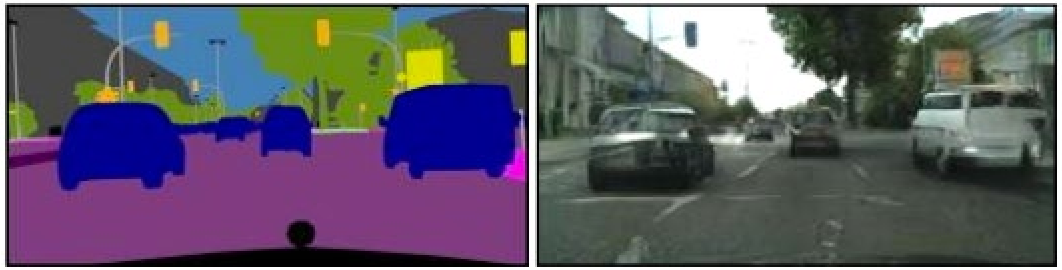
AI for the Media

Week 6, Domain 2 Domain



18.2.2022 / UAL-CCI

~ Vít Růžička

Overview

Domain 2 Domain Models (*pre-recorded lecture*):

- **What can we do** with these models?
- **What does the model need?**
  - Combining what we already learned about to make this work!
- **Limitations and follow-up models**

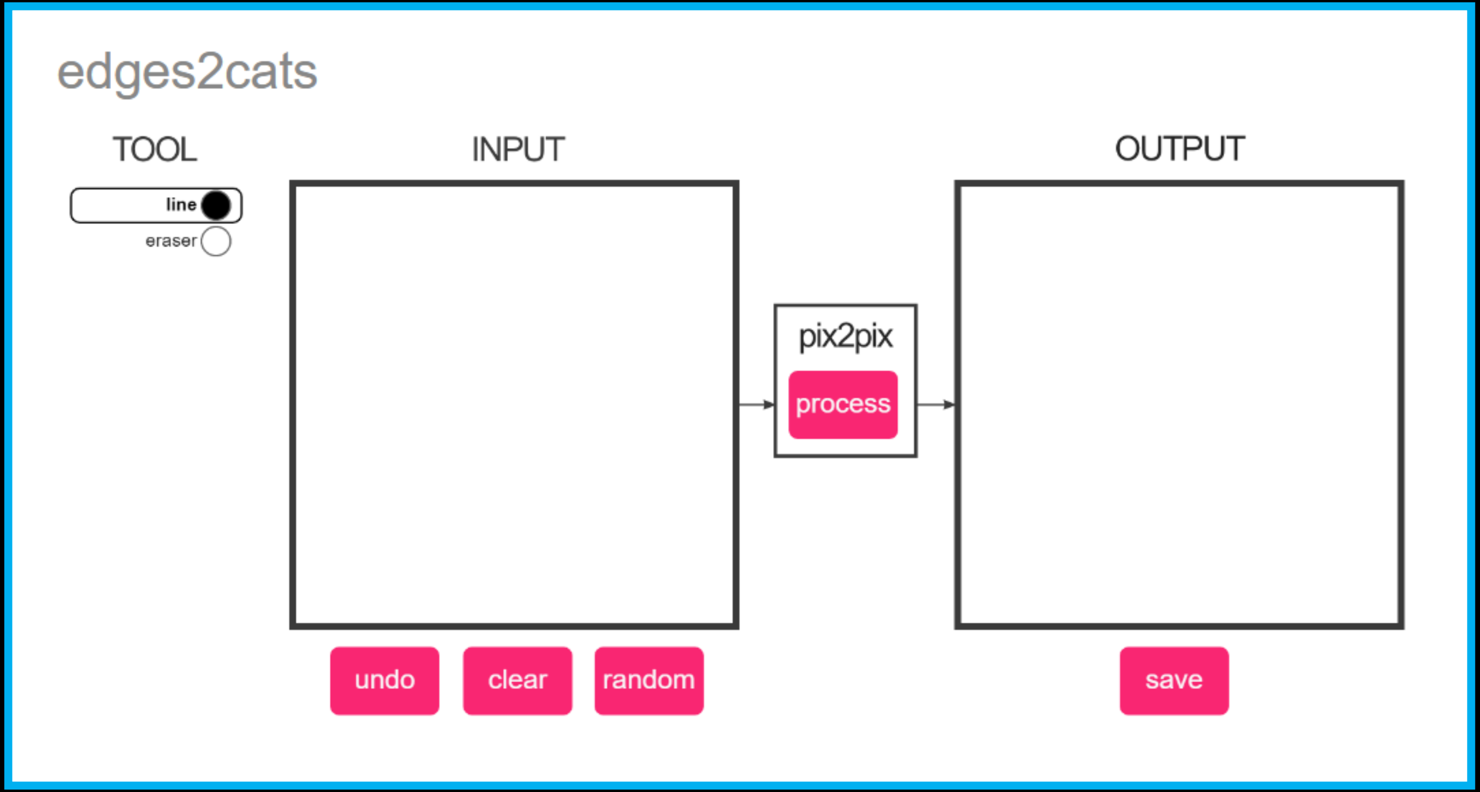
Practical session (*during the live session*):

- **Code**: Training a pix2pix model

I Motivation

Motivation for today

Domain to domain (or image to image) **models**



pix2pix (2017)

Online demo:

affinelayer.com/pixsrv/

Example 1: Learning to see…

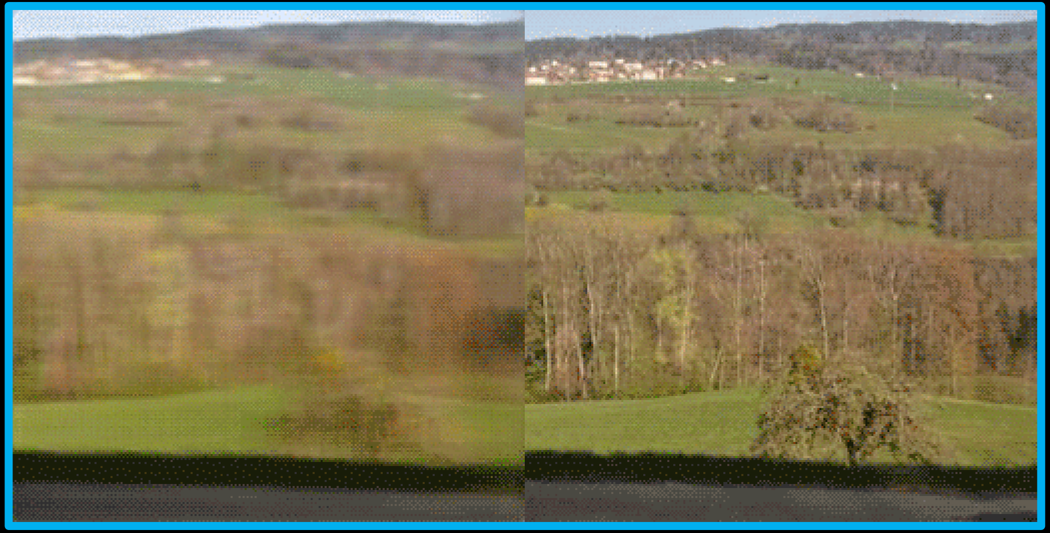
- Custom **pix2pix** running in real-time and interactively at the “AI: More than Human” exhibition at Barbican

Video: vimeo.com/260612034
Info: memo.tv/works/learning-to-see/

Learning to see: Gloomy Sunday, Memo Akten, 2017

Example 2: Predicting the future …

- Uses **pix2pix** trained on a sequence of frames from a video
    - Also shows the progress of the trained network (rubbish at the beginning, but gets better)

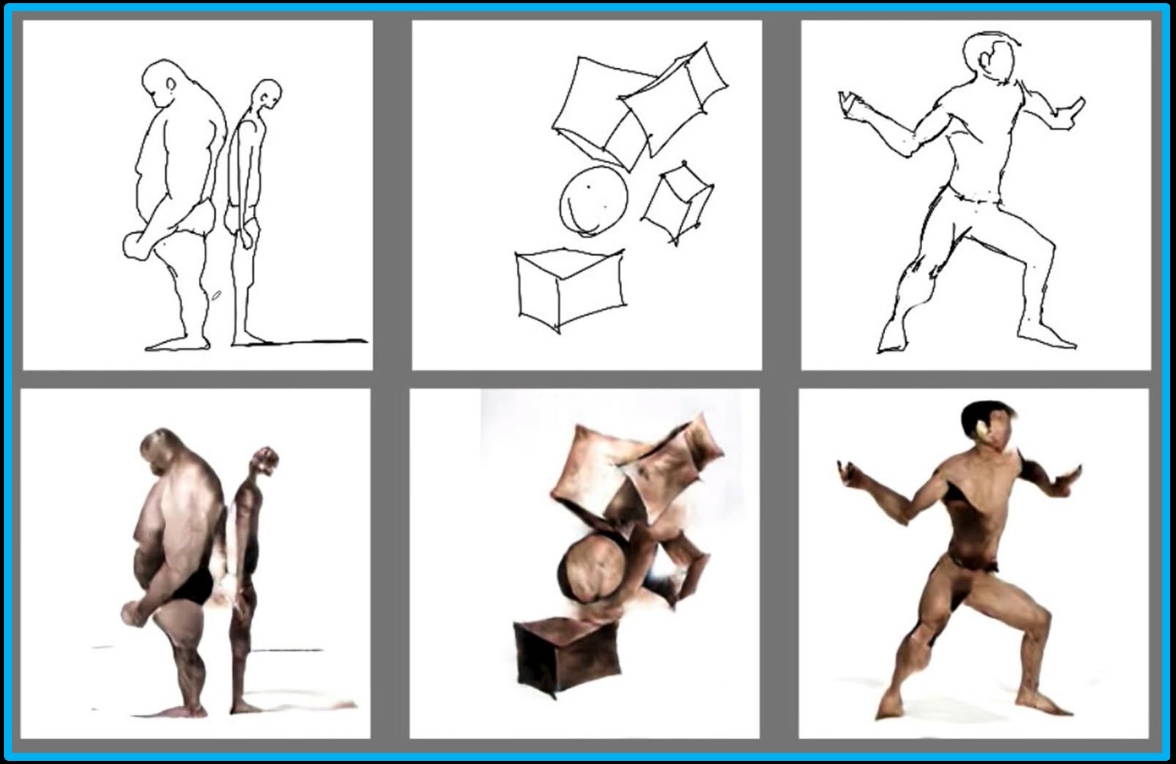


Video: youtube.com/watch?v=lr59AhOPgWQ
Blog: https://magenta.tensorflow.org/nfp_p2p

