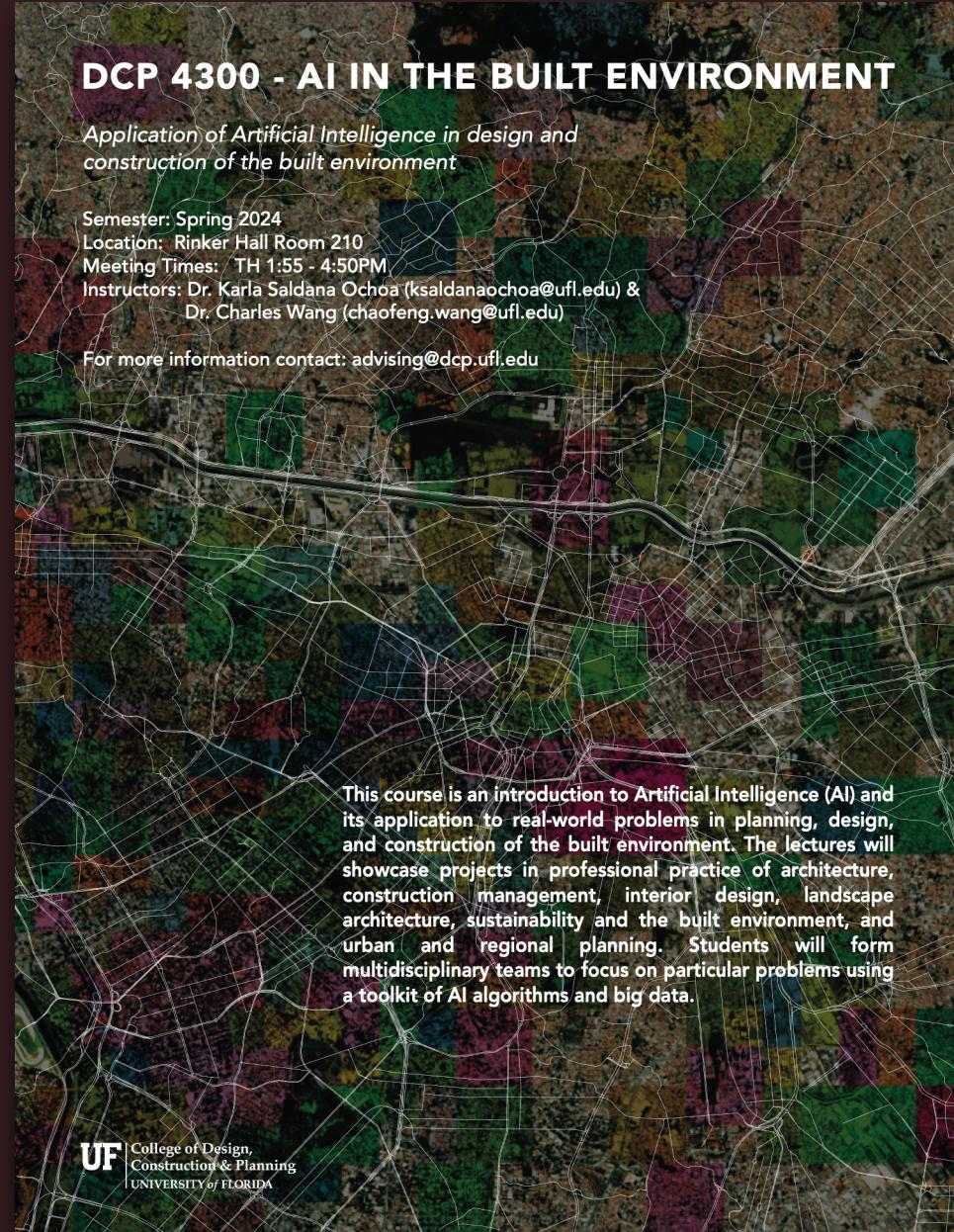




AI IN THE BUILT ENVIRONMENT

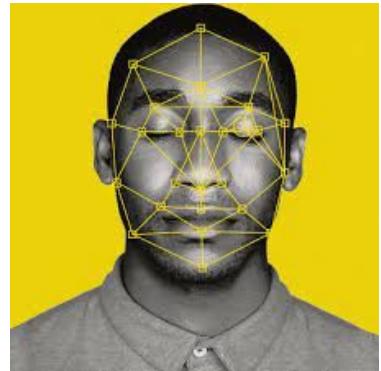
Professors:
Dr. Karla Saldana Ochoa
TA:
Mobina Noorani

University of Florida
College of Design Construction and Planning





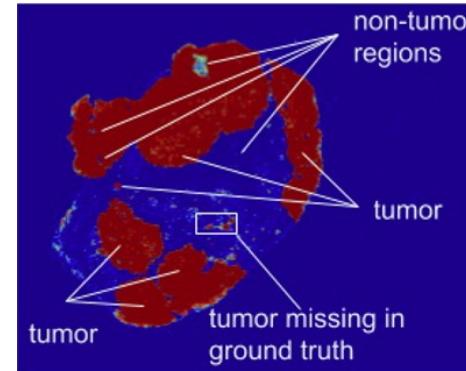
Applications of Computer Vision



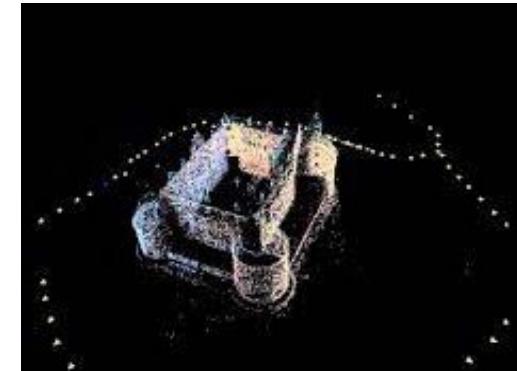
Face recognition



Autonomous driving



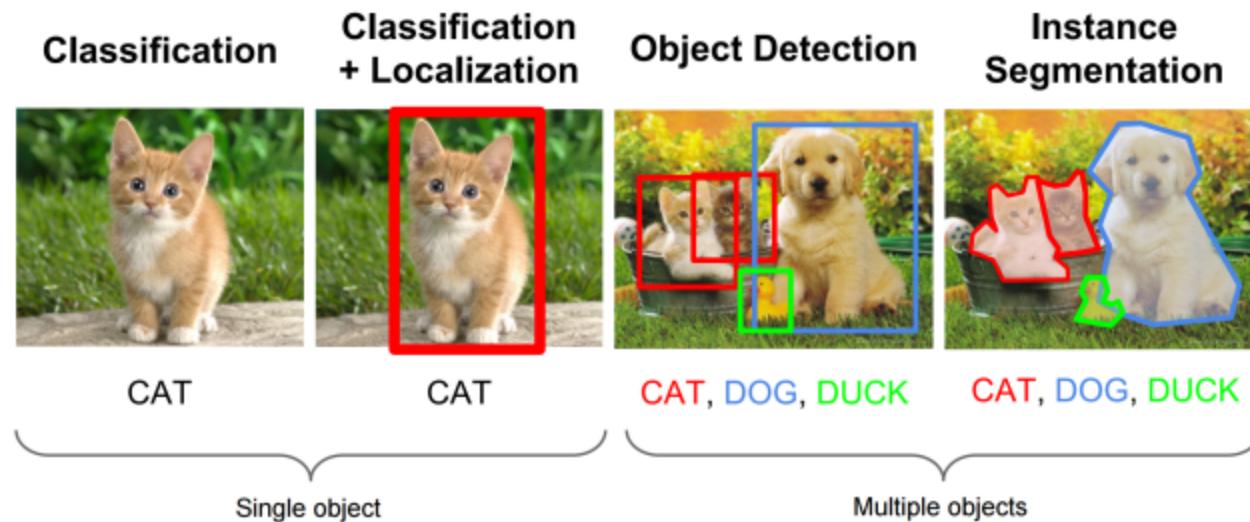
Disease diagnosis



3D reconstruction

...

Applications of Computer Vision



Applications of Computer Vision

Classification

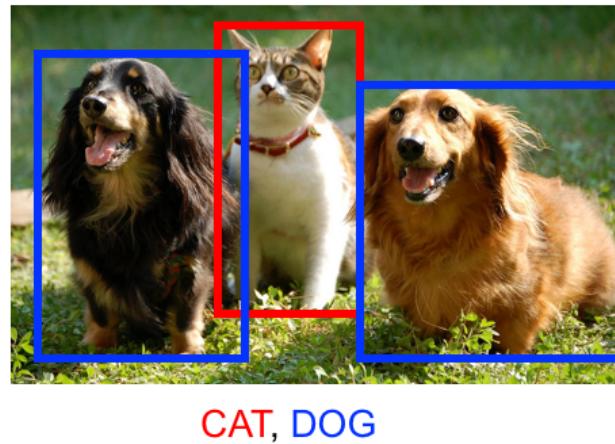


cat

dog

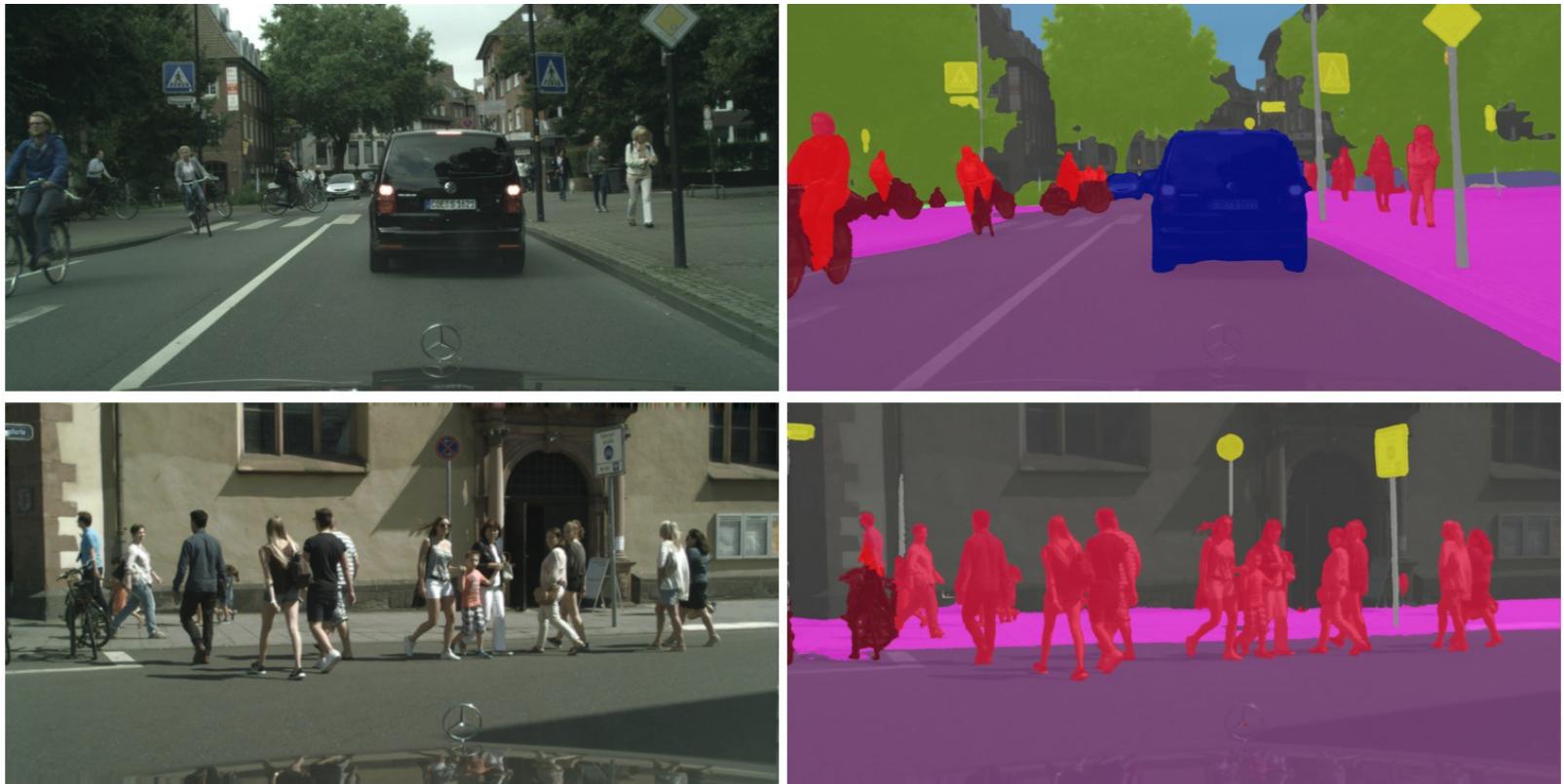
Dog/cat

Object detection

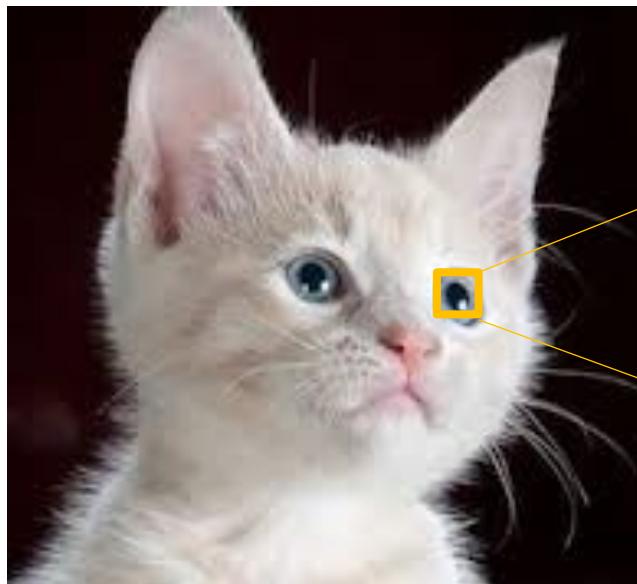


Applications of Computer Vision

Semantic Segmentation



What we see



What the computer sees

1	5	10	5
6	4	12	4
10	5	12	11
5	11	23	9

A 256x256 RGB image is a 256x256x3 matrix

Images



Visual Illusion: <https://www.youtube.com/watch?v=9Gw23ayxY-I>

Images



Vision



It started from the research on cat's vision system

Vision

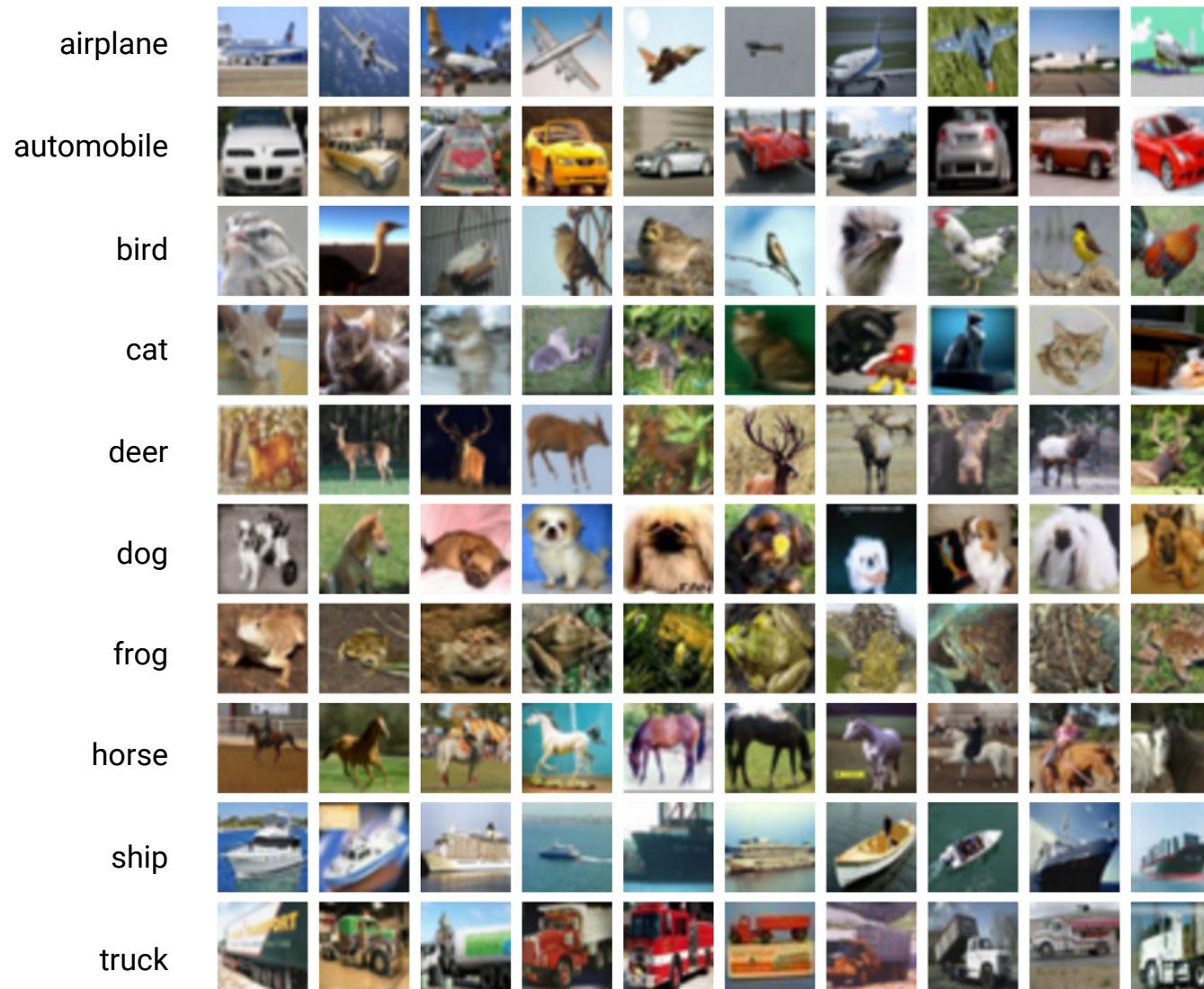


simple features



complex features





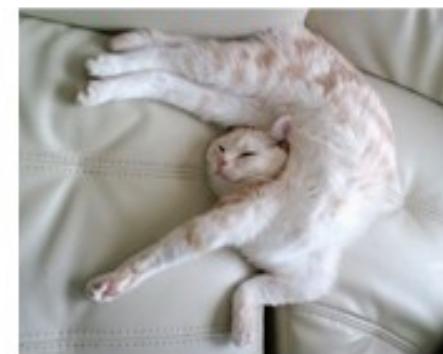
viewpoint variation



scale variation



deformation



occlusion



illumination condition



background clutter



a-class variation



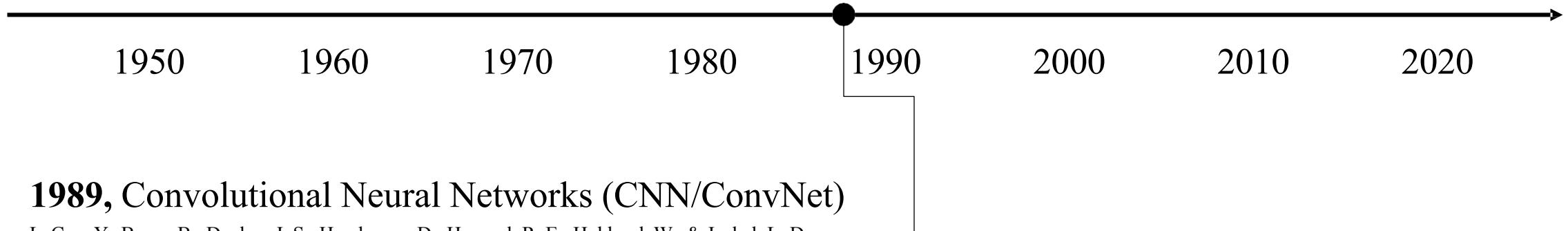
The early-stage computer vision

- Edge Detection
- Dilation, Erosion
- Perspective Transformation
- Cropping
- Scaling, Interpolations, And Re-Sizing
- Thresholding
- Sharpening
- Blurring
- Contours
- Line Detection
- Blob Detection
- ...



