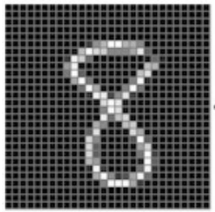
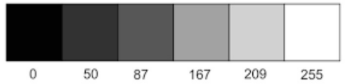
Convolutional Neural Networks

모두의연구소

박은수 Research Director

LeNet 1





Gray Image

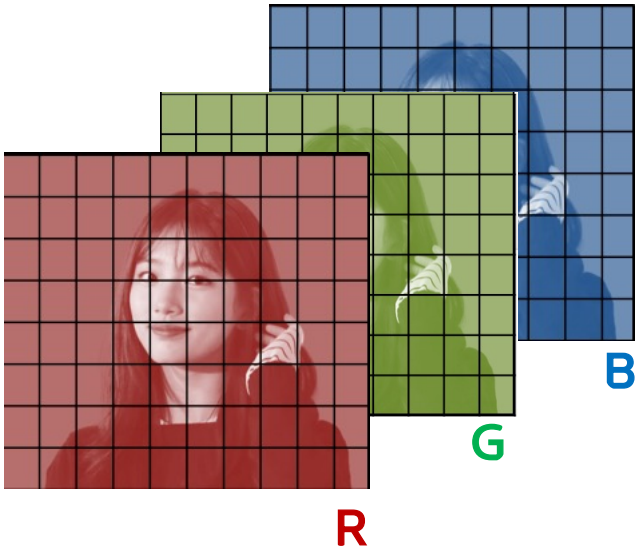
28 x 28
784 pixels

0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	4	62	146	182	254	254	181	176	139	15	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	34	186	253	217	208	136	136	136	166	232	99	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	61	242	208	111	3	0	0	0	0	0	18	32	107	43	0	0	0	0	0
0	0	0	0	0	0	0	0	0	156	242	23	0	0	0	0	0	0	0	13	191	181	6	0	0	0	0	0
0	0	0	0	0	0	0	0	0	121	255	98	3	0	0	0	0	0	8	194	225	12	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	169	253	120	3	0	0	0	0	128	247	51	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	3	111	244	169	19	0	14	131	249	117	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	59	241	235	72	142	229	66	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0	25	218	254	231	36	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0	0	133	253	221	33	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0	19	237	111	196	217	19	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0	174	138	0	23	193	204	18	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	96	224	0	0	0	25	218	169	3	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	215	138	0	0	0	0	86	253	99	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	215	97	0	0	0	0	3	162	214	11	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	215	97	0	0	0	0	0	118	253	68	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	185	157	0	0	0	0	0	40	254	98	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	50	244	61	0	0	0	0	112	244	58	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0	174	251	142	59	83	167	244	111	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0	6	133	253	253	253	169	61	3	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

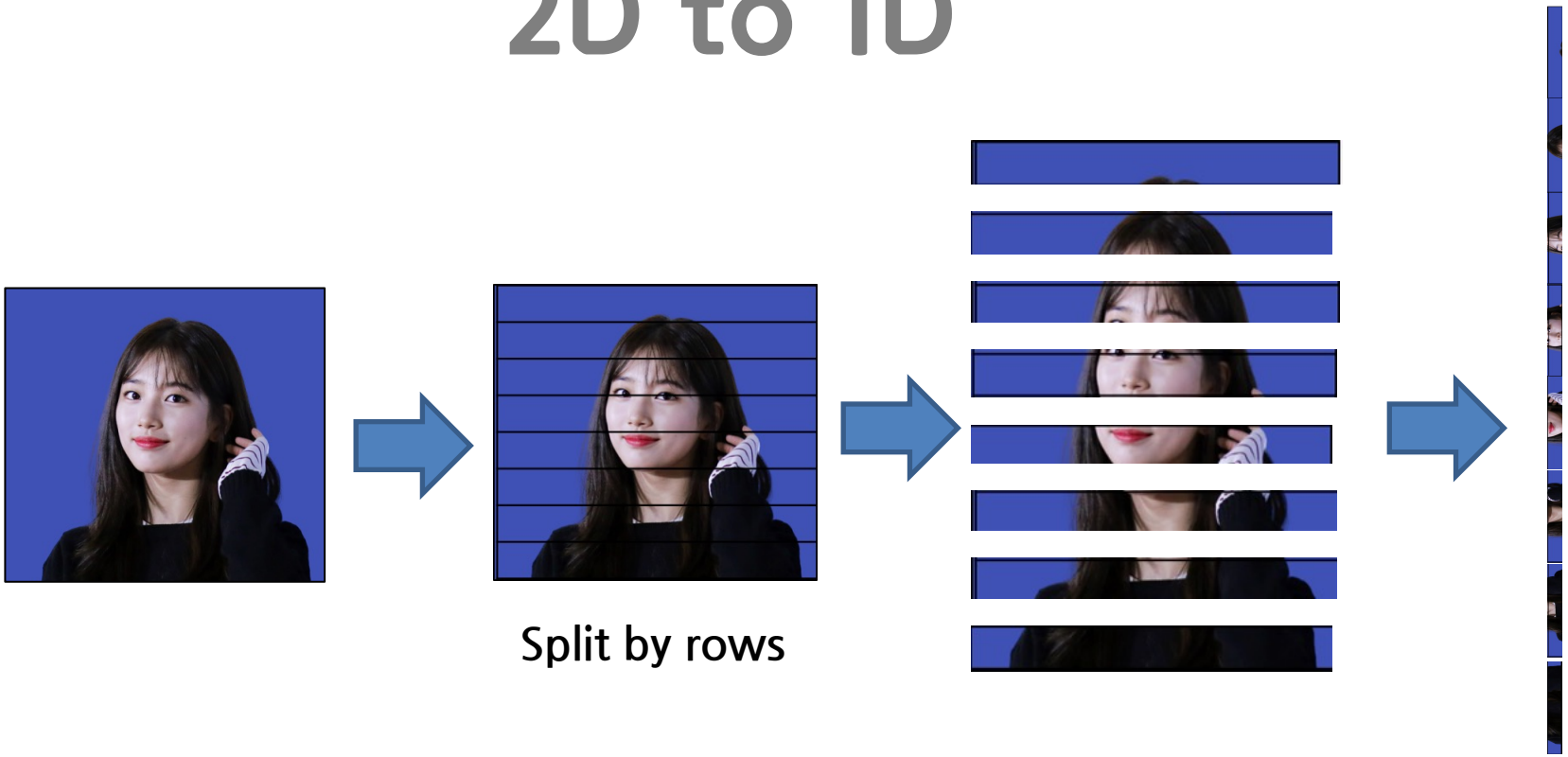
https://www.ovh.com/blog/deep-learning-explained-to-my-8-year-old-daughter/

Color Image

모두의연구소



2D to 1D



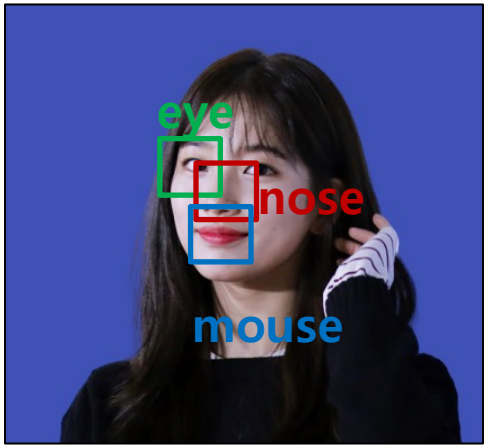
Split by rows

2D spatial features are removed

2D Image characteristics

모두의연구소

2D image

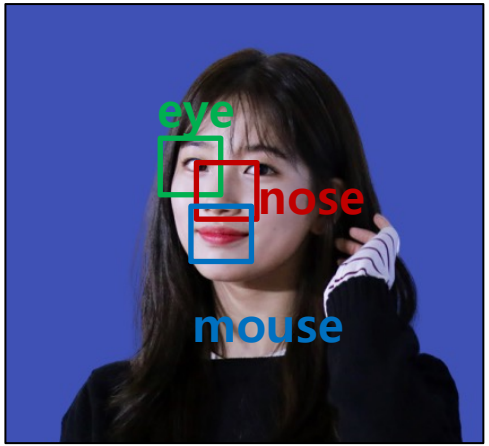


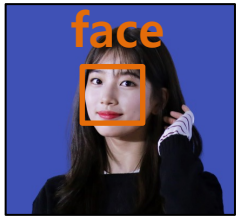
- Having 2D spatial features

2D Image characteristics

모두의연구소

2D image



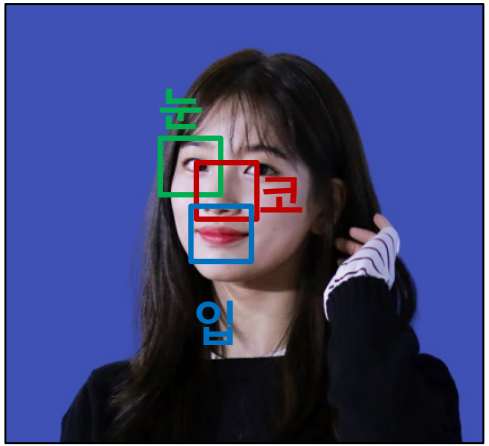


- Having 2D spatial features
- Different features according to image scale

딥러닝의 이미지 인식 방법

모두의연구소

영상의 특징



이러한 특징을 잘 활용한 뉴럴 네트워크는 ?

