

CS354

Nathan Sprague

November 8, 2022

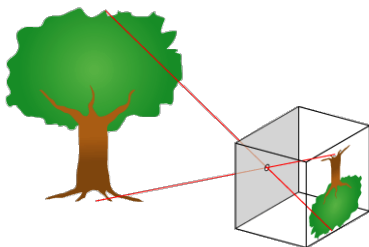
Computer Vision and Image Processing

- Computer Vision:
 - Working backward from an image of a scene to a description of the scene. The description could include:
 - 3D structure
 - Object labels
 - Complex descriptions: "The boy is sneaking up on his mother"
 - All of these are hard.

Computer Vision and Image Processing

- Computer Vision:
 - Working backward from an image of a scene to a description of the scene. The description could include:
 - 3D structure
 - Object labels
 - Complex descriptions: "The boy is sneaking up on his mother"
 - All of these are hard.
- Image processing:
 - Low level image transformations
 - blurring, sharpening, resizing etc.
 - Computer vision generally involves some initial image processing.

Image Formation



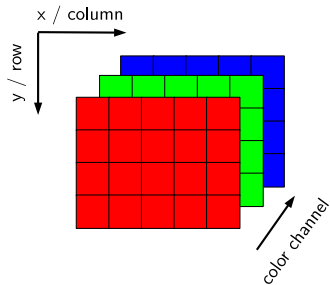
<http://commons.wikimedia.org/wiki/File:Pinhole-camera.png>

$$\begin{bmatrix} x \\ y \\ 1 \end{bmatrix} \sim \begin{bmatrix} f_x & 0 & 0 & 0 \\ 0 & f_y & 0 & 0 \\ 0 & 0 & 1 & 0 \end{bmatrix} \begin{bmatrix} X \\ Y \\ Z \\ 1 \end{bmatrix}$$

<https://staff.fnwi.uva.nl/r.vandenboomgaard/IPC20162017/LectureNotes/CV/PinholeCamera/PinholeCamera.html>

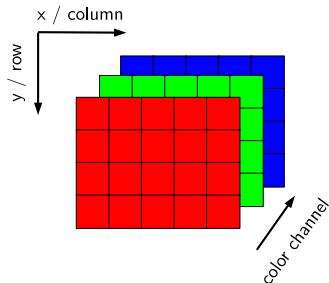
- OpenCV is an old and widely used computer vision library
- Default computer vision library used with ROS
- Written mostly in C++, with Python bindings
- Python OpenCV uses numpy arrays to represent images

Image Representations



- Color images are often stored as a collection of RGB triples
- (0, 0, 0) is black, (255, 255, 255) is white.
- RGB Color Model

Images In Numpy



- We will work with images stored as three-dimensional numpy arrays:
 - `img[row, col, color]`
- `img[0, 0, 0]` - Upper-left red value
- `img[3, 4, 2]` - Lower-right blue value
- `img[0:1, 0:2, :]` - Crop of upper left corner

Arithmetic with Images

- Many low level operations on image can be performed either with OpenCV *or* with numpy:
- [OpenCV Arithmetic Tutorial](#)
- By default, images are 8-bit unsigned integers (which can lead to unexpected results.)

Why is Computer Vision Hard?

- Let's look at some balloons...

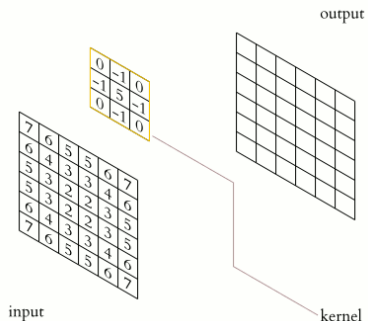
Why is Computer Vision Hard?

