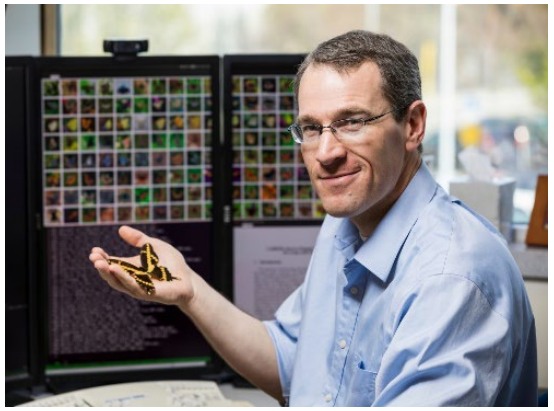
Computer Vision:
Understanding, Interpreting and Learning from Visual Data

DSSI
DATA SCIENCE
SUMMER INSTITUTE

Lawrence Livermore
National Laboratory

DAY FOUR

July 25, 2019
July 30, 2019
July 31, 2019
August 2, 2019



Ryan Farrell

BYU
BRIGHAM YOUNG
UNIVERSITY

Visualization, Deep Learning, Other Topics

Kullback-Leibler Divergence

Definition: Kullback-Leibler Divergence

For two probability distributions $f(x)$ and $g(x)$ for a random variable X, the Kullback-Leibler divergence or relative entropy is given as:

$$D(f||g) = \sum_{x \in X} f(x) \log \frac{f(x)}{g(x)}$$

The KL divergence compares the entropy of two distributions over the same random variable.

Intuitively, the KL divergence number of additional bits required when encoding a random variable with a distribution $f(x)$ using the alternative distribution $g(x)$.

From Frank Keller, Edinburgh

Kullback-Leibler Divergence

Theorem: Properties of the Kullback-Leibler Divergence

1. $D(f||g) \geq 0$;
2. $D(f||g) = 0$ iff $f(x) = g(x)$ for all $x \in X$;
3. $D(f||g) \neq D(g||f)$;
4. $I(X;Y) = D(f(x,y)||f(x)f(y))$.

So the mutual information is the KL divergence between $f(x,y)$ and $f(x)f(y)$. It measures how far a distribution is from independence.

From Frank Keller, Edinburgh

Kullback-Leibler Divergence

Example

For a random variable $X = \{0, 1\}$ assume two distributions $f(x)$ and $g(x)$ with $f(0) = 1 - r$, $f(1) = r$ and $g(0) = 1 - s$, $g(1) = s$:

$$\begin{aligned} D(f||g) &= (1-r)\log\frac{1-r}{1-s} + r\log\frac{r}{s} \\ D(g||f) &= (1-s)\log\frac{1-s}{1-r} + s\log\frac{s}{r} \end{aligned}$$

If $r = s$ then $D(f||g) = D(g||f) = 0$. If $r = \frac{1}{2}$ and $r = \frac{1}{4}$:

$$\begin{aligned} D(f||g) &= \frac{1}{2}\log\frac{\frac{1}{2}}{\frac{3}{4}} + \frac{1}{2}\log\frac{\frac{1}{2}}{\frac{1}{4}} = 0.2075 \\ D(g||f) &= \frac{3}{4}\log\frac{\frac{3}{4}}{\frac{1}{2}} + \frac{1}{4}\log\frac{\frac{1}{4}}{\frac{1}{2}} = 0.1887 \end{aligned}$$

From Frank Keller, Edinburgh

(WHITEBOARD)

