

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

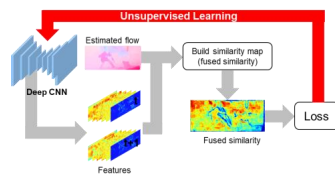
Research Details

Summary & Verdict

Research Summary

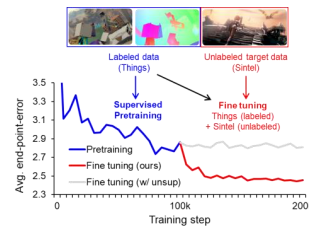
Advancing Video Motion Learning

2D Motion: Optical Flow



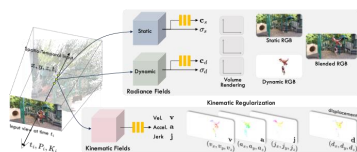
Woobin Im, Tae-Kyun Kim, Sung-Eui Yoon
[Unsupervised] *SimFlow*, ECCV 2020

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**

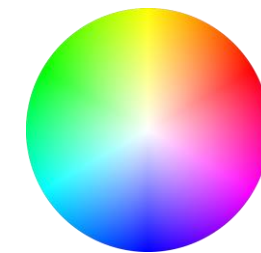
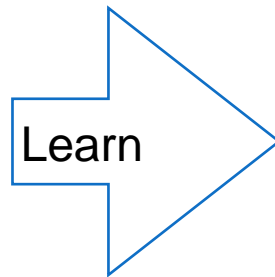
Work done during NAVER internship

2D Motion in video

Optical Flow: Pixel-level motion in consecutive frames



Optical Flow Datasets



Color wheel

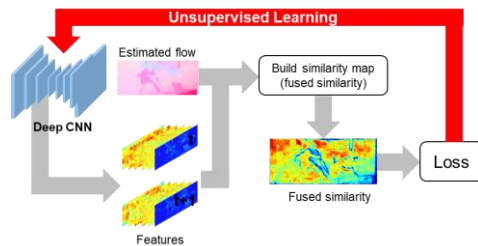
Woobin Im, Sebin Lee, Sung-Eui Yoon, *Flow Supervisor*, ECCV 2022

2D Motion in video

- **Un- / Semi-supervised Learning (optical flow)**

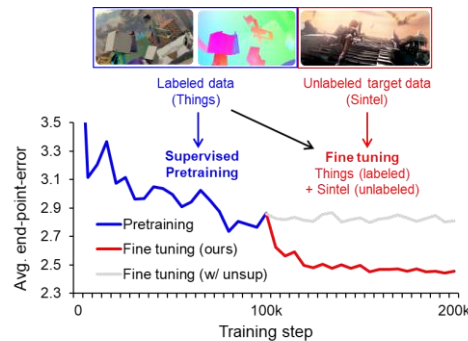
- **Woobin Im et al., Unsupervised Learning of Optical Flow with Deep Feature Similarity, ECCV 2020**
- **Woobin Im et al., Semi-Supervised Learning of Optical Flow by Flow Supervisor, ECCV 2022**

→ Uncovering 2D motion in a video



Woobin Im, Tae-Kyun Kim, Sung-Eui Yoon
[Unsupervised] SimFlow, ECCV 2020

Finalist at Qualcomm Innovation Fellowship Korea ([QIFK](#))



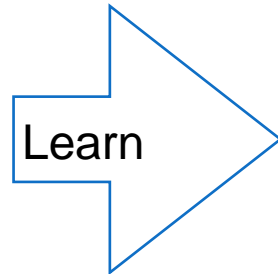
Woobin Im, Sebin Lee, Sung-Eui Yoon
[Semi-supervised] Flow Supervisor, ECCV 2022

3D Motion in video

Kinematic Fields: Physical Field representing motion in 3D space



Monocular 2D Video



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

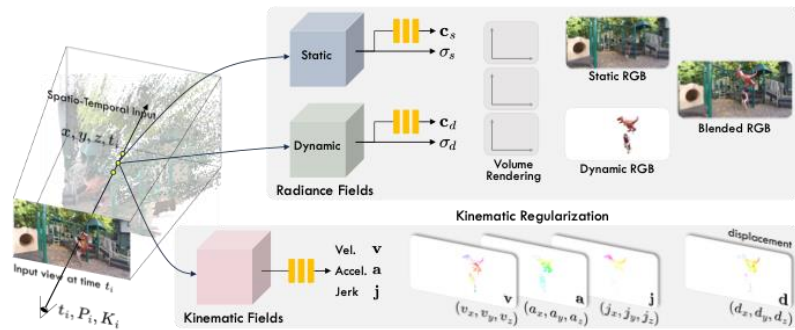
Woobin Im et al., "Regularizing Dynamic Radiance Fields with Kinematic Fields", under review

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



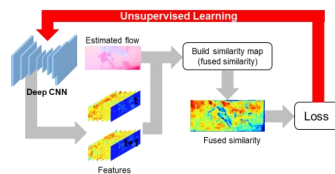
Woobin Im, et al.