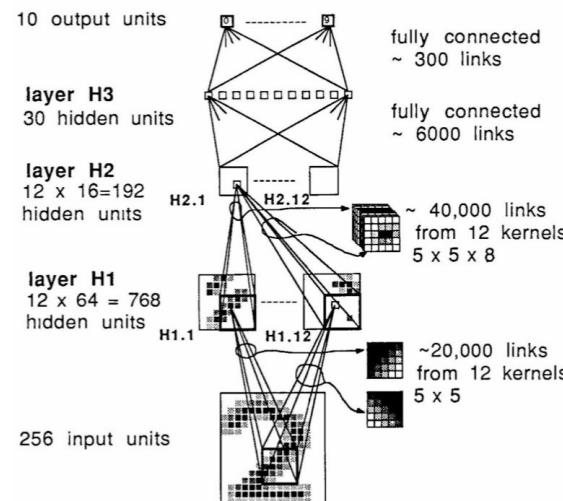
<https://opencv.org/>

Key points in the history of computer vision



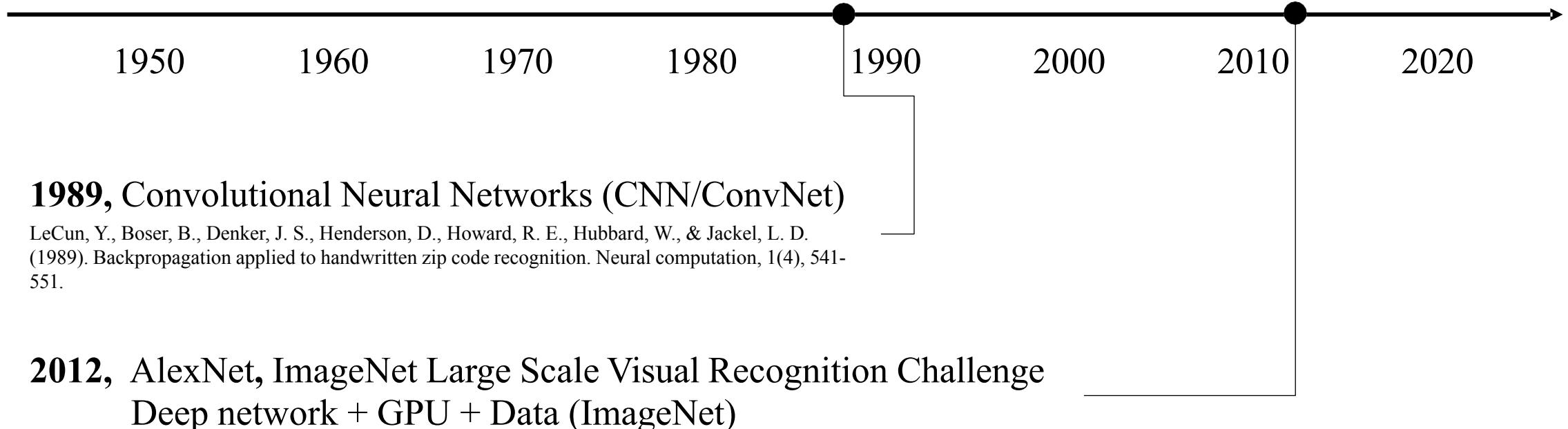
1989, Convolutional Neural Networks (CNN/ConvNet)

LeCun, Y., Boser, B., Denker, J. S., Henderson, D., Howard, R. E., Hubbard, W., & Jackel, L. D. (1989). Backpropagation applied to handwritten zip code recognition. *Neural computation*, 1(4), 541-551.

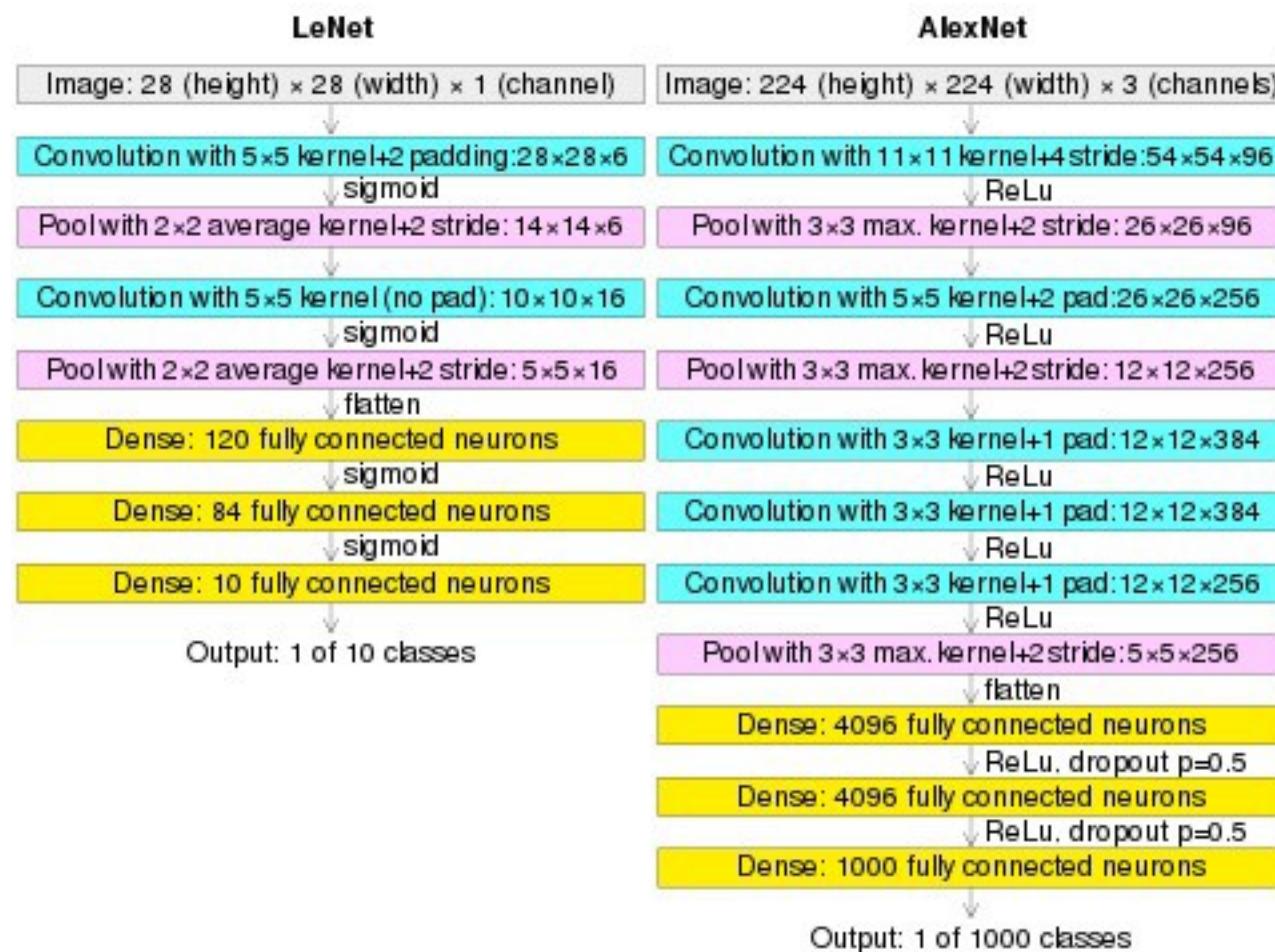


Yann LeCun demonstrating LeNet 1, 1993

Key points in the history of computer vision



Key points in the history of computer vision

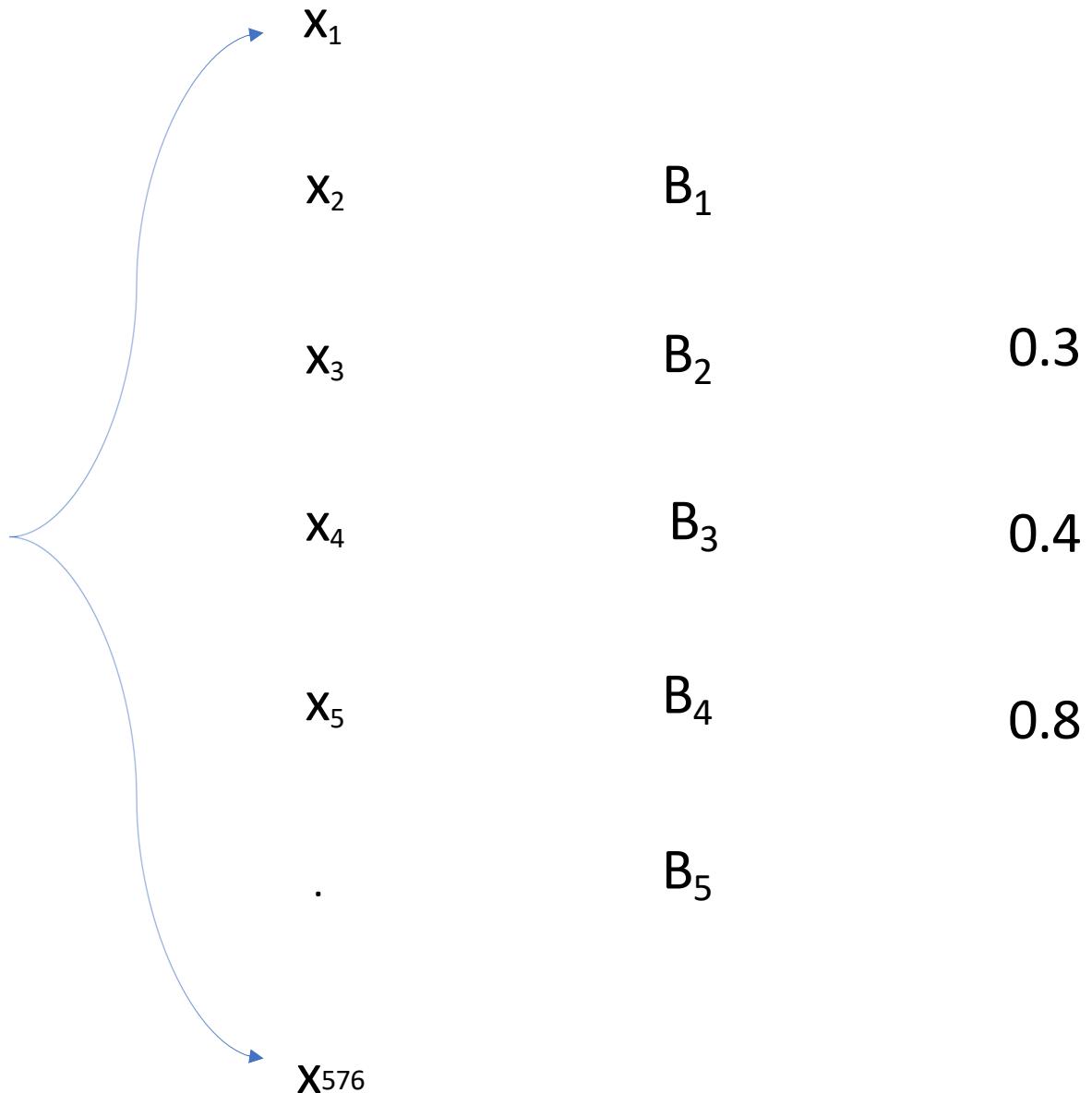


<https://en.wikipedia.org/wiki/AlexNet>



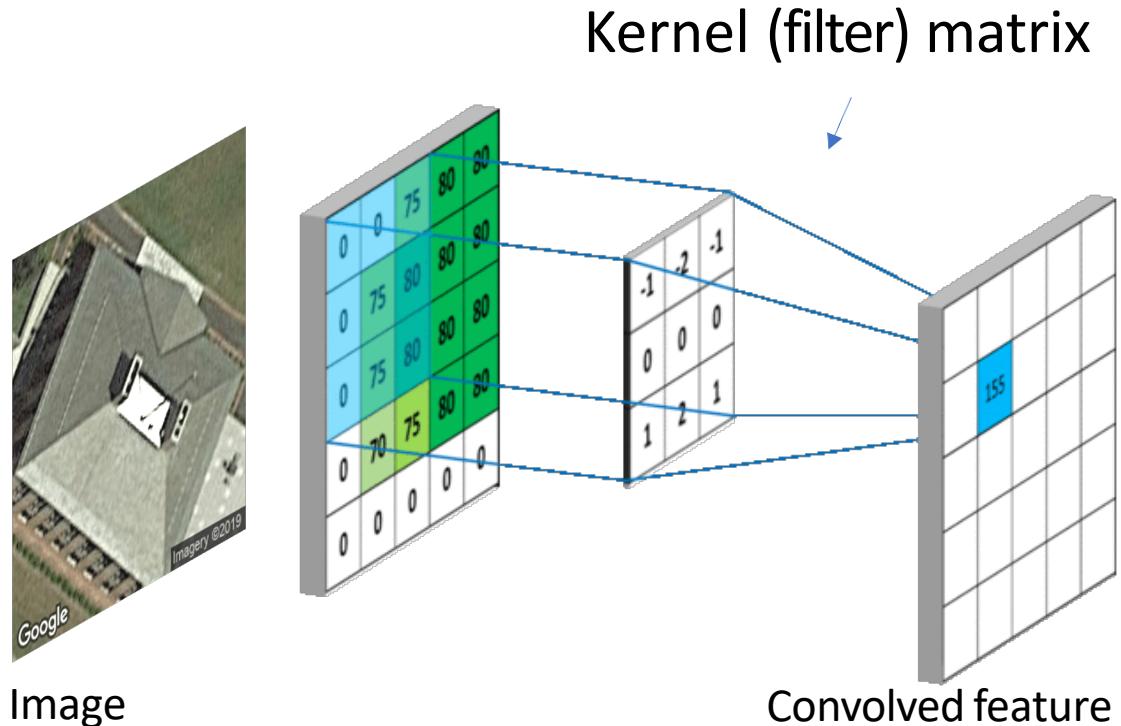
A 24x24 image can be expanded as a vector
 $[x_1, x_2, \dots x_{576}]$

A brute way...



Convolutional layer

Purpose: extracting features.

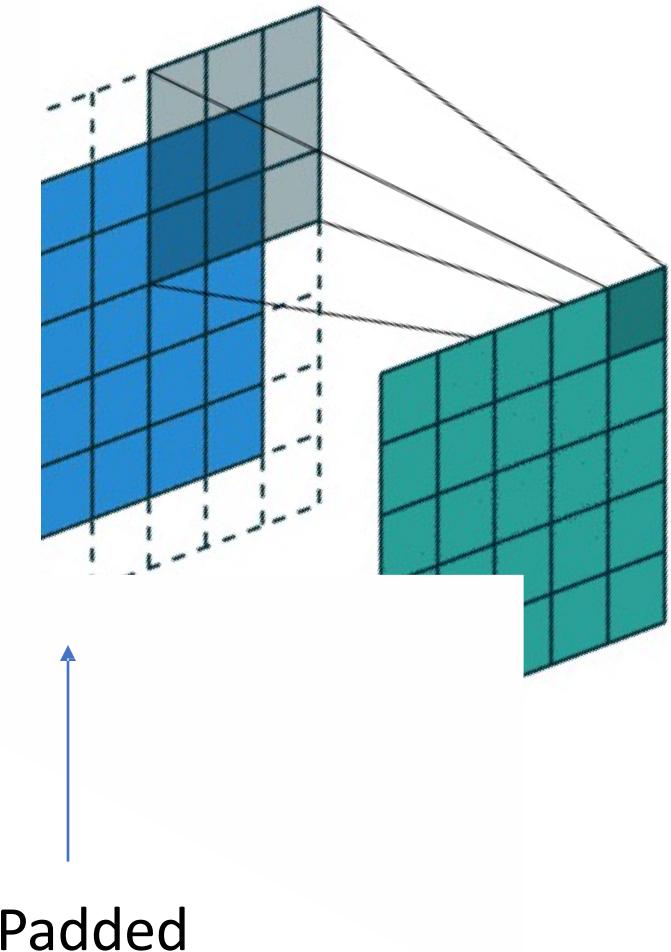


Input: 5x5x1
Kernel: 3x3
Stride: 1 (size of the 'slide')
Padding: 0
Output: 3x3x1

A 2D convolution operation

Convolutional layer

Purpose: extracting features.