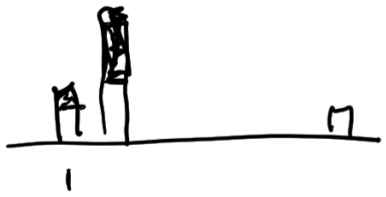
KL-DIVERGENCE

f

g

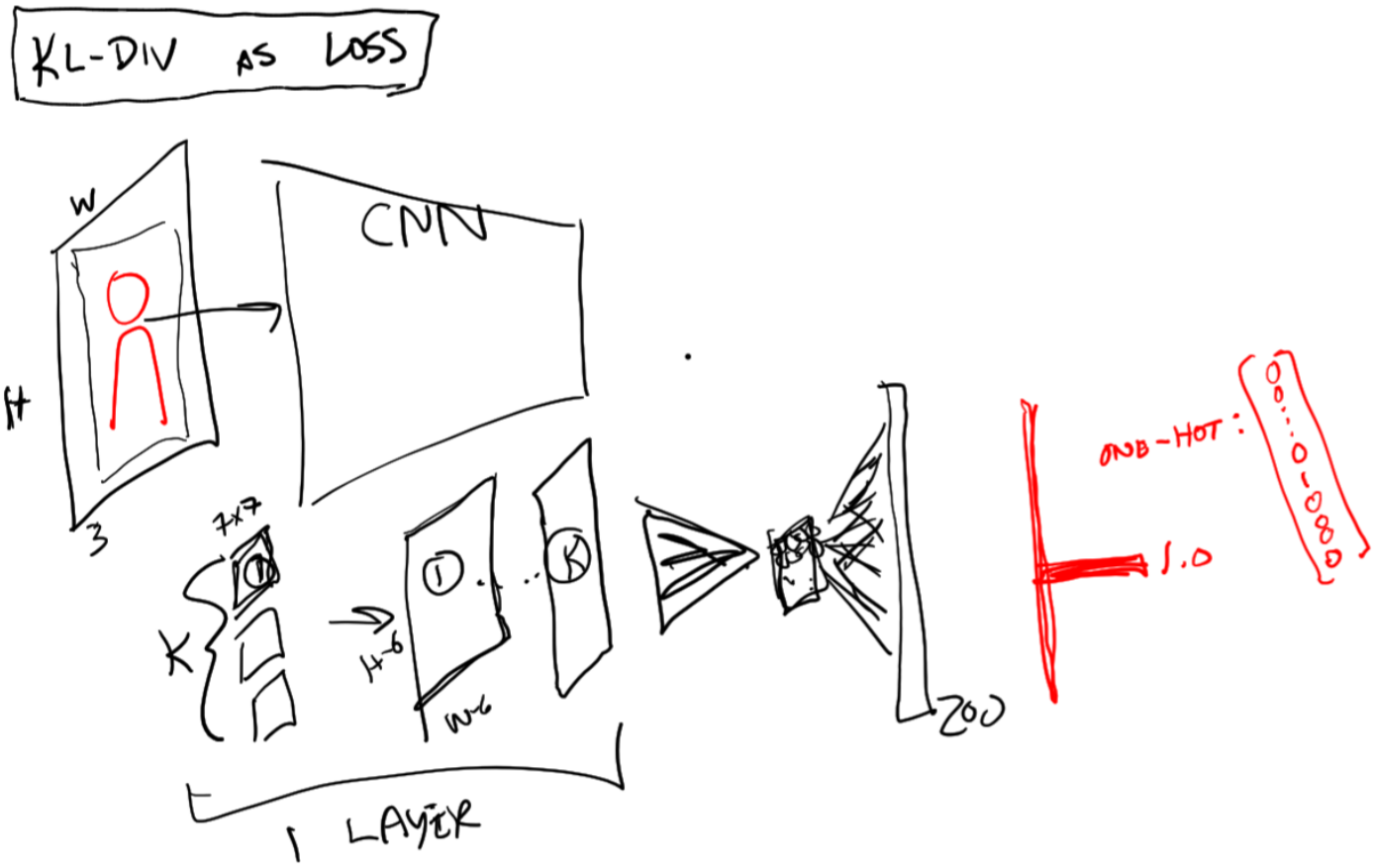
$$\sum_x f(x) \log \frac{f(x)}{g(x)}$$

EARTH MOVER'S DISTANCE

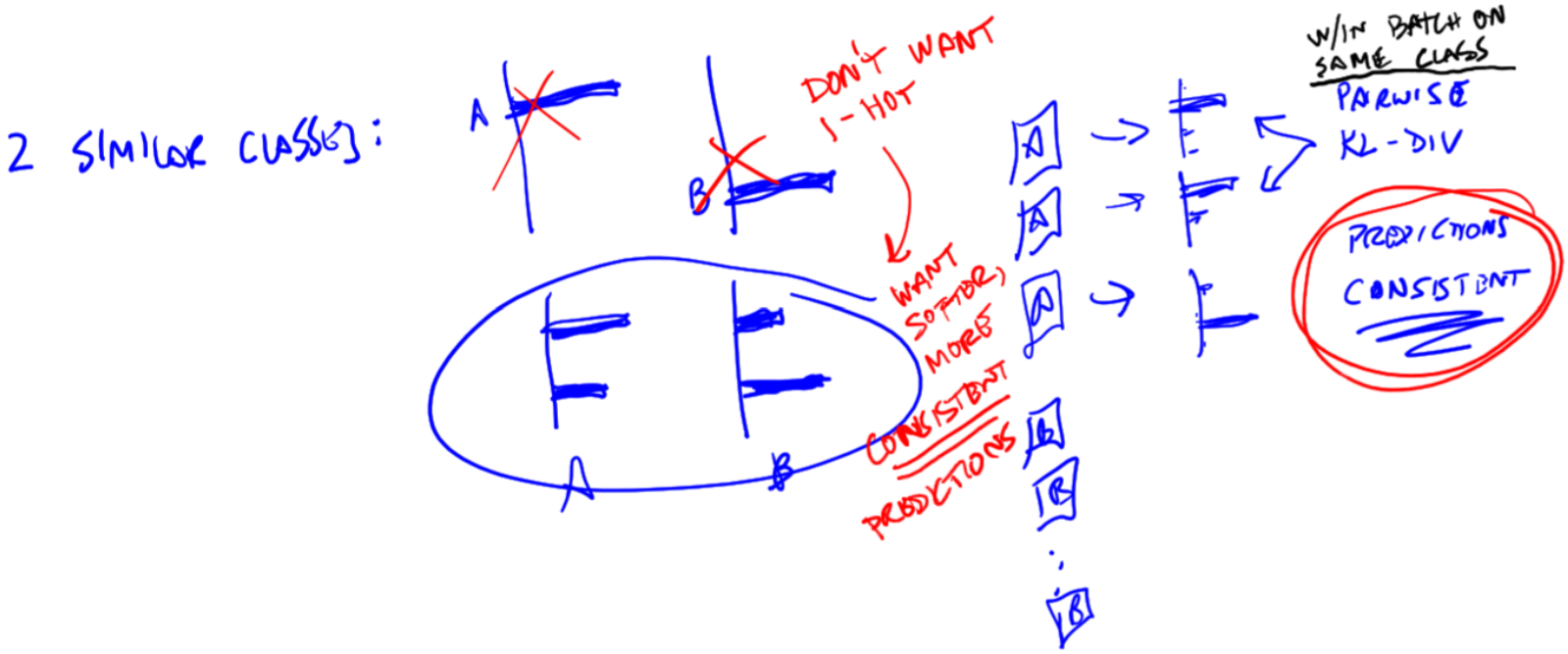


