Geometric Deep Learning Self-Study Group

Session 6

November 17, 2025

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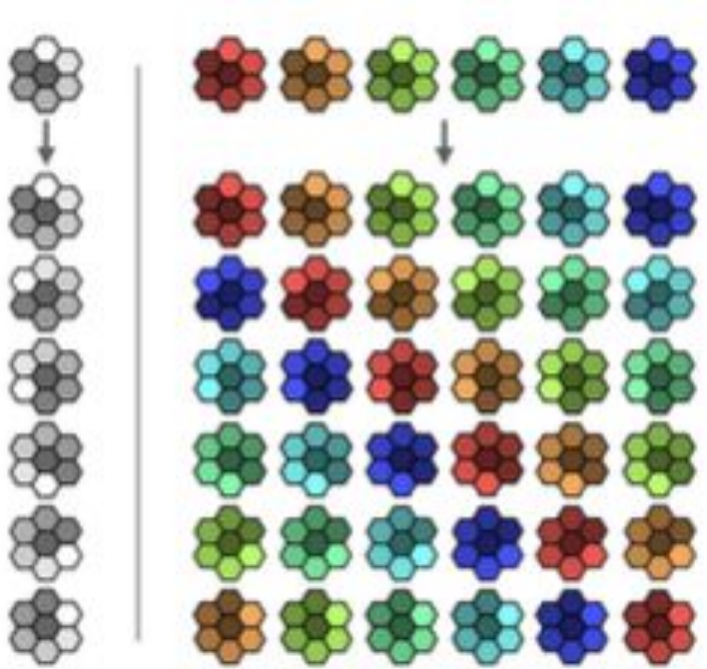
https://armargolis.github.io/

Session Outline

Equivariance and Invariance
Aaron (15 minutes)

Quantum Formalism Academy
Bambordé (15 minutes)

Homework
Aaron (30 minutes)

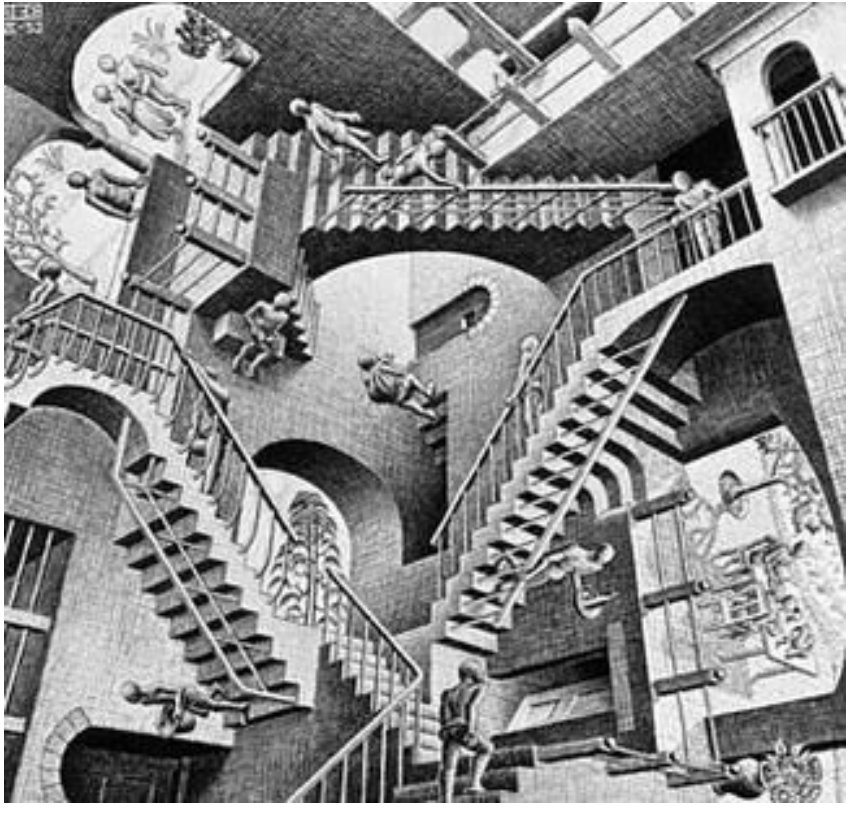


Source:
Taco Cohen, Maurice Weiler, Berkay Kicanaoglu, Max Welling
https://proceedings.mlr.press/v97/cohen19d/cohen19d.pdf