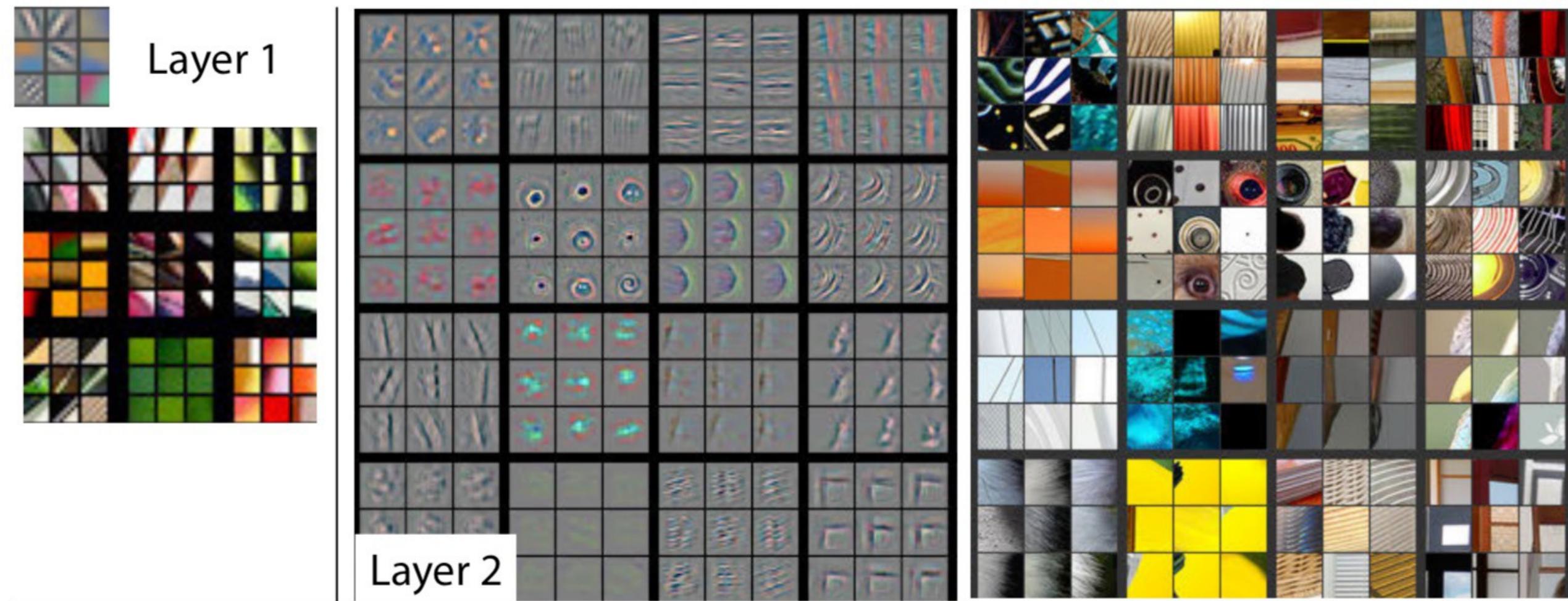


Input: 5x5x1
Kernel: 3x3
Stride: 1 (size of the ‘slide’)
Padding: 1
Output: 5x5x1

https://github.com/vdumoulin/conv_arithmetic

Learn features hierarchically

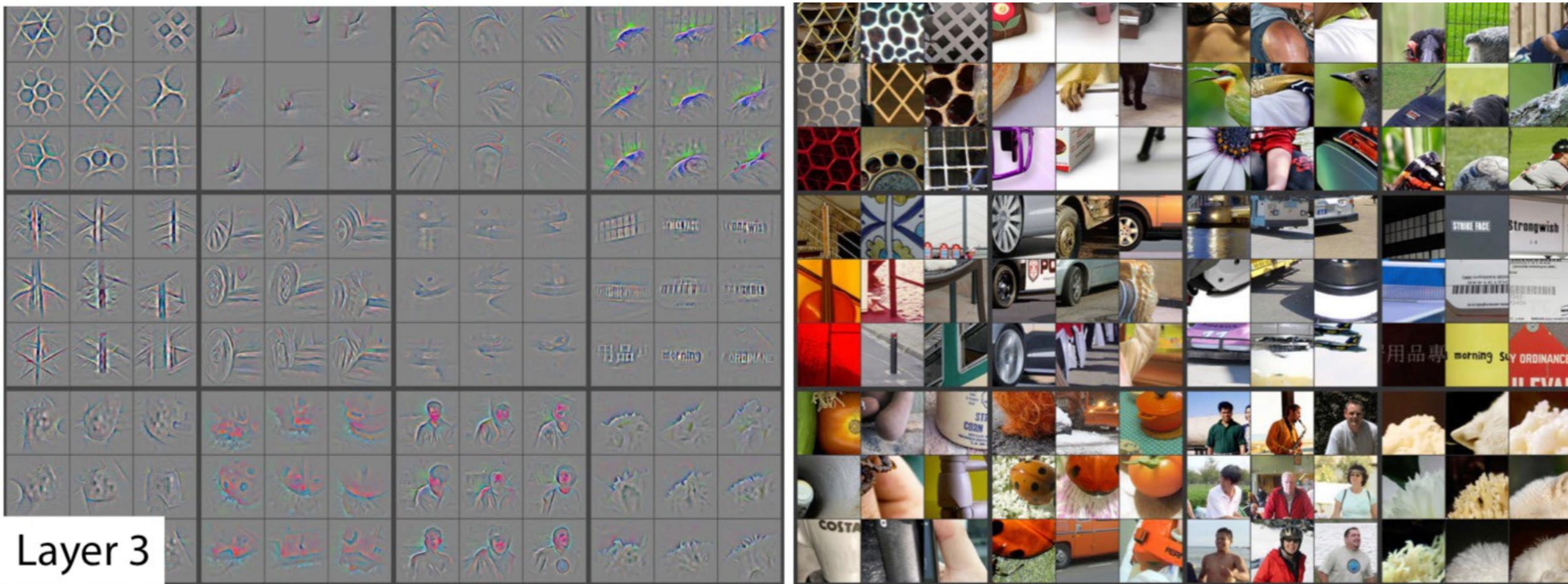
The first layers of CNN detect general features: Edges, Corners, Circles, Blobs colors, ...



Zeiler, Matthew D., and Rob Fergus. "Visualizing and understanding convolutional networks." European conference on computer vision. Springer, Cham, 2014.

Learn features hierarchically

As it goes deeper into the CNN, it starts to detect more concrete things such as eyes, faces, and full objects.



Zeiler, Matthew D., and Rob Fergus. "Visualizing and understanding convolutional networks." European conference on computer vision. Springer, Cham, 2014.

Learn features hierarchically

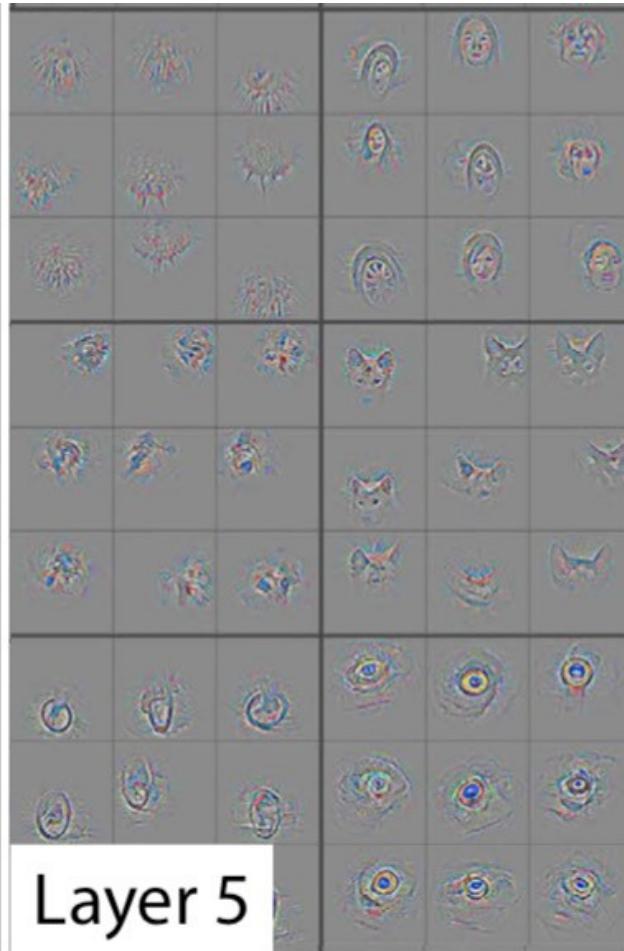
More concrete things ...



Layer 4

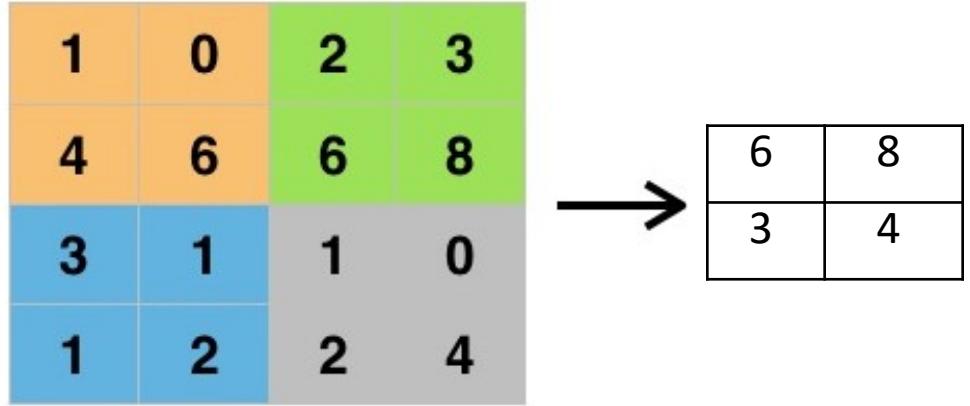


Layer 5



Zeiler, Matthew D., and Rob Fergus. "Visualizing and understanding convolutional networks." European conference on computer vision. Springer, Cham, 2014.

Pooling Layer

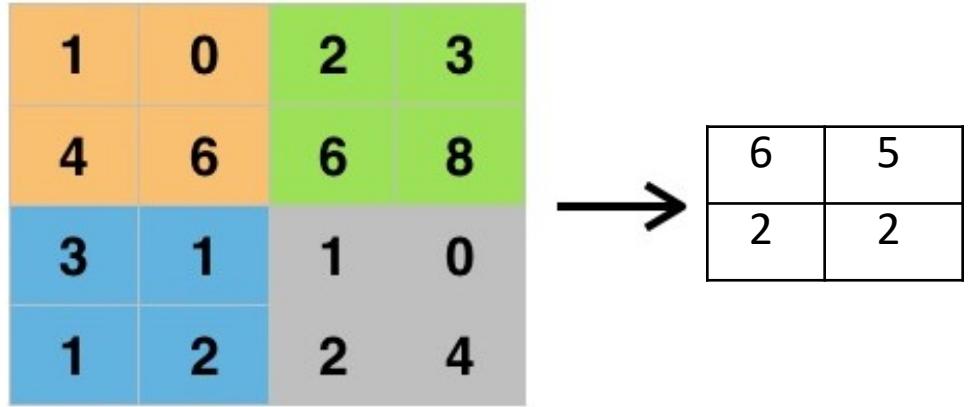


Max pooling
Average pooling
L2-norm pooling
...

Max pooling

Purpose: extracting dominant feature and reduce dimensionality

Pooling Layer

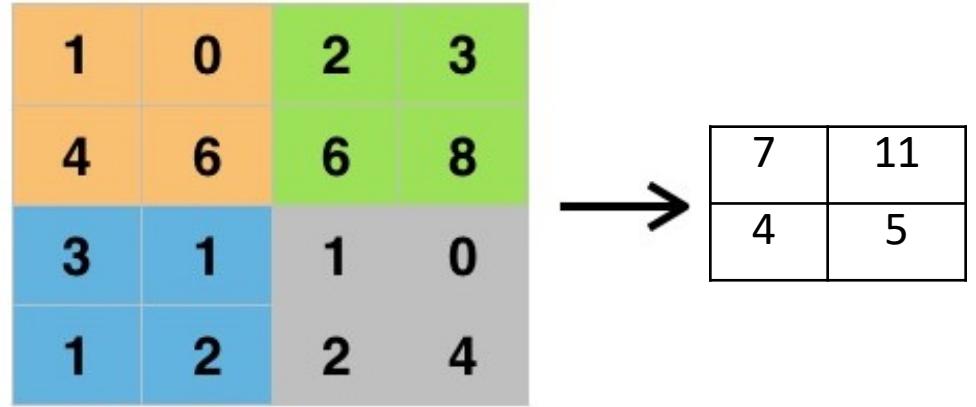


Max pooling
Average pooling
L2-norm pooling
...

Average pooling

Purpose: extracting dominant feature and reduce dimensionality

Pooling Layer

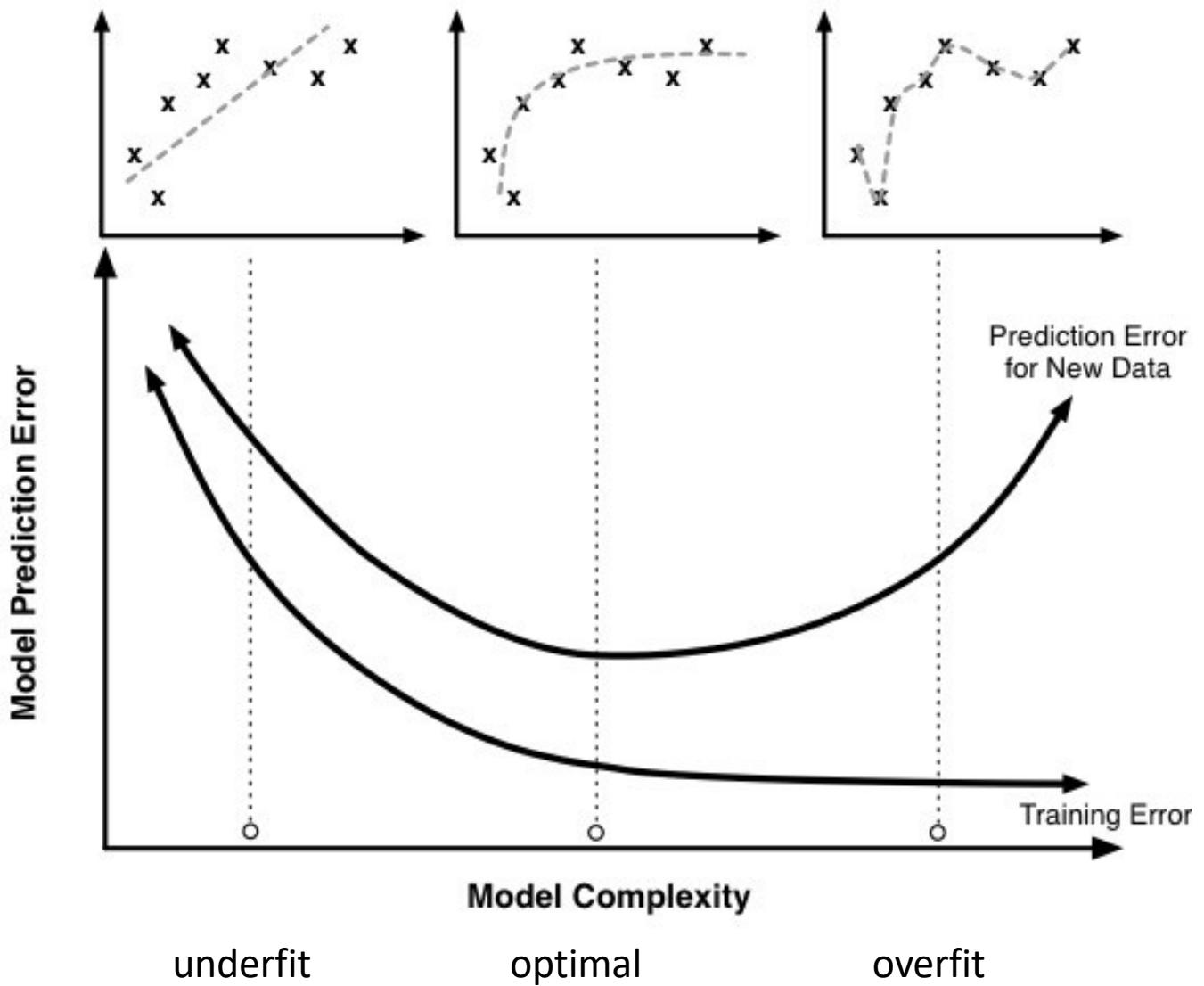


Max pooling
Average pooling
L2-norm pooling
...

L2-norm pooling

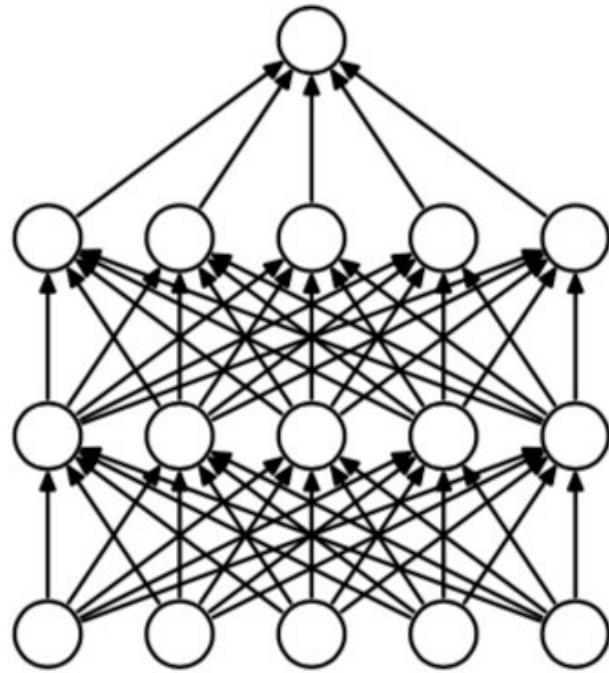
Purpose: extracting dominant feature and reduce dimensionality

What is a good model?

