Increasing Solar adoption in the Developing World by analyzing low-resolution Satellite images

Rudradeb Mitra

PyData Warsaw, 30th October 2018

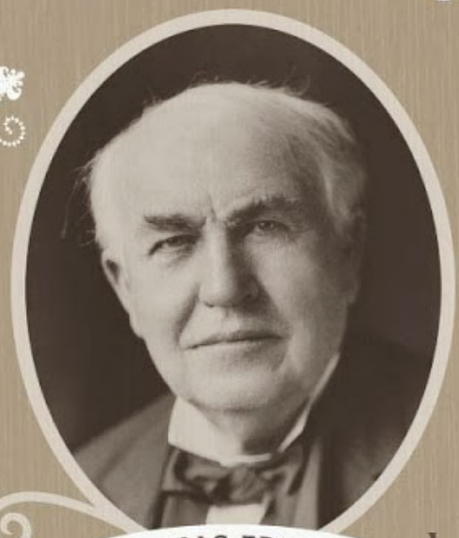
Content

- Why do we need to identify rooftops in satellite images using Machine Learning (Business Use Case)
- How are we building the solution (Technical solution)
  - Gathering Data
  - Product Development
- Future and the role of Communities (Visionary)

I. The Problem

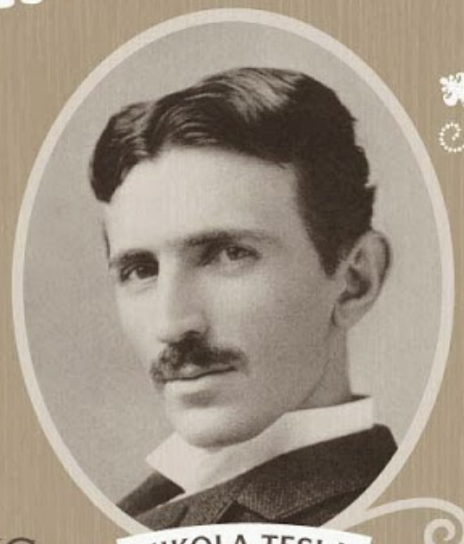
THE CURRENT WAR

THE TALE OF AN EARLY TECH RIVALRY



THOMAS EDISON

VS.



NIKOLA TESLA

You would have never found two geniuses so spiteful of each other beyond turn-of-the-century inventors Nikola Tesla and Thomas Edison. They worked together—and hated each other. Let's compare their life, achievements, and embittered battles.

DC

DIRECT CURRENT

The flow of electricity is in one direction only. The system operates at the same voltage level throughout and is not as efficient for high-voltage, long distance transmission.

Direct current runs through:

- Battery-Powered Devices
- Fuel and Solar Cells
- Light Emitting Diodes

"[TESLA'S] IDEAS ARE SPLENDID, BUT THEY ARE UTTERLY IMPRACTICAL."

- THOMAS EDISON

AC

ALTERNATING CURRENT

Electric charge periodically reverses direction and is transmitted to customers by a transformer that could handle much higher voltages.

Alternating current runs through:

- Car Motors
- Radio Signals
- Appliances

"IF EDISON HAD A NEEDLE TO FIND IN A HAYSTACK, HE WOULD PROCEED AT ONCE... UNTIL HE FOUND THE OBJECT OF HIS SEARCH. I WAS A SORRY WITNESS OF SUCH DOINGS, KNOWING THAT A LITTLE THEORY AND CALCULATION WOULD HAVE SAVED HIM 90 PERCENT OF HIS LABOR."

- NIKOLA TESLA

LATE BLOOMER

Thomas Edison, the youngest in his family, didn't learn to talk until he was almost 4 years old.

FALLING OUT

Edison promised Tesla a generous reward if he could smooth out his direct current system. The young engineer took on the assignment and ended up saving Edison more than $100,000 (millions of dollars by today's standards). When Tesla asked for his rightful compensation, Edison declined to pay him. Tesla resigned shortly after, and the elder inventor spent the rest of his life campaigning to discredit his counterpart.

"Genius is one percent inspiration and ninety nine percent perspiration."

-Thomas Edison

1847	BORN	1858
Milan, Ohio	BIRTHPLACE	Smiljan, Croatia
Wizard of Menlo Park	NICKNAME	Wizard of the West
Home-schooled and self-taught	EDUCATION	Studied math, physics, and mechanics at The Polytechnic Institute at Gratz
Mass communication and business	FORTE	Electromagnetism and electromechanical engineering
Trial and error	METHOD	Getting inspired and seeing the invention in his mind in detail before fully constructing it
DC (Direct Current)	WAR OF CURRENTS: ELECTRICAL TRANSMISSION IDEA	AC (Alternating Current)
Incandescent light bulb; phonograph; cement making technology; motion picture camera; DC motors and electric power	NOTABLE INVENTIONS	Tesla coil - resonant transformer circuit; radio transmitter; fluorescent light; AC motors and electric power generation system
1,093	NUMBER OF US PATENTS	112
0	NUMBER OF NOBEL PRIZES WON	0
1	NUMBER OF ELEPHANTS ELECTROCUTED	0
1931—Passed away peacefully in his New Jersey home, surrounded by friends and family	DEATH	1943—Died lonely and in debt in Room 3327 at the New Yorker Hotel

EDISON FRIES AN ELEPHANT

In order to prove the dangers of Tesla's alternating current, Thomas Edison staged a highly publicized electrocution of the three-ton elephant known as "Topsy." She died instantly after being shocked with a 6,600-volt AC charge.

WAR OF CURRENTS OFFICIALLY SETTLED

In 2007, Con Edison ended 125 years of direct current electricity service that began when Thomas Edison opened his power station in 1882. It changed to only provide alternating current.

NOBEL PRIZE CONTROVERSY

In 1915, both Edison and Tesla were to receive Nobel Prizes for their strides in physics, but ultimately, neither won. It is rumored to have been caused by their animosity towards each other and refusal to share the coveted award.

SOURCES: CHENEY, MARGARET. "TESLA: MAN OUT OF TIME" | UTH, ROBERT. "TESLA: MASTER OF LIGHTNING." | THOMASEDISON.COM | PBS.ORG | WEB.MIT.EDU | WIRED.COM

A COLLABORATION BETWEEN GOOD AND COLUMN FIVE

Centralized System

"Imagine a future where energy is cheap, clean and abundant for all. Where each home or building is self-sufficient."

