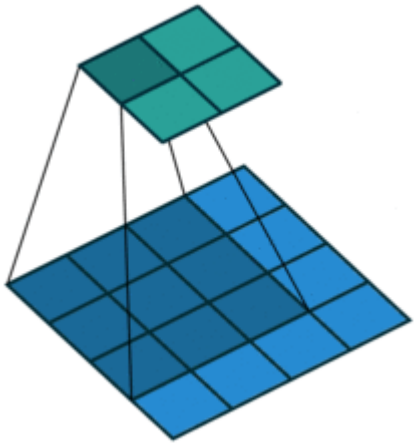
Convolution, De-convolution, Transposed convolution, Fractional-stride convolution

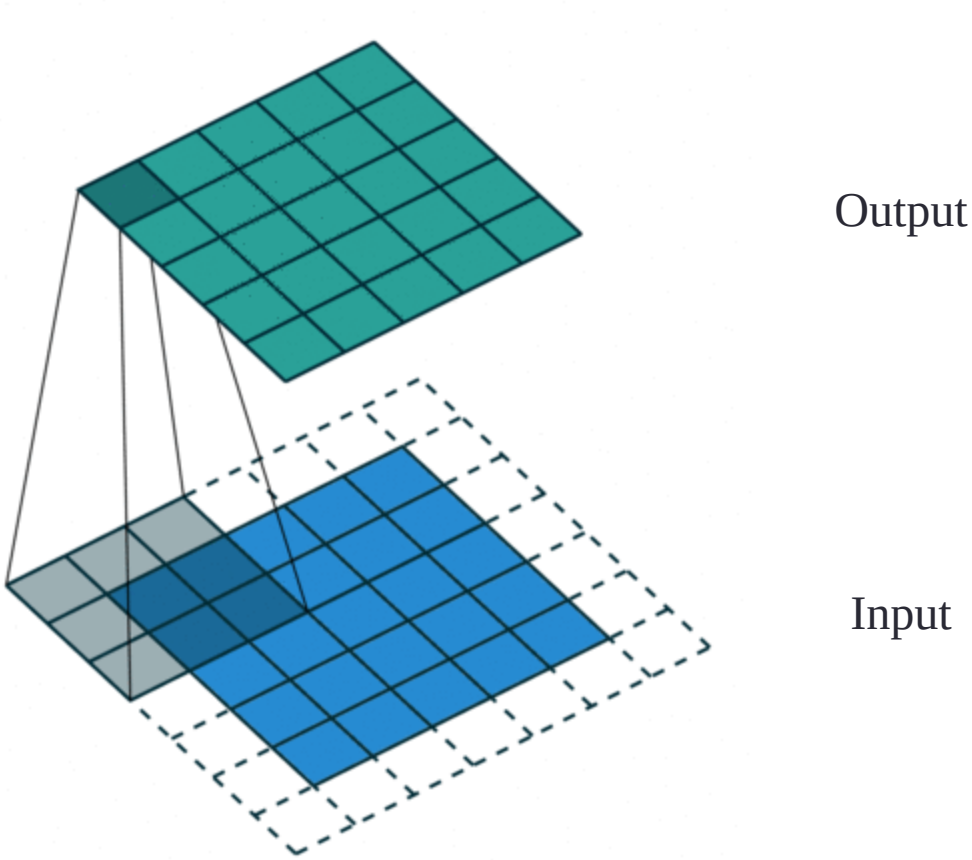
Convolution (no padding, stride=1)

- Input: 4x4, Filter: 3x3, Output: 2x2 (2=4-3+1)