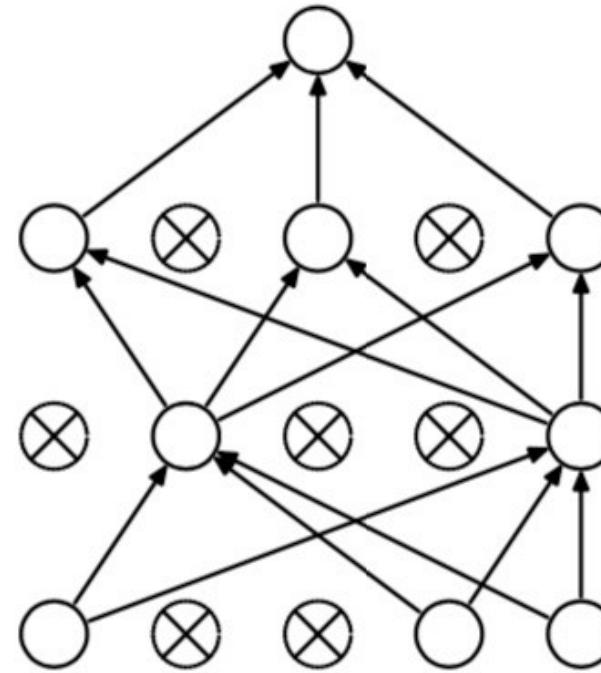


Dropout Layer

Purpose: extracting features.



(a) Standard Neural Net



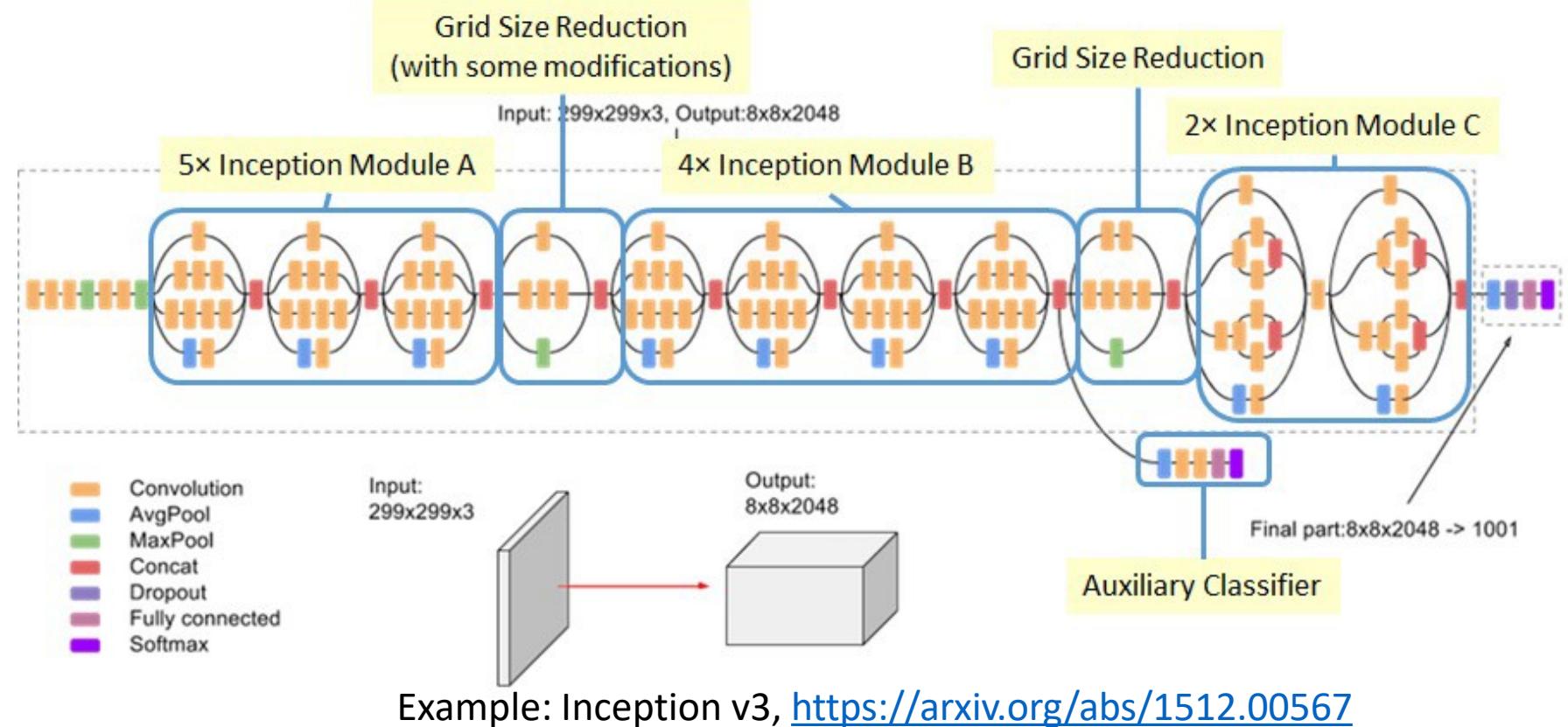
(b) After applying dropout.

Srivastava, N., Hinton, G., Krizhevsky, A., Sutskever, I., & Salakhutdinov, R. (2014). Dropout: a simple way to prevent neural networks from overfitting. *The journal of machine learning research*, 15(1), 1929-1958. <https://www.cs.toronto.edu/~hinton/absps/JMLRdropout.pdf>

Purpose: fight overfitting

Popular deep CNN architectures

- AlexNet
- VGGNet
- GoogLeNet
- Microsoft ResNet
- Google Inception
- ...



Build one from scratch (ResNet)

<https://www.analyticsvidhya.com/blog/2021/08/how-to-code-your-resnet-from-scratch-in-tensorflow/>

The weights in a pretrained neural network is the leaned knowledge.

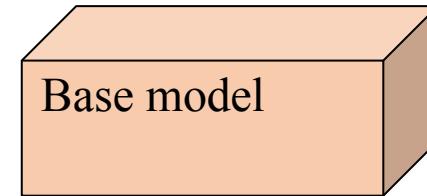
So a deep CNN trained on a large dataset contains knowledge (weights) that can be used to understand basic features in any given new image.

This is the concept of transfer learning.

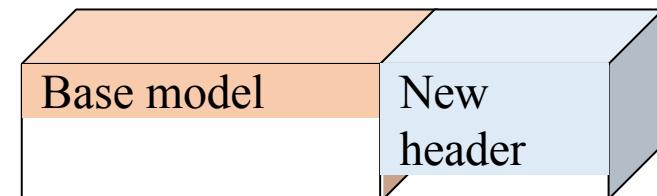
To do transfer learning, we

- Freeze the first layers of the pretrained neural network. These are the layers that detect general features that are common across all domains.
- Then we finetune the deeper layers with our own training data and add new layers to classify new categories included in our training dataset.

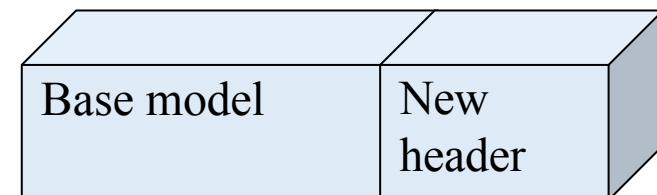
Take a pre-trained model (with learned weights) as base model



Add a header and train with the base model's weights frozen



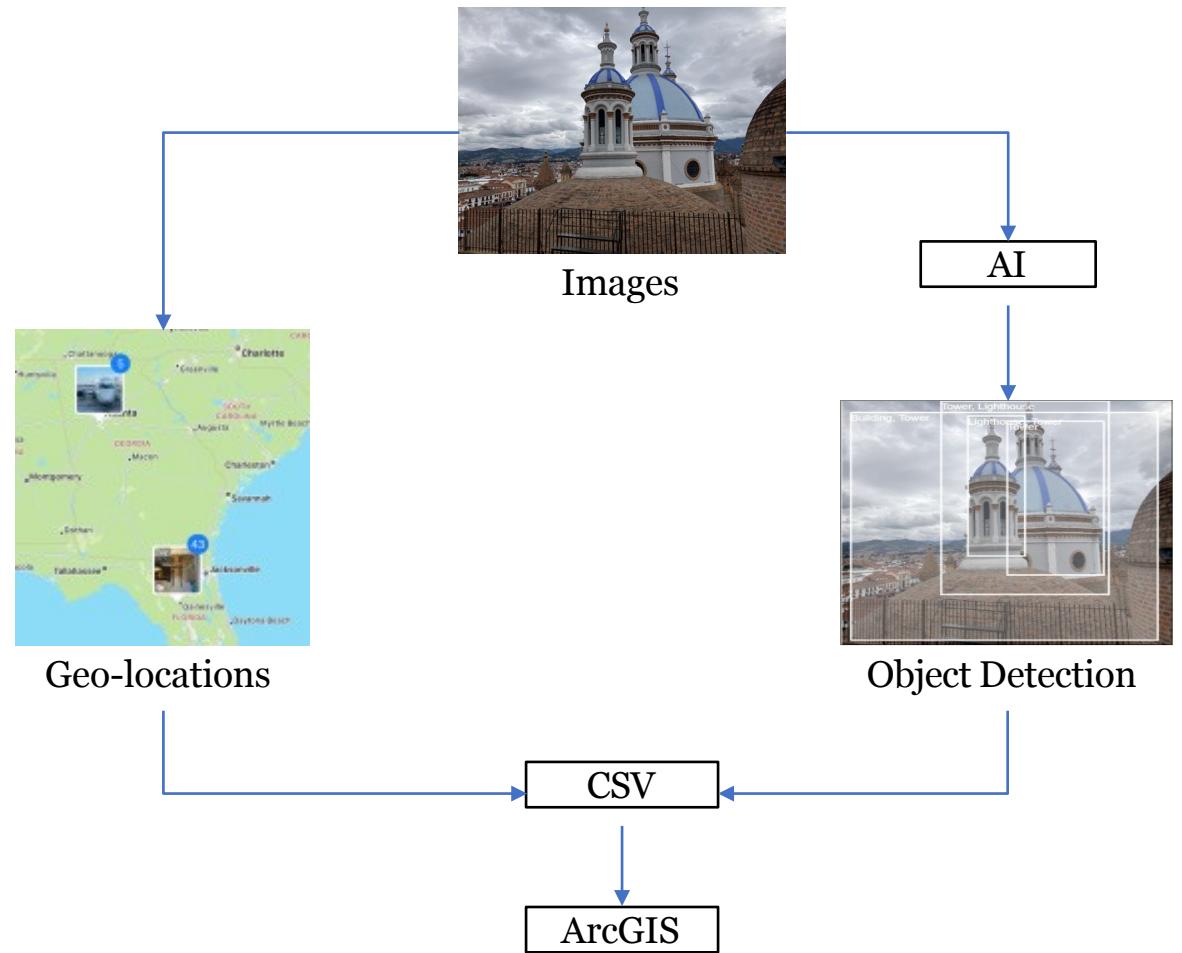
Unfreeze the base model and train

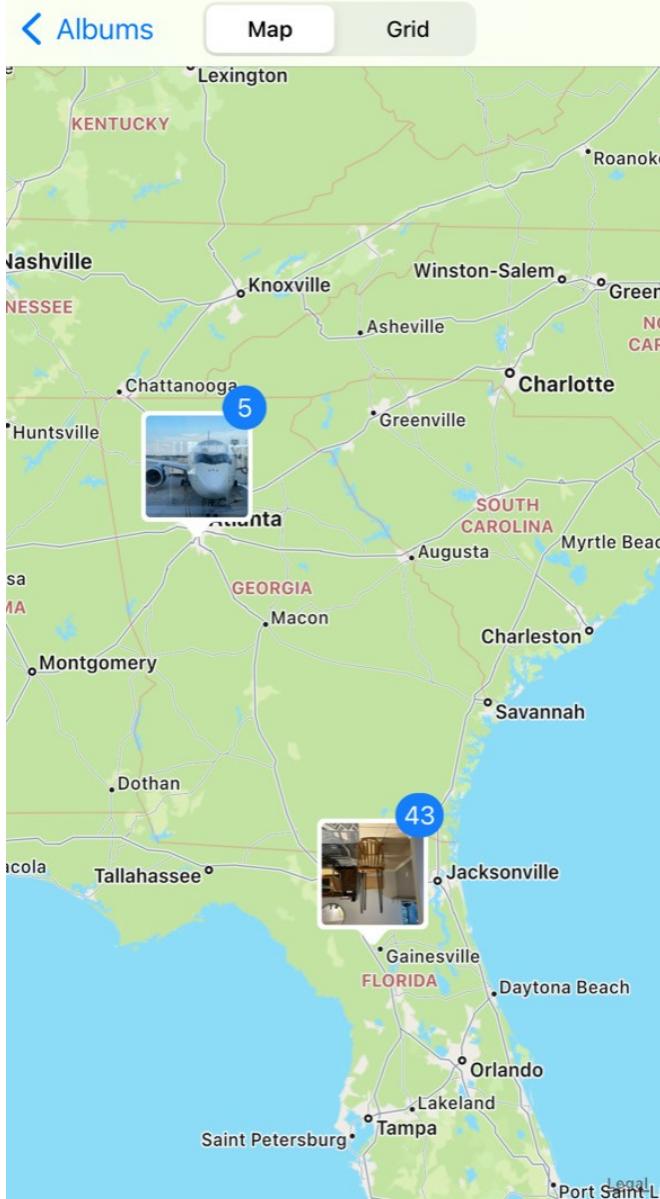


Application

Framework

Object Detection + Geo-tagged Images Site
mapping using personal mobile device



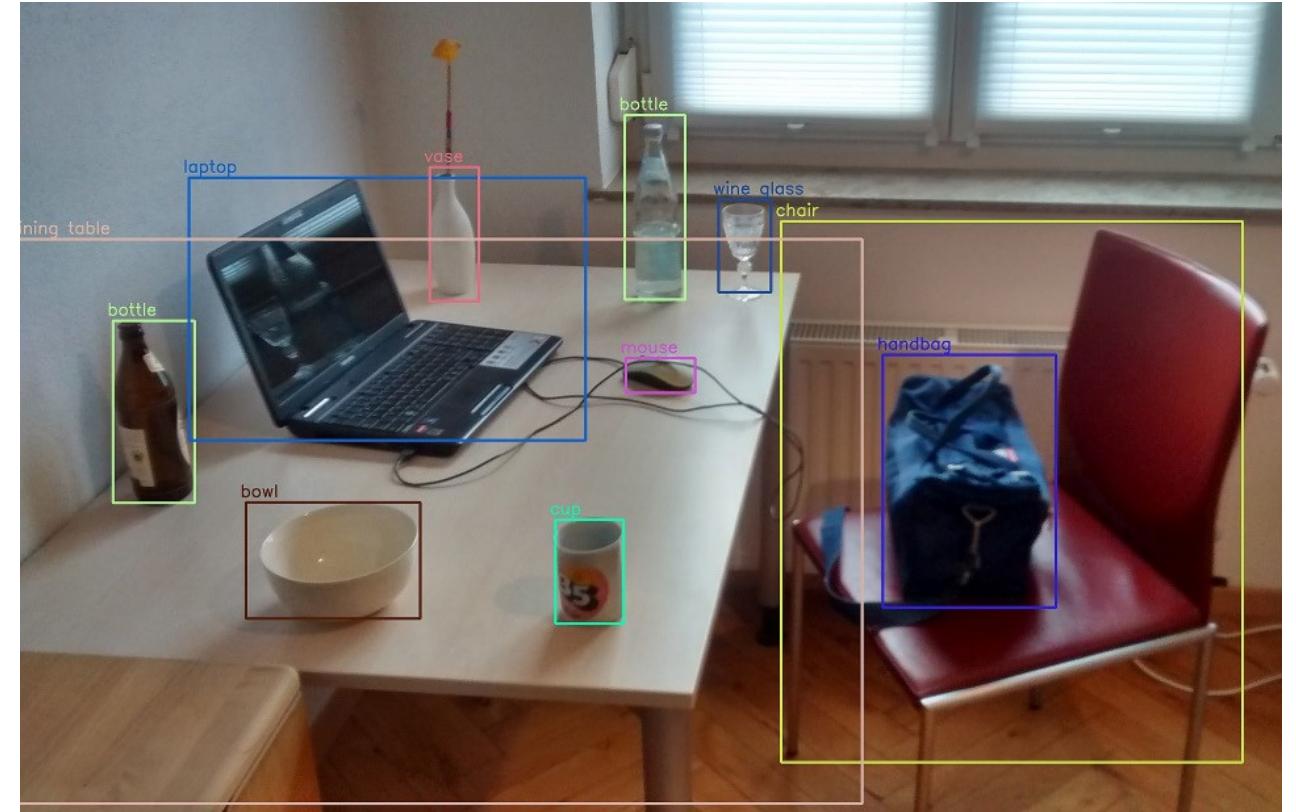


Geo-tagged Images

Our **cellphones** are now equipped with **GPS modules** that allow us to tag our photos with **geo-locations**.

Object Detection with AI

The state-of-the-art Artificial Intelligence has provided us an easy solution for detecting objects from images.



Object Detection using AI

Geo-tags + Object Detection

A small Web Application for easy site mapping using photos taken from smart phones

<https://guozifeng91.github.io/GulfSouth>



Preparations and taking Photos

[Privacy](#) Location Services

Enable GPS on your smart phone

The first step is to allow your photo to record the GPS coordinate when taking photos

For example, in iOS,
go to **Settings> Privacy> Location Services> Camera**

[Camera](#) **Formats**

CAMERA CAPTURE

High Efficiency

Most Compatible

To reduce file size, capture photos and videos in the High Efficiency HEIF/HEVC format. Most Compatible will always use JPEG/H.264. 4K at 60 fps, 1080p at 240 fps, and HDR video require High Efficiency.