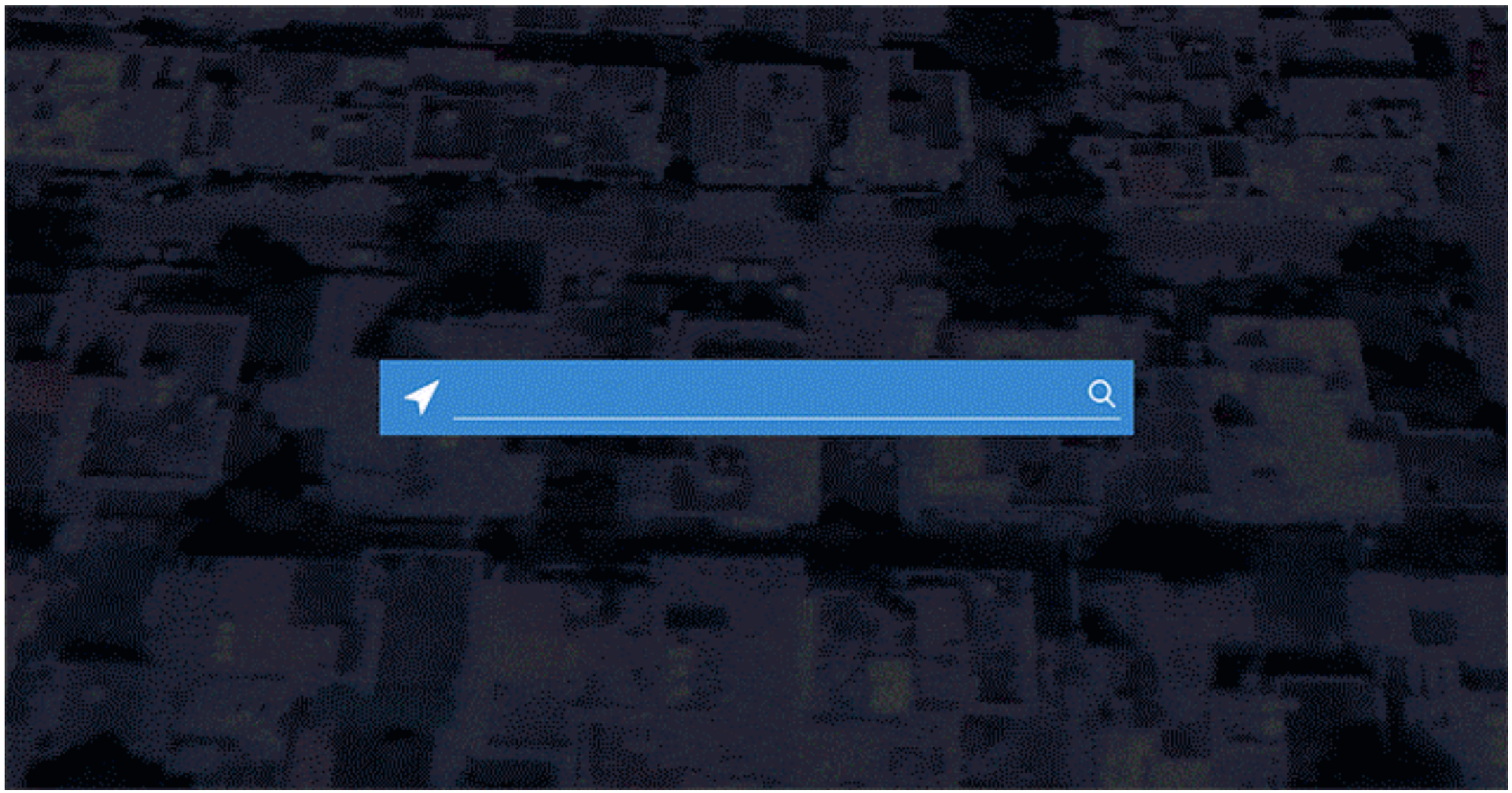
-Rudradeb Mitra,

Machine Learning bringing a new era in the Energy sector

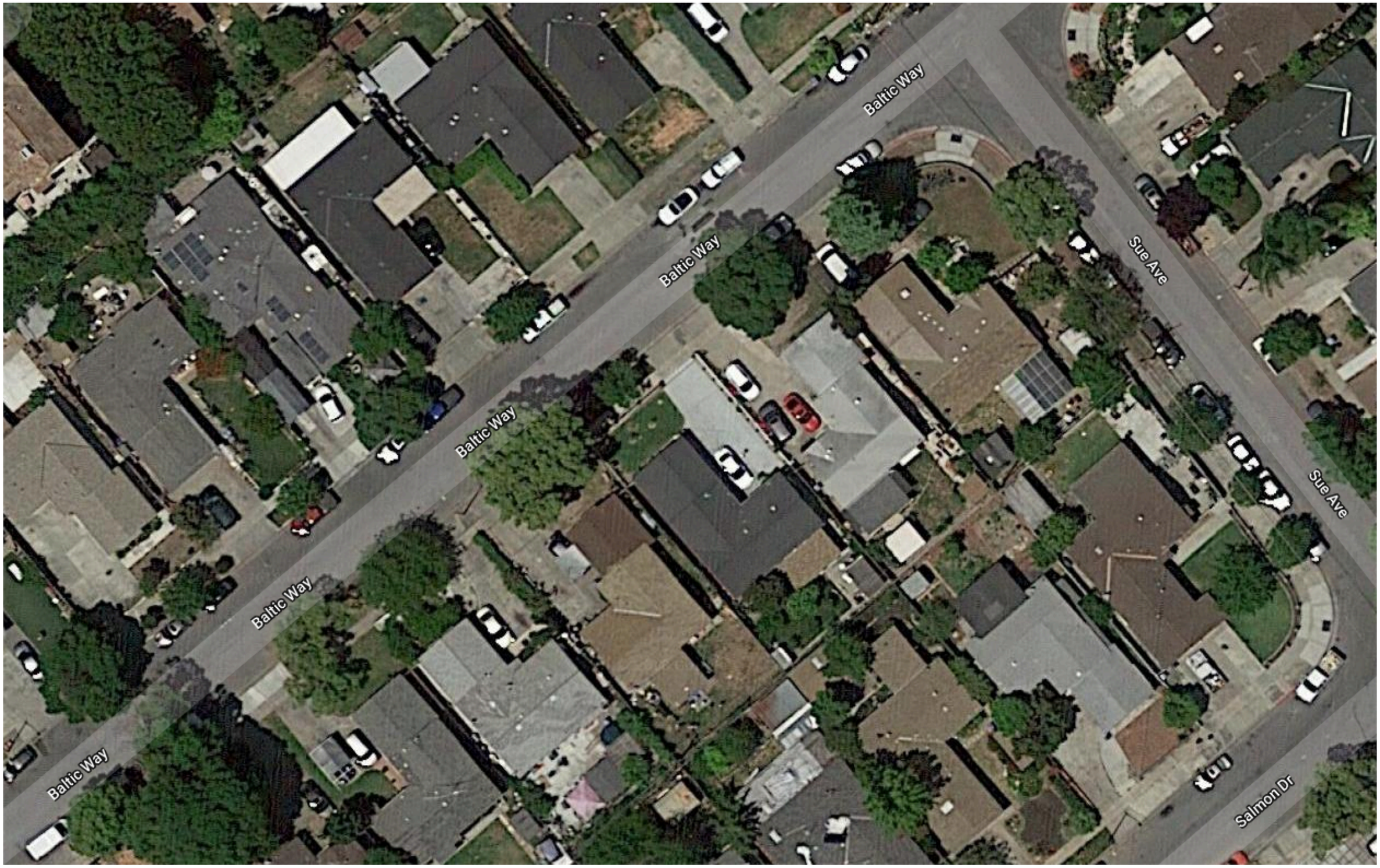
https://medium.com/savera-ai/machine-learning-bringing-a-new-era-in-the-energy-sector-distributed-abundant-and-a-clean-world-cf06365c29ff

How to build such a future?

What Intelligent Machines can do?

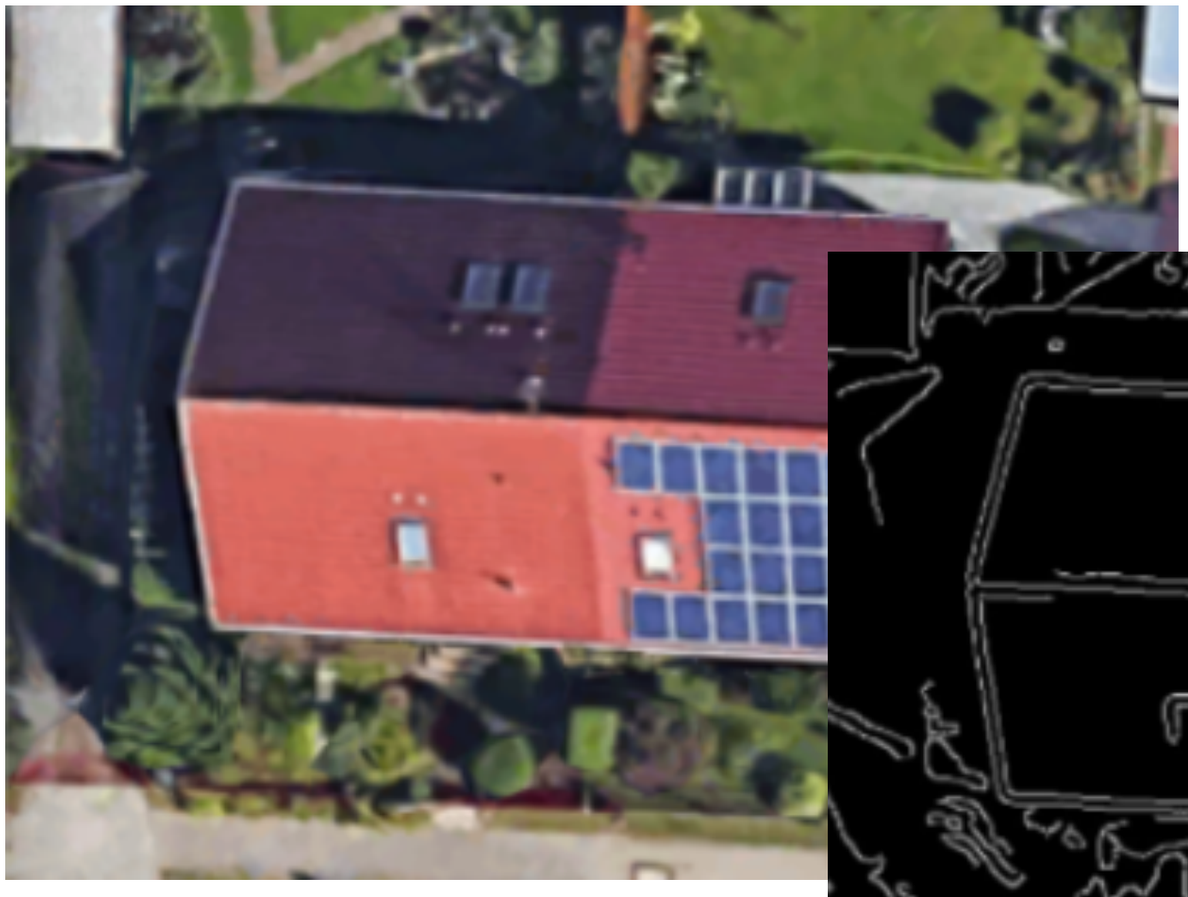


Satellite Rooftop Images from San Francisco

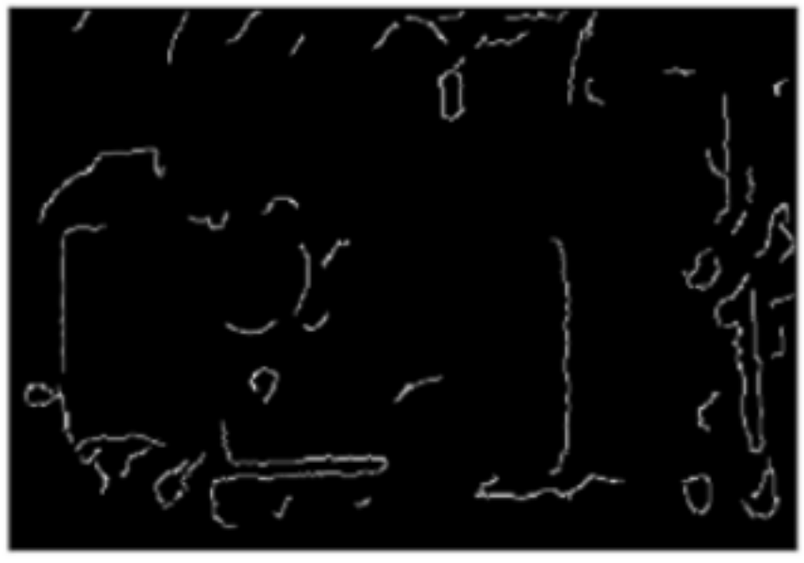


But ground facts in majority of the world is different....