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

Work done during NAVER internship

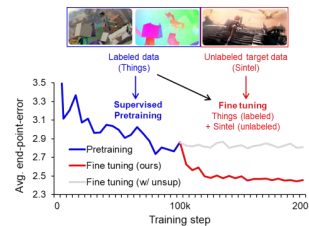
Advancing Video Motion Learning

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



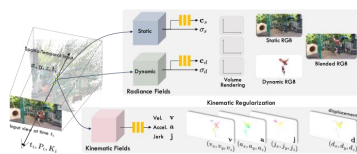
Woobin Im, Tae-Kyun Kim, Sung-Eui Yoon
[Unsupervised] SimFlow, ECCV 2020

Finalist at Qualcomm Innovation Fellowship Korea ([QIFK](#)), 2020



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

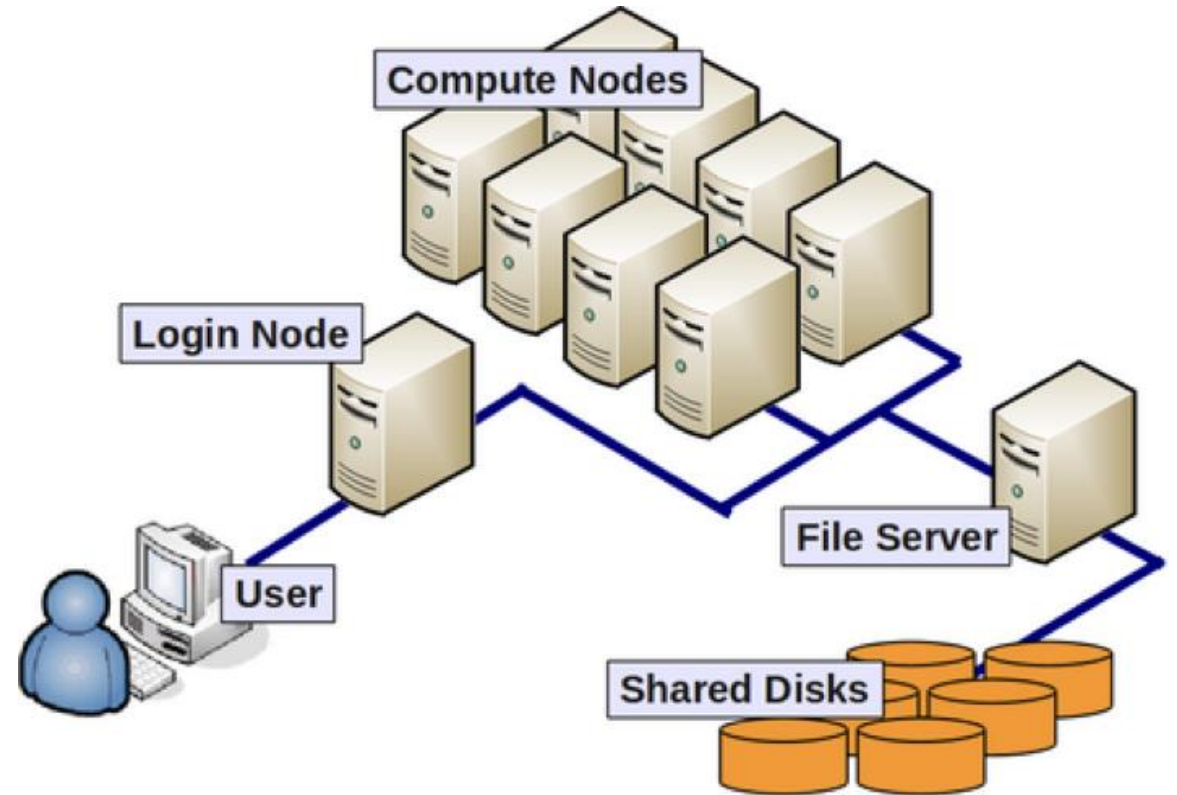


그림 출처: https://hbctraining.github.io/Intro-to-shell-flipped/lessons/08_HPC_intro_and_terms.html



**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**

88.8	91	77	51.6	No data	26.6	90	82.6
85.4	33.6	63.8	70.4	96.6	75.6	0	91.4
81.4	0	29	11.8	14.4	8.20	72.2	86.2
0	94.6	86	71	67	50	82.4	72.6
88.8	87	54	80.4	88.6	77	63.2	70
41.6	31.4	8.60	69	56.6	44.6	51.2	70.2