Predicting the future, one frame at a time, Damien Henry, 2017

Example 3: Sculpting with AI …

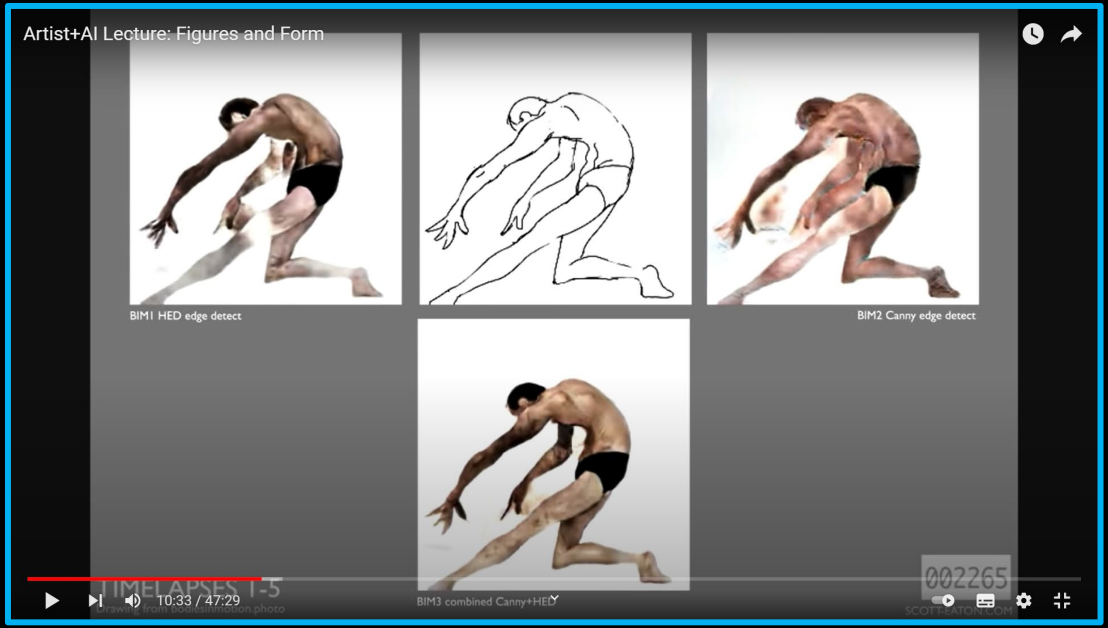
- Improved versions of **pix2pix** trained with custom dataset of human bodies



Video: youtube.com/watch?v=TN7Ydx9ygPo
Info: nvidia.com/en-us/research/ai-art-gallery/artists/scott-eaton/

"Human Allocation of Space" and "Experiments with Geometry & Motion, I", Scott Eaton, 2019-2020

Scott Eaton’s description



https://youtu.be/TN7Ydx9ygPo?t=480

Motivation for today

Learning how these artworks were made!

Dataset:

Motivation for today

Learning how these artworks were made!

Dataset:

To edges:

Motivation for today

Learning how these artworks were made!

Dataset:

To edges:

Train a model on this translation

Motivation for today

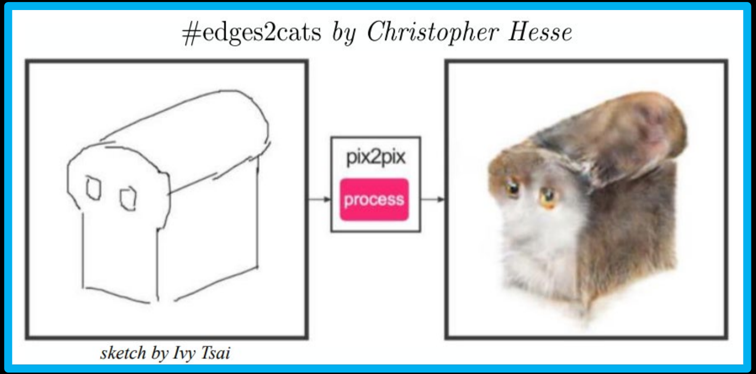
Learning how these artworks were made!

Dataset:

To edges:

Train a model on this translation

Then use the model on new kinds of data:



II How to get there?

Domain to Domain

Images from domain A

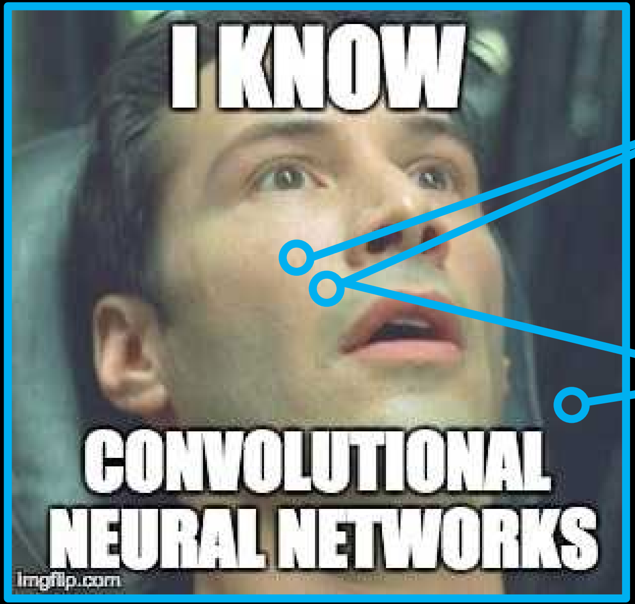
???

Images from domain B

What kind of model can we use here?

Convolutional layers (recap)

Intuition: working with images

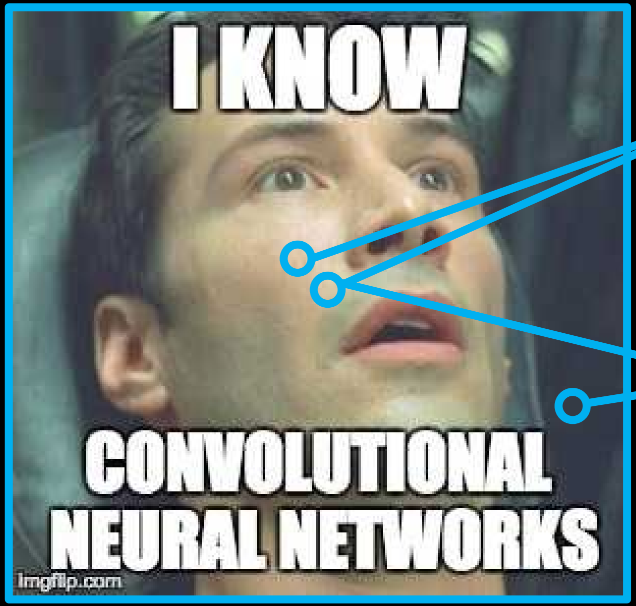


Nearby pixels correspond.

Far away pixels don't.

Convolutional layers (recap)

Intuition: working with images



Nearby pixels correspond.

Far away pixels don't.