How most systems in Western World are built



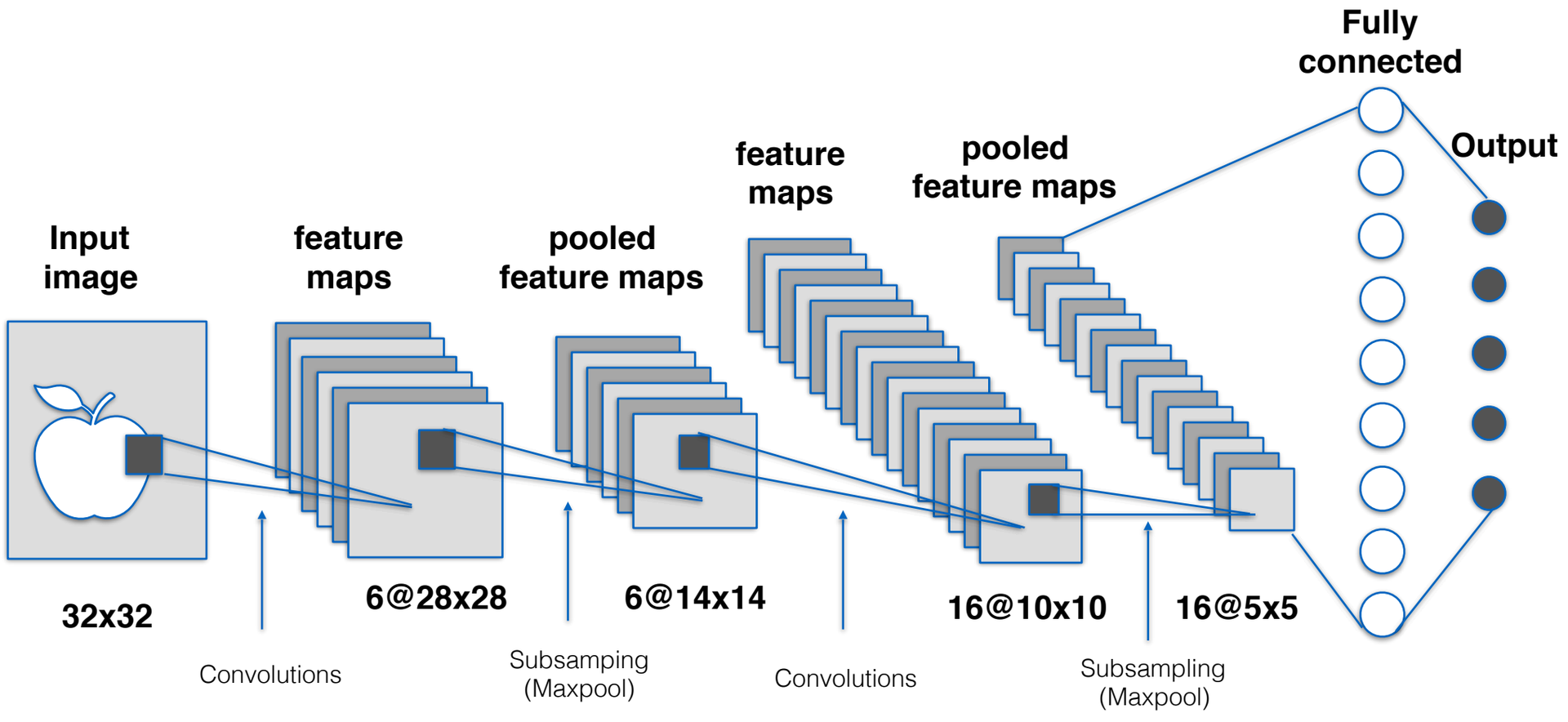
So when we applied same algorithms we got...



So we want Intelligent Machines to

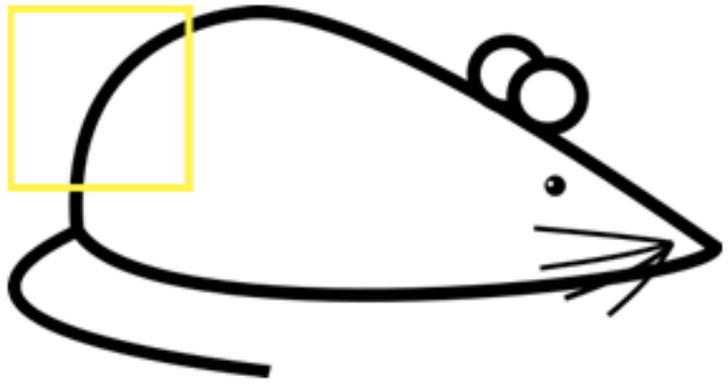
II. The Solution

Convolutional Neural Network



Convolution Layer: Applying filters

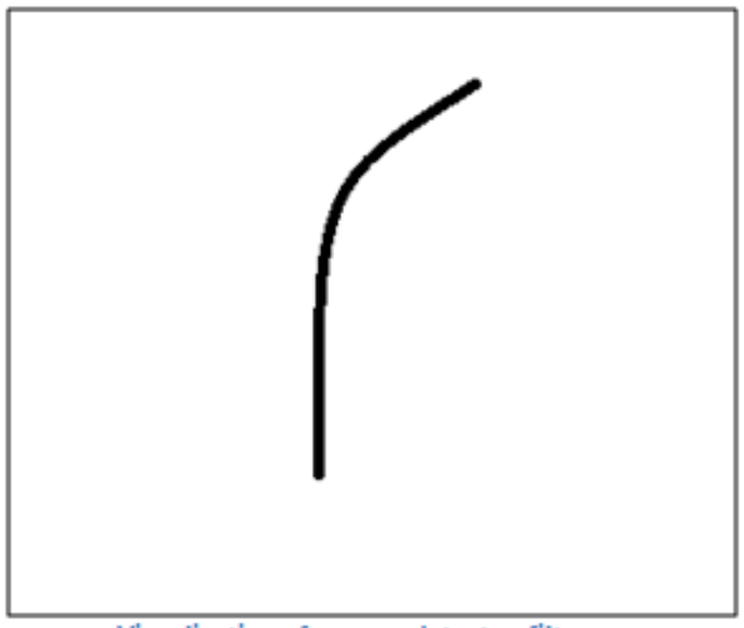
Original image



Visualization of the filter on the image

0	0	0	0	0	30	0
0	0	0	0	30	0	0
0	0	0	30	0	0	0
0	0	0	30	0	0	0
0	0	0	30	0	0	0
0	0	0	30	0	0	0
0	0	0	0	0	0	0

Pixel representation of filter



Visualization of a curve detector filter

https://adeshpande3.github.io/A-Beginner%27s-Guide-To-Understanding-Convolutional-Neural-Networks/

Convolution Layer: Applying filters

Visualization of the receptive field

0	0	0	0	0	0	30
0	0	0	0	50	50	50
0	0	0	20	50	0	0
0	0	0	50	50	0	0
0	0	0	50	50	0	0
0	0	0	50	50	0	0
0	0	0	50	50	0	0

Pixel representation of the receptive field

*

0	0	0	0	0	30	0
0	0	0	0	30	0	0
0	0	0	30	0	0	0
0	0	0	30	0	0	0
0	0	0	30	0	0	0
0	0	0	30	0	0	0
0	0	0	0	0	0	0

Pixel representation of filter

Multiplication and Summation = (50*30)+(50*30)+(50*30)+(20*30)+(50*30) = 6600 (A large number!)

https://adeshpande3.github.io/A-Beginner%27s-Guide-To-Understanding-Convolutional-Neural-Networks/

Convolution Layer: Applying filters

Visualization of the filter on the image

0	0	0	0	0	0	0
0	40	0	0	0	0	0
40	0	40	0	0	0	0
40	20	0	0	0	0	0
0	50	0	0	0	0	0
0	0	50	0	0	0	0
25	25	0	50	0	0	0

Pixel representation of receptive field

*

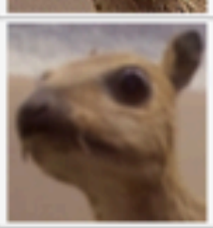
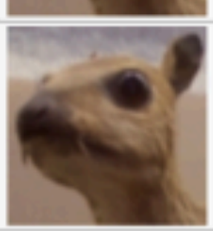
0	0	0	0	0	30	0
0	0	0	0	30	0	0
0	0	0	30	0	0	0
0	0	0	30	0	0	0
0	0	0	30	0	0	0
0	0	0	30	0	0	0
0	0	0	0	0	0	0