- Let's look at some balloons...
- Computer vision is hard (in part) because there is no simple mapping from an object to its pixel-level appearance
- Appearance is influenced by
 - Lighting
 - Viewing angle and distance
 - Camera properties

Image Processing - Convolutions

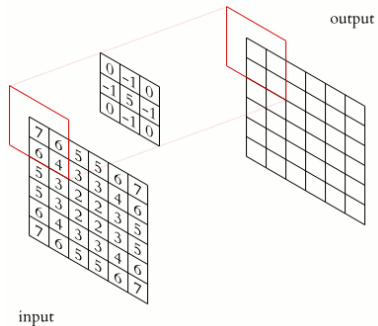
- Many low-level image processing tasks can be handled with the convolution operator:
 - Image Convolutions

Image Processing - Convolution Example



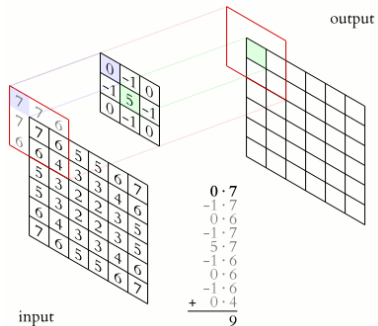
http://upload.wikimedia.org/wikipedia/commons/4/4f/3D_Convolution_Animation.gif
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Image Processing - Convolution Example



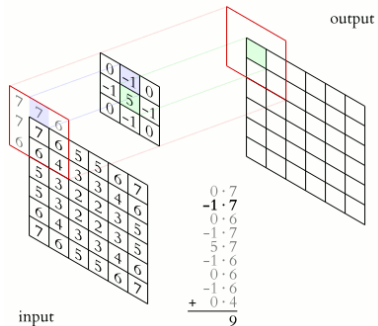
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Image Processing - Convolution Example



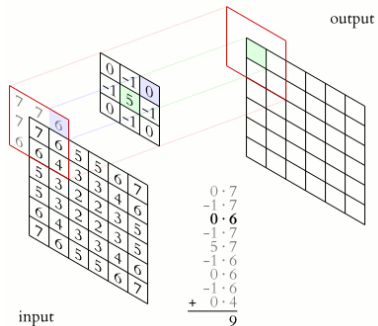
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Image Processing - Convolution Example



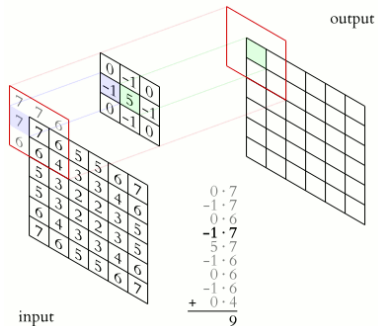
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Image Processing - Convolution Example



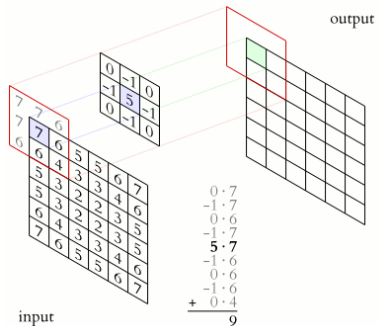
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Image Processing - Convolution Example



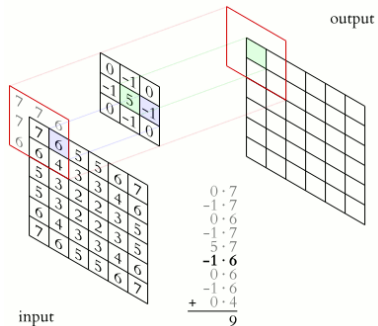
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Image Processing - Convolution Example



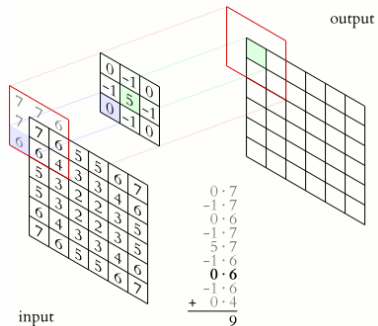
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Image Processing - Convolution Example