<u>Manual</u> Convolutional filter:

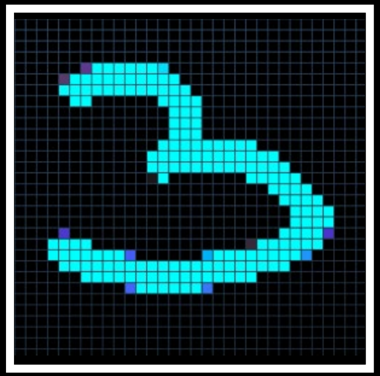
emboss

-2	-1	0
-1	1	1
0	1	2

3x3 conv

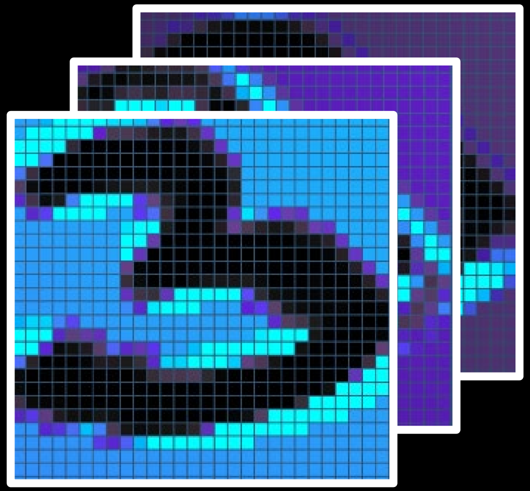
Convolutional layers (recap)

<u>Learned</u> Convolutional filters:



Input to the layer

Layer with 5x5 convolution



Outputs of the convolution

- Interactive Convolutional Neural Network (runs in the browser and has good visualization): cs.cmu.edu/~aharley/vis/conv/flat.html

First idea: Convolutional NN

Images from domain A

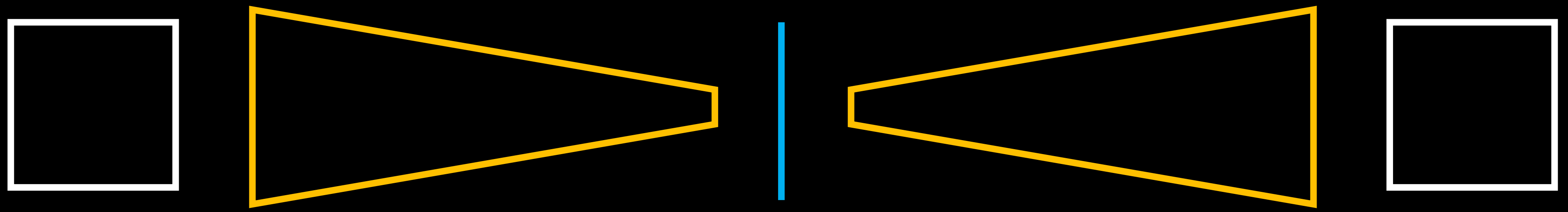
Fully Convolutional Neural Network ?

Images from domain B

- "Fully Convolutional" with only convolutional layers
- Problem: Too complicated task, no separation for different object sizes

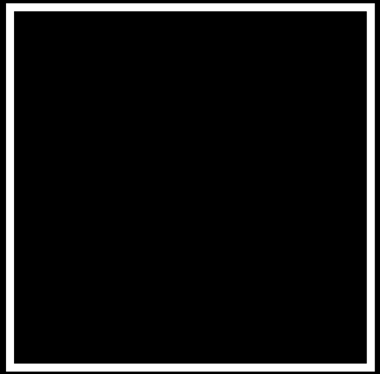
Encoder-Decoder models (recap)

Auto-encoder models

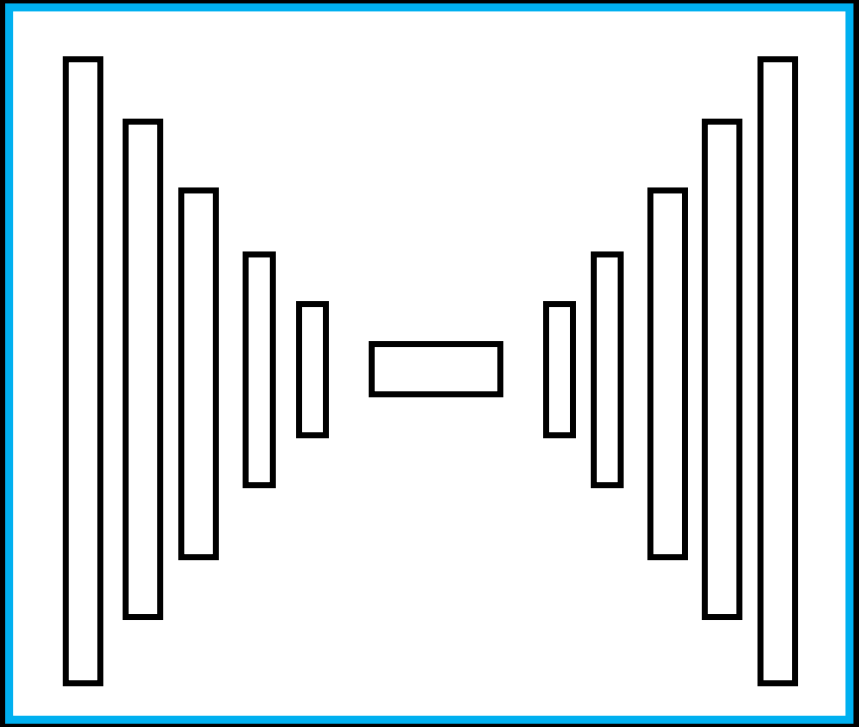


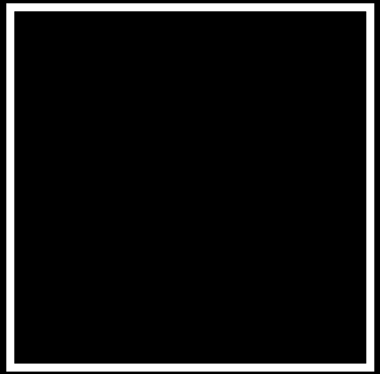
- AE models are trained to reconstruct images as best as they can, while forcing the image through a lower dimensional latent vector

Second idea: Auto-Encoders



Images from domain A



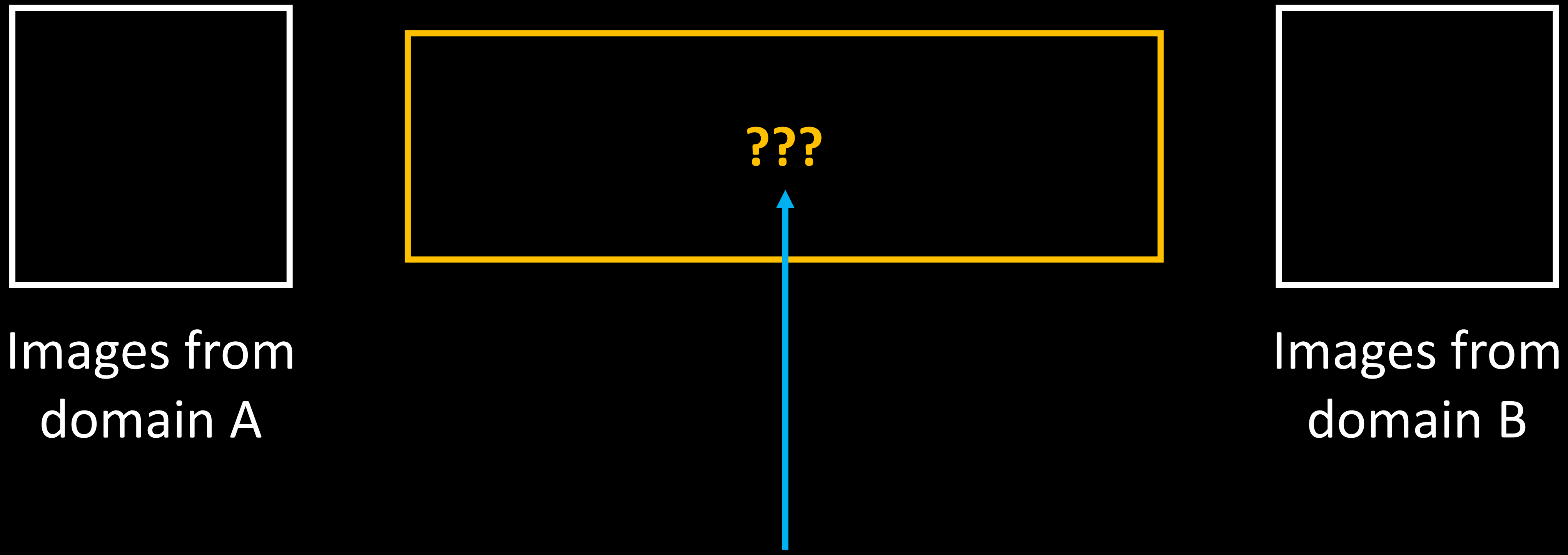


Images from domain B

- Encoder-decoder architecture to learn the translation?
- Problem: AE models force the reconstruction through a small bottleneck
    - We loose a lot of information in the process and the results would be *blurry*