Pixel representation of filter

Multiplication and Summation = 0

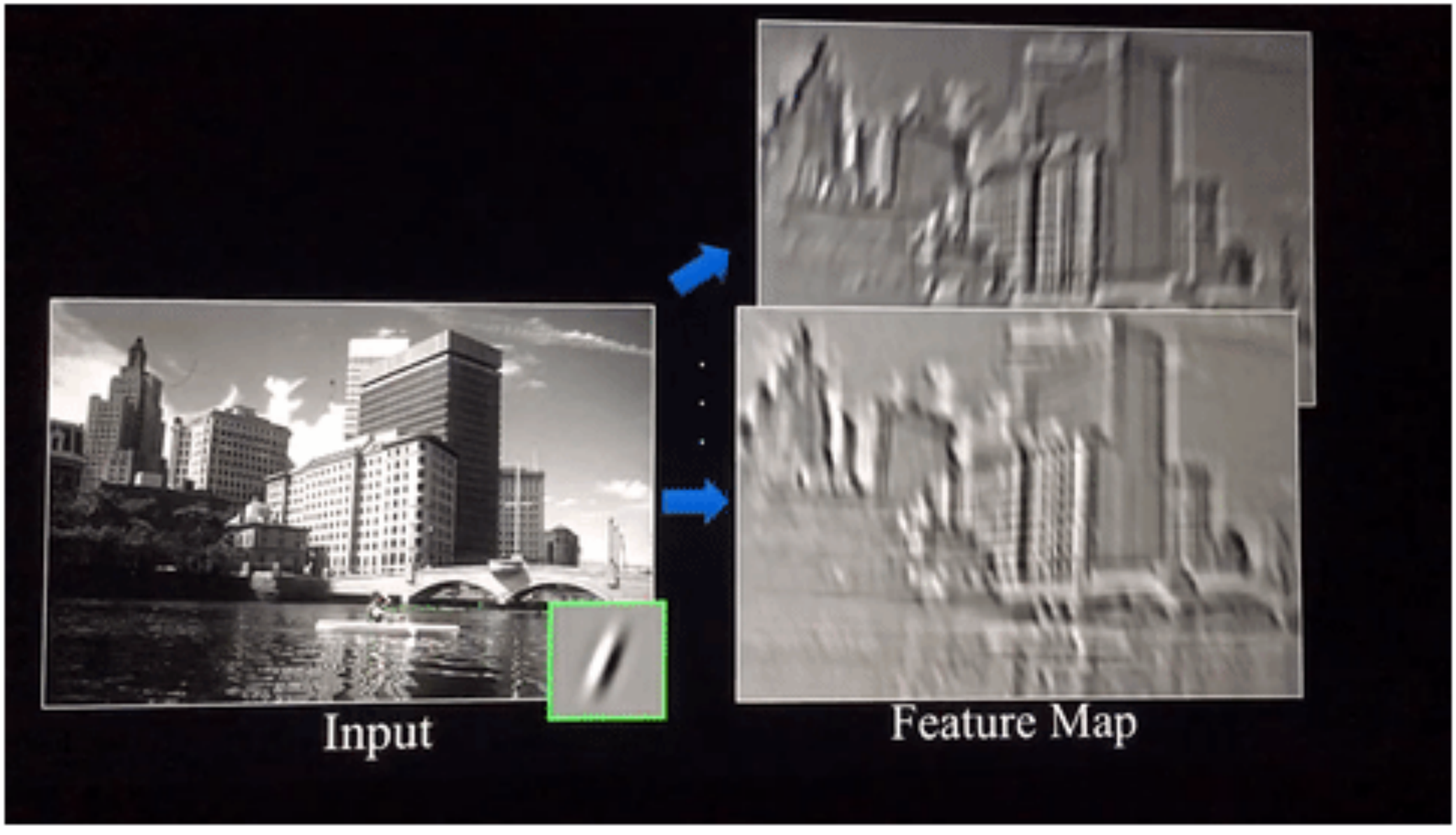
https://adeshpande3.github.io/A-Beginner%27s-Guide-To-Understanding-Convolutional-Neural-Networks/

Convolution Layer: Filters

Operation	Filter	Convolved Image
Identity	$\begin{bmatrix} 0 & 0 & 0 \\ 0 & 1 & 0 \\ 0 & 0 & 0 \end{bmatrix}$	
Edge detection	$\begin{bmatrix} 1 & 0 & -1 \\ 0 & 0 & 0 \\ -1 & 0 & 1 \end{bmatrix}$	
	$\begin{bmatrix} 0 & 1 & 0 \\ 1 & -4 & 1 \\ 0 & 1 & 0 \end{bmatrix}$	
	$\begin{bmatrix} -1 & -1 & -1 \\ -1 & 8 & -1 \\ -1 & -1 & -1 \end{bmatrix}$	
Sharpen	$\begin{bmatrix} 0 & -1 & 0 \\ -1 & 5 & -1 \\ 0 & -1 & 0 \end{bmatrix}$	
Box blur (normalized)	$\frac{1}{9}\begin{bmatrix} 1 & 1 & 1 \\ 1 & 1 & 1 \\ 1 & 1 & 1 \end{bmatrix}$	
Gaussian blur (approximation)	$\frac{1}{16}\begin{bmatrix} 1 & 2 & 1 \\ 2 & 4 & 2 \\ 1 & 2 & 1 \end{bmatrix}$	

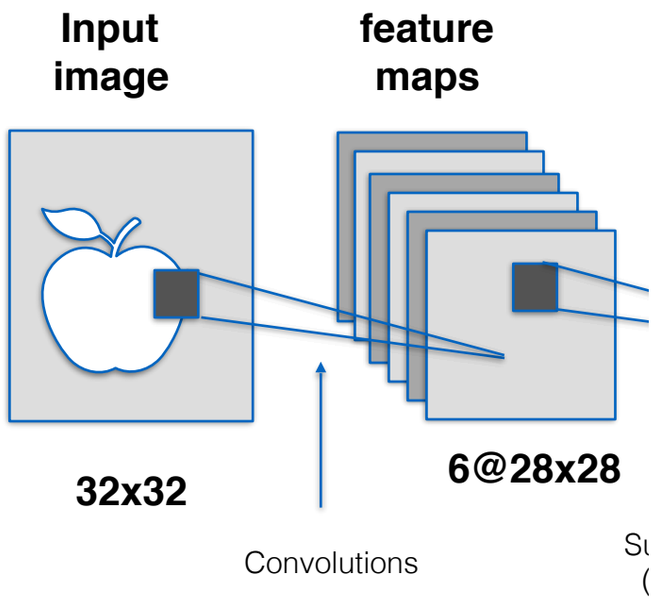
https://ujjwalkarn.me/2016/08/11/intuitive-explanation-convnets/