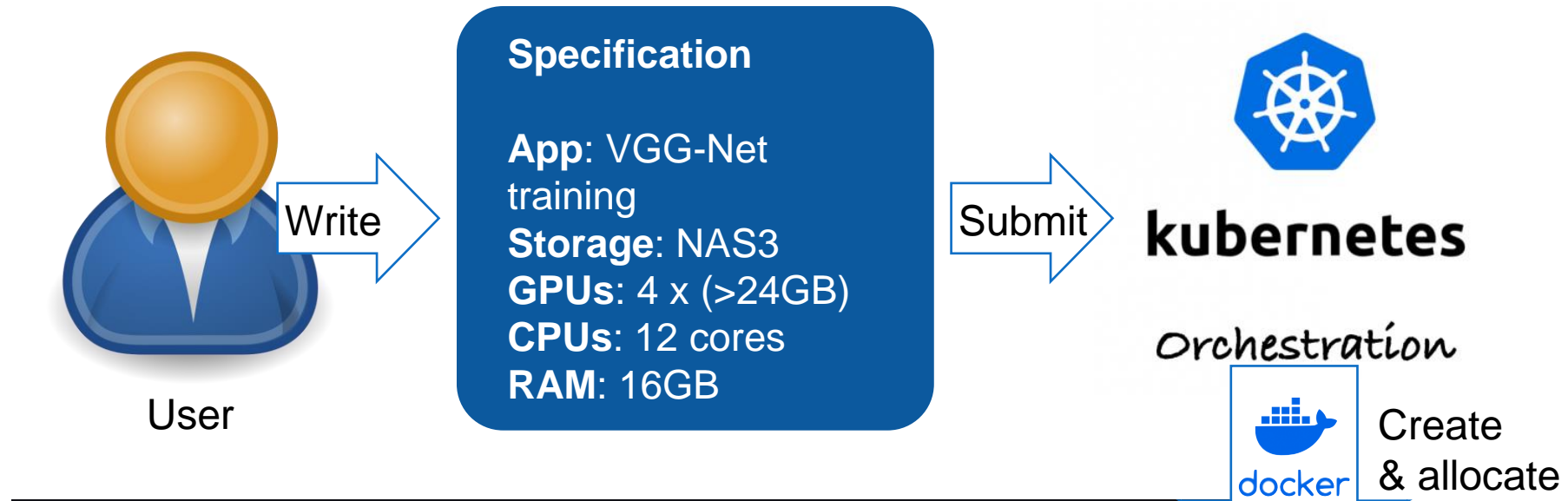
Jobs (utilization) running on our cluster

Total GPU count								
4	3	4	2	4	4	4	2	4
4	4	4	4	2	4	4	4	4

Nodes and available GPUs

GPU Cluster Service

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



Total GPU count ⓘ

sgvr-gpu-002	sgvr-gpu-003	sgvr-gpu-004	sgvr-gpu-009	sgvr-gpu-011	sgvr-gpu-012	sgvr-gpu-013	sgvr-gpu-015	sgvr-gpu-016
4	3	4	2	4	4	4	2	4
sgvr-gpu-017	sgvr-gpu-018	sgvr-gpu-019	sgvr-gpu-020	sgvr-gpu-021	sgvr-gpu-022	sgvr-gpu-023	sgvr-gpu-024	sgvr-gpu-025
4	4	4	4	2	4	4	4	4

GPU Cluster (multiple nodes x GPUs)

GPU Cluster Service (Monitoring)

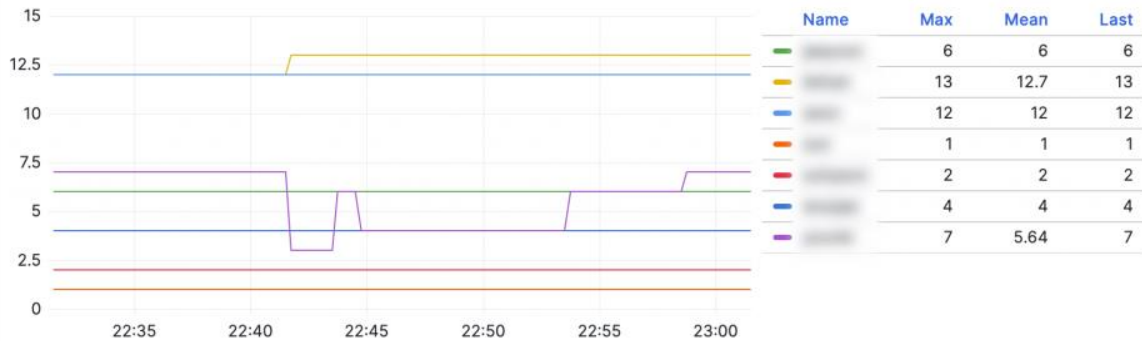
<https://sgvr.kaist.ac.kr/ml-research-environment/>