Remaining Sessions:
Dec 1: Manifolds

Equivariance

“A Change in Perspective is worth 80 IQ points.”
-Alan Kay

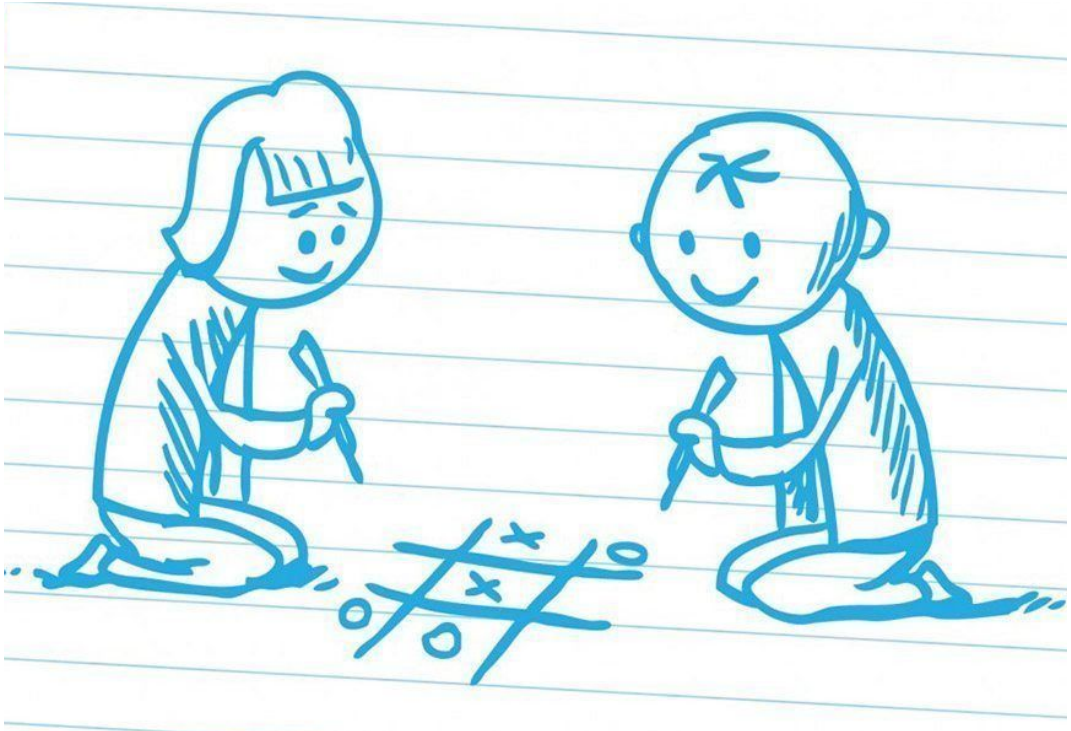


“Relativity”
by MC Escher

Invariance and Equivariance

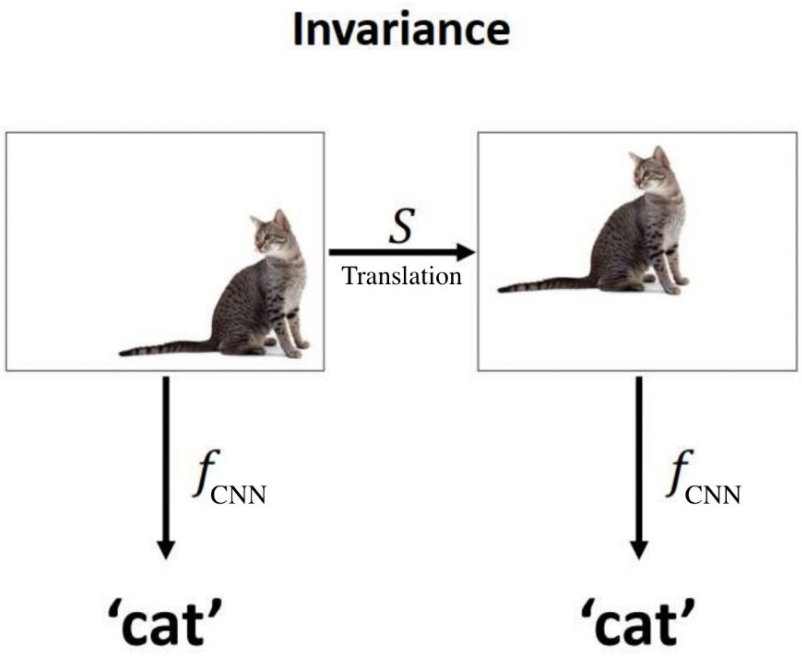
Invariant:
Number of X's and O's
Who has won