- 2차원 공간적 특징을 가짐
- 크기에 따라 같은 영역도 다른 특징을 가짐

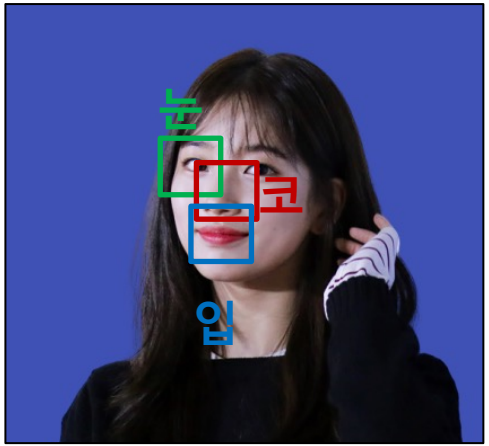
딥러닝의 이미지 인식 방법

모두의연구소

영상의 특징

이러한 특징을 잘 활용한
뉴럴 네트워크는 ?

Convolutional Neural Networks (CNNs)



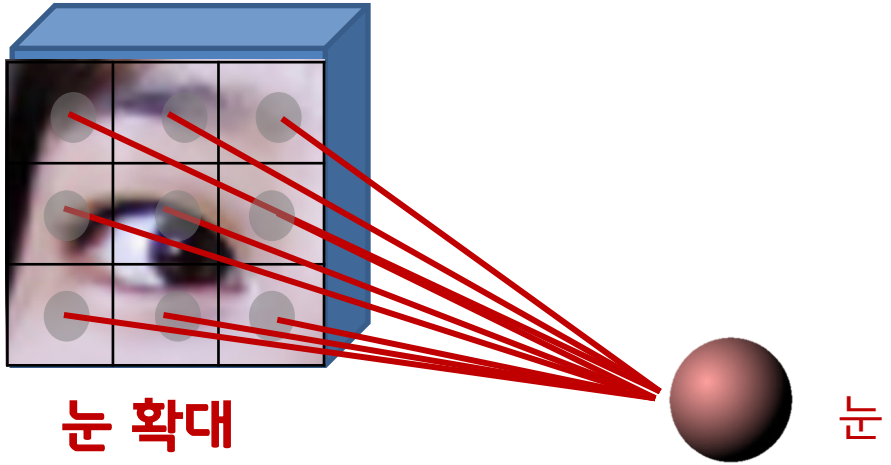
수지

- 2차원 공간적 특징을 가짐
- 크기에 따라 같은 영역도 다른 특징을 가짐

눈, 코, 입 찾기

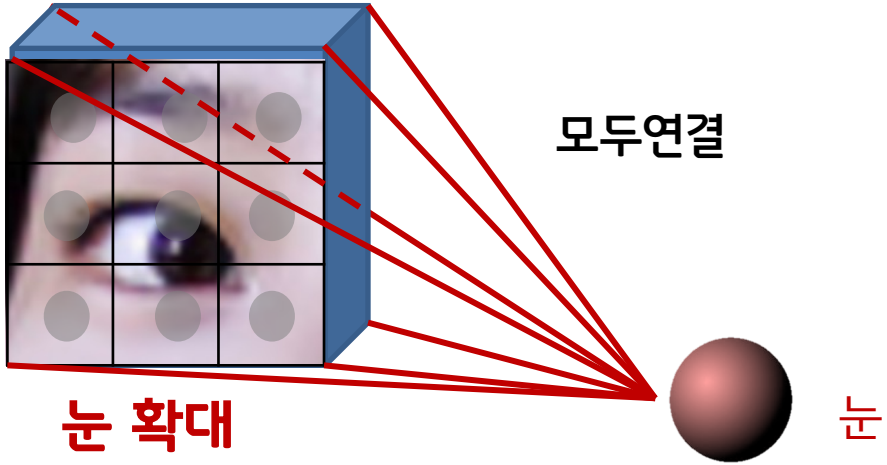
모두의연구소

3x3x3 (height x width x channel)



눈, 코, 입 찾기

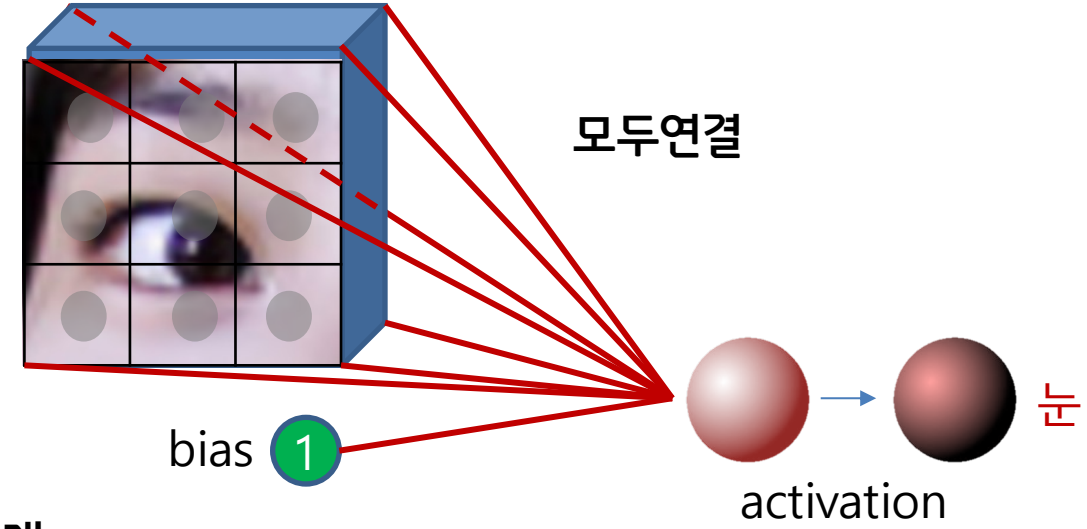
3x3x3 (height x width x channel)



눈, 코, 입 찾기

모두의연구소

3x3x3 (height x width x channel)

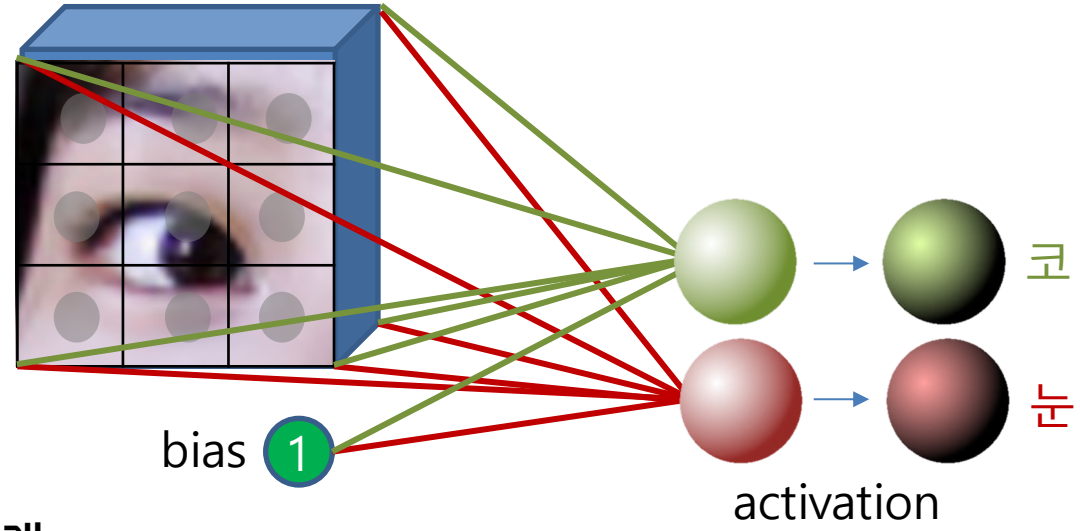


- 3x3 필터 1개
  - 파라미터(weight) 의 수 : 3x3x3(filter) + 1 (bias)

눈, 코, 입 찾기

모두의연구소

3x3x3 (height x width x channel)

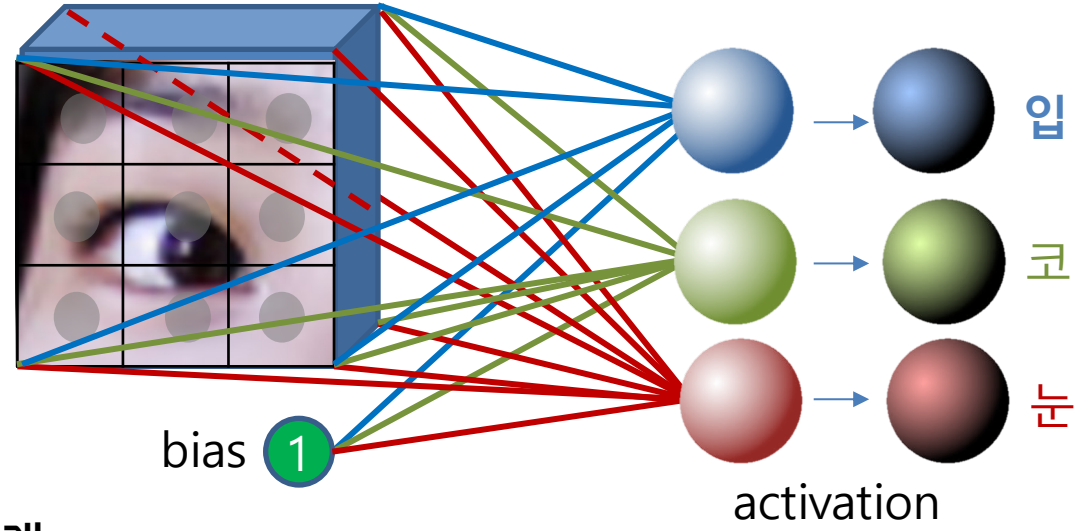


- 3x3 필터 2개
  - 파라미터(weight) 의 수 : (3x3x3+1)x2

눈, 코, 입 찾기

모두의연구소

3x3x3 (height x width x channel)