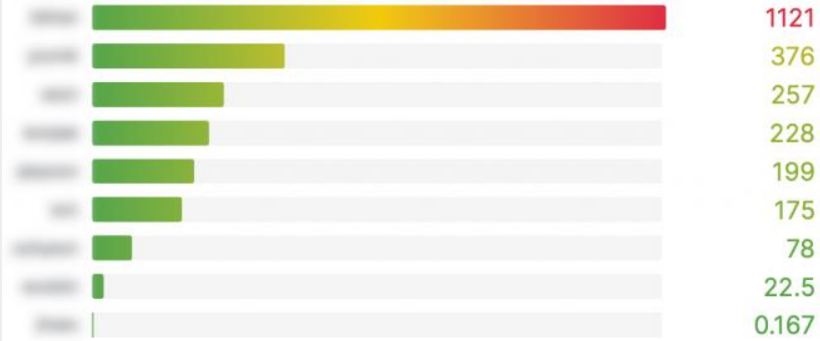
Grafana
Monitoring

Overview

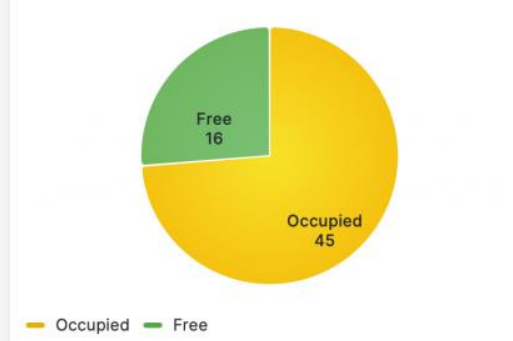
Allocated GPUs by Elastic GPU Pods



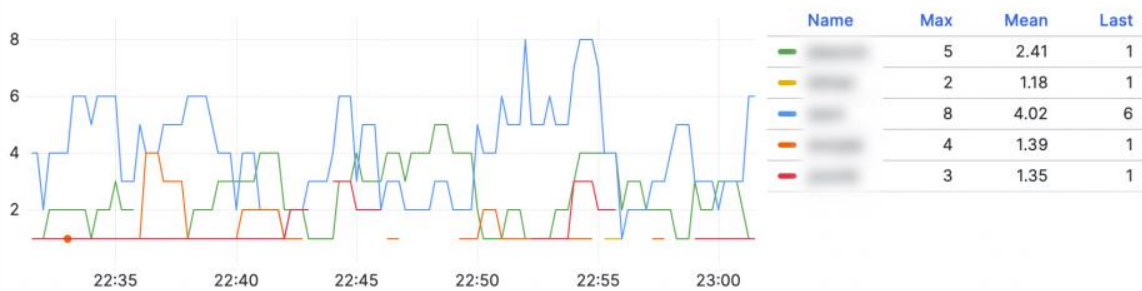
GPU Hour (#GPU × Time) last 3 days



Free / Occupied



Allocated GPUs (Util < 20%) by Elastic GPU Pods



Pods with low util

pod	avg util (2m)
[Redacted]	7
[Redacted]	8.50
[Redacted]	9.75
[Redacted]	0
[Redacted]	0

Free / Occupied GPU Status



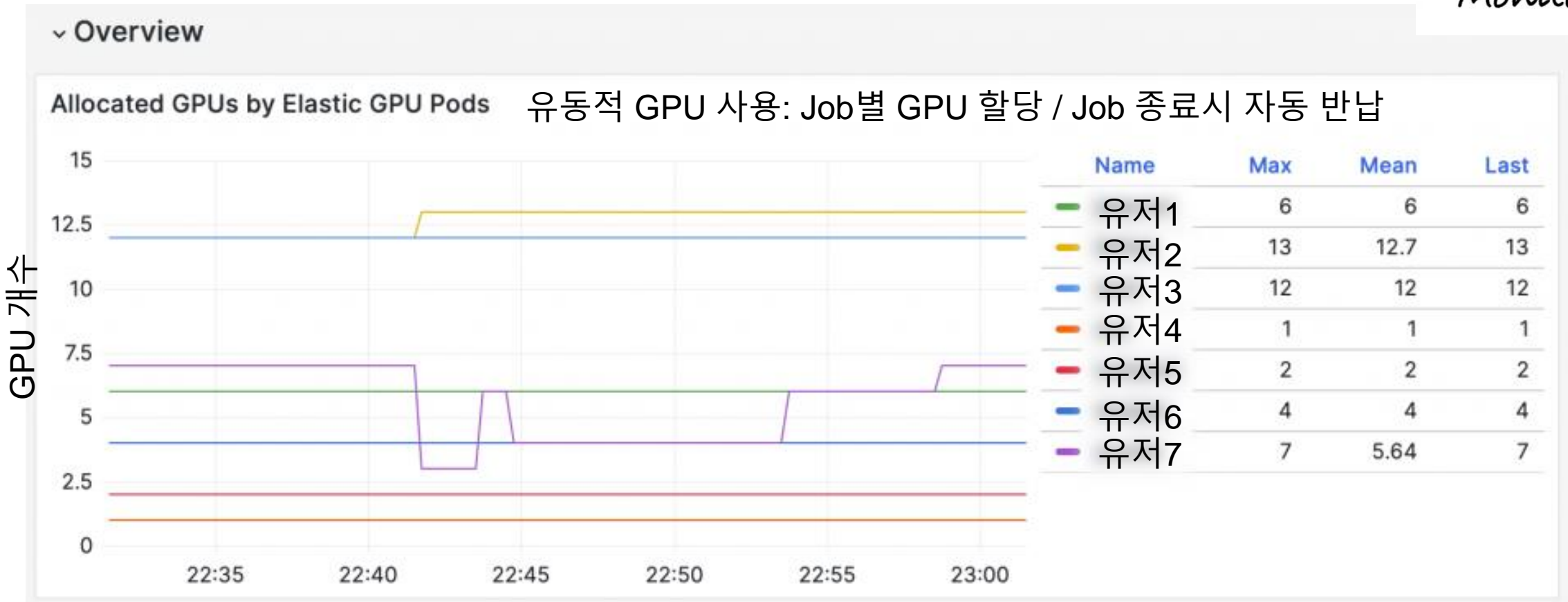
GPU Cluster Service (Monitoring)

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



Grafana

Monitoring



GPU Cluster Service (Monitoring)