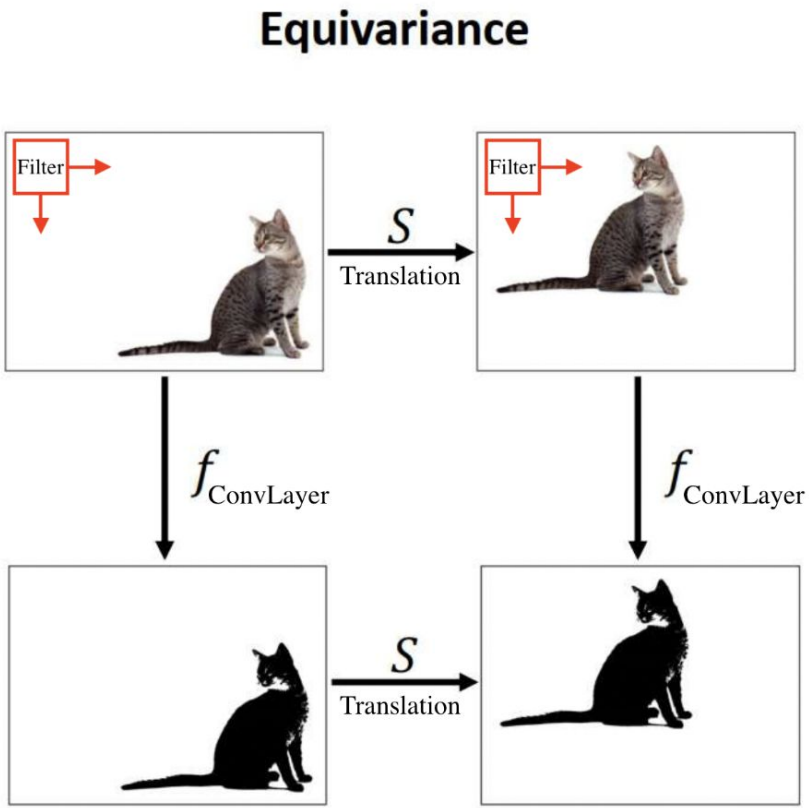
Equivariant:
Each square- lower right corner
to her is upper left corner to him