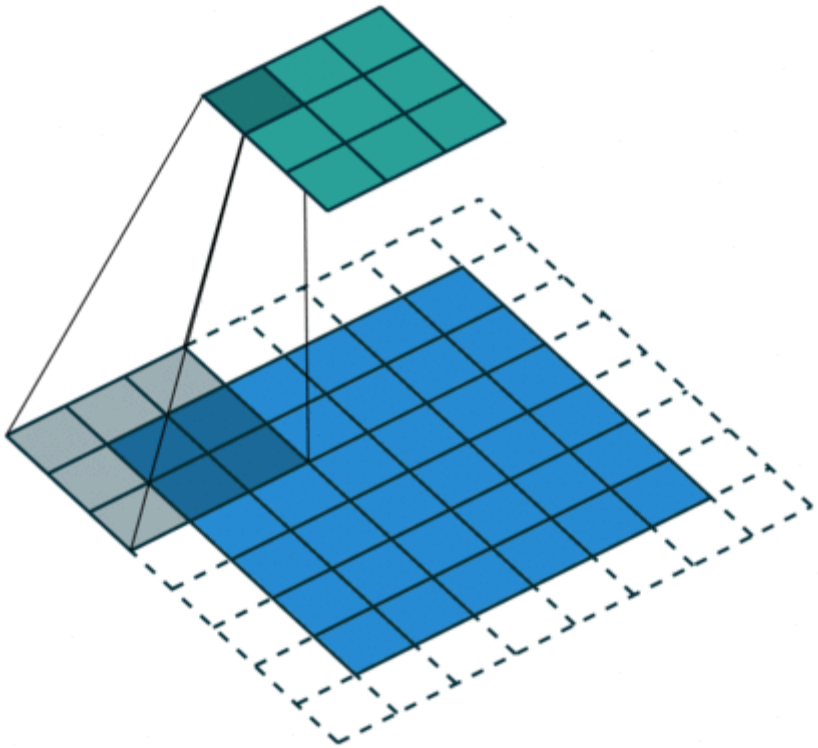
Convolution (padding, stride=1)

- Input: 5x5, Filter: 3x3, Output: 5x5



Convolution (padding, stride=2)

