

Machine Learning for SuperNEMO Tracking

Adam Mendl

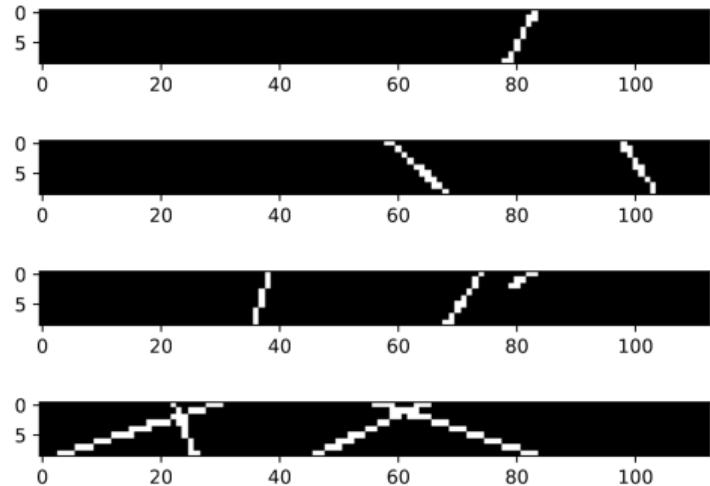
Institute of Experimental and Applied Physics, Czech Technical University in Prague
Faculty of Mathematics and Physics, Charles University

SuperNEMO Collaboration Meeting; July 3 2023



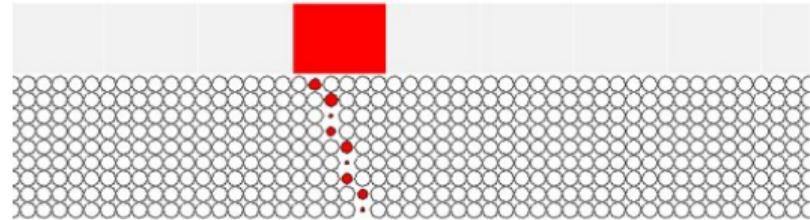
Goals and Outline

- ▶ Counting tracks in event



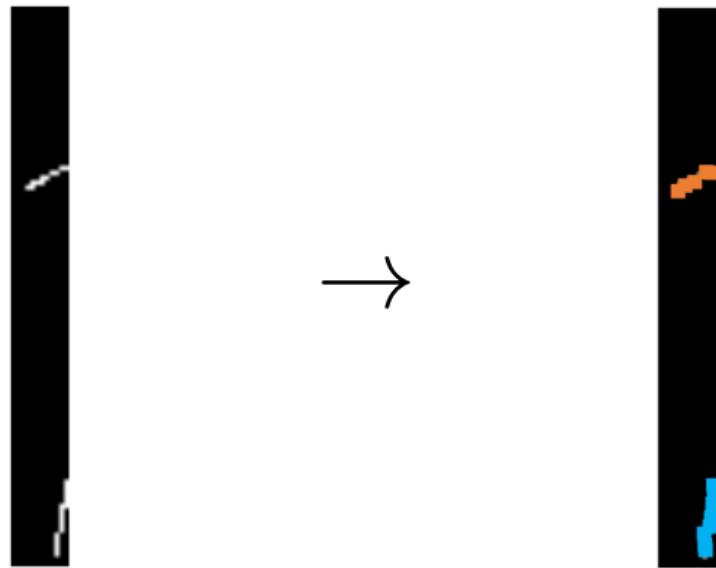
Goals and Outline

- ▶ Counting tracks in event
- ▶ Associated calorimeter hits



Goals and Outline

- ▶ Counting tracks in event
- ▶ Associated calorimeter hits
- ▶ Clustering tracker hits