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



Grafana
Monitoring

GPU Hour (#GPU × Time) last 3 days

User 1



1121

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/>

sgvrcluster-support Kubernetes, GPU servers, an... Search

```

1 N/A N/A 2833 C /usr/lib/xorg/Xorg 4MiB
1 N/A N/A 617007 C python 21418MiB
2 N/A N/A 2833 G /usr/lib/xorg/Xorg 4MiB
2 N/A N/A 617007 C python 21338MiB
3 N/A N/A 2833 G /usr/lib/xorg/Xorg 9MiB
3 N/A N/A 2997 G /usr/bin/gnome-shell 3MiB
3 N/A N/A 617007 C python 21338MiB
sgvr-user@sgvr-dev-003:~$ ps -p 617007 -o etime
ELAPSED
52:08
    
```

👍 2

Woobin Im 02/19/2024 8:55 PM
 혹시 비교적 긴 시간 GPU 점유가 필요하다면 Debug Pod을 활용하면 됩니다.
<https://github.com/yoonlab/sgvr-cluster/tree/main/templates/debug-template>
 현재 Policy상 3일까지 사용 가능합니다.

Wooyung Son 02/25/2024 1:44 AM
 @Woobin Im what a beautiful gpustat!

```

Every 1.0s: gpustat
Node      Status Avail(#GPU) Avail(#CPU) Avail(Gi) nvidia.com/gpu.product
-----
sgvr-gpu-002 Ready 4/4 40 (99%) 945 (100%) NVIDIA-GeForce-RTX-2080-Ti
sgvr-gpu-003 Ready 1/3 16 (55%) 31 (24%) NVIDIA-TITAN-RTX
sgvr-gpu-004 Ready 0/4 20 (70%) 234 (88%) NVIDIA-TITAN-RTX
sgvr-gpu-009 Ready 2/2 20 (97%) 66 (100%) NVIDIA-GeForce-RTX-2080-Ti
sgvr-gpu-011 Ready 0/4 4 (13%) 63 (24%) NVIDIA-GeForce-RTX-3090
sgvr-gpu-012 Ready 0/4 4 (13%) 63 (24%) NVIDIA-TITAN-RTX
sgvr-gpu-013 Ready 0/4 16 (55%) 183 (68%) NVIDIA-GeForce-RTX-3090
sgvr-gpu-015 Ready 0/2 6 (34%) 91 (68%) NVIDIA-GeForce-RTX-3090
sgvr-gpu-016 Ready 0/4 10 (34%) 157 (59%) NVIDIA-GeForce-RTX-3090
sgvr-gpu-017 Ready 0/4 5 (16%) 127 (48%) NVIDIA-GeForce-RTX-3090
sgvr-gpu-018 Ready 0/4 23 (80%) 243 (91%) NVIDIA-GeForce-RTX-3090
sgvr-gpu-019 Ready 3/4 23 (80%) 194 (72%) NVIDIA-GeForce-RTX-3090
sgvr-gpu-020 Ready 0/4 21 (73%) 78 (29%) NVIDIA-GeForce-RTX-3090-Ti
sgvr-gpu-021 Ready 1/2 16 (77%) 32 (49%) -
sgvr-gpu-022 Ready 4/4 28 (98%) 269 (100%) NVIDIA-GeForce-RTX-3090-Ti
sgvr-gpu-023 Ready 1/4 16 (55%) 166 (62%) NVIDIA-GeForce-RTX-3090-Ti
sgvr-gpu-024 Ready 1/4 25 (88%) 192 (72%) NVIDIA-GeForce-RTX-4090
    
```

Woobin Im 02/20/2024 12:08 AM
 Feeling your pod being slow? Check throttling status at
<https://sgvrcluster.kaist.ac.kr/grafana/d/b597dc14-30d0-4025-8ae3-5765f582dd13/pod-info?orgId=1&var-pod=All&from=1708351488417&to=1708355088417>
 This chart displays the throttling rate over time for each pod. A value of 0.2 for a pod indicates that it undergoes throttling for 20% of its operational duration.

Name	Mean	Max
son-02-seqnet-cuhk-each-each-13nnnnnnnn-bz1-0-njp8f	0.200	0.232
son-22-olmnetplus-prw-each-each-15nnnnnnnn-bz1-0-7qdzr	0.0747	0.145
son-22-olmnetplus-prw-each-each-14nnnnnnnn-bz1-0-v9skm	0.0707	0.138
son-17-olmnetplus-prw-each-each-12nnnnnnnn-bz1-0-llsq9	0.0559	0.132
lhseo-nba-b4-f18-convit-order-lr1e-4-ope-e100-mean-std	0.0504	0.110
son-25-seqnet-prw-each-each-12nnnnnnnn-bz1-0-54z62	0.0396	0.109
son-25-coat-cuhk-each-each-12nnnnnnnn-bz1-0-z7bfh	0.0426	0.0921
lhseo-nba-b4-f18-convit-order-lr1e-4-ope-e100	0.0699	0.0833
lhseo-nba-b4-f18-timesformer-time-lr1e-4-none-e100	0.0630	0.0783
lhseo-nba-b4-f18-timesformer-time-l5e-5-none-e100	0.0605	0.0766
lhseo-nba-b4-f18-convit-clis-lr1e-4-spe-e100	0.0619	0.0736
son-21-olmnetplus-prw-each-each-13nnnnnnnn-bz1-0-bmq7h	0.0179	0.0497
son-17-seqnet-prw-gg-each-13nnnnnnnn-bz1-0-r6sl6	0.0202	0.0459