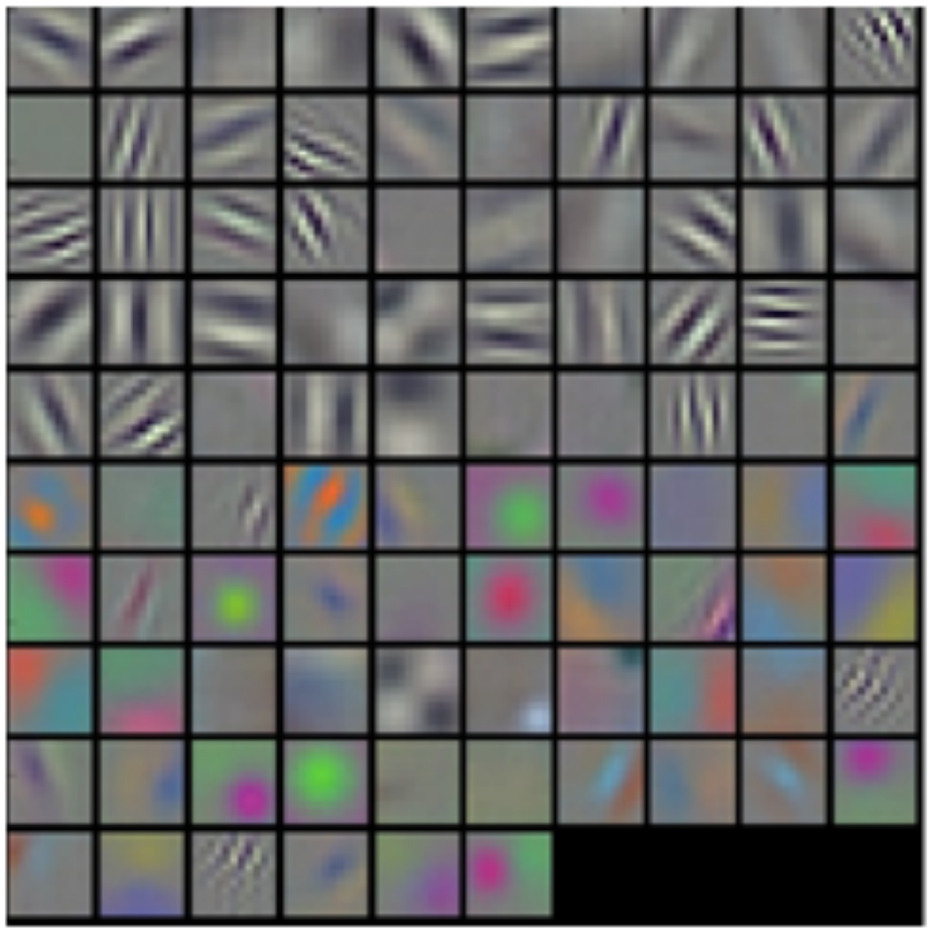
Convolution Layer: Filters



https://ujjwalkarn.me/2016/08/11/intuitive-explanation-convnets/

Convolutional Neural Network

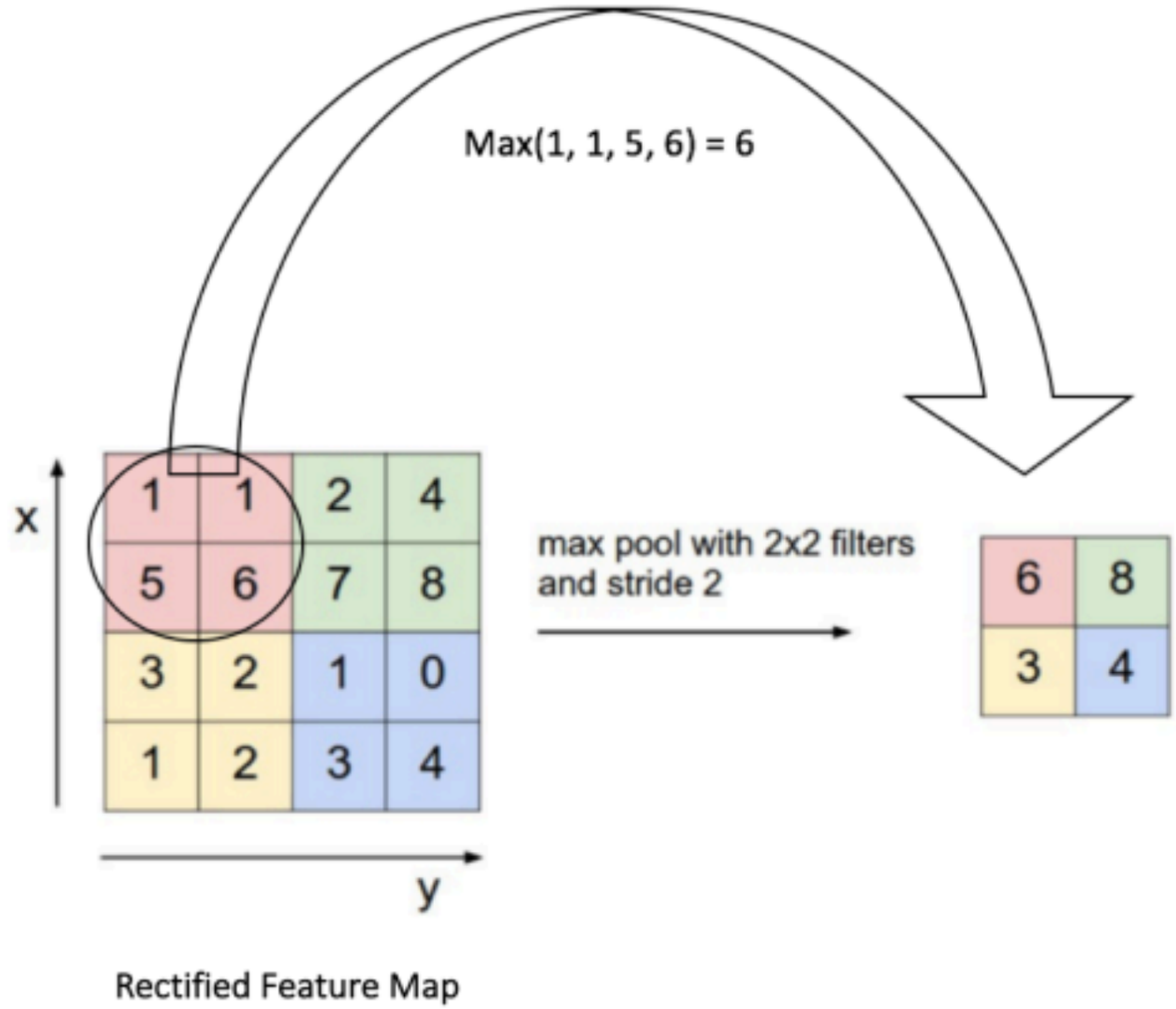




Visualizations of filters

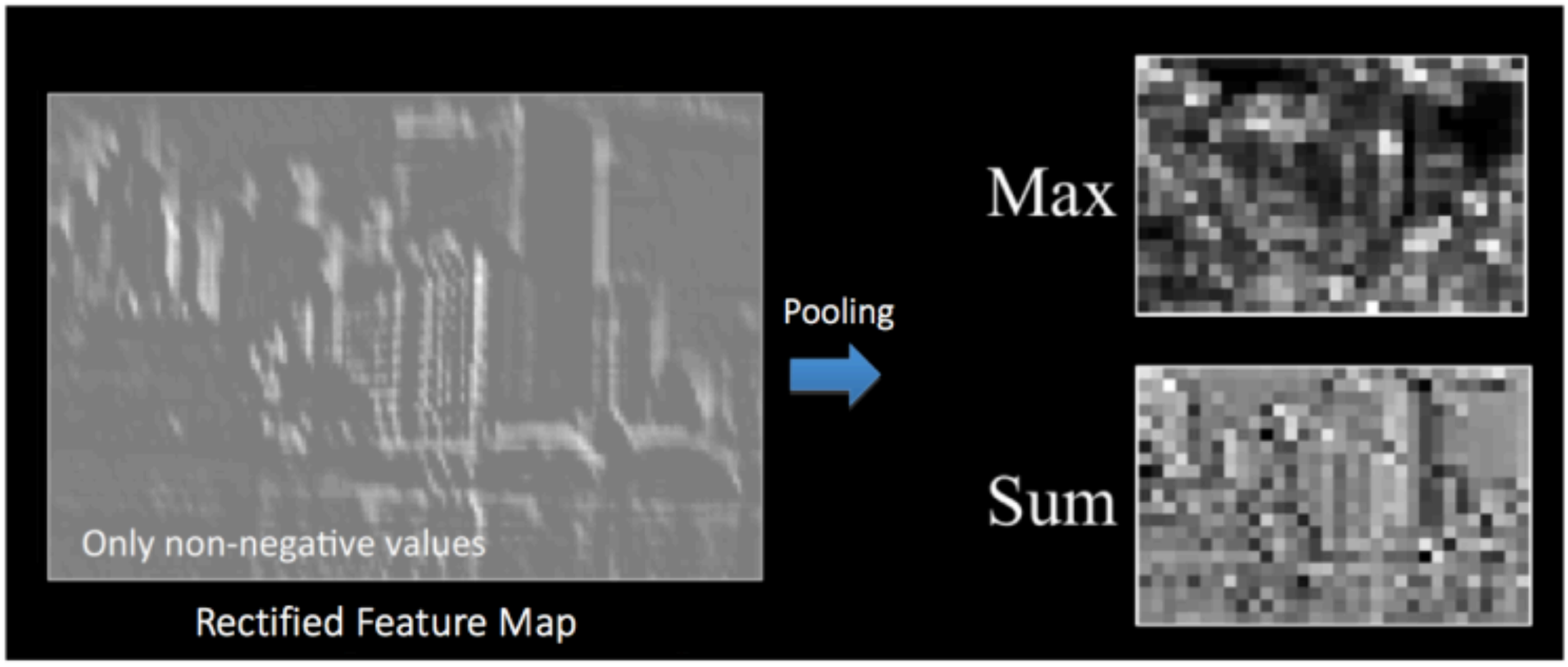
The above image came from Stanford's CS 231N course taught by Andrej Karpathy and Justin Johnson.

Maxpool



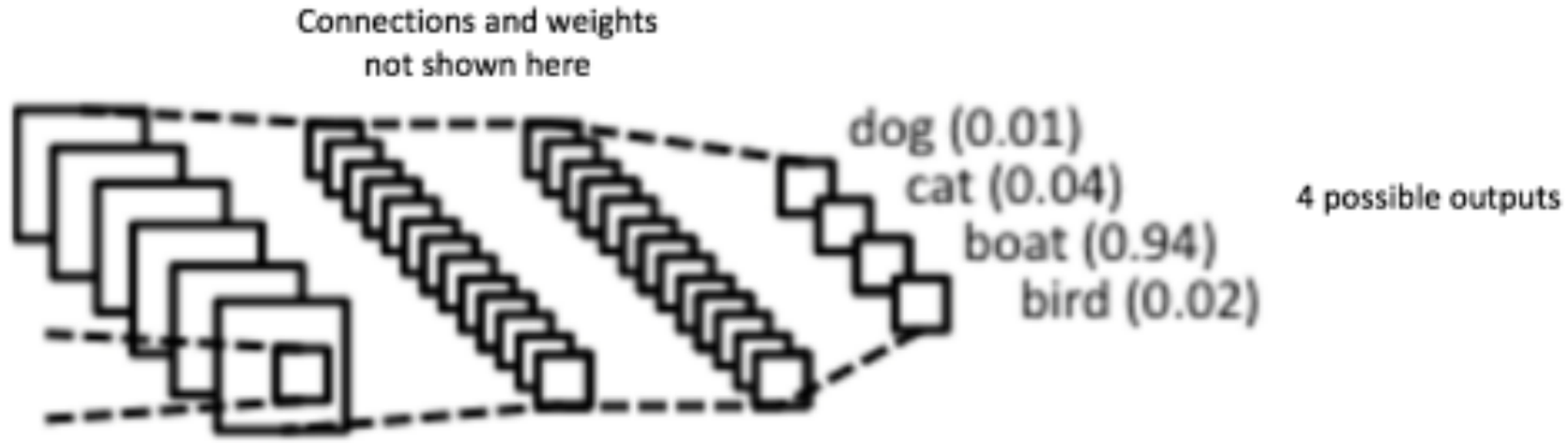
https://ujjwalkarn.me/2016/08/11/intuitive-explanation-convnets/