Goals and Outline

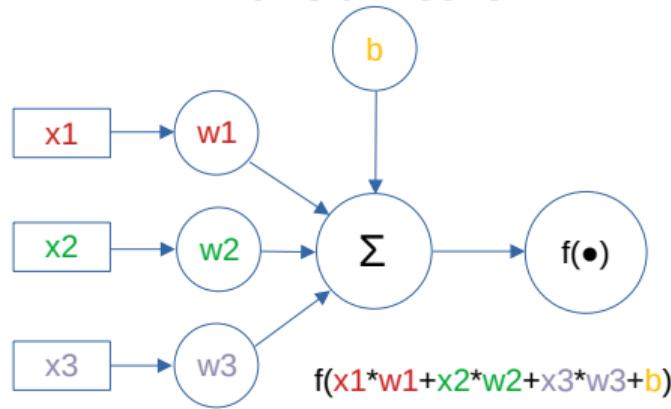
- ▶ Counting tracks in event
- ▶ Associated calorimeter hits
- ▶ Clustering tracker hits
- ▶ CapsNET



[Hinton et al., 2018]

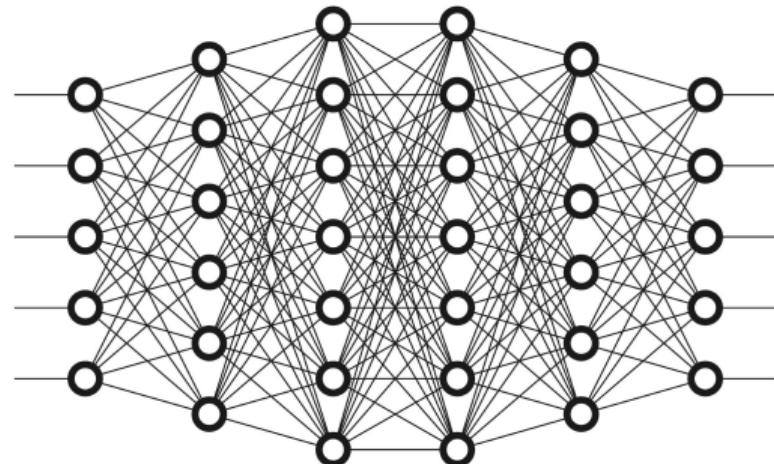
Neural Networks