😬 2

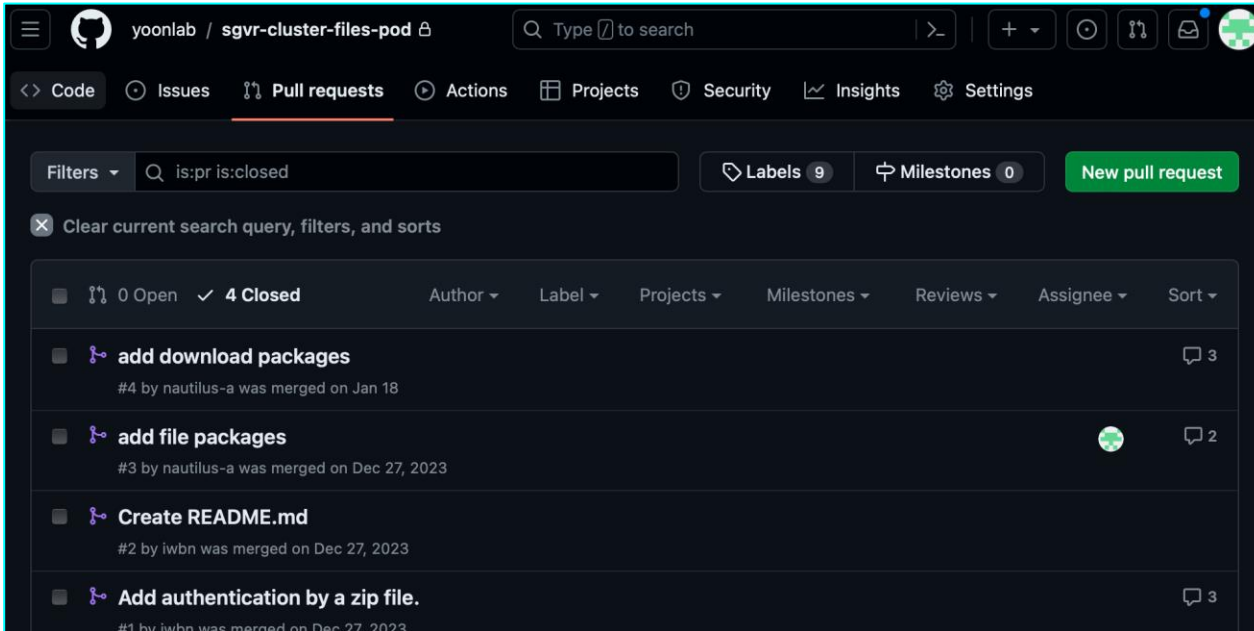
Woobin Im 02/20/2024 12:15 PM
 Will reboot sgvr-gpu-003 due to a hardware issue

Wooyung Son 02/20/2024 11:37 PM
 24번 서버 ssd1 200G 정도 정리하였습니다!
 👍 1

Kyubeom Han 02/20/2024 11:38 PM
 24번 서버 ssd1 200G 정도 정리하였습니다!