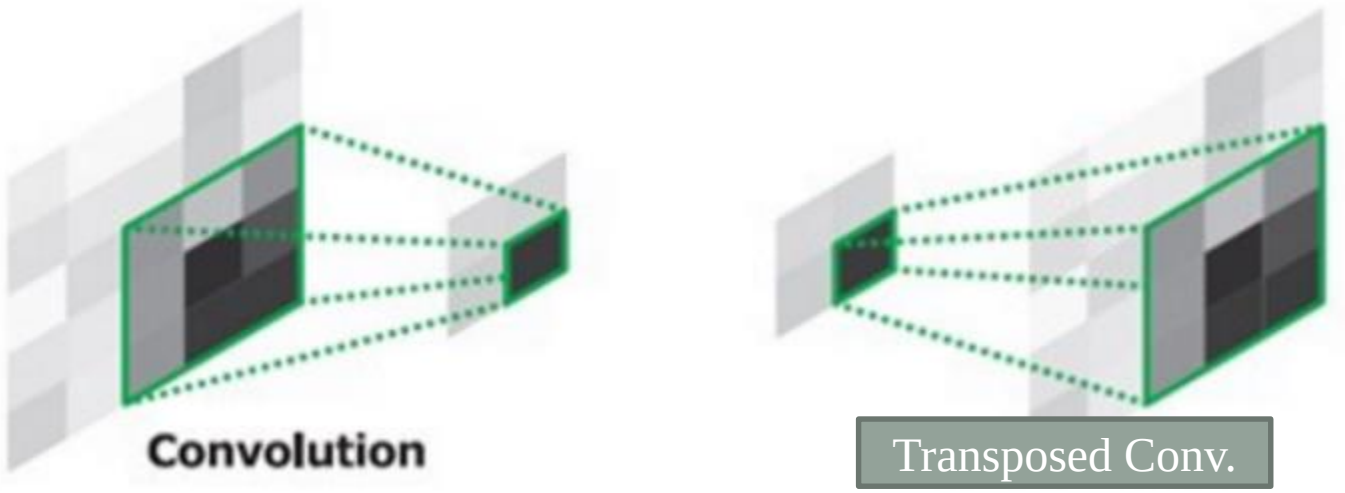
- Input: 6x6, Filter: 3x3, Output: 3x3



TRANSPOSED CONVOLUTION

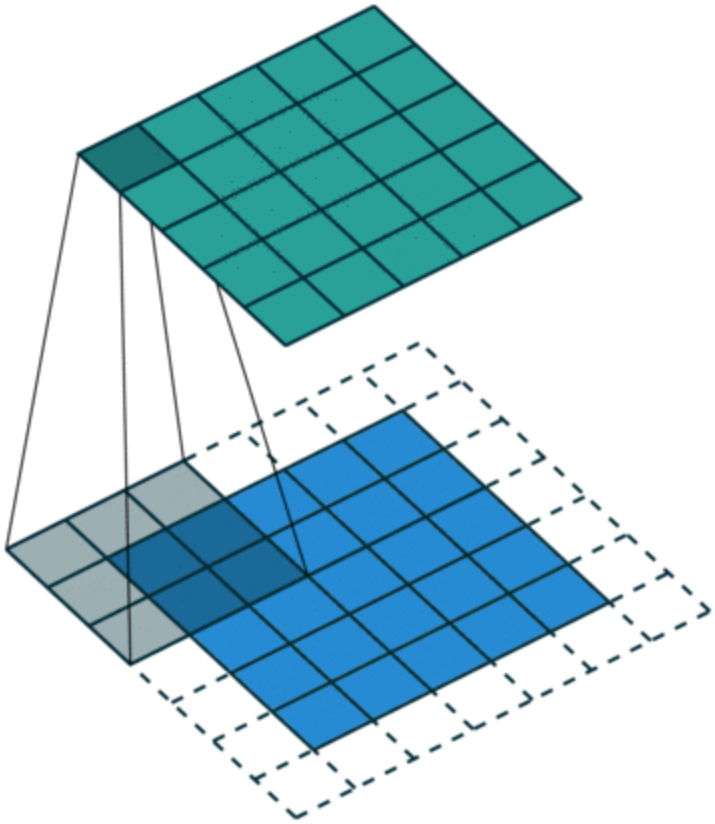
Motivations

- Need to use a transformation going in the **opposite direction of a normal convolution**
  - Decoding layer of a convolutional auto-encoder
  - Project feature maps to a higher-dimensional space (up-sampling)

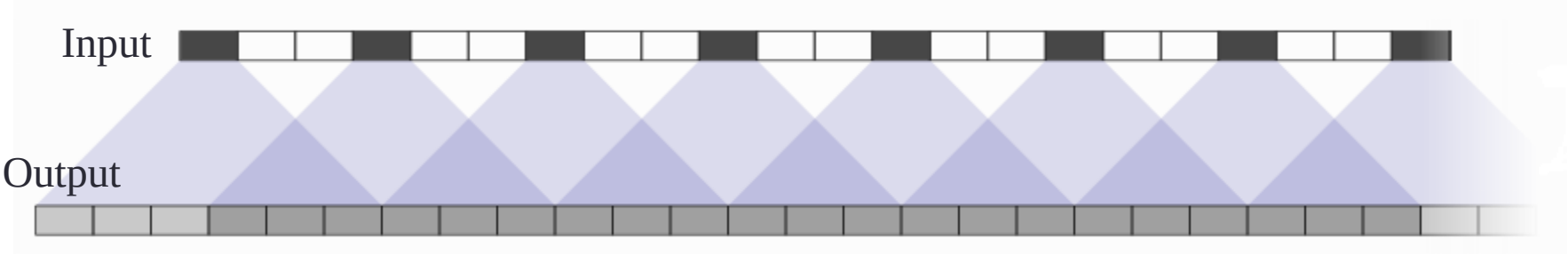


Operation

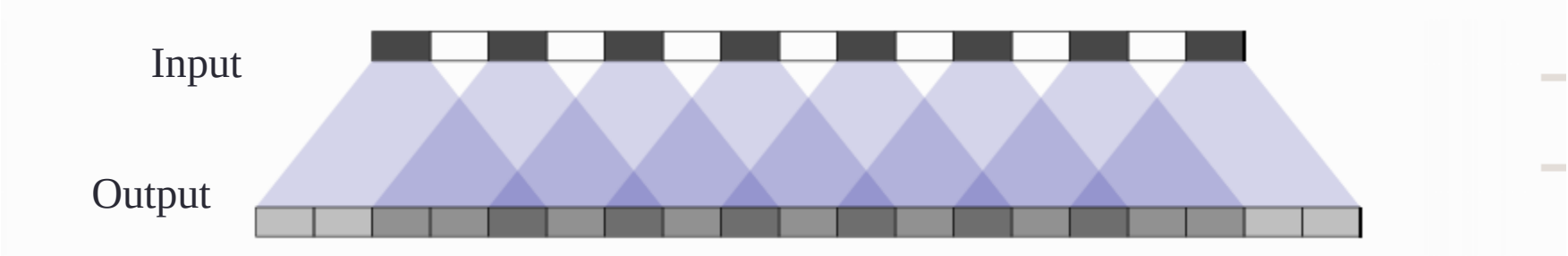
- Input: 5x5, Filter: 3x3, Output: 5x5, Stride=1