Artificial neuron

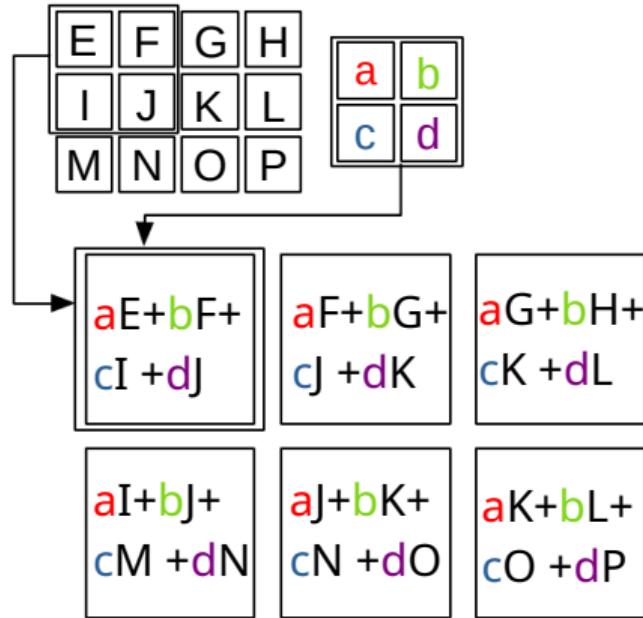


f ... nonlinear (usually arcus tangent like) function

Deep fully connected neural network

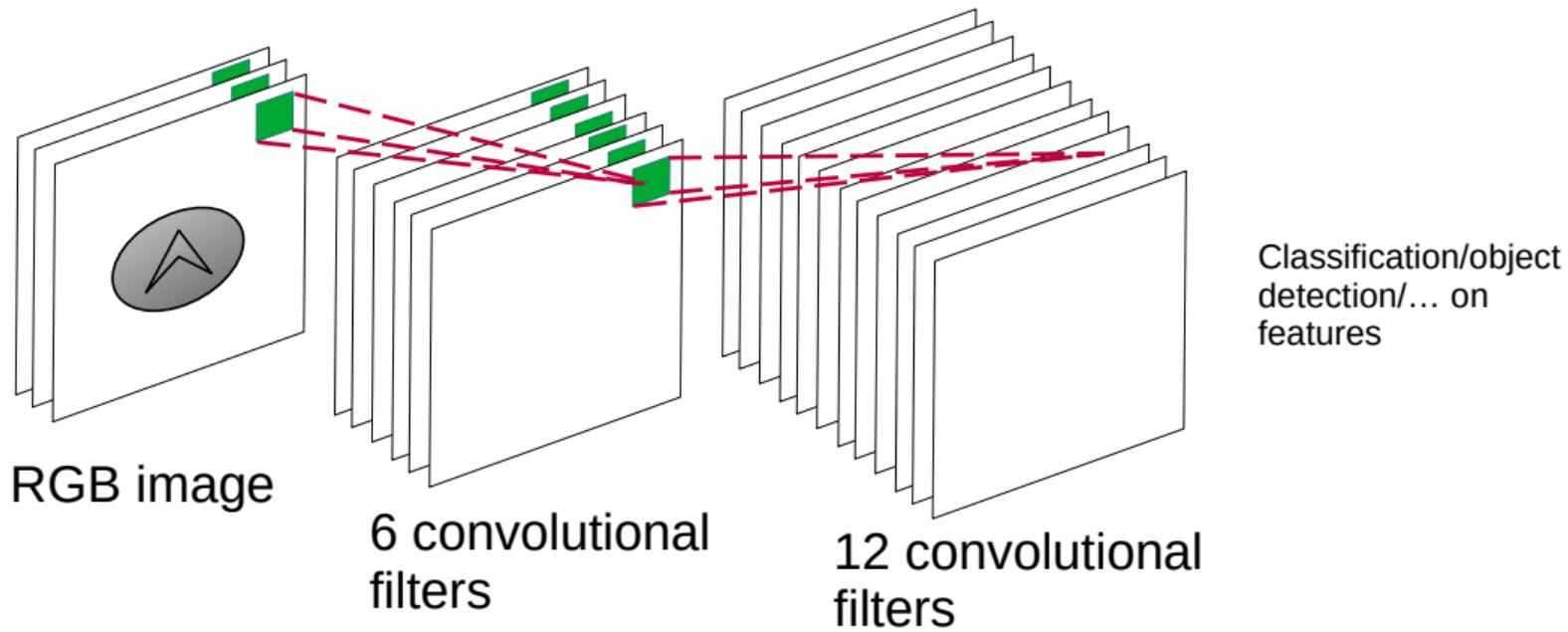


Convolution

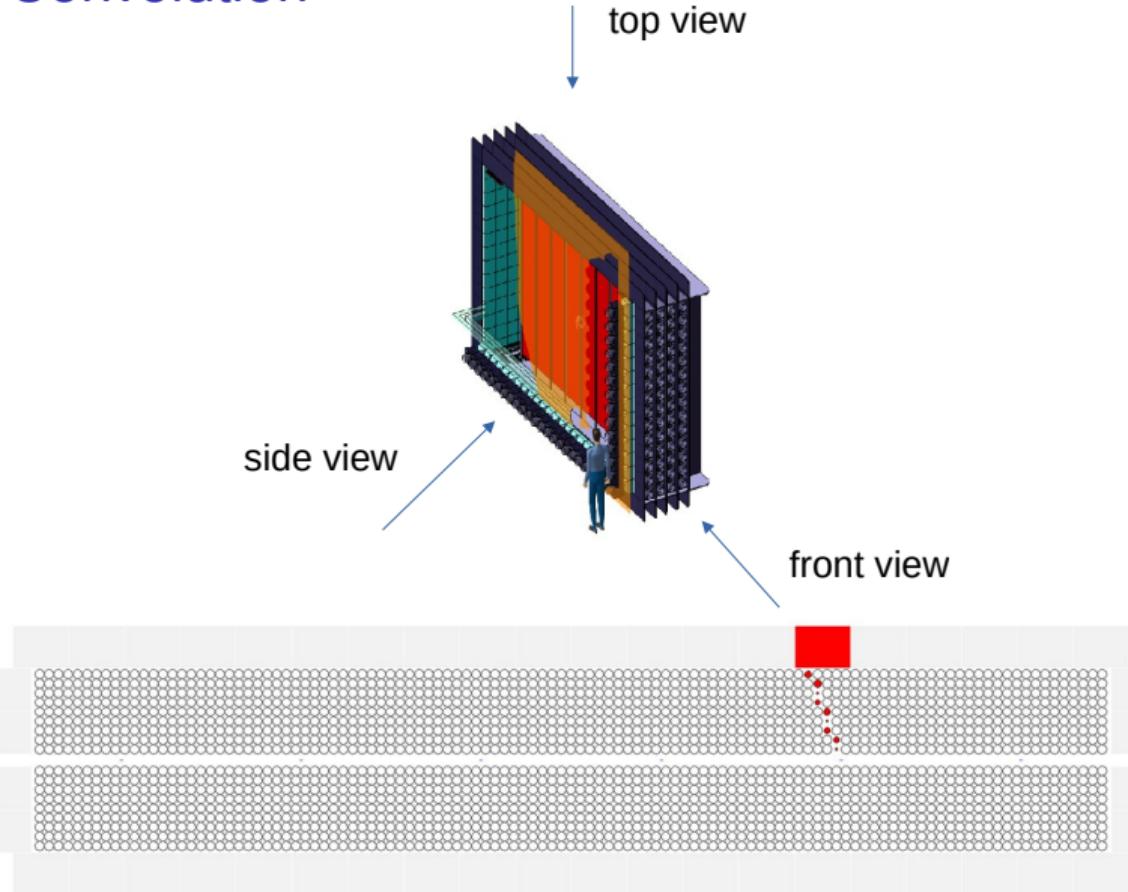


