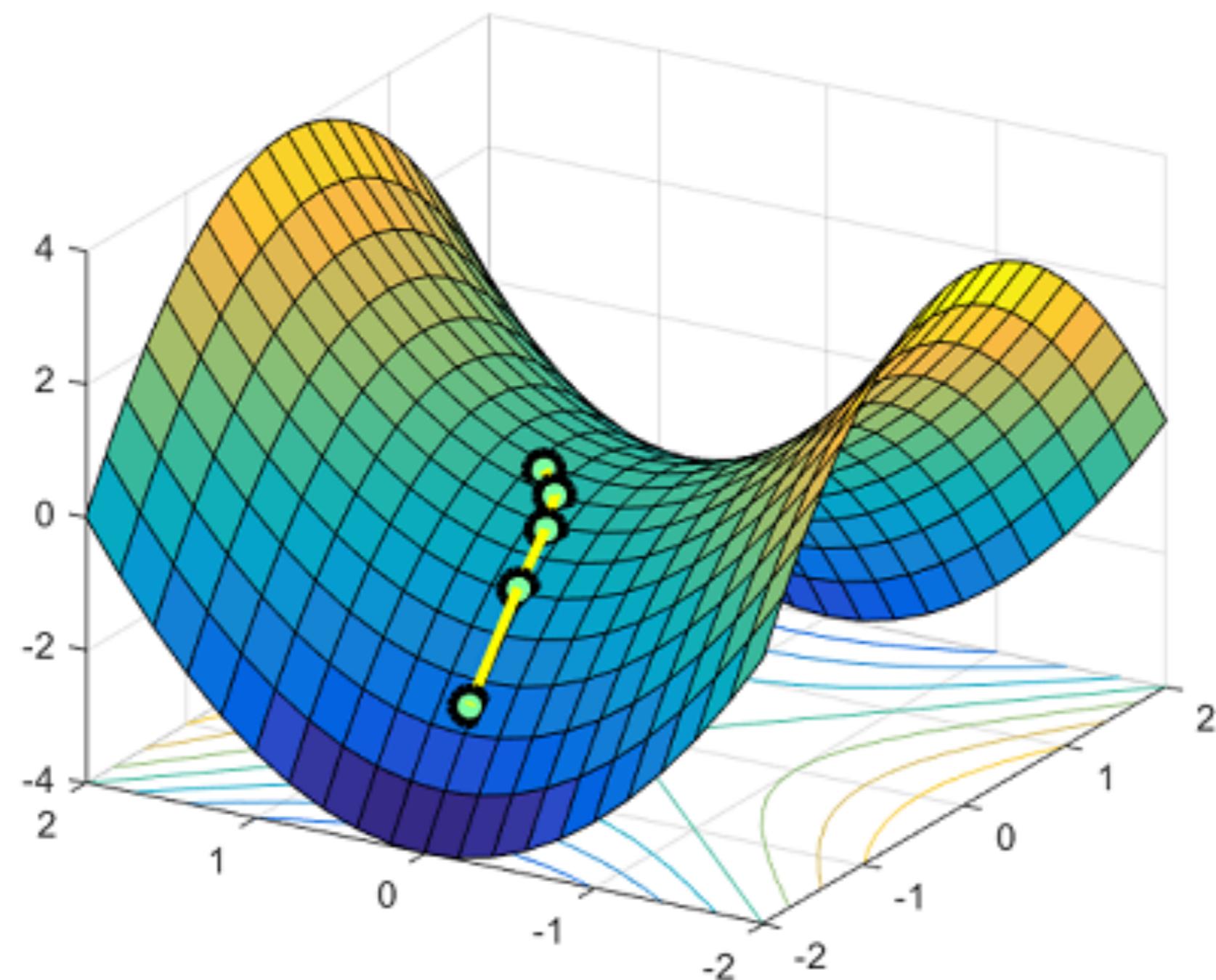
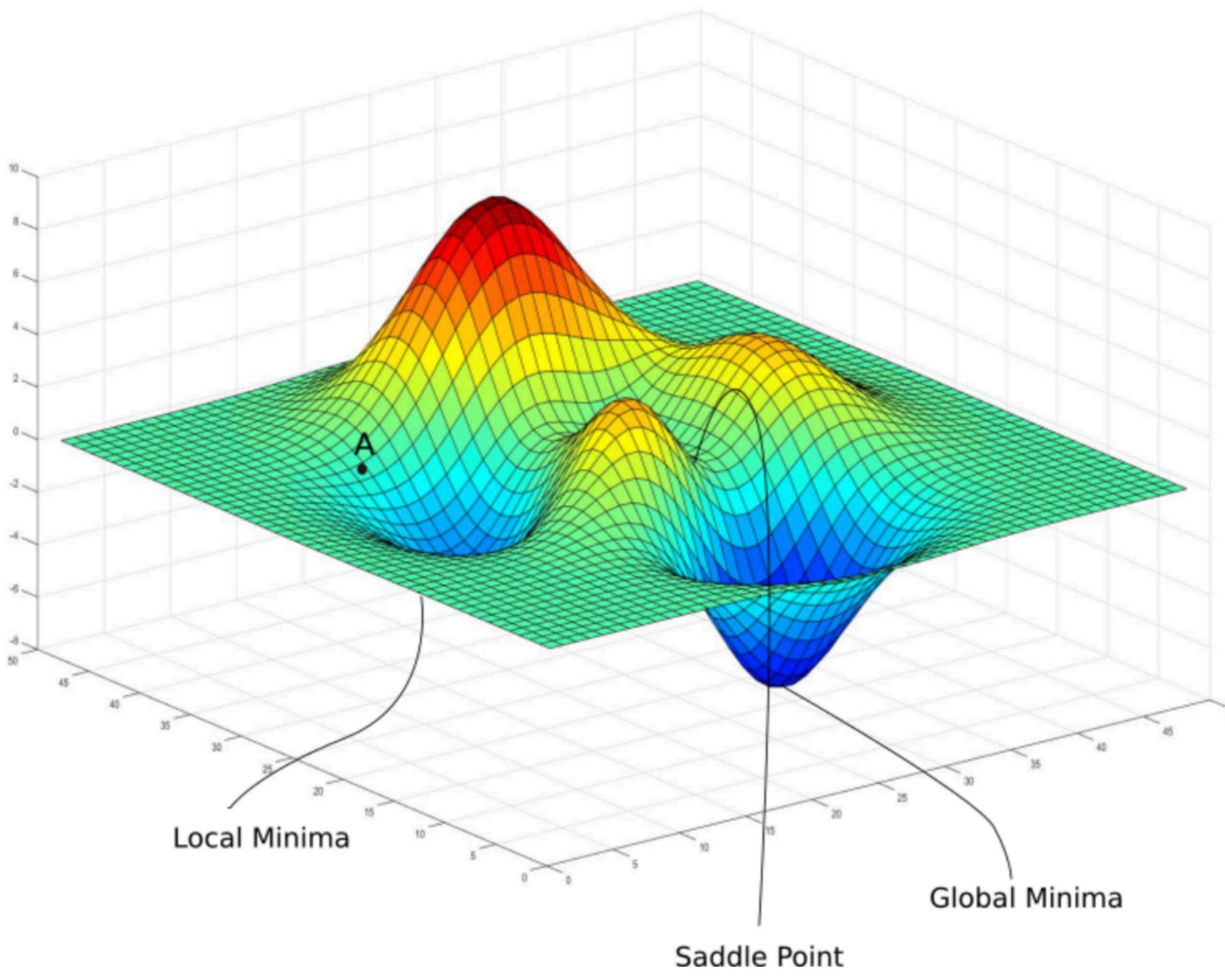
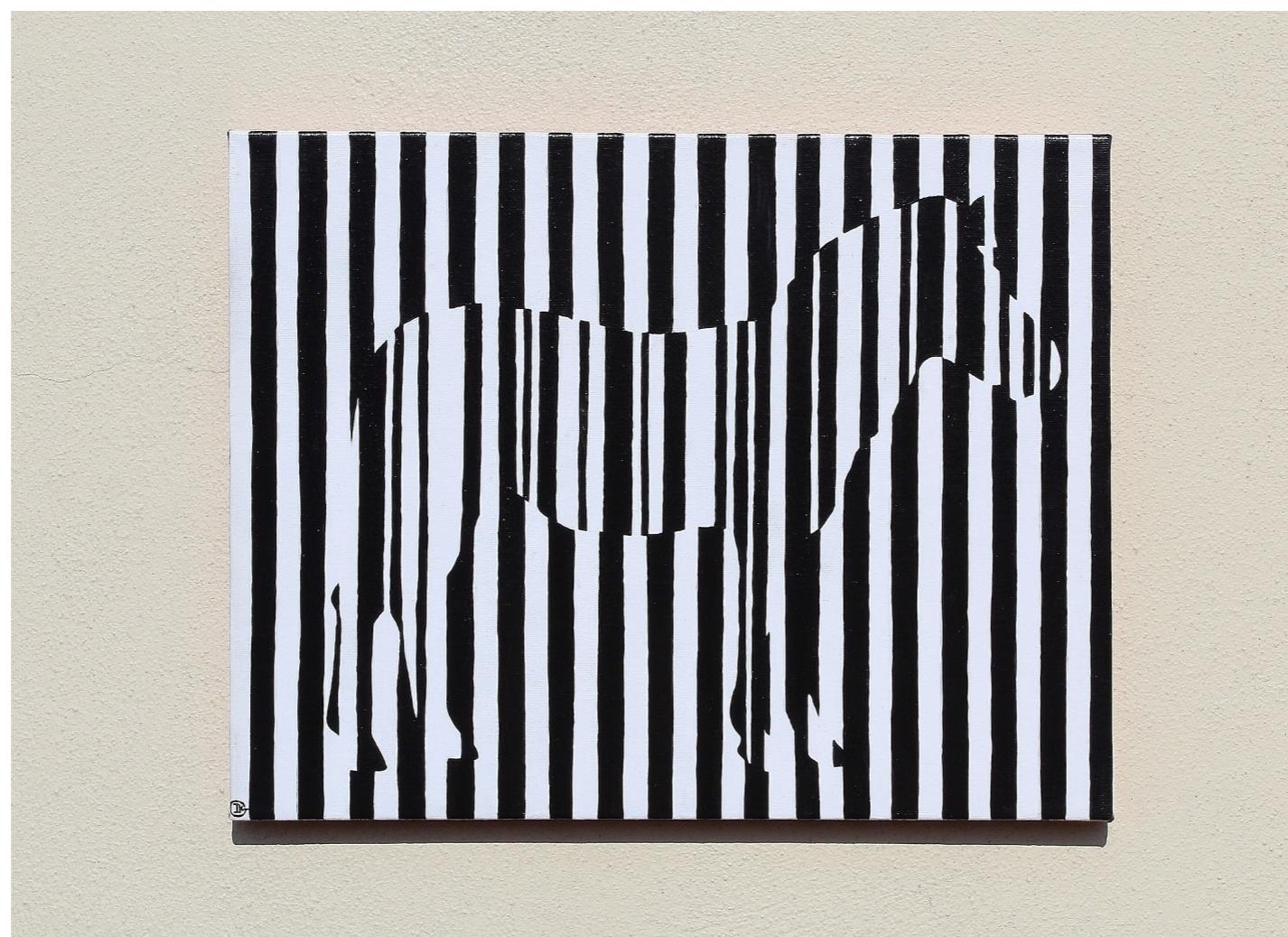


SC201

Lecture 13







10	10	10	0	0	0
10	10	10	0	0	0
10	10	10	0	0	0
10	10	10	0	0	0
10	10	10	0	0	0
10	10	10	0	0	0

*

-1	0	1
-1	0	1
-1	0	1

=

10	10	10	0	0	0
10	10	10	0	0	0
10	10	10	0	0	0
10	10	10	0	0	0
10	10	10	0	0	0
10	10	10	0	0	0

*

-1	0	1
-1	0	1
-1	0	1

=



10	10	10	0	0	0
10	10	10	0	0	0
10	10	10	0	0	0
10	10	10	0	0	0
10	10	10	0	0	0
10	10	10	0	0	0

*

-1	0	1
-1	0	1
-1	0	1

=



10	10	10	0	0	0
10	10	10	0	0	0
10	10	10	0	0	0
10	10	10	0	0	0
10	10	10	0	0	0
10	10	10	0	0	0

*

-1	0	1
-1	0	1
-1	0	1

=

0			



10	10	10	0	0	0
10	10	10	0	0	0
10	10	10	0	0	0
10	10	10	0	0	0
10	10	10	0	0	0
10	10	10	0	0	0

*

-1	0	1
-1	0	1
-1	0	1

=

0			



10	10	10	0	0	0
10	10	10	0	0	0
10	10	10	0	0	0
10	10	10	0	0	0
10	10	10	0	0	0
10	10	10	0	0	0

*

-1	0	1
-1	0	1
-1	0	1

=

0	-30		



10	10	10	0	0	0
10	10	10	0	0	0
10	10	10	0	0	0
10	10	10	0	0	0
10	10	10	0	0	0
10	10	10	0	0	0

*

-1	0	1
-1	0	1
-1	0	1

=

0	-30		



10	10	10	0	0	0
10	10	10	0	0	0
10	10	10	0	0	0
10	10	10	0	0	0
10	10	10	0	0	0
10	10	10	0	0	0

*

-1	0	1
-1	0	1
-1	0	1

=

0	-30	-30	



10	10	10	0	0	0
10	10	10	0	0	0
10	10	10	0	0	0
10	10	10	0	0	0
10	10	10	0	0	0
10	10	10	0	0	0

*

-1	0	1
-1	0	1
-1	0	1

=

0	-30	-30	0



10	10	10	0	0	0
10	10	10	0	0	0
10	10	10	0	0	0
10	10	10	0	0	0
10	10	10	0	0	0
10	10	10	0	0	0

*

-1	0	1
-1	0	1
-1	0	1

=

0	-30	-30	0



10	10	10	0	0	0
10	10	10	0	0	0
10	10	10	0	0	0
10	10	10	0	0	0
10	10	10	0	0	0
10	10	10	0	0	0

*

-1	0	1
-1	0	1
-1	0	1

=

0	-30	-30	0
0			



10	10	10	0	0	0
10	10	10	0	0	0
10	10	10	0	0	0
10	10	10	0	0	0
10	10	10	0	0	0
10	10	10	0	0	0

*

-1	0	1
-1	0	1
-1	0	1

=

0	-30	-30	0
0			



10	10	10	0	0	0
10	10	10	0	0	0
10	10	10	0	0	0
10	10	10	0	0	0
10	10	10	0	0	0
10	10	10	0	0	0

*

-1	0	1
-1	0	1
-1	0	1

=

0	-30	-30	0
0	-30		



10	10	10	0	0	0
10	10	10	0	0	0
10	10	10	0	0	0
10	10	10	0	0	0
10	10	10	0	0	0
10	10	10	0	0	0

*

-1	0	1
-1	0	1
-1	0	1

=

0	-30	-30	0
0	-30		



10	10	10	0	0	0
10	10	10	0	0	0
10	10	10	0	0	0
10	10	10	0	0	0
10	10	10	0	0	0
10	10	10	0	0	0

*

-1	0	1
-1	0	1
-1	0	1

=

0	-30	-30	0
0	-30	-30	



10	10	10	0	0	0
10	10	10	0	0	0
10	10	10	0	0	0
10	10	10	0	0	0
10	10	10	0	0	0
10	10	10	0	0	0

*

-1	0	1
-1	0	1
-1	0	1

=

0	-30	-30	0
0	-30	-30	0



10	10	10	0	0	0
10	10	10	0	0	0
10	10	10	0	0	0
10	10	10	0	0	0
10	10	10	0	0	0
10	10	10	0	0	0

*

-1	0	1
-1	0	1
-1	0	1

=

0	-30	-30	0
0	-30	-30	0
0			



10	10	10	0	0	0
10	10	10	0	0	0
10	10	10	0	0	0
10	10	10	0	0	0
10	10	10	0	0	0
10	10	10	0	0	0

*

-1	0	1
-1	0	1
-1	0	1

=

0	-30	-30	0
0	-30	-30	0
0	-30		



10	10	10	0	0	0
10	10	10	0	0	0
10	10	10	0	0	0
10	10	10	0	0	0
10	10	10	0	0	0
10	10	10	0	0	0

*

-1	0	1
-1	0	1
-1	0	1

=

0	-30	-30	0
0	-30	-30	0
0	-30	-30	



10	10	10	0	0	0
10	10	10	0	0	0
10	10	10	0	0	0
10	10	10	0	0	0
10	10	10	0	0	0
10	10	10	0	0	0

*

-1	0	1
-1	0	1
-1	0	1

=

0	-30	-30	0
0	-30	-30	0
0	-30	-30	0



10	10	10	0	0	0
10	10	10	0	0	0
10	10	10	0	0	0
10	10	10	0	0	0
10	10	10	0	0	0
10	10	10	0	0	0

*

-1	0	1
-1	0	1
-1	0	1

=

0	-30	-30	0
0	-30	-30	0
0	-30	-30	0
0			



10	10	10	0	0	0
10	10	10	0	0	0
10	10	10	0	0	0
10	10	10	0	0	0
10	10	10	0	0	0
10	10	10	0	0	0

*

-1	0	1
-1	0	1
-1	0	1

=

0	-30	-30	0
0	-30	-30	0
0	-30	-30	0
0	-30		



10	10	10	0	0	0
10	10	10	0	0	0
10	10	10	0	0	0
10	10	10	0	0	0
10	10	10	0	0	0
10	10	10	0	0	0

*

-1	0	1
-1	0	1
-1	0	1

=

0	-30	-30	0
0	-30	-30	0
0	-30	-30	0
0	-30	-30	



10	10	10	0	0	0
10	10	10	0	0	0
10	10	10	0	0	0
10	10	10	0	0	0
10	10	10	0	0	0
10	10	10	0	0	0

*

-1	0	1
-1	0	1
-1	0	1

=

0	-30	-30	0
0	-30	-30	0
0	-30	-30	0
0	-30	-30	0



10	10	10	0	0	0
10	10	10	0	0	0
10	10	10	0	0	0
10	10	10	0	0	0
10	10	10	0	0	0
10	10	10	0	0	0

*

-1	0	1
-1	0	1
-1	0	1

=

0	-30	-30	0
0	-30	-30	0
0	-30	-30	0
0	-30	-30	0



$$\begin{bmatrix} 0 & -30 & -30 & 0 \\ 0 & -30 & -30 & 0 \\ 0 & -30 & -30 & 0 \\ 0 & -30 & -30 & 0 \end{bmatrix}$$

*

$$\begin{bmatrix} -1 & 0 & 1 \\ -1 & 0 & 1 \\ -1 & 0 & 1 \end{bmatrix}$$

=

$$\begin{bmatrix} 0 & -30 & -30 & 0 \\ 0 & -30 & -30 & 0 \\ 0 & -30 & -30 & 0 \\ 0 & -30 & -30 & 0 \end{bmatrix}$$

*

$$\begin{bmatrix} -1 & 0 & 1 \\ -1 & 0 & 1 \\ -1 & 0 & 1 \end{bmatrix}$$

=

$$\begin{bmatrix} & \\ & \end{bmatrix}$$

0	-30	-30	0
0	-30	-30	0
0	-30	-30	0
0	-30	-30	0

*

-1	0	1
-1	0	1
-1	0	1

=

$$\begin{bmatrix} 0 & -30 & -30 & 0 \\ 0 & -30 & -30 & 0 \\ 0 & -30 & -30 & 0 \\ 0 & -30 & -30 & 0 \end{bmatrix}$$

*

$$\begin{bmatrix} -1 & 0 & 1 \\ -1 & 0 & 1 \\ -1 & 0 & 1 \end{bmatrix}$$

=

$$\begin{bmatrix} -90 \\ \end{bmatrix}$$

$$\begin{bmatrix} 0 & -30 & -30 & 0 \\ 0 & -30 & -30 & 0 \\ 0 & -30 & -30 & 0 \\ 0 & -30 & -30 & 0 \end{bmatrix}$$

*

$$\begin{bmatrix} -1 & 0 & 1 \\ -1 & 0 & 1 \\ -1 & 0 & 1 \end{bmatrix}$$

=

$$\begin{bmatrix} -90 \\ \vdots \\ \vdots \end{bmatrix}$$

$$\begin{bmatrix} 0 & -30 & -30 & 0 \\ 0 & -30 & -30 & 0 \\ 0 & -30 & -30 & 0 \\ 0 & -30 & -30 & 0 \end{bmatrix}$$

*

$$\begin{bmatrix} -1 & 0 & 1 \\ -1 & 0 & 1 \\ -1 & 0 & 1 \end{bmatrix}$$

=

$$\begin{bmatrix} -90 & 90 \\ \quad & \quad \end{bmatrix}$$

$$\begin{bmatrix} 0 & -30 & -30 & 0 \\ 0 & -30 & -30 & 0 \\ 0 & -30 & -30 & 0 \\ 0 & -30 & -30 & 0 \end{bmatrix}$$

*

$$\begin{bmatrix} -1 & 0 & 1 \\ -1 & 0 & 1 \\ -1 & 0 & 1 \end{bmatrix}$$

=

$$\begin{bmatrix} -90 & 90 \\ \quad & \quad \end{bmatrix}$$

$$\begin{bmatrix} 0 & -30 & -30 & 0 \\ 0 & -30 & -30 & 0 \\ 0 & -30 & -30 & 0 \\ 0 & -30 & -30 & 0 \end{bmatrix}$$

*

$$\begin{bmatrix} -1 & 0 & 1 \\ -1 & 0 & 1 \\ -1 & 0 & 1 \end{bmatrix}$$

=

$$\begin{bmatrix} -90 & 90 \\ -90 & \end{bmatrix}$$

$$\begin{bmatrix} 0 & -30 & -30 & 0 \\ 0 & -30 & -30 & 0 \\ 0 & -30 & -30 & 0 \\ 0 & -30 & -30 & 0 \end{bmatrix}$$