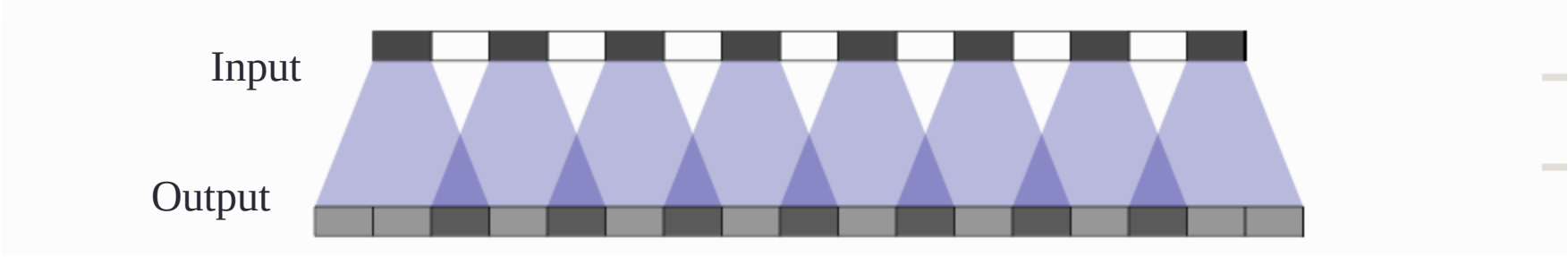
Stride=3,Filter=6



Stride=2,Filter=5

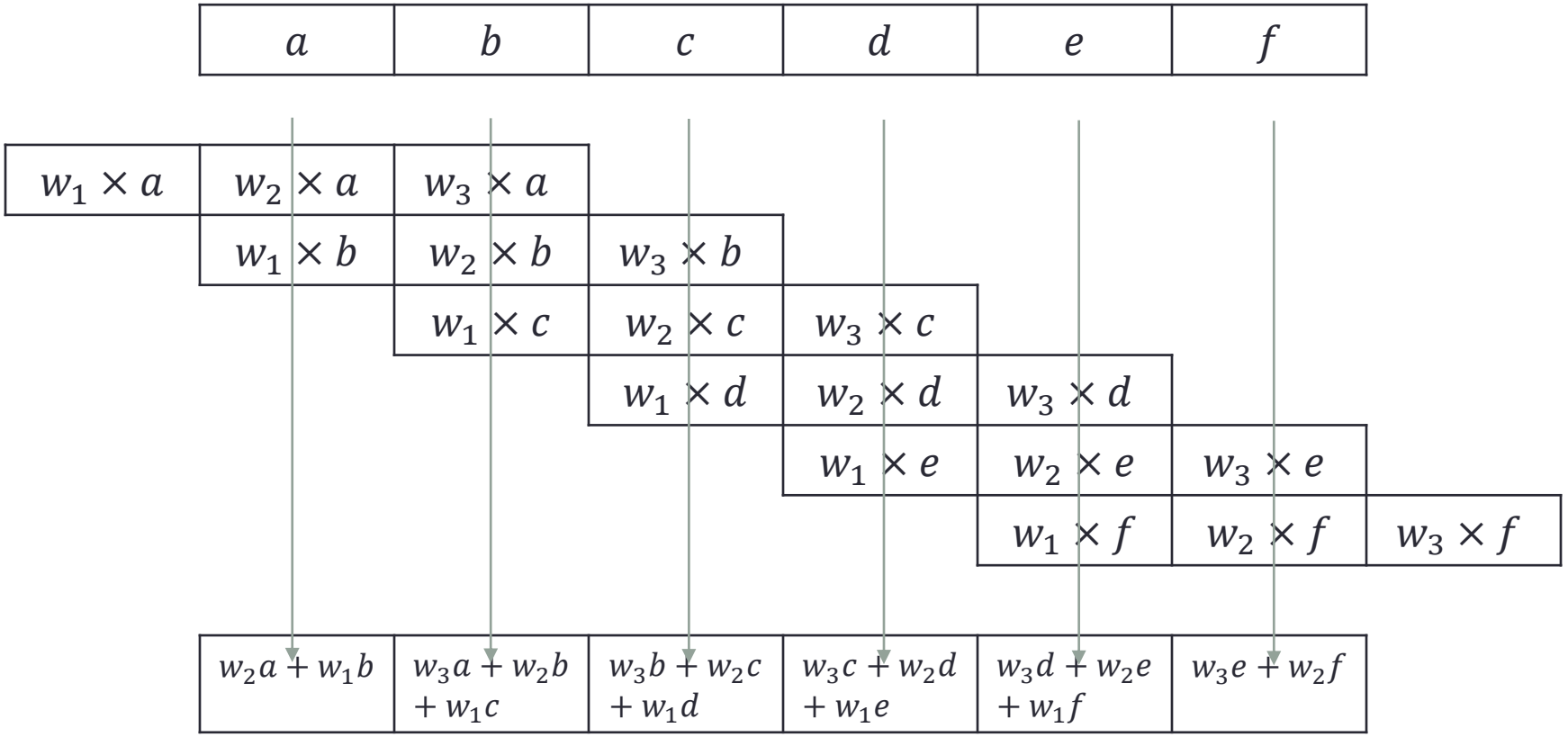


Stride=2,Filter=3



WHY IT IS CALLED TRANSPOSED CONV. FRACTIONAL-STRIDE CONV.