Convolutions applied to an image

Convolutional Neural Network



Tracker and Convolution

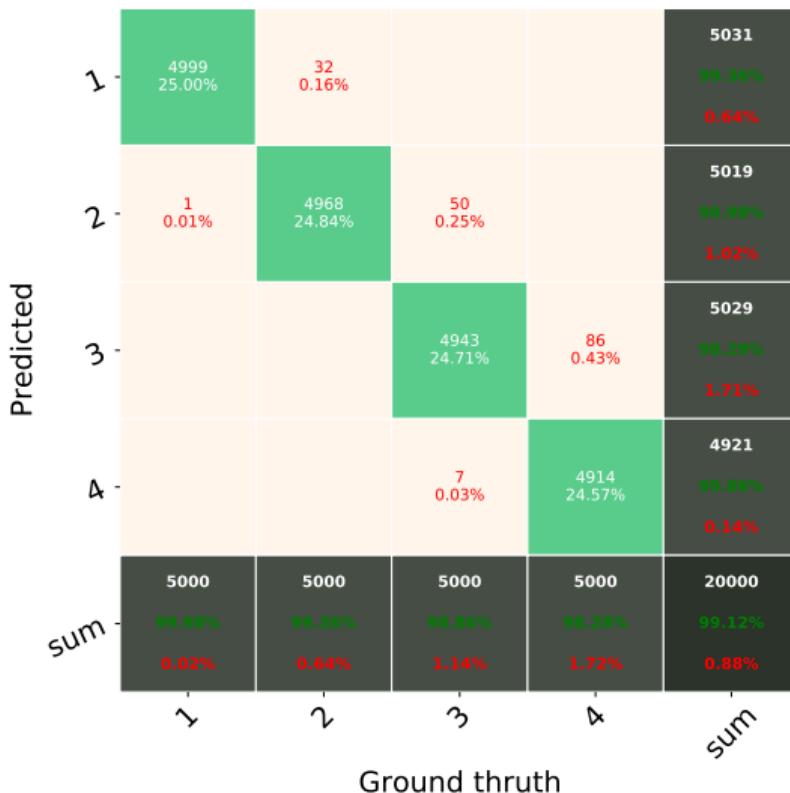


Single/Multi Label Classification



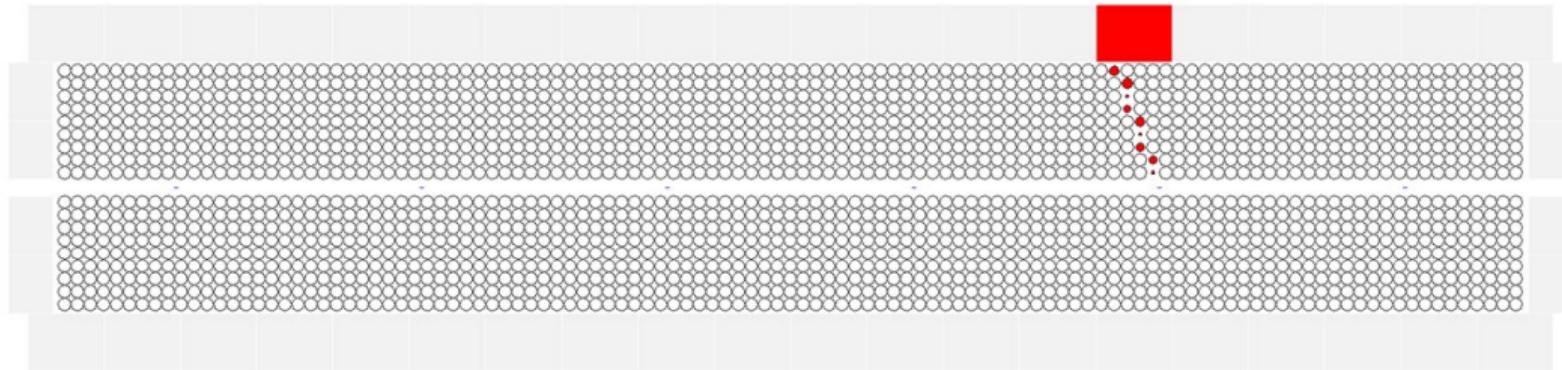
car	1
person	1
truck	0
train	0
plane	0
