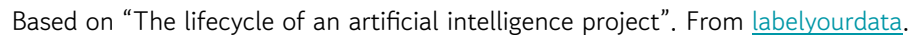




Deep Learning on DESI Data

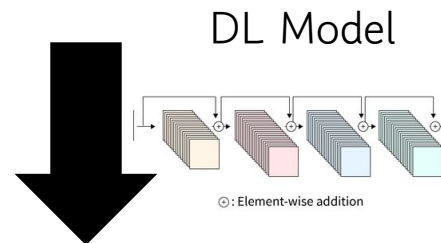
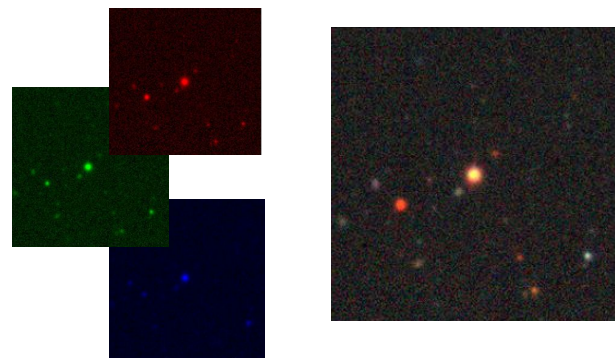
by
John Suárez-Pérez, Ph.D.