Transposed convolution with stride



Transposed convolution with stride

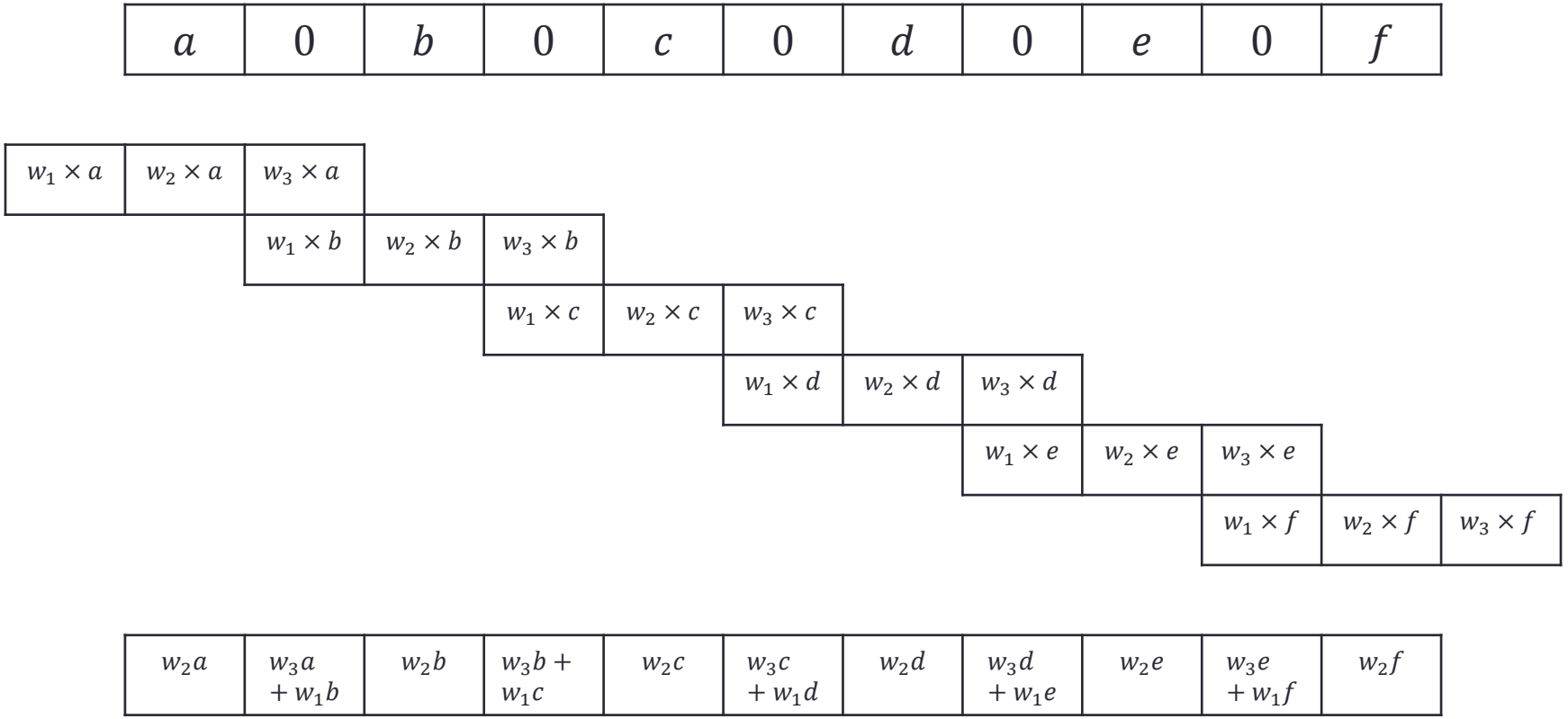
a	b	c	d	e	f

w_3	w_2	w_1

: Transpose filter & Do the convolution!