Maxpool vs Sumpool



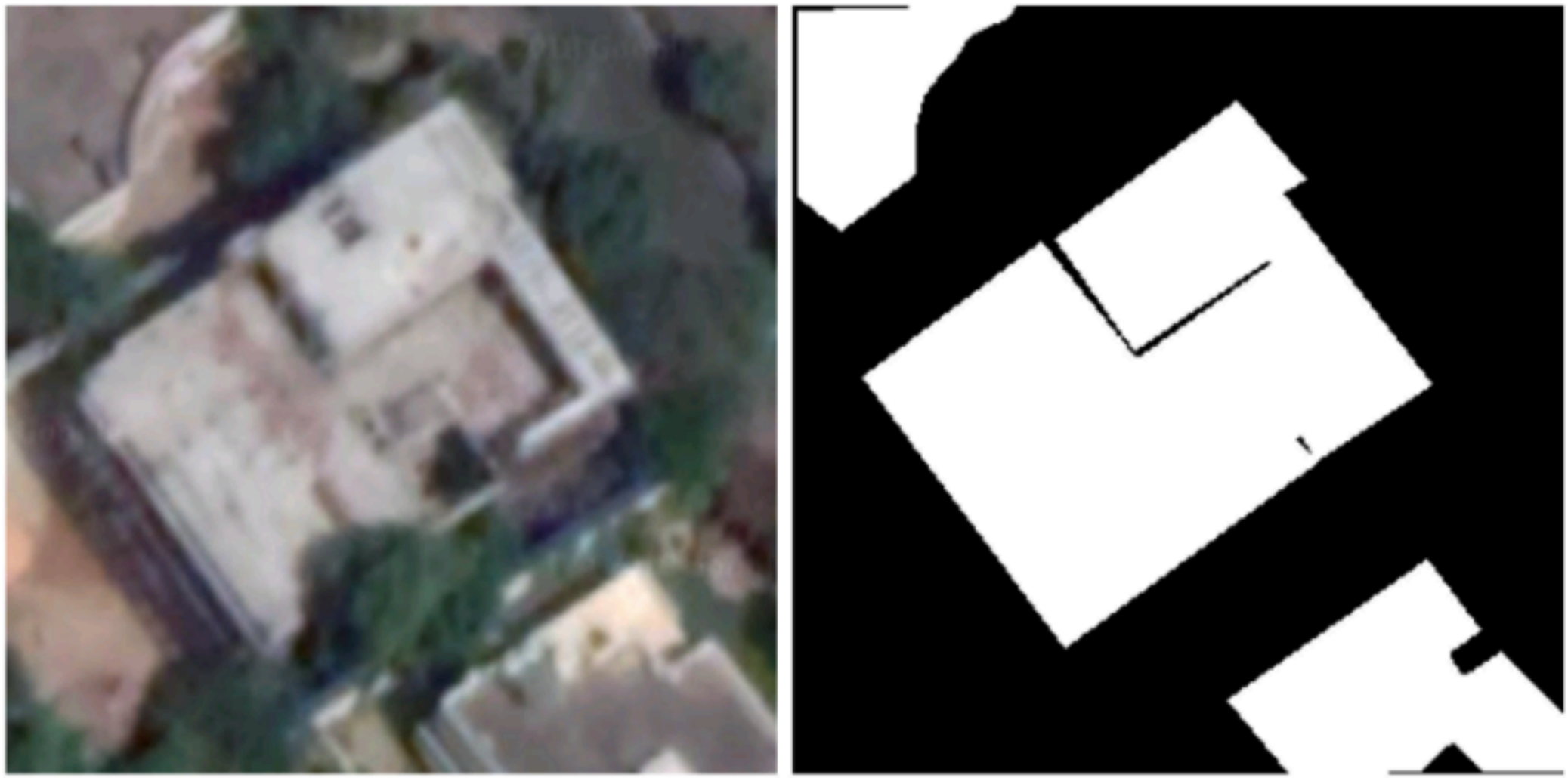
https://ujjwalkarn.me/2016/08/11/intuitive-explanation-convnets/

Fully-connected layer



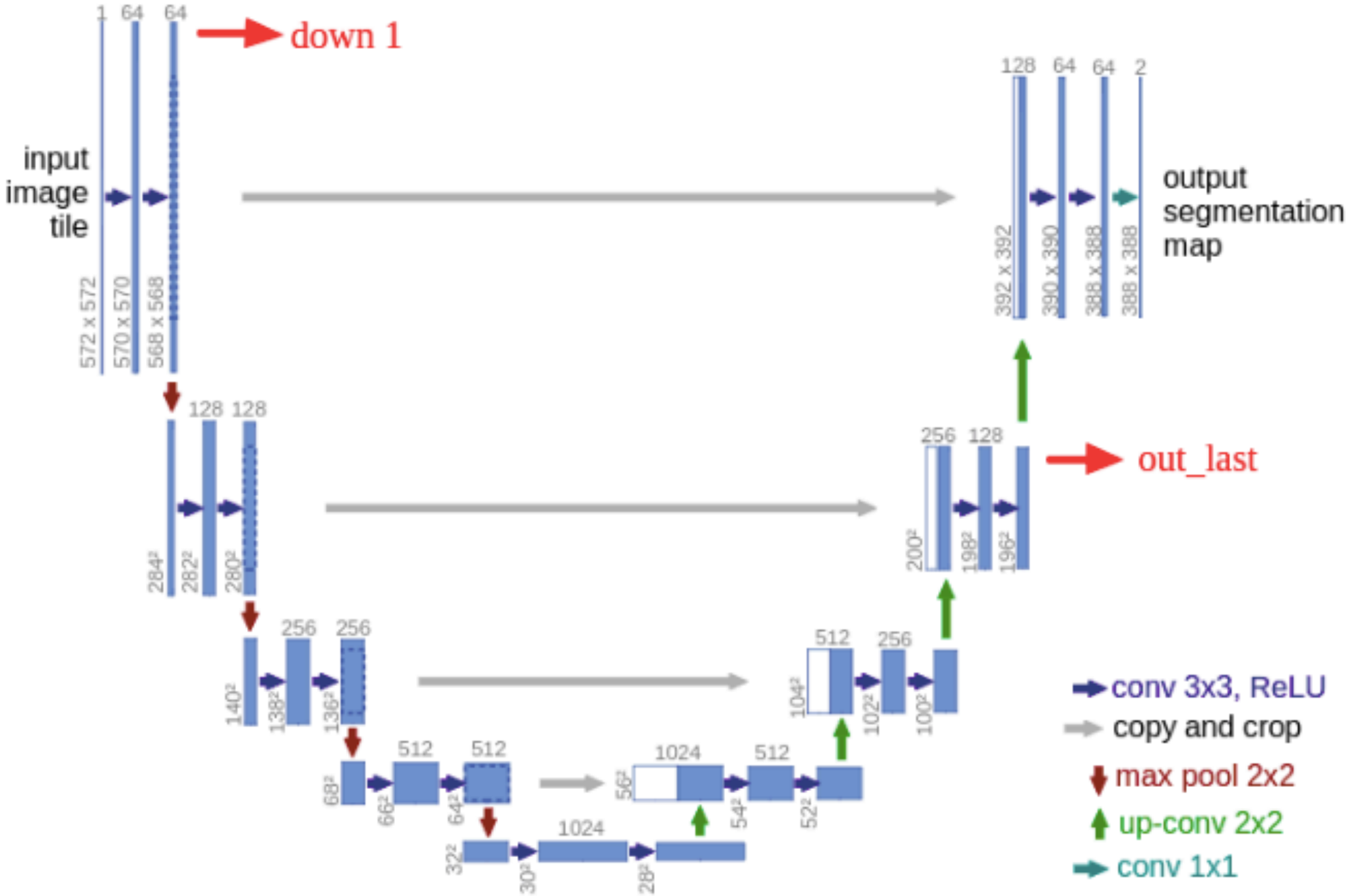
https://ujjwalkarn.me/2016/08/11/intuitive-explanation-convnets/

Image Segmentation



We want to segment the image into two segments — roof and not roof(left) for a given input image(right).

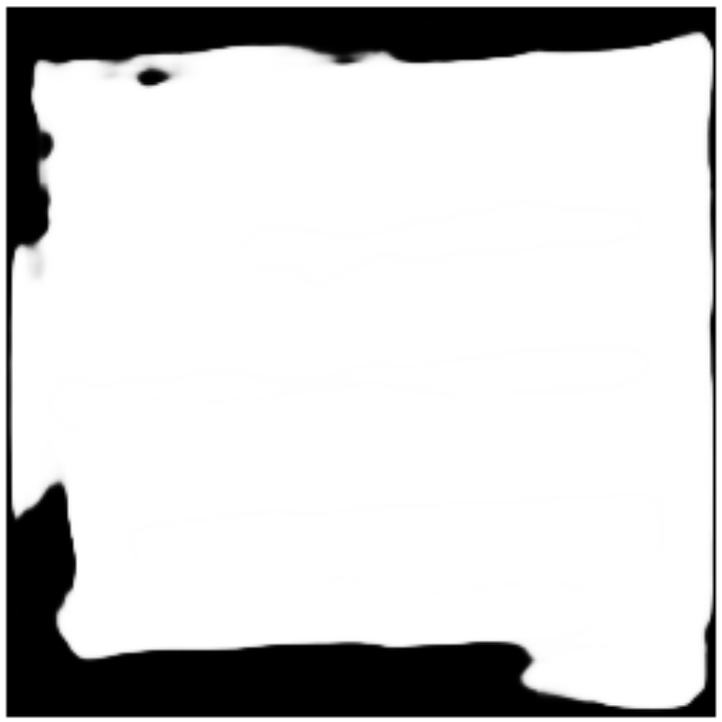
U-Net



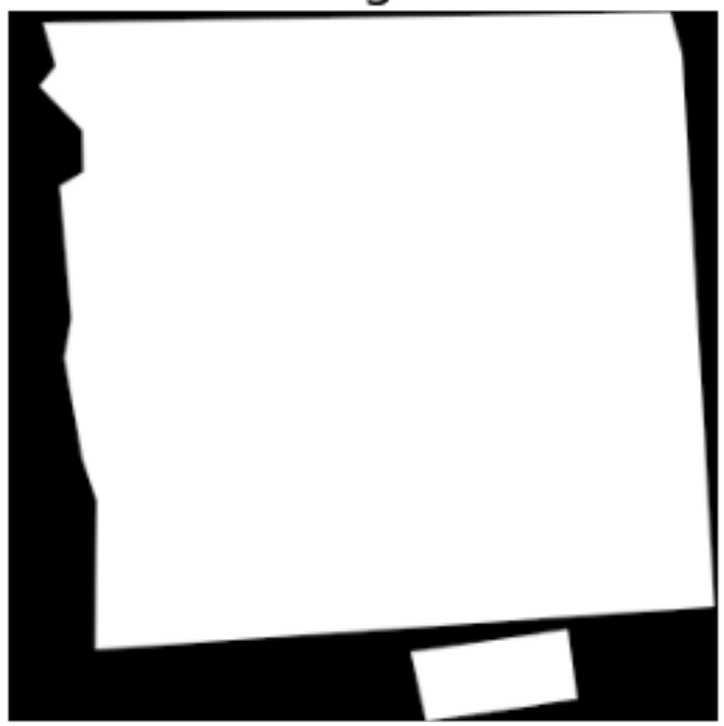
https://medium.com/@keremturgutlu/semantic-segmentation-u-net-part-1-d8d6f6005066