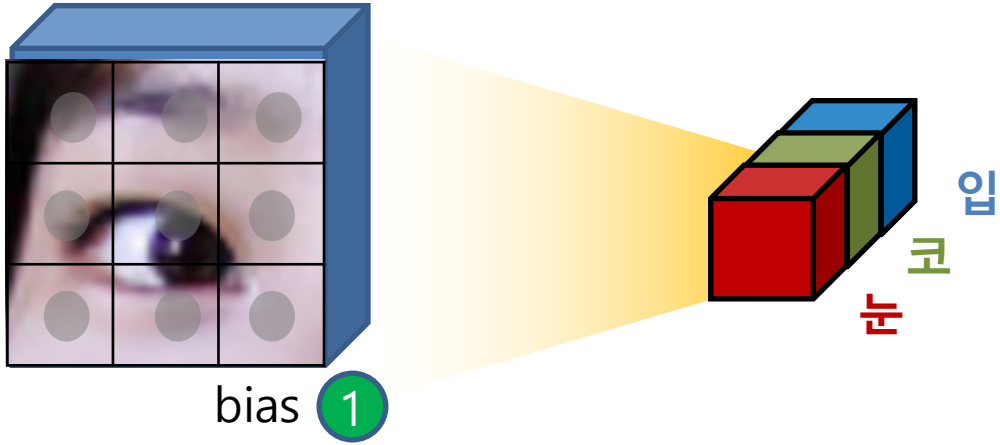


- 3x3 필터 3개
  - 파라미터(weight) 의 수 : (3x3x3+1)x3

눈, 코, 입 찾기

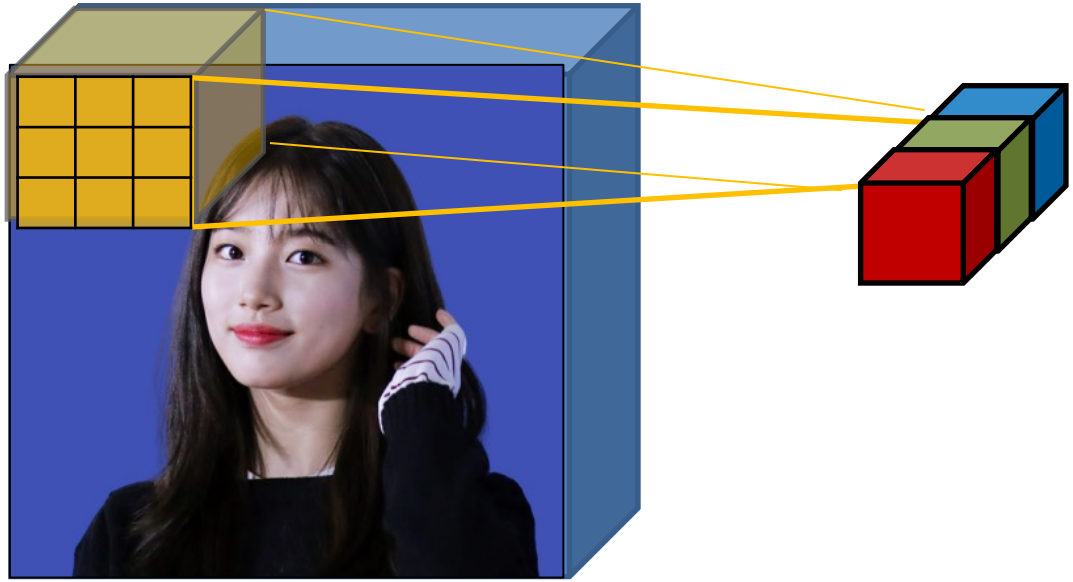
모두의연구소

3x3x3 (height x width x channel)



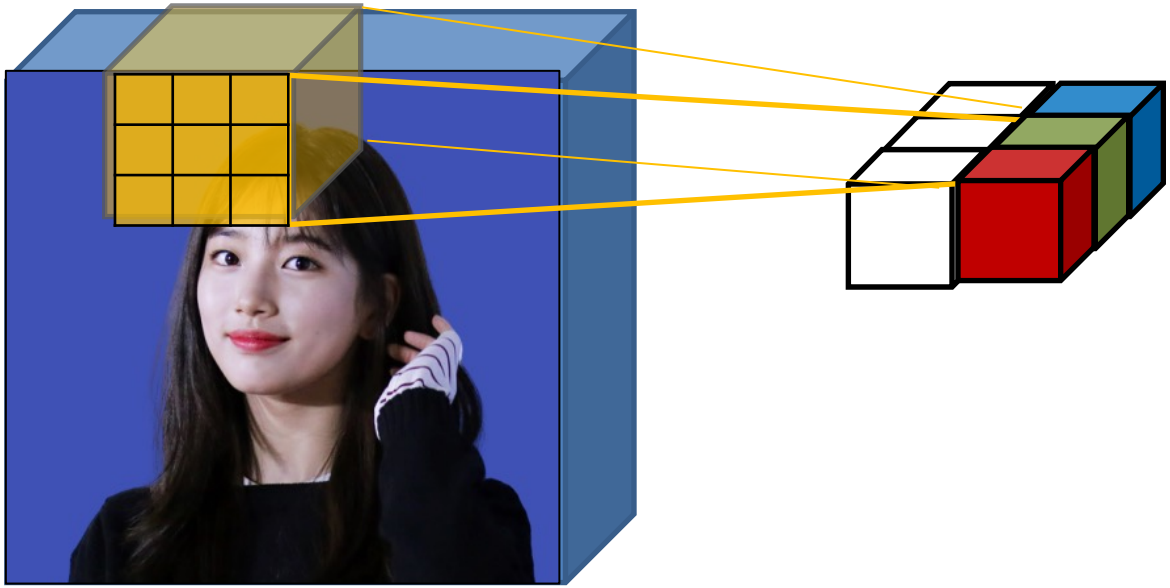
- 3x3 필터 3개
  - 파라미터(weight) 의 수 : (3x3x3+1)x3

Sliding Window



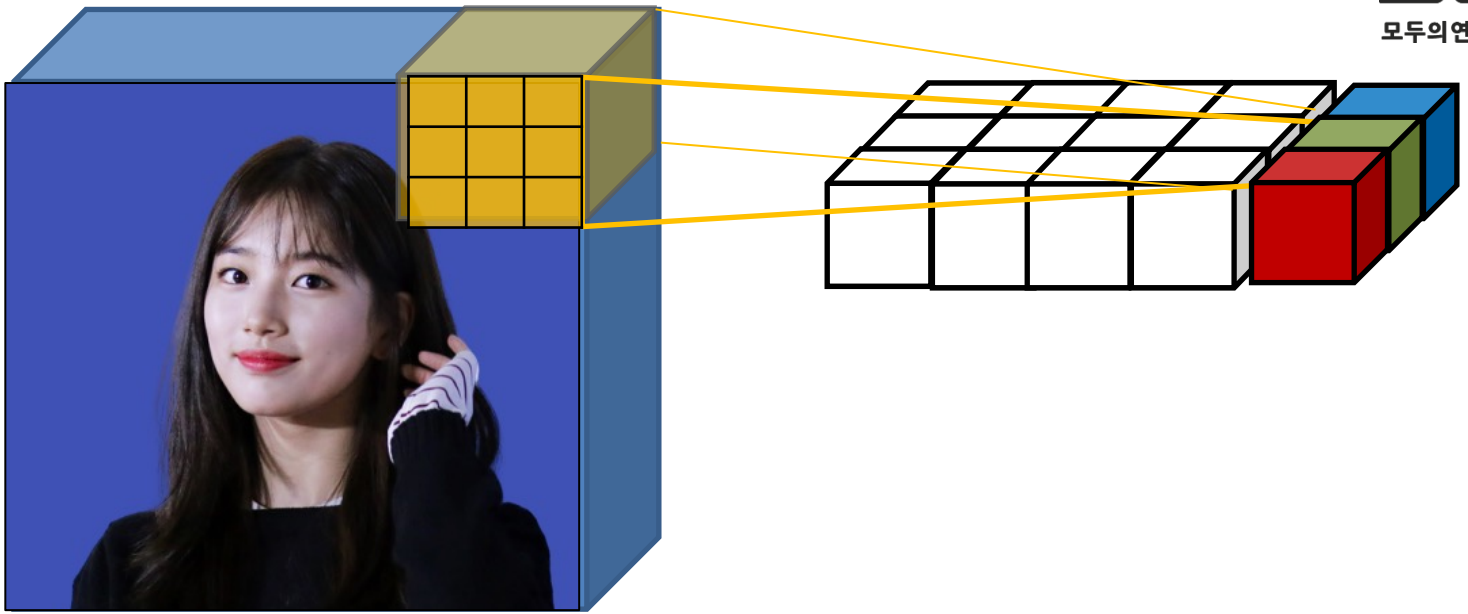
- 3x3 필터 3개
  - 파라미터(weight) 의 수 : (3x3x3+1)x3