*

$$\begin{bmatrix} -1 & 0 & 1 \\ -1 & 0 & 1 \\ -1 & 0 & 1 \end{bmatrix}$$

=

$$\begin{bmatrix} -90 & 90 \\ -90 & \end{bmatrix}$$

$$\begin{bmatrix} 0 & -30 & -30 & 0 \\ 0 & -30 & -30 & 0 \\ 0 & -30 & -30 & 0 \\ 0 & -30 & -30 & 0 \end{bmatrix}$$

*

$$\begin{bmatrix} -1 & 0 & 1 \\ -1 & 0 & 1 \\ -1 & 0 & 1 \end{bmatrix}$$

=

$$\begin{bmatrix} -90 & 90 \\ -90 & 90 \end{bmatrix}$$

$$\begin{bmatrix} 0 & -30 & -30 & 0 \\ 0 & -30 & -30 & 0 \\ 0 & -30 & -30 & 0 \\ 0 & -30 & -30 & 0 \end{bmatrix}$$

*

$$\begin{bmatrix} -1 & 0 & 1 \\ -1 & 0 & 1 \\ -1 & 0 & 1 \end{bmatrix}$$

=

$$\begin{bmatrix} -90 & 90 \\ -90 & 90 \end{bmatrix}$$

-90	90
-90	90

-90	90
-90	90



-90	90
-90	90

Flatten()



-90	90
-90	90

Flatten()

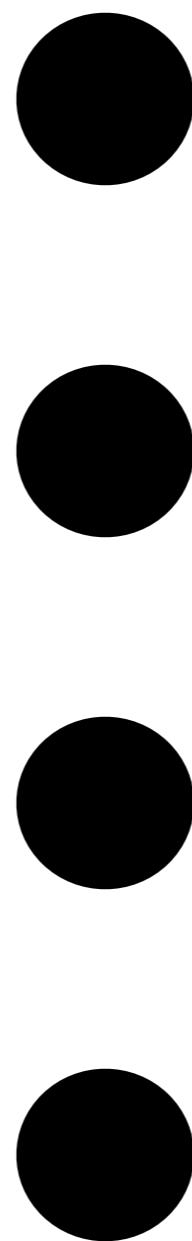


-90
90
-90
90

-90	90
-90	90

Flatten()

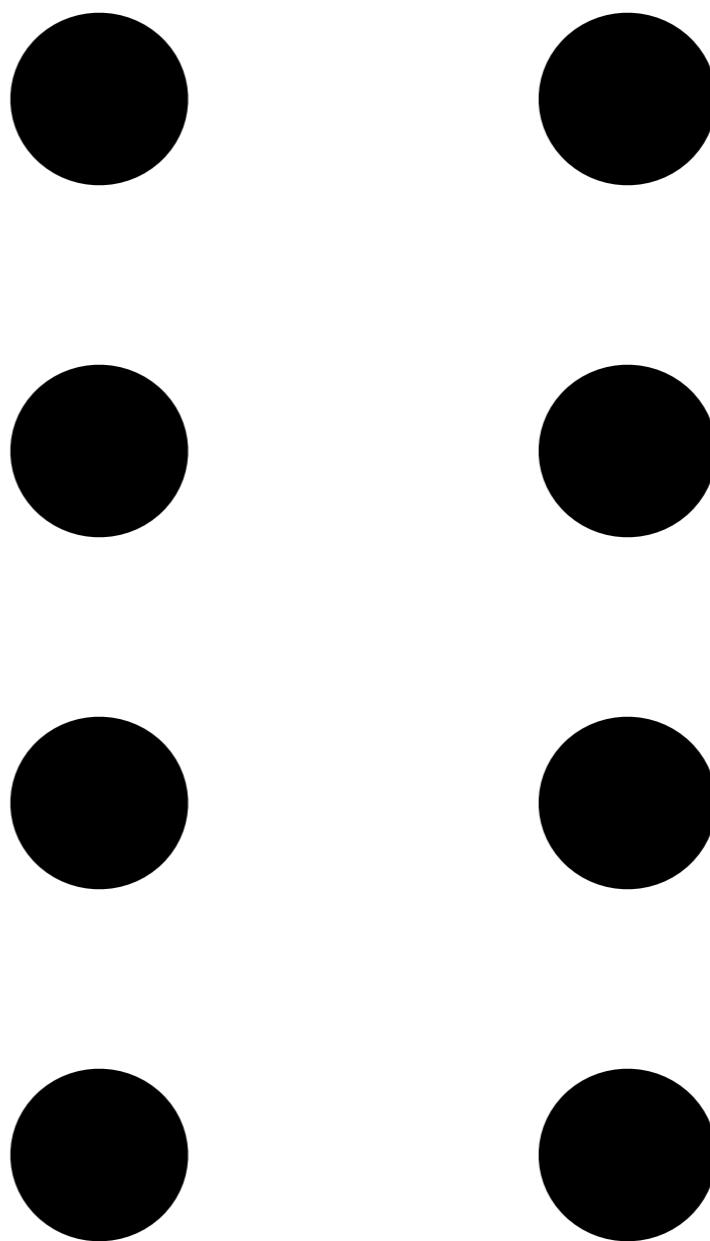
-90
90
-90
90



-90	90
-90	90

Flatten()

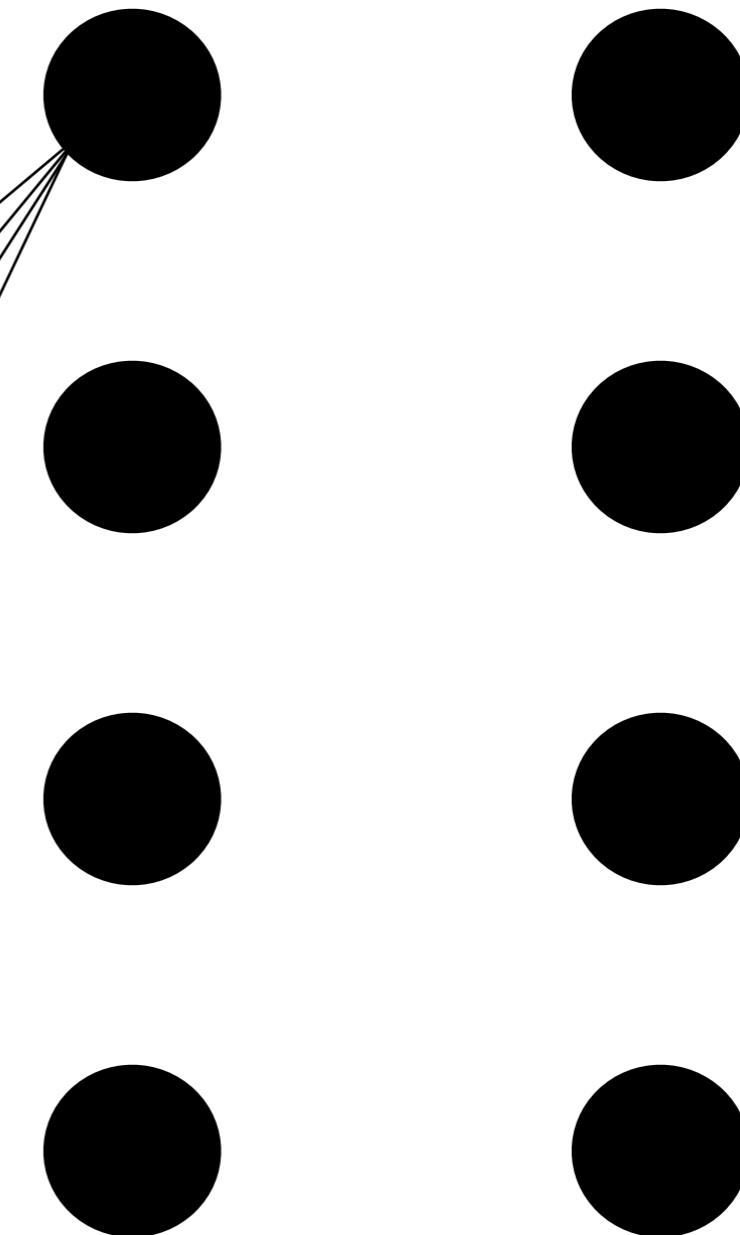
-90
90
-90
90



-90	90
-90	90

Flatten() 

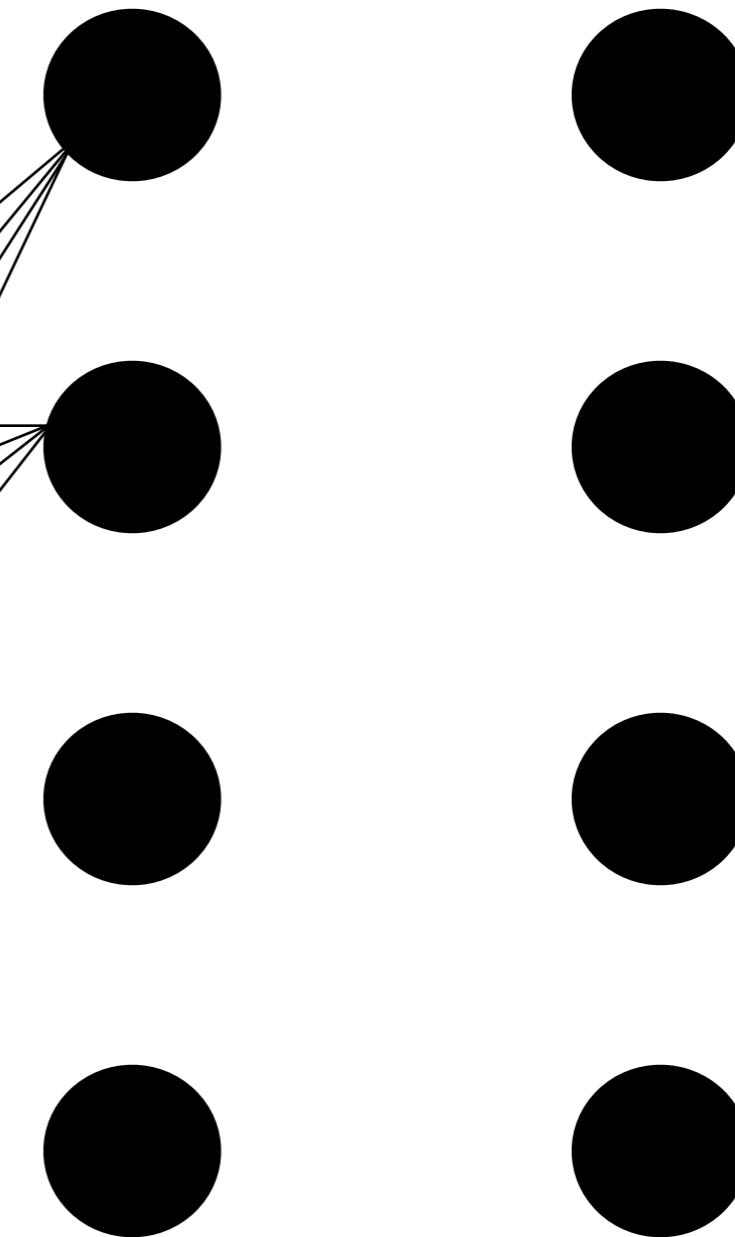
-90
90
-90
90



-90	90
-90	90

Flatten() 

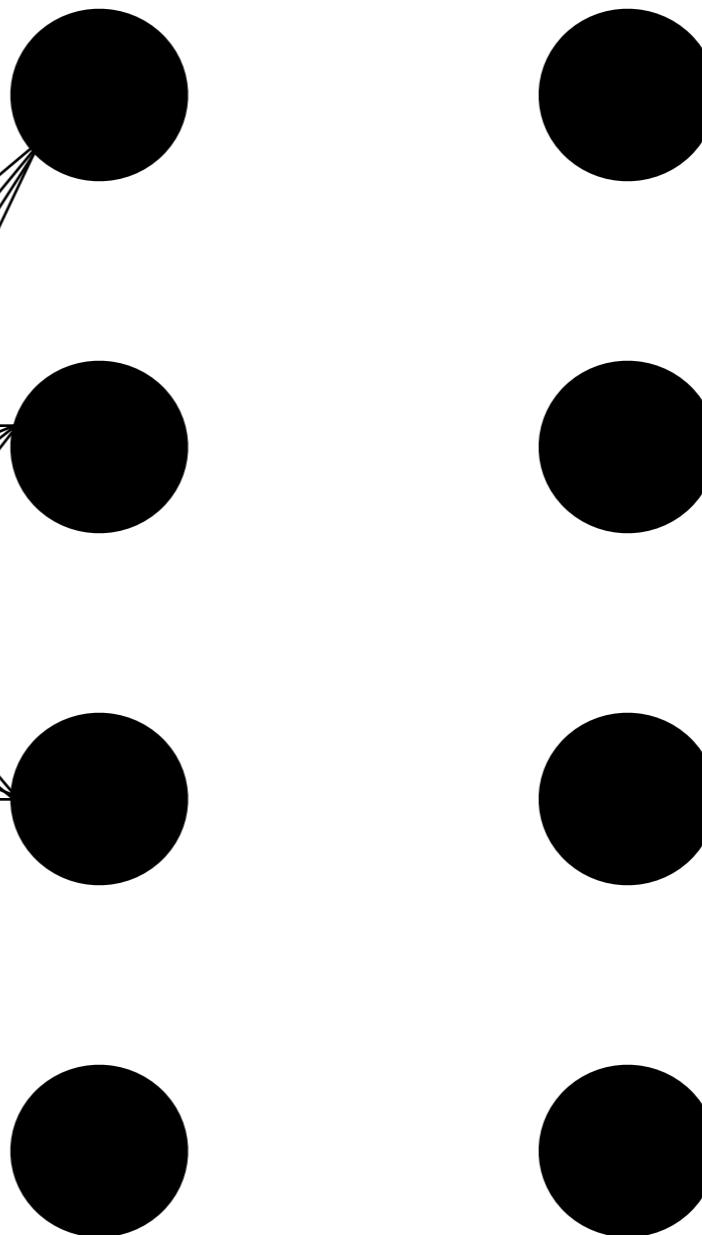
-90
90
-90
90



-90	90
-90	90

Flatten() 

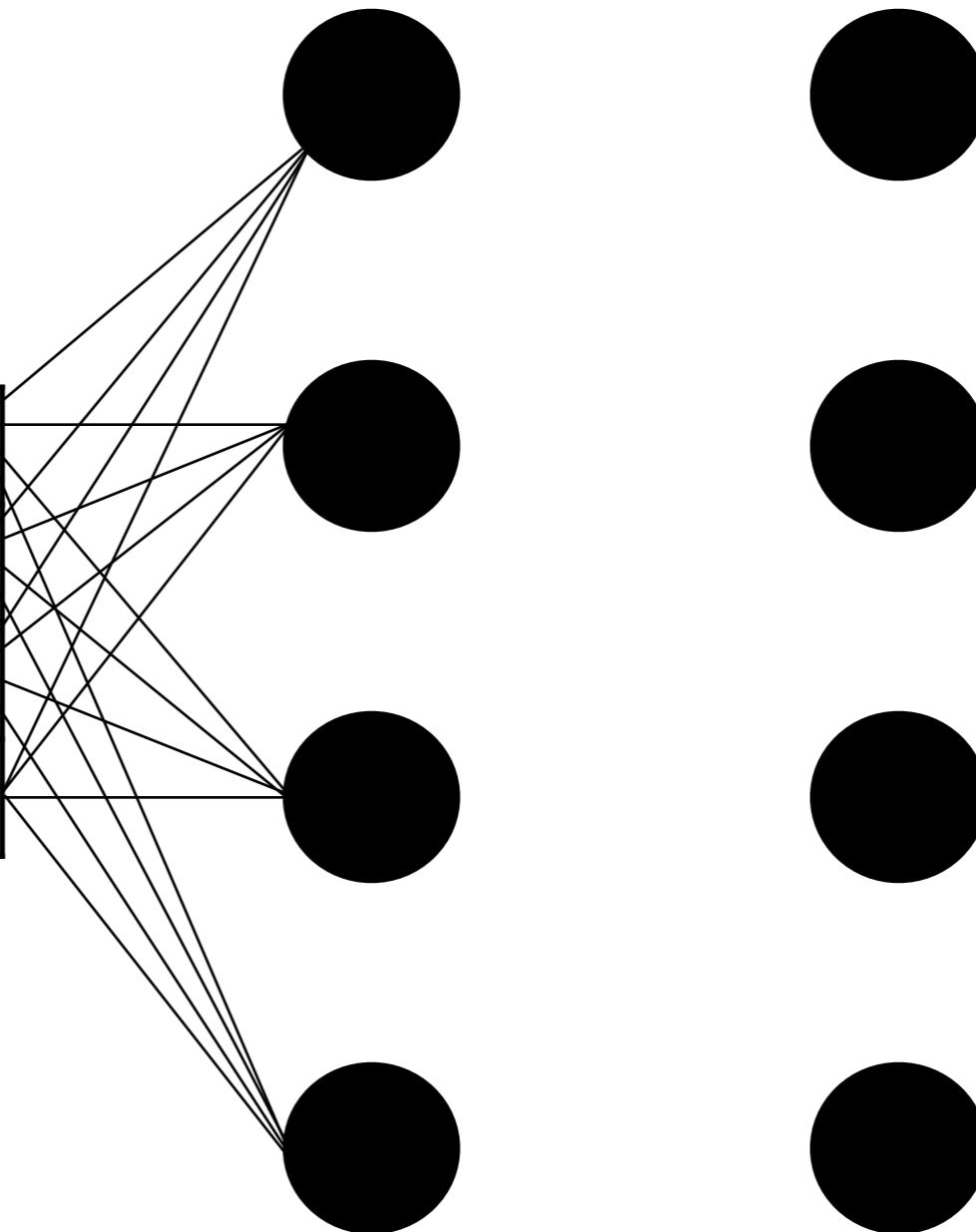
-90
90
-90
90



-90	90
-90	90

Flatten() 

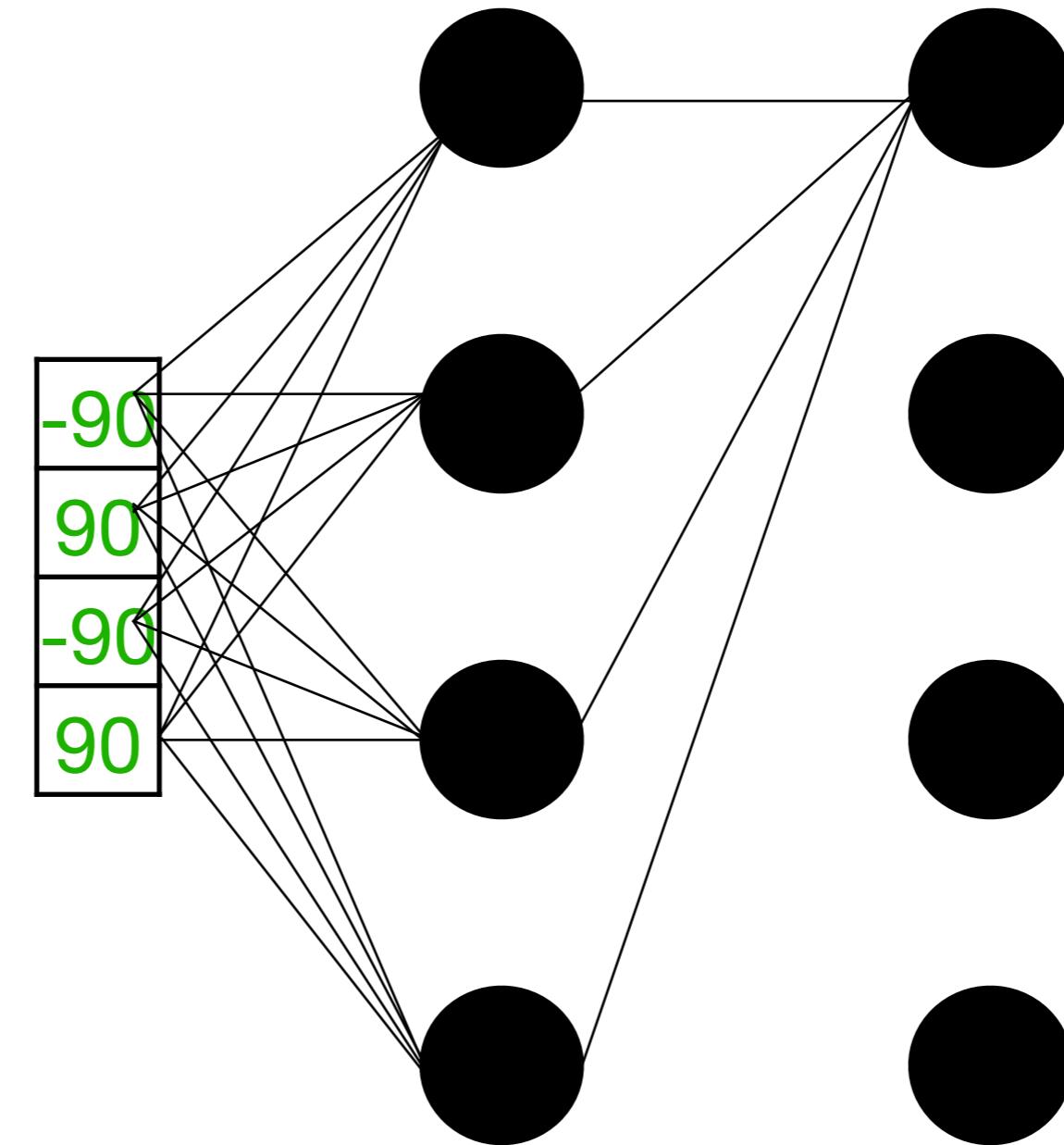
-90
90
-90
90



-90	90
-90	90

Flatten() 