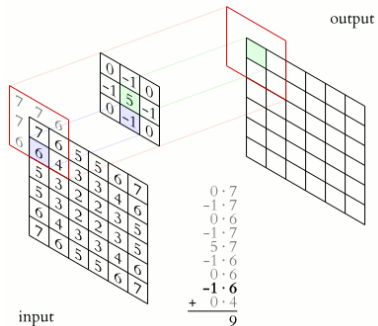
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Image Processing - Convolution Example



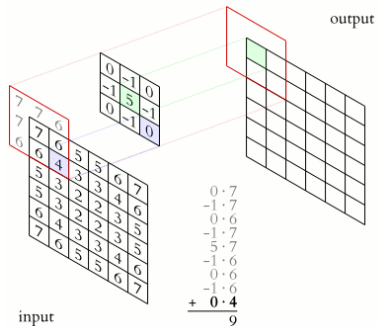
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Image Processing - Convolution Example



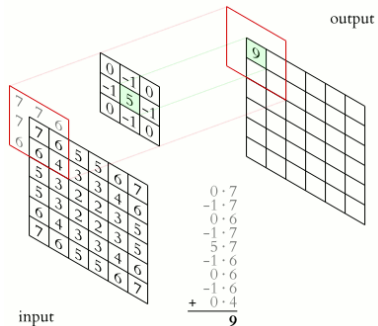
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Image Processing - Convolution Example



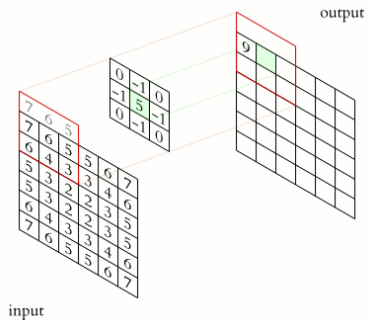
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Image Processing - Convolution Example



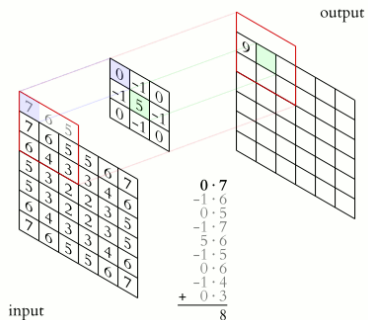
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Image Processing - Convolution Example



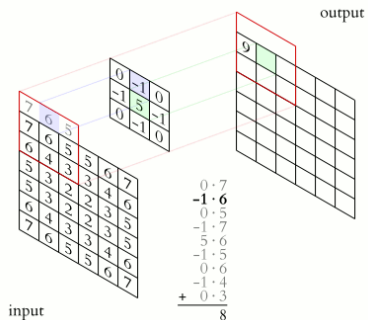
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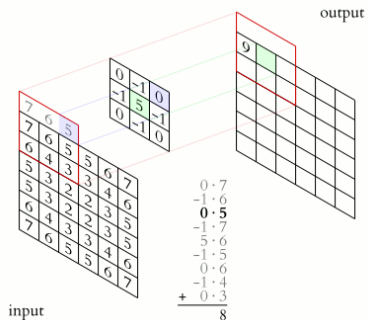
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Image Processing - Convolution Example



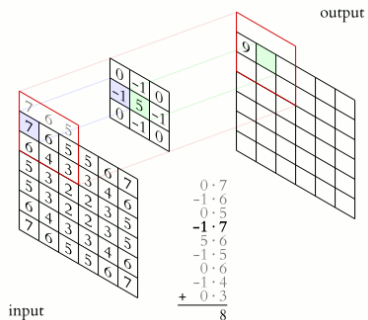
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Image Processing - Convolution Example



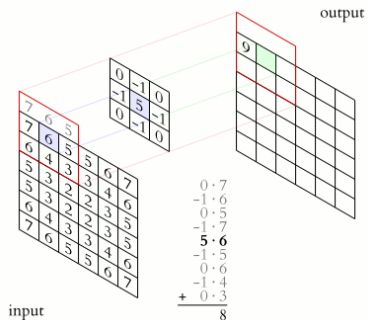
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Image Processing - Convolution Example



