Introduction: How to Create an Image?

Jun-Yan Zhu

16-726, Spring 2021

Teaching Staff

Jun-Yan Zhu

Carnegie Mellon University

MIT

Adobe

- Computer Vision, Computer Graphics, Machine Learning, Computational Photography
- Love pets (cat & dog), gaming (mostly FIFA these days)

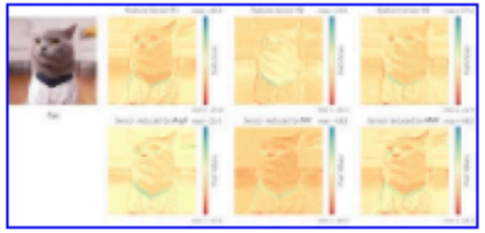
Cat Paper Collection

As reported by Cisco, 90% of net traffic will be visual, and indeed, most of the visual data are cat photos and videos. Thus, understanding, modeling, and synthesizing our feline friends becomes a more and more critical research problem these days, especially for our cat lovers.

Cat Paper Collection is an academic paper collection that includes computer graphics, computer vision, and machine learning papers that produce experimental results related to **cats**. If you would like to add/remove an article, please send an email to **Jun-Yan Zhu** (junyanz at cs dot cmu dot edu). We thank all the authors for their contribution and support.

See also **GitHub** | **CSV file**

Flow-edge Guided Video Completion
Chen Gao, Ayush Saraf, Jia-Bin Huang, Johannes Kopf
In ECCV 2020
[Paper] [Project]



Matching Guided Distillation
Kaiyu Yue, Jiangfan Deng, Feng Zhou
In ECCV 2020
[Paper] [Project]

Strong 3D Printing by TPMS Injection
Xin Yan, Cong Rao, Lin Lu, Andrei Sharf, Haisen Zhao, Baoquan Chen
In IEEE TVCG 2019
[Paper]

Viraj Mehta

- Interested in control, generative modeling, nuclear fusion
- From Austin, TX
- Undergrad in math at Stanford
- Fly airplanes
- Was on jeopardy once

Yufei

RI PhD student with Abhinav Gupta, Shubham Tulsiani
Sports lover: badminton, soccer, running, etc.

Born and raised in Beijing

13-17 Tsinghua CS

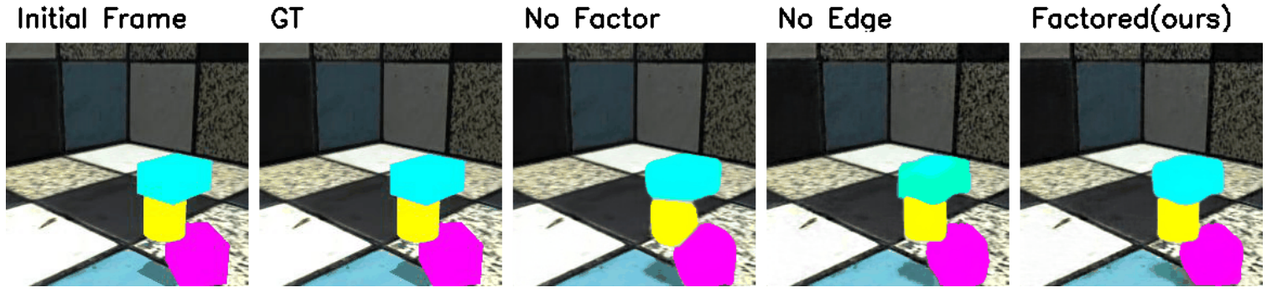
17-19 CMU MSR

19-??? CMU PhD

Spatial Inference for Generic Cats

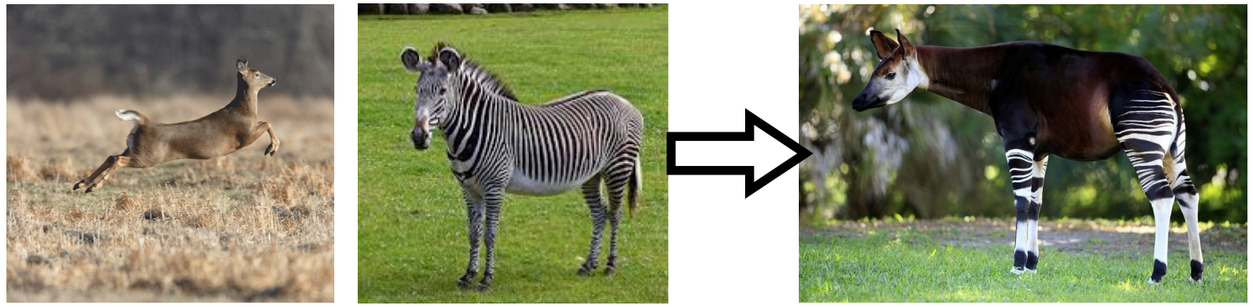
Weakly supervise 3D reconstruction using GAN.

Compositional Reps. of Interactions



Generate videos via scene graph using VAE.

Generalizing to Novel Categories



Generalize to novel categories using GNN.