pedestrian crossing	1
hellicopter	0

Tracks Counting - Single Label Classification



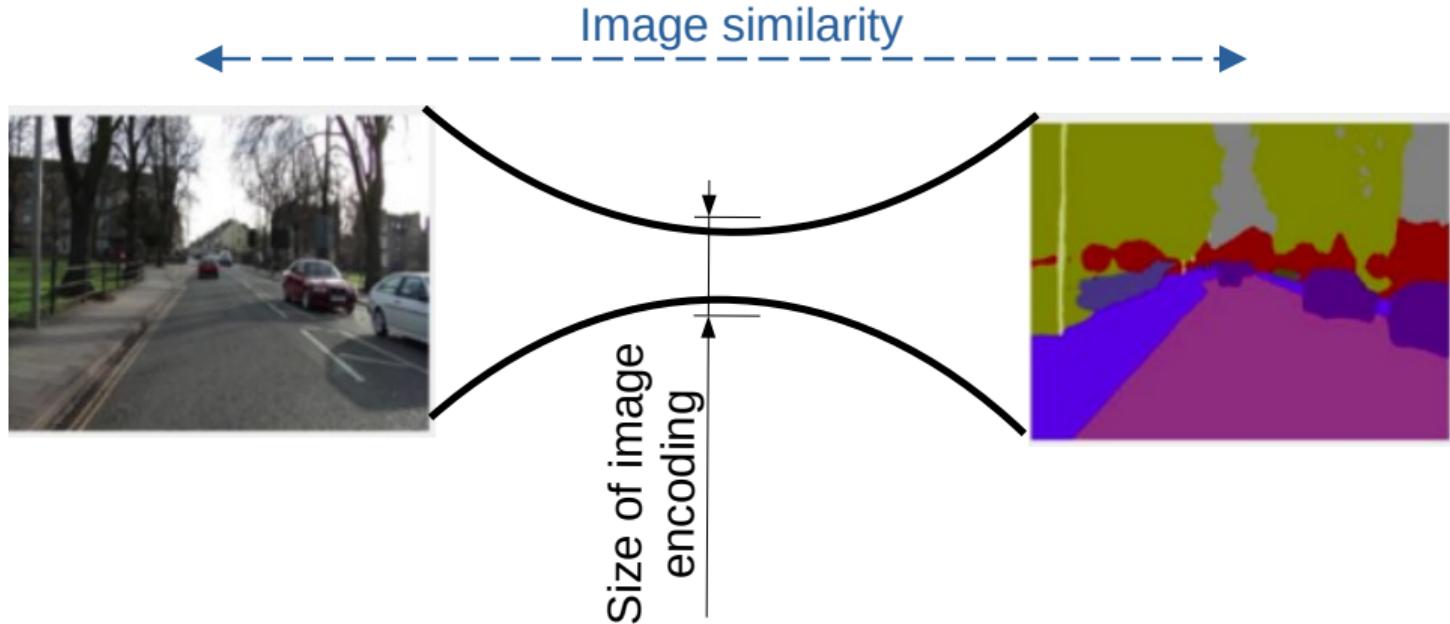
- ▶ SN-I Egenerator
- ▶ Top/Front/Side model trained on 180k events.
- ▶ Transfer learning on 70k events.
- ▶ Tested on 20k events.