Sliding Window



- 3x3 필터 3개
  - 파라미터(weight) 의 수 : (3x3x3+1)x3

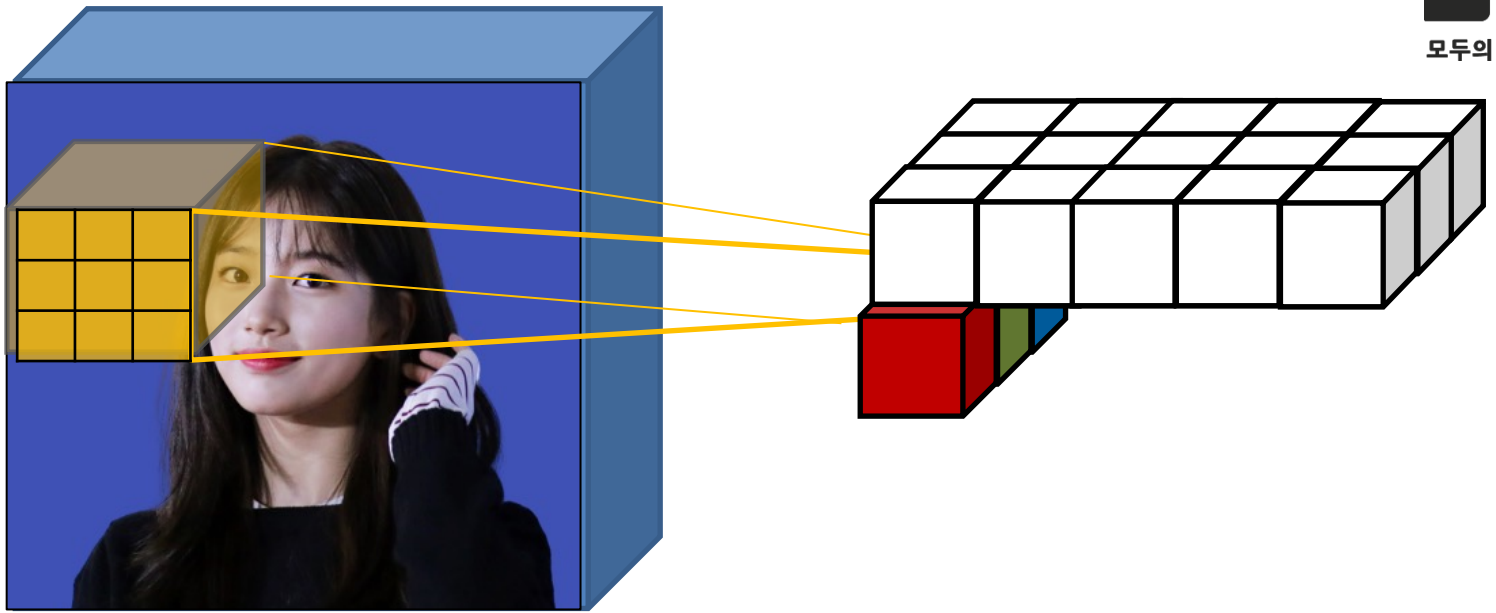
Sliding Window



- 3x3 필터 3개
  - 파라미터(weight) 의 수 : (3x3x3+1)x3

Sliding Window

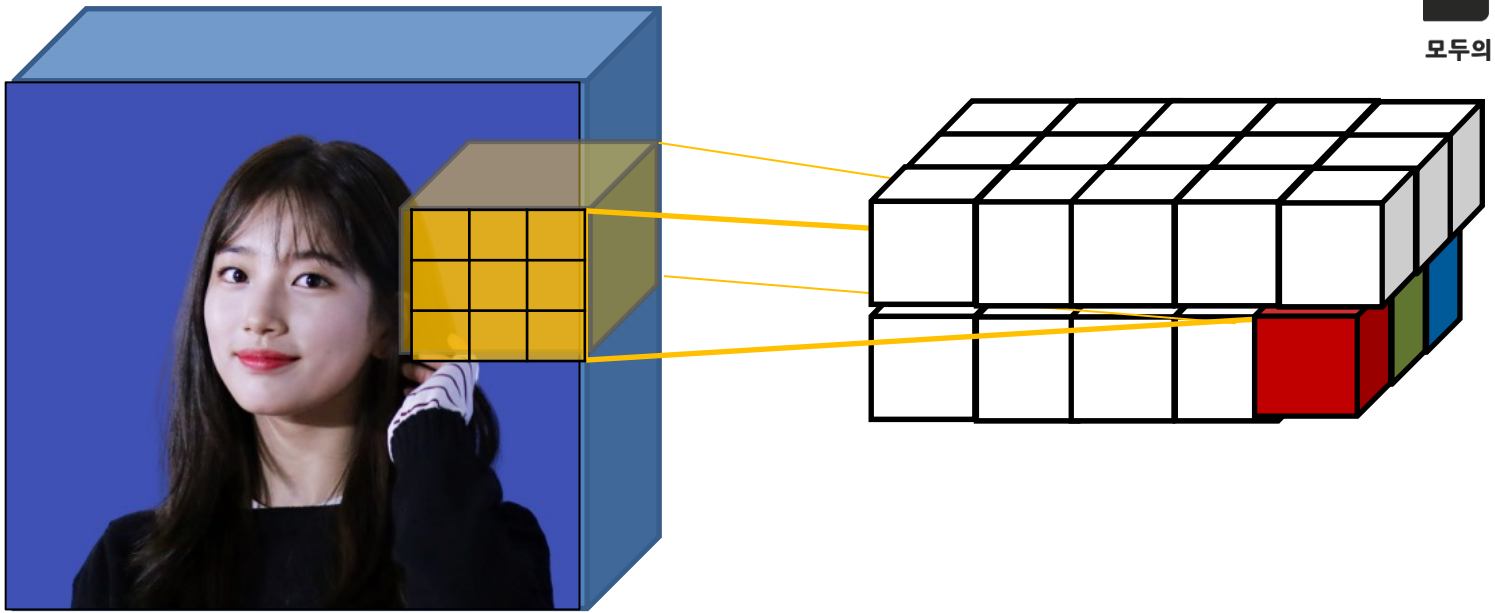
모두의연구소



- 3x3 필터 3개
  - 파라미터(weight) 의 수 : (3x3x3+1)x3

Sliding Window

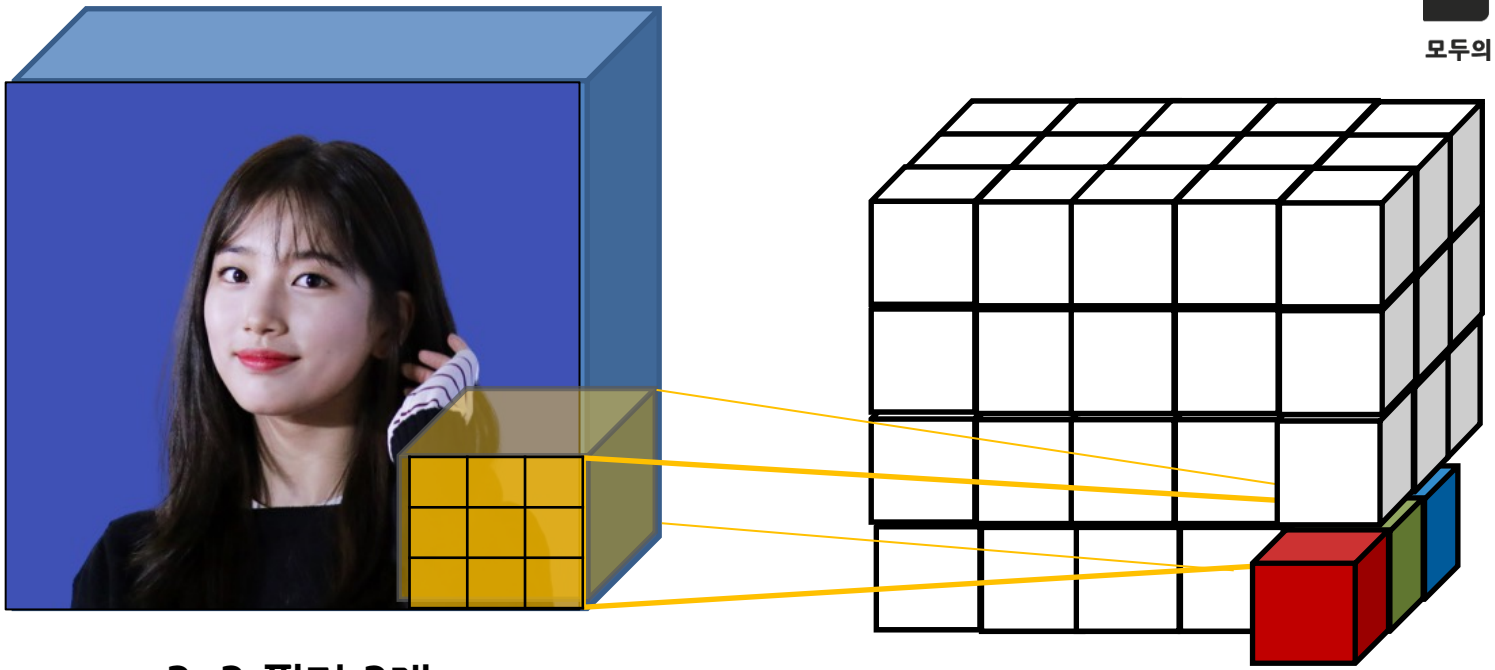
모두의연구소



- 3x3 필터 3개
  - 파라미터(weight) 의 수 : (3x3x3+1)x3

Sliding Window

모두의연구소



- 3x3 필터 3개
  - 파라미터(weight) 의 수 : (3x3x3+1)x3

2차원 특성을 유지하려면

32 : 높이

