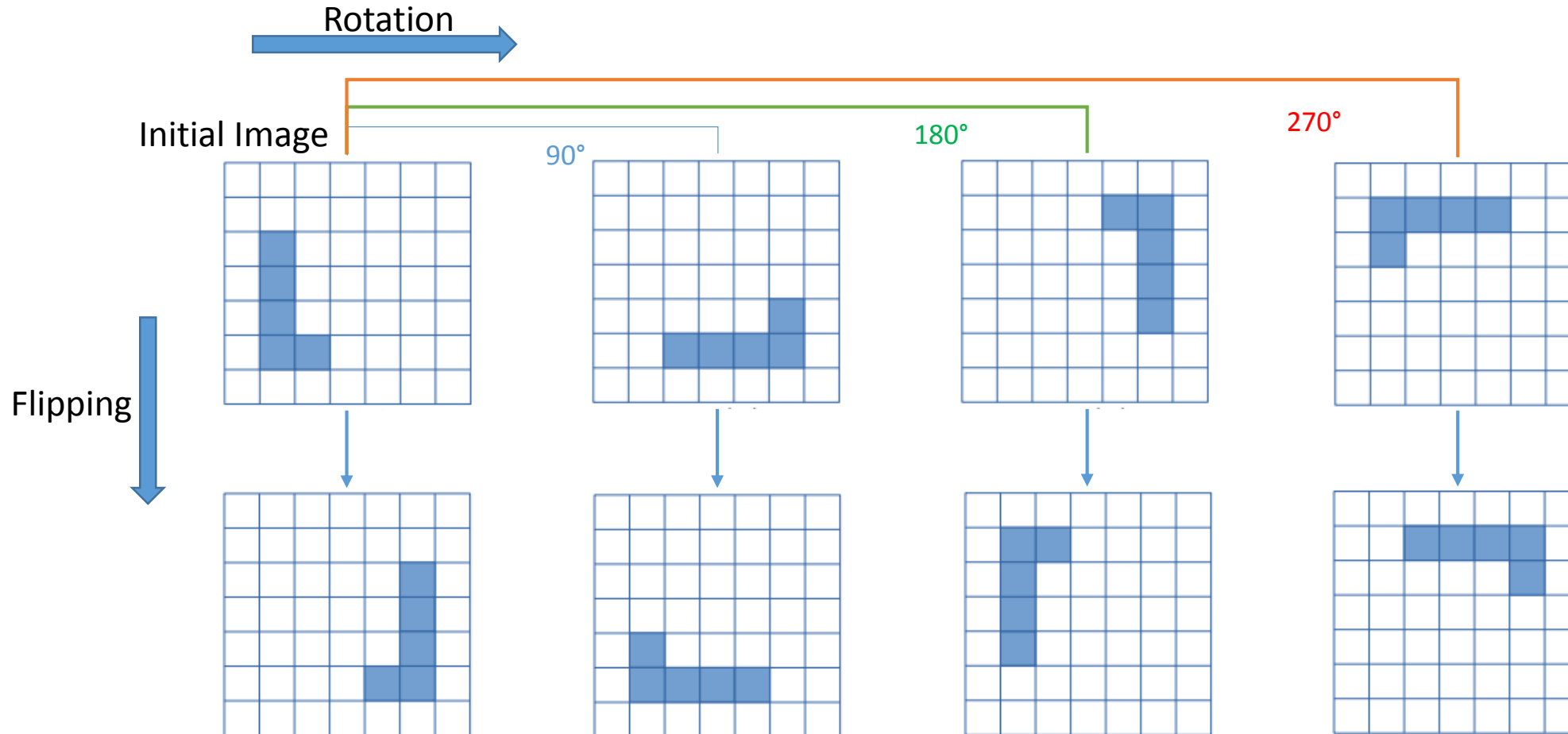


# Spatial Data Augmentation Using Geometric Transformations

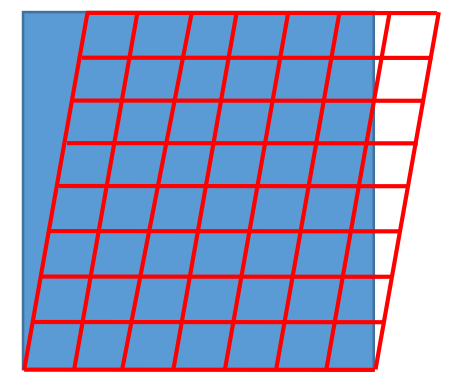
Salim MALEK

- The objective of data augmentation in deep learning is to avoid overfitting and increase the generalization capability of the trained model.
- 2 augmentation techniques using geometric transformations are applied:
- Rotation :  $90^\circ$ ,  $180^\circ$  and  $270^\circ$
- Flipping : called also reflection

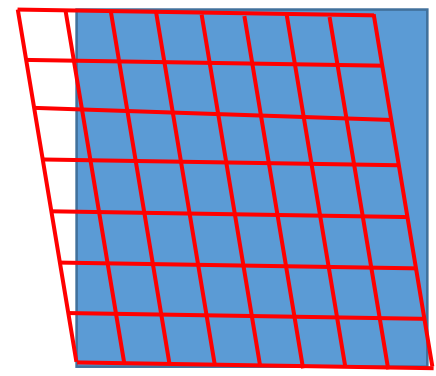
## Geometric Transformations: Rotation + Flipping (mirror reflection)



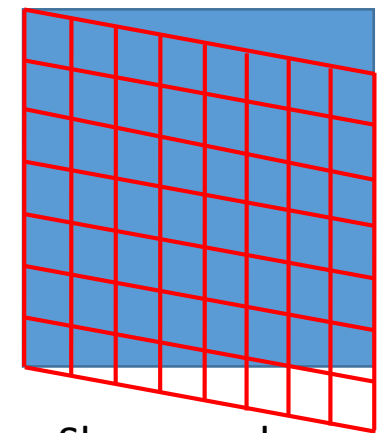
# Geometric Transformations: Shearing



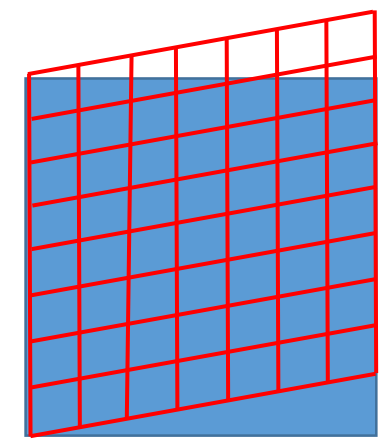
Shear left-right



Shear right-left



Shear up-down



Shear down-up

## CNN Spatial classification Strategy

### Train on 3 Phases:

- Phase I (P.I) : train only the 2 last fully connected layers
- Phase II (P.II) : train only the first convolutional layer
- Phase III (P.III) : train both the first convolutional layer and the 2 last fully connected layers

Model	learning rate pattern		
	P.I	P.II	P.III
$M_{min}$	$10^{-4}$	$10^{-4}$	$10^{-4}$
$M_{avg_1}$	$10^{-3}$	$10^{-3}$	$10^{-4}$
$M_{avg_2}$	$10^{-3}$	$10^{-3}$	$10^{-3}$
$M_{max}$	$10^{-4}$	$10^{-3}$	$10^{-3}$

Models used for the comparison (training with/without augmented data)