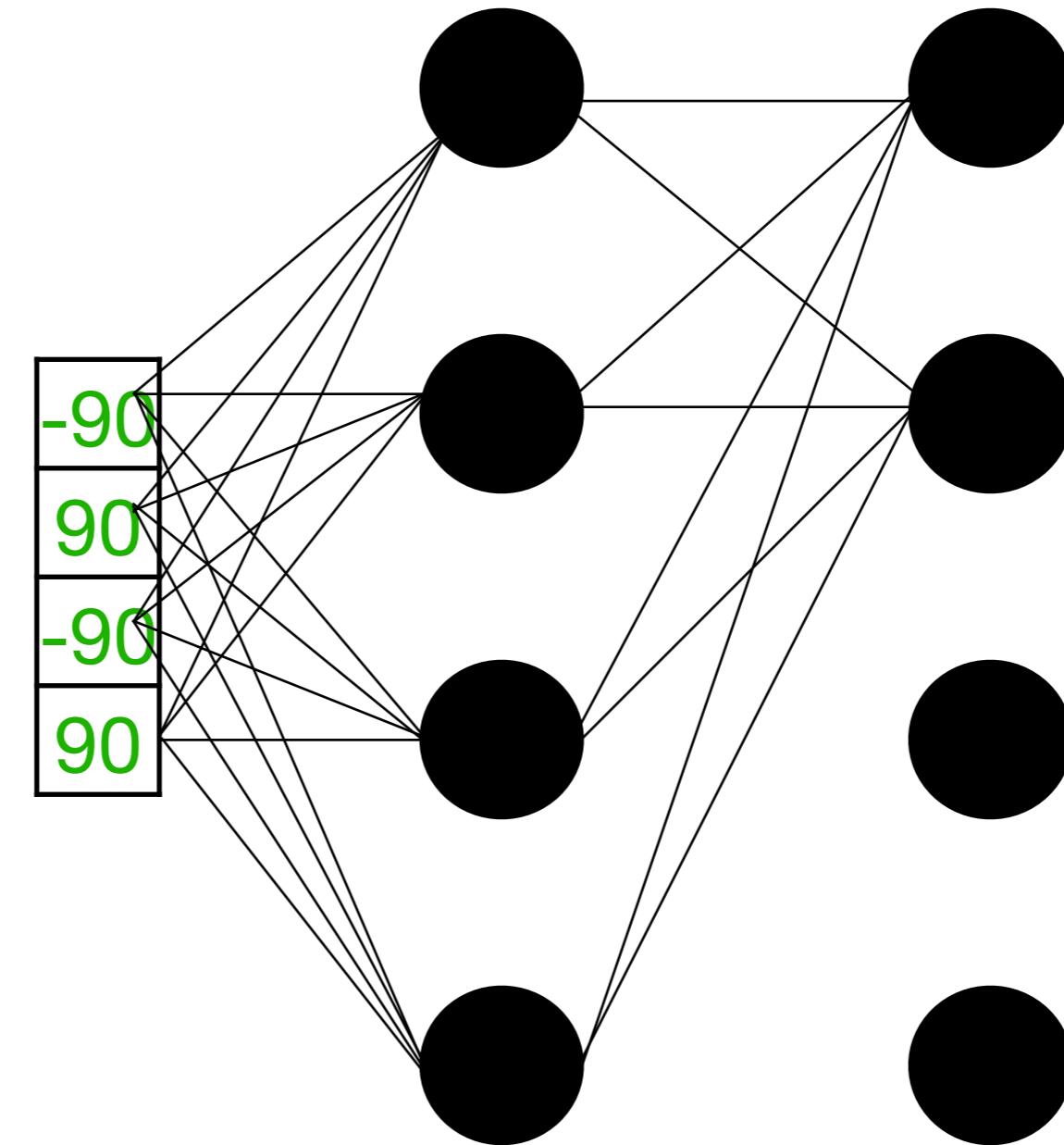
-90
90
-90
90



-90	90
-90	90

Flatten() →

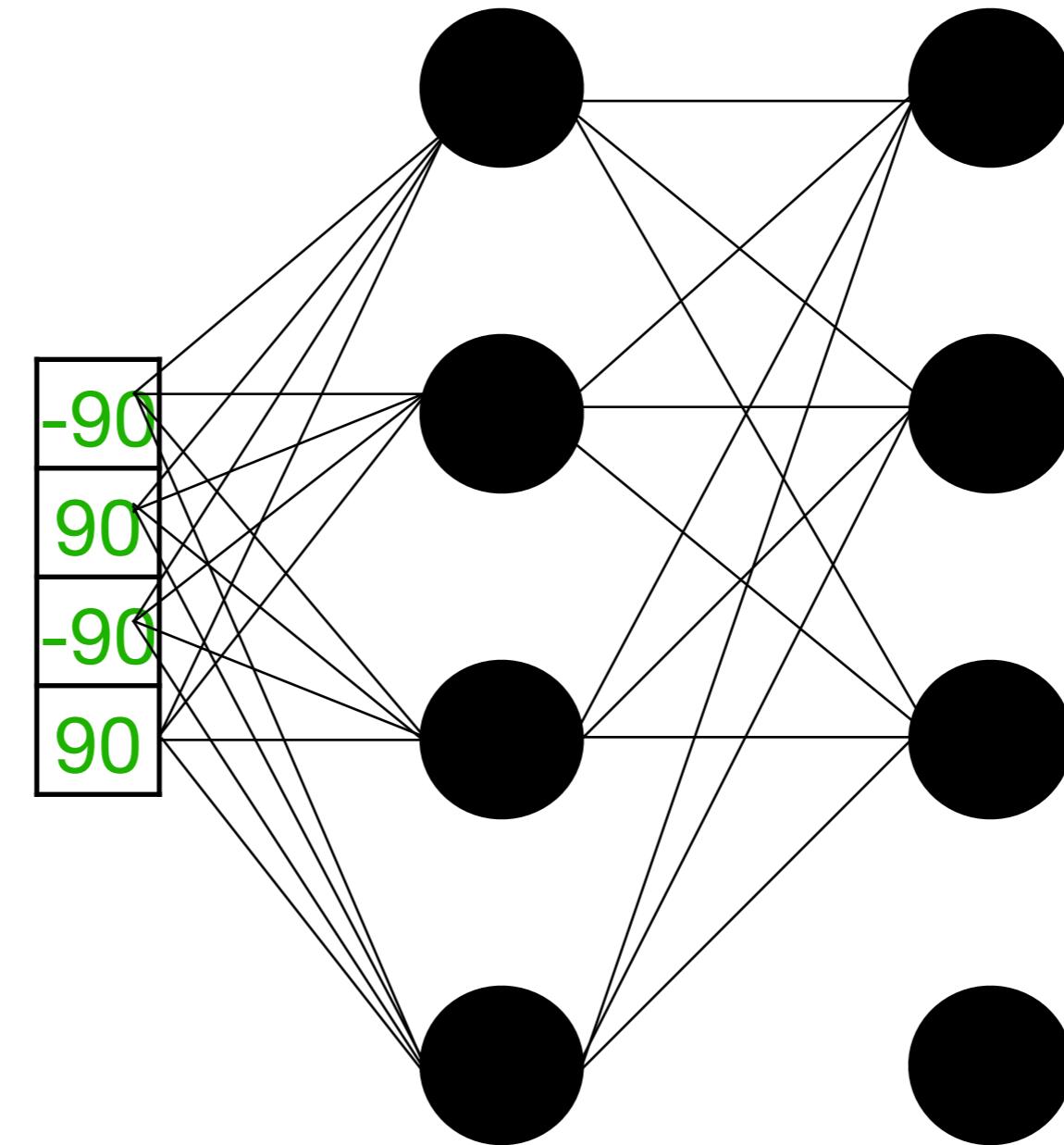
-90
90
-90
90



-90	90
-90	90

Flatten() →

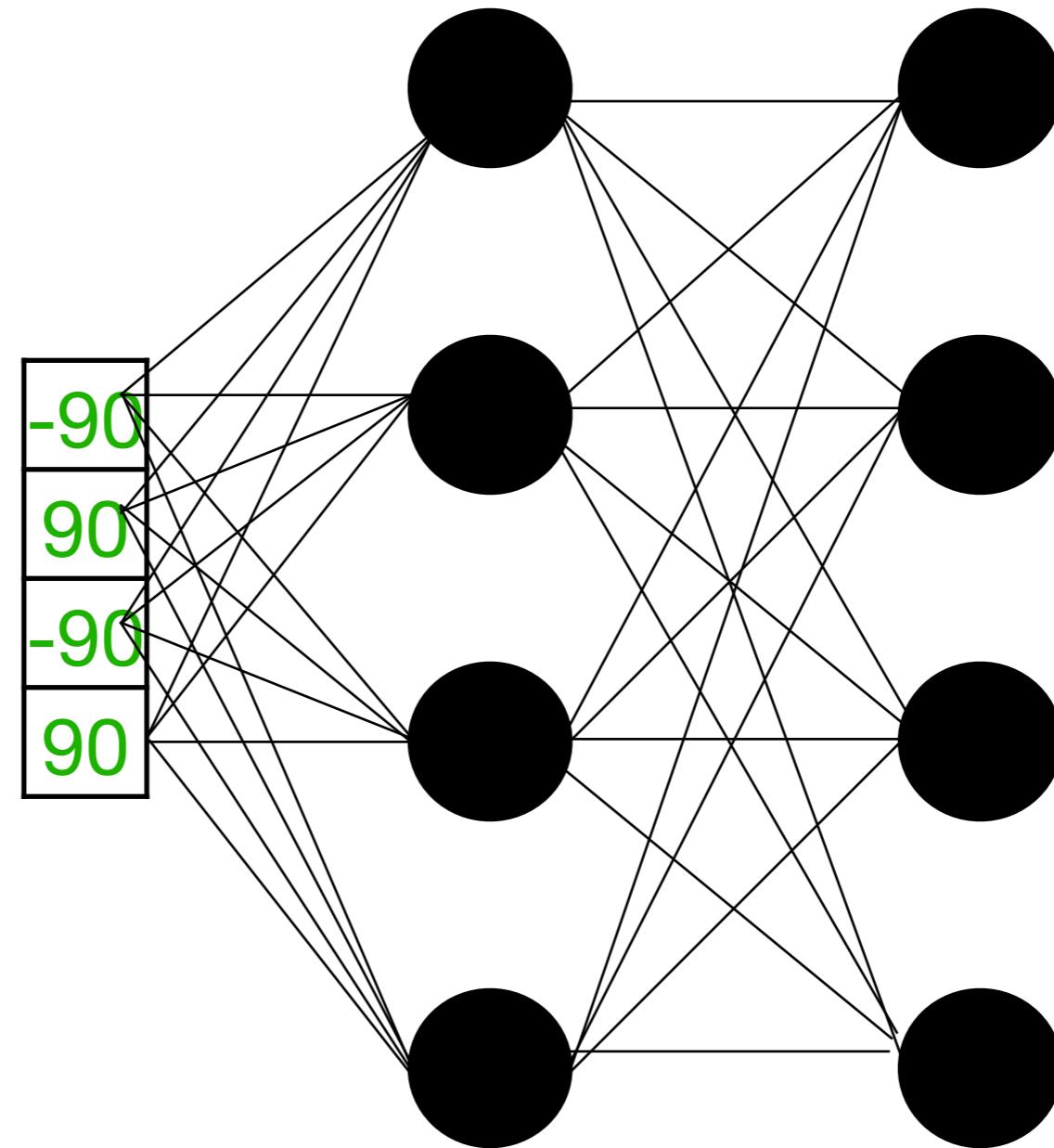
-90
90
-90
90



-90	90
-90	90

Flatten() →

-90
90
-90
90



Convolutional Neural Network

Learn to detect edges

10	10	10	0	0	0
10	10	10	0	0	0
10	10	10	0	0	0
10	10	10	0	0	0
10	10	10	0	0	0
10	10	10	0	0	0

*

-1	0	1
-1	0	1
-1	0	1

=

10	10	10	0	0	0
10	10	10	0	0	0
10	10	10	0	0	0
10	10	10	0	0	0
10	10	10	0	0	0
10	10	10	0	0	0

*

-1	0	1
-1	0	1
-1	0	1

=



10	10	10	0	0	0
10	10	10	0	0	0
10	10	10	0	0	0
10	10	10	0	0	0
10	10	10	0	0	0
10	10	10	0	0	0

*

-1	0	1
-1	0	1
-1	0	1

=



10	10	10	0	0	0
10	10	10	0	0	0
10	10	10	0	0	0
10	10	10	0	0	0
10	10	10	0	0	0
10	10	10	0	0	0

*

-1	0	1
-1	0	1
-1	0	1

=

0			



10	10	10	0	0	0
10	10	10	0	0	0
10	10	10	0	0	0
10	10	10	0	0	0
10	10	10	0	0	0
10	10	10	0	0	0

*

-1	0	1
-1	0	1
-1	0	1

=

0			



10	10	10	0	0	0
10	10	10	0	0	0
10	10	10	0	0	0
10	10	10	0	0	0
10	10	10	0	0	0
10	10	10	0	0	0

*

-1	0	1
-1	0	1
-1	0	1

=

0	-30		



10	10	10	0	0	0
10	10	10	0	0	0
10	10	10	0	0	0
10	10	10	0	0	0
10	10	10	0	0	0
10	10	10	0	0	0

*

-1	0	1
-1	0	1
-1	0	1

=

0	-30		



10	10	10	0	0	0
10	10	10	0	0	0
10	10	10	0	0	0
10	10	10	0	0	0
10	10	10	0	0	0
10	10	10	0	0	0

*

-1	0	1
-1	0	1
-1	0	1

=

0	-30	-30	



10	10	10	0	0	0
10	10	10	0	0	0
10	10	10	0	0	0
10	10	10	0	0	0
10	10	10	0	0	0
10	10	10	0	0	0

*

-1	0	1
-1	0	1
-1	0	1

=

0	-30	-30	0



10	10	10	0	0	0
10	10	10	0	0	0
10	10	10	0	0	0
10	10	10	0	0	0
10	10	10	0	0	0
10	10	10	0	0	0

*

-1	0	1
-1	0	1
-1	0	1

=

0	-30	-30	0



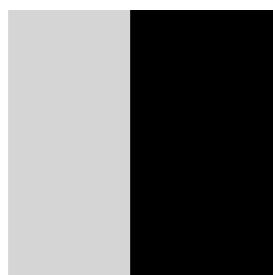
10	10	10	0	0	0
10	10	10	0	0	0
10	10	10	0	0	0
10	10	10	0	0	0
10	10	10	0	0	0
10	10	10	0	0	0

*

-1	0	1
-1	0	1
-1	0	1

=

0	-30	-30	0
0			



10	10	10	0	0	0
10	10	10	0	0	0
10	10	10	0	0	0
10	10	10	0	0	0
10	10	10	0	0	0
10	10	10	0	0	0

*

-1	0	1
-1	0	1
-1	0	1

=

0	-30	-30	0
0			



10	10	10	0	0	0
10	10	10	0	0	0
10	10	10	0	0	0
10	10	10	0	0	0
10	10	10	0	0	0
10	10	10	0	0	0

*

-1	0	1
-1	0	1
-1	0	1

=

0	-30	-30	0
0	-30		



10	10	10	0	0	0
10	10	10	0	0	0
10	10	10	0	0	0
10	10	10	0	0	0
10	10	10	0	0	0
10	10	10	0	0	0

*

-1	0	1
-1	0	1
-1	0	1

=

0	-30	-30	0
0	-30		



10	10	10	0	0	0
10	10	10	0	0	0
10	10	10	0	0	0
10	10	10	0	0	0
10	10	10	0	0	0
10	10	10	0	0	0

*

-1	0	1
-1	0	1
-1	0	1

=

0	-30	-30	0
0	-30	-30	



10	10	10	0	0	0
10	10	10	0	0	0
10	10	10	0	0	0
10	10	10	0	0	0
10	10	10	0	0	0
10	10	10	0	0	0

*

-1	0	1
-1	0	1
-1	0	1

=

0	-30	-30	0
0	-30	-30	0



10	10	10	0	0	0
10	10	10	0	0	0
10	10	10	0	0	0
10	10	10	0	0	0
10	10	10	0	0	0
10	10	10	0	0	0

*

-1	0	1
-1	0	1
-1	0	1

=

0	-30	-30	0
0	-30	-30	0
0			



10	10	10	0	0	0
10	10	10	0	0	0
10	10	10	0	0	0
10	10	10	0	0	0
10	10	10	0	0	0
10	10	10	0	0	0

*

-1	0	1
-1	0	1
-1	0	1

=

0	-30	-30	0
0	-30	-30	0
0	-30		



10	10	10	0	0	0
10	10	10	0	0	0
10	10	10	0	0	0
10	10	10	0	0	0
10	10	10	0	0	0
10	10	10	0	0	0

*

-1	0	1
-1	0	1
-1	0	1

=

0	-30	-30	0
0	-30	-30	0
0	-30	-30	



10	10	10	0	0	0
10	10	10	0	0	0
10	10	10	0	0	0
10	10	10	0	0	0
10	10	10	0	0	0
10	10	10	0	0	0

*

-1	0	1
-1	0	1
-1	0	1

=

0	-30	-30	0
0	-30	-30	0
0	-30	-30	0



10	10	10	0	0	0
10	10	10	0	0	0
10	10	10	0	0	0
10	10	10	0	0	0
10	10	10	0	0	0
10	10	10	0	0	0

*

-1	0	1
-1	0	1
-1	0	1

=

0	-30	-30	0
0	-30	-30	0
0	-30	-30	0
0			



10	10	10	0	0	0
10	10	10	0	0	0
10	10	10	0	0	0
10	10	10	0	0	0
10	10	10	0	0	0
10	10	10	0	0	0

*

-1	0	1
-1	0	1
-1	0	1

=

0	-30	-30	0
0	-30	-30	0
0	-30	-30	0
0	-30		



10	10	10	0	0	0
10	10	10	0	0	0
10	10	10	0	0	0
10	10	10	0	0	0
10	10	10	0	0	0
10	10	10	0	0	0

*

-1	0	1
-1	0	1
-1	0	1

=

0	-30	-30	0
0	-30	-30	0
0	-30	-30	0
0	-30	-30	



10	10	10	0	0	0
10	10	10	0	0	0
10	10	10	0	0	0
10	10	10	0	0	0
10	10	10	0	0	0
10	10	10	0	0	0

*

-1	0	1
-1	0	1
-1	0	1

=

0	-30	-30	0
0	-30	-30	0
0	-30	-30	0
0	-30	-30	0



10	10	10	0	0	0
10	10	10	0	0	0
10	10	10	0	0	0
10	10	10	0	0	0
10	10	10	0	0	0
10	10	10	0	0	0

*

-1	0	1
-1	0	1
-1	0	1

=

0	-30	-30	0
0	-30	-30	0
0	-30	-30	0
0	-30	-30	0



$$\begin{bmatrix} 0 & -30 & -30 & 0 \\ 0 & -30 & -30 & 0 \\ 0 & -30 & -30 & 0 \\ 0 & -30 & -30 & 0 \end{bmatrix}$$

*

$$\begin{bmatrix} -1 & 0 & 1 \\ -1 & 0 & 1 \\ -1 & 0 & 1 \end{bmatrix}$$

=

$$\begin{bmatrix} 0 & -30 & -30 & 0 \\ 0 & -30 & -30 & 0 \\ 0 & -30 & -30 & 0 \\ 0 & -30 & -30 & 0 \end{bmatrix}$$

*

$$\begin{bmatrix} -1 & 0 & 1 \\ -1 & 0 & 1 \\ -1 & 0 & 1 \end{bmatrix}$$

=

$$\begin{bmatrix} & \\ & \end{bmatrix}$$

0	-30	-30	0
0	-30	-30	0
0	-30	-30	0
0	-30	-30	0

*

-1	0	1
-1	0	1
-1	0	1

=

0	-30	-30	0
0	-30	-30	0
0	-30	-30	0
0	-30	-30	0

*

-1	0	1
-1	0	1
-1	0	1

=

-90	

$$\begin{bmatrix} 0 & -30 & -30 & 0 \\ 0 & -30 & -30 & 0 \\ 0 & -30 & -30 & 0 \\ 0 & -30 & -30 & 0 \end{bmatrix}$$

*

$$\begin{bmatrix} -1 & 0 & 1 \\ -1 & 0 & 1 \\ -1 & 0 & 1 \end{bmatrix}$$

=

$$\begin{bmatrix} -90 \\ \vdots \\ \vdots \end{bmatrix}$$

$$\begin{bmatrix} 0 & -30 & -30 & 0 \\ 0 & -30 & -30 & 0 \\ 0 & -30 & -30 & 0 \\ 0 & -30 & -30 & 0 \end{bmatrix}$$

*

$$\begin{bmatrix} -1 & 0 & 1 \\ -1 & 0 & 1 \\ -1 & 0 & 1 \end{bmatrix}$$

=

$$\begin{bmatrix} -90 & 90 \\ \quad & \quad \end{bmatrix}$$

$$\begin{bmatrix} 0 & -30 & -30 & 0 \\ 0 & -30 & -30 & 0 \\ 0 & -30 & -30 & 0 \\ 0 & -30 & -30 & 0 \end{bmatrix}$$

*

$$\begin{bmatrix} -1 & 0 & 1 \\ -1 & 0 & 1 \\ -1 & 0 & 1 \end{bmatrix}$$

=

$$\begin{bmatrix} -90 & 90 \\ \quad & \quad \end{bmatrix}$$

$$\begin{bmatrix} 0 & -30 & -30 & 0 \\ 0 & -30 & -30 & 0 \\ 0 & -30 & -30 & 0 \\ 0 & -30 & -30 & 0 \end{bmatrix}$$

*

$$\begin{bmatrix} -1 & 0 & 1 \\ -1 & 0 & 1 \\ -1 & 0 & 1 \end{bmatrix}$$

=

$$\begin{bmatrix} -90 & 90 \\ -90 & \end{bmatrix}$$

$$\begin{bmatrix} 0 & -30 & -30 & 0 \\ 0 & -30 & -30 & 0 \\ 0 & -30 & -30 & 0 \\ 0 & -30 & -30 & 0 \end{bmatrix}$$

*

$$\begin{bmatrix} -1 & 0 & 1 \\ -1 & 0 & 1 \\ -1 & 0 & 1 \end{bmatrix}$$

=

$$\begin{bmatrix} -90 & 90 \\ -90 & \end{bmatrix}$$

$$\begin{bmatrix} 0 & -30 & -30 & 0 \\ 0 & -30 & -30 & 0 \\ 0 & -30 & -30 & 0 \\ 0 & -30 & -30 & 0 \end{bmatrix}$$

*

$$\begin{bmatrix} -1 & 0 & 1 \\ -1 & 0 & 1 \\ -1 & 0 & 1 \end{bmatrix}$$

=

$$\begin{bmatrix} -90 & 90 \\ -90 & 90 \end{bmatrix}$$

$$\begin{bmatrix} 0 & -30 & -30 & 0 \\ 0 & -30 & -30 & 0 \\ 0 & -30 & -30 & 0 \\ 0 & -30 & -30 & 0 \end{bmatrix}$$

*

$$\begin{bmatrix} -1 & 0 & 1 \\ -1 & 0 & 1 \\ -1 & 0 & 1 \end{bmatrix}$$

=

$$\begin{bmatrix} -90 & 90 \\ -90 & 90 \end{bmatrix}$$

$$\begin{bmatrix} 0 & -30 & -30 & 0 \\ 0 & -30 & -30 & 0 \\ 0 & -30 & -30 & 0 \\ 0 & -30 & -30 & 0 \end{bmatrix}$$

*

$$\begin{bmatrix} -1 & 0 & 1 \\ -1 & 0 & 1 \\ -1 & 0 & 1 \end{bmatrix}$$

=

$$\begin{bmatrix} -90 & 90 \\ -90 & 90 \end{bmatrix}$$

$$\begin{bmatrix} 0 & -30 & -30 & 0 \\ 0 & -30 & -30 & 0 \\ 0 & -30 & -30 & 0 \\ 0 & -30 & -30 & 0 \end{bmatrix}$$

*

$$\begin{bmatrix} -1 & 0 & 1 \\ -1 & 0 & 1 \\ -1 & 0 & 1 \end{bmatrix}$$

=

$$\begin{bmatrix} -90 & 90 \\ -90 & 90 \end{bmatrix}$$

10	10	10	0	0	0
10	10	10	0	0	0
10	10	10	0	0	0
10	10	10	0	0	0
10	10	10	0	0	0
10	10	10	0	0	0

*

-1	0	1
-1	0	1
-1	0	1

=

0	-30	-30	0
0	-30	-30	0
0	-30	-30	0
0	-30	-30	0

?