PHOTO CAPTURE

Apple ProRAW

Show Camera control for ProRAW. ProRAW is a 12-bit file that uses the Linear DNG format to retain more information and dynamic range in the file, providing additional flexibility when editing exposure and white balance. Each file is approximately 25 MB.

Make sure to have the correct format

Please make sure that your photos are stored in **JPEG format**.

For iOS, go to **Settings > Camera > Formats**, and select **Most Compatible**

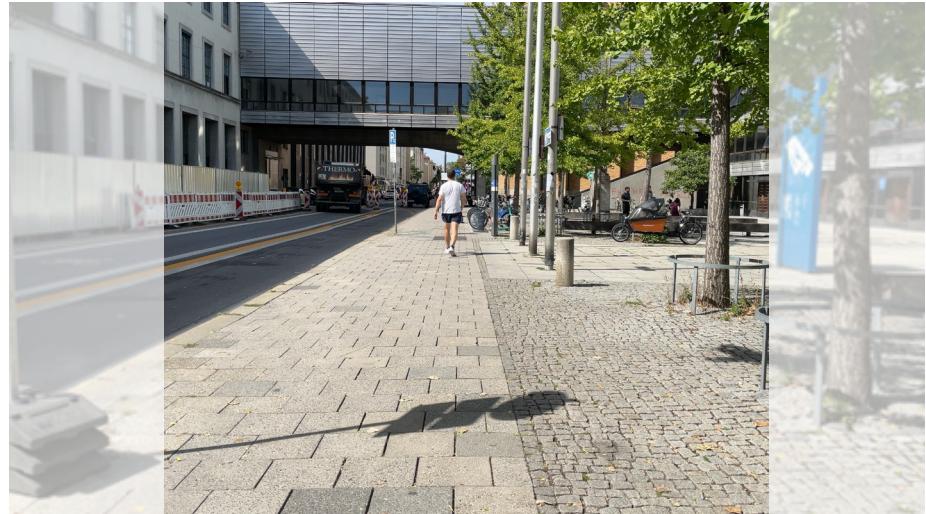
For Android, see <https://support.google.com/accounts/answer/3467281?hl=en>

Taking the photos

We can now go to our site and take photos with GPS and JPEG format enabled.

Please try to put the contents **near the center**, because the Web Application will **clip the photo** when the **aspect ratio** becomes large

The reason that we must clip the photo is that, the AI detector was developed using square images, it only accept square images as inputs and cannot make good detections if we squeeze too much the images with large aspect ratios



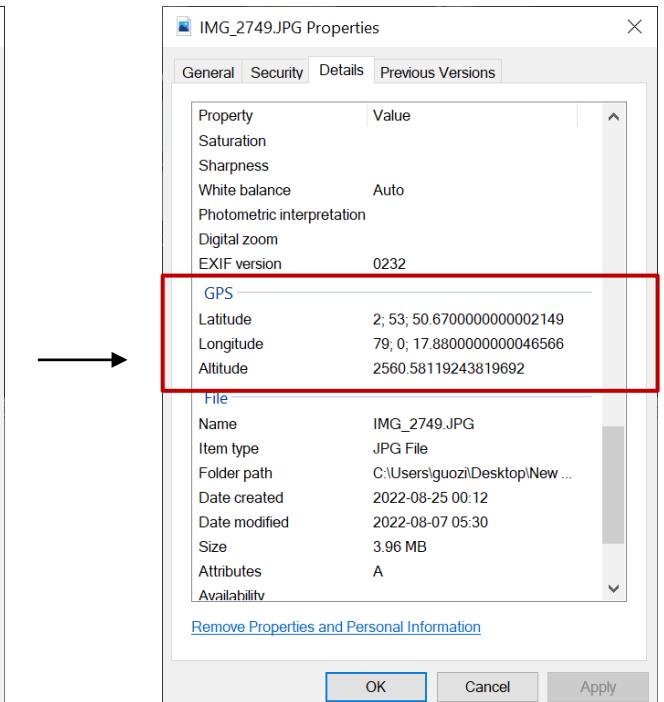
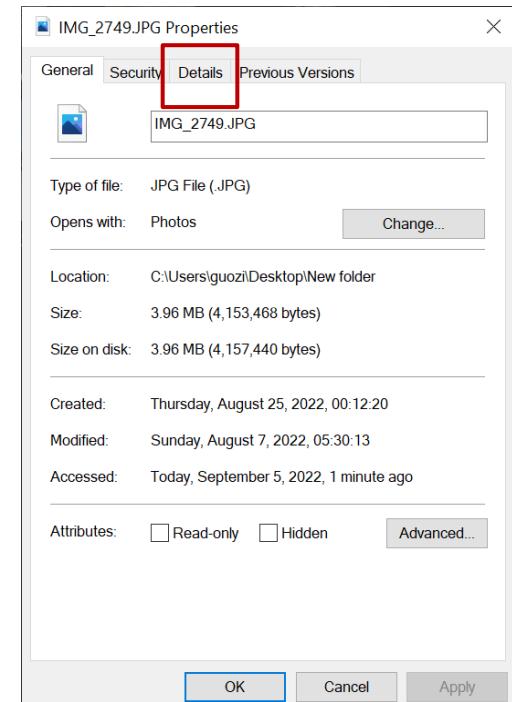


Export the raw files

After we have the photos. we need **to export the raw file** so that the GPS information is embedded with the photo

Usually, we can do this by connecting our phone with our computer using USB

If done correctly, there should be GPS coordinates in the photo's **file property**



Processing the Photos

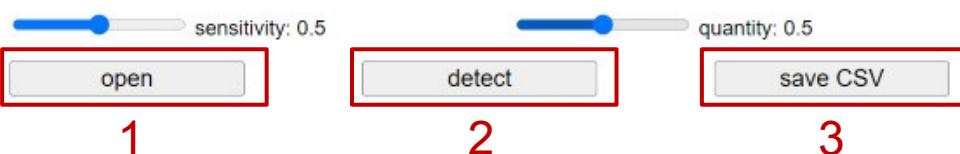
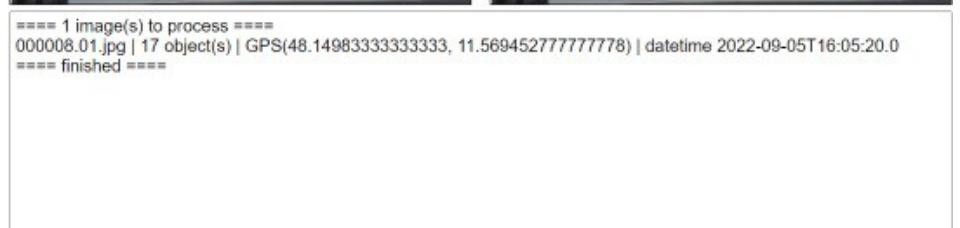
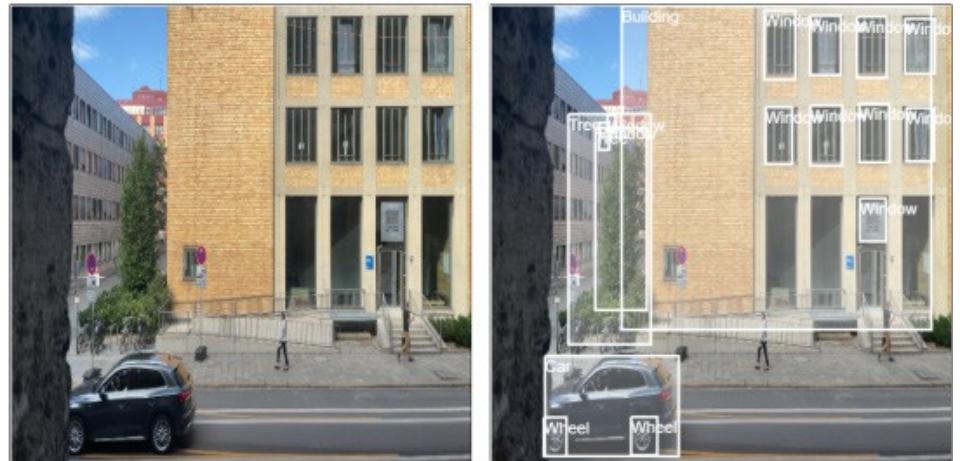
Object Detection using AI

Process the geo-tagged JPEG photos

Now, go to the Web Application (<https://guozifeng91.github.io/GulfSouth>) and process your photos.

1. Click **Open** to select the photos.
2. Click **Detect** to run object detection on the selected photos
3. Click **Save CSV** to save the results to your local drive

This application **runs locally** (i.e., your browser downloads the AI model and runs it in your own computer), **there is no server** and therefore it would **not send your data elsewhere**.



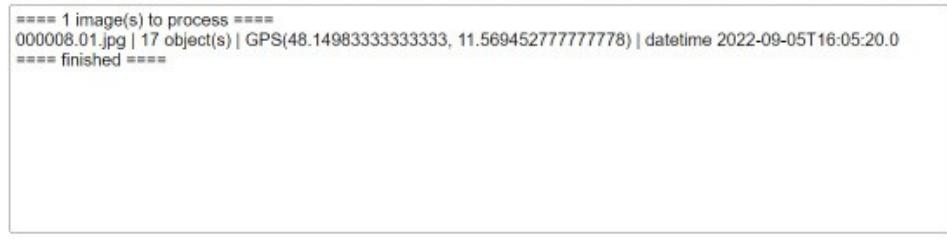
Object Detection using AI

Play with the parameters

In addition, you can play with the parameters until you are satisfied with the detection outputs.

The first value controls the **sensitivity** of detecting objects, the higher the value, the more objects can be detected (also more false detections)

The second value controls the **quantity** of detected objects (i.e., overlap detections), the higher the value, the more bounding boxes



sensitivity: 0.5

open

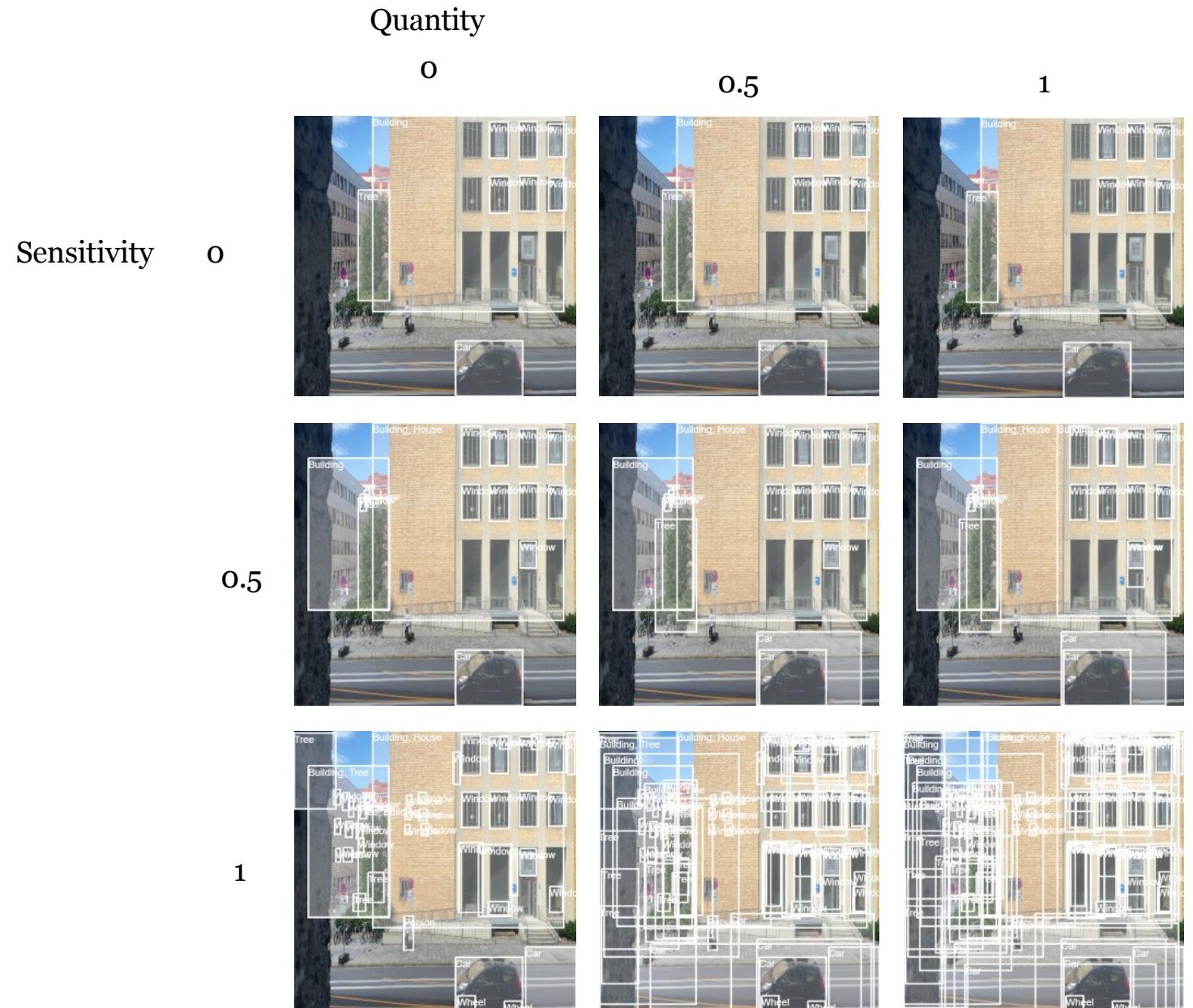
quantity: 0.5

detect

save CSV

Play with the parameters

Here is an example of the effect of these two parameters



Output CSV

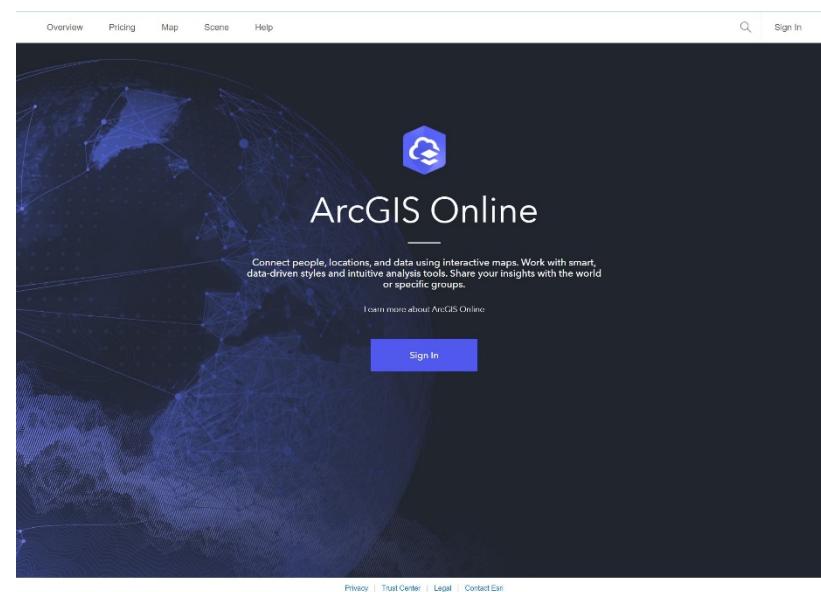
Here is an example of the output CSV

You can open this CSV with Excel (MS Office) or other text editors

	A	B	C	D	E	F	G
1	latitude	longitude	datetime	filename	object_nar	object_quantity	
2	48.1502	11.56684	2022-09-(YKAU4121	Car		1	
3	48.1502	11.56684	2022-09-(YKAU4121	Wheel		5	
4	48.1502	11.56684	2022-09-(YKAU4121	Building		2	
5	48.1502	11.56684	2022-09-(YKAU4121	Land_vehic		1	
6	48.15015	11.56683	2022-09-(YBAL6163.	Window		6	
7	48.15015	11.56683	2022-09-(YBAL6163.	Building		1	
8	48.15015	11.56683	2022-09-(YBAL6163.	House		1	
9	48.15015	11.56683	2022-09-(YBAL6163.	Wheel		1	
10	48.15015	11.56683	2022-09-(YBAL6163.	Bicycle		1	
11	48.15019	11.56781	2022-09-(XSLX5164.	Building		3	
12	48.15019	11.56781	2022-09-(XSLX5164.	Wheel		3	
13	48.15019	11.56781	2022-09-(XSLX5164.	Car		5	
14	48.15019	11.56781	2022-09-(XSLX5164.	Tree		2	
15	48.15019	11.56781	2022-09-(XSLX5164.	Person		1	
16	48.15019	11.56781	2022-09-(XSLX5164.	Window		9	
17	48.15022	11.56774	2022-09-(WUCK587:	Motorcycle		1	
18	48.15022	11.56774	2022-09-(WUCK587:	Land_vehic		1	
19	48.15022	11.56774	2022-09-(WUCK587:	Car		5	
20	48.15022	11.56774	2022-09-(WUCK587:	Footwear		1	
21	48.15022	11.56774	2022-09-(WUCK587:	Building		4	
22	48.15022	11.56774	2022-09-(WUCK587:	Person		3	
23	48.15022	11.56774	2022-09-(WUCK587:	Tree		1	
24	48.15022	11.56774	2022-09-(WUCK587:	Window		11	
25	48.15022	11.56774	2022-09-(WUCK587:	Wheel		1	
26	48.15016	11.56794	2022-09-(RWOA677	Car		4	
27	48.15016	11.56794	2022-09-(RWOA677	Building		2	
28	48.15016	11.56794	2022-09-(RWOA677	Wheel		5	
29	48.15016	11.56794	2022-09-(RWOA677	Person		2	
30	48.15016	11.56794	2022-09-(RWOA677	Tree		1	
31	48.15002	11.56672	2022-09-(RVOB8502	Car		3	
32	48.15002	11.56672	2022-09-(RVOB8502	Wheel		8	
33	48.15002	11.56672	2022-09-(RVOB8502	Window		12	
34	48.15002	11.56672	2022-09-(RVOB8502	Building		1	
35	48.15006	11.56828	2022-09-(REEE7382.	Footwear		21	
36	48.15006	11.56828	2022-09-(REEE7382.	Man		2	
37	48.15006	11.56828	2022-09-(REEE7382.	Person		3	
38	48.15006	11.56828	2022-09-(REEE7382.	Bicycle		2	
39	48.15006	11.56828	2022-09-(REEE7382.	Motorcycle		1	
40	48.15006	11.56828	2022-09-(REEE7382.	Land_vehic		1	
41	48.15006	11.56828	2022-09-(REEE7382.	Wheel		4	