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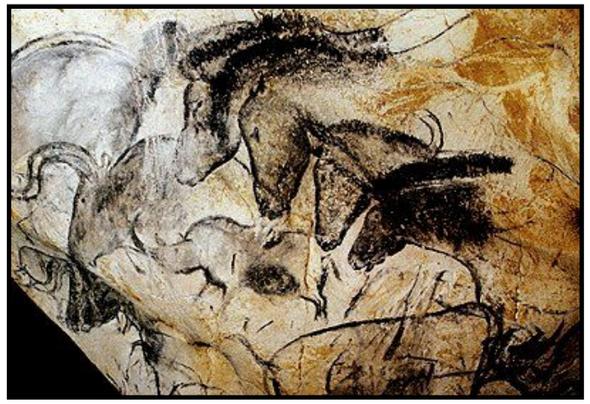
16-726, Spring 2021

Visual Content Creation

Cave art

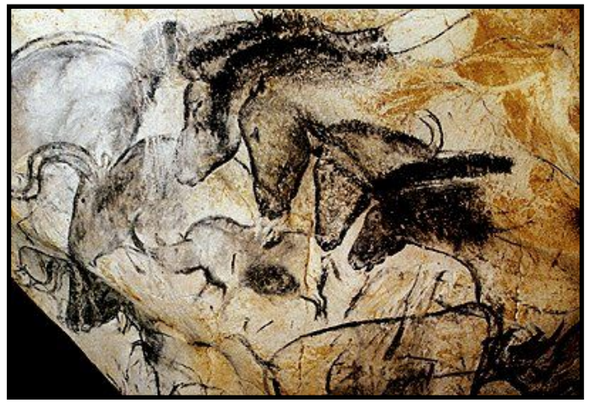


Time

32,000 BC

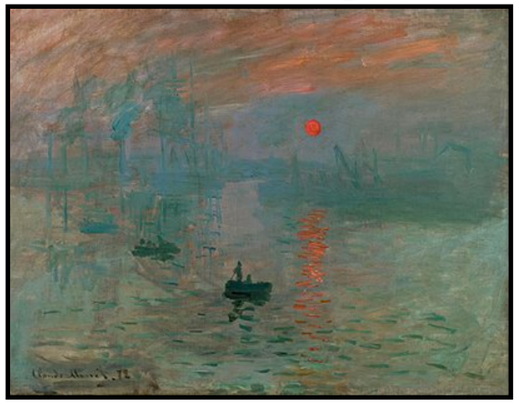
Visual Content Creation

Cave art



Sculpture

Painting



Time

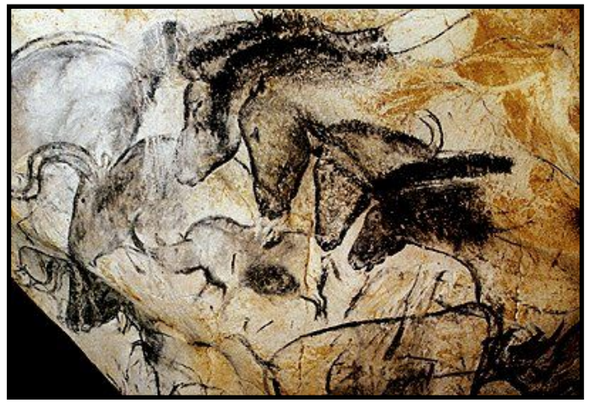
32,000 BC

1498

1872

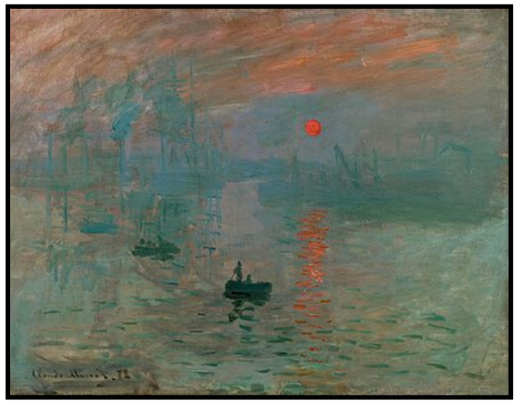
Visual Content Creation

Cave art



Sculpture

Painting



Computer Graphics

Time

32,000 BC

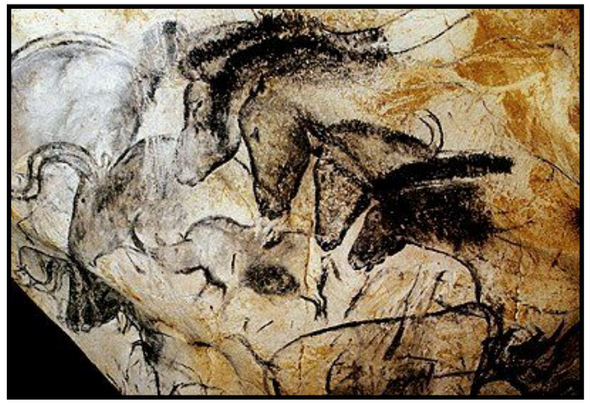
1498

1872

2012

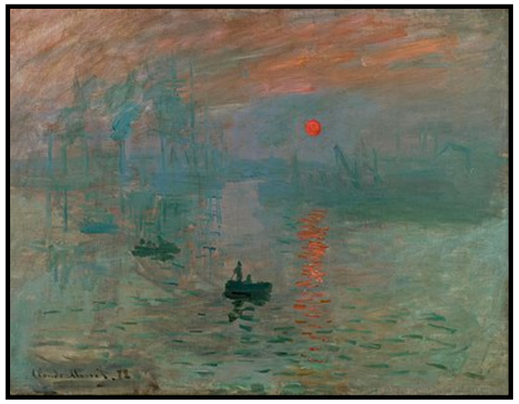
Who is creating visual content?