10	10	10	0	0	0
10	10	10	0	0	0
10	10	10	0	0	0
10	10	10	0	0	0
10	10	10	0	0	0
10	10	10	0	0	0

*

-1	0	1
-1	0	1
-1	0	1

=

0	-30	-30	0
0	-30	-30	0
0	-30	-30	0
0	-30	-30	0

10	10	10	0	0	0
10	10	10	0	0	0
10	10	10	0	0	0
10	10	10	0	0	0
10	10	10	0	0	0
10	10	10	0	0	0

*

-1	0	1
-1	0	1
-1	0	1

=

0	-30	-30	0
0	-30	-30	0
0	-30	-30	0
0	-30	-30	0

10	10	10	0	0	0
10	10	10	0	0	0
10	10	10	0	0	0
10	10	10	0	0	0
10	10	10	0	0	0
10	10	10	0	0	0

0	-30	-30	0
0	-30	-30	0
0	-30	-30	0
0	-30	-30	0

-90	90
-90	90

Effective Receptive Field

10	10	10	0	0	0
10	10	10	0	0	0
10	10	10	0	0	0
10	10	10	0	0	0
10	10	10	0	0	0
10	10	10	0	0	0

0	-30	-30	0
0	-30	-30	0
0	-30	-30	0
0	-30	-30	0

-90	90
-90	90

Zero Padding

10	10	10	0	0	0
10	10	10	0	0	0
10	10	10	0	0	0
10	10	10	0	0	0
10	10	10	0	0	0
10	10	10	0	0	0

*

-1	0	1
-1	0	1
-1	0	1

=

10	10	10	0	0	0	
10	10	10	0	0	0	
10	10	10	0	0	0	
10	10	10	0	0	0	
10	10	10	0	0	0	

*

-1	0	1
-1	0	1
-1	0	1

=

0	0	0	0	0	0	0	0
0	10	10	10	0	0	0	0
0	10	10	10	0	0	0	0
0	10	10	10	0	0	0	0
0	10	10	10	0	0	0	0
0	10	10	10	0	0	0	0
0	10	10	10	0	0	0	0
0	0	0	0	0	0	0	0

*

-1	0	1
-1	0	1
-1	0	1

=

0	0	0	0	0	0	0	0
0	10	10	10	0	0	0	0
0	10	10	10	0	0	0	0
0	10	10	10	0	0	0	0
0	10	10	10	0	0	0	0
0	10	10	10	0	0	0	0
0	10	10	10	0	0	0	0
0	0	0	0	0	0	0	0

*

-1	0	1
-1	0	1
-1	0	1

=

0	0	0	0	0	0	0	0
0	10	10	10	0	0	0	0
0	10	10	10	0	0	0	0
0	10	10	10	0	0	0	0
0	10	10	10	0	0	0	0
0	10	10	10	0	0	0	0
0	10	10	10	0	0	0	0
0	0	0	0	0	0	0	0

*

-1	0	1
-1	0	1
-1	0	1

=

20				

-1	0	1
-1	0	1
-1	0	1

[REDACTED]

0	0	0	0	0	0	0	0
0	10	10	10	0	0	0	0
0	10	10	10	0	0	0	0
0	10	10	10	0	0	0	0
0	10	10	10	0	0	0	0
0	10	10	10	0	0	0	0
0	10	10	10	0	0	0	0
0	0	0	0	0	0	0	0

*

-1	0	1
-1	0	1
-1	0	1

[REDACTED]

0	0	0	0	0	0	0	0
0	10	10	10	0	0	0	0
0	10	10	10	0	0	0	0
0	10	10	10	0	0	0	0
0	10	10	10	0	0	0	0
0	10	10	10	0	0	0	0
0	10	10	10	0	0	0	0
0	0	0	0	0	0	0	0

-1	0	1
-1	0	1
-1	0	1

Page 1

0	0	0	0	0	0	0	0
0	10	10	10	0	0	0	0
0	10	10	10	0	0	0	0
0	10	10	10	0	0	0	0
0	10	10	10	0	0	0	0
0	10	10	10	0	0	0	0
0	10	10	10	0	0	0	0
0	0	0	0	0	0	0	0

*

-1	0	1
-1	0	1
-1	0	1

=

20	0	-20	-20	0	

0	0	0	0	0	0	0	0
0	10	10	10	0	0	0	0
0	10	10	10	0	0	0	0
0	10	10	10	0	0	0	0
0	10	10	10	0	0	0	0
0	10	10	10	0	0	0	0
0	10	10	10	0	0	0	0
0	0	0	0	0	0	0	0

*

-1	0	1
-1	0	1
-1	0	1

=

20	0	-20	-20	0	0

0	0	0	0	0	0	0	0
0	10	10	10	0	0	0	0
0	10	10	10	0	0	0	0
0	10	10	10	0	0	0	0
0	10	10	10	0	0	0	0
0	10	10	10	0	0	0	0
0	10	10	10	0	0	0	0
0	0	0	0	0	0	0	0

*

-1	0	1
-1	0	1
-1	0	1

=

20	0	-20	-20	0	0
30					

0	0	0	0	0	0	0	0
0	10	10	10	0	0	0	0
0	10	10	10	0	0	0	0
0	10	10	10	0	0	0	0
0	10	10	10	0	0	0	0
0	10	10	10	0	0	0	0
0	10	10	10	0	0	0	0
0	0	0	0	0	0	0	0

*

-1	0	1
-1	0	1
-1	0	1

=

20	0	-20	-20	0	0
30	0				

0	0	0	0	0	0	0	0
0	10	10	10	0	0	0	0
0	10	10	10	0	0	0	0
0	10	10	10	0	0	0	0
0	10	10	10	0	0	0	0
0	10	10	10	0	0	0	0
0	10	10	10	0	0	0	0
0	0	0	0	0	0	0	0

*

-1	0	1
-1	0	1
-1	0	1

=

20	0	-20	-20	0	0
30	0	-30			

0	0	0	0	0	0	0	0
0	10	10	10	0	0	0	0
0	10	10	10	0	0	0	0
0	10	10	10	0	0	0	0
0	10	10	10	0	0	0	0
0	10	10	10	0	0	0	0
0	10	10	10	0	0	0	0
0	0	0	0	0	0	0	0

*

-1	0	1
-1	0	1
-1	0	1

=

20	0	-20	-20	0	0
30	0	-30	-30		

0	0	0	0	0	0	0	0
0	10	10	10	0	0	0	0
0	10	10	10	0	0	0	0
0	10	10	10	0	0	0	0
0	10	10	10	0	0	0	0
0	10	10	10	0	0	0	0
0	10	10	10	0	0	0	0
0	0	0	0	0	0	0	0

*

-1	0	1
-1	0	1
-1	0	1

=

20	0	-20	-20	0	0
30	0	-30	-30	0	

0	0	0	0	0	0	0	0
0	10	10	10	0	0	0	0
0	10	10	10	0	0	0	0
0	10	10	10	0	0	0	0
0	10	10	10	0	0	0	0
0	10	10	10	0	0	0	0
0	10	10	10	0	0	0	0
0	0	0	0	0	0	0	0

*

-1	0	1
-1	0	1
-1	0	1

=

20	0	-20	-20	0	0
30	0	-30	-30	0	0

0	0	0	0	0	0	0	0
0	10	10	10	0	0	0	0
0	10	10	10	0	0	0	0
0	10	10	10	0	0	0	0
0	10	10	10	0	0	0	0
0	10	10	10	0	0	0	0
0	10	10	10	0	0	0	0
0	0	0	0	0	0	0	0

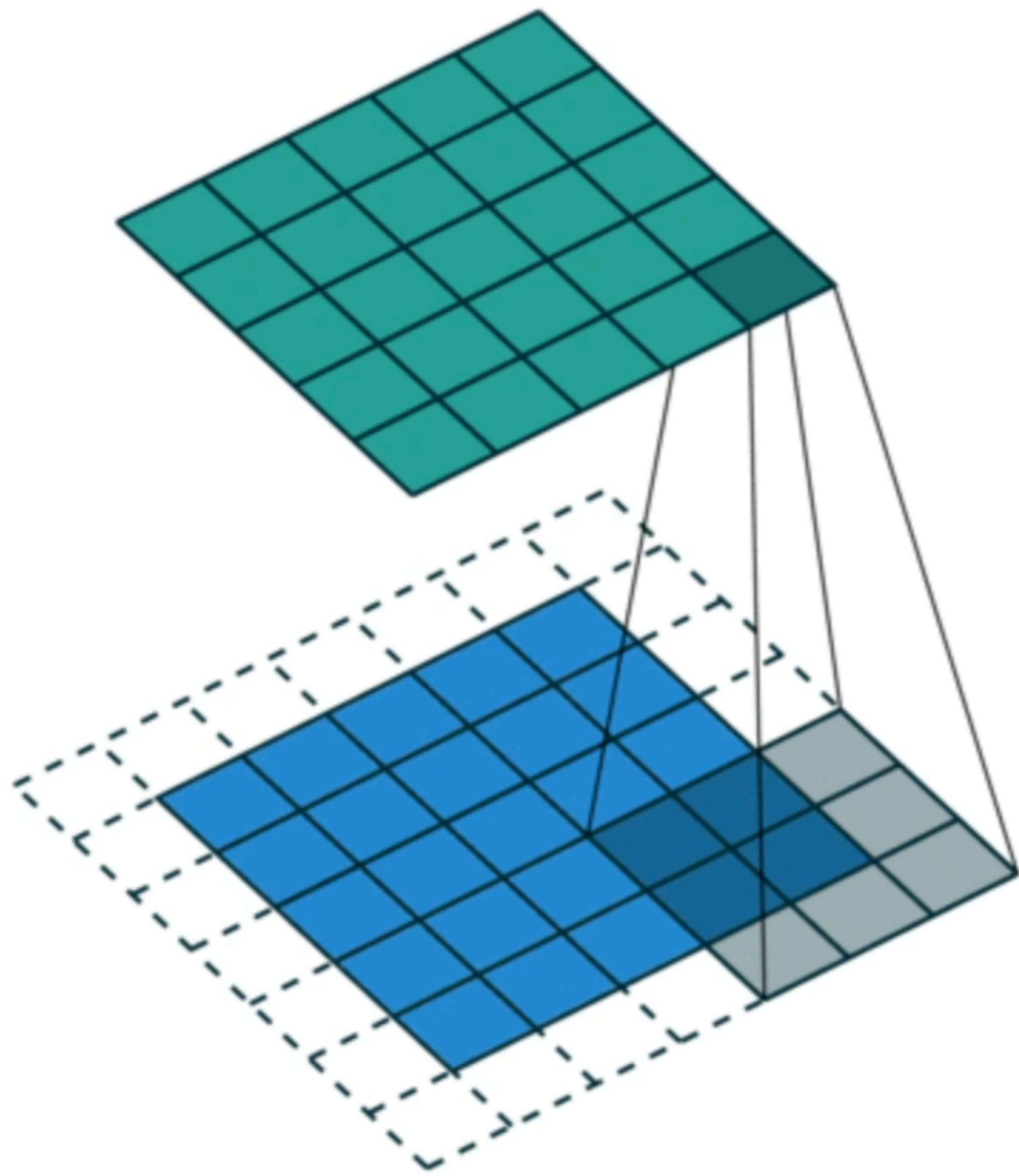
*

-1	0	1
-1	0	1
-1	0	1

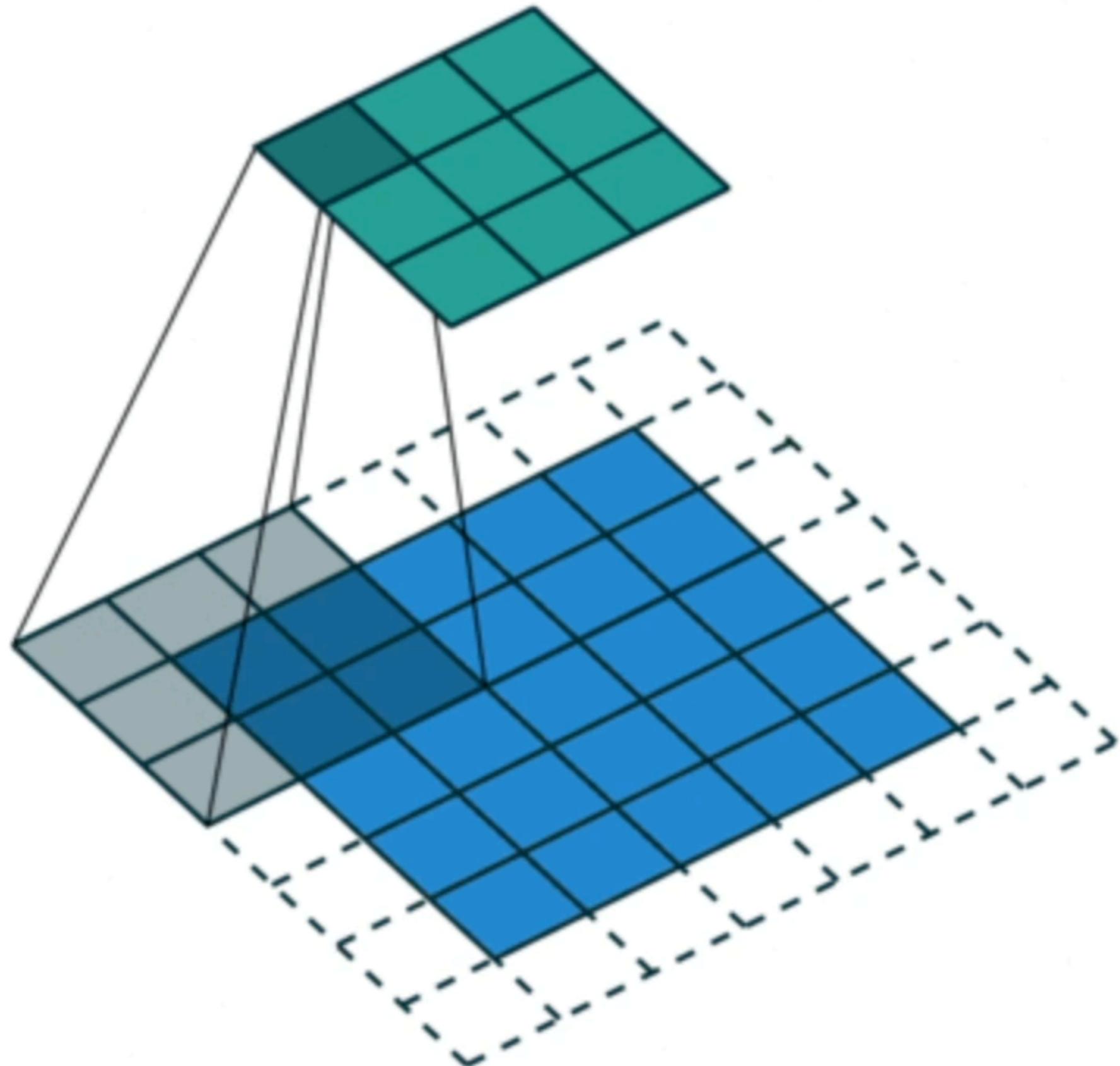
=

20	0	-20	-20	0	0
30	0	-30	-30	0	0
30	0	-30	-30	0	0
30	0	-30	-30	0	0
30	0	-30	-30	0	0
20	0	-20	-20	0	0

