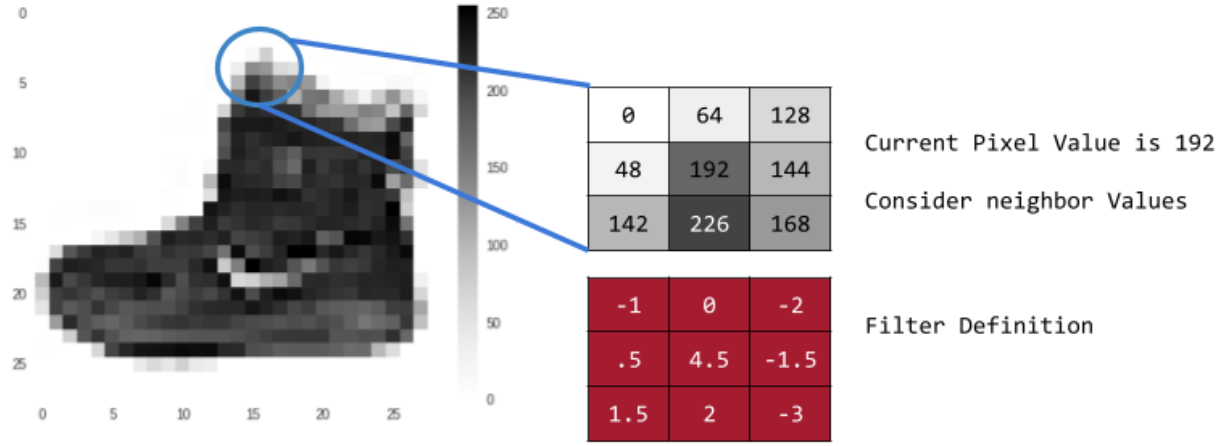
Quick Recap

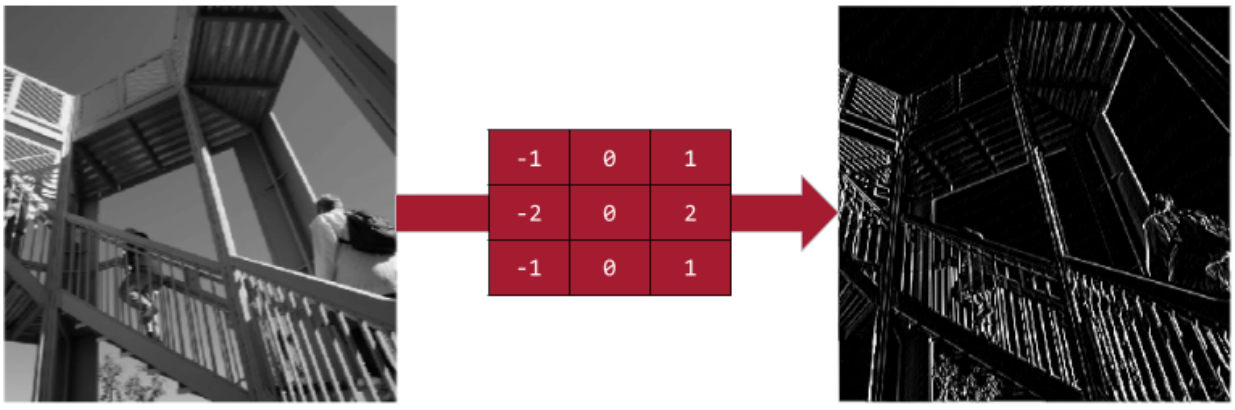
Over the last few lessons you've gone from a single neuron to classify Y=wX+b to having layers of these that could classify images, giving you basic computer vision.

