

# Different methods used in Upsampling

Guo-Wei Wei<sup>1,2,3</sup> and Rui Wang<sup>1</sup>

<sup>1</sup> Department of Mathematics, Michigan State University, MI 48824, USA

<sup>2</sup> Department of Biochemistry and Molecular Biology  
Michigan State University, MI 48824, USA

<sup>3</sup> Department of Electrical and Computer Engineering  
Michigan State University, MI 48824, USA

## Contents

<b>1</b>	<b>Transposed Convolution</b>	<b>1</b>
<b>2</b>	<b>Un-Pooling</b>	<b>2</b>
2.1	Nearest Neighbor . . . . .	2
2.2	Bed of Nails . . . . .	3
2.3	Bilinear . . . . .	3
2.3.1	align_corners = False . . . . .	3
2.3.2	align_corners = True . . . . .	3
2.4	Max-Pooling indices . . . . .	3

# 1 Transposed Convolution

Learnable parameters are used for upsampling.  
First, We will explain how convolution layers works.

$$\begin{array}{|c|c|c|} \hline w_{00} & w_{01} & w_{02} \\ \hline w_{10} & w_{11} & w_{12} \\ \hline w_{20} & w_{21} & w_{22} \\ \hline \end{array} * \begin{array}{|c|c|c|c|} \hline x_0 & x_1 & x_2 & x_3 \\ \hline x_4 & x_5 & x_6 & x_7 \\ \hline x_8 & x_9 & x_{10} & x_{11} \\ \hline x_{12} & x_{13} & x_{14} & x_{15} \\ \hline \end{array} = \begin{array}{|c|c|} \hline Y_0 & Y_1 \\ \hline Y_2 & Y_3 \\ \hline \end{array}$$

We unrolling the convolution operation to matrix multiplication, then we have:

$$\begin{array}{|c|c|c|c|c|c|c|c|c|c|c|c|c|c|c|} \hline w_{00} & w_{01} & w_{02} & 0 & w_{10} & w_{11} & w_{12} & 0 & w_{20} & w_{21} & w_{22} & 0 & 0 & 0 & 0 & 0 \\ \hline 0 & w_{00} & w_{01} & w_{02} & 0 & w_{10} & w_{11} & w_{12} & 0 & w_{20} & w_{21} & w_{22} & 0 & 0 & 0 & 0 \\ \hline 0 & 0 & 0 & 0 & w_{00} & w_{01} & w_{02} & 0 & w_{10} & w_{11} & w_{12} & 0 & w_{20} & w_{21} & w_{22} & 0 \\ \hline 0 & 0 & 0 & 0 & 0 & w_{00} & w_{01} & w_{02} & 0 & w_{10} & w_{11} & w_{12} & 0 & w_{20} & w_{21} & w_{22} \\ \hline \end{array} \times \begin{array}{|c|} \hline x_0 \\ \hline x_1 \\ \hline x_2 \\ \hline x_3 \\ \hline x_4 \\ \hline x_5 \\ \hline x_6 \\ \hline x_7 \\ \hline x_8 \\ \hline x_9 \\ \hline x_{10} \\ \hline x_{11} \\ \hline x_{12} \\ \hline x_{13} \\ \hline x_{14} \\ \hline x_{15} \\ \hline \end{array} = \begin{array}{|c|} \hline Y_0 \\ \hline Y_1 \\ \hline Y_2 \\ \hline Y_3 \\ \hline \end{array}$$

Next, we will focus on how deconvolution(Transposed convolution) works.

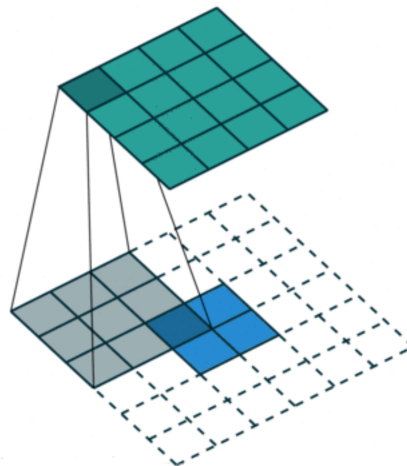


Figure 1: Transposed convolution

$w_{00}$	0	0	0
$w_{01}$	$w_{00}$	0	0
$w_{02}$	$w_{01}$	0	0
0	$w_{02}$	0	0
$w_{10}$	0	$w_{00}$	0
$w_{11}$	$w_{10}$	$w_{01}$	$w_{00}$
$w_{12}$	$w_{11}$	$w_{02}$	$w_{01}$
0	$w_{12}$	0	$w_{02}$
$w_{20}$	0	$w_{10}$	0
$w_{21}$	$w_{20}$	$w_{11}$	$w_{10}$
$w_{22}$	$w_{21}$	$w_{12}$	$w_{11}$
0	$w_{22}$	0	$w_{12}$
0	0	$w_{20}$	0
0	0	$w_{21}$	$w_{20}$
0	0	$w_{22}$	$w_{21}$
0	0	0	$w_{22}$

 $\times$ 

$Y_0$
$Y_1$
$Y_2$
$Y_3$

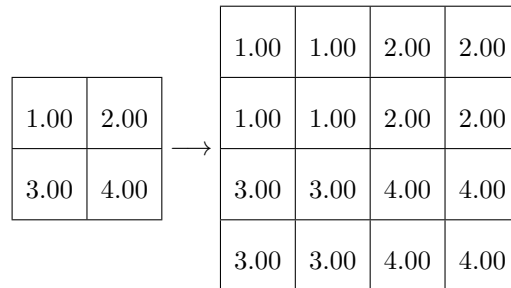
 $=$ 

$x_0$
$x_1$
$x_2$
$x_3$
$x_4$
$x_5$
$x_6$
$x_7$
$x_8$
$x_9$
$x_{10}$
$x_{11}$
$x_{12}$
$x_{13}$
$x_{14}$
$x_{15}$

## 2 Un-Pooling

No Learnable parameters are used for upsampling.

### 2.1 Nearest Neighbor



## 2.2 Bed of Nails

		1.00	0.00	2.00	0.00
		0.00	0.00	0.00	0.00
1.00	2.00	→	3.00	0.00	4.00
3.00	4.00		0.00	0.00	0.00

## 2.3 Bilinear

`align_corners` (bool, optional): if “True”, the corner pixels of the input and output tensors are aligned, and thus preserving the values at those pixels.

### 2.3.1 `align_corners = False`

		1.00	1.25	1.75	2.00
		1.50	1.75	2.25	2.50
1.00	2.00	→	2.50	2.75	3.25
3.00	4.00		3.00	3.25	3.75
			3.50	4.00	

### 2.3.2 `align_corners = True`

		1.00	1.33	1.67	2.00
		1.67	2.00	2.33	2.67
1.00	2.00	→	2.33	2.67	3.00
3.00	4.00		3.00	3.33	3.67
			3.67	4.00	

## 2.4 Max-Pooling indices

1.00	9.00	3.00	9.00
1.00	1.00	2.00	5.00
2.00	0.00	2.00	0.00
0.00	1.00	1.00	4.00

→ Max Pooling →

9.00	9.00
2.00	4.00

→ ... →

1.00	2.00
3.00	4.00

→ Max Unpooling →

0.00	1.00	0.00	2.00
0.00	0.00	0.00	0.00
3.00	0.00	0.00	0.00
0.00	0.00	0.00	4.00