And results for Predicting Roof Edges

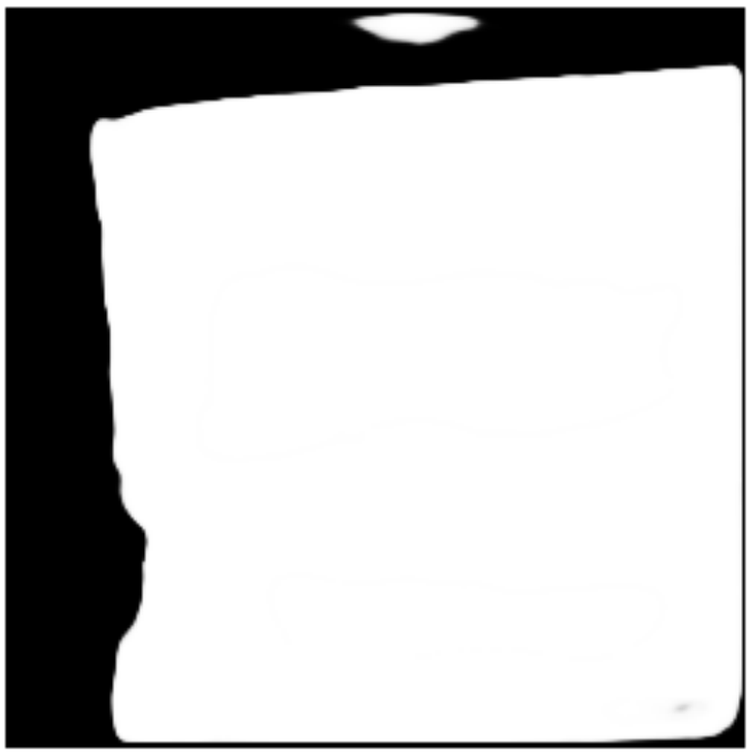
Predicted



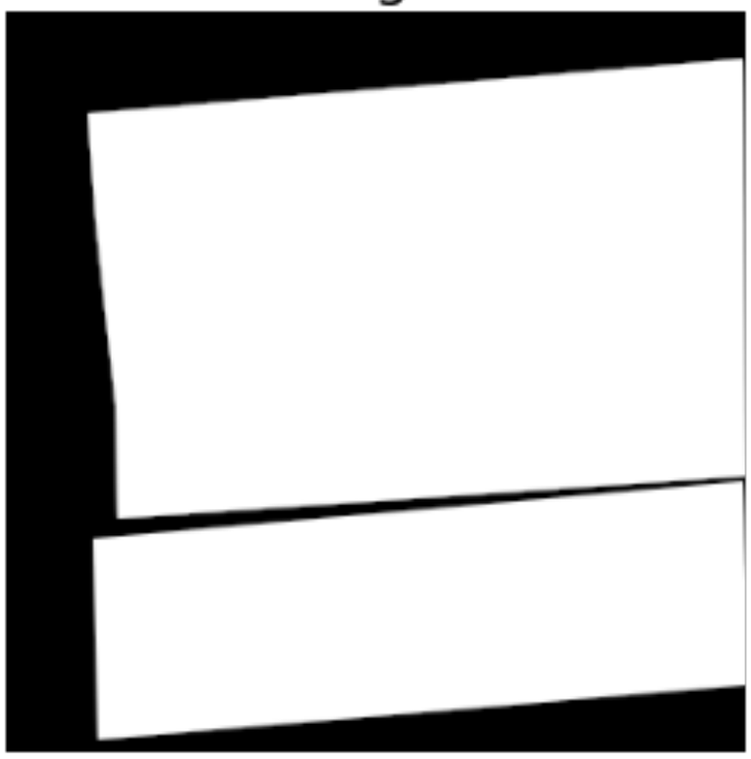
Target



Predicted



Target

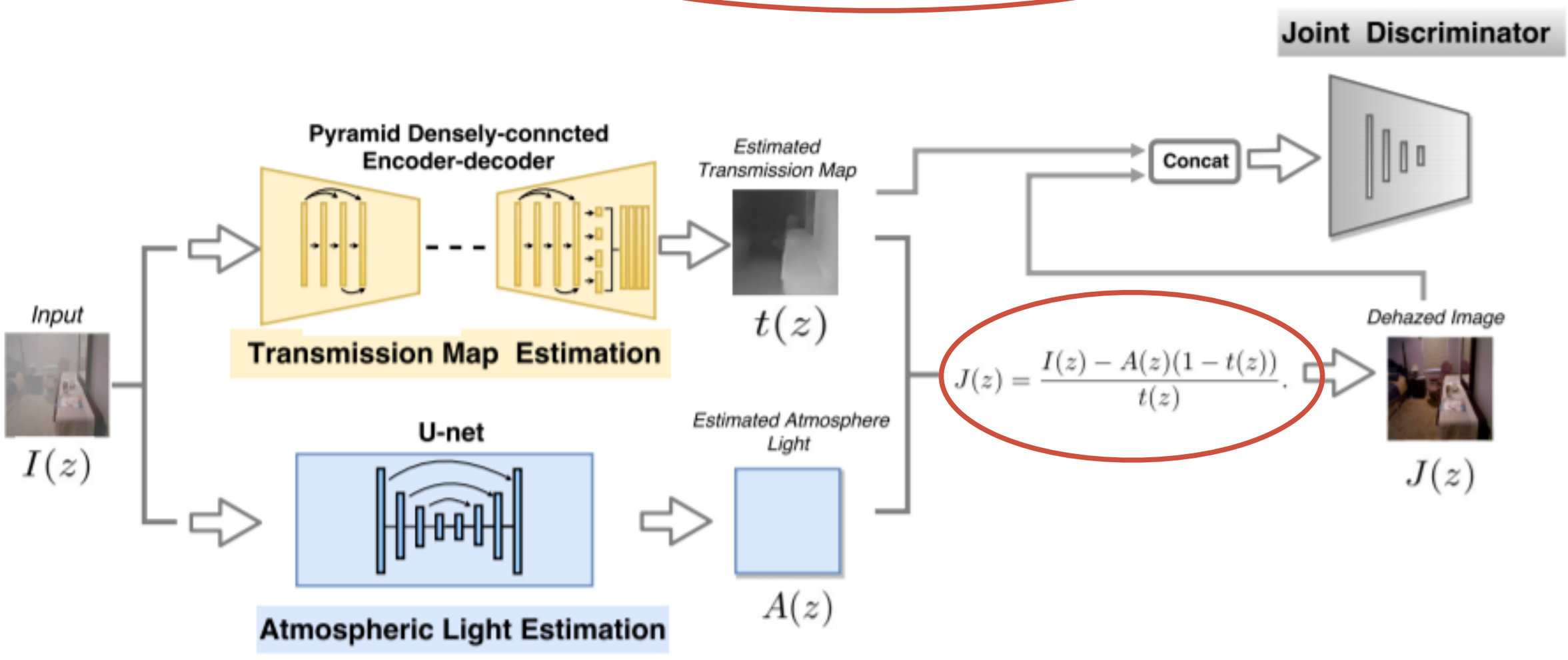


III. The Future

Hazed Images

Overview of the Model (as described in the paper)