QTY x DIST.

KL-Div as a LOSS



KL-Div as a LOSS

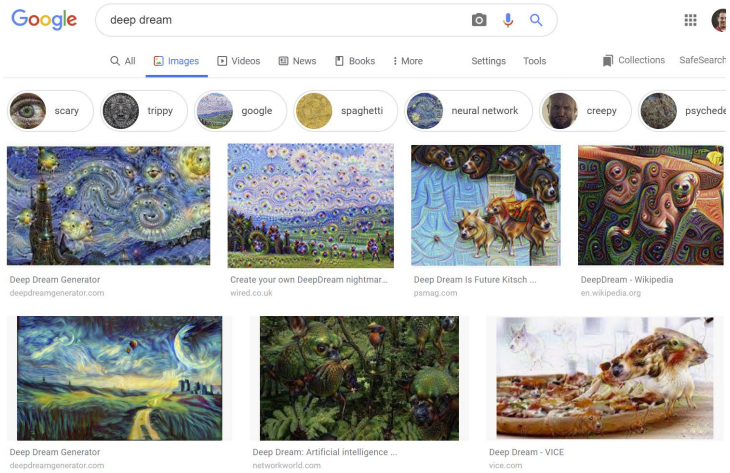


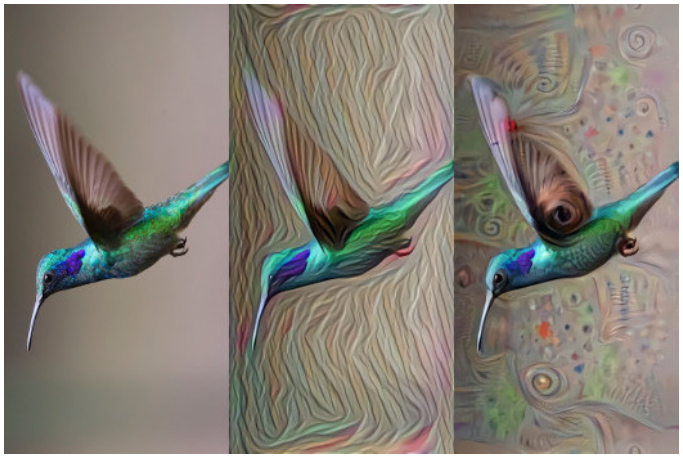
CNNs and Class Activation Map (CAM)