Open-Source Community

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



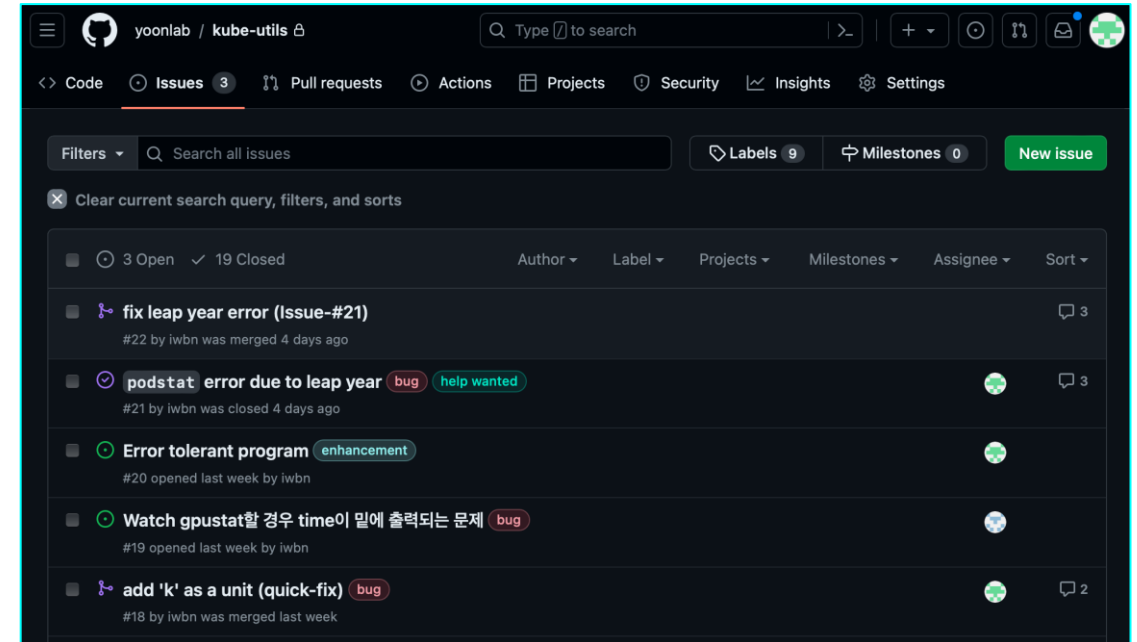
yoonlab / sgvr-cluster-files-pod

Code Issues Pull requests Actions Projects Security Insights Settings

Filters is:pr is:closed Labels 9 Milestones 0 New pull request

Clear current search query, filters, and sorts

0 Open	4 Closed	Author	Label	Projects	Milestones	Reviews	Assignee	Sort



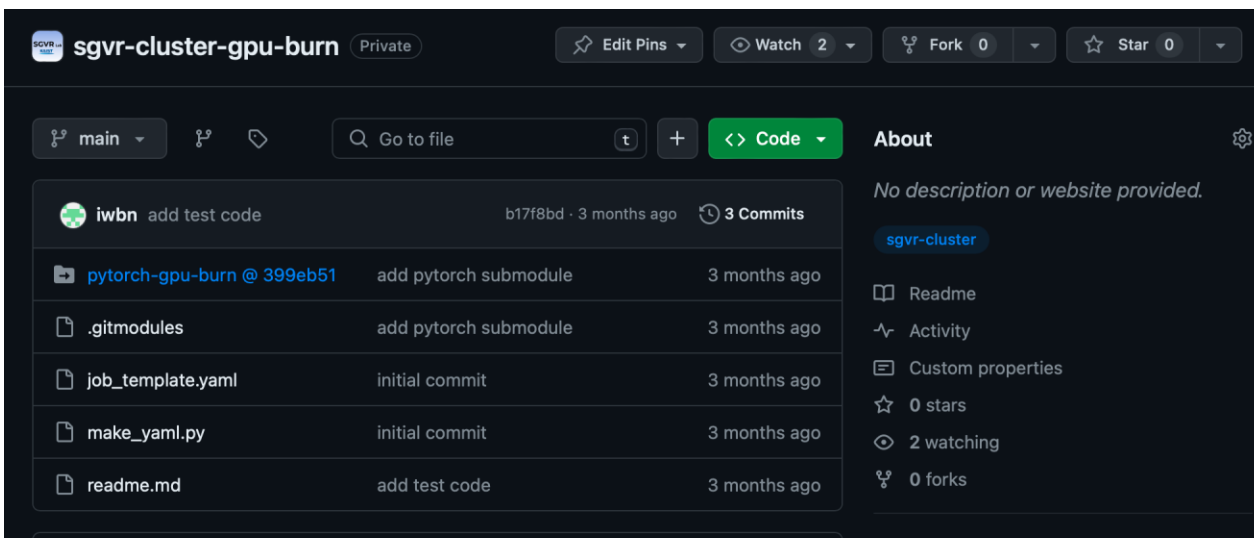
yoonlab / kube-utils

Code Issues 3 Pull requests Actions Projects Security Insights Settings

Filters Search all issues Labels 9 Milestones 0 New issue

Clear current search query, filters, and sorts

3 Open	19 Closed	Author	Label	Projects	Milestones	Assignee	Sort



sgvr-cluster-gpu-burn Private

Edit Pins Watch 2 Fork 0 Star 0

main Go to file Code About

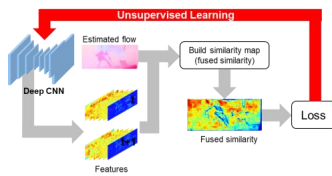
iwbn	add test code	b17f8bd · 3 months ago	3 Commits

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

Summary & Future Work

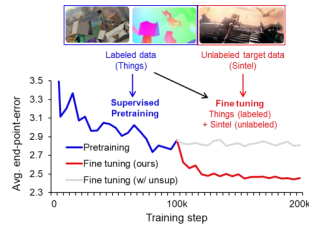
Advancing Video Motion Learning

2D Motion: Optical Flow



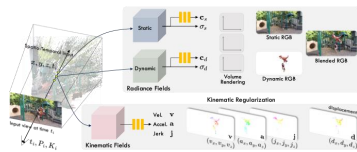
Woobin Im, Tae-Kyun Kim, Sung-Eui Yoon
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Finalist at Qualcomm Innovation Fellowship Korea ([QIFK](#))