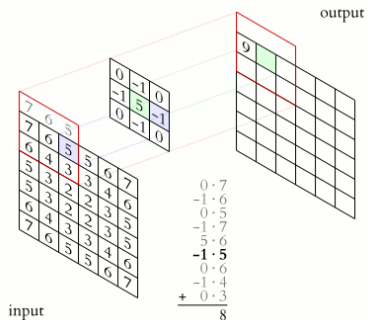
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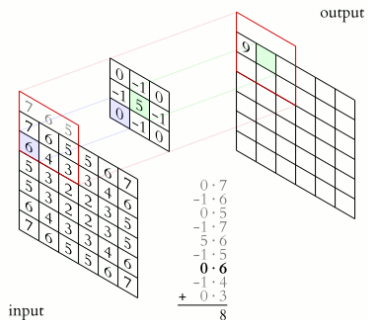
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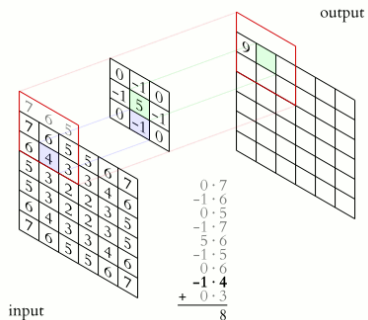
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Image Processing - Convolution Example



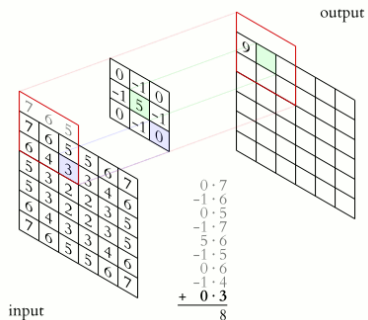
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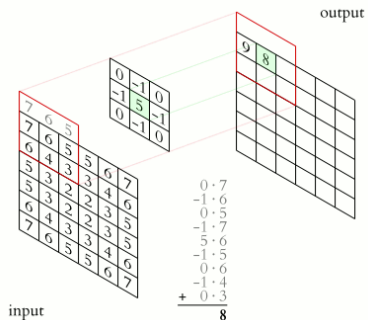
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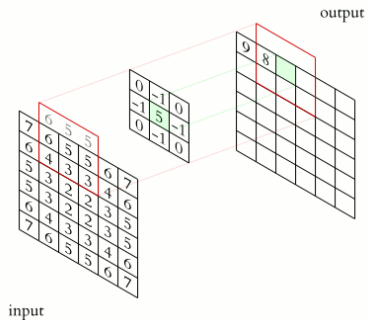
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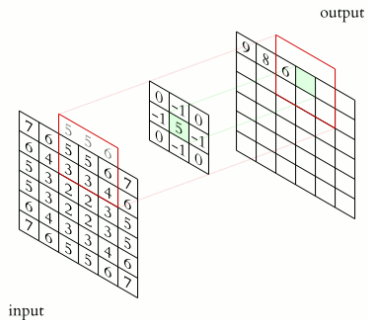
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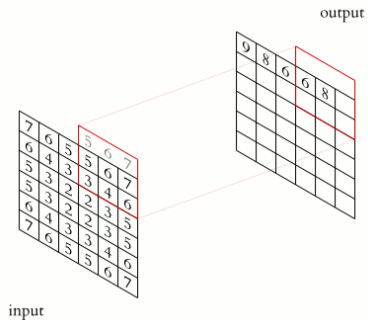
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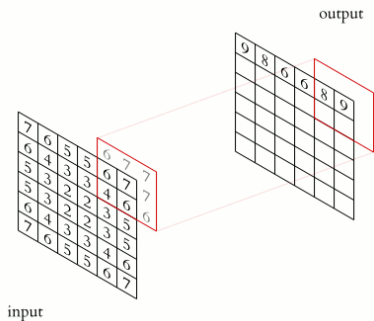
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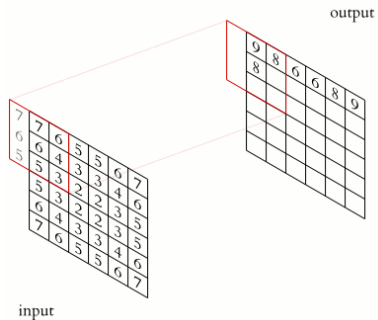
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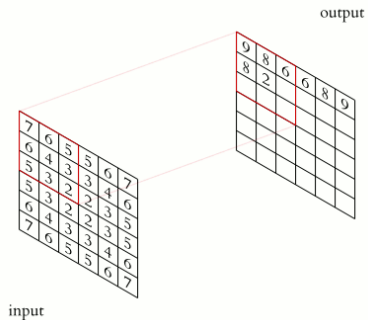
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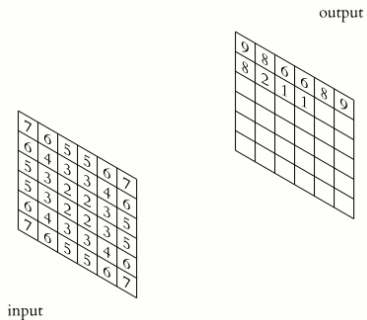
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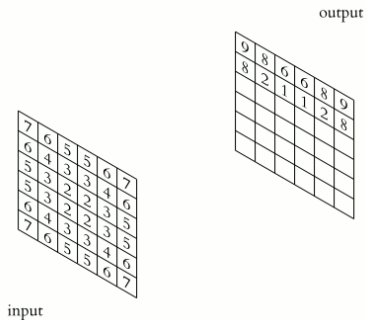
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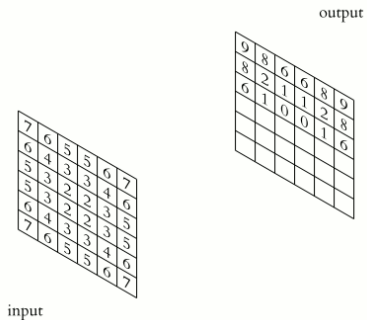
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Image Processing - Convolution Example

