Daniel Kim

GitHub Link for HW 4: https://github.com/DanielKim512/Intro2DL.git

1. Object detection is important in self automated cars due to the need of recognizing what is in the car's surroundings. Safety is the highest priority and so the object detection system would need to replicate a human's classification task or be even better. With the advancement in AI and technology, self-automated cars should eventually surpass a humans' limits. To implement, firstly would need to introduce features such as color. A car's vision when driving will see many different colors to distinguish. This will help a car be able to distinguish between a car and non-car. This is accomplished using the RGB color space. Through manipulating and transforming color values, structural ques such as gradient would be helpful. By summing gradient magnitudes of each sample, a representation of the structure of a car for example would be clearly seen due to weighting. There are many features to select, and the important thing is to combine all the features to create the best object detection system. After layering multiple features, it is now time to build a classifier to train. There are many ways to create a classifier, but it is important to maintain low training and testing error with no underlying problems such as overfitting. After the feature selection and classifier building, next step is to implement a method to search for vehicles. This is where techniques such as the sliding window technique are helpful by looking through an image in a sliding fashion and using the classifier for each step. Hopefully if built correctly, the object detection system will be able to identify vehicles and take one step closer to a future with automated cars.
2. YOLO is an algorithm that detects and recognizes various objects in a picture in real time. The two questions it answers is what the object is and where the object is. The popularity of YOLO is due to the high accuracy and speed of the algorithm. YOLO uses CNN and requires only a single forward propagation through a neural network. In detail, YOLO uses residual block technique which is dividing the image into various grids. Then it uses a bounding box regression that outlines an object in an image. This outline is created to predict width, height, class, and center from the bounding box regression. Finally, it employs Intersection over union in which the predicted box equals the real box. That means the IOU is equal to 1. This way, any bounding box that are not equal to the real box are eliminated. All three techniques are combined to show how YOLO works.
3. Formula for negative log likelihood is

   $$l(\theta) = -\sum_{i=1}^{n}\left(y_i \log \hat{y}_{\theta,i} + (1 - y_i)\log\left(1 - \hat{y}_{\theta,i}\right)\right)$$

   Where yi = 0 indicates that the data was mislabeled. Therefore, only the second term is

   $$H(p,q) = -\sum_{x\in\mathcal{X}} p(x)\log q(x)$$

   Which is also the formula for cross entropy.

4. dy/dx = $\dfrac{(\cos(\sqrt{x})+2)\sqrt{x}+(\cos(\sqrt{x})+1)\sin(\sqrt{x})}{\sqrt{x}}$. Calculations of the reverse trace can be found below. The denominator of sqrt(x) is the most influential. If x = 0, dy/dx = 0. If the gradient had no skip connection from x to y, then vanishing gradient problem would occur. Skip connections are used to tackle on the vanishing gradient problem. That way, they have an uninterrupted gradient flow from the first layer to the last layer.

$$y = (\sin(\sqrt{x}) + \sqrt{x})^2 + x$$

$w_1 = x$
$w_2 = \sqrt{w_1}$
$w_3 = \sin(w_2)$
$w_4 = (w_2 + w_3)^2$
$w_5 = w_1 + w_4$
$y = w_5$

$$\frac{dy}{dy} = 1 = \frac{dy}{dw_5}$$

$$\frac{dy}{dw_4} = \frac{dy}{dw_5}\cdot\frac{dw_5}{dw_4} = 1\cdot(1) = 1$$

$$\frac{dy}{dw_3} = \frac{dy}{dw_4}\cdot\frac{dw_4}{dw_3} = 1\cdot(2w_2 + 2w_3)$$

$$\frac{dy}{dw_2} = \frac{dy}{dw_3}\cdot\frac{dw_3}{dw_2} + \frac{dy}{dw_4}\cdot\frac{dw_4}{dw_2} = (2w_2+2w_3)\cdot\cos(w_2) + 1\cdot(2w_2+2w_3) = (2w_2+2w_3)(\cos(w_2)+1)$$

$$\frac{dy}{dw_1} = \frac{dy}{dw_5}\cdot\frac{dw_5}{dw_1} + \frac{dy}{dw_2}\cdot\frac{dw_2}{dw_1} = (1\cdot 1) + (2w_2+2w_3)(\cos(w_2)+1)\cdot\frac{1}{2\sqrt{w_1}}$$

$$1 + \left[\left[2\sqrt{x} + 2\sin(\sqrt{x})\right]\left[\cos(\sqrt{x})+1\right]\right]\cdot\frac{1}{2\sqrt{x}}$$

$$1 + \left[2\sqrt{x}\cdot\cos(\sqrt{x}) + 2\sqrt{x} + 2\sin(\sqrt{x})\cos(\sqrt{x}) + 2\sin(\sqrt{x})\right]\cdot\frac{1}{2\sqrt{x}}$$

$$1 + \cos(\sqrt{x}) + 1 + \frac{2\sin(\sqrt{x})\cos(\sqrt{x})}{2\sqrt{x}} + \frac{2\sin(\sqrt{x})}{2\sqrt{x}}$$

$$\cos(\sqrt{x}) + 2 + \frac{\cancel{2}\sin(\sqrt{x})(\cos(\sqrt{x})+1)}{\cancel{2}\sqrt{x}}$$

$$\frac{\sqrt{x}\cos(\sqrt{x})}{\sqrt{x}} + \frac{2\sqrt{x}}{\sqrt{x}} + \frac{\sin(\sqrt{x})(\cos(\sqrt{x})+1)}{\sqrt{x}}$$

$$\boxed{\frac{dy}{dx} = \frac{\sqrt{x}\cos(\sqrt{x}) + 2\sqrt{x} + \sin(\sqrt{x})\cos(\sqrt{x}) + \sin(\sqrt{x})}{\sqrt{x}}}$$

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