Associated Calohit - Multi Label Classification

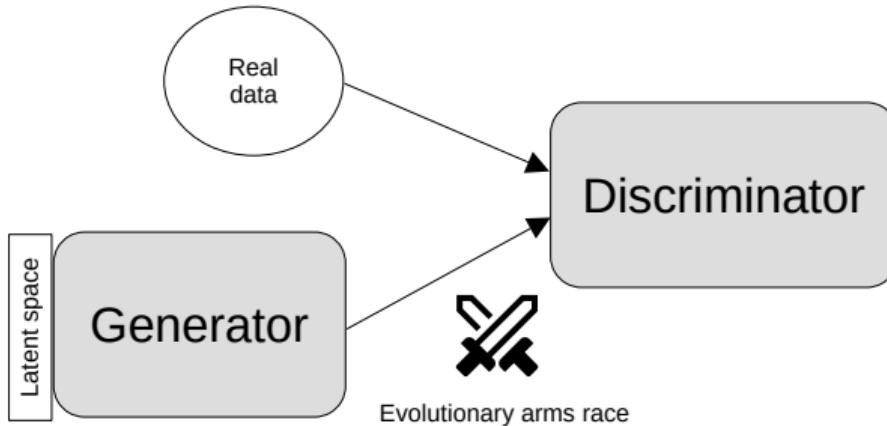


- ▶ Row/Column of calorimeter is label

Clustering Tracker Hits - Convolutional Autoencoders

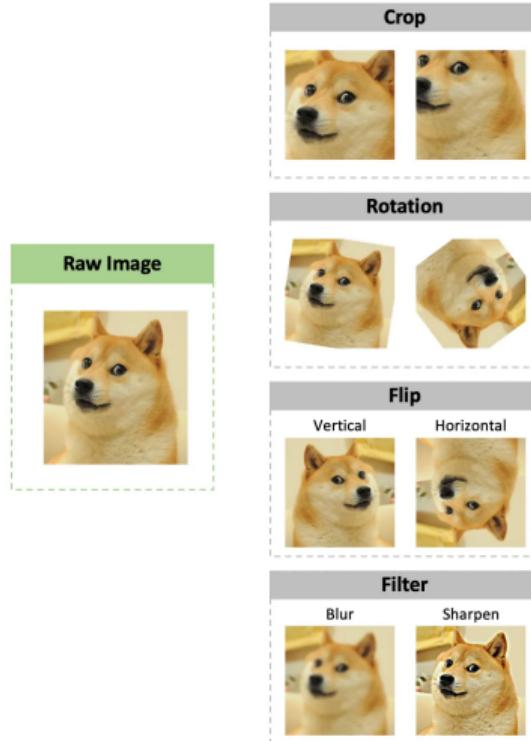


Clustering Tracker Hits - Generative Adversarial Networks



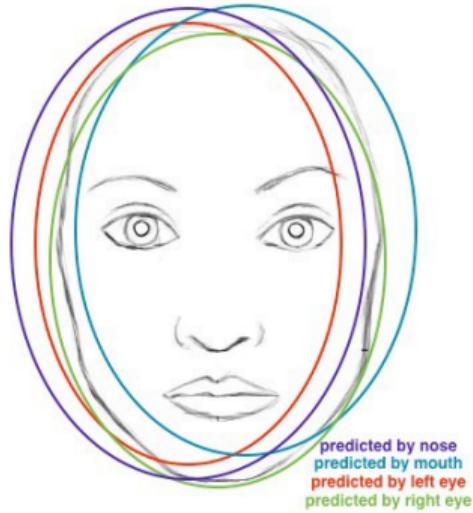