***)** PS: now it’s a good time to take a pause

Domain to Domain

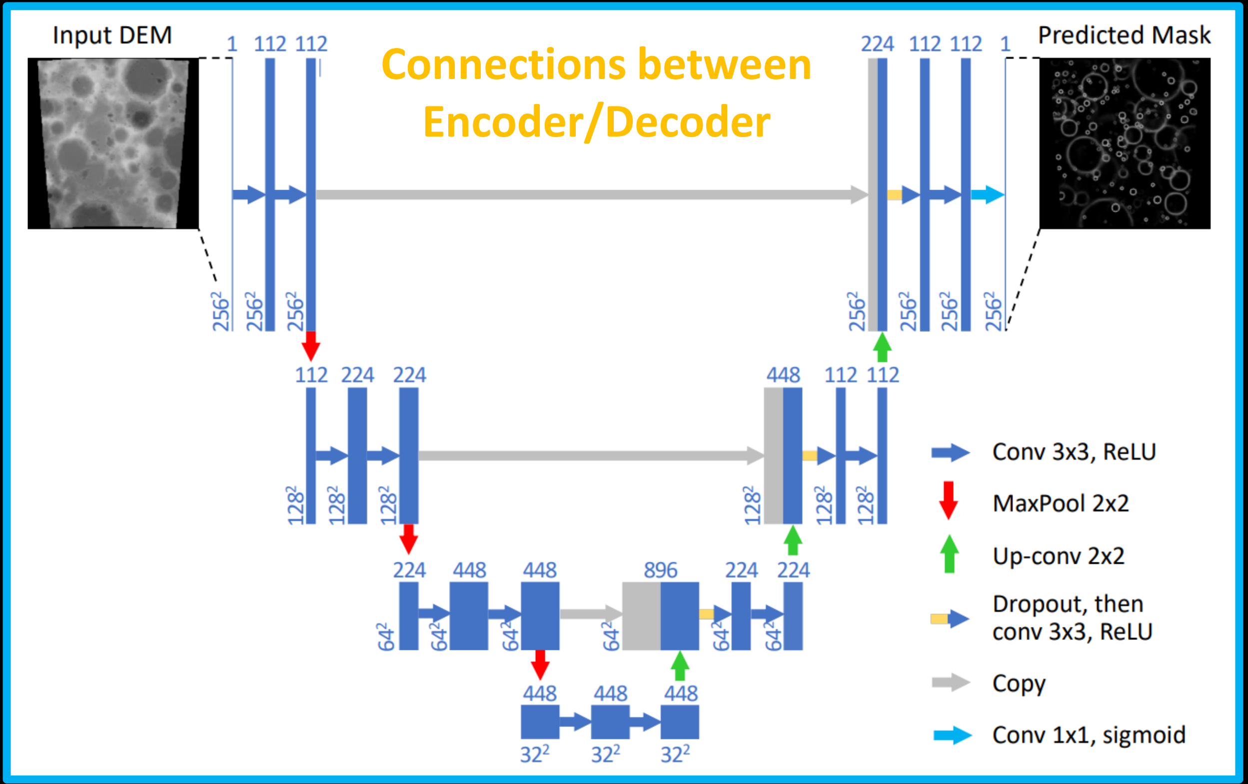


What kind of model can we use here?

Not: Fully Conv NNs, AutoEncoders, …

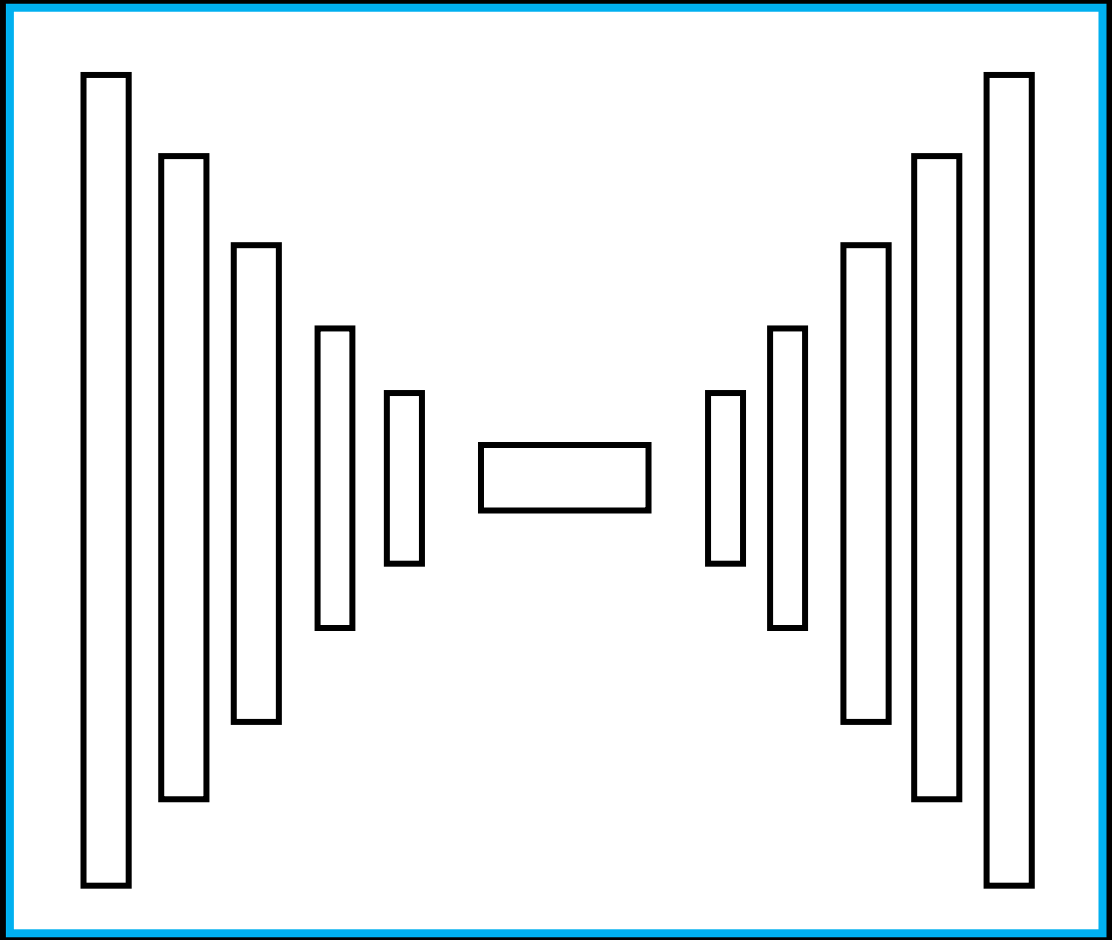
Adding skip connections

- Idea for the **U-Net model**:
  - Add **skip connections** between the encoder and decoder networks
  - Paper with U-Net applied on the task of lunar crater identification

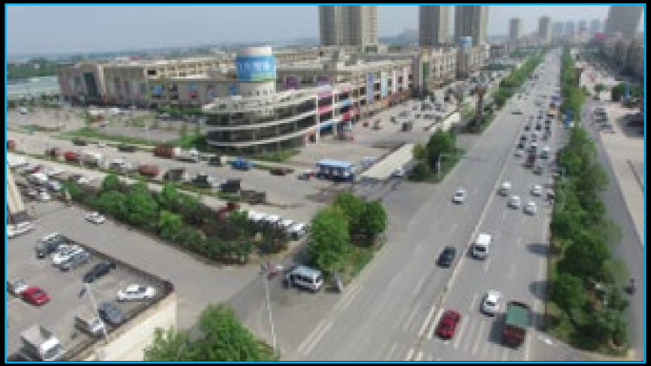


(PS: U-Net is from 2015, this paper from 2018)

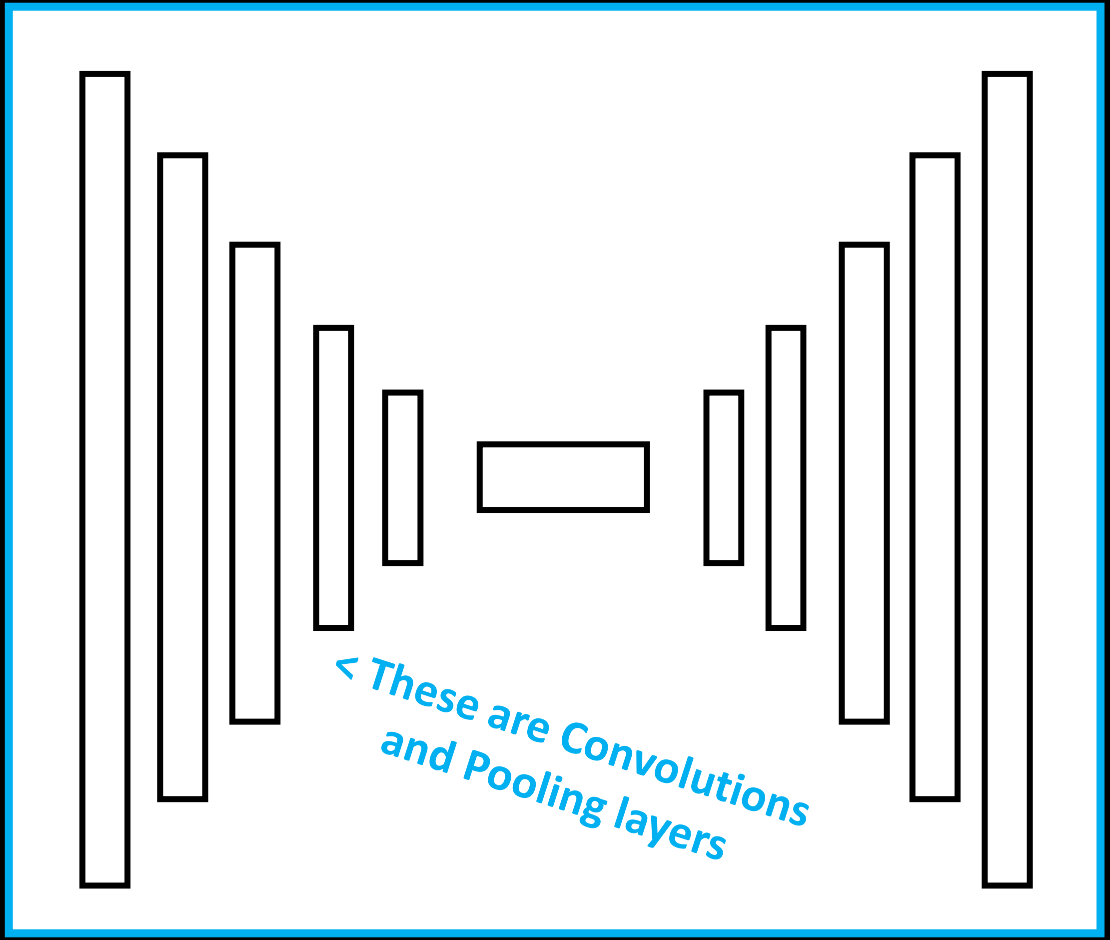
U-Net

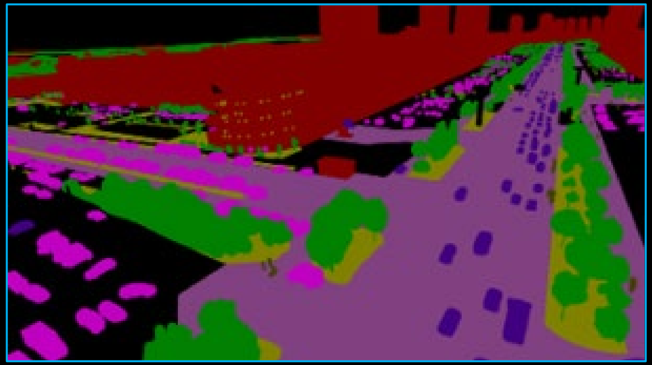


U-Net



Images from one "domain"