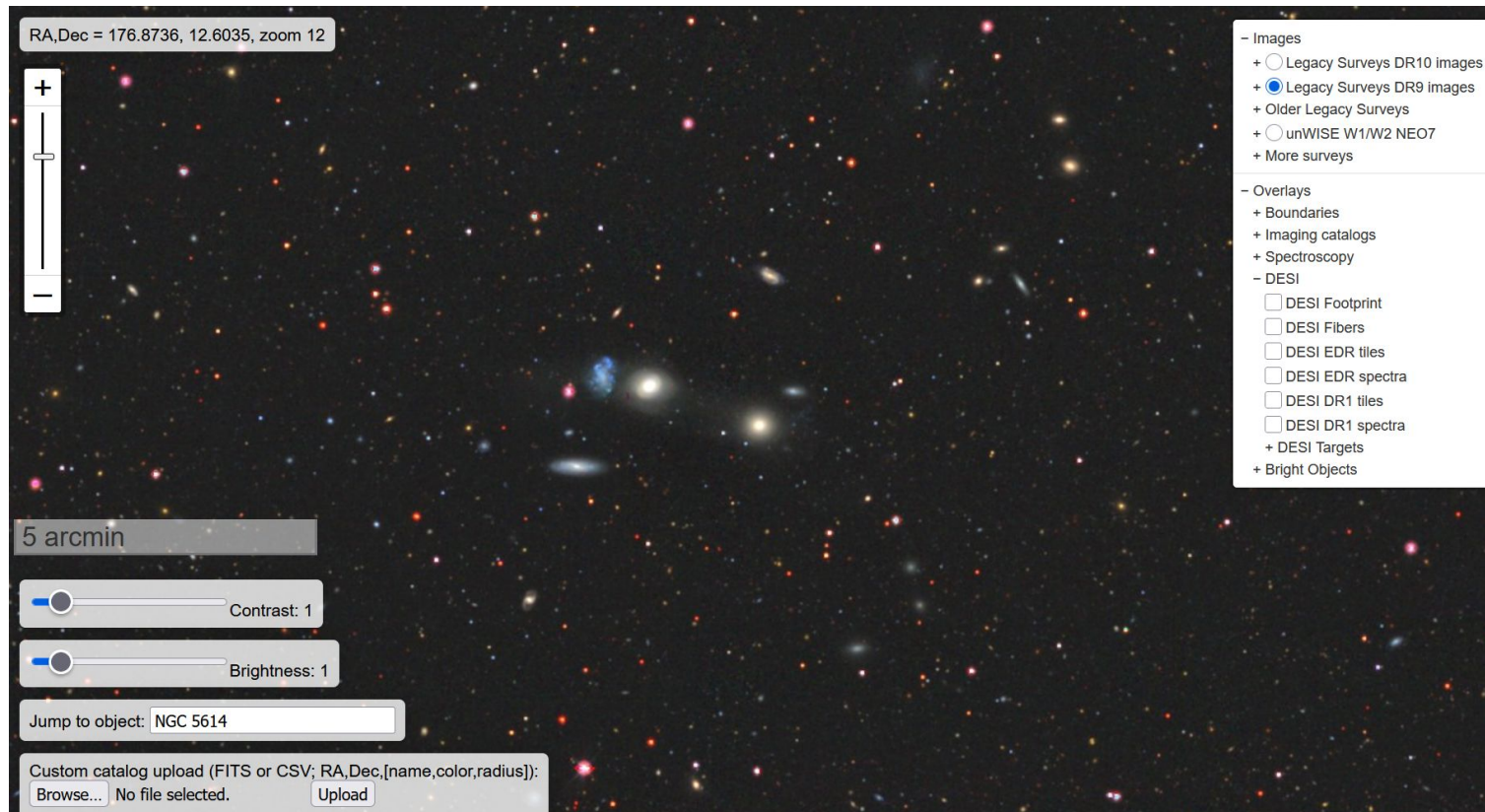


DESI z_{photo} prediction

- ❑ Data from the Legacy Imaging Survey
- ❑ Using different NN structures trained with images to predict z_photo
- ❑ Training: 70%, testing: 30%



Redshift (spectroscopic)





Obtaining Images and Raw Data

Images for all 3 of the Legacy Surveys can be viewed directly using [the Sky viewer](#) and raw data can be obtained through [the NOIRLab portal](#) (see also the information near [the bottom of the files](#) page). Note that the weight map images (the `oow` files) that can be retrieved either from the viewer or portal are in the same units as $1/\text{skyrms}^2$ in the [survey-ccds-<camera>-dr9.fits.gz](#) files. But, these images need to be multiplied by both gain and `exptime` to retrieve units of electrons (for `<camera>` of `mosaic` or `gprime`).

Sections of the Legacy Surveys for DR9 can be obtained as JPEGs or FITS files using the cutout service, for example, as follows:

JPEG: <https://www.legacysurvey.org/viewer/jpeg-cutout?ra=190.1086&dec=1.2005&layer=ls-dr9&pixscale=0.262>

FITS: <https://www.legacysurvey.org/viewer/fits-cutout?ra=190.1086&dec=1.2005&layer=ls-dr9&pixscale=0.262&bands=grz>

This will merge the northern (MzLS+BASS) and southern (DECam) images at a line corresponding to $\text{Dec}=32.375^\circ$.

To request images from only the northern or southern surveys, specify *dr9-north* or *dr9-south*, for example:

JPEG (DECaLS): <https://www.legacysurvey.org/viewer/jpeg-cutout?ra=190.1086&dec=1.2005&layer=ls-dr9-south&pixscale=0.262>

FITS (DECaLS): <https://www.legacysurvey.org/viewer/fits-cutout?ra=190.1086&dec=1.2005&layer=ls-dr9-south&pixscale=0.262&bands=grz>