https://www.youcubed.org/tasks/tic-tac-toe-sums/

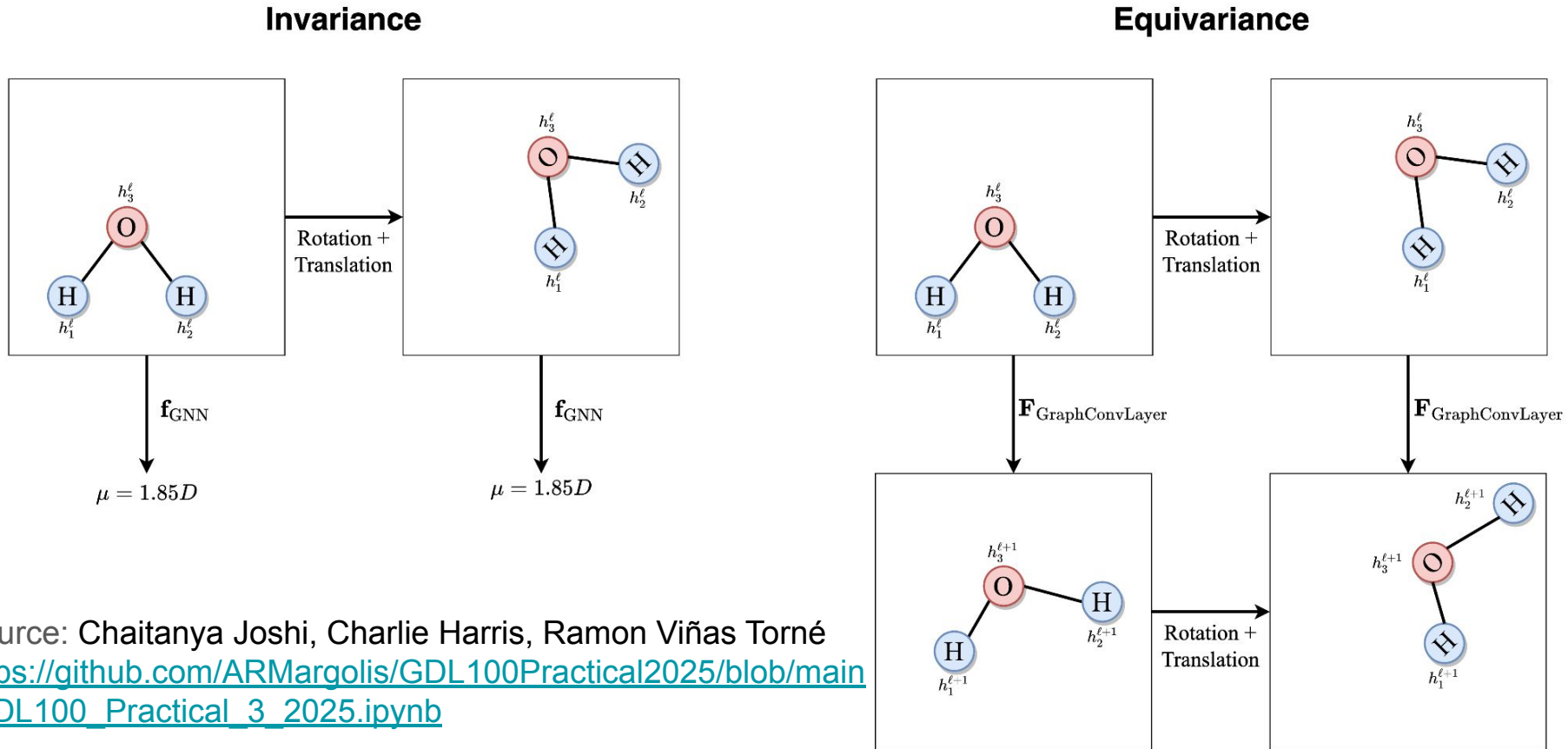
Invariance and Equivariance in 2D





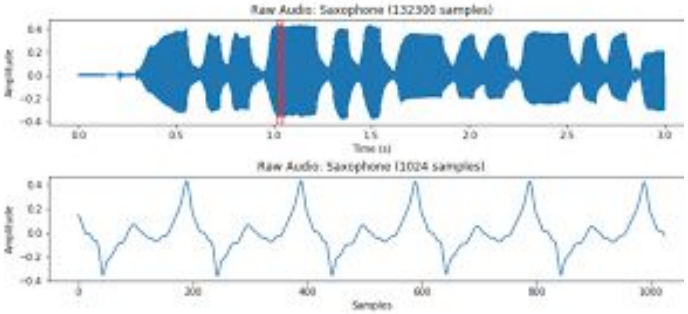
Source: Chaitanya Joshi, Charlie Harris, Ramon Viñas Torné
https://github.com/ARMargolis/GDL100Practical2025/blob/main/GDL100_Practical_3_2025.ipynb

Invariance and Equivariance in 3D

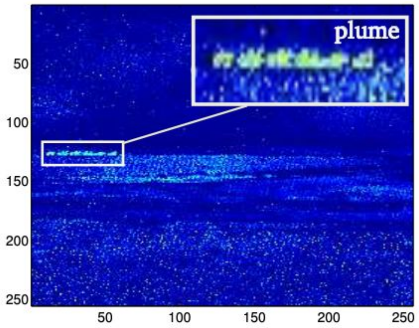


Source: Chaitanya Joshi, Charlie Harris, Ramon Viñas Torné
https://github.com/ARMargolis/GDL100Practical2025/blob/main/GDL100_Practical_3_2025.ipynb