- ▶ **Discriminator** tries to distinguish between real data samples and artificially generated samples.
- ▶ **Generator** tries to fool discriminator

Beyond Convolution - CapsNET

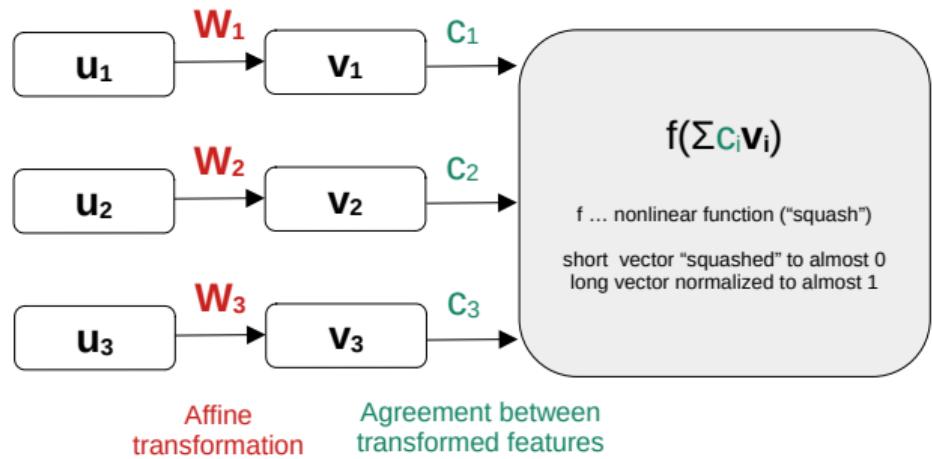


[Hinton et al., 2018]

Beyond Convolution - CapsNET



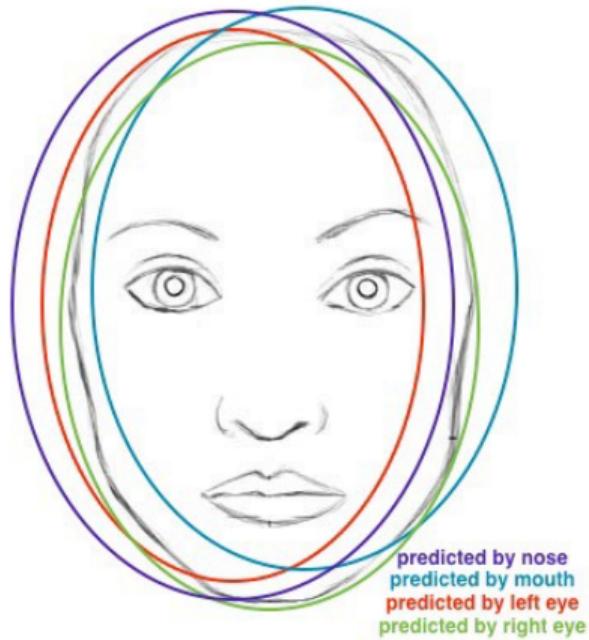
[Pechyonkin, 2017]