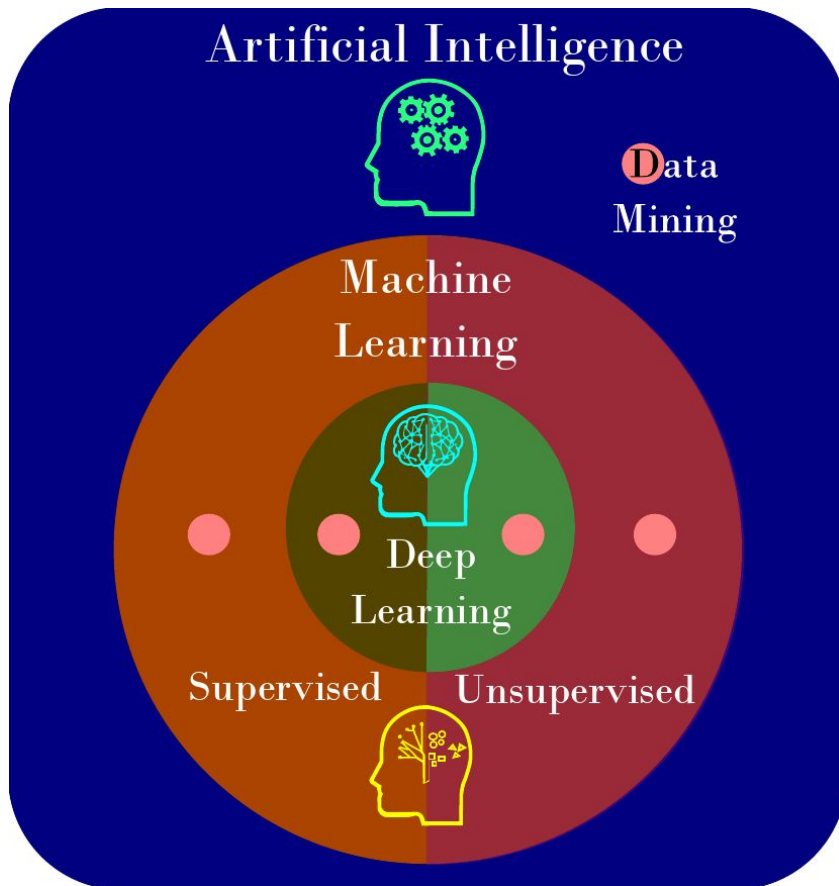
JPEG (BASS/MzLS): <https://www.legacysurvey.org/viewer/jpeg-cutout?ra=154.7709&dec=46.4537&layer=ls-dr9-north&pixscale=0.262>

FITS (BASS/MzLS): <https://www.legacysurvey.org/viewer/fits-cutout?ra=154.7709&dec=46.4537&layer=ls-dr9-north&pixscale=0.262&bands=grz>

What is AI?



- ❑ Simulating of human intelligence in machines (visual perception, speech recognition, decision-making, language processing).
- ❑ Algorithms and models that can process large amounts of data, trained with techniques as Supervised or Unsupervised learning.
- ❑ Main subfields of AI are Machine & Deep learning. Data Mining cut across both.





Supervised

- Used for classification or regression tasks.
- Requires to use labels to make predictions.

ML Algorithms

- * Support Vector Machines
- * K-nearest neighbors
- * Decision Trees
- * Random Forest.

DL Algorithms

- * Multi-Layer Perceptron
- * Convolutional Neural Network
- * Recurrent Neural Network
- * Transformers

Unsupervised

- Used for clustering or dimensionality reduction tasks.
- Doesn't require to use labels. Used to find patterns.