Cave art



Sculpture

Painting



Computer Graphics

Time

32,000 BC

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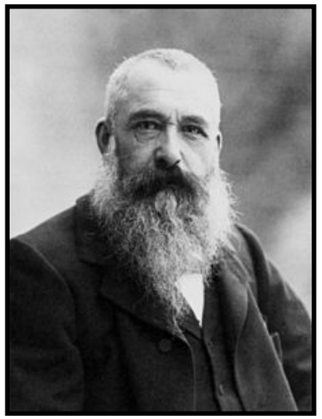
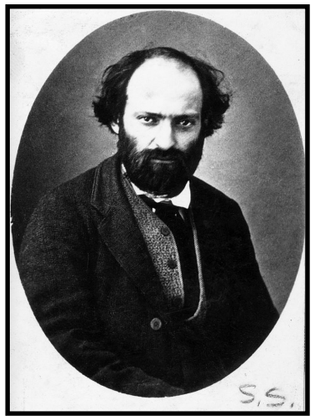
1872

2012

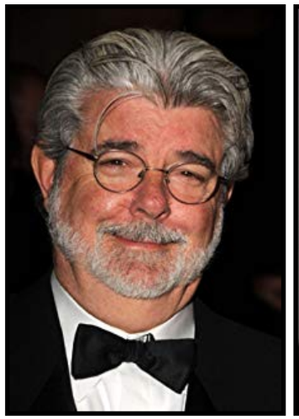
Michelangelo



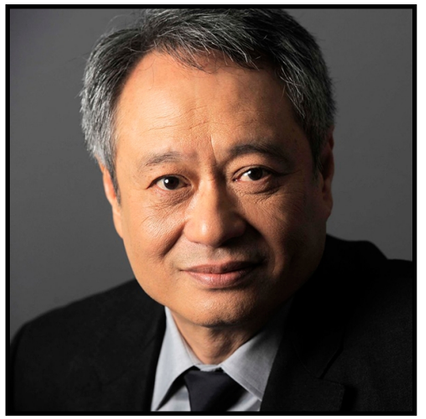
Claude Monet



Paul Cezanne

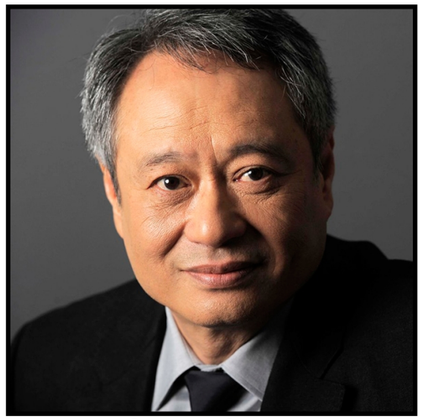


George Lucas

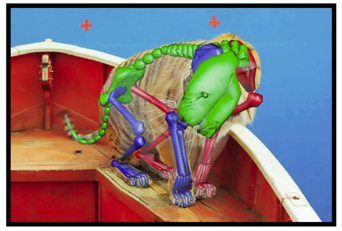


Ang Lee

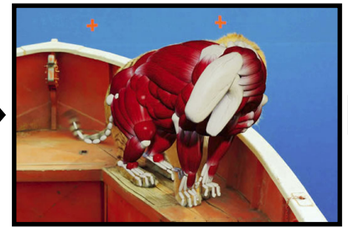
Who is creating visual content?