Stride=1



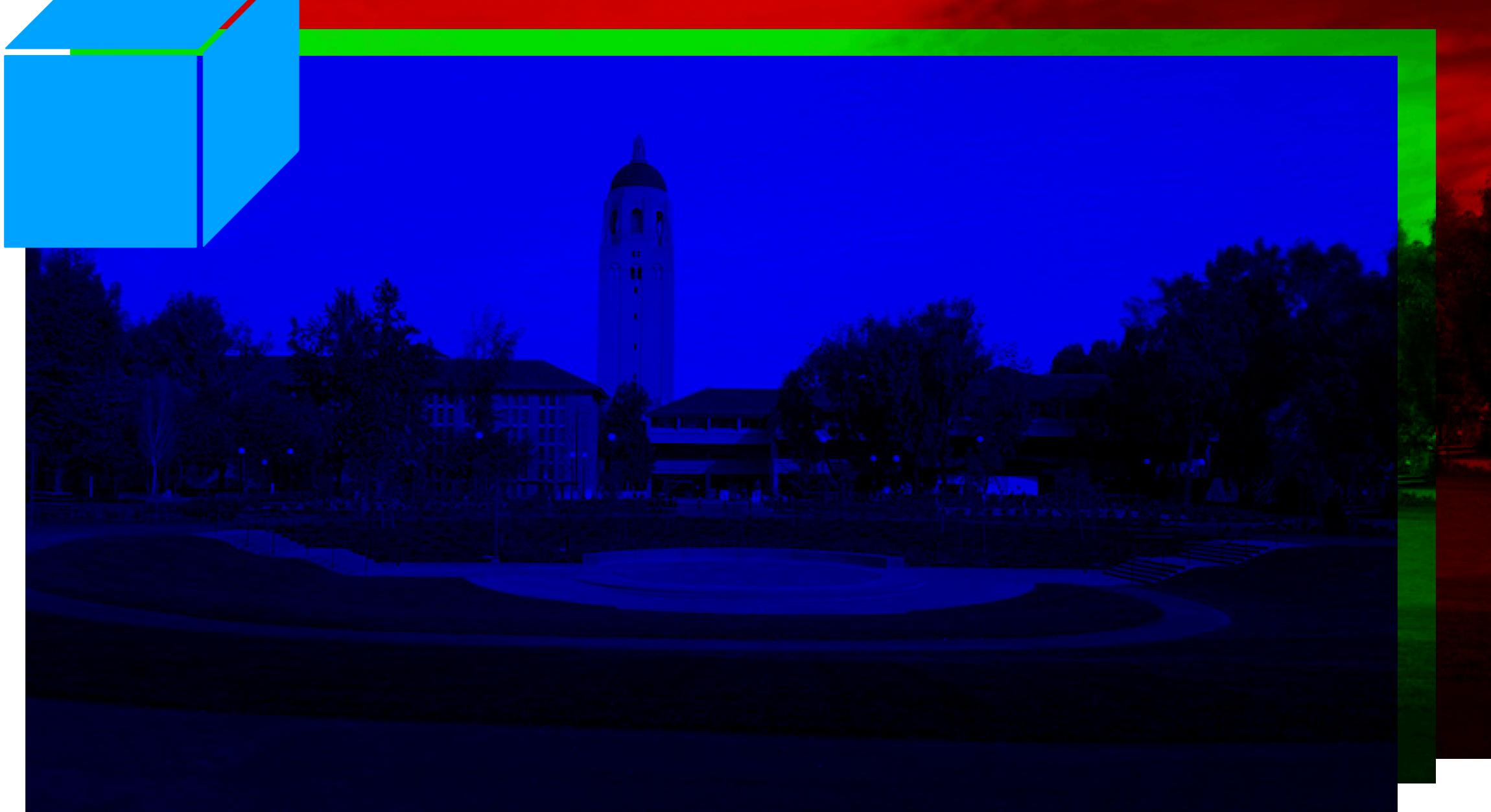
Stride=2



Convolution Operation with Stride Length = 2

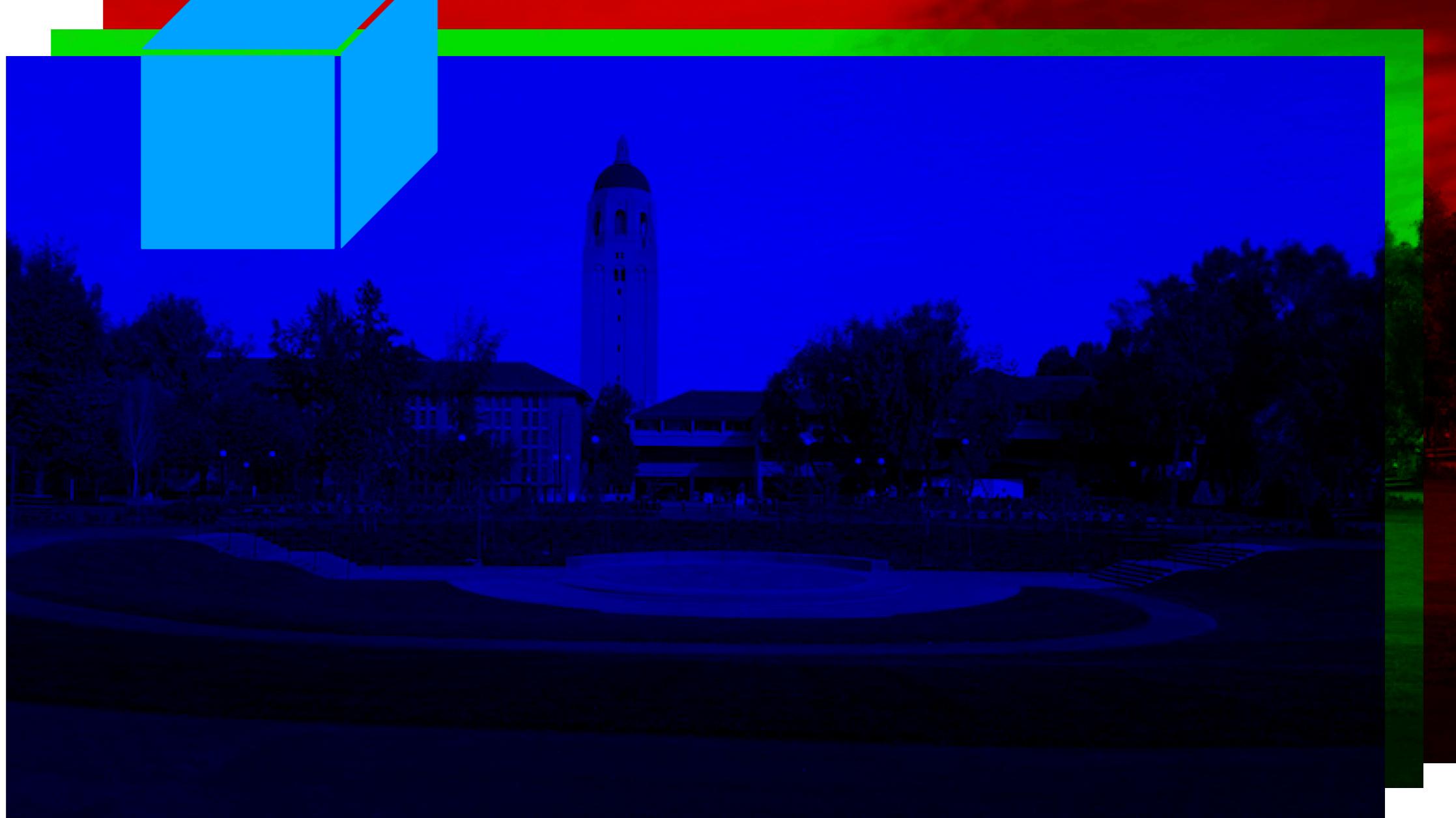




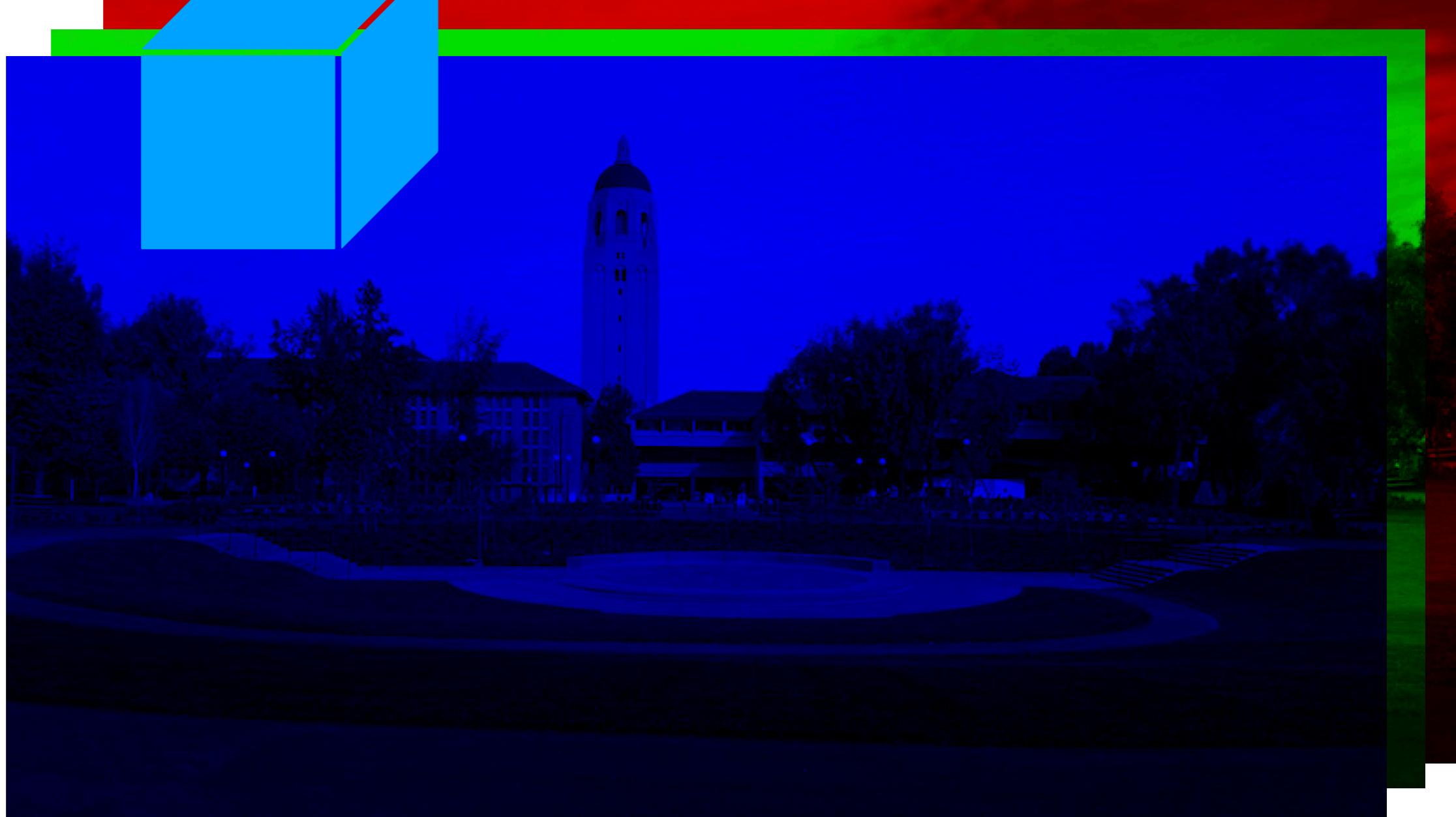


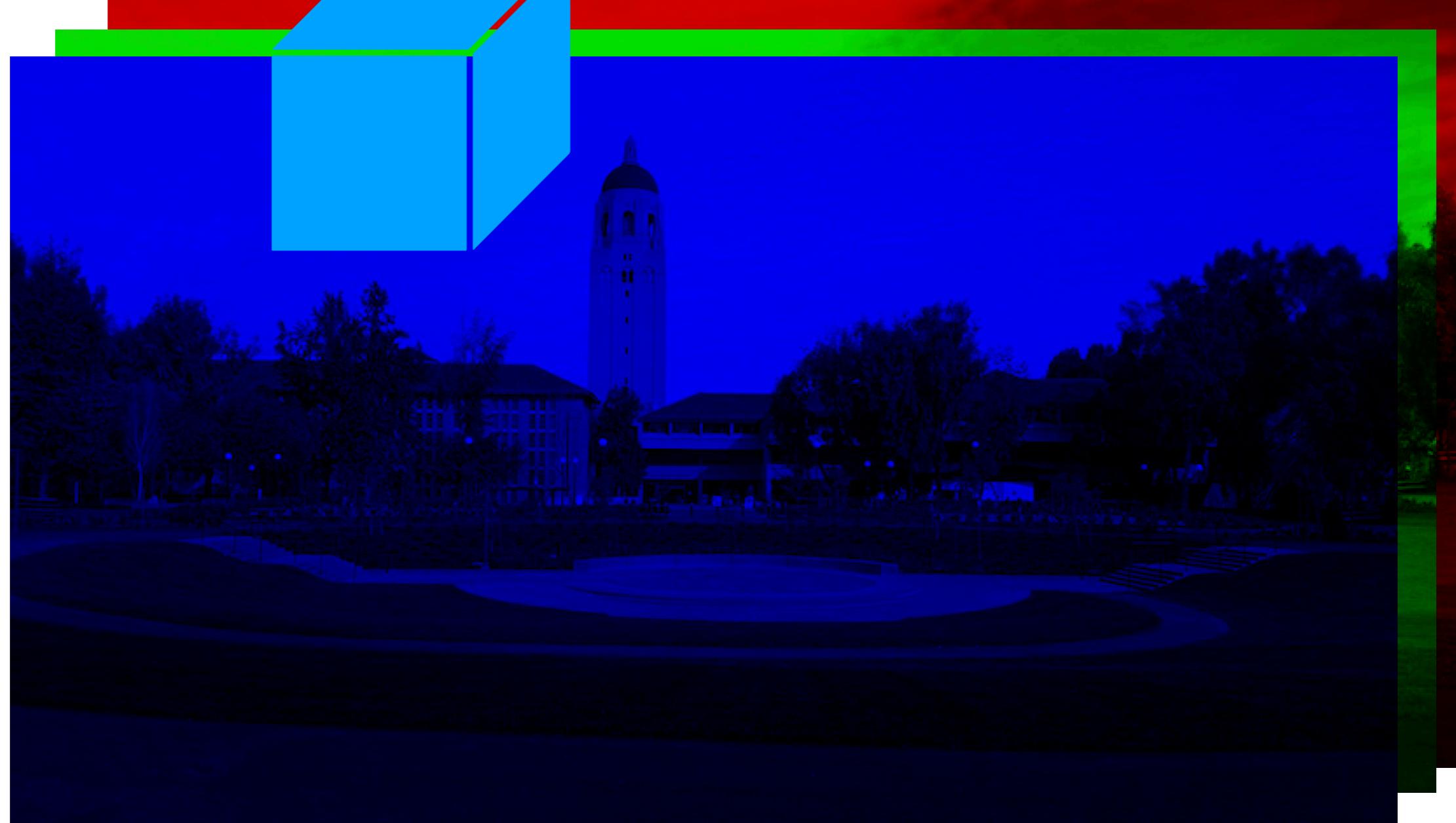


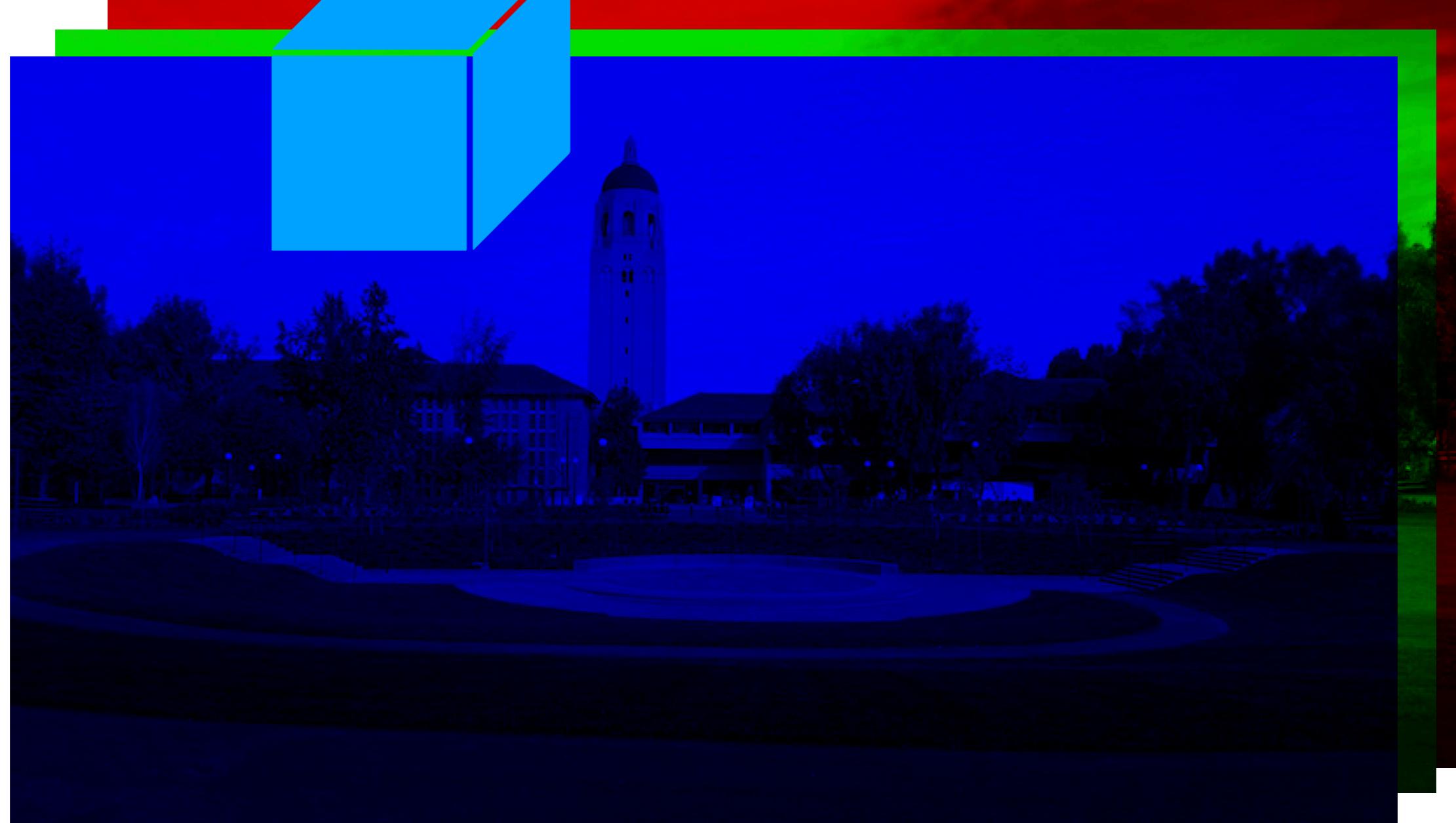
10

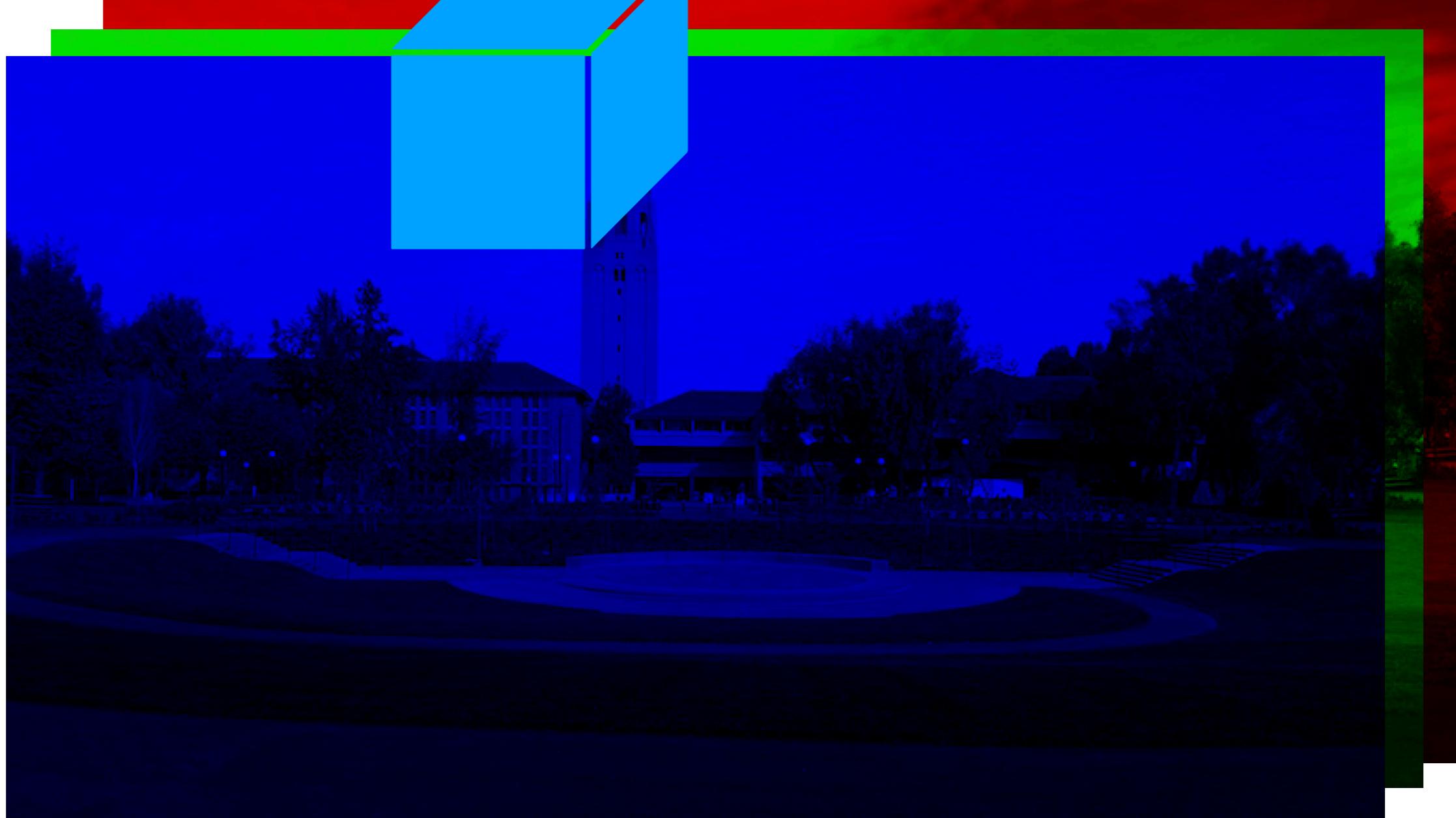


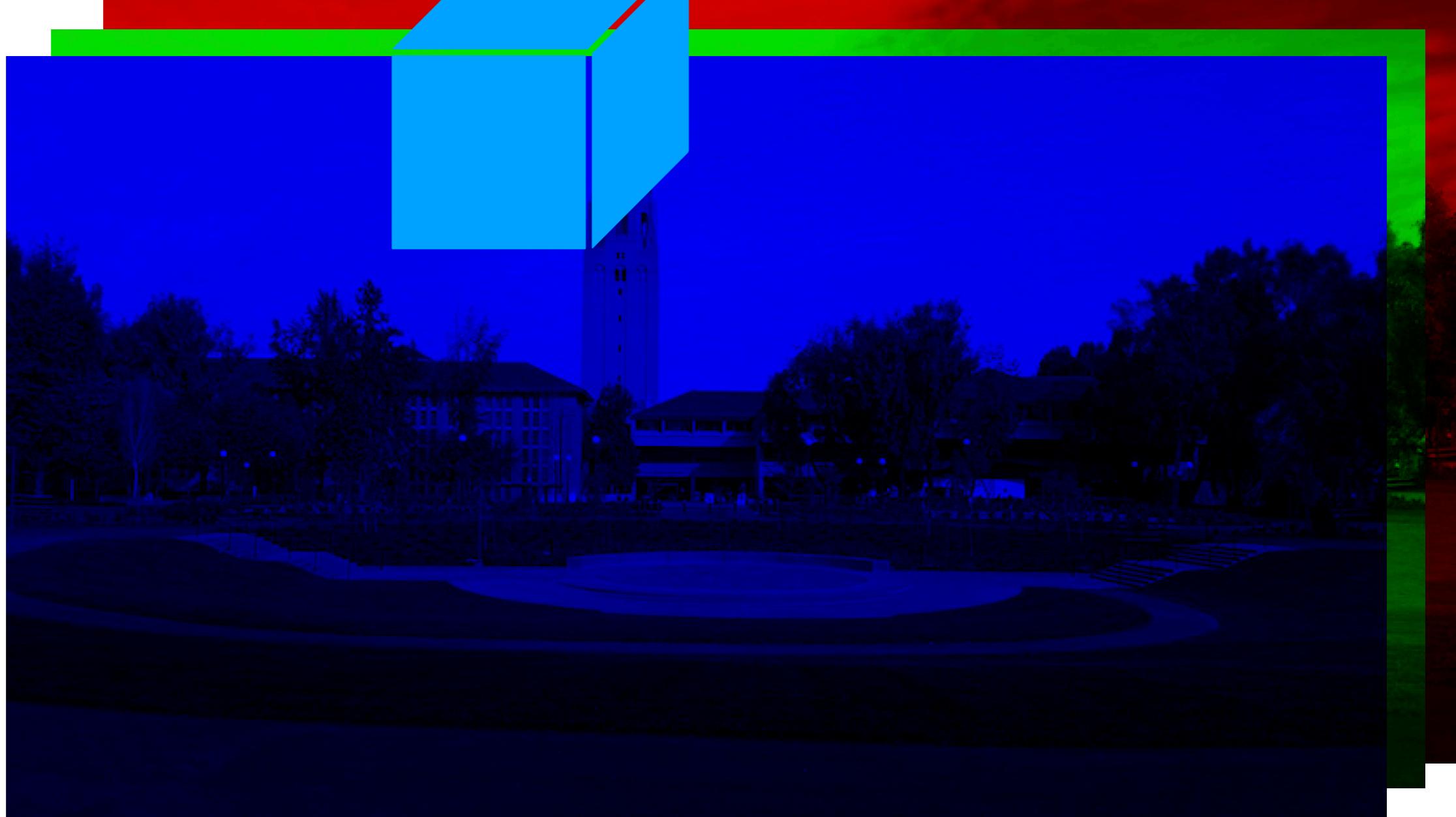
10

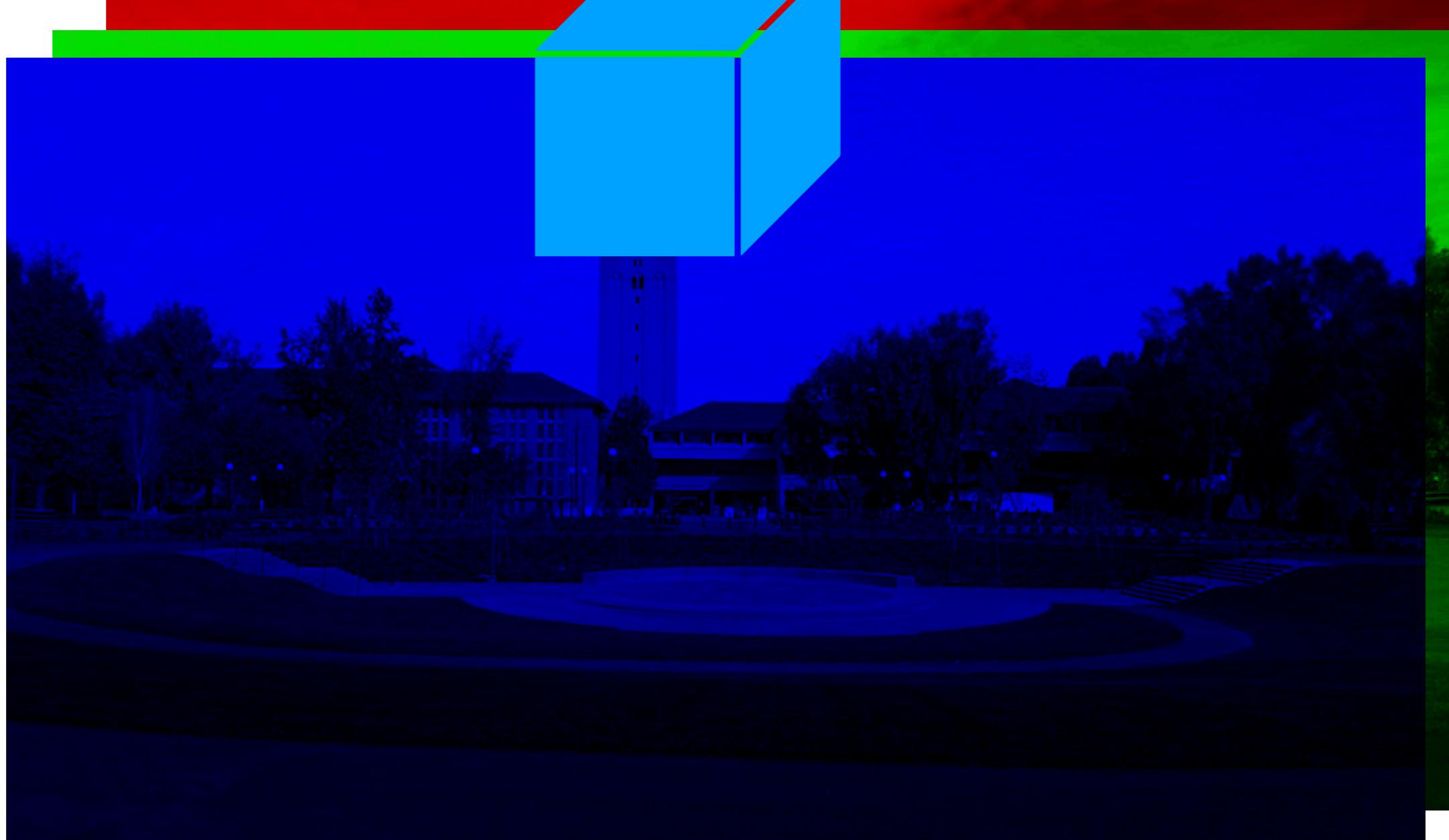