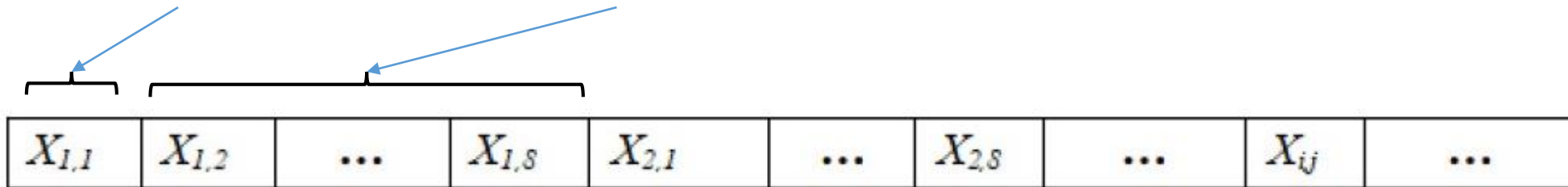
## Results 1: impact of using augmented data

Model	Training with augmented data	
	no	yes
$M_{min}$	89.39 ± 0.00	<b>93.18 ± 0.00</b>
$M_{avg_1}$	90.83 ± 0.43	<b>94.39 ± 0.73</b>
$M_{avg_2}$	90.91 ± 0.00	<b>94.62 ± 1.15</b>
$M_{max}$	93.56 ± 0.40	<b>93.94 ± 0.00</b>
Average	91.17 ± 0.64	94.03 ± 0.47

Results of classification with and without using Augmented data

## Results 2: impact of arranging training data in blocks

Origin sample and its augmentations ...



Model	block-based training	
	no	yes
$M_{min}$	93.11 ± 0.24	<b>93.18 ± 0.00</b>
$M_{avg1}$	94.24 ± 0.39	<b>94.39 ± 0.73</b>
$M_{avg2}$	93.03 ± 1.63	<b>94.62 ± 1.15</b>
$M_{max}$	91.67 ± 0.00	<b>91.74 ± 0.24</b>
Average	93.01 ± 0.56	<b>93.48 ± 0.53</b>

BLOCK-BASED VS SHUFFLING TRAINING DATA BEFORE THE TRAINING

## Results 2: impact of number of epochs

Training						Testing	
with augmented data			learning rate			Accuracy %	
P.I	P.II	P.III	P.I	P.II	P.III	1000ep	125ep
No	No	No	$10^{-3}$	$10^{-3}$	$10^{-3}$	$90.91 \pm 0^*$	$90.98 \pm 0.24$
			$10^{-3}$	$10^{-3}$	$10^{-4}$	$90.83 \pm 0.43^*$	$90.53 \pm 0.40$
No	No	Yes	$10^{-3}$	$10^{-3}$	$10^{-3}$	$94.62 \pm 1.15$	$94.47 \pm 0.62$
			$10^{-3}$	$10^{-3}$	$10^{-4}$	$94.39 \pm 0.73$	$95.08 \pm 0.40$
No	Yes	Yes	$10^{-3}$	$10^{-3}$	$10^{-3}$	$86.36 \pm 0$	$87.88 \pm 0$
			$10^{-3}$	$10^{-3}$	$10^{-4}$	$87.12 \pm 0$	$87.88 \pm 0$
No	No	No	$10^{-4}$	$10^{-3}$	$10^{-3}$	$93.56 \pm 0.4^{**}$	$93.18 \pm 0$
			$10^{-4}$	$10^{-4}$	$10^{-4}$	$89.39 \pm 1.75^{***}$	$89.39 \pm 0$
No	No	Yes	$10^{-4}$	$10^{-3}$	$10^{-3}$	$91.74 \pm 0.24$	$91.89 \pm 0.51$
			$10^{-4}$	$10^{-4}$	$10^{-4}$	$89.39 \pm 0$	$81.89 \pm 0.24$
No	Yes	Yes	$10^{-4}$	$10^{-3}$	$10^{-3}$	$93.94 \pm 0$	$93.18 \pm 0$
			$10^{-4}$	$10^{-4}$	$10^{-4}$	$93.18 \pm 0$	$86.97 \pm 0.32$

RESULTS OBTAINED USING 1000 EPOCHS AND 125 EPOCHS.



Thank you for your attention