Adds [attention mechanism](#) [Vaswani et al., 2017] into architecture

Beyond Convolution - CapsNET

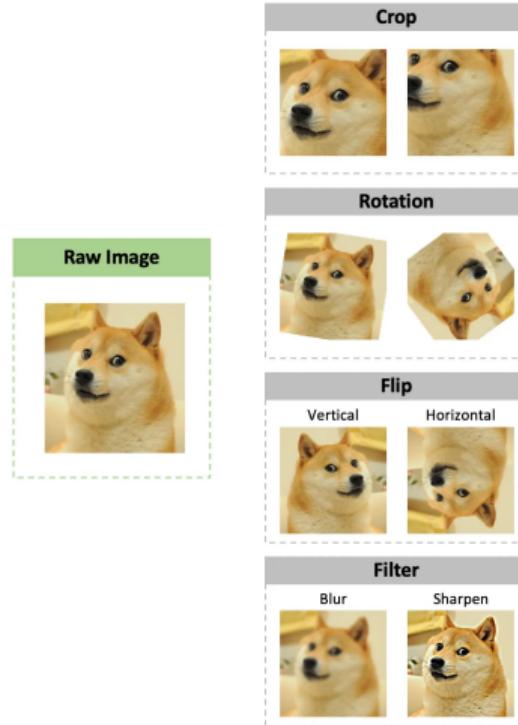
- ▶ Convolutional Layer
- ▶ Primary Capsule Layer
- ▶ Capsule Layer 1
- ▶ ...
- ▶ Capsule Layer N



[Pechyonkin, 2017]

Beyond Convolution - CapsNET

- ▶ rotation and deformation invariant



Beyond Convolution - CapsNET

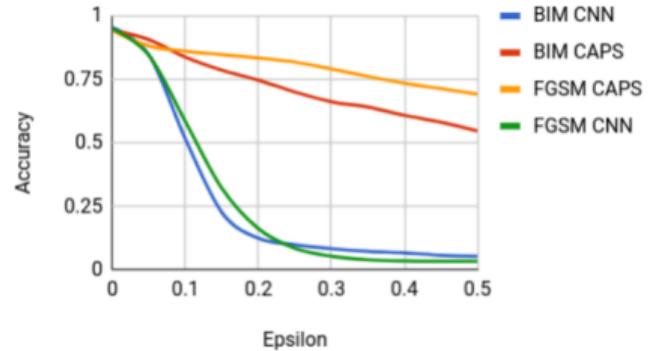
- ▶ rotation and deformation invariant
- ▶ mastered overlapping rotated digits



[Hinton et al., 2018]

Beyond Convolution - CapsNET

- ▶ rotation and deformation invariant
- ▶ mastered overlapping rotated digits
- ▶ robust



[Hinton et al., 2018]

Beyond Convolution - CapsNET

- ▶ rotation and deformation invariant
- ▶ mastered overlapping rotated digits
- ▶ robust
- ▶ smaller and faster model ?



Work in progress

- ▶ Train track counting algorithm on data from my generator.
- ▶ Finish associated calohit recognition (multi-label classification).
- ▶ Finish CapsNET implementation in TensorFlow.
- ▶ Clustering (GANs and autoencoders)

Github and Wiki

- ▶ https://github.com/amendl/SuperNEMO_ML_applications
- ▶ <https://nemo.lpc-caen.in2p3.fr/wiki/NEMO/SuperNEMO/Analysis/MLAdam>

Other links (within SuperNEMO):

Matteos repo (empty) <https://github.com/SuperNEMO-DBD/CNNforReconstruction>
SN-IEgenerator <https://github.com/SuperNEMO-DBD/SN-IEgenerator>
sndisplay <https://github.com/emchauve/sndisplay>

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Thank you for your attention