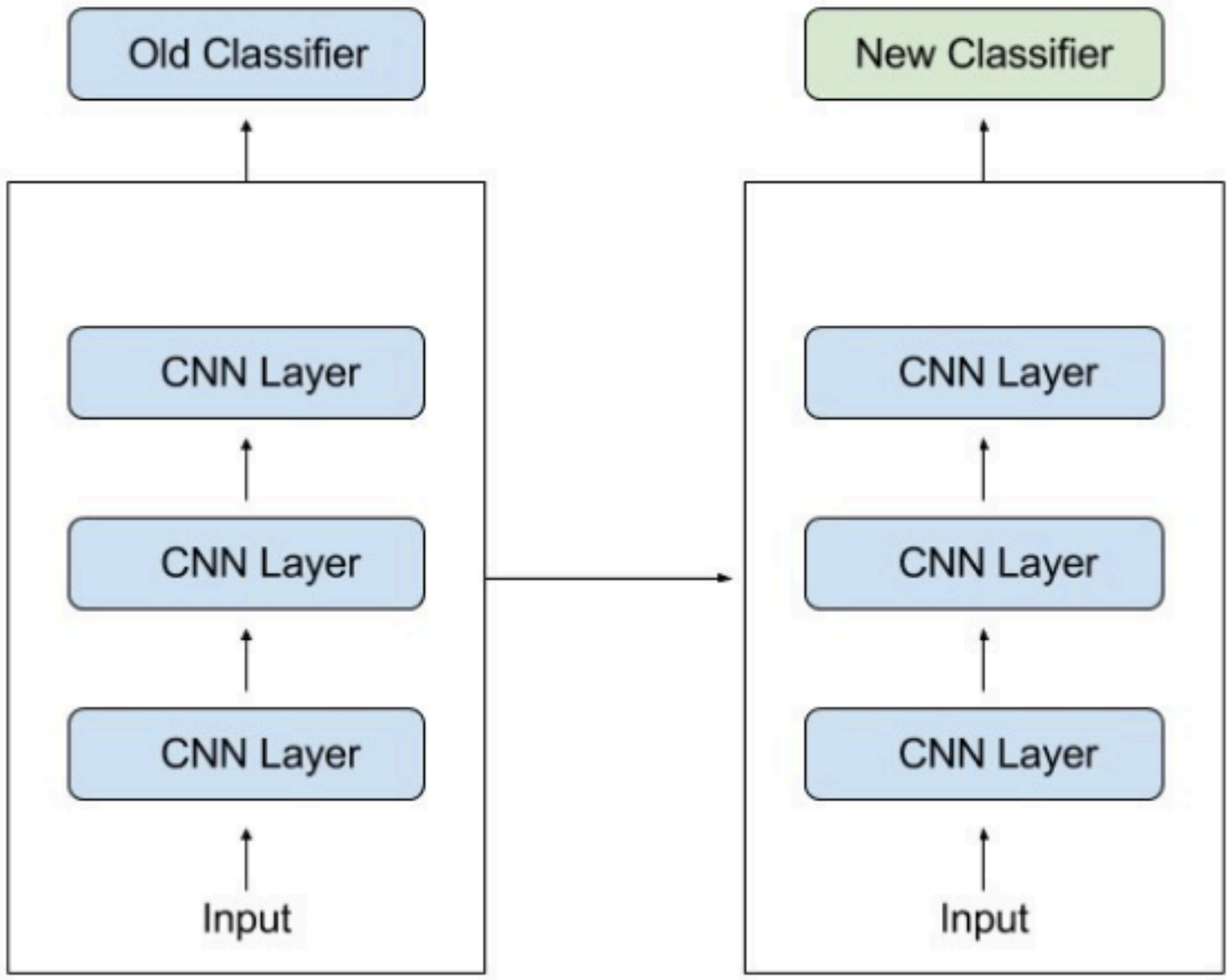
$$I(z) = J(z)t(z) + A(z)(1 - t(z))$$



Dehazing results

Dehazing results

Transfer Learning



Model trained for recognizing a backpack on an Image, which will be used to identify Sunglasses. In the earlier layers, the model has learned to recognize features and because of that, we will only re-train the latter layers, so that it will learn what separates sunglasses from other objects.

https://towardsdatascience.com/transfer-learning-946518f95666


solar panel 0.955
solar panel 0.991
solar panel 0.960
solar panel 0.961
solar panel 0.942
solar panel 0.969
solar panel 0.938
solar panel 0.941
solar panel 0.932
solar panel 0.981


solar panel 0.933
solar panel 0.964
solar panel 0.989
solar panel 0.957
solar panel 0.990
solar panel 0.939
solar panel 0.947
solar panel 0.927
solar panel 0.987
solar panel 0.948
Google


Google


solar panel 0.999
solar panel 0.959
solar panel 0.997
solar panel 0.988
solar panel 0.947
solar panel 0.954

IV. The Vision

Community driven development

Rudradeb Mitra
Author of Creating Value with AI (https://amzn.to/2MuuEOh) | 6 startups | 10 yrs as an AI Engineer/Researcher
Sep 24 · 5 min read

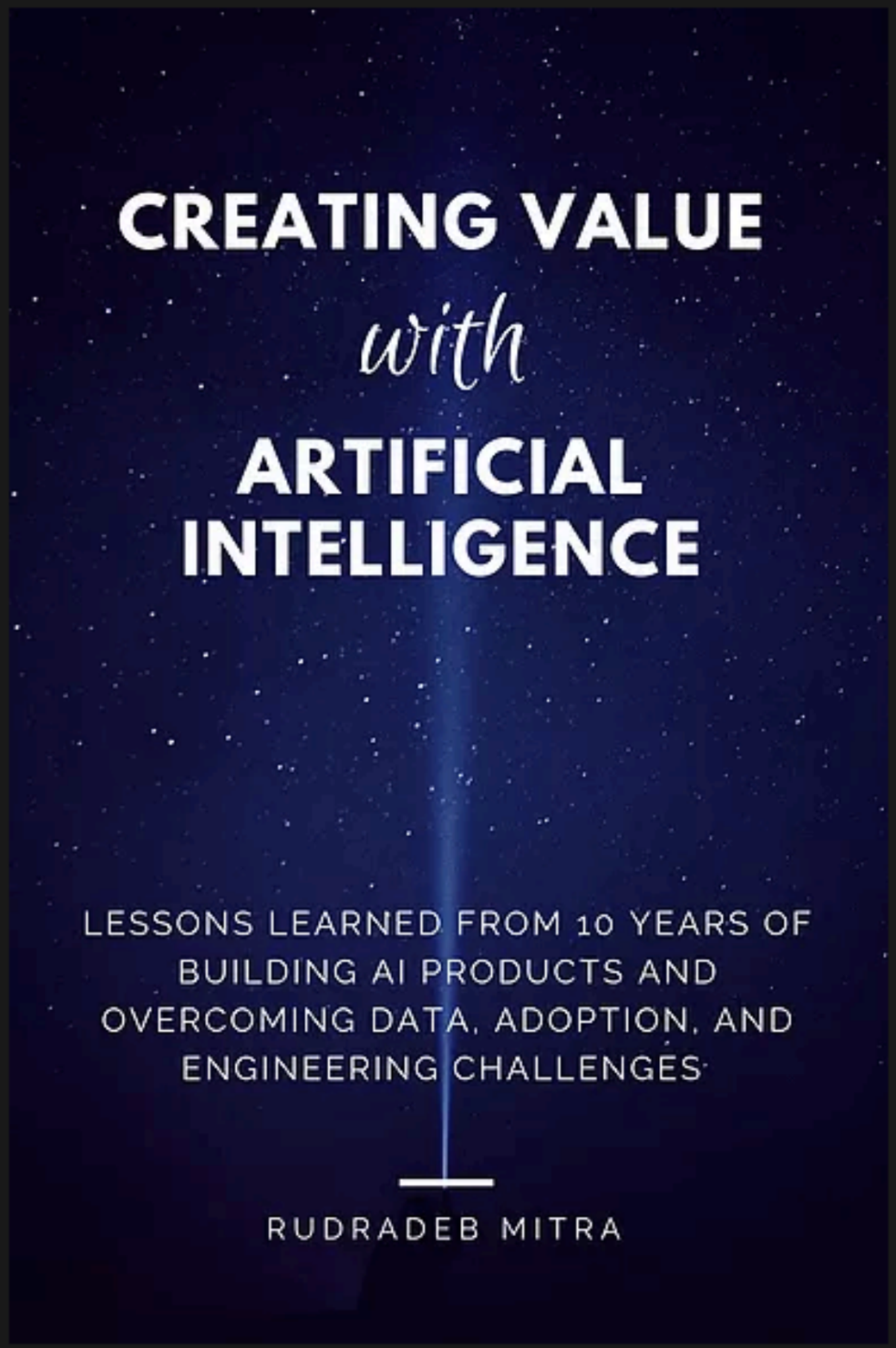
The Potential of Communities and Machine Learning for Good

For any technology to be successful, it needs to move from the early adopter market segment to the majority, i.e., **crossing the chasm**. Till now Machine Learning has been primarily in the hype phase and adoption has been mostly driven by the early adopters and innovators. I envision that in the next few years ML (and in general AI) will move from the hype phase to the correction phase (Figure 1) if the focus is kept on user adoption and value creation.

Jeannine Siviy
Patterns | Possibilities | Pathfinding
6h

Wondering if anybody in my network has read this. Seems the premise is about generating genuine **#Value** with AI, and as a means to do so, take a human centric approach. Which (prior to actually reading), I'm interpreting as human centric (human+tech, not "tech only") for all 3 of the following: the business case, the technical solution/implementation, and the operation. (**Roland Rust** **Rudradeb Mitra**, any readers out there, yes?)

Article worth a look by same author on ML adoption, community & grass roots movements at **https://bit.ly/2y8mN3W**.



"The author does a phenomenal job of describing AI and also giving real-world examples of its application that we can all understand!"

"This book can transform your vision on how you can even imagine building or make smarter things."

"This is the book of the year from my side. Thank you"

"It is an amazing book. Completely different style and based on facts."

"An enthralling read for anyone working on or interested in learning more about AI."

"A great book, about a subject that is not easily grasped by the vast majority of people, in a very light way, accessible to everyone."

"I hardly knew anything about AI, but now I guess, I'm quite good at understanding it. Brilliant book. Very simple and neat language. "

Feel free to connect: https://www.linkedin.com/in/mitrar/

Dehazing / Removing the fogs

The image degradation (atmospheric scattering model) due to the presence of haze is mathematically formulated as :

$$I(z) = J(z)t(z) + A(z)(1 - t(z))$$

where I is the observed hazy image, J is the true scene radiance, A is the global atmospheric light, indicating the intensity of the ambient light, t is the transmission map.

$$\hat{J}(z) = \frac{I(z) - \hat{A}(z)(1 - \hat{t}(z))}{\hat{t}(z)}$$