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



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**

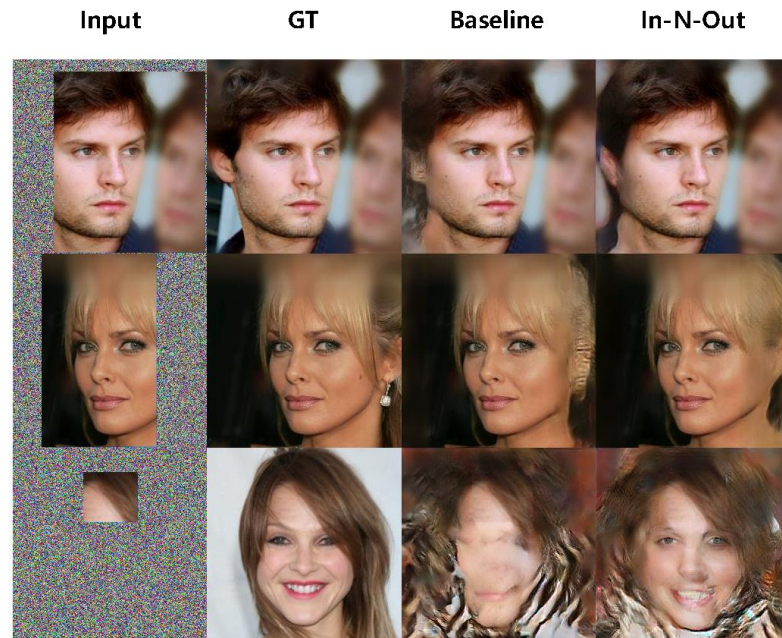


Figure from **In-N-Out**

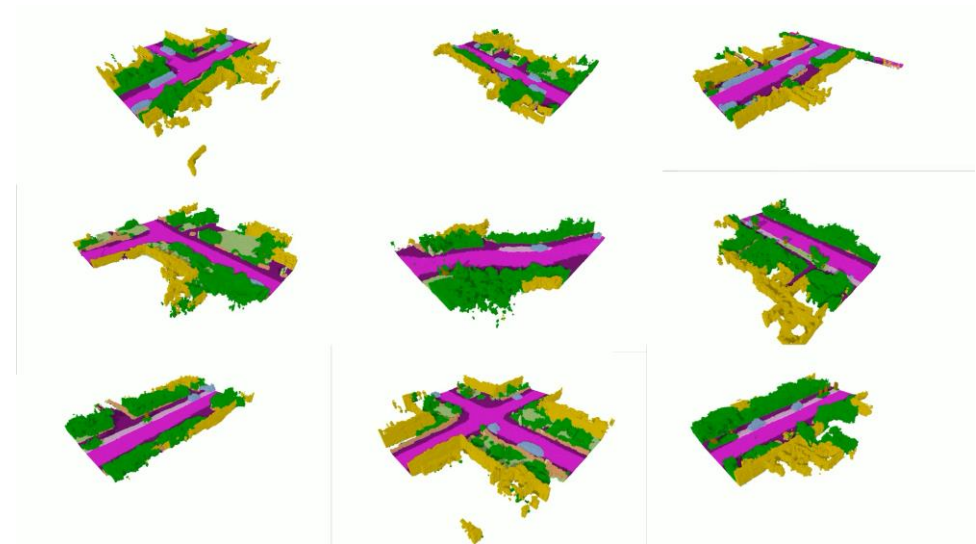
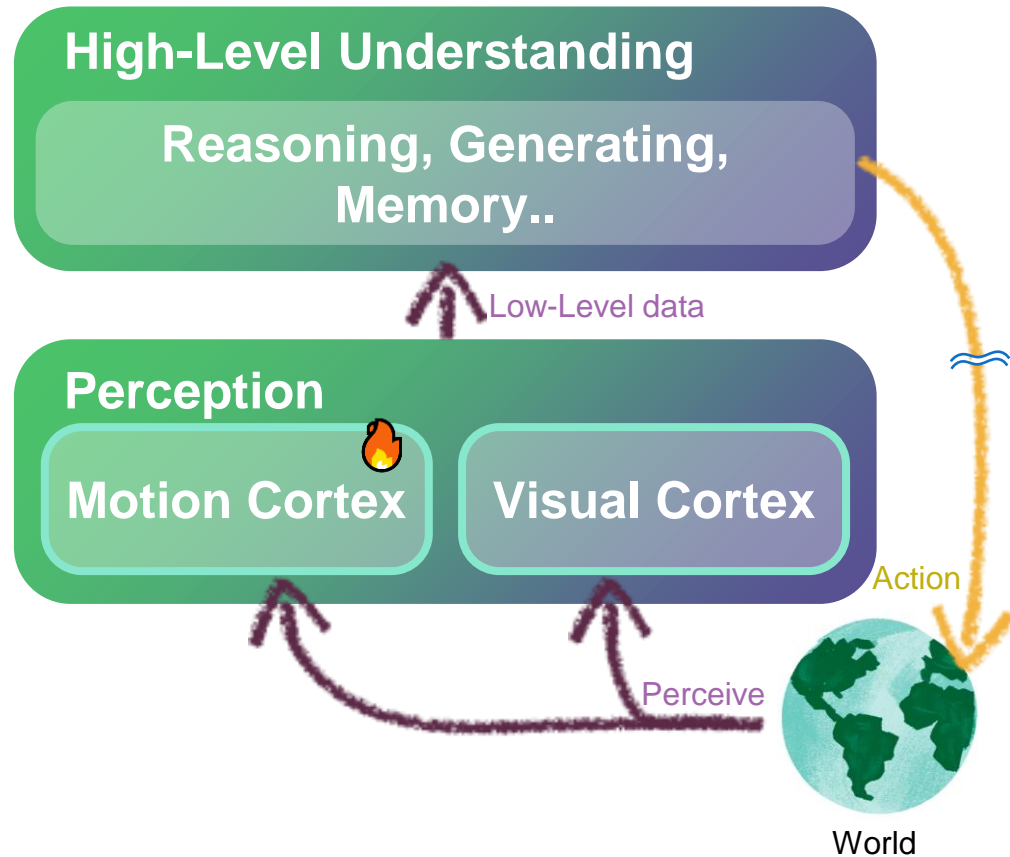


Figure from **SemCity**

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