DL Algorithms

- * Autoencoders

ML Algorithms

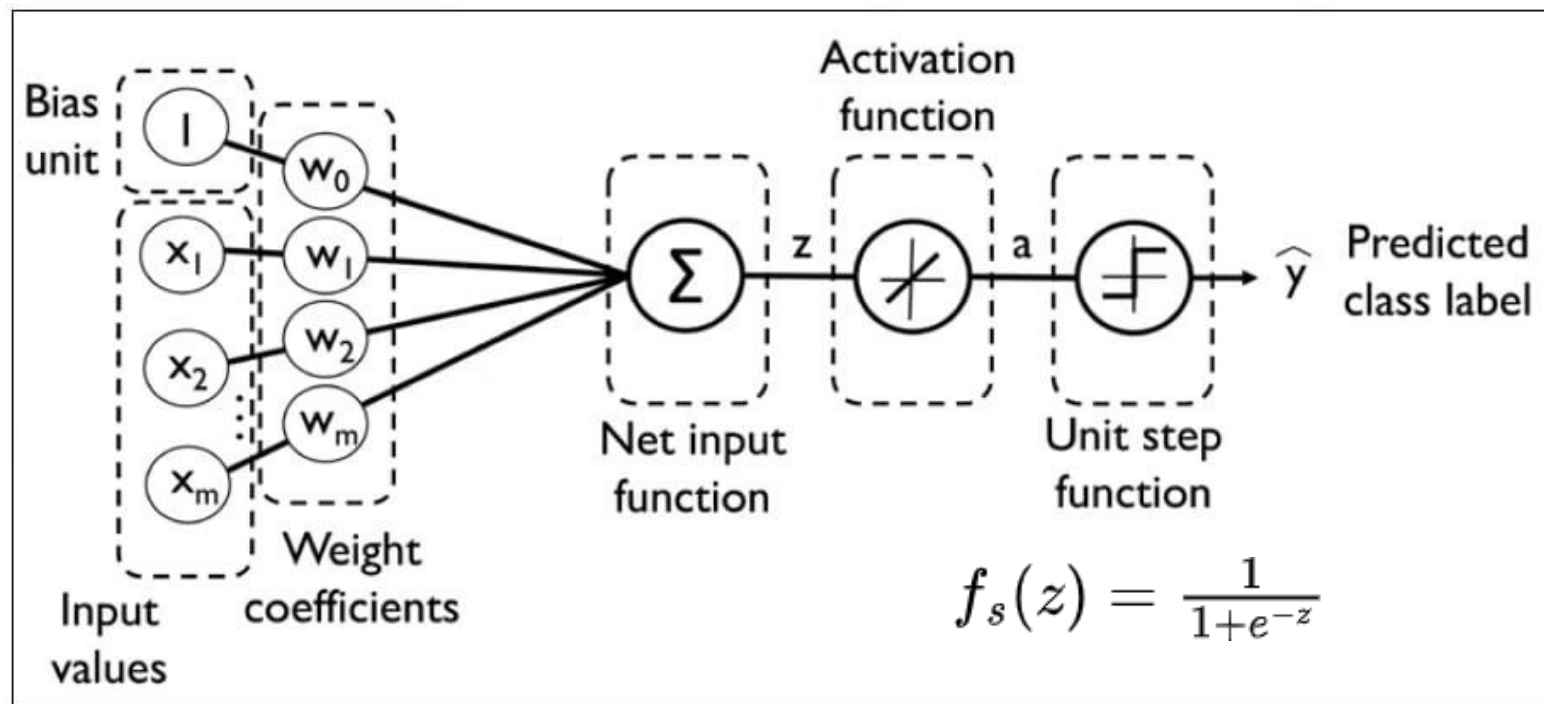
Clustering:

- * K-means clustering
- * DBScan
- * Gaussian Mixture Models

Dimensionality Reduction:

- * PCA
- * Isometric Map
- * T-SNE
- * UMAP

Multilayer Perceptron



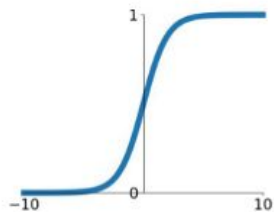
$$z = \beta_0 + \beta_1 x_1 + \beta_2 x_2 + \beta_3 x_1^2 + \beta_4 x_2^2 + \beta_5 x_1 x_2$$