Ang Lee



Skeleton



Geometry

Texture

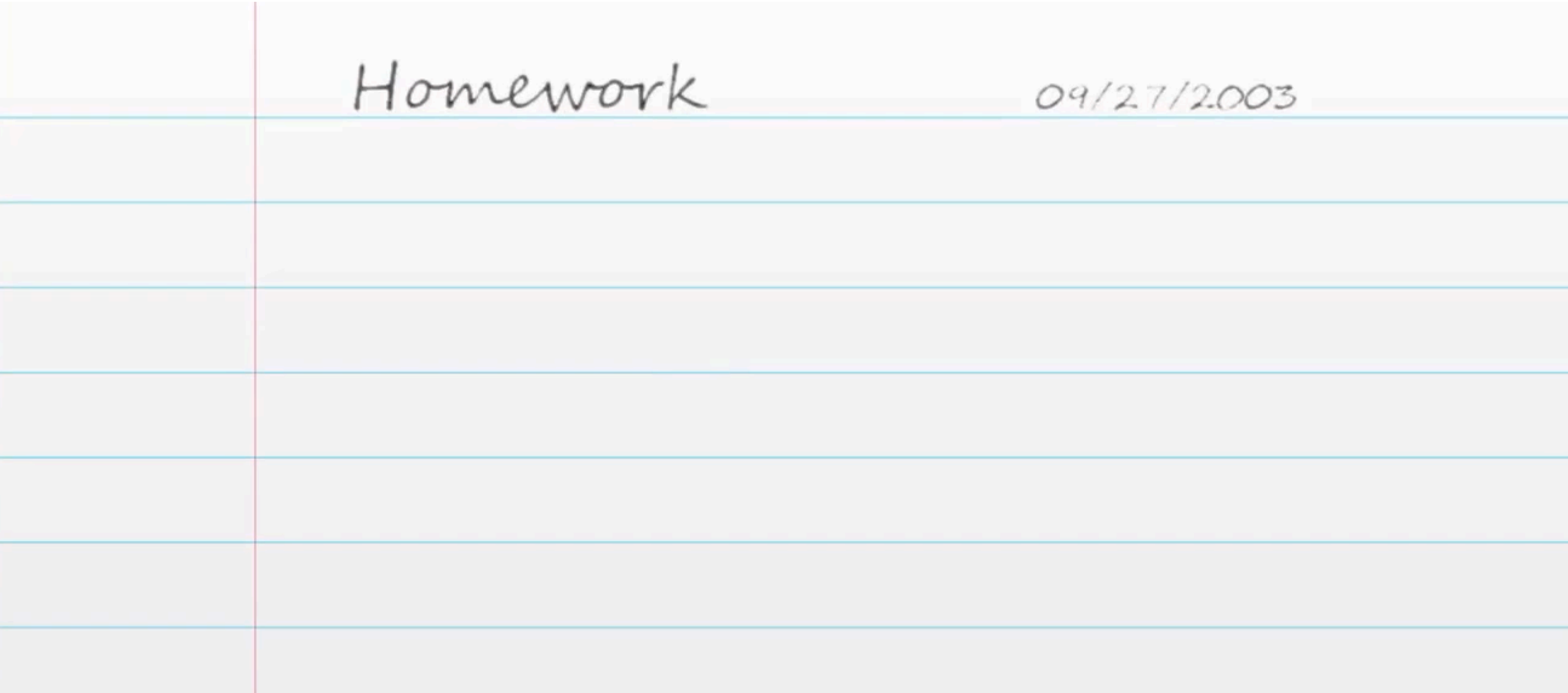
Details

Image

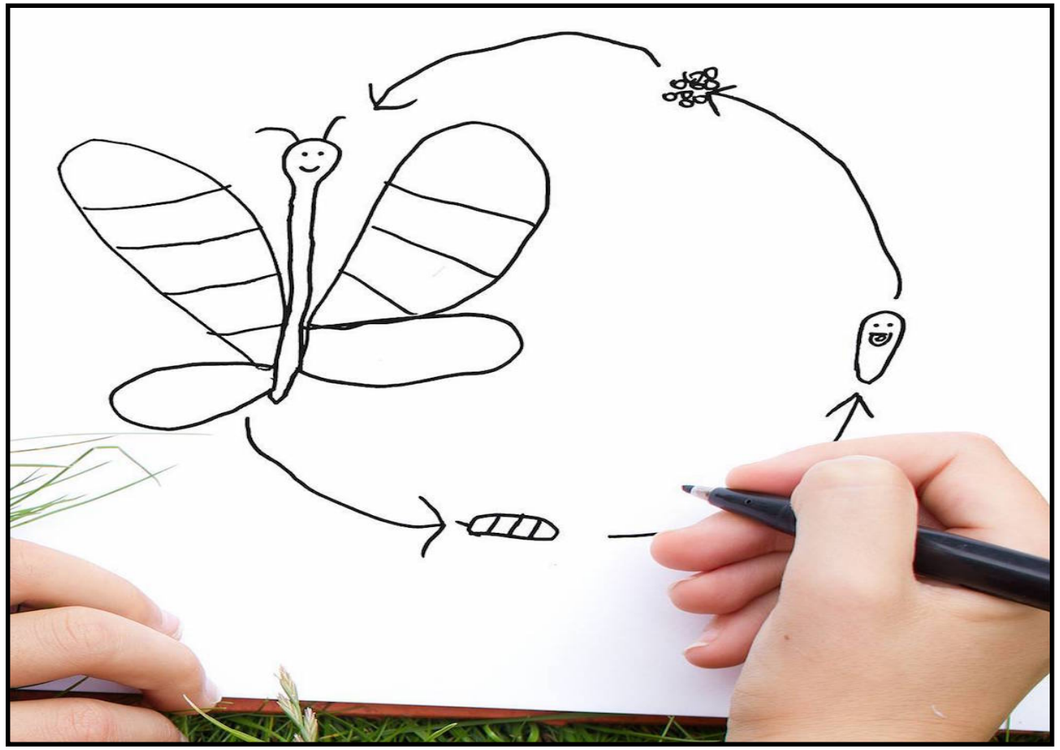
Idea

Visual Content

Who is creating visual content?



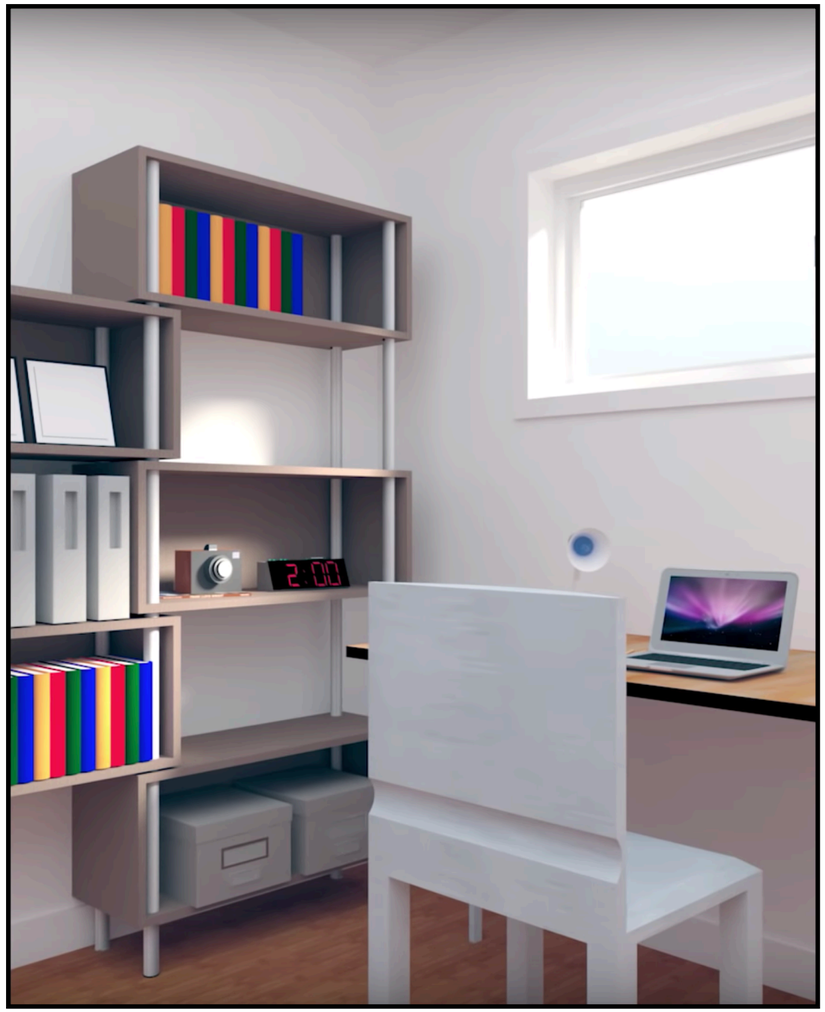
Who is creating visual content?