You then learned about filters, and about how filters work to amend images:

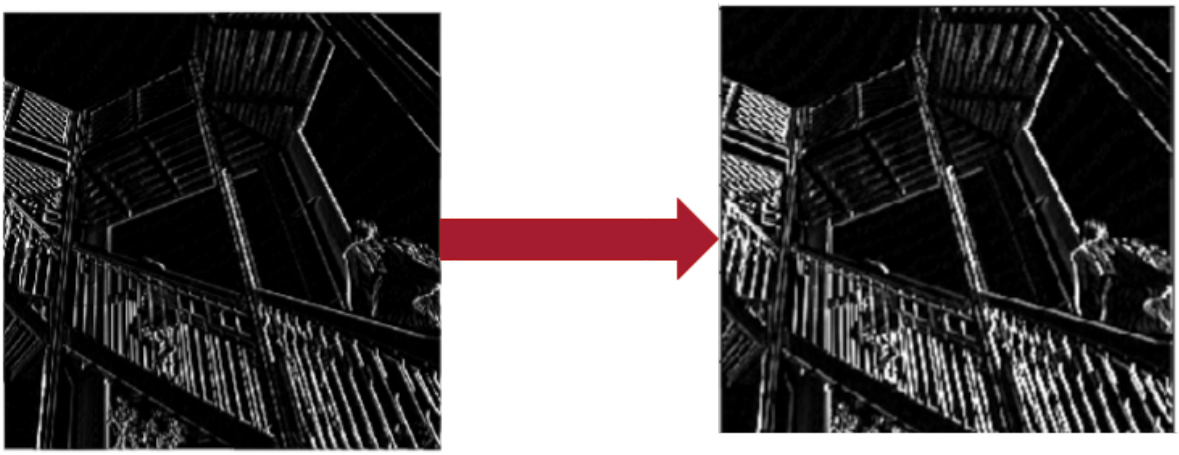



```
CURRENT_PIXEL_VALUE = 192
NEW_PIXEL_VALUE = (-1 * 0) + (0 * 64) + (-2 * 128) +
                  (.5 * 48) + (4.5 * 192) + (-1.5 * 144) +
                  (1.5 * 42) + (2 * 226) + (-3 * 168)
```

Filters could then be used to extract features from images. Here you can see a basic filter that removes most of the information from the image except for vertical lines:

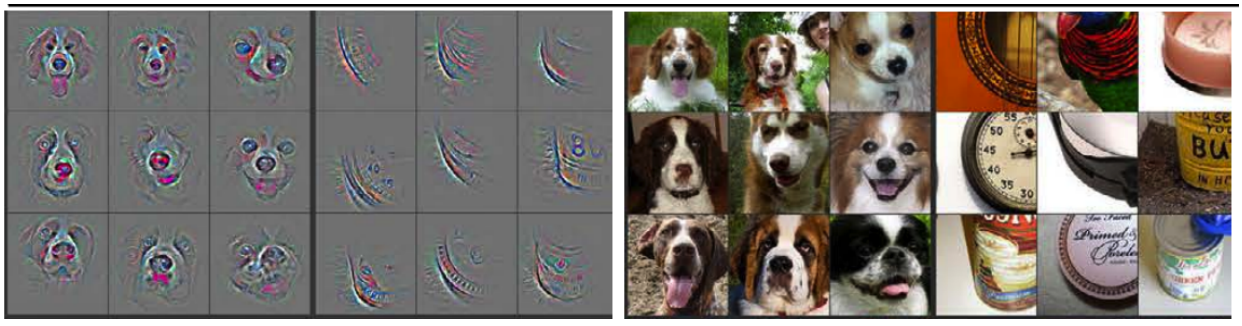


When combined with pooling, an image like the one above could be compressed *and* could have the features enhanced.



You explored adding convolutional layers with Fashion MNIST, and by extracting features, and then classifying those, instead of attempting to classify raw pixels, you achieved a better result. But these images were very simple -- 28x28 monochrome images containing a single subject, and it was centered. Can convolutions help with understanding the contents of more complex images?

The short answer is 'yes', and you'll explore that with images that are more real-world in the coming lessons. As a taste of what's possible there's a great paper here -- https://arxiv.org/pdf/1311.2901v3.pdf -- where the authors explore how a Convolutional Neural Network can 'see' features. So, on the left diagram here, you can see the results of a filter when applied to what are obviously dogs, as well as curved items like clocks. The images on the right are actually *reconstructions* of images using these filters -- where these images were generated by the neural network by going backwards through filters!



That's obviously beyond the scope of what we're doing here -- but it's interesting to see where the journey might take you! For some code on how to create visualizations of your filters check out: https://keras.io/examples/vision/visualizing_what_convnets_learn/