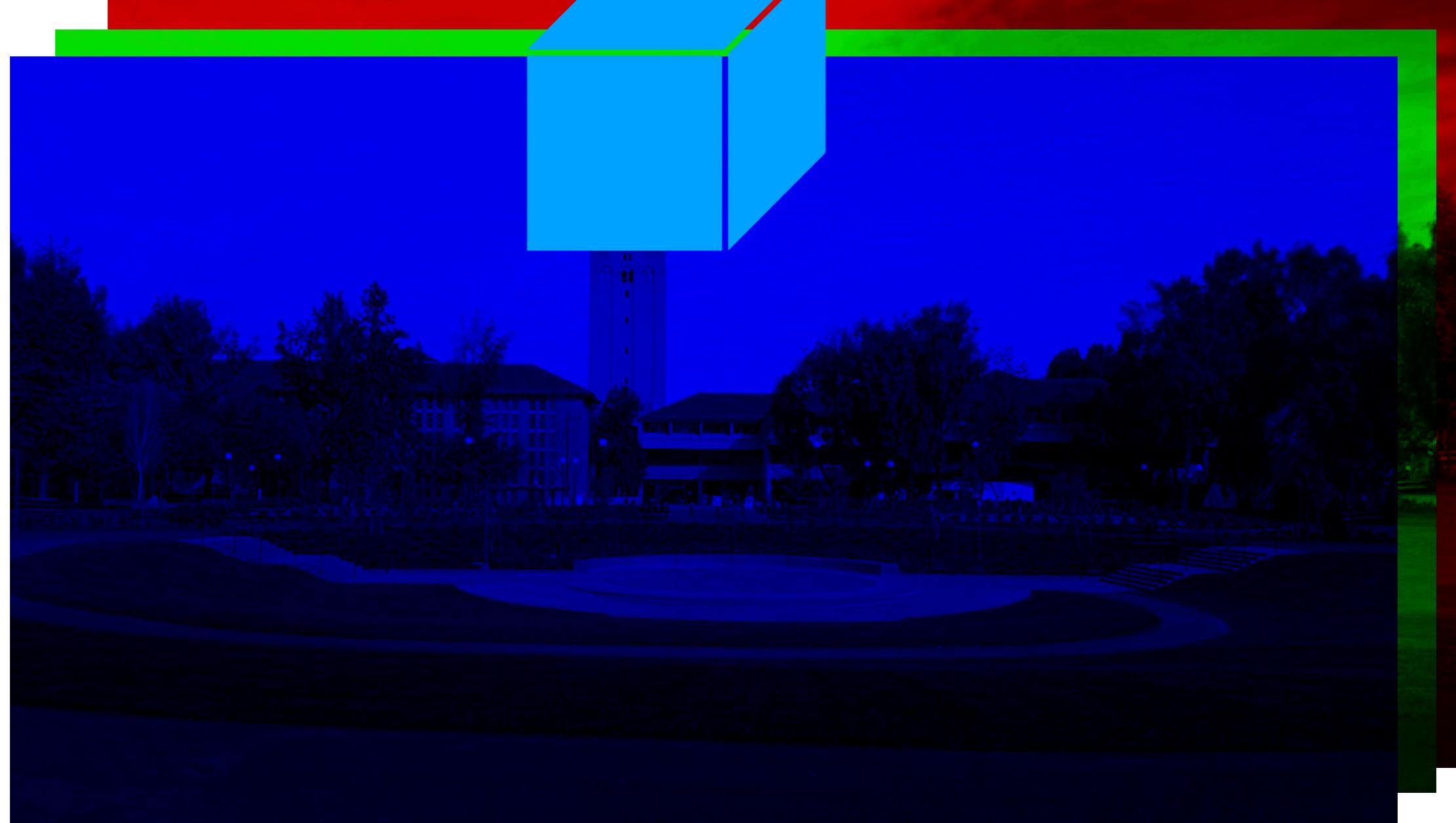


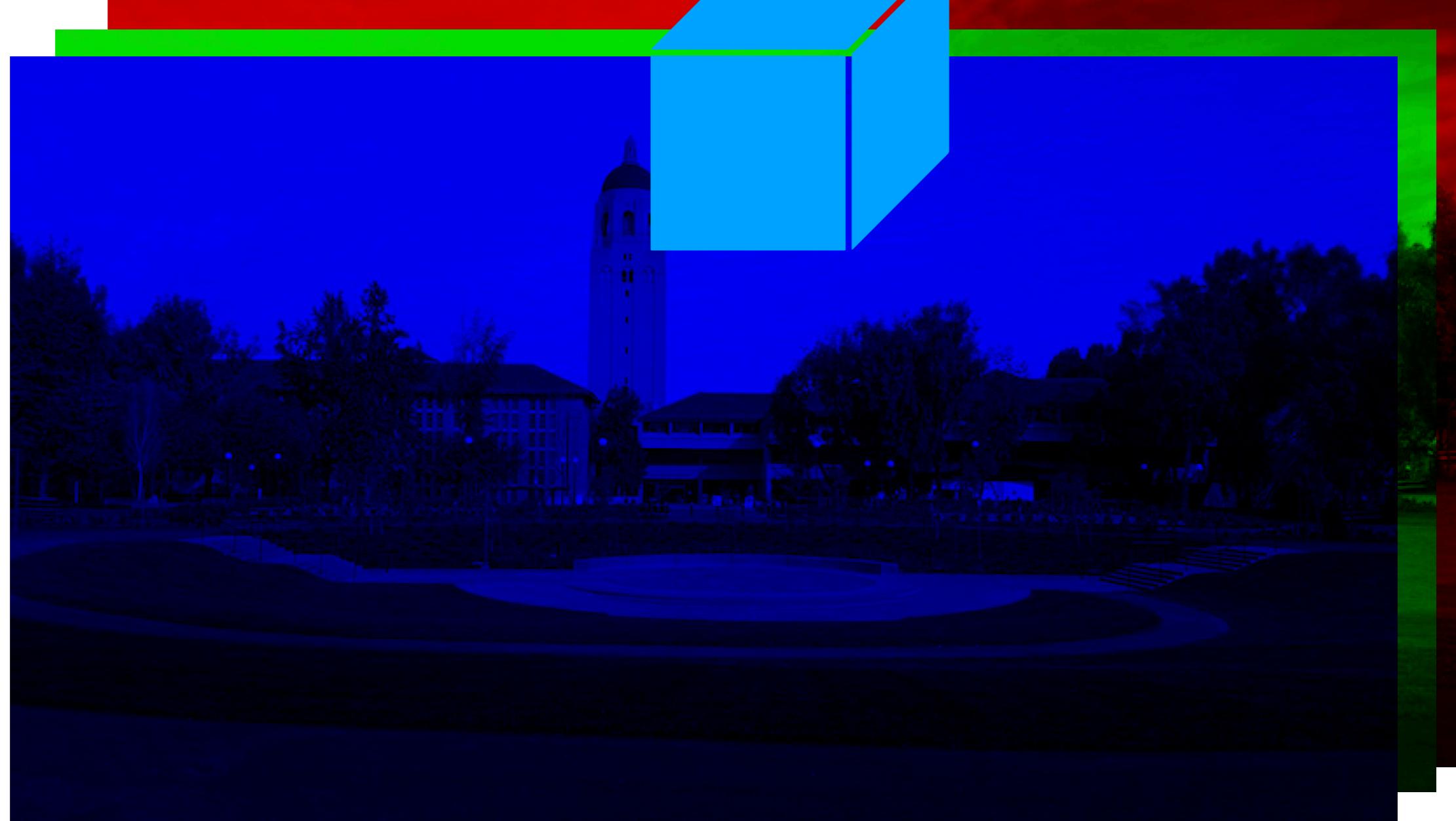


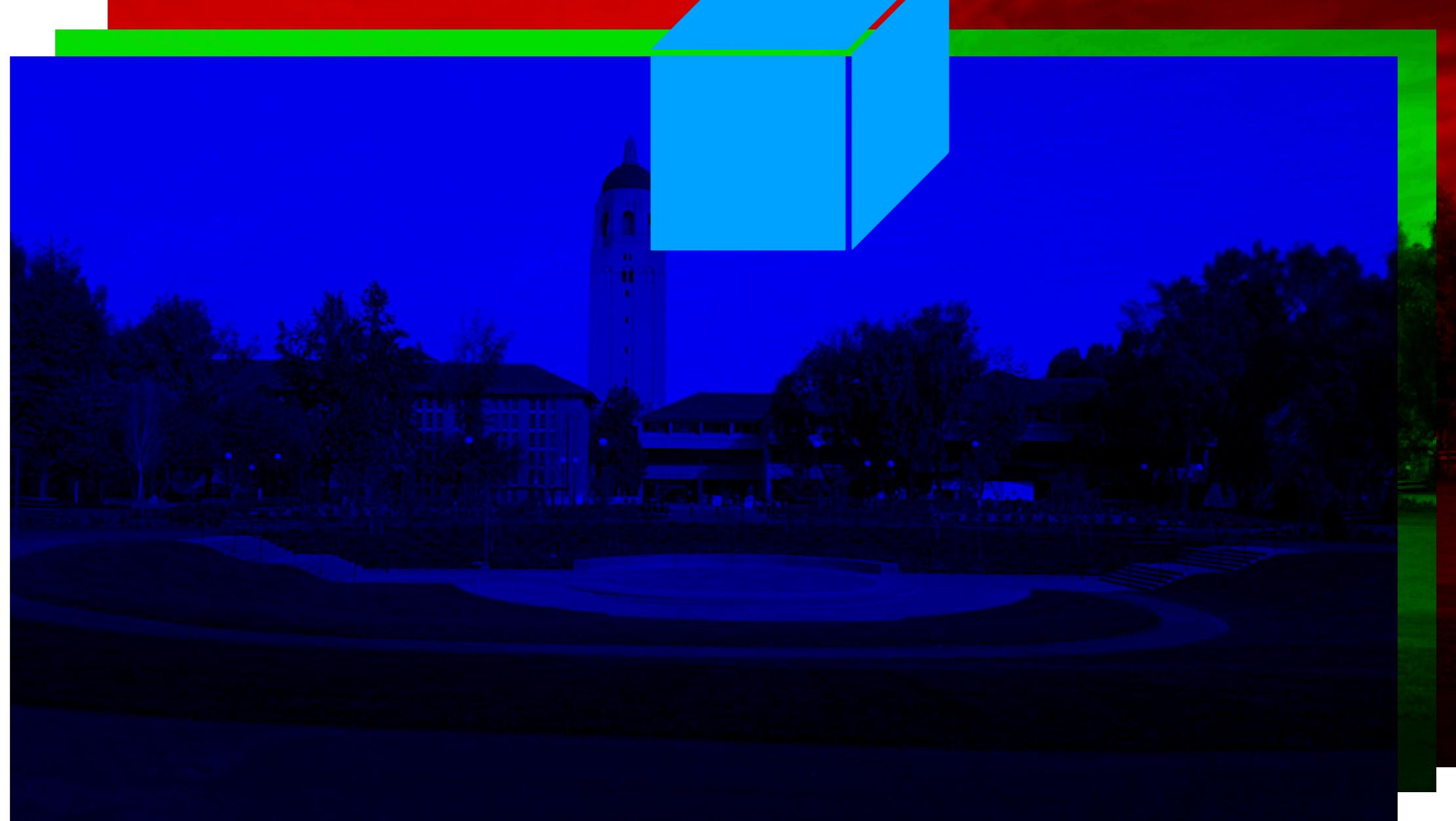










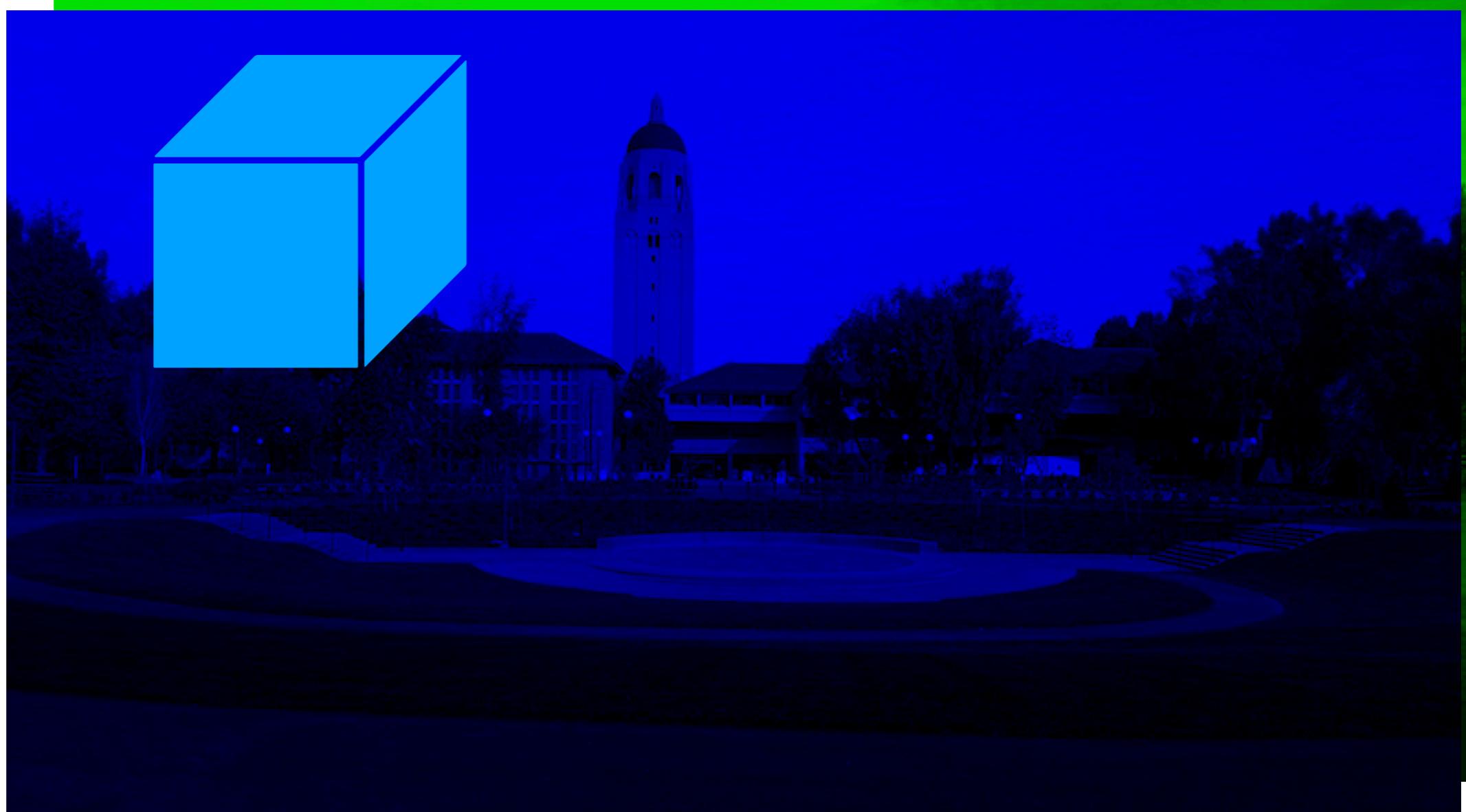


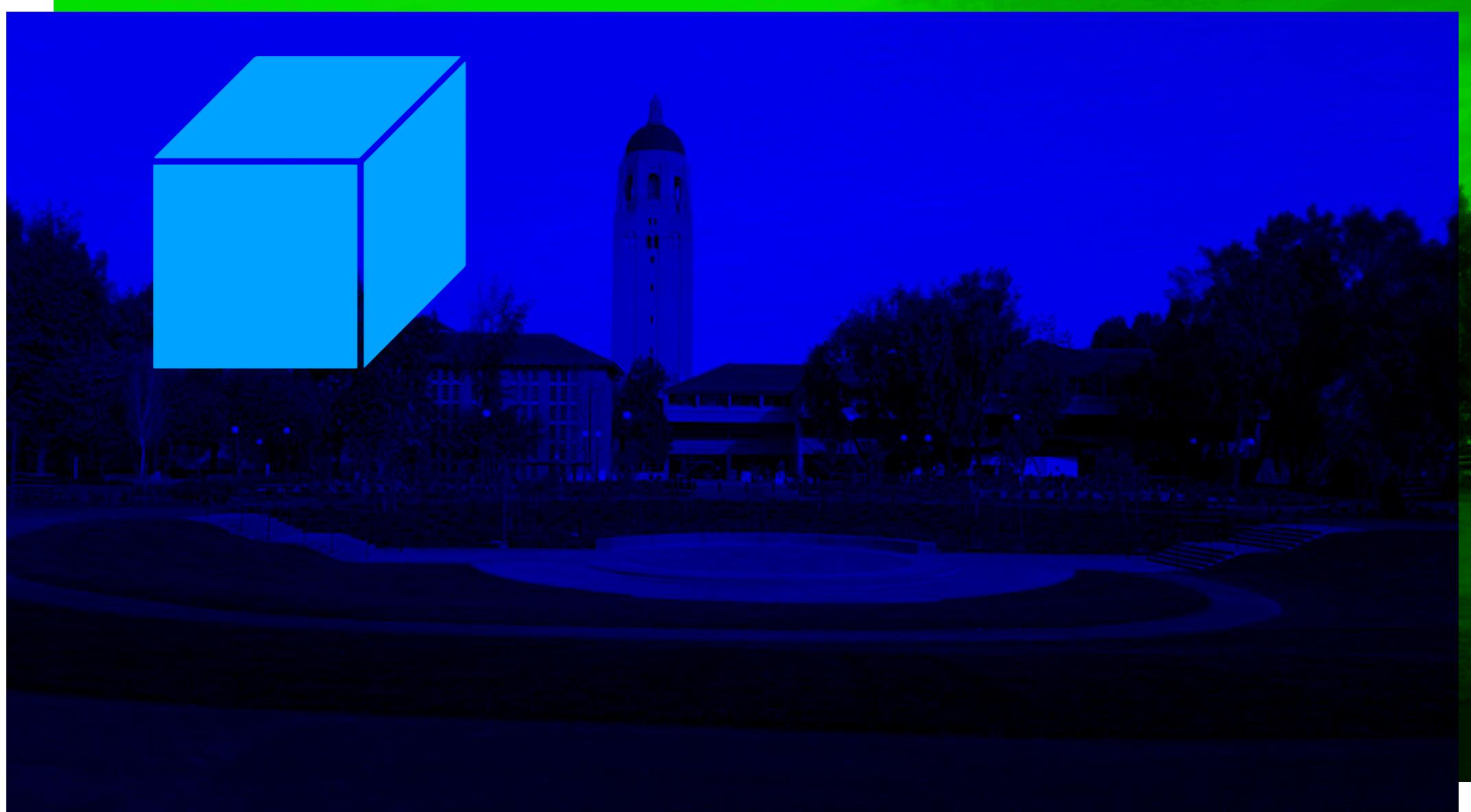


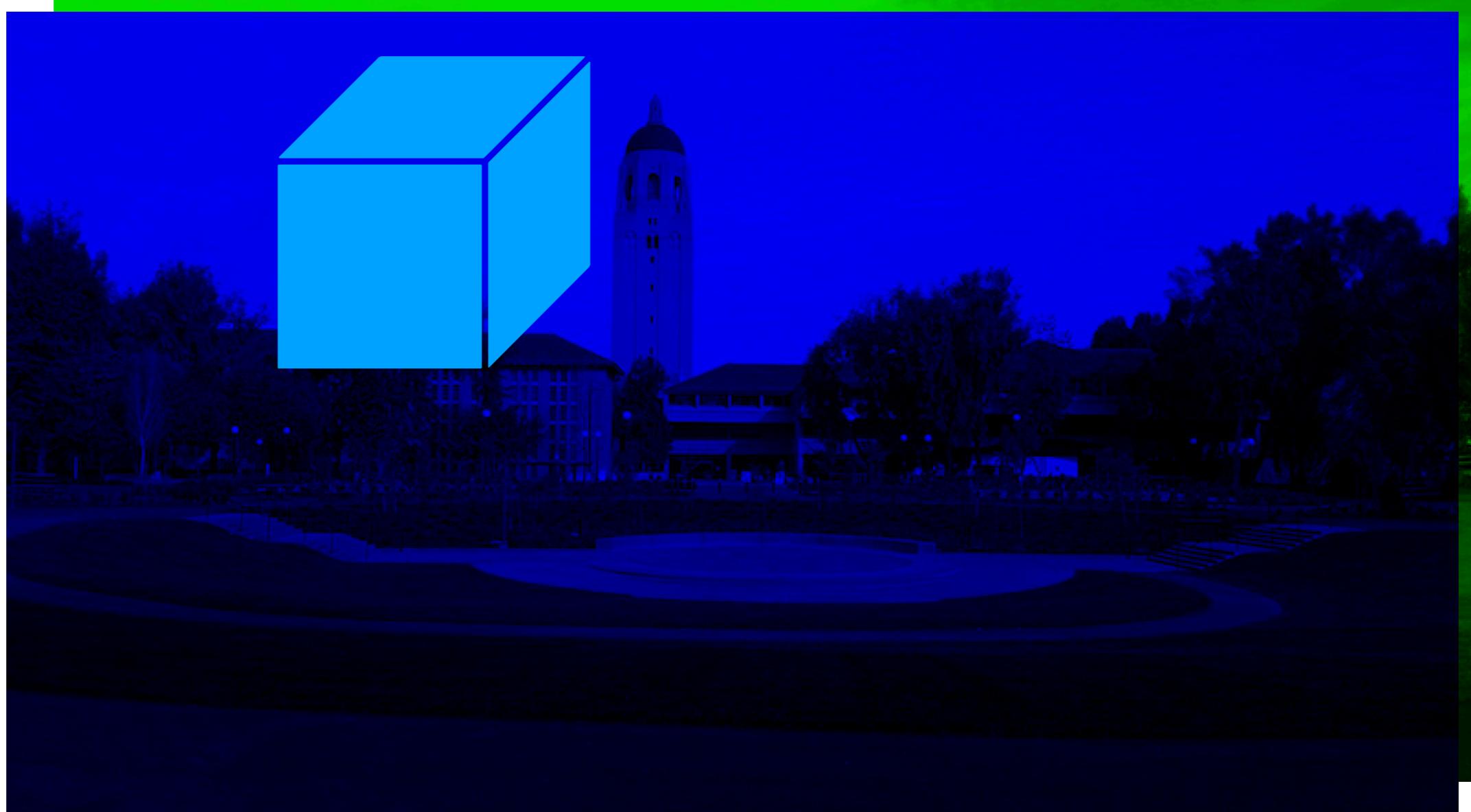


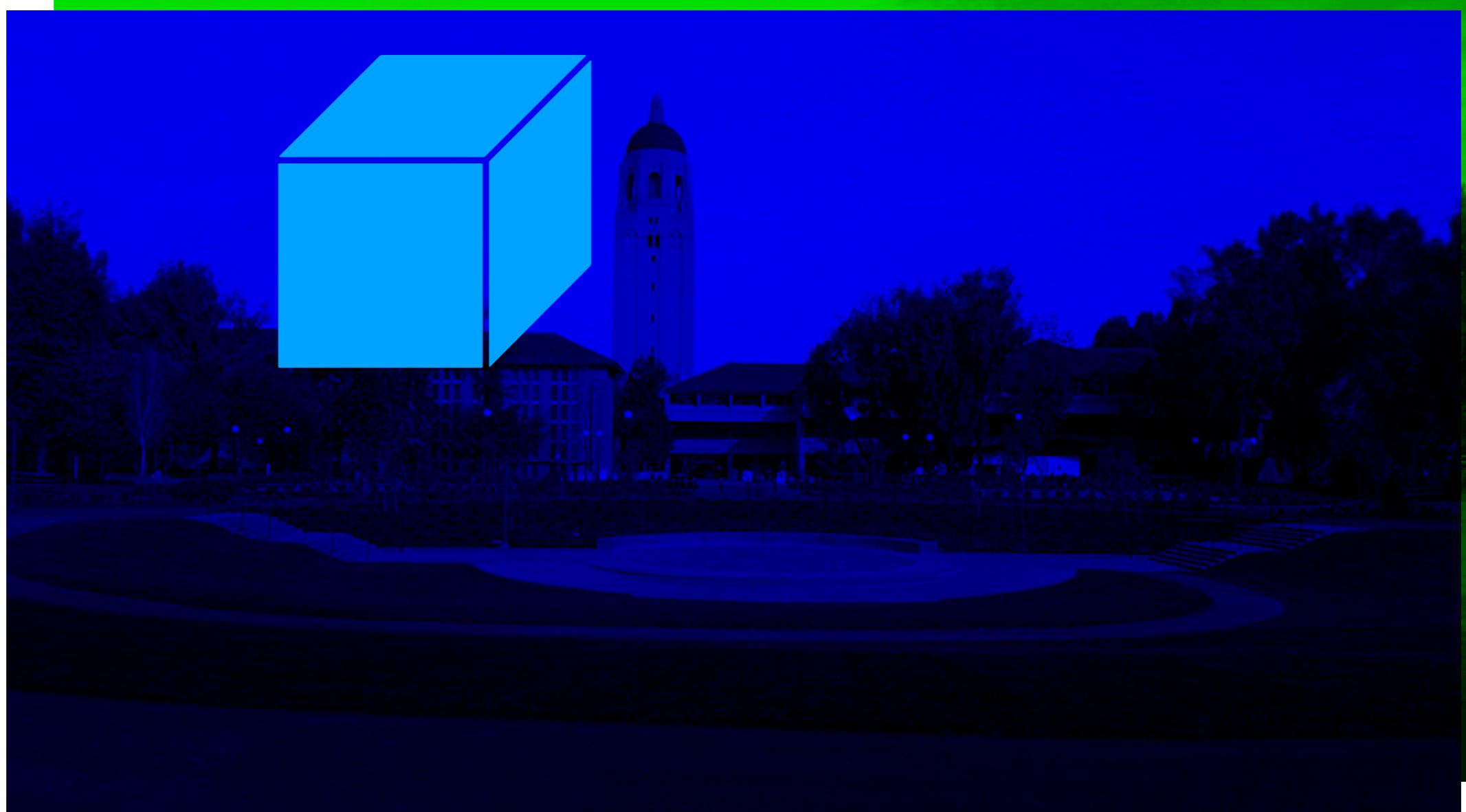


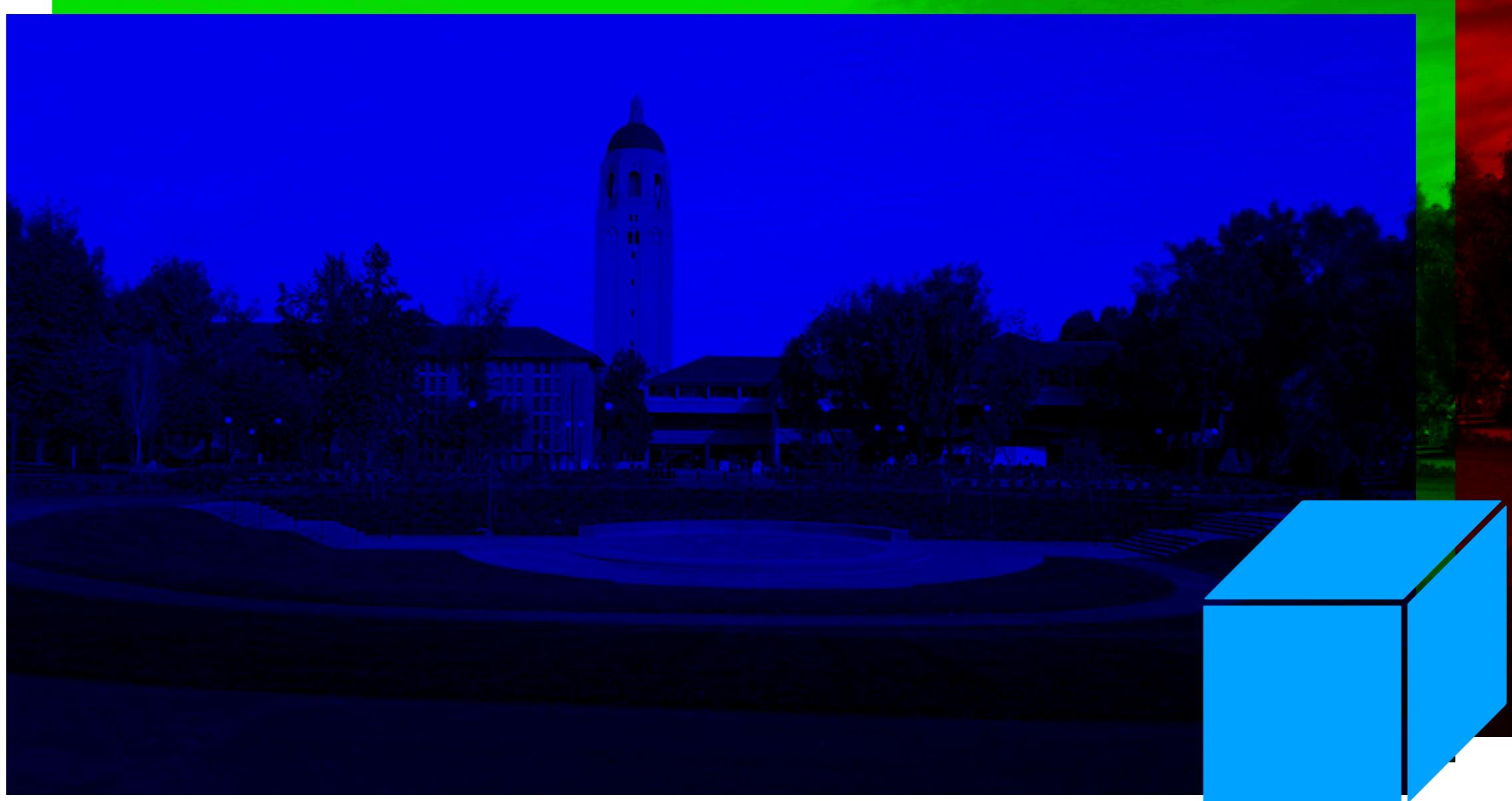


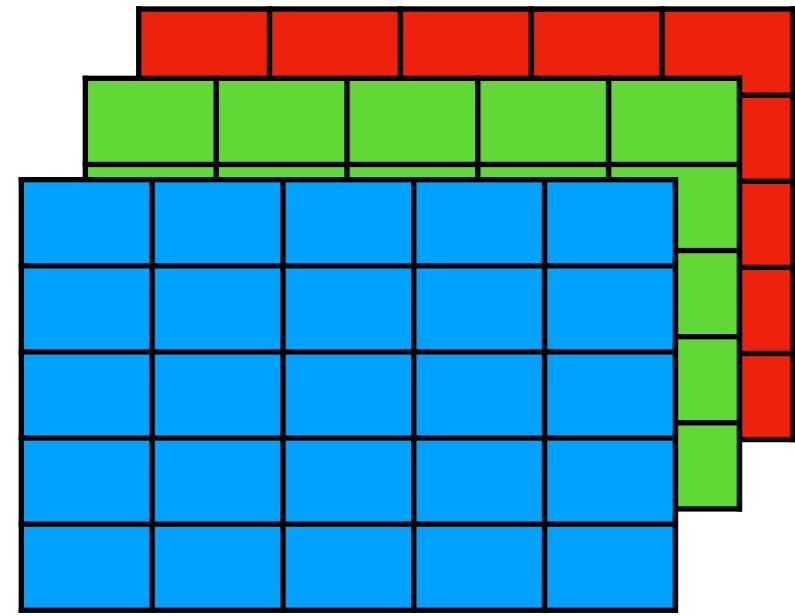


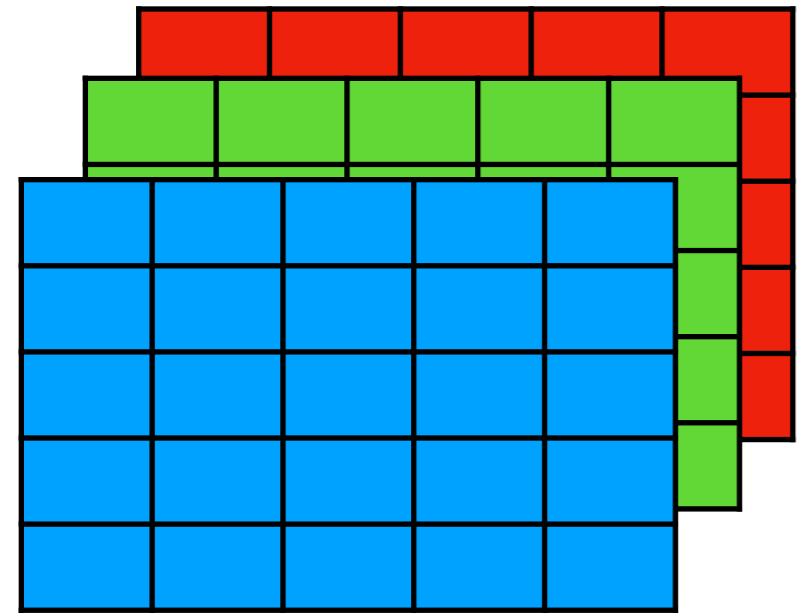