$w_2a + w_1b$	$w_3a + w_2b + w_1c$	$w_3b + w_2c + w_1d$	$w_3c + w_2d + w_1e$	$w_3d + w_2e + w_1f$	$w_3e + w_2f$

Transposed convolution with stride



Transposed convolution with stride

a	0	b	0	c	0	d	0	e	0	f

w_3	w_2	w_1

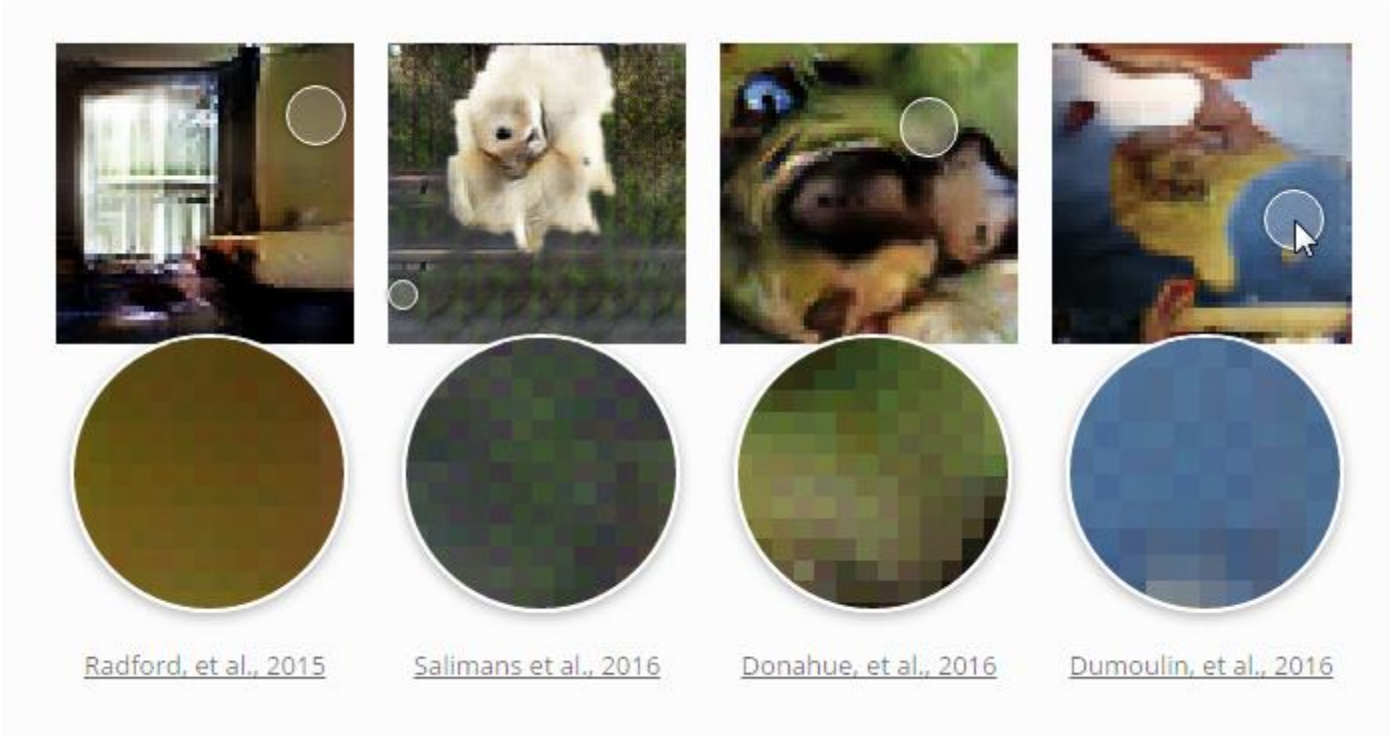
: Transpose filter & Do the convolution!