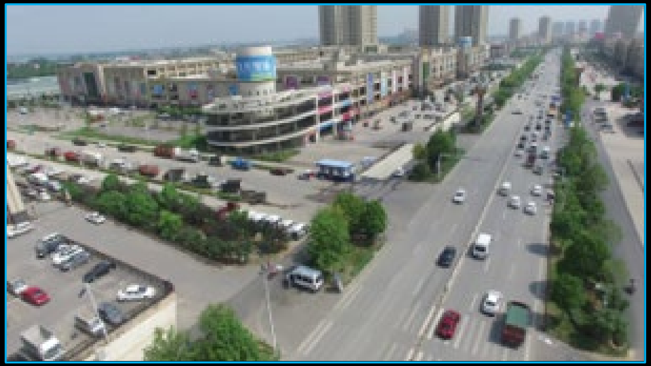




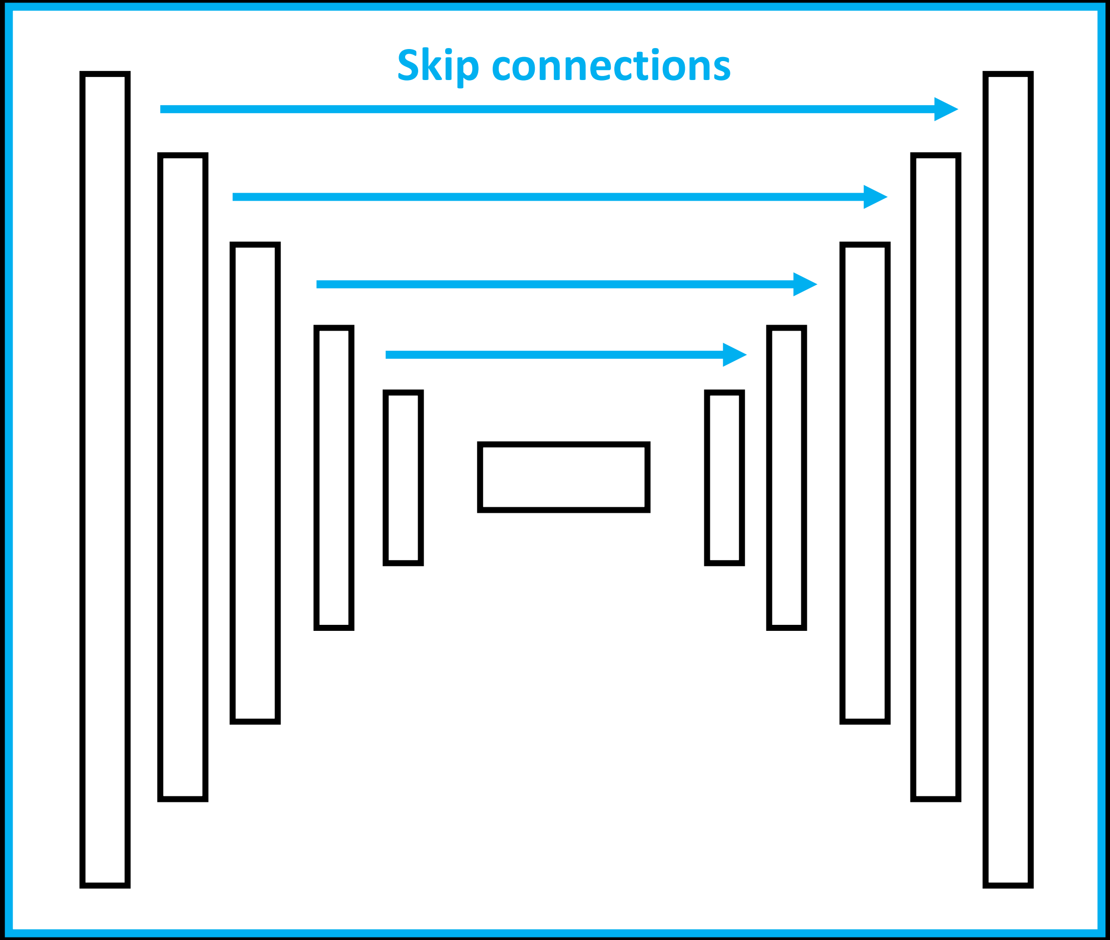
Paired images from another "domain"

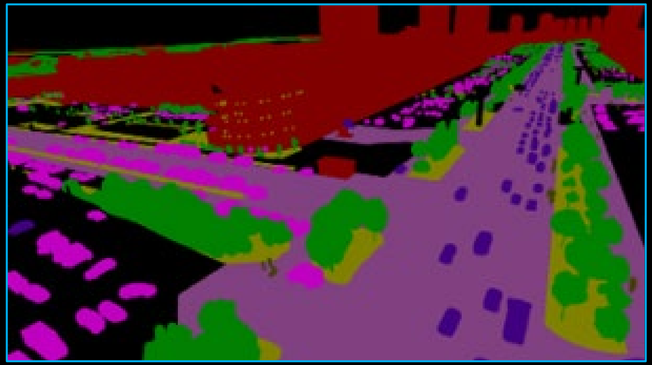
- Connects one image to another while going through a bottleneck

U-Net



Images from one "domain"

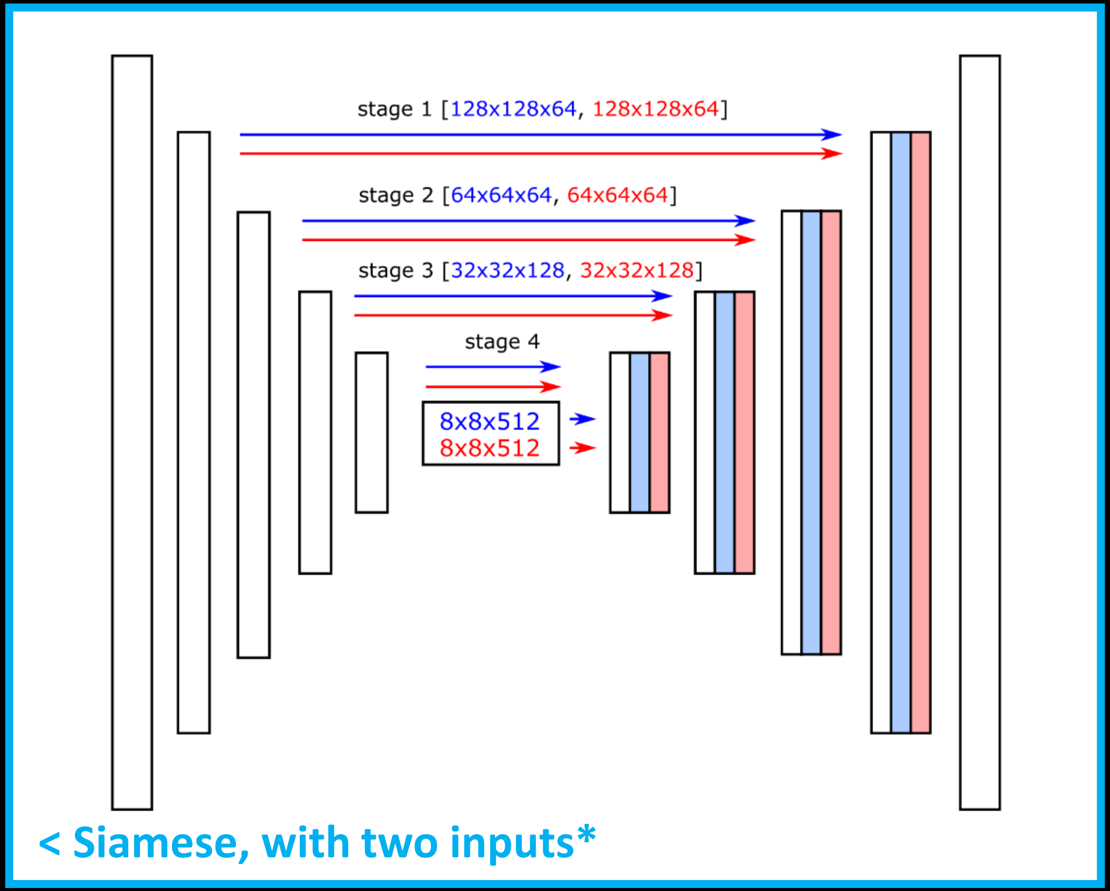




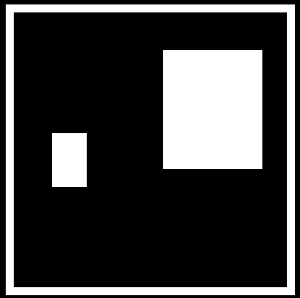
Paired images from another "domain"