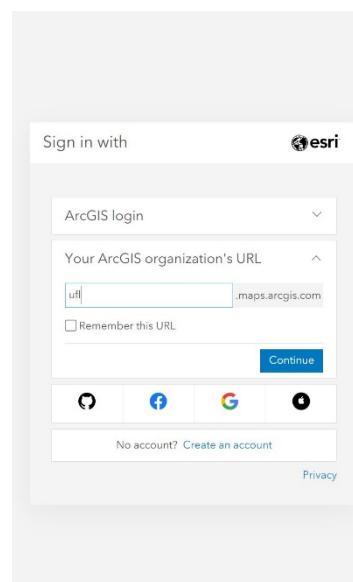
Map making with CSVs in ArcGIS

1



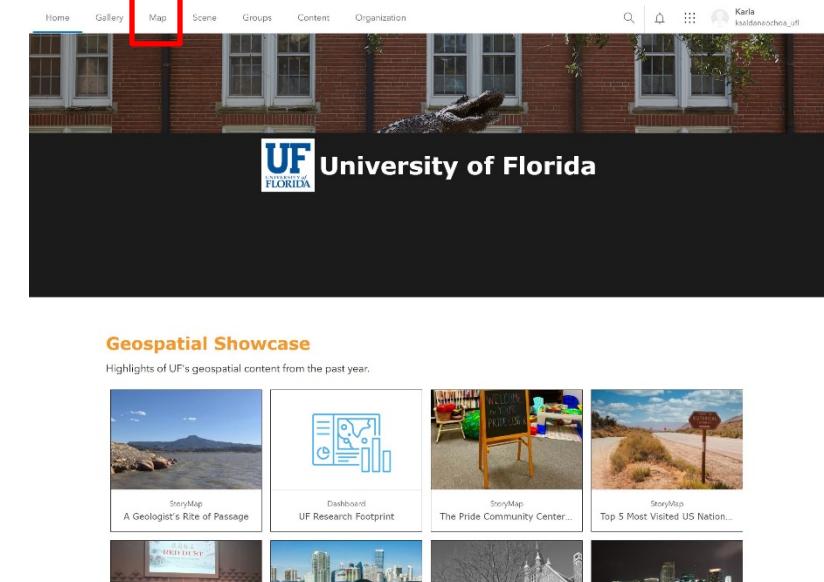
Go to <https://www.arcgis.com/index.html>

2



Type ufl -> Continue -> select University of Florida

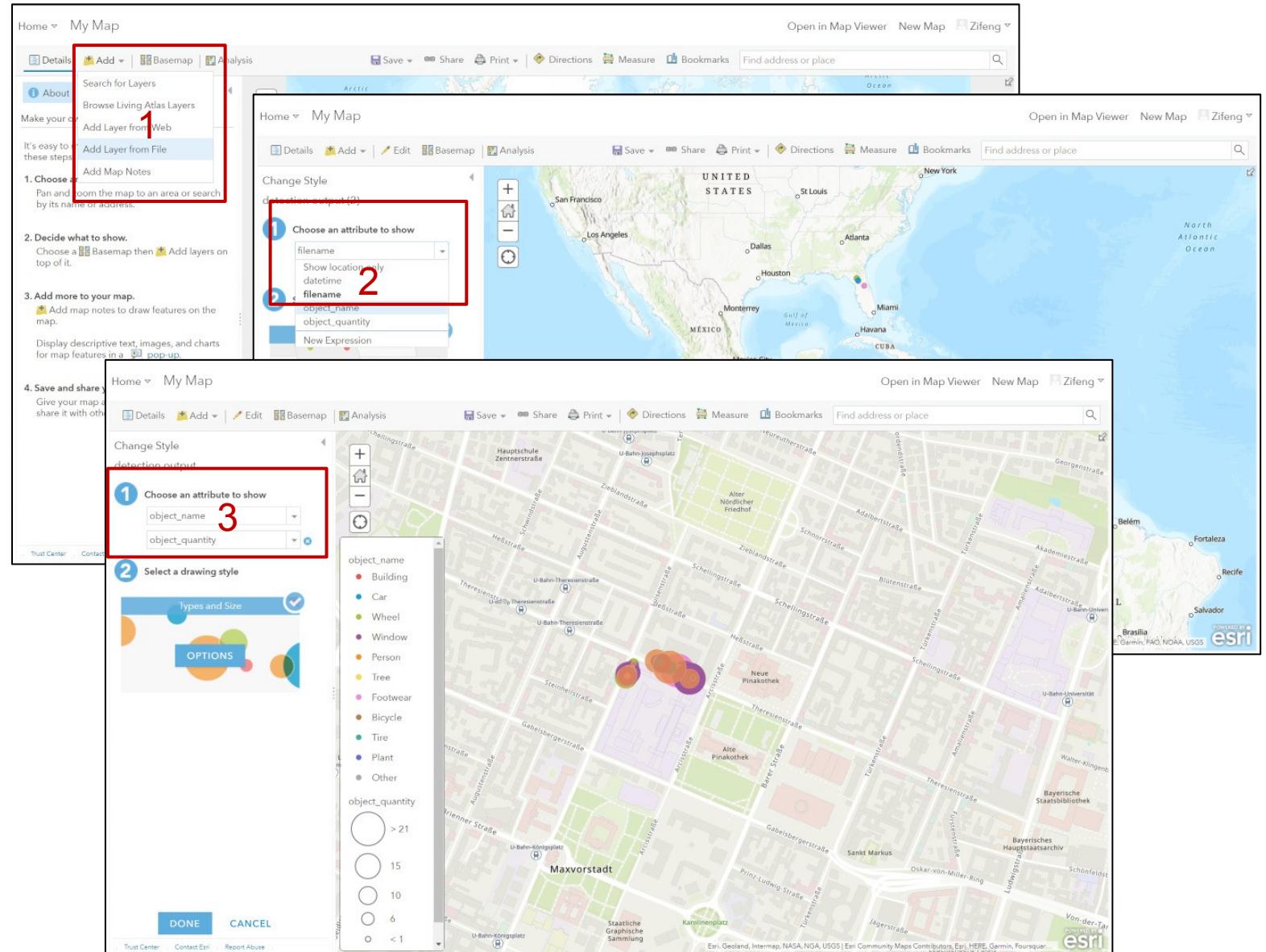
3



Click on Map

Import the CSV to ArcGIS

The output CSV can now be imported to the ArcGIS online for visualization



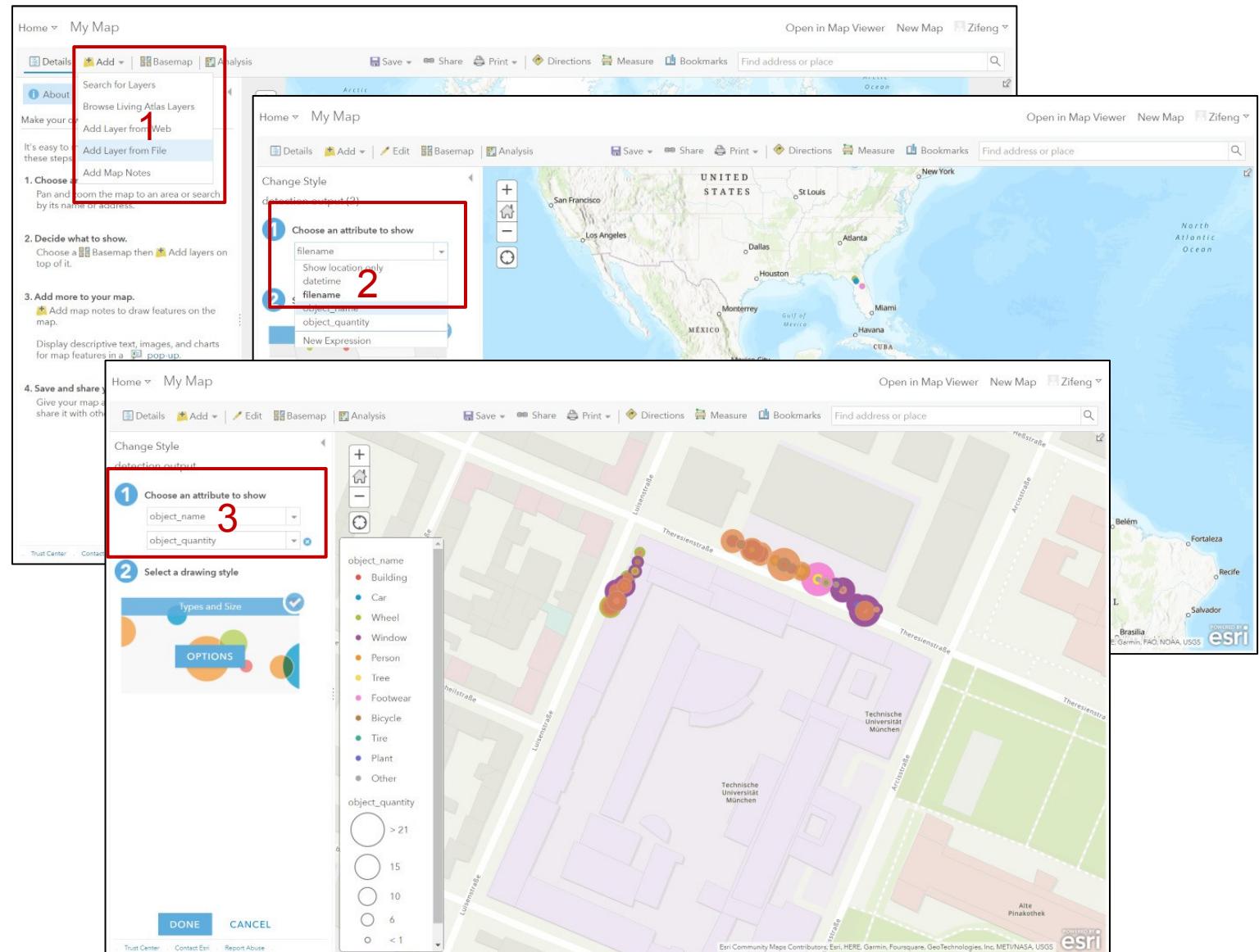
Too much information?

Too messy?

The CSV contains many data, and we should post-process our CSV to show specific maps

For example,

- Spatial Maps of specific category
- Temporal Maps of specific region



Play with the CSV to get different Maps

Spatial Map of Specific Category

Open the CSV using Excel (MS Office) First, we

select column E (object_name)

Then, we use Data>Filter to select the rows For

example, here I selected "Car"

The image shows a Microsoft Excel interface with several numbered callouts:

- Callout 1:** Points to the column header "object_name" in the first row of the data table.
- Callout 2:** Points to the "Data" tab in the ribbon menu.
- Callout 3:** Points to the "Filter" icon in the ribbon menu.
- Callout 4:** Points to the filter dropdown menu for column E, which is currently set to "Sort A to Z".
- Callout 5:** Points to the filter dropdown menu for column E, where the "Car" checkbox is selected.
- Callout 6:** Points to the "OK" button in the filter dialog box.

The data table contains columns: latitude, longitude, datetime, filename, object, and object_quantity. The "object" column is being filtered. The "object_name" column shows various categories like Bicycle, Car, Bus, etc. The "object" column shows numerical values. The "object_quantity" column shows counts. The filter dropdown lists all categories with checkboxes, and the "Car" checkbox is checked in the second screenshot.

Spatial Map of Specific Category

Excel will show us rows that have only Car

We can Copy Paste the results to a new Excel Sheet

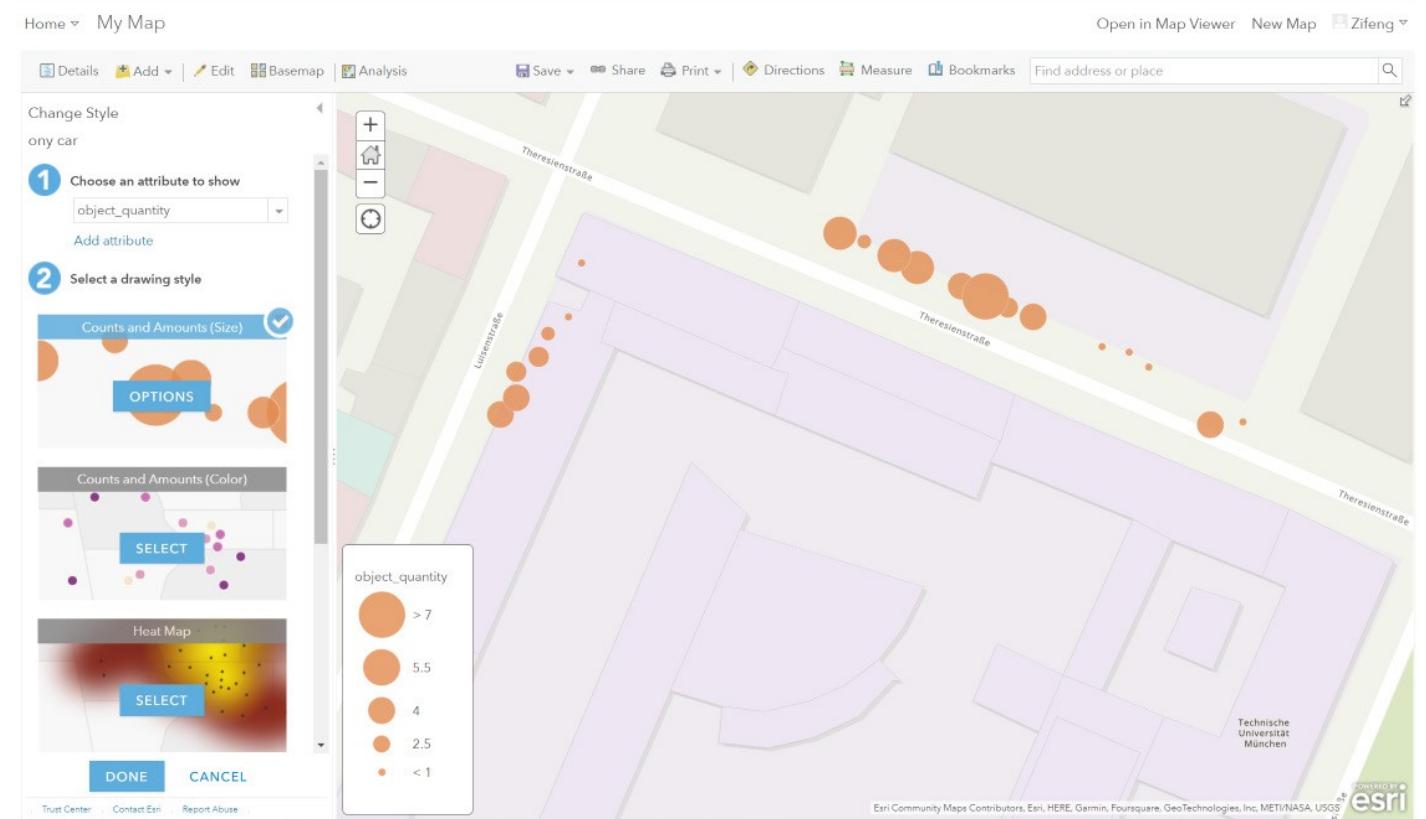
	A	B	C	D	E	F	G
1	latitude	longitude	datetime	filename	object_nar	object_quantity	
2	48.15	11.566	2022-01-01	YKAU41	Car	5	
13	48.15019	11.56781	2022-09-01	(XSLX5164	Car	5	
19	48.15022	11.56774	2022-09-01	(WUCK587	Car	5	
26	48.15016	11.56794	2022-09-01	(RWOA677	Car	4	
31	48.15002	11.56672	2022-09-01	(RVOB8502	Car	3	
48	48.15	11.56848	2022-09-01	(QPRY1883	Car	1	
54	48.1501	11.56814	2022-09-01	(QJDM0531	Car	4	
63	48.15026	11.56759	2022-09-01	(QFQX9105	Car	5	
75	48.15003	11.56842	2022-09-01	(OWGX423	Car	1	
79	48.14989	11.56865	2022-09-01	(KRRO6651	Car	4	
87	48.14991	11.56661	2022-09-01	(KOXI0695	Car	4	
93	48.15007	11.56675	2022-09-01	(KPXT4475	Car	2	
98	48.14999	11.56666	2022-09-01	(JYKN1948	Car	3	
108	48.15024	11.56766	2022-09-01	(IHKV7830	Car	2	
109	48.1501	11.56681	2022-09-01	(ICTY65071	Car	1	
114	48.15012	11.56807	2022-09-01	(GWFG2711	Car	3	
121	48.15002	11.56672	2022-09-01	(GTLQ9223	Car	3	
134	48.15004	11.56834	2022-09-01	(FOGF8136	Car	1	
135	48.1499	11.56875	2022-09-01	(ESUI99221	Car	1	
147	48.14994	11.56666	2022-09-01	(ESGU8937	Car	4	
159	48.15014	11.56801	2022-09-01	(EBZO9997	Car	7	
168							