Kid’s drawing

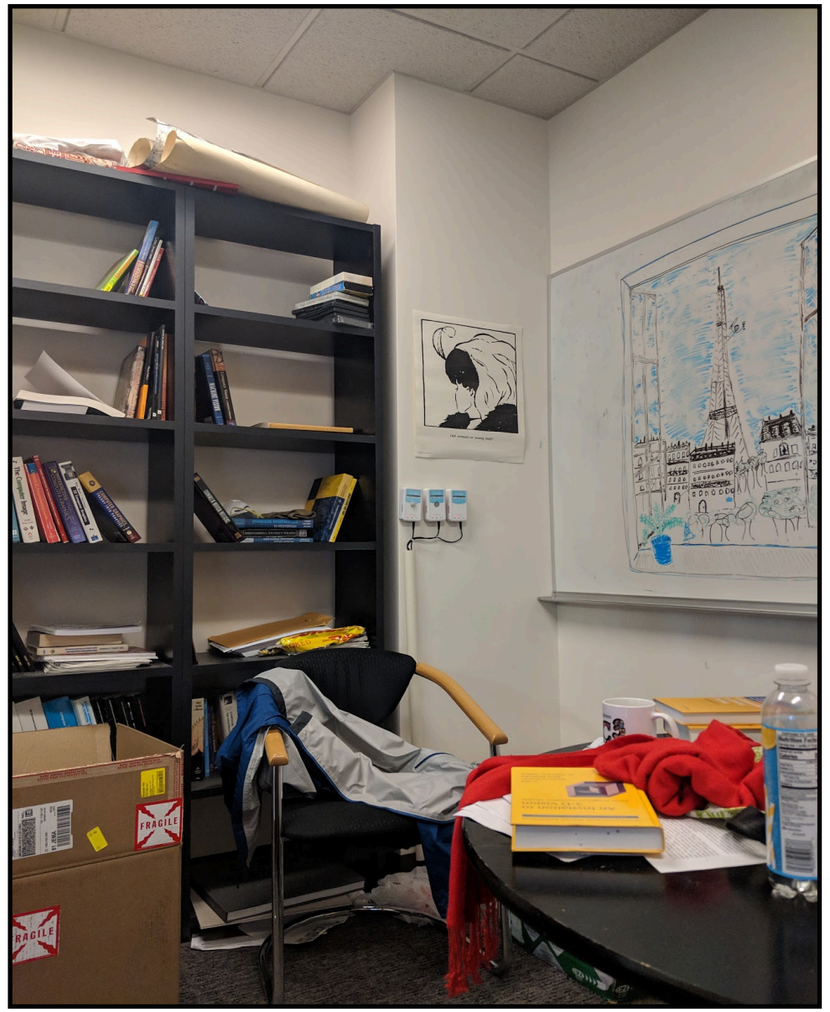
Photoshop result by his father

Creating Visual Realism Manually



CG office

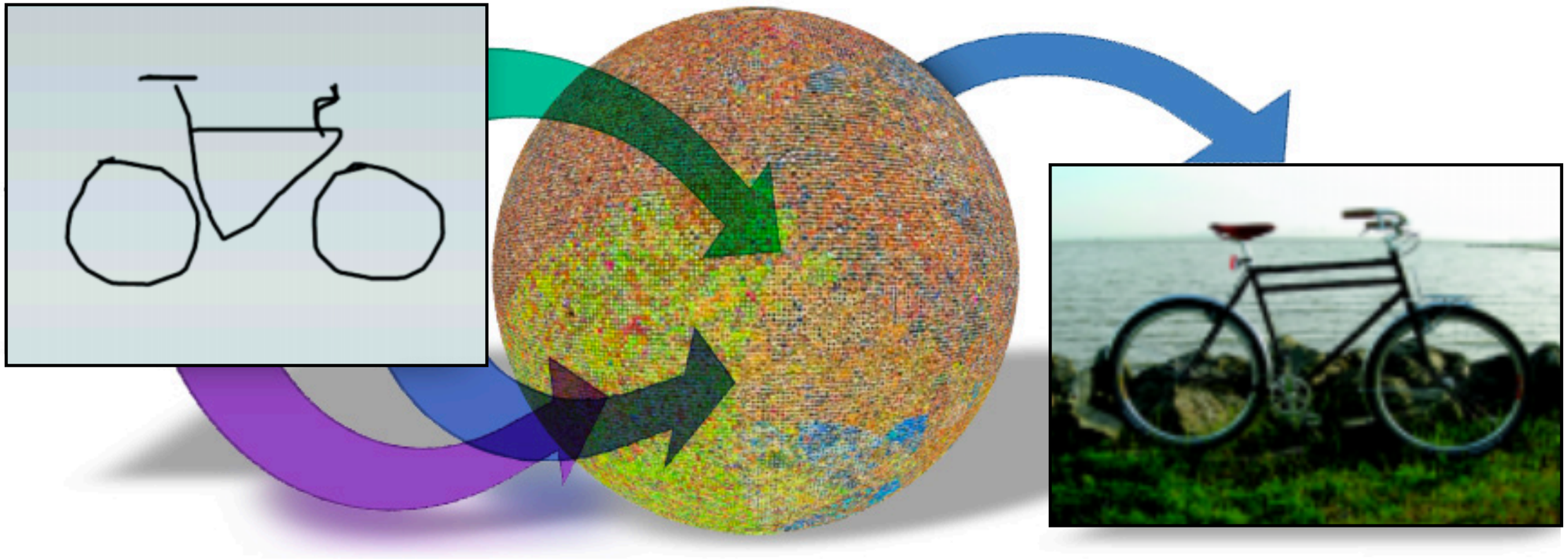
CG office (more details)