- Tensorflow Playground
- Fred Hohman Blog Post
- Saurabh Pal Blog Post (CAM near bottom)

From

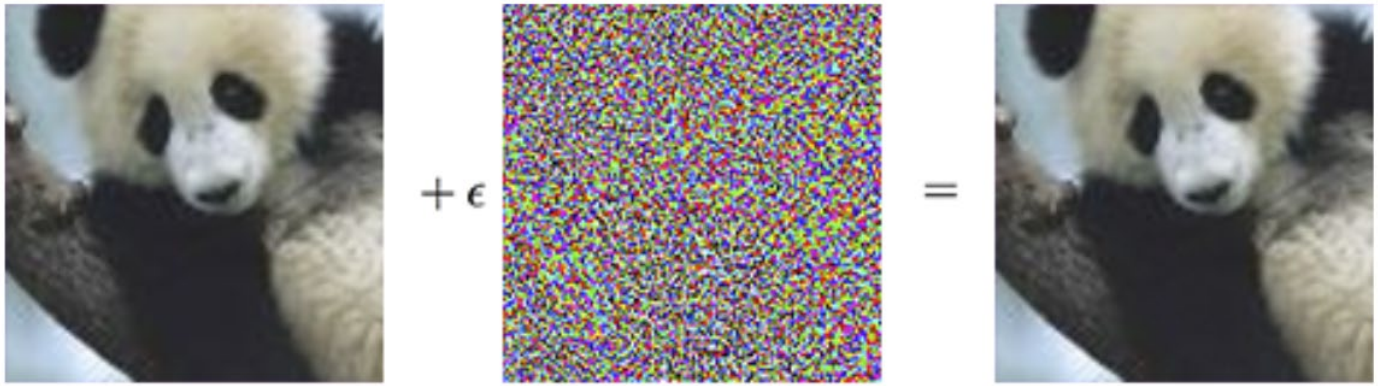
Deep Dream





[Image Search](), [Example](), and [How-to-with-Tensorflow]()

Adversarial Attacks



"panda"
57.7% confidence

"gibbon"
99.3% confidence

Image Source and Additional Details (Open AI Blog)

(WHITEBOARD)

EXPLAINABLE AI = "EX AI"

VISION + LANGUAGE

HOG HISTOGRAM ORIENTED GRADIENTS 2005

DPM = DEFORMABLE PART MODEL

HOG Features (Example)