32 : 너비

3 : 채널

w

5 : 높이는 우리가 설정

5 : 너비도 우리가 설정

3 : 채널

$W^T X + b$

2차원 특성을 유지하려면

32 : 높이

32 : 너비

3 : 채널

w

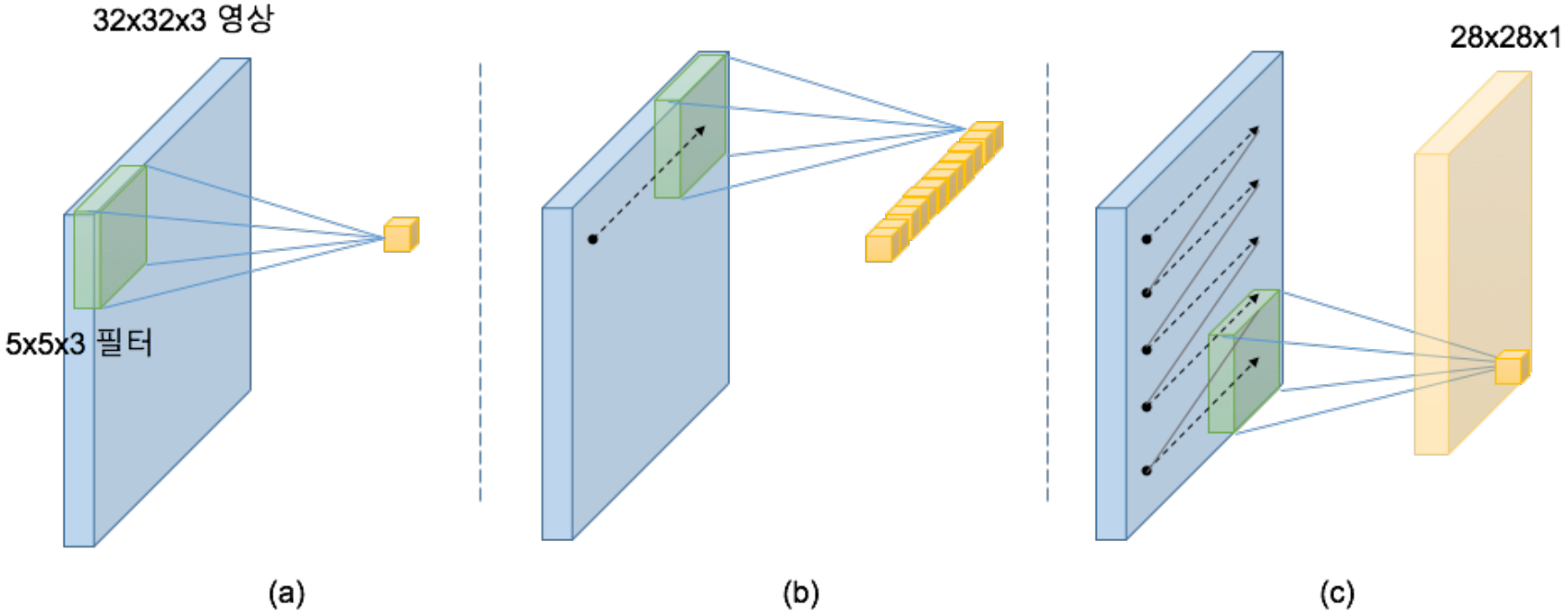
5 : 높이는 우리가 설정

5 : 너비도 우리가 설정

3 : 채널

$$W^T X + b$$

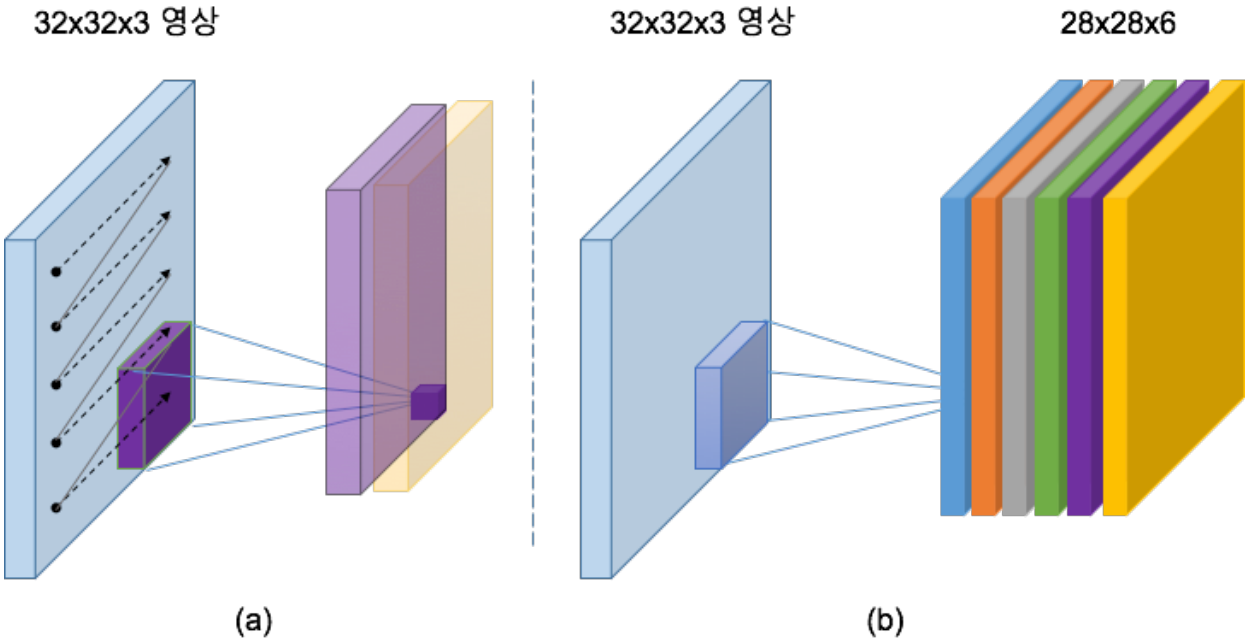
Convolution Layer



Convolution Layer

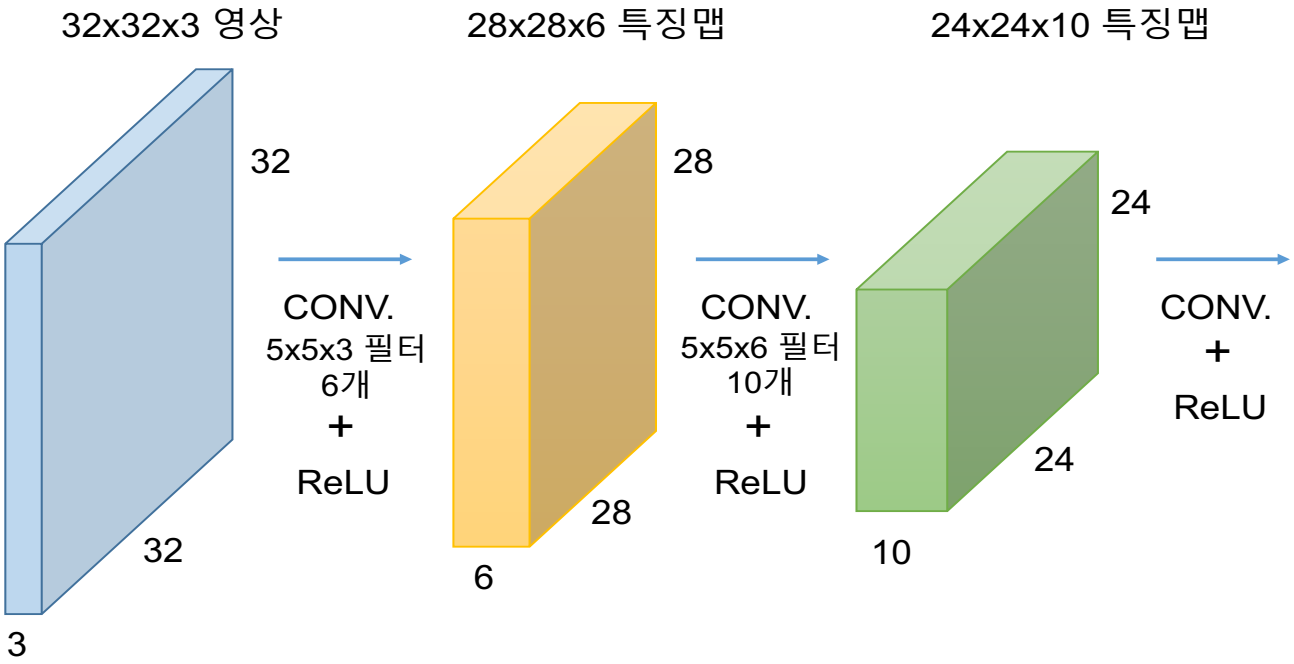
모두의연구소

똑같은 크기의 필터 6개를 더 만들어 봅시다



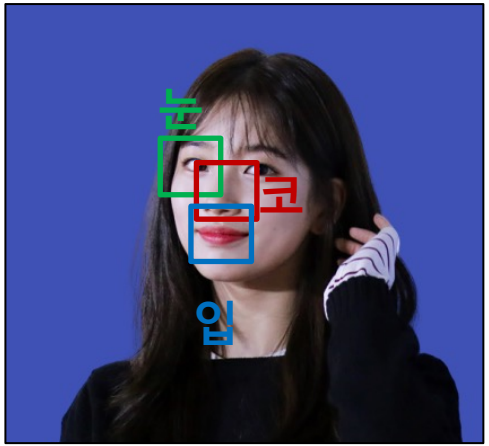
Convolution Layer

컨볼루션 네트워크는 활성화 함수를 포함한 컨볼루션 레이어의 연결 입니다



Pooling Layer

