

# HexaConv

## Discussion

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# Traditional CNNs

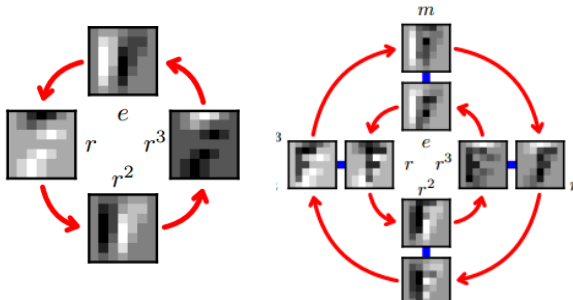
- Slide a FCN over image
- Hence weight sharing
- Equivariant to translation

# Group CNNs [1]

- Increase weight sharing by introducing more symmetry groups
- Rotation (around  $n\frac{\pi}{2}$ ) and flipping

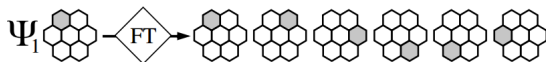
# Group CNNs [1]

- Slide a filter as well mirror and rotate it
- 4 rotations  $\times$  2 flipping = 8 symmetry groups
- Remains equivariant if image is rotated or flipped
- Parameter explosion, reduced by reducing number of filters per layer (which can be a downside)



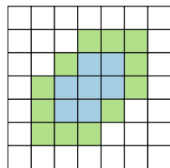
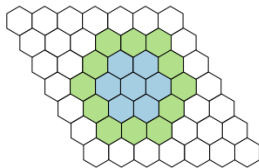
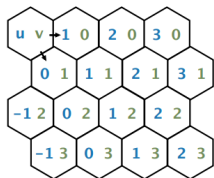
# HexaConv

- Same idea as Group CNNs
- But 6 groups of rotations  $\times$  2 for flipping = 12 symmetry groups



## Axial coordiante system

- Use bilinear interpolation for hexagonal sampling
- Store in axial coordinate system
- Maps hexagon to a parallelogram like structure in 2D memory
- Convolution can be done by using rectangular convolution



# HexaConv

- Convolution can be done by using rectangular convolution
- Followed by a masking operation
- Symmetry groups can be exploited by pre-computing indexes of the filters for the transformations

# Results

Table 1: CIFAR-10 performance comparison

Model	Error	Params
$\mathbb{Z}^2$	$11.50 \pm 0.30$	338000
$\mathbb{Z}^2$ Axial	$11.25 \pm 0.24$	337000
$p4$	$10.08 \pm 0.23$	337000
$p6$ Axial	$9.98 \pm 0.32$	336000
$p4m$	$8.96 \pm 0.46$	337000
$p6m$ Axial	$8.64 \pm 0.34$	337000

Table 2: AID performance comparison



Model	Error	Params
$\mathbb{Z}^2$	$19.3 \pm 0.34$	917000
$\mathbb{Z}^2$ Axial	$17.8 \pm 0.37$	916000
$p4$	$10.7 \pm 0.36$	915000
$p6$ Axial	$8.7 \pm 0.72$	916000
VGG (Transfer)	$9.8 \pm 0.50$	-



# Images

Full credit of all the images goes to the following two papers.

# References I

-  T. Cohen and M. Welling, “Group equivariant convolutional networks,” in *International Conference on Machine Learning*, pp. 2990–2999, 2016.
-  E. Hoogeboom, J. W. Peters, T. S. Cohen, and M. Welling, “Hexaconv,” *arXiv preprint arXiv:1803.02108*, 2018.