	A	B	C	D	E	F	G
1	latitude	longitude	datetime	filename	object_nar	object_quantity	
2	48.1502	11.56684	2022-09-01	(YKAU4121	Car	1	
3	48.15019	11.56781	2022-09-01	(XSLX5164	Car	5	
4	48.15022	11.56774	2022-09-01	(WUCK587	Car	5	
5	48.15016	11.56794	2022-09-01	(RWOA677	Car	4	
6	48.15002	11.56672	2022-09-01	(RVOB8502	Car	3	
7	48.15	11.56848	2022-09-01	(QPRY1883	Car	1	
8	48.1501	11.56814	2022-09-01	(QJDM0531	Car	4	
9	48.15026	11.56759	2022-09-01	(QFQX9105	Car	5	
10	48.15003	11.56842	2022-09-01	(OWGX423	Car	1	
11	48.14989	11.56865	2022-09-01	(KRRO6651	Car	4	
12	48.14991	11.56661	2022-09-01	(KOXI0695	Car	4	
13	48.15007	11.56675	2022-09-01	(KPXT4475	Car	2	
14	48.14999	11.56666	2022-09-01	(JYKN1948	Car	3	
15	48.15024	11.56766	2022-09-01	(IHKV7830	Car	2	
16	48.1501	11.56681	2022-09-01	(ICTY65071	Car	1	
17	48.15012	11.56807	2022-09-01	(GWFG2711	Car	3	
18	48.15002	11.56672	2022-09-01	(GTLQ9223	Car	3	
19	48.15004	11.56834	2022-09-01	(FOGF8136	Car	1	
20	48.1499	11.56875	2022-09-01	(ESUI99221	Car	1	
21	48.14994	11.56666	2022-09-01	(ESGU8937	Car	4	
22	48.15014	11.56801	2022-09-01	(EBZO9997	Car	7	
23							

Spatial Map of Specific Category

Save the new Excel Sheet as a **new CSV**

Import this CSV to ArcGIS shows a map of the quantity of cars



Temporal Map of the Region

We first need to parse the **datetime** from **Texts to Values**

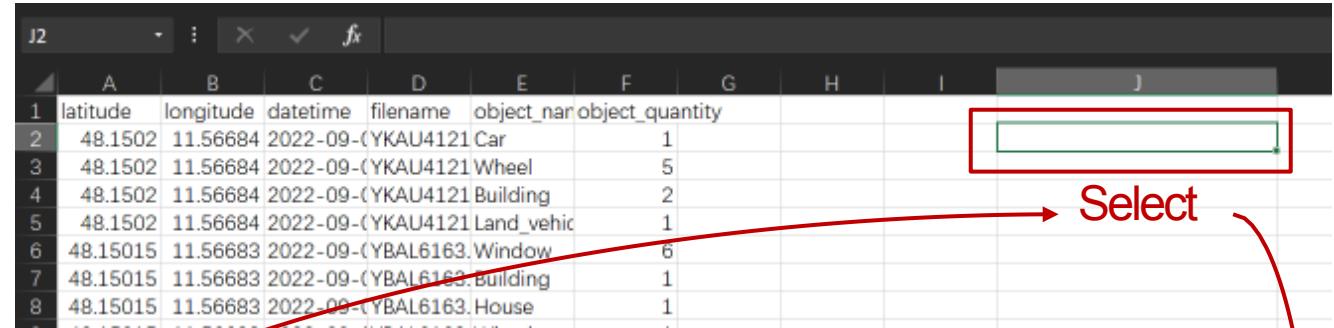
with a little googling (<https://stackoverflow.com/questions/4896116/parsing-an-iso8601-date-time-including-timezone-in-excel>)

here is how to do it

Click **any empty cell in the 2nd row** (I took J2), and copy paste this formula:

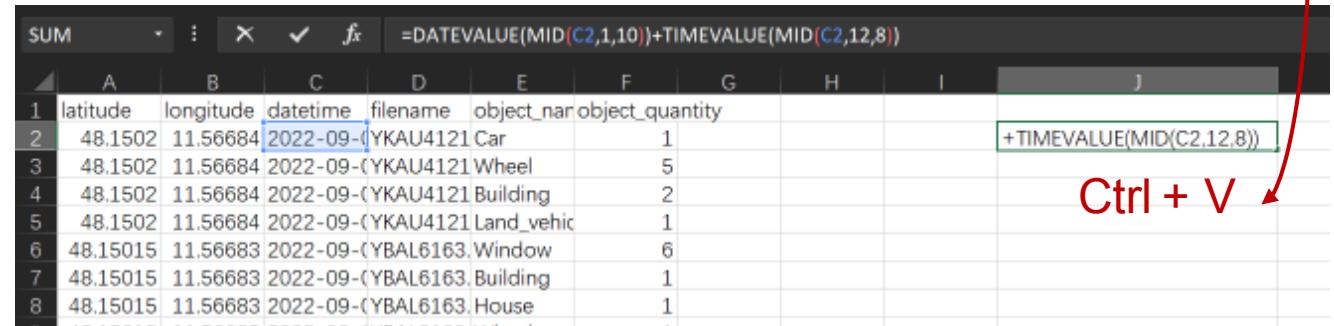
=DATEVALUE(MID(C2,1,10))+TIMEVALUE(MID(C2,12,8))

Ctrl + C



J2	A	B	C	D	E	F	G	H	I	J
	1	latitude	longitude	datetime	filename	object_nar	object_quantity			
	2	48.1502	11.56684	2022-09-(YKAU4121	Car		1			
	3	48.1502	11.56684	2022-09-(YKAU4121	Wheel		5			
	4	48.1502	11.56684	2022-09-(YKAU4121	Building		2			
	5	48.1502	11.56684	2022-09-(YKAU4121	Land_vehic		1			
	6	48.15015	11.56683	2022-09-(YBAL6163.	Window		6			
	7	48.15015	11.56683	2022-09-(YBAL6163.	Building		1			
	8	48.15015	11.56683	2022-09-(YBAL6163.	House		1			

Select



SUM	A	B	C	D	E	F	G	H	I	J
	1	latitude	longitude	datetime	filename	object_nar	object_quantity			
	2	48.1502	11.56684	2022-09-(YKAU4121	Car		1			+TIMEVALUE(MID(C2,12,8))
	3	48.1502	11.56684	2022-09-(YKAU4121	Wheel		5			
	4	48.1502	11.56684	2022-09-(YKAU4121	Building		2			
	5	48.1502	11.56684	2022-09-(YKAU4121	Land_vehic		1			
	6	48.15015	11.56683	2022-09-(YBAL6163.	Window		6			
	7	48.15015	11.56683	2022-09-(YBAL6163.	Building		1			
	8	48.15015	11.56683	2022-09-(YBAL6163.	House		1			

Ctrl + V

J167	A	B	C	D	E	F	G	H	I	J
161	48.15014	11.56801	2022-09-(EBZO9997	Window	2					
162	48.14992	11.56859	2022-09-(DXVB1783	Building	4					
163	48.14992	11.56859	2022-09-(DXVB1783	Tree	10					
164	48.14992	11.56859	2022-09-(DXVB1783	Footwear	2					
165	48.14992	11.56859	2022-09-(DXVB1783	Person	1					
166	48.14992	11.56859	2022-09-(DXVB1783	Window	12					
167	48.14992	11.56859	2022-09-(DXVB1783	Plant	1					
168										
169										

Click (notice the same column J)

Temporal Map of the Region

Then, we populate the formula to the entire column

First, use the scroll bar to go to the last row that has data, Click the cell of your selected column (J167 here)

Then, use the scroll bar to go to the top, Shift + Click your cell that has the formula

Then, press Ctrl + D to populate the formula

J167	A	B	C	D	E	F	G	H	I	J
1	latitude	longitude	datetime	filename	object_nar	object_quantity				
2	48.1502	11.56684	2022-09-(YKAU4121	Car	1					
3	48.1502	11.56684	2022-09-(YKAU4121	Wheel	5					
4	48.1502	11.56684	2022-09-(YKAU4121	Building	2					
5	48.1502	11.56684	2022-09-(YKAU4121	Land_vehic	1					
6	48.15015	11.56683	2022-09-(YBAL6163.	Window	6					
7	48.15015	11.56683	2022-09-(YBAL6163.	Building	1					
8	48.15015	11.56683	2022-09-(YBAL6163.	House	1					
9	48.15015	11.56683	2022-09-(YBAL6163.	Wheel	1					

Shift + Click (to select the entire column)

J167	A	B	C	D	E	F	G	H	I	J
1	latitude	longitude	datetime	filename	object_nar	object_quantity				
2	48.1502	11.56684	2022-09-(YKAU4121	Car	1					44810.55593
3	48.1502	11.56684	2022-09-(YKAU4121	Wheel	5					44810.55593
4	48.1502	11.56684	2022-09-(YKAU4121	Building	2					44810.55593
5	48.1502	11.56684	2022-09-(YKAU4121	Land_vehic	1					44810.55593
6	48.15015	11.56683	2022-09-(YBAL6163.	Window	6					44810.55602
7	48.15015	11.56683	2022-09-(YBAL6163.	Building	1					44810.55602
8	48.15015	11.56683	2022-09-(YBAL6163.	House	1					44810.55602

Ctrl + D to populate the formula

Temporal Map of the Region

Then, we calculate the time from the values

Select another empty cell in row 2 (I took H2) and Copy
Paste this formula:

=TIME(HOUR(J2), MINUTE(J2), SECOND(J2))

Ctrl + C

Important: make sure the red letter matches the column where you just populated the data with

A	B	C	D	E	F	G	H	I	J
1	latitude	longitude	datetime	filename	object_nar	object_quantity			
2	48.1502	11.56684	2022-09-(YKAU4121	Car	1				44810.55593
3	48.1502	11.56684	2022-09-(YKAU4121	Wheel	5				44810.55593
4	48.1502	11.56684	2022-09-(YKAU4121	Building	2				44810.55593
5	48.1502	11.56684	2022-09-(YKAU4121	Land_vehic	1				44810.55593
6	48.15015	11.56683	2022-09-(YBAL6163	Window	6				44810.55602
7	48.15015	11.56683	2022-09-(YBAL6163	Building	1				

A	B	C	D	E	F	G	H	I	J
1	latitude	longitude	datetime	filename	object_nar	object_quantity			
2	48.1502	11.56684	2022-09-(YKAU4121	Car	1		1:20 PM		44810.55593
3	48.1502	11.56684	2022-09-(YKAU4121	Wheel	5				44810.55593
4	48.1502	11.56684	2022-09-(YKAU4121	Building	2				44810.55593
5	48.1502	11.56684	2022-09-(YKAU4121	Land_vehic	1				44810.55593
6	48.15015	11.56683	2022-09-(YBAL6163	Window	6				44810.55602
7	48.15015	11.56683	2022-09-(YBAL6163	Building	1				

Temporal Map of the Region

Temporal Map of the Region

And then populate the formula to this new column using the same method mentioned before

Now we have the data for time value

You can get the **date value** using the same process, just change the formula to

=DATE(YEAR(J2), MONTH(J2), DAY(J2))

	A	B	C	D	E	F	G	H	I	J
1	latitude	longitude	datetime	filename	object_nar	object_quantity				
2	48.1502	11.56684	2022-09-(YKAU4121	Car	1		1:20 PM			44810.55593
3	48.1502	11.56684	2022-09-(YKAU4121	Wheel	5		1:20 PM			44810.55593
4	48.1502	11.56684	2022-09-(YKAU4121	Building	2		1:20 PM			44810.55593
5	48.1502	11.56684	2022-09-(YKAU4121	Land_vehic	1		1:20 PM			44810.55593
6	48.15015	11.56683	2022-09-(YBAL6163.	Window	6		1:20 PM			44810.55602
7	48.15015	11.56683	2022-09-(YBAL6163.	Building	1		1:20 PM			44810.55602
8	48.15015	11.56683	2022-09-(YBAL6163.	House	1		1:20 PM			44810.55602
9	48.15015	11.56683	2022-09-(YBAL6163.	Wheel	1		1:20 PM			44810.55602
10	48.15015	11.56683	2022-09-(YBAL6163.	Bicycle	1		1:20 PM			44810.55602
11	48.15019	11.56781	2022-09-(XSLX5164.	Building	3		1:18 PM			44810.55455
12	48.15019	11.56781	2022-09-(XSLX5164.	Wheel	3		1:18 PM			44810.55455
13	48.15019	11.56781	2022-09-(XSLX5164.	Car	5		1:18 PM			44810.55455
14	48.15019	11.56781	2022-09-(XSLX5164.	Tree	2		1:18 PM			44810.55455
15	48.15019	11.56781	2022-09-(XSLX5164.	Person	1		1:18 PM			44810.55455
16	48.15019	11.56781	2022-09-(XSLX5164.	Window	9		1:18 PM			44810.55455
17	48.15022	11.56774	2022-09-(WUCK587:	Motorcycle	1		1:18 PM			44810.55461
18	48.15022	11.56774	2022-09-(WUCK587:	Land_vehic	1		1:18 PM			44810.55461
19	48.15022	11.56774	2022-09-(WUCK587:	Car	5		1:18 PM			44810.55461
20	48.15022	11.56774	2022-09-(WUCK587:	Footwear	1		1:18 PM			44810.55461
21	48.15022	11.56774	2022-09-(WUCK587:	Building	4		1:18 PM			44810.55461
22	48.15022	11.56774	2022-09-(WUCK587:	Person	3		1:18 PM			44810.55461
23	48.15022	11.56774	2022-09-(WUCK587:	Tree	1		1:18 PM			44810.55461
24	48.15022	11.56774	2022-09-(WUCK587:	Window	11		1:18 PM			44810.55461
25	48.15022	11.56774	2022-09-(WUCK587:	Wheel	1		1:18 PM			44810.55461
26	48.15016	11.56794	2022-09-(RWOA677	Car	4		1:18 PM			44810.55449
27	48.15016	11.56794	2022-09-(RWOA677	Building	2		1:18 PM			44810.55449
28	48.15016	11.56794	2022-09-(RWOA677	Wheel	5		1:18 PM			44810.55449

Temporal Map of the Region

We can now use the time values to create temporal maps

This is done by specifying the start and end values for the row-filtering

The screenshot shows a Microsoft Excel spreadsheet with the following details:

- Excel ribbon:** The "Data" tab is selected.
- Context menu:** A context menu is open over the header of column H, with the "Filter" option highlighted.
- Number Filters dialog:** The "Number Filters" dialog box is open, showing filter criteria for column H. It includes:
 - Search input field
 - Checkboxes for: (Select All), 1:17 PM, 1:18 PM, 1:20 PM, 1:21 PM
 - Buttons: OK and Cancel
- Red numbered annotations:**
 - Annotation 1: Points to the "Sort" button in the ribbon's "Data" tab.
 - Annotation 2: Points to the "Filter" icon in the ribbon's "Data" tab.
 - Annotation 3: Points to the "Filter" icon in the "Sort & Filter" group of the ribbon's "Data" tab.
 - Annotation 4: Points to the dropdown arrow in the column H header.
 - Annotation 5: Points to the "Number Filters" button in the "Filter" dialog.
 - Annotation 6: Points to the "Between..." button in the "Number Filters" dialog.

A	B	C	D	E	F	G	H
1	latitude	longitude	datetime	filename	object	nar	object quantity
2	48.1502	11.56684	2022-09-(YKAU4121C				
3	48.1502	11.56684	2022-09-(YKAU4121V				
4	48.1502	11.56684	2022-09-(YKAU4121B				
5	48.1502	11.56684	2022-09-(YKAU4121L				
6	48.15015	11.56683	2022-09-(YBAL6163.V				
7	48.15015	11.56683	2022-09-(YBAL6163.B				
8	48.15015	11.56683	2022-09-(YBAL6163.H				
9	48.15015	11.56683	2022-09-(YBAL6163.V				
10	48.15015	11.56683	2022-09-(YBAL6163.B				
11	48.15019	11.56781	2022-09-(XSLX5164.B				
12	48.15019	11.56781	2022-09-(XSLX5164.V				
13	48.15019	11.56781	2022-09-(XSLX5164.C				
14	48.15019	11.56781	2022-09-(XSLX5164.T				
15	48.15019	11.56781	2022-09-(XSLX5164.P				
16	48.15019	11.56781	2022-09-(XSLX5164.V				
17	48.15022	11.56774	2022-09-(WUCK587:M				
18	48.15022	11.56774	2022-09-(WUCK587:L				
19	48.15022	11.56774	2022-09-(WUCK587:C				
20	48.15022	11.56774	2022-09-(WUCK587:F				
21	48.15022	11.56774	2022-09-(WUCK587:B				
22	48.15022	11.56774	2022-09-(WUCK587:P				
23	48.15022	11.56774	2022-09-(WUCK587:T				
24	48.15022	11.56774	2022-09-(WUCK587:V				
25	48.15022	11.56774	2022-09-(WUCK587:V				
26	48.15016	11.56794	2022-09-(RWOA677:C				
27	48.15016	11.56794	2022-09-(RWOA677:B				
28	48.15016	11.56794	2022-09-(RWOA677:V				
29	48.15016	11.56794	2022-09-(RWOA677:P				
30	48.15016	11.56794	2022-09-(RWOA677 Tree	1		1:18 PM	
31	48.15002	11.56672	2022-09-(RVOB8502 Car	3		1:20 PM	

Temporal Map of the Region

Again, we can copy paste the results to a new Excel Sheet, and save it as CSV

Note that we only need column A to F

Repeat this process multiple times for different time period, and save each output as a new CSV