My advisor’s office

Data-Driven Graphics (2000s)

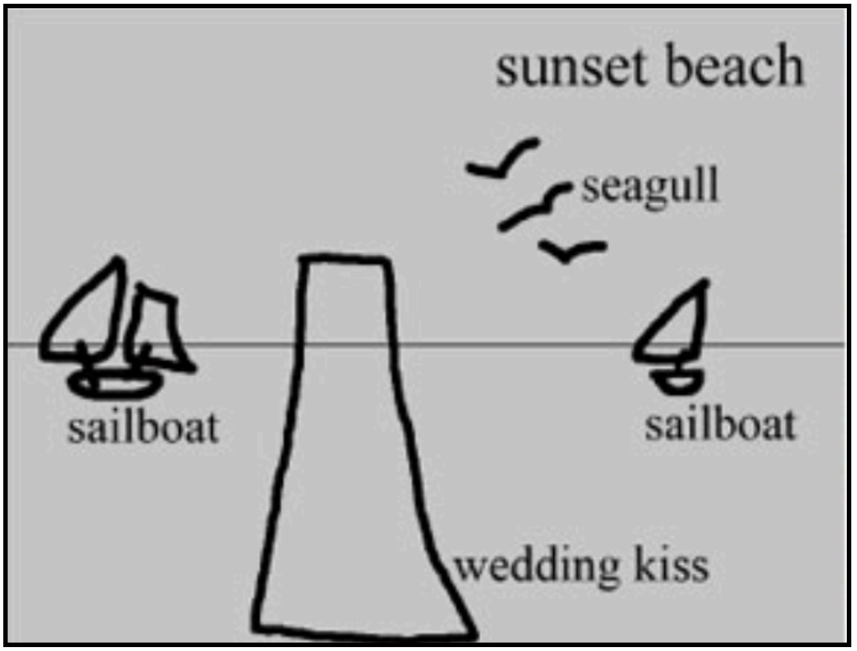
Graphics → Image Retrieval



Picture from James Hays

Data-Driven Graphics (2000s)

Compositing multiple parts



User Input

Database images

Output

Sketch2Photo [Tao et al. SIGGRAPH Asia 2009]

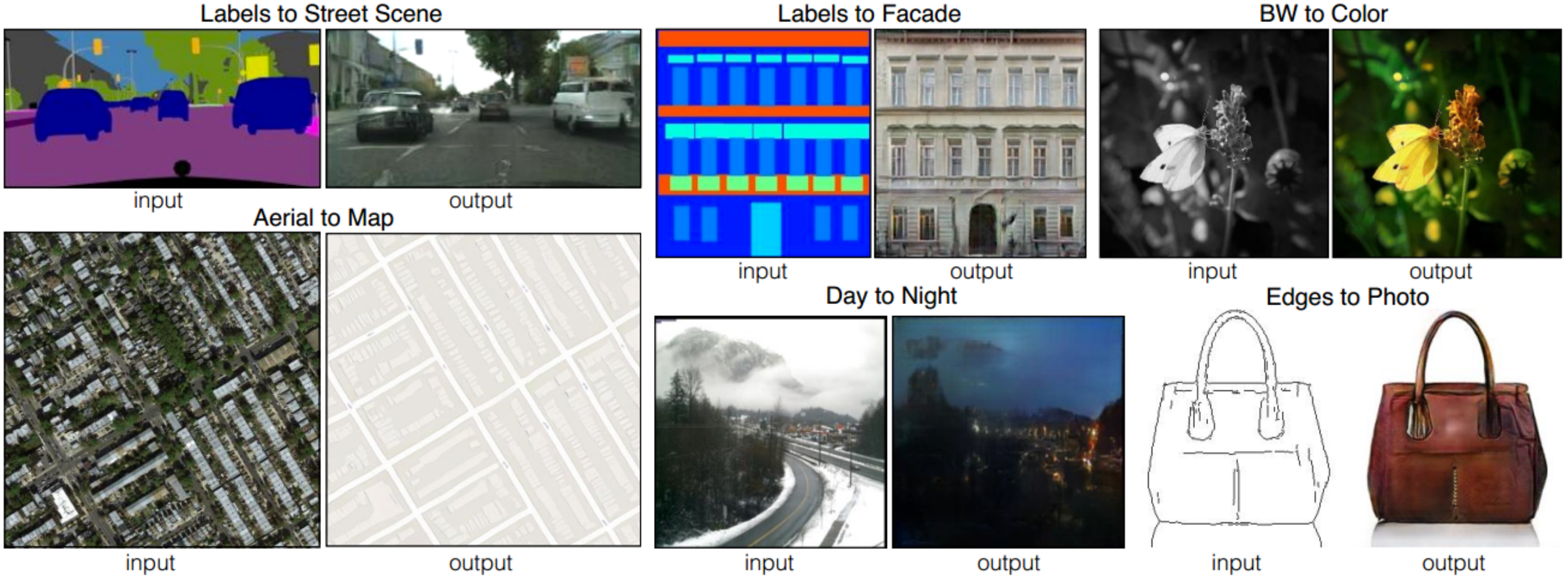
Data-Driven Graphics (2000s)