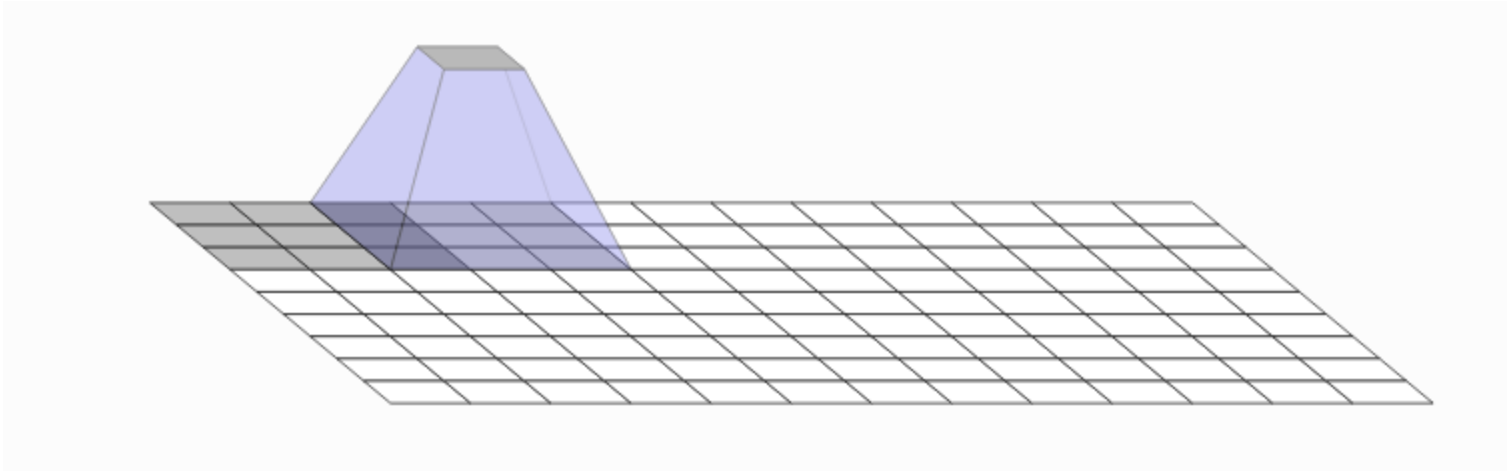
w_2a	$w_3a + w_1b$	w_2b	$w_3b + w_1c$	w_2c	$w_3c + w_1d$	w_2d	$w_3d + w_1e$	w_2e	$w_3e + w_1f$	w_2f