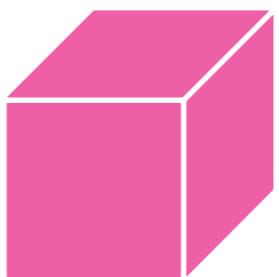




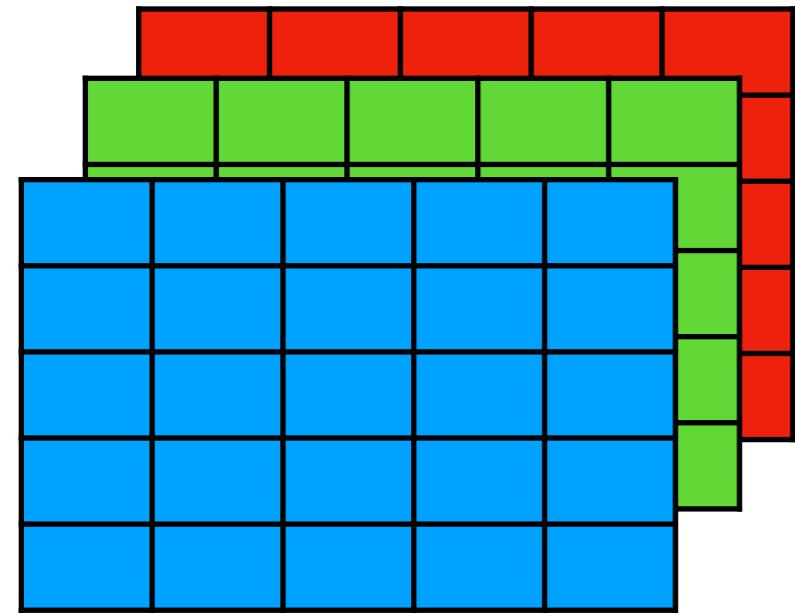




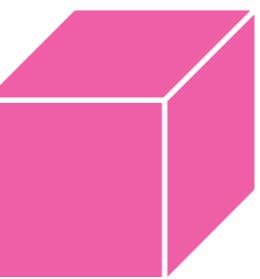
*



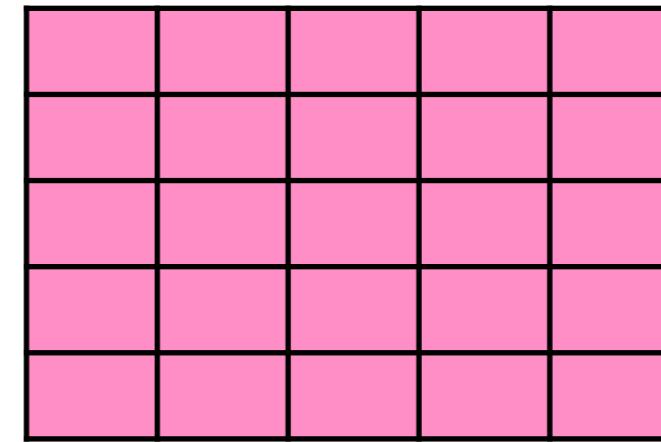
$$\begin{array}{c} \text{A 5x5 matrix of blue squares} \\ \text{A 2x5 matrix of green squares} \\ \text{A 1x5 matrix of red squares} \end{array} * \begin{array}{c} \text{A 3D pink cube} \end{array} = \begin{array}{c} \text{A 5x5 matrix of pink squares} \end{array}$$