Activation Functions

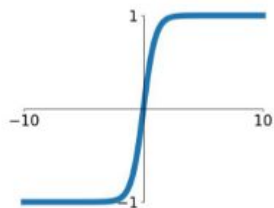
Sigmoid

$$\sigma(x) = \frac{1}{1+e^{-x}}$$



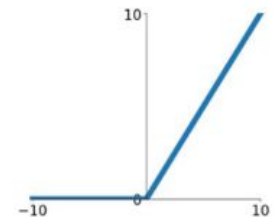
tanh

$$\tanh(x)$$



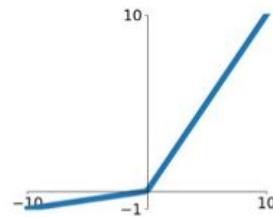
ReLU

$$\max(0, x)$$



Leaky ReLU

$$\max(0.1x, x)$$

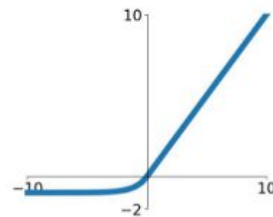


Maxout

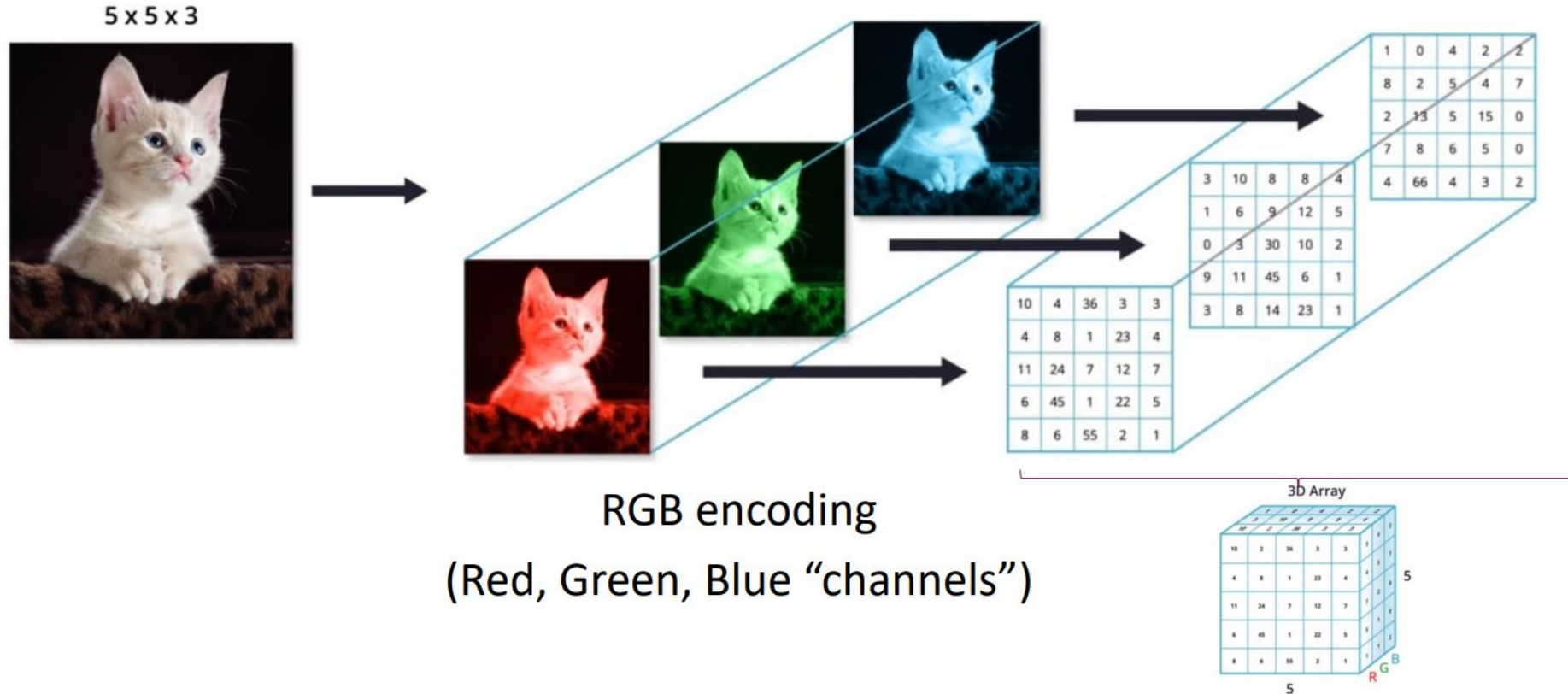
$$\max(w_1^T x + b_1, w_2^T x + b_2)$$

ELU

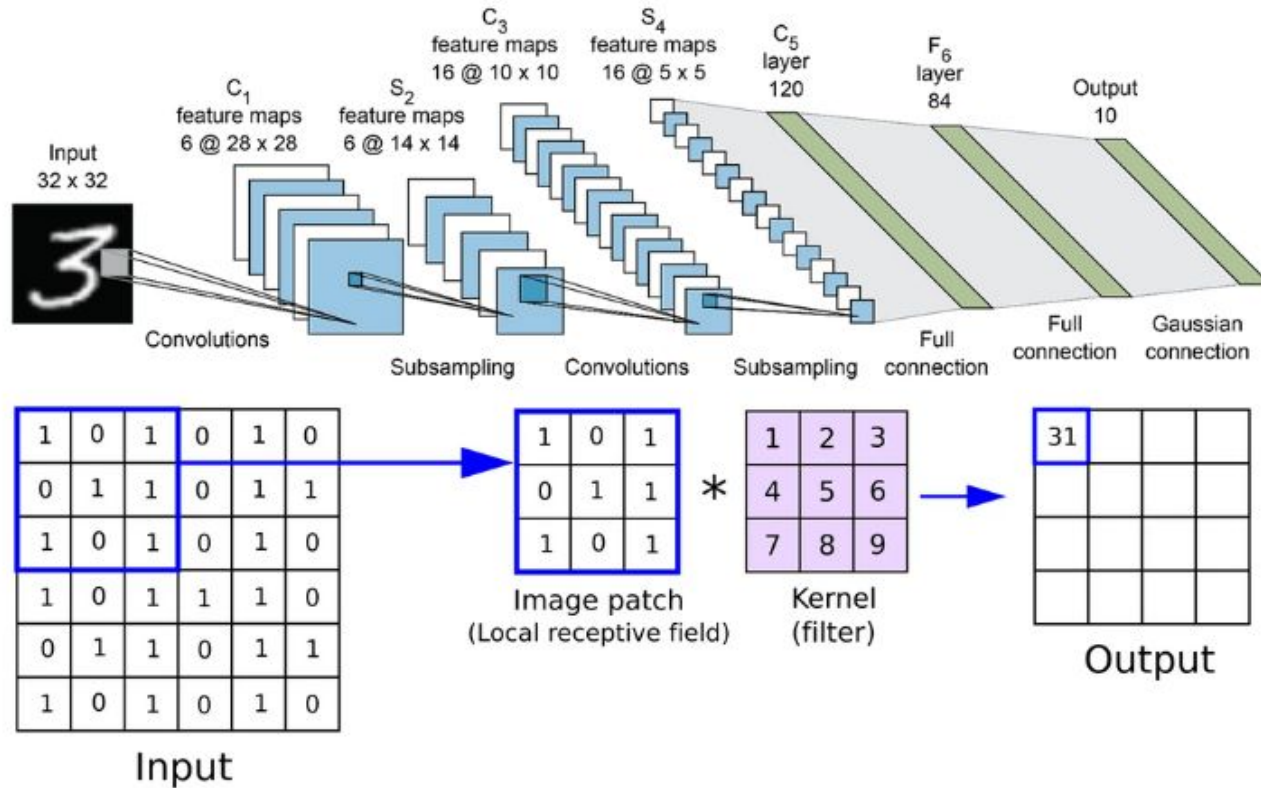
$$\begin{cases} x & x \geq 0 \\ \alpha(e^x - 1) & x < 0 \end{cases}$$