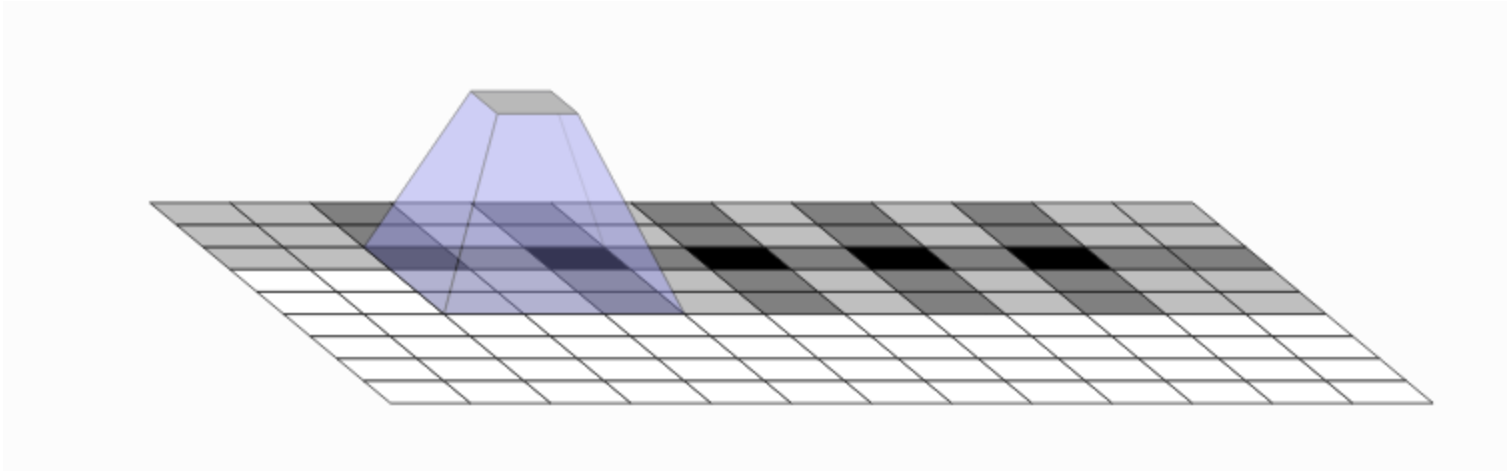
TRANSPOSED CONVOLUTION SIDE EFFECTS

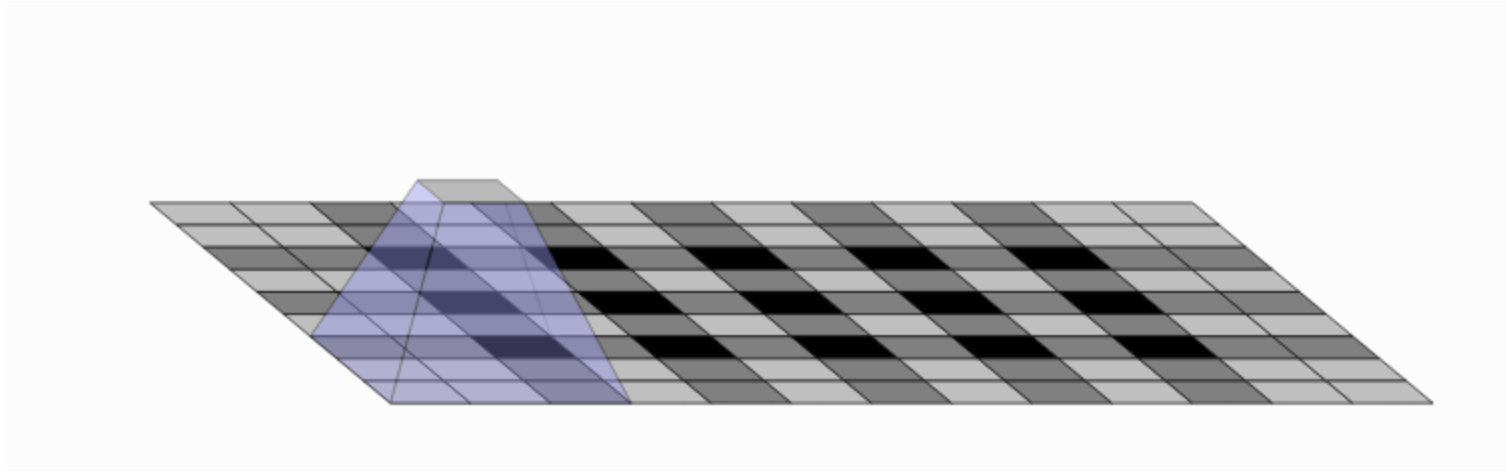
http://distill.pub/2016/deconv-checkerboard/

Checkerboard Artifacts





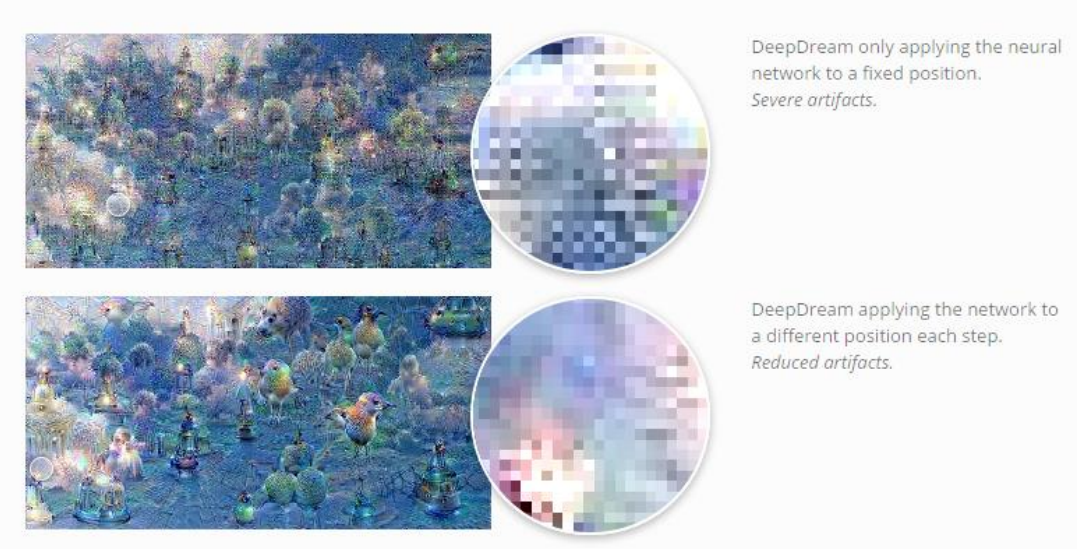




Alternatives

- The same holds for
  - Back propagation

- Solutions
  - Transposed convolution → Resize convolution
  - Jittering



IMPLEMENTATION

In TensorFlow

In tensorflow,

```
def deconv2d(value, filter, output_shape, strides, padding="SAME",
             name=None):
```

```
return gen_nn_ops.conv2d_backprop_input(input_sizes=output_shape_,
                                        filter=filter,
                                        out_backprop=value,
                                        strides=strides,
                                        padding=padding,
                                        name=name)
```

- Performing transposed convolution, by putting input into the backpropagation operation.