*

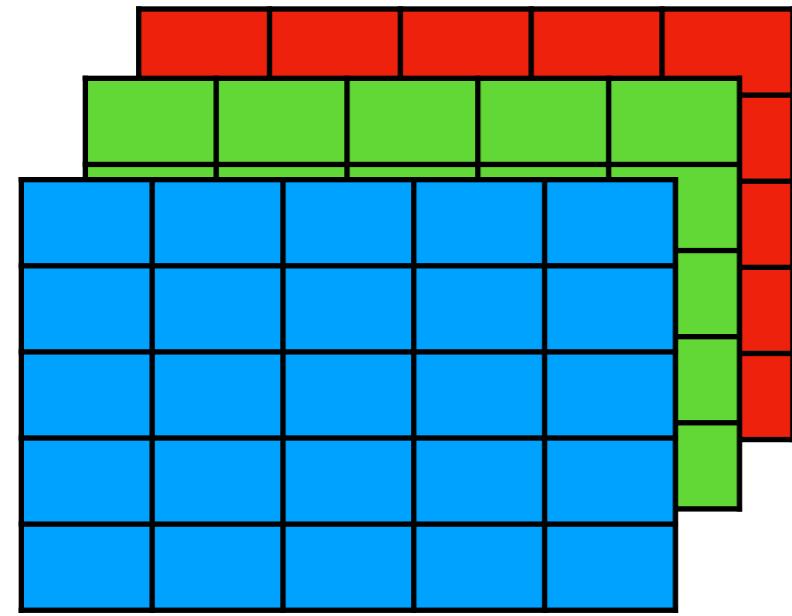


=

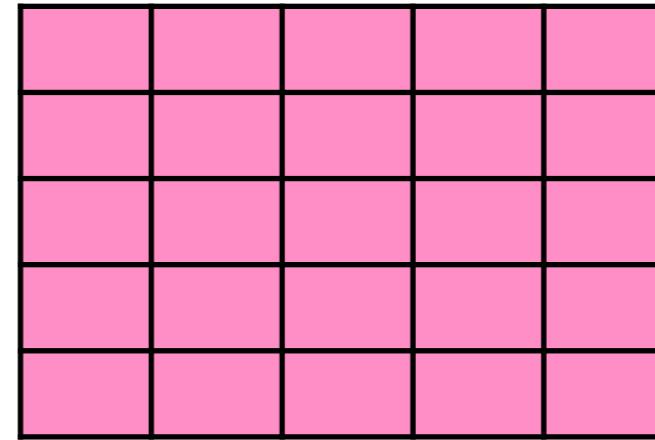


*

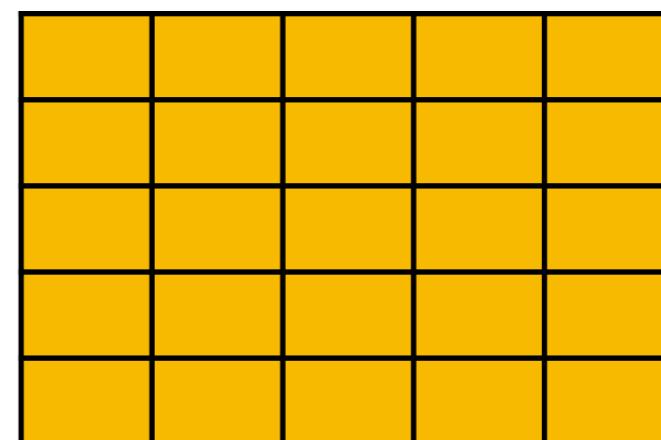


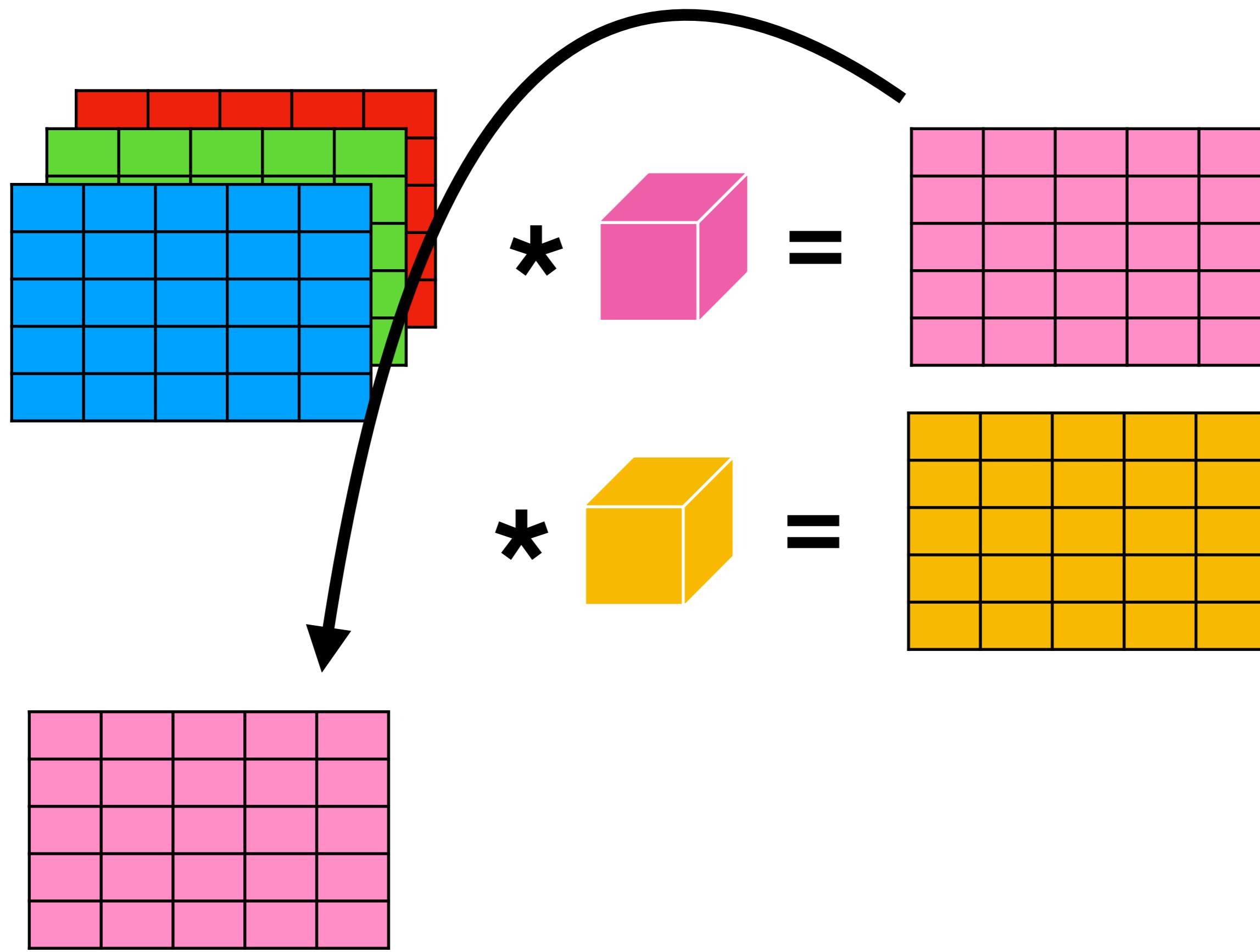


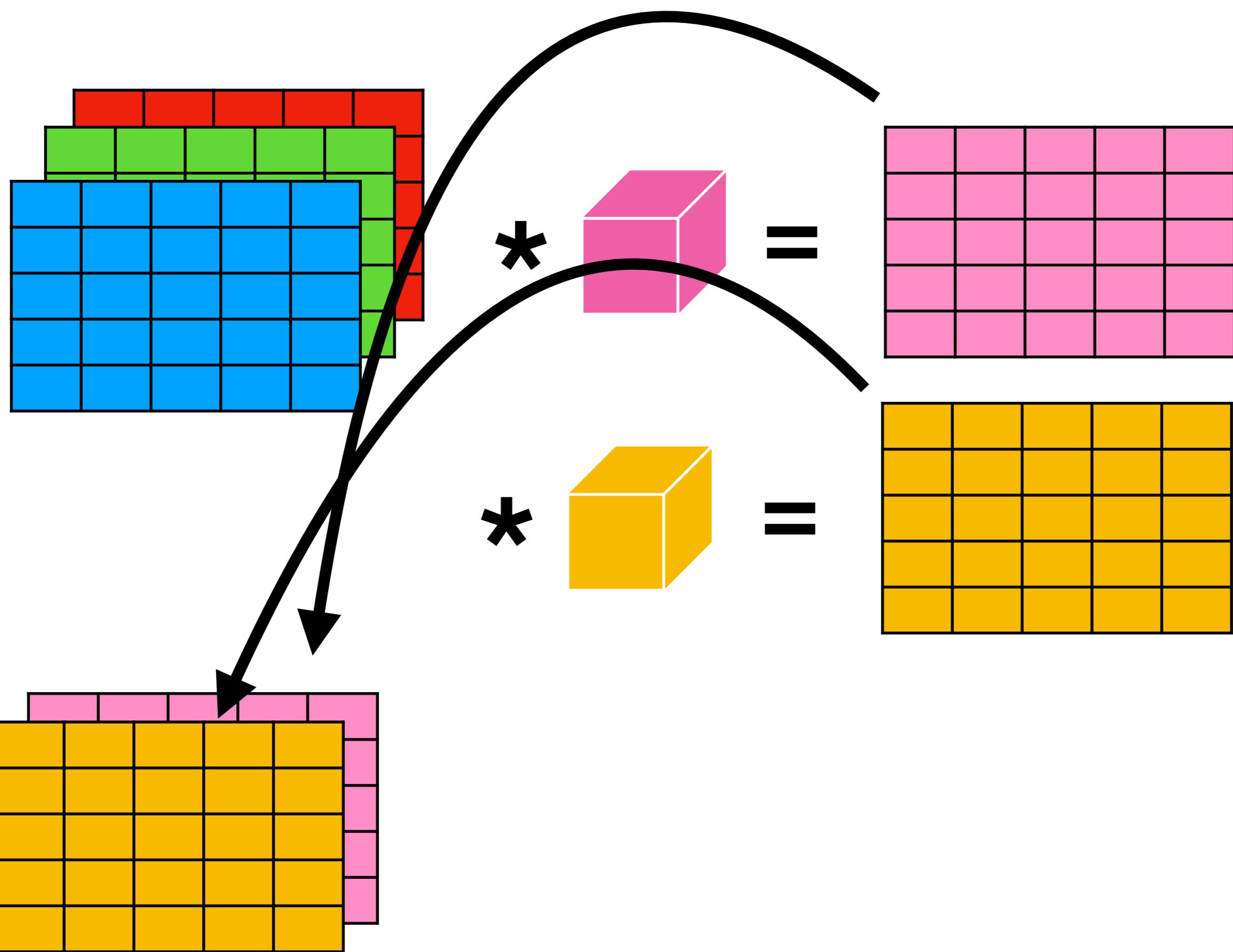
* =

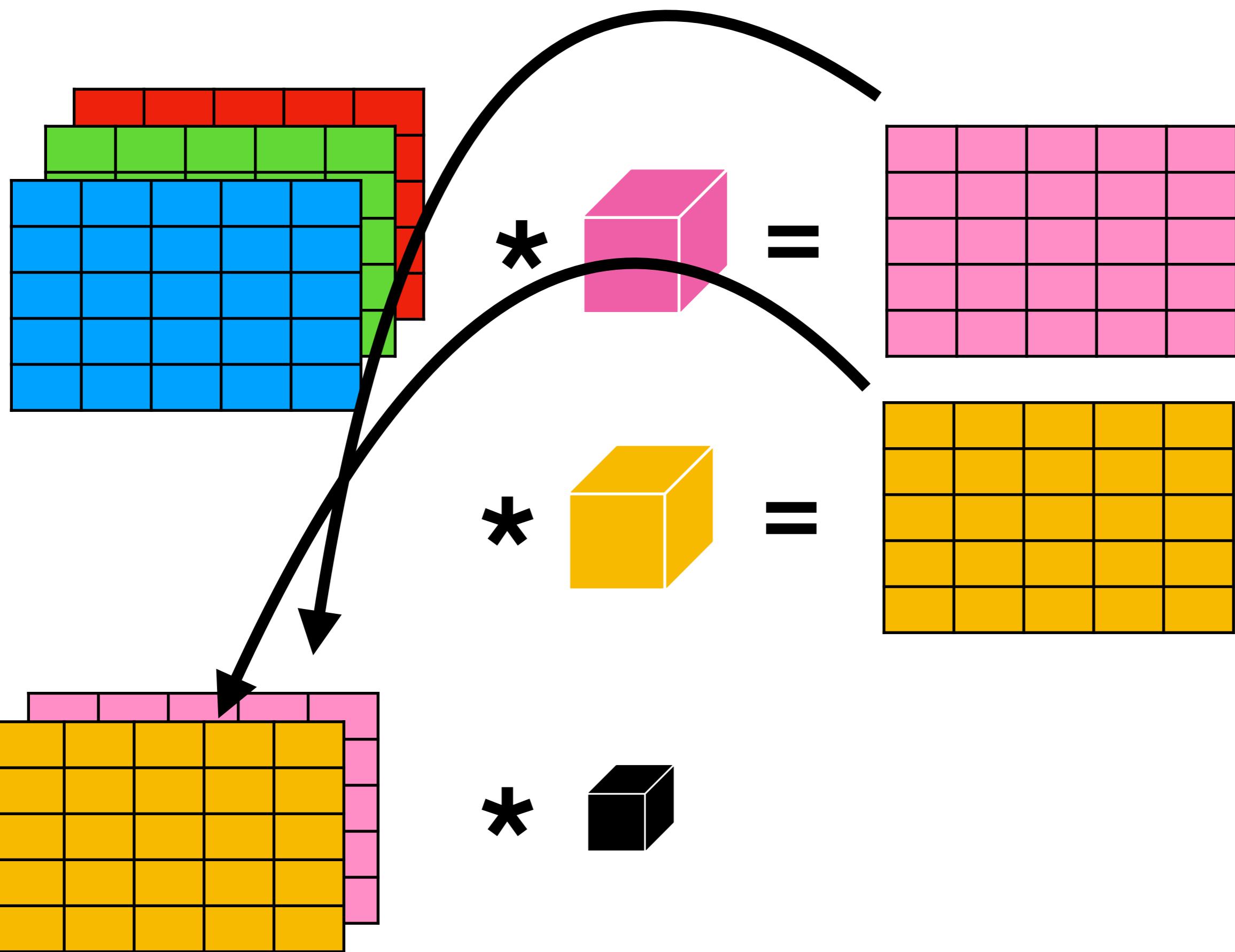


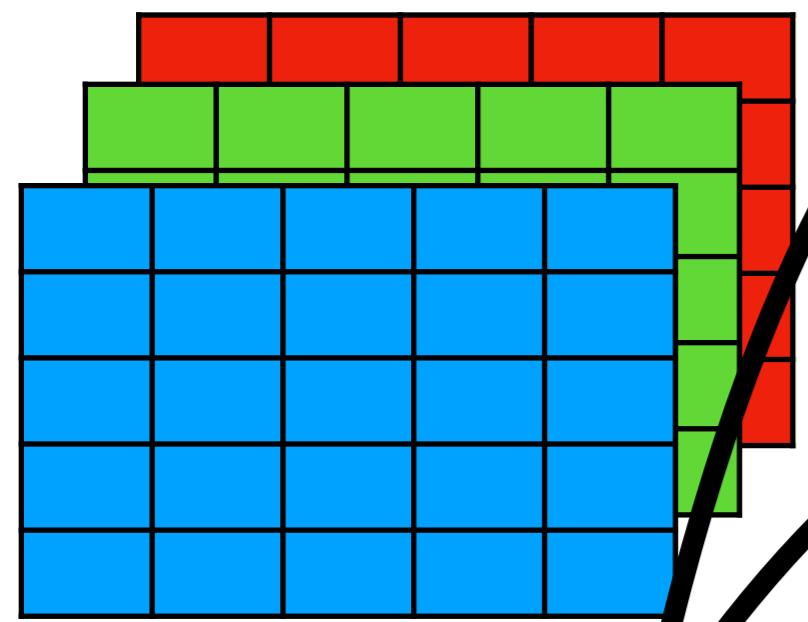
* =





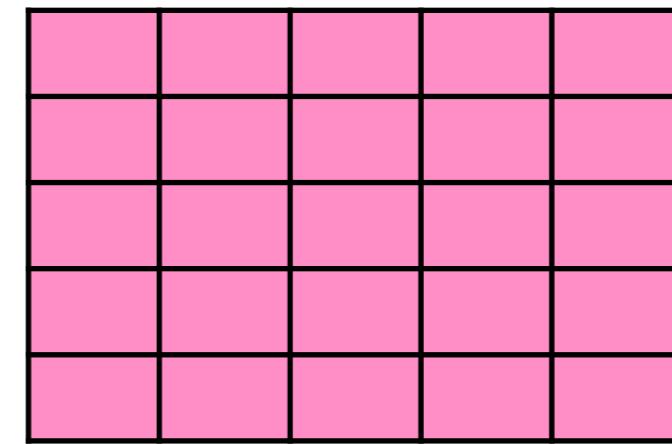






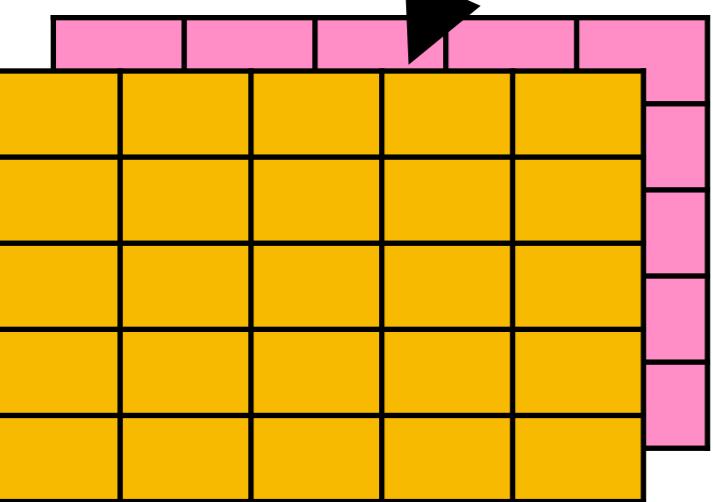
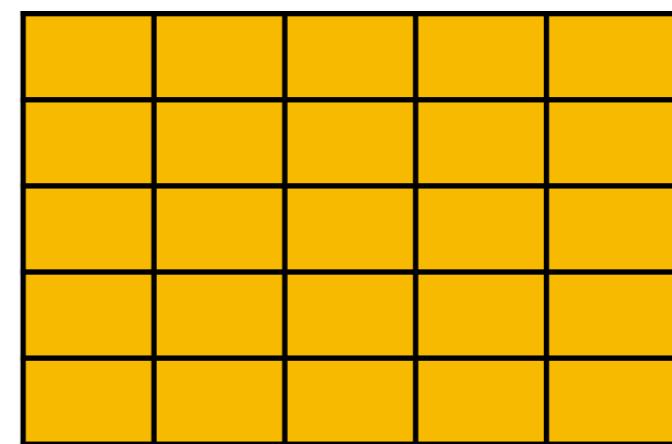
$$\begin{matrix} * & \end{matrix} =$$

A 3x3 matrix of pink blocks, representing a kernel. It is positioned next to the multiplication symbol and equals sign.



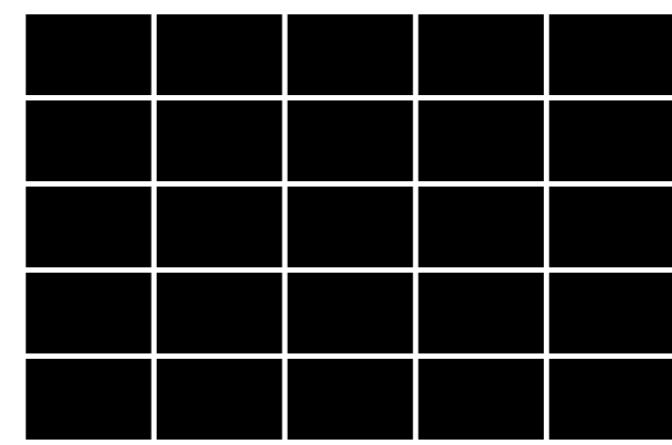
$$\begin{matrix} * & \end{matrix} =$$

A 3x3 matrix of yellow blocks, representing a kernel. It is positioned next to the multiplication symbol and equals sign.



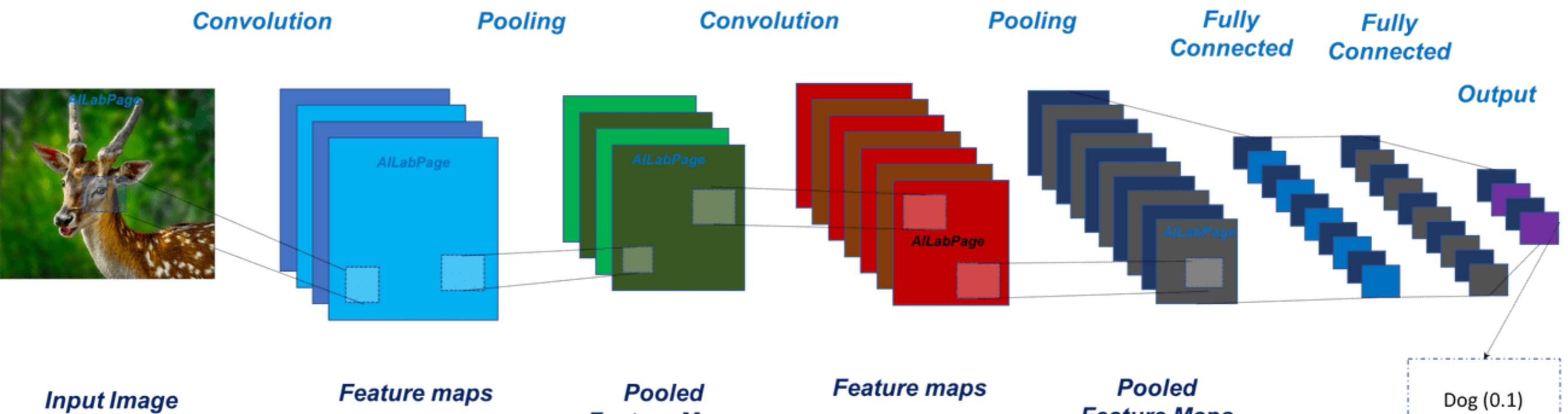
$$\begin{matrix} * & \end{matrix} =$$

A 3x3 matrix of black blocks, representing a kernel. It is positioned next to the multiplication symbol and equals sign.



Convolutional Neural Network

Convolution Neural Network



Input Image

Feature maps

Pooled Feature Maps

Feature maps

Pooled Feature Maps

Dog (0.1)
Cat(0.4)
Deer(0.94)
Lion(0.2)

AI Lab Page

Data Source - Open Internet various sources

Image Source - <https://vinodsblog.com>

via @vinod1975