Convolutional Neural Network



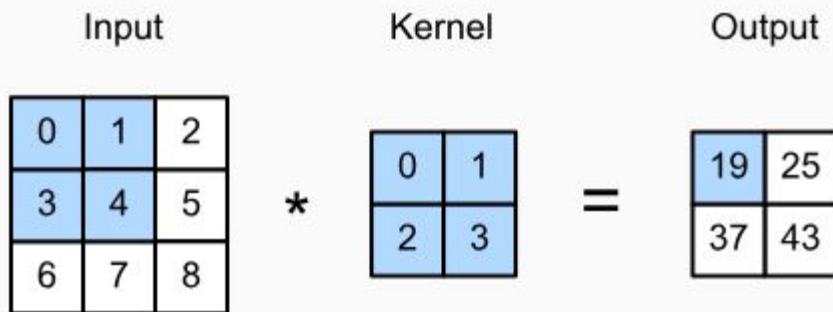
Convolutional Neural Network



Convolutional Operation



DIVE INTO
DEEP LEARNING

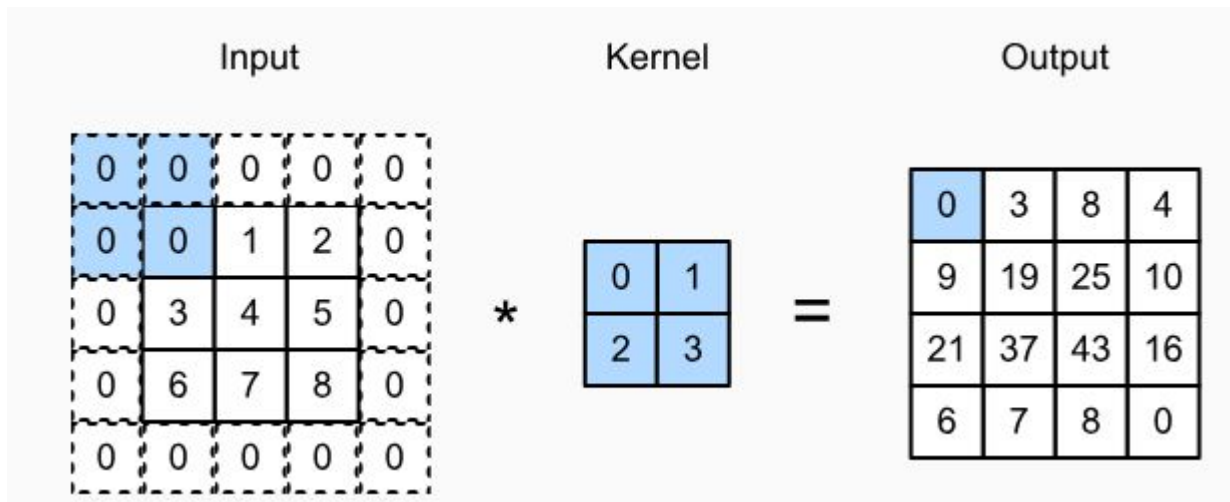


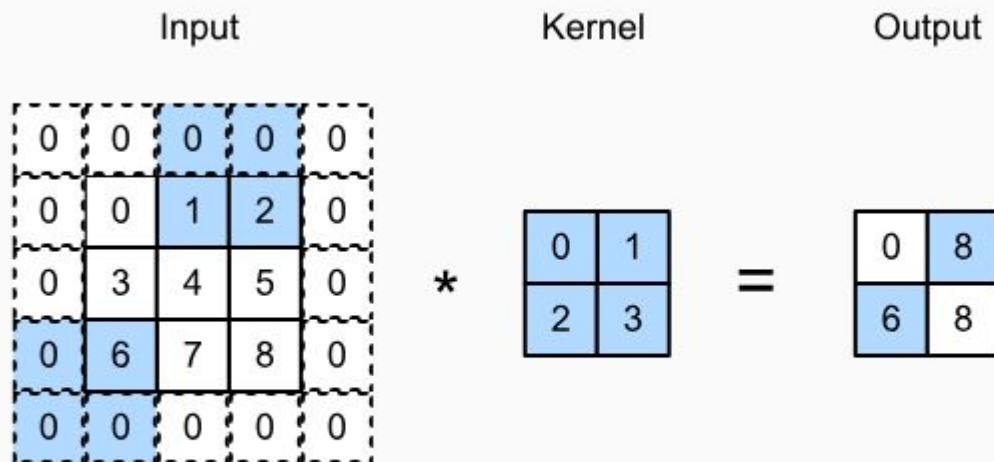
$$0 \times 0 + 1 \times 1 + 3 \times 2 + 4 \times 3 = 19$$

Padding



DIVE INTO
DEEP LEARNING





Cross-correlation with strides of 3 and 2 for height and width, respectively.