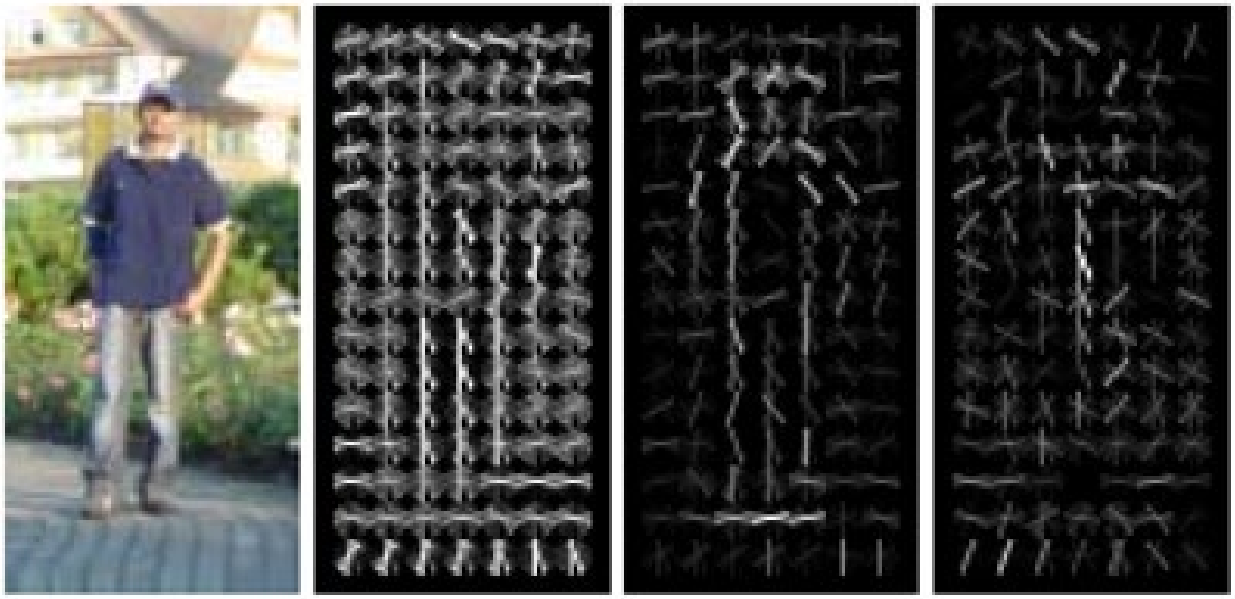
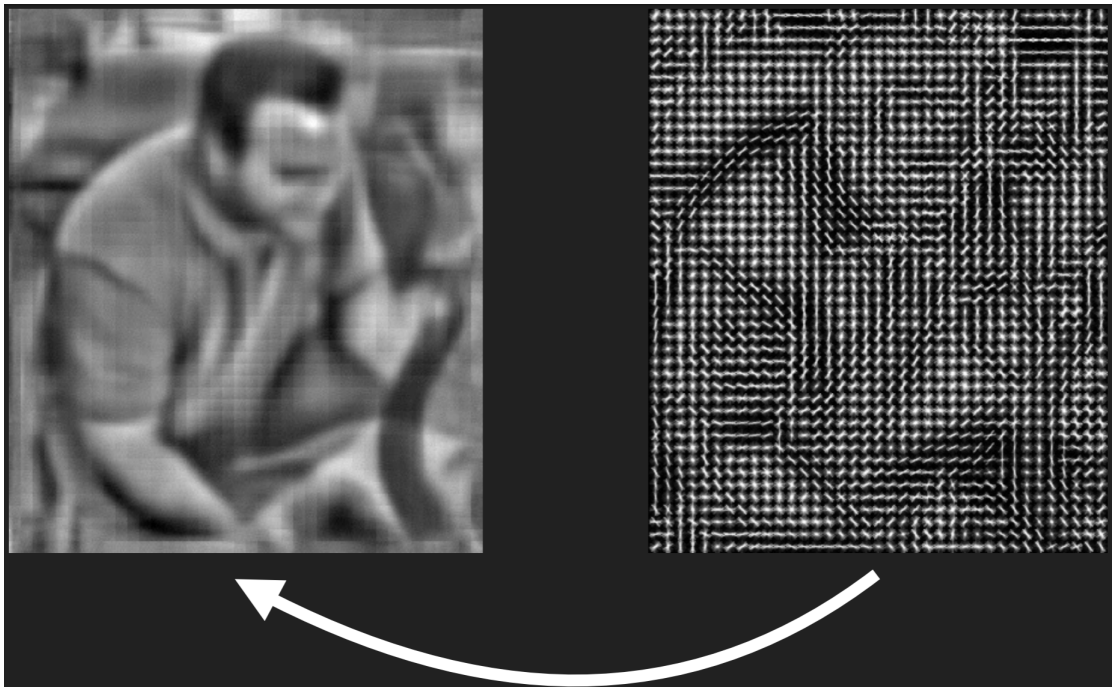


Image Source

HOGGLES



Hoggles slides from Carl Vondrick (Columbia)