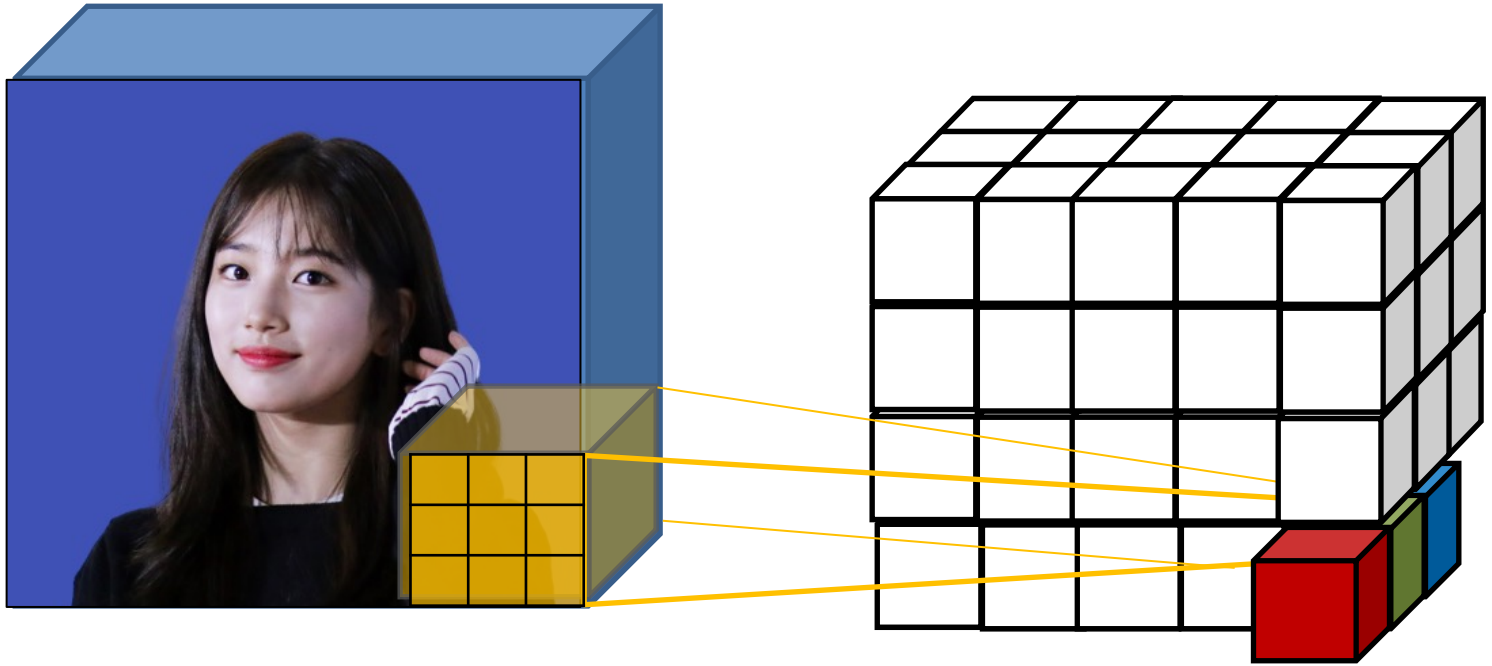
영상의 특징



- 2차원 공간적 특징을 가짐
- 크기에 따라 같은 영역도 다른 특징을 가짐

Pooling Layer

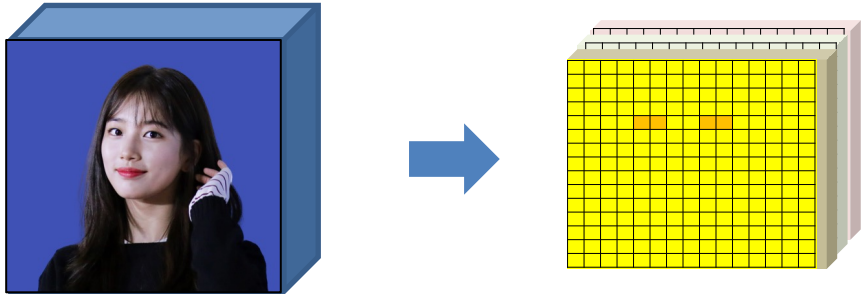
모두의연구소



Pooling Layer

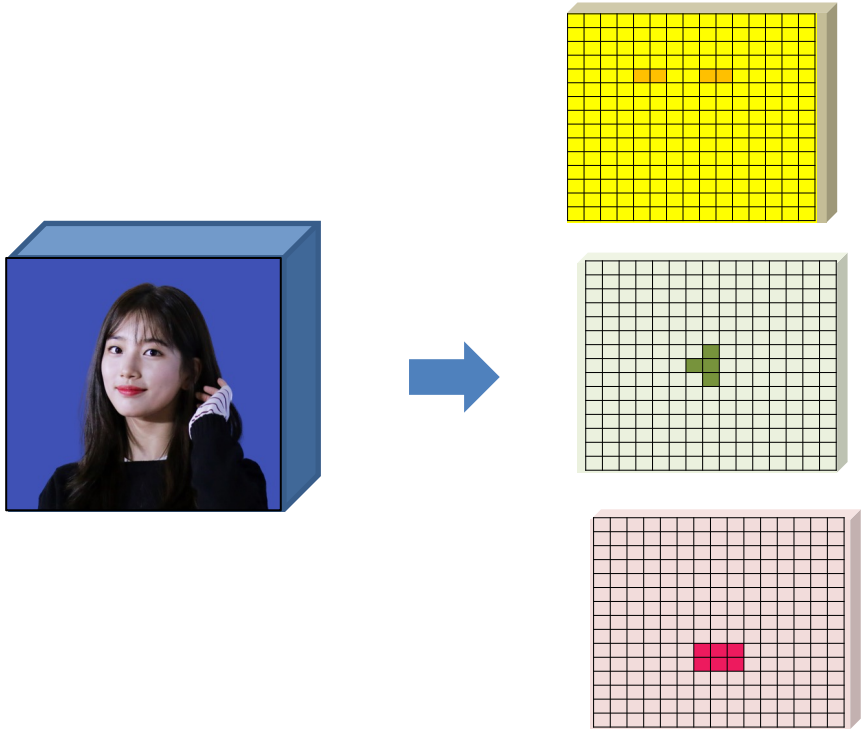
모두의연구소

Convolution layer



총 3채널

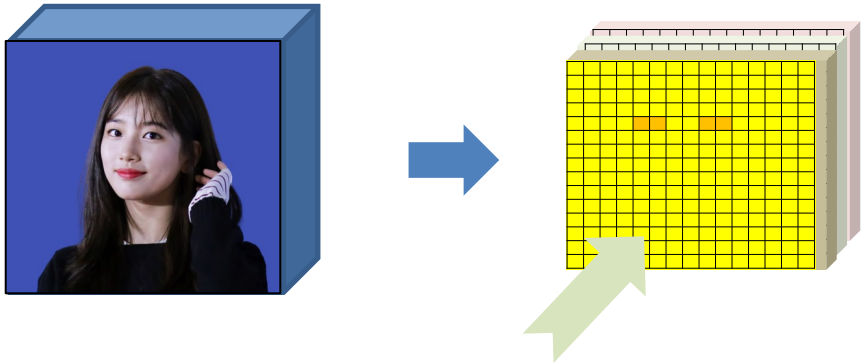
Pooling Layer



총 3채널

Pooling Layer

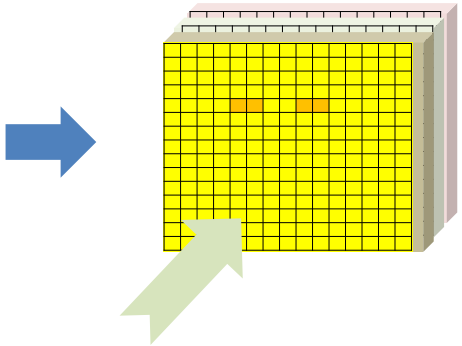
모두의연구소



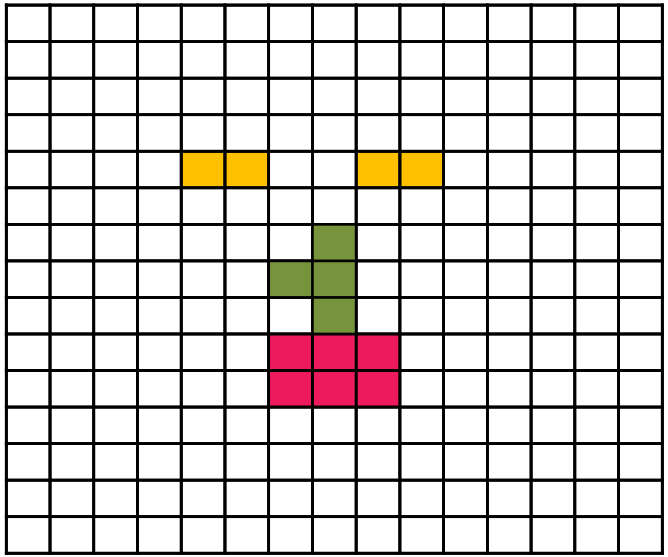
정면에서 보면 ?

Pooling Layer

모두의연구소

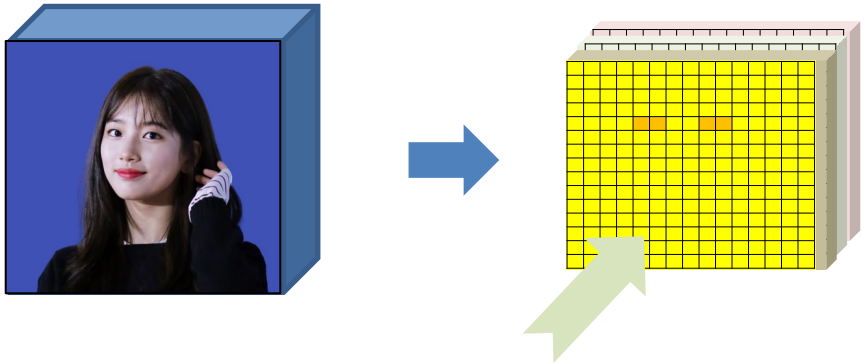


정면에서 보면 ?