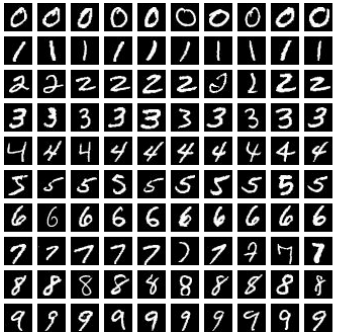
Invariant, Equivariant or Neither?



Sound Identification

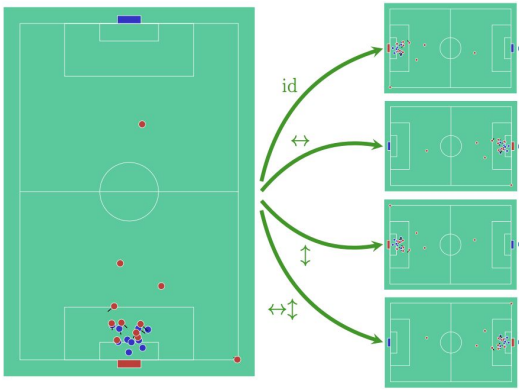


Plume Detection

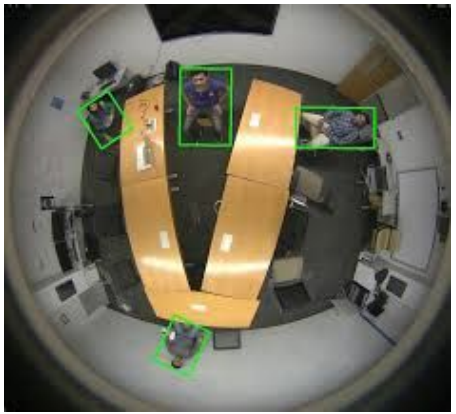


MNIST

Satellite Imagery

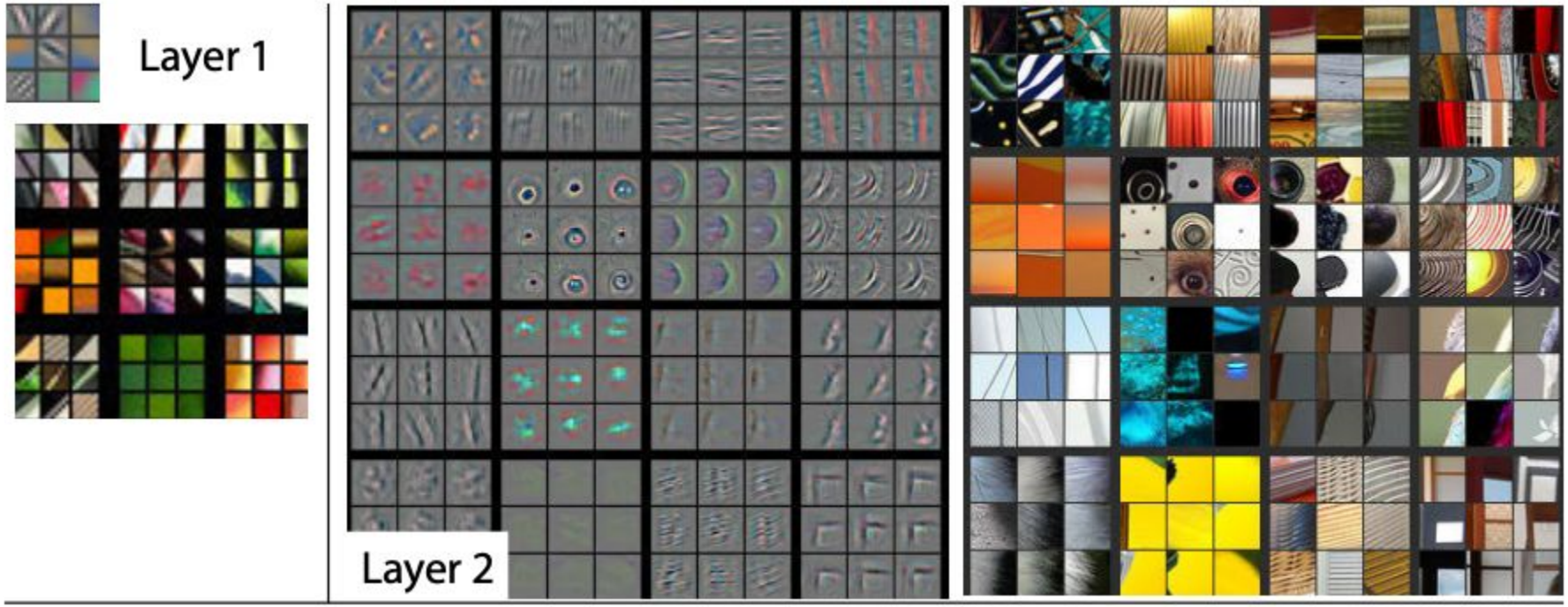


Sports (Corner Kicks)



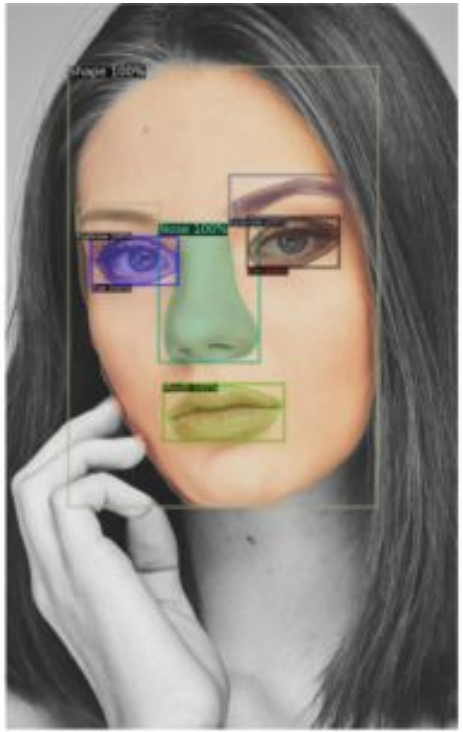
Fisheye Lenses

Equivariance: Layer by Layer



Source: Visualizing and Understanding Convolutional Networks
By Matthew D. Zeiler, Rob Fergus

Picasso Problem: The wrong type of invariance



Source:
Valentina Gliozzi, Gian Luca Pozzato, Alberto Valese
https://www.sciencedirect.com/science/article/abs/pii/S0141938222000439