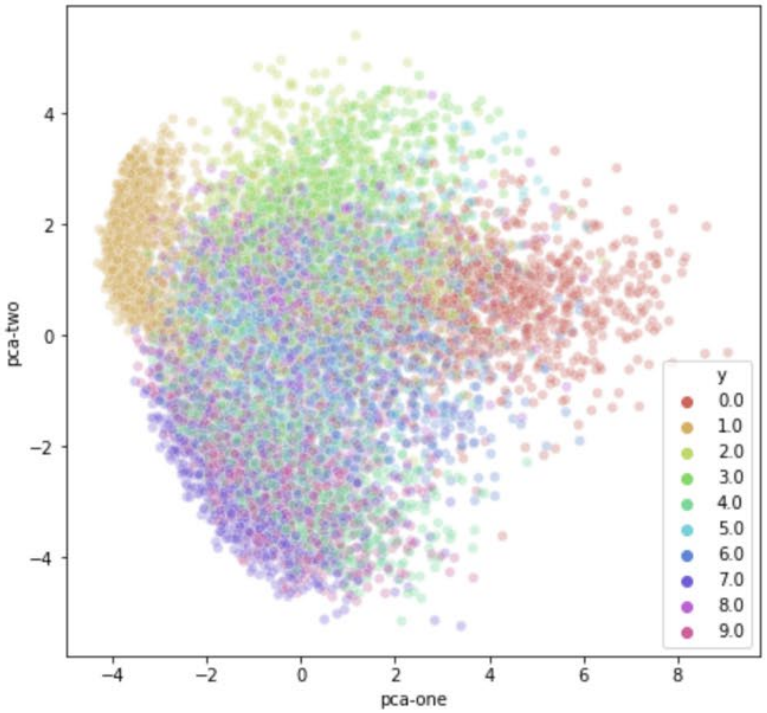
distill.pub

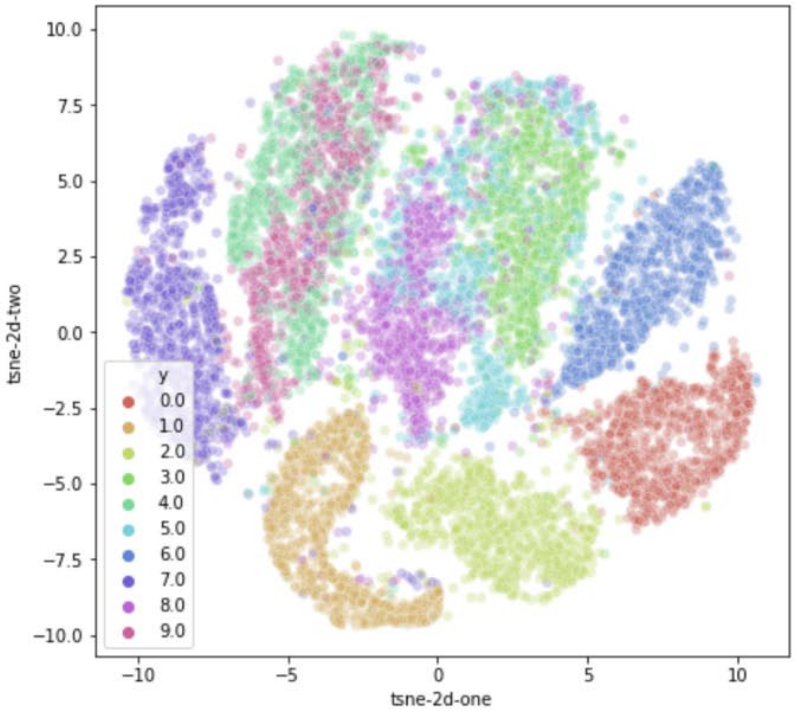
Currently 18 “articles” including:

- Open Questions about GANs
- Visualizing Memorization in RNNs
- Attention and Augmented RNNs

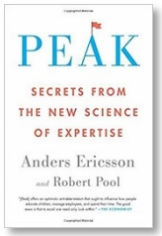
- A Visual Exploration of Gaussian Processes
- Exploring Neural Networks with Activation Atlases
- How to Use t-SNE Effectively

PCA (linear) vs. t-SNE (nonlinear)

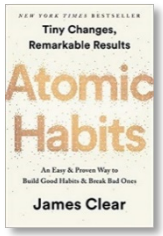




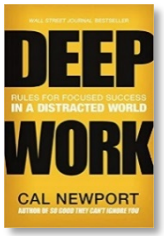
Recommended Books



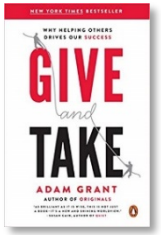
Peak
by *Anders Ericcson*



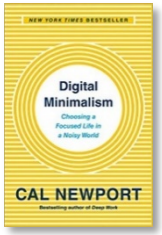
Atomic Habits
by *James Clear*



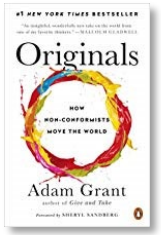
Deep Work
by *Cal Newport*



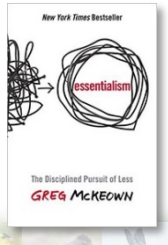
Give and Take
by *Adam Grant*



Digital Minimalism
by *Cal Newport*



Originals
by *Adam Grant*



Essentialism
by *Greg McKeown*