- Additionally: "*skip connections*" that allow the information to flow

U-Net in a real-world scenario



Label

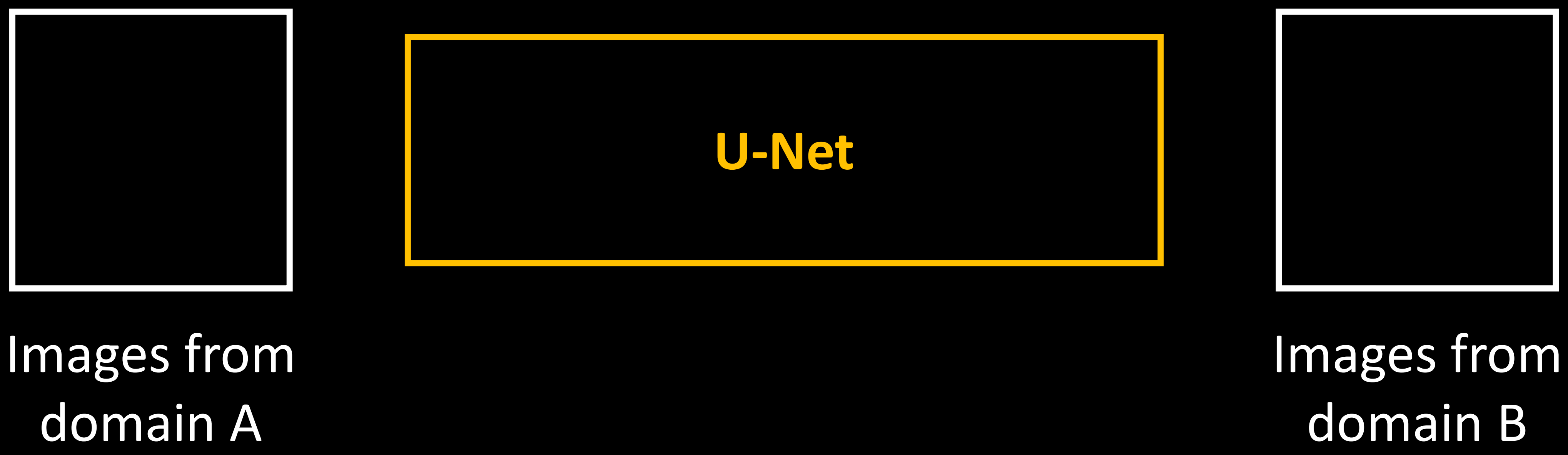


Prediction

- Can be adapted to many tasks – for example this “change detection”, where it needed to learn *which kind of change* we care about

* Our paper from 2020: https://arxiv.org/abs/2008.11201

Third idea: U-Net

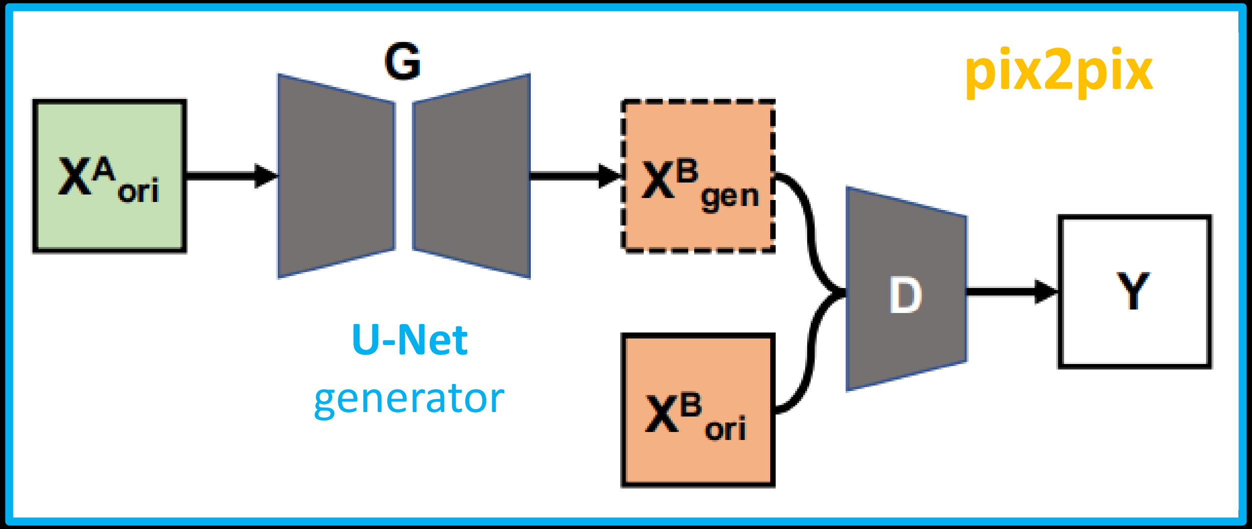


- Encoder-decoder model with skip connections
- Almost there! We can do even better … < Add adversarial training

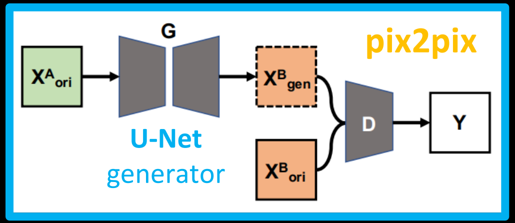
III **pix2pix** model

Pix2Pix

- Uses ideas from the Generative Adversarial Network (GAN) models
  - Generator is a U-Net network
  - With the **addition of the discriminator network and adversarial training**



Final idea: pix2pix



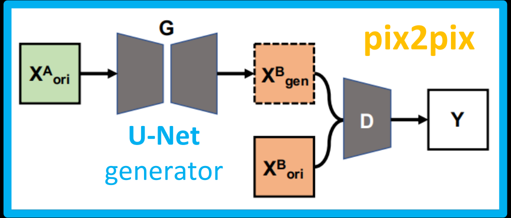
pix2pix *(the trained generator network bit)*

Images from domain A

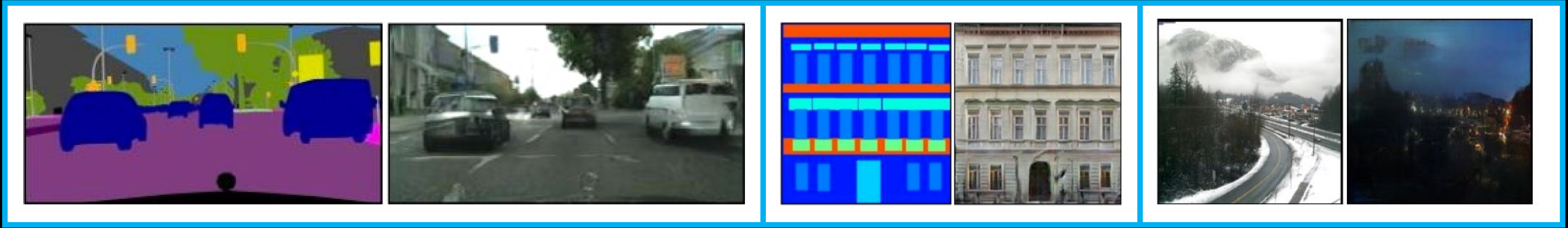
Images from domain B

- Encoder-decoder model with skip connections with adversarial training helping the quality of the generative model

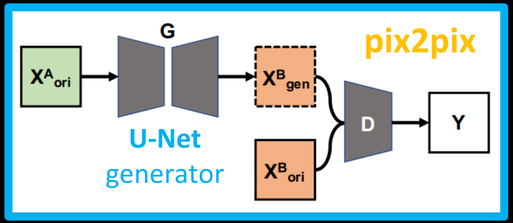
Pix2Pix



- General purpose **image-to-image translation:**
  - From their 2017 paper: *"Many problems in image processing, computer graphics, and computer vision can be posed as "translating" an input image into a corresponding output image."*
  - Translating without specifically defining the rules – data-driven translating between two domains by showing **paired** examples:
    - [Image from A, Corresponding Image from B] * N samples



Pix2Pix



- General purpose **image-to-image translation:**

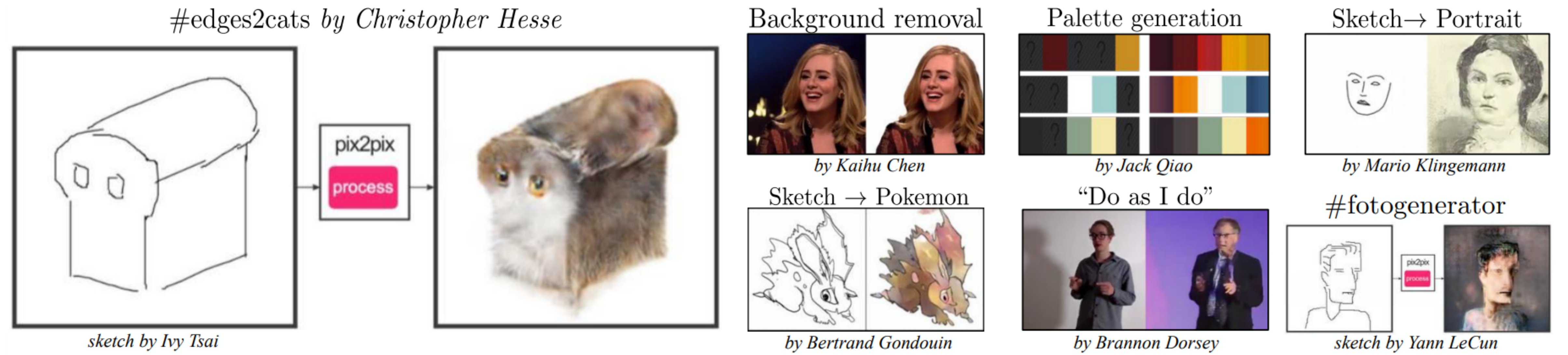
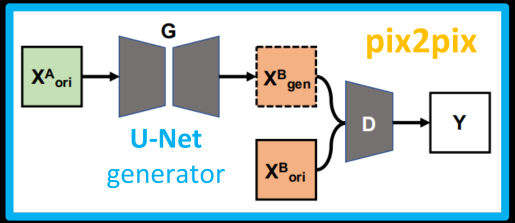