Tip for the homework

https://colab.research.google.com/drive/1h7U15-qFC2yy6roRIfLPk5TSlo6sONsm

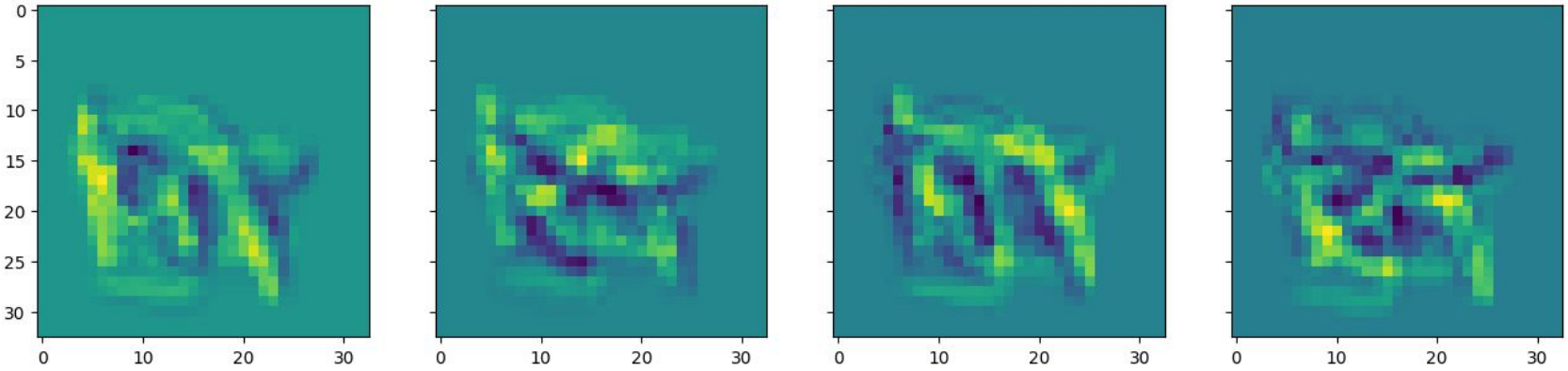
To make it easier to see what convolutions are doing, replace the randomly generated inputs with MNIST

```
from torchvision import datasets, transforms
from torch.utils.data import DataLoader
import torch

transform = transforms.ToTensor()
train_dataset = datasets.MNIST(root="./data", train=True, download=True, transform=transform)

x = torch.zeros(batchsize, in_channels, S, S)
for i in range(batchsize):
 for j in range(in_channels):
   x[i, j, :28, :28]=train_dataset[batchsize*i+j][0]
```