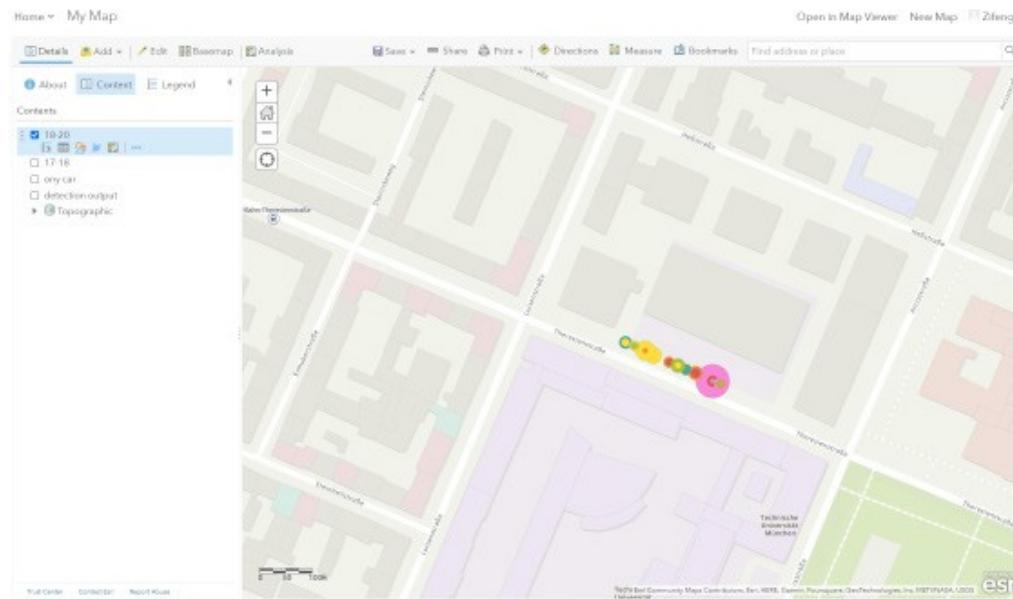
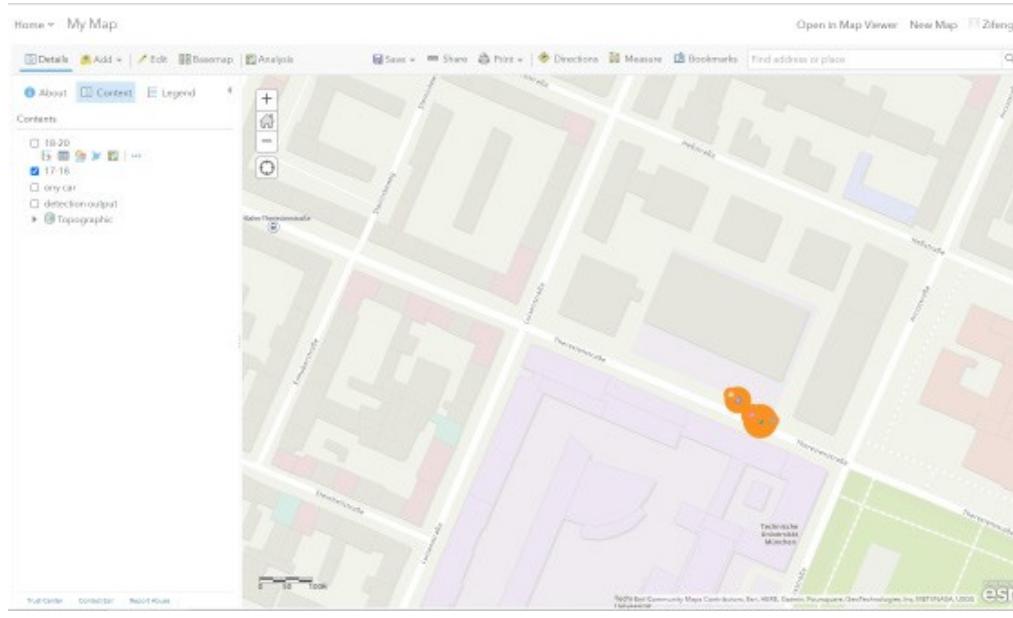
A	B	C	D	E	F	G	H	I	J	K
1	latitude	longitude	datetime	filename	object_name	object_quantity				
2	48.1502	11.56684	2022-09-(YKAU4121	Car		1	1:20 PM			44810.55593
3	48.1502	11.56684	2022-09-(YKAU4121	Wheel		5	1:20 PM			44810.55593
4	48.1502	11.56684	2022-09-(YKAU4121	Building		2				
5	48.1502	11.56684	2022-09-(YKAU4121	Land_vehic		1				
6	48.15015	11.56683	2022-09-(YBAL6163.	Window		6				
7	48.15015	11.56683	2022-09-(YBAL6163.	Building		1				
8	48.15015	11.56683	2022-09-(YBAL6163.	House		1				
9	48.15015	11.56683	2022-09-(YBAL6163.	Wheel		1				
10	48.15015	11.56683	2022-09-(YBAL6163.	Bicycle		1				
11	48.15019	11.56781	2022-09-(XSLX5164.	Building		3				
12	48.15019	11.56781	2022-09-(XSLX5164.	Wheel		3				
13	48.15019	11.56781	2022-09-(XSLX5164.	Car		5				
14	48.15019	11.56781	2022-09-(XSLX5164.	Tree		2				
15	48.15019	11.56781	2022-09-(XSLX5164.	Person		1				
16	48.15019	11.56781	2022-09-(XSLX5164.	Window		9	1:18 PM			44810.55455
17	48.15022	11.56774	2022-09-(WUCK587:	Motorcycle		1	1:18 PM			44810.55461
18	48.15022	11.56774	2022-09-(WUCK587:	Land_vehic		1	1:18 PM			44810.55461
19	48.15022	11.56774	2022-09-(WUCK587:	Car		5	1:18 PM			44810.55461

A	B	C	D	E	F	G	H
1	latitude	longitude	datetime	filename	object_name	object_quantity	
2	48.15	11.566	2022-01-	YKAU41	Car		1:20 PM
46	48.15	11.56848	2022-09-(QPRY1883	Tree		2	1:17 PM
47	48.15	11.56848	2022-09-(QPRY1883	Building		3	1:17 PM
48	48.15	11.56848	2022-09-(QPRY1883	Car		1	1:17 PM
49	48.15	11.56848	2022-09-(QPRY1883	Window		15	1:17 PM
50	48.15	11.56848	2022-09-(QPRY1883	Person		3	1:17 PM
51	48.15	11.56848	2022-09-(QPRY1883	Wheel		2	1:17 PM
52	48.15	11.56848	2022-09-(QPRY1883	Footwear		2	1:17 PM
53	48.15	11.56848	2022-09-(QPRY1883	Plant		1	1:17 PM
69	48.15003	11.56842	2022-09-(OWGX423	Building		2	1:17 PM
70	48.15003	11.56842	2022-09-(OWGX423	Tree		6	1:17 PM
71	48.15003	11.56842	2022-09-(OWGX423	Person		4	1:17 PM
72	48.15003	11.56842	2022-09-(OWGX423	Footwear		1	1:17 PM
73	48.15003	11.56842	2022-09-(OWGX423	Window		7	1:17 PM
74	48.15003	11.56842	2022-09-(OWGX423	Plant		2	1:17 PM
75	48.15003	11.56842	2022-09-(OWGX423	Car		1	1:17 PM
79	48.14989	11.56865	2022-09-(KRRO6651	Car		4	1:17 PM
80	48.14989	11.56865	2022-09-(KRRO6651	Building		3	1:17 PM
81	48.14989	11.56865	2022-09-(KRRO6651	Tree		6	1:17 PM

Temporal Map of the Region

We now have a temporal map that shows the information between 1:17 pm – 1:18 pm

and between 1:18 – 1:20 pm



Useful Apps

Useful APPs

The process of taking geo-tagged photos can be assisted with some time-lapse-taking Apps

For example:

Skyflow (User-defined intervals + GPS + JPEG format) <https://apps.apple.com/us/app/skyflow-time-lapse-shooting/id937208291>

App Store Preview

This app is available only on the App Store for iPhone, iPad, and Apple Watch.



Skyflow – Time-lapse shooting 4+

Andrey Kovalyov

★★★★★ 4.7 • 373 Ratings

Free - Offers In-App Purchases

Screenshots iPhone iPad Apple Watch

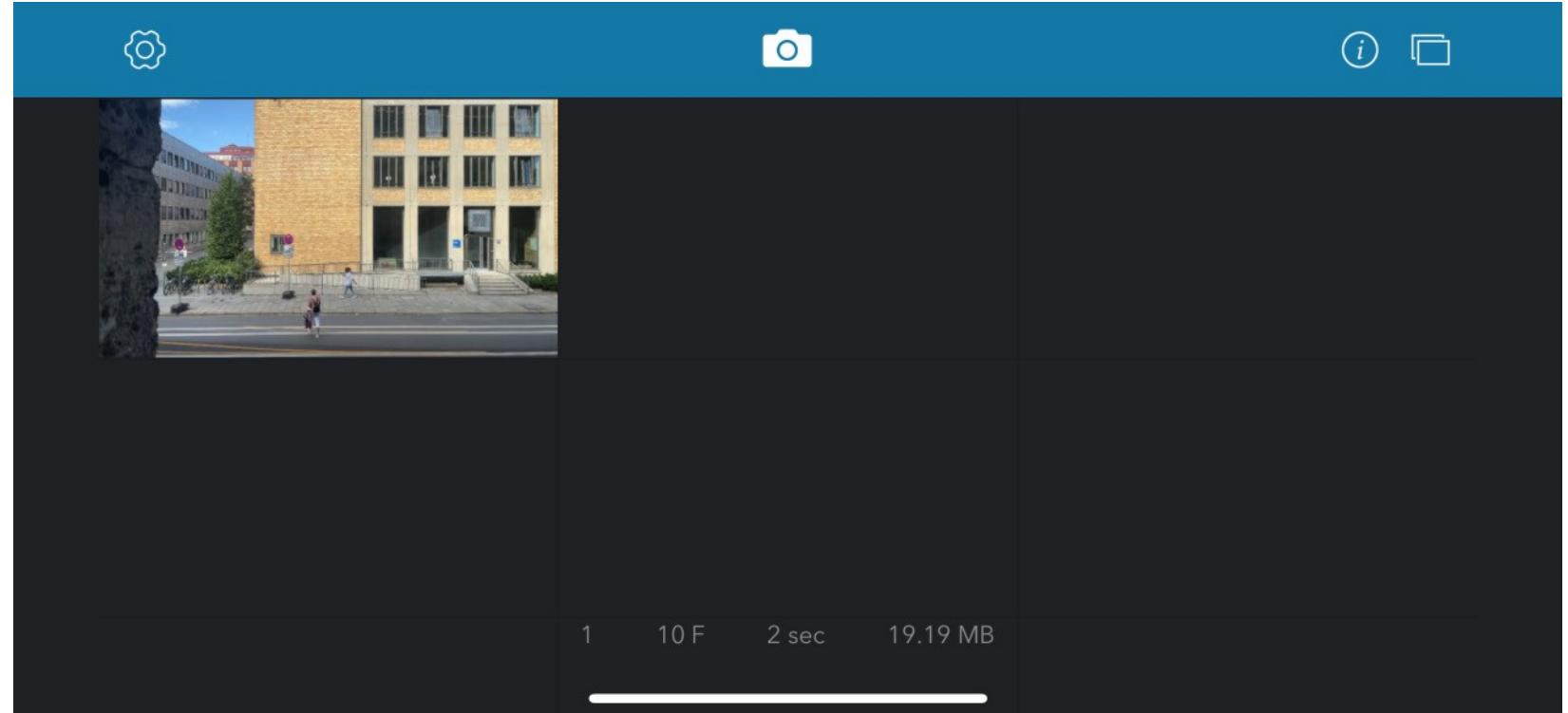


Skyflow is an incredibly handy and functional tool for photographers who aim for the best quality time-lapse shooting!

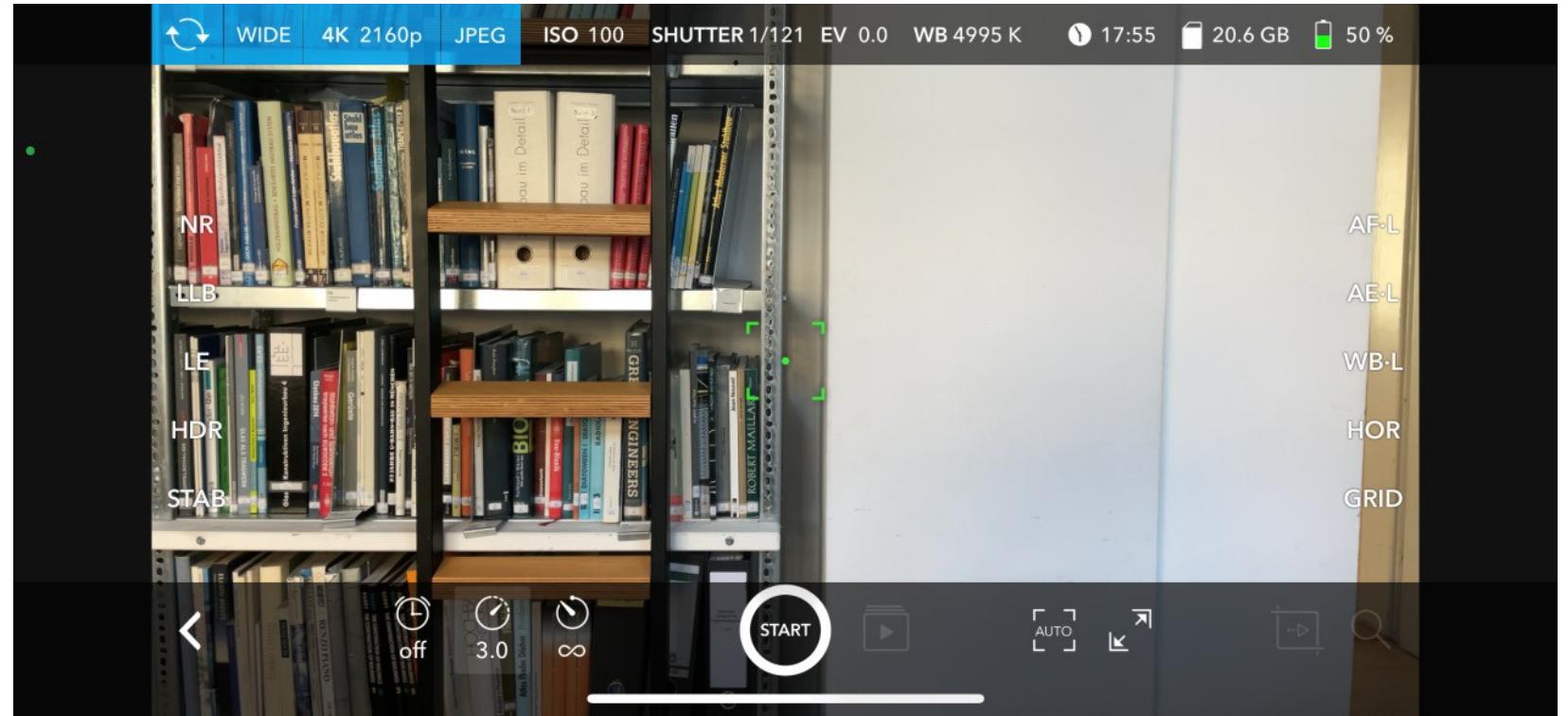
It has many options, such as choice of shooting resolution and format, motion blur and light trails effects, HDR, panning motion and more.

After shooting is complete you'll need to export your time-lapse as a video file or image sequence. And the most amazing feature of Skyflow is that it allows you to change the playback speed of the final video even after the end of shooting!

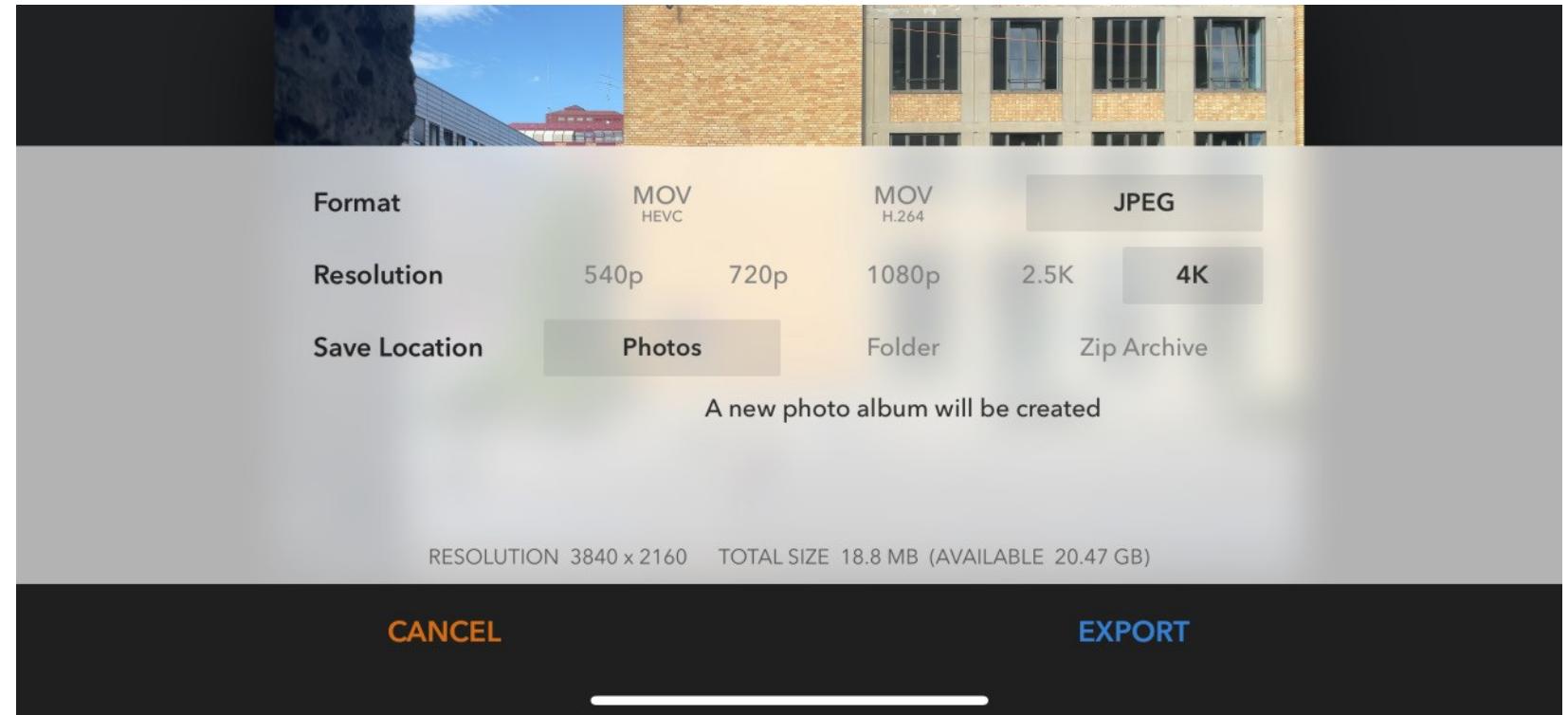
Main Window and Recordings



Camera and Settings



Exports



Important

Make sure these two settings **match**

Otherwise, the software resizes the images and we lose GPS coordinate