input

7	6	5			
6	4	3	5	6	7
5	3	2	3	4	6
5	3	2	2	3	5
6	4	3	2	3	5
7	6	5	3	4	6
			5	6	7

output

9	8	6			
8	2	1	6	8	9
6	1	0	1	2	8
6	1	0	0	1	6
			0	1	6

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Image Processing - Convolution Example

input

7	6	5			
6	4	3	5	6	7
5	3	2	3	4	6
5	3	2	2	3	5
6	4	2	2	3	5
7	6	3	3	4	6
	6	5	5	6	7

output

9	8	6			
8	2	1	6	8	9
6	1	0	1	2	8
6	1	0	0	1	6
8	2	1	0	1	6
		1	1	2	8

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Image Processing - Convolution Example

input

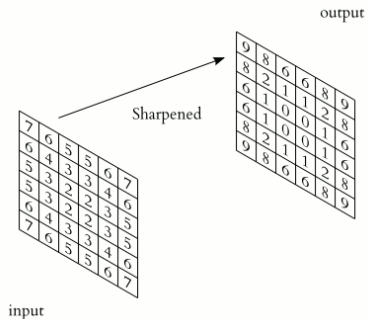
7	6	5	5	6	7
6	4	3	3	4	7
5	3	2	2	3	6
5	3	2	2	3	5
6	4	3	3	4	6
7	6	5	5	6	7

output

9	8	6	6	8	9
8	2	1	1	2	8
6	1	0	0	1	6
6	1	0	0	1	6
8	2	1	1	2	8
9	8	6	6	8	9

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