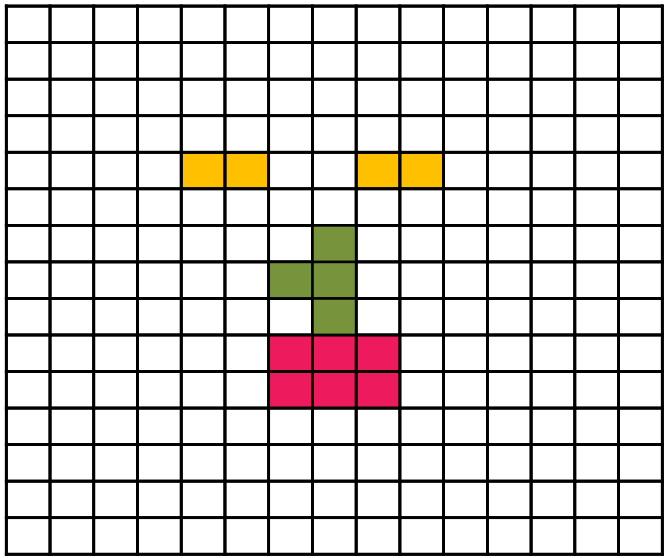


Pooling Layer

모두의연구소



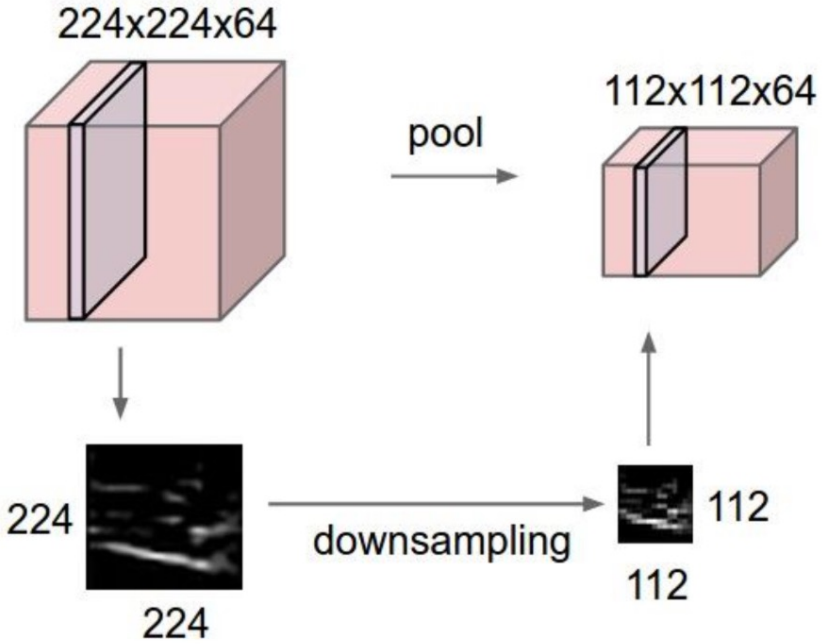
정면에서 보면 ?



3x3 필터로 얼굴을 인식할 수 있을까?

Pooling Layer

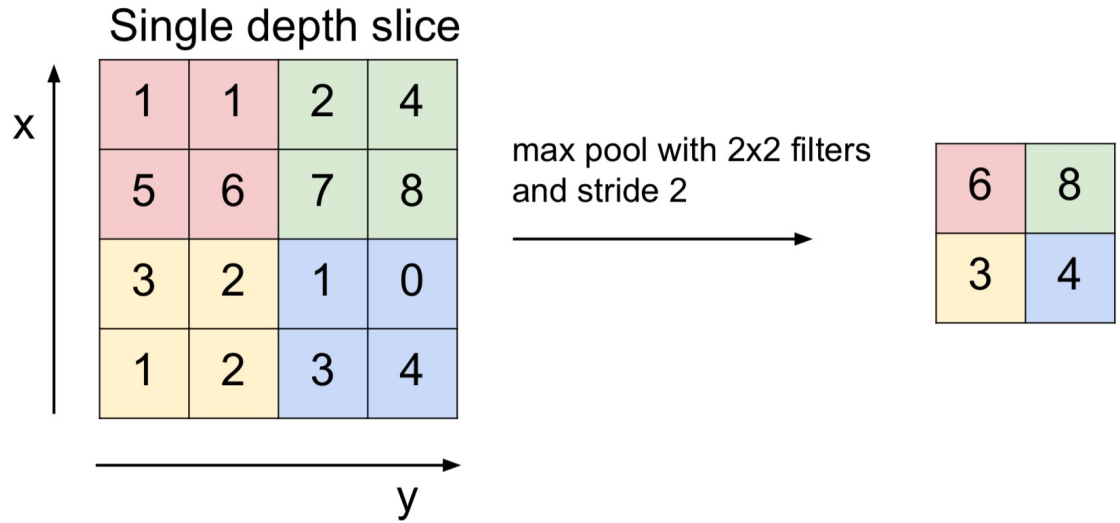
- makes the representations smaller and more manageable
- operates over each activation map independently:



Pooling Layer

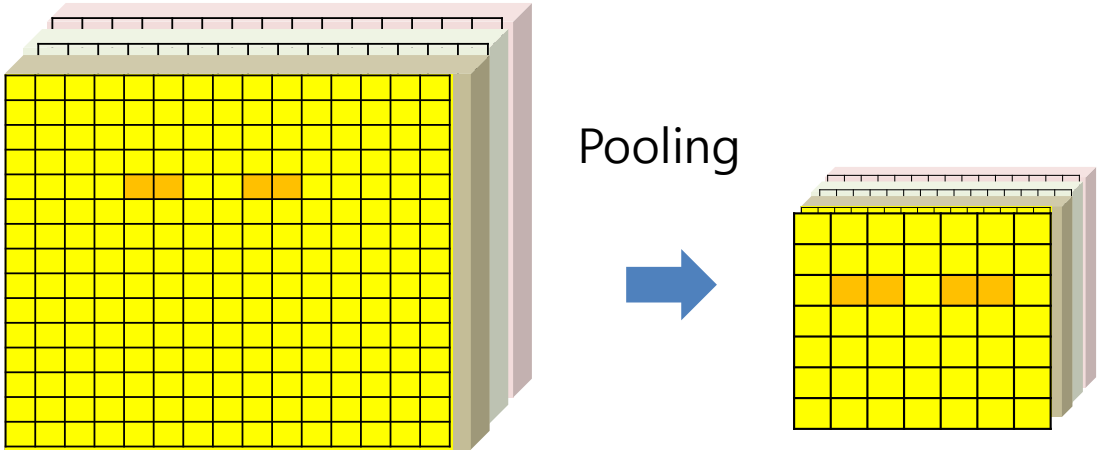
모두의연구소

- 세로·가로 방향의 공간을 줄이는 연산
  - 2x2 최대 풀링(max pooling)을 스트라이드 2로

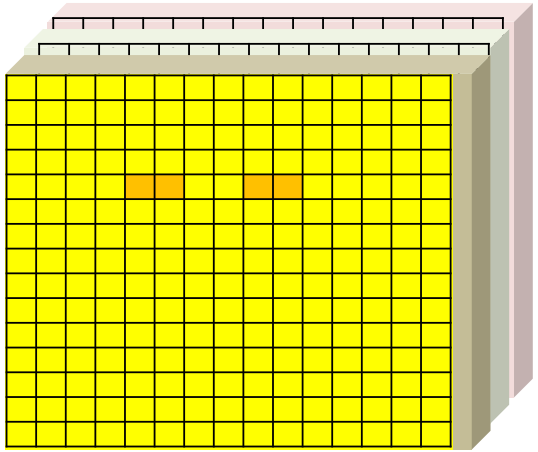


  - 평균 풀링(Average pooling)도 있습니다

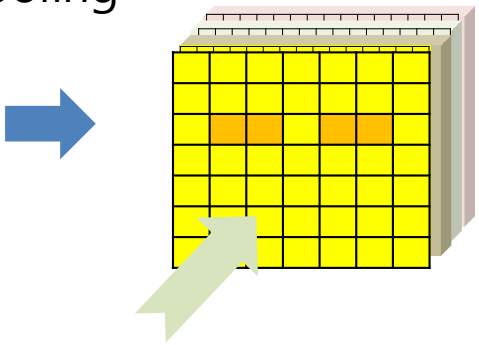
Pooling Layer

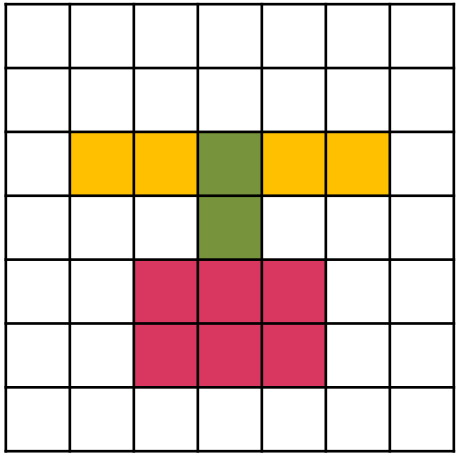


Pooling Layer



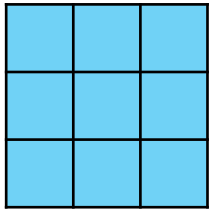
Pooling





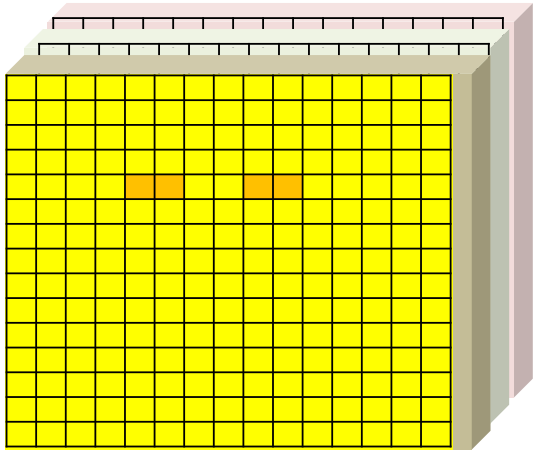
정면에서 보면 ?

