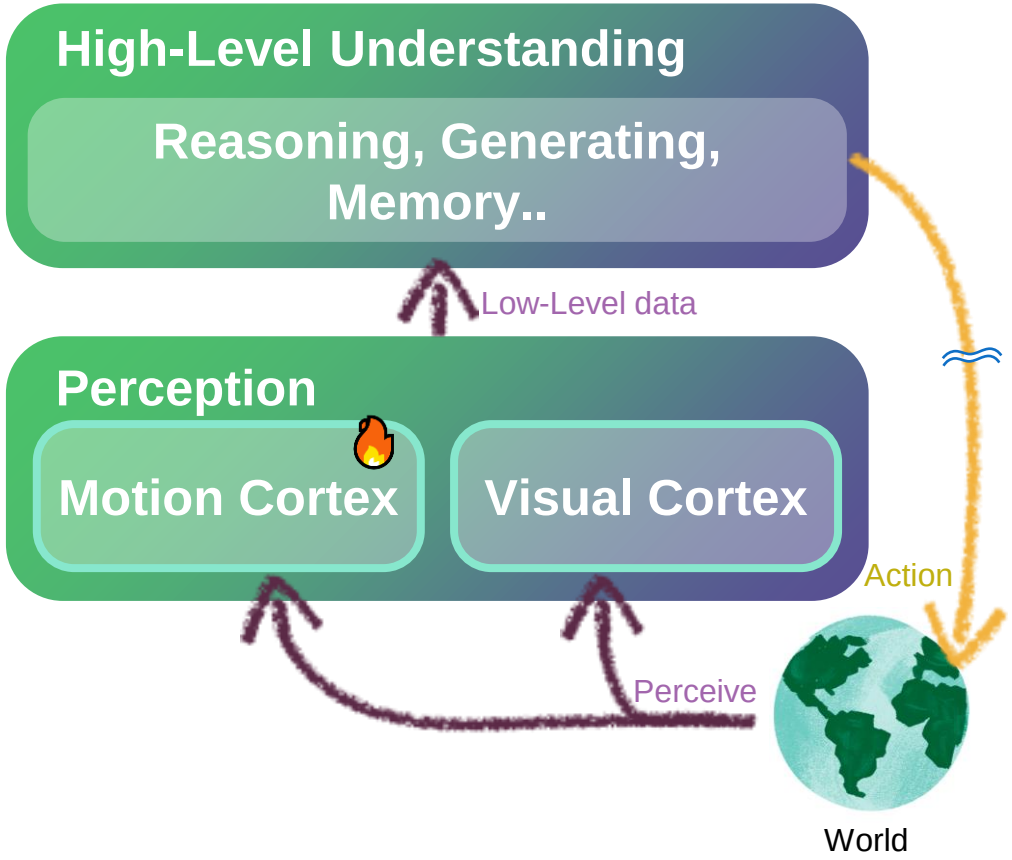


Figure from **SemCity**

# Motion-Aware Lifelong Perception Learning




- Research theme
  - Motion perception **in 2D or 3D**
  - Self-supervised learning **(e.g., un- / semi- supervised)**
  - Physically-based learning **(e.g., kinematic fields)**

## Future Work

AI Multi-Modal Large Model

**+ Motion + 3D**

**+ Self-Improving**

**→ Closer to**

# Thanks for listening

**How to become expert at thing:**
Accomplish projects depth wise, learning “on demand”
Teach/summarize everything you learn in your own words
Only compare yourself to younger you, never to others

-Andrej Karpathy