- Hard to combine pieces
- No understanding of visual realism

Help everyone
easily create visual content

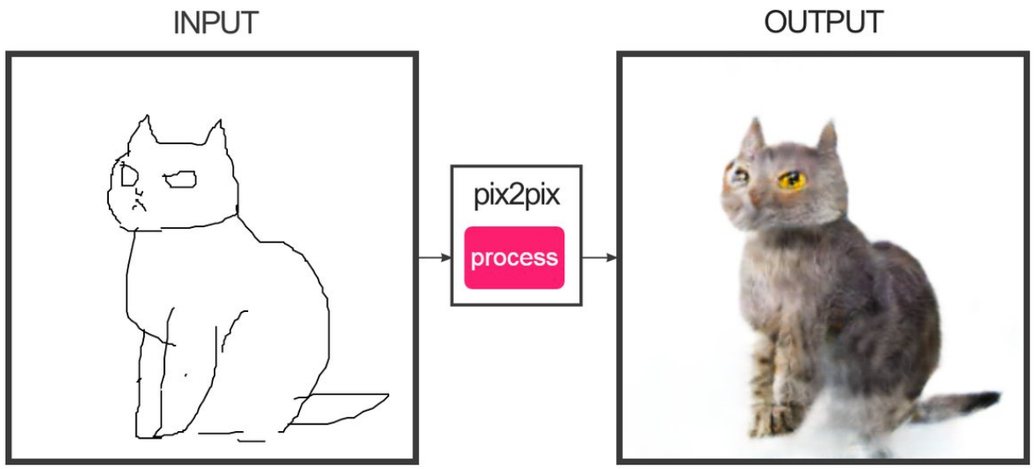
Teach machines
how to create realistic content

Image-to-Image Translation with **pix2pix**

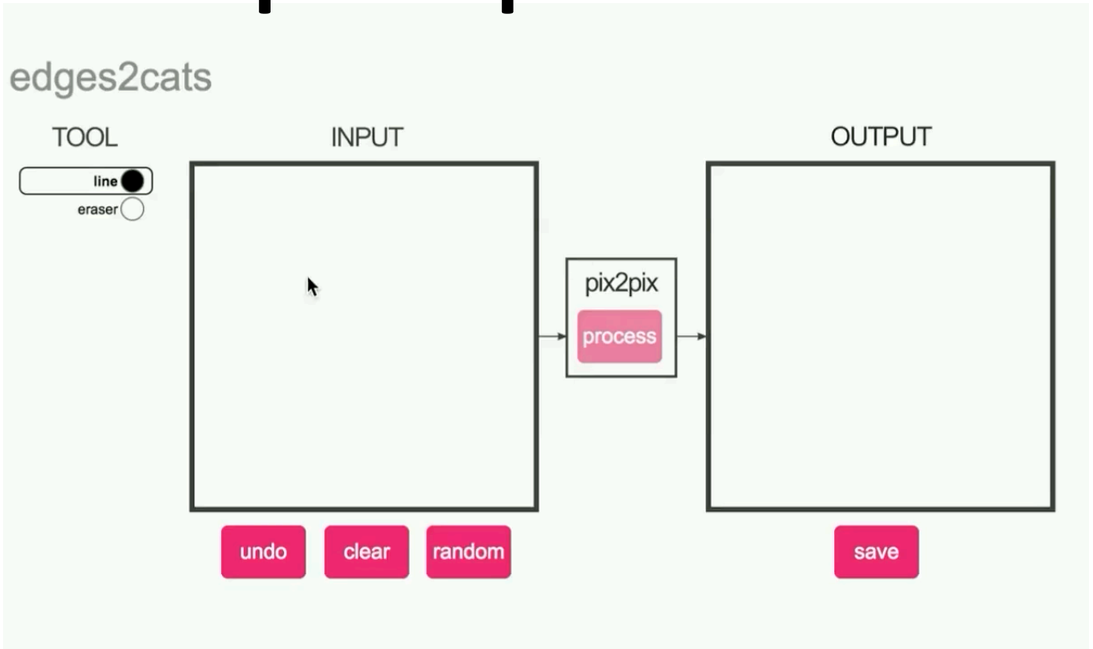


pix2pix [Isola, Zhu, Zhou, Efros. CVPR 2017]