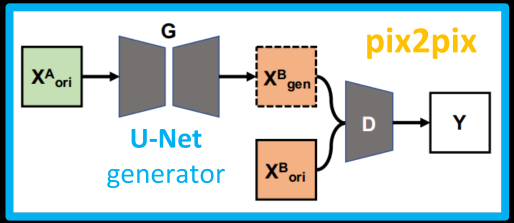
Figure 11: Example applications developed by online community based on our `pix2pix` codebase: *#edges2cats* [3] by Christopher Hesse, *Background removal* [6] by Kaihu Chen, *Palette generation* [5] by Jack Qiao, *Sketch → Portrait* [7] by Mario Klingemann, *Sketch→ Pokemon* [1] by Bertrand Gondouin, *"Do As I Do" pose transfer* [2] by Brannon Dorsey, and *#fotogenerator* by Bosman et al. [4].

Pix2Pix limitations



- For training it needs **paired data**
  - dataset of images from domain A, and dataset of corresponding images from domain B
  - Simple example *"horse 2 zebra"* model, would require careful arranging of animals

Pix2Pix limitations



- For training it needs **paired data**
  $\Rightarrow$ **CycleGAN** (next week)
  - dataset of images from domain A, and dataset of corresponding images from domain B
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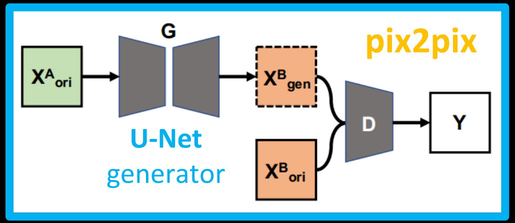
Pix2Pix limitations



- For training it needs **paired data** $\Rightarrow$ **CycleGAN** (next week)
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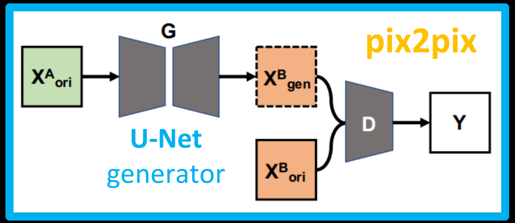
- Basic pix2pix has relatively **low resolution**

Pix2Pix limitations



- For training it needs **paired data** ⇒ **CycleGAN** (next week)
  - dataset of images from domain A, and dataset of corresponding images from domain B
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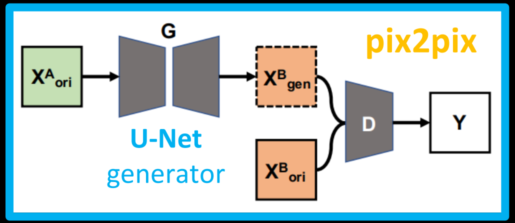
- Basic pix2pix has relatively **low resolution** ⇒ **pix2pixHD**

Pix2Pix limitations



- For training it needs **paired data** $\Rightarrow$ **CycleGAN** (next week)
  - dataset of images from domain A, and dataset of corresponding images from domain B
  - Simple example *"horse 2 zebra"* model, would require careful arranging of animals
- Basic pix2pix has relatively **low resolution** $\Rightarrow$ **pix2pixHD**
- For animation, we want something to enforce **temporal consistency** between consecutive frames

IV **uses** and follow-up work

Follow-up papers?

- **Pix2Pix HD (2018)**
  - Allows **higher resolution** of the trained pictures (from 256x256px up to 2048x1024px!)

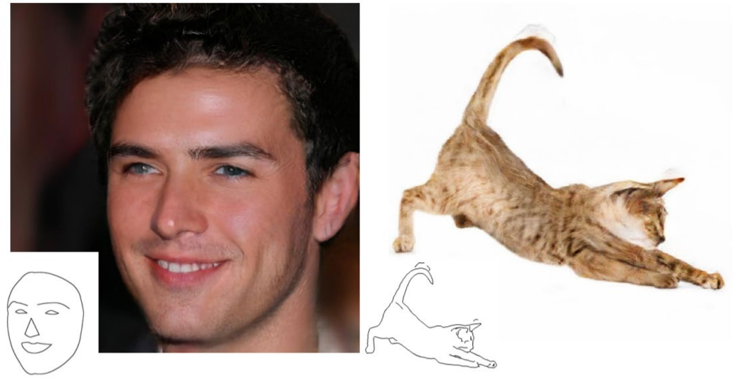


Figure 2: Example results of using our framework for translating edges to high-resolution natural photos, using CelebA-HQ [26] and internet cat images.

Code: github.com/NVIDIA/pix2pixHD

Example project:

GAN Theft Auto: Autonomous Texturing of Procedurally Generated Interactive Cities

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Lingdong Huang
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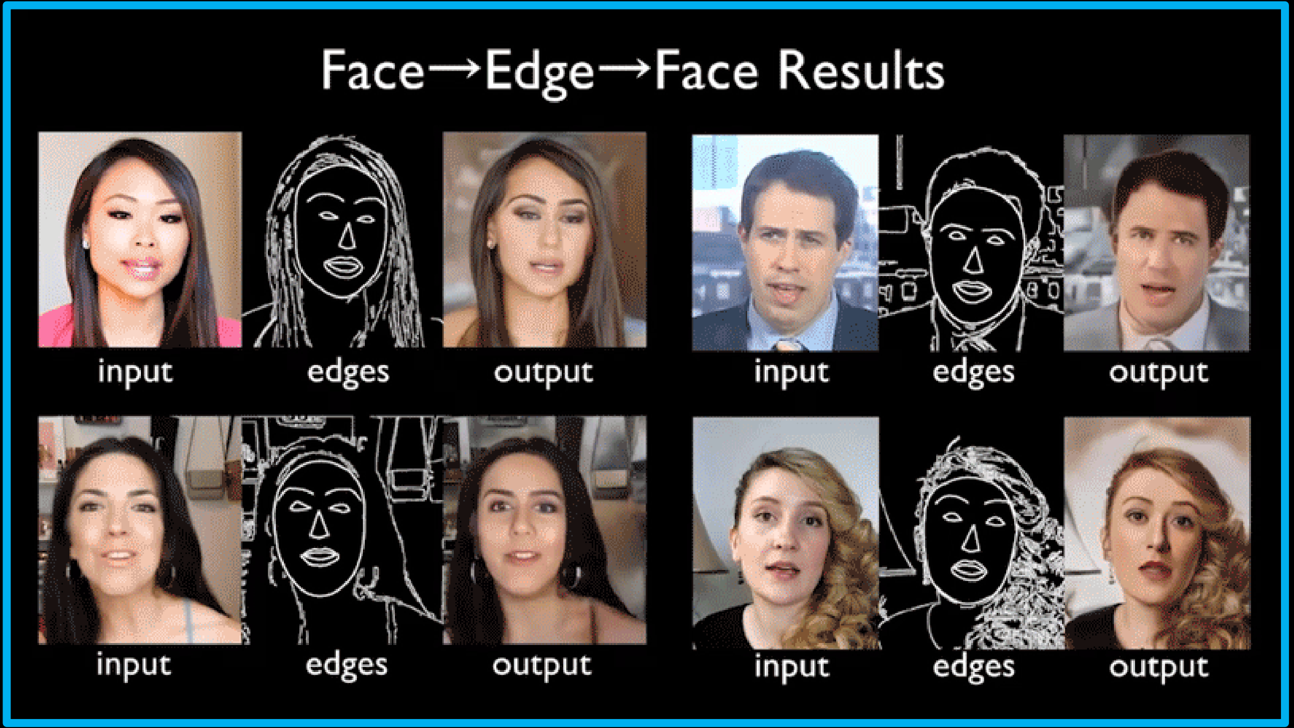
Hizal Çelik
Carnegie Mellon University
Pittsburgh, USA
hizalc@andrew.cmu.edu

Figure 1: Cross-views of Cityscape [Left] and GTA V [Right] texturings using Pix2PixHD.

Follow-up papers?

- **Vid2Vid (2018)**
  - Keep **temporal consistency** between frames



Code: github.com/NVIDIA/vid2vid

Follow-up papers?