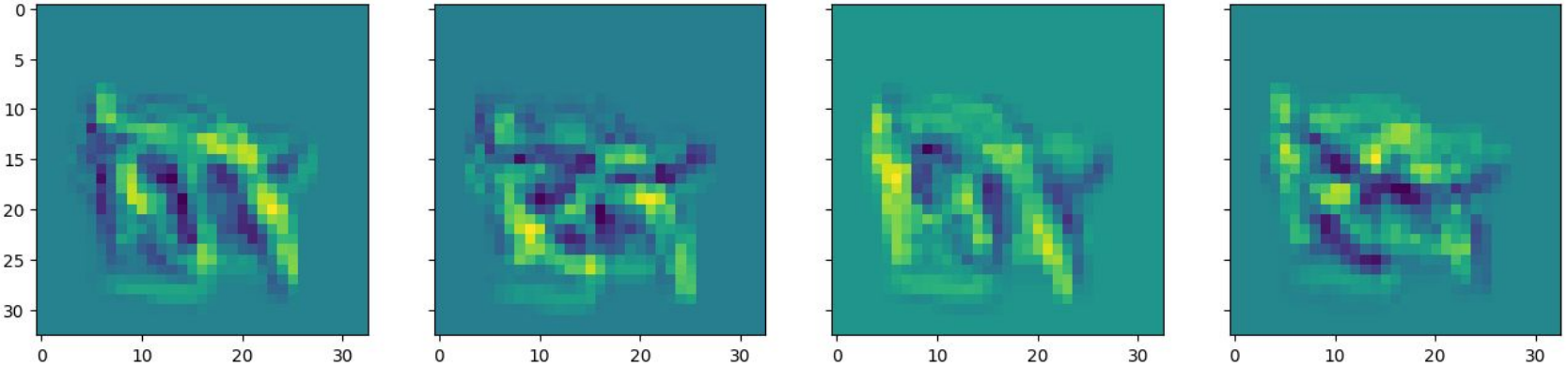
Tip for the homework (Result)

https://colab.research.google.com/drive/1h7U15-qFC2yy6roRIfLPk5TSlo6sONsm

g(Psi(x))



Psi(g(x))



References and Resources

Main Reference:
Geometric Deep Learning: Grids, Groups, Graphs, Geodesics, and Gauges
Michael M. Bronstein, Joan Bruna, Taco Cohen, Petar Veličković
https://geometricdeeplearning.com/book/ We'll use the chapters rather than the big pdf

Additional References:
Mathematical Foundations of Geometric Deep Learning by Borde and Bronstein
https://www.arxiv.org/abs/2508.02723
Introduction to Geometric Deep Learning by Patrick Nicolas
https://patricknicolas.substack.com/p/introduction-to-geometric-deep-learning

Further Reading:
Valence Labs
https://portal.valencelabs.com

Graph Learning on Wednesdays
https://sites.google.com/view/graph-learning-on-weds