Pooling Layer

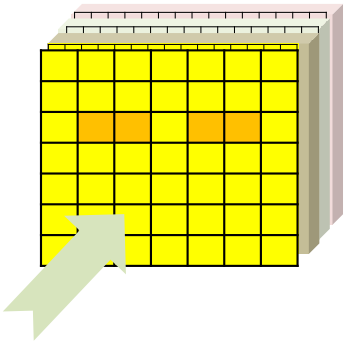


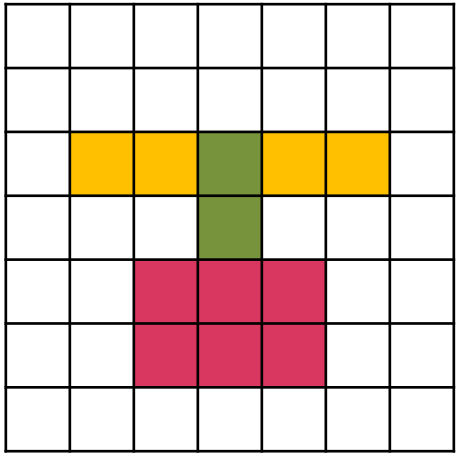
얼굴필터

모두의연구소



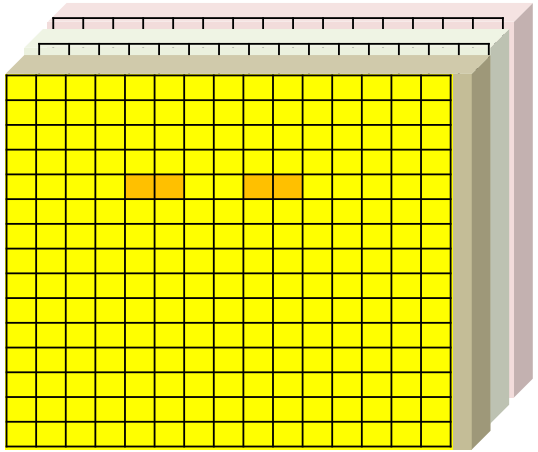
Pooling



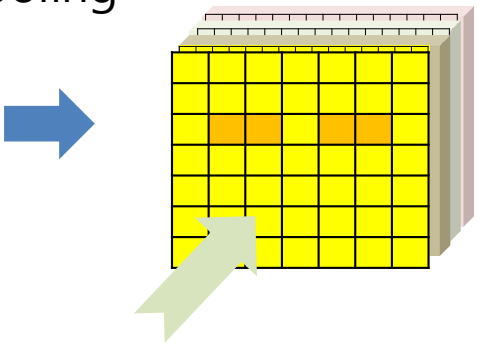


정면에서 보면 ?

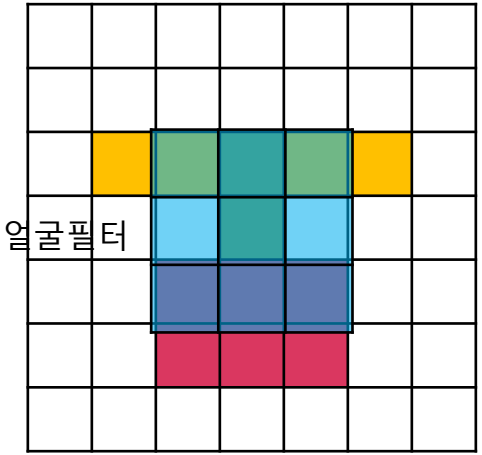
Pooling Layer



Pooling



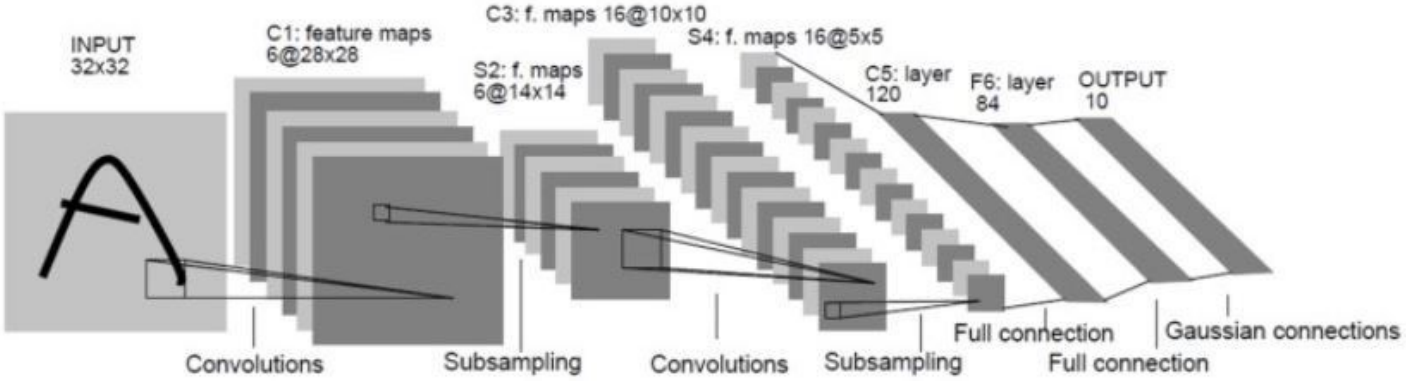
정면에서 보면 ?



눈, 코, 입을 특징을 합하여
얼굴로 인식가능

Convolutional Neural Networks

모두의연구소



LeNet-5

이미지 출처 : Lecun 1998, Gradient-based learning applied to document recognition

강아지 분류기

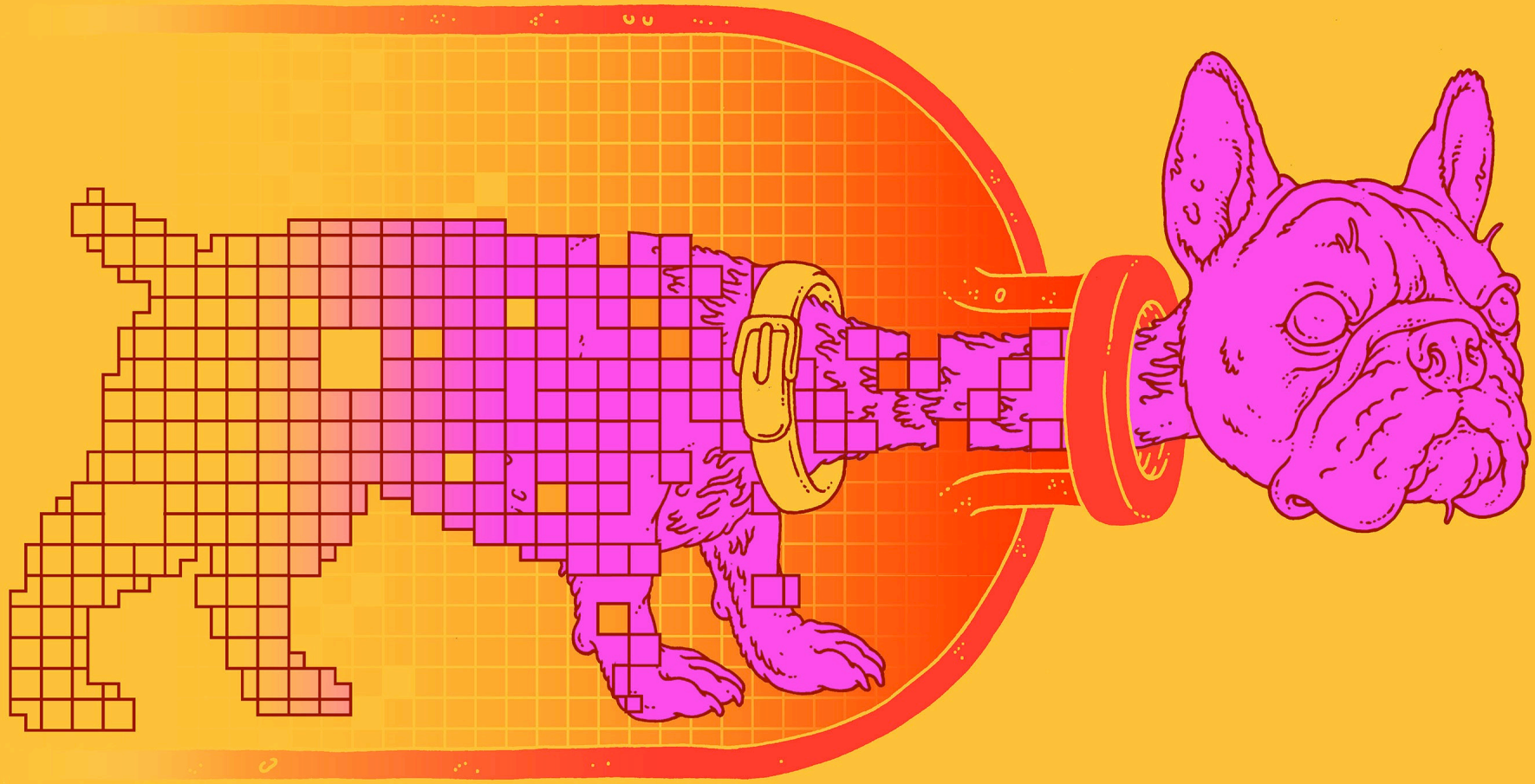


그림 : https://www.quantamagazine.org/new-theory-cracks-open-the-black-box-of-deep-learning-20170921/

박 은 수 Research Director

E-mail : es.park@modulabs.co.kr