- **SPADE** and the interactive demo **GauGAN (2019)**
  - **Interactive** painting tool based on pix2pix like models

Code: github.com/NVlabs/SPADE

Summary from the lecture

- **Combining ideas from last classes**, we can achieve image2image models:
  - **Convolutional layers** (working with images)
  - **Encoder decoder models** (split small details and large context)
  - **U-Nets: Skip connections** (allow information to keep at the original resolution)
  - **Adversarial training** (more realistic images)

Links and additional readings:

- **Online pix2pix demos**: affinelayer.com/pixsrv/
  - **Follow-up papers**: pix2pixHD (with high. res.), vid2vid (with frame to frame consistency), SPADE (interactive), … *(and many more…)*

- **Bonus readings:**
  - About **Pix2Pix** on ML4A – blog with code

End of the lecture

*) PS: follows material for the practical session …

AI for the Media

Week 6, Domain 2 Domain

Practical: **pix2pix training**

18.2.2022 / UAL-CCI

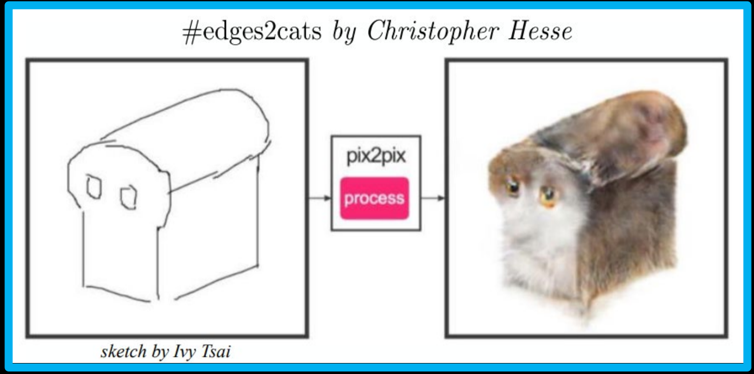
~ Vít Růžička

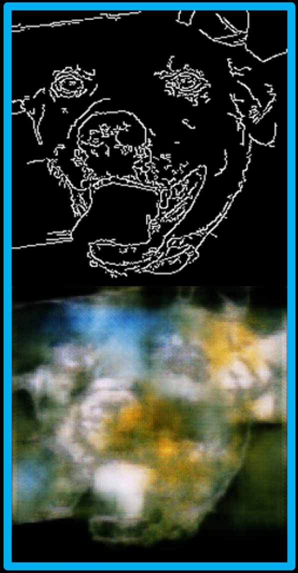
Practical: Domain 2 Domain

Training Pix2Pix models

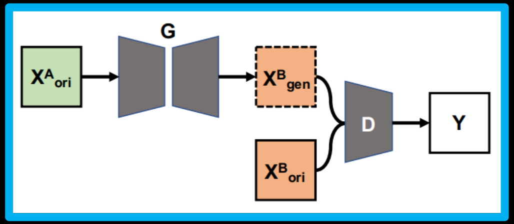
Namely using the sketch2image with our own data.

Continue with Colab demo on Github …

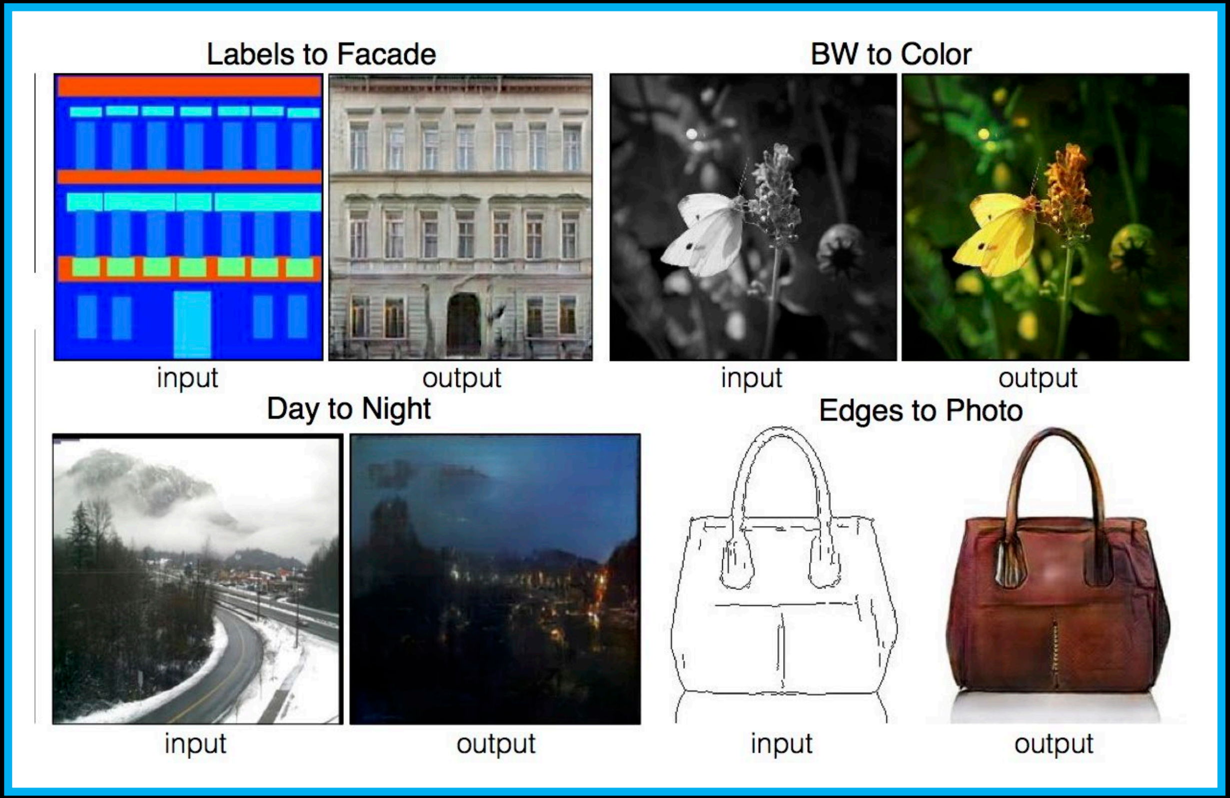




Pix2Pix



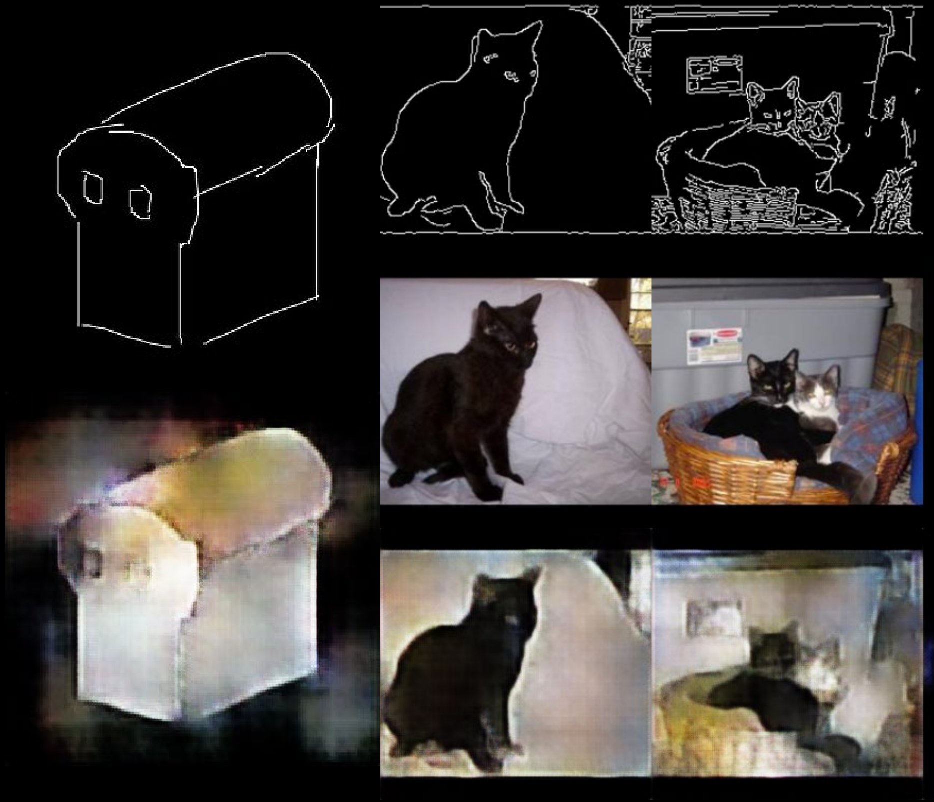
- You might recall that we will need **paired data** in our dataset:
  - Data from domain **A**
  - Data from domain **B**



- And we will be learning the **translation between A to B**

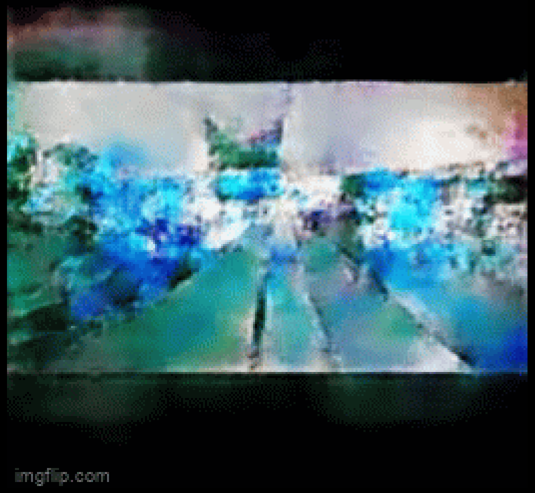
Examples from training:

- **ps:** remember that the model saw only the edges/sketch when reconstructing these images
- **(note)** the pix2pix demo's have much better quality of the trained models



Demo with a video ->

- Note that there is almost no temporal consistency between these frames …
- Longer **video:** here



The end