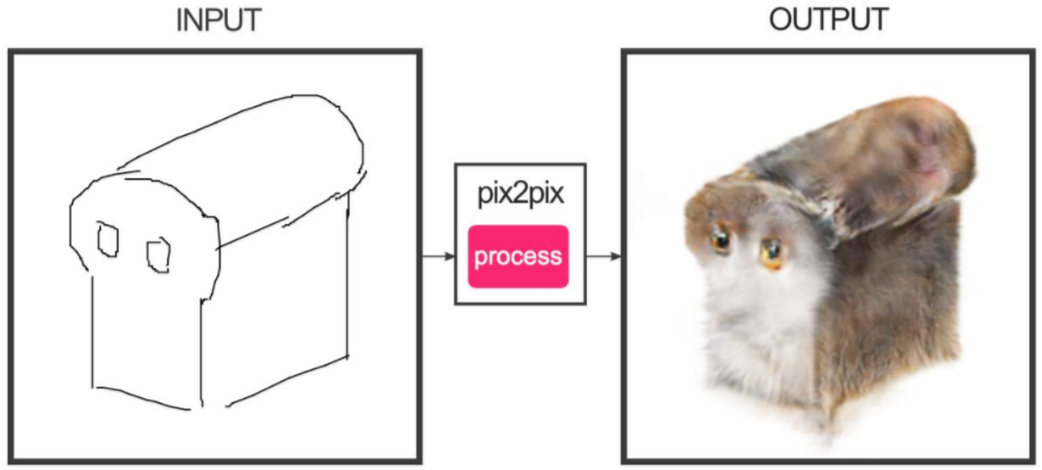
#edges2cats with pix2pix



@gods_tail



@matthematician

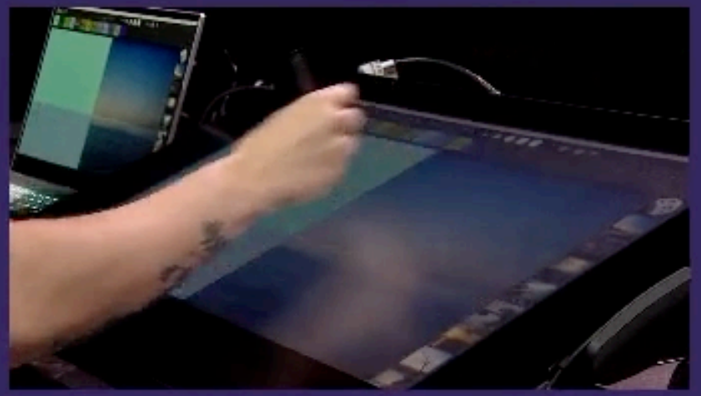


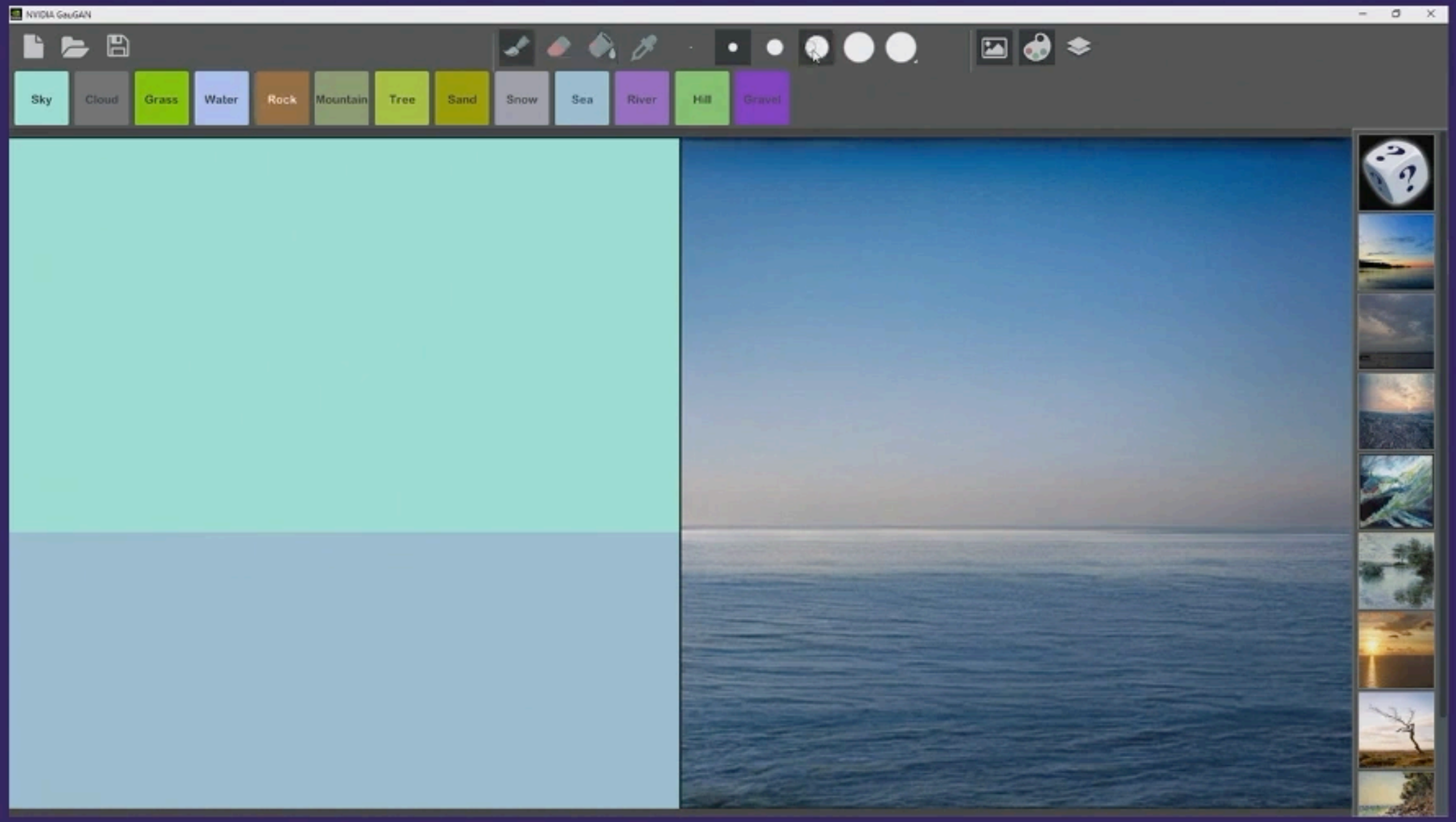
Ivy Tasi @ivymyt

Vitaly Vidmirov @vvid

By Christopher Hesse https://affinelayer.com/pixsrv/

GauGAN [Park, Liu, Wang, Zhu. 2019]





thrive
SIGGRAPH2019
LOS ANGELES | 28 JULY - 1 AUGUST

SIGGRAPH 2019 Real-time Live! “Best of Show Award" and "Audience Choice Award"

By Darek Zabrocki, Concept Designer and Illustrator

Collection Style Transfer

Photograph ©Alexei Efros

Monet

Van Gogh

Cezanne

Ukiyo-e

CycleGAN [Zhu, Park, Isola, Efros. 2017]

Monet’s paintings → photographic style

CycleGAN [Zhu, Park, Isola, Efros. 2017]

Horse → Zebra

CycleGAN [Zhu, Park, Isola, Efros. 2017]

Failure case

Failure case

Swapping Autoencoder For Deep Image Manipulation

Taesung Park[1], Jun-Yan Zhu[2], Oliver Wang[2], Jingwan Lu[2], Eli Shechtman[2], Alexei Efros[1], Richard Zhang[2]

[1]UC Berkeley, [2]Adobe Research

Swapping Autoencoder [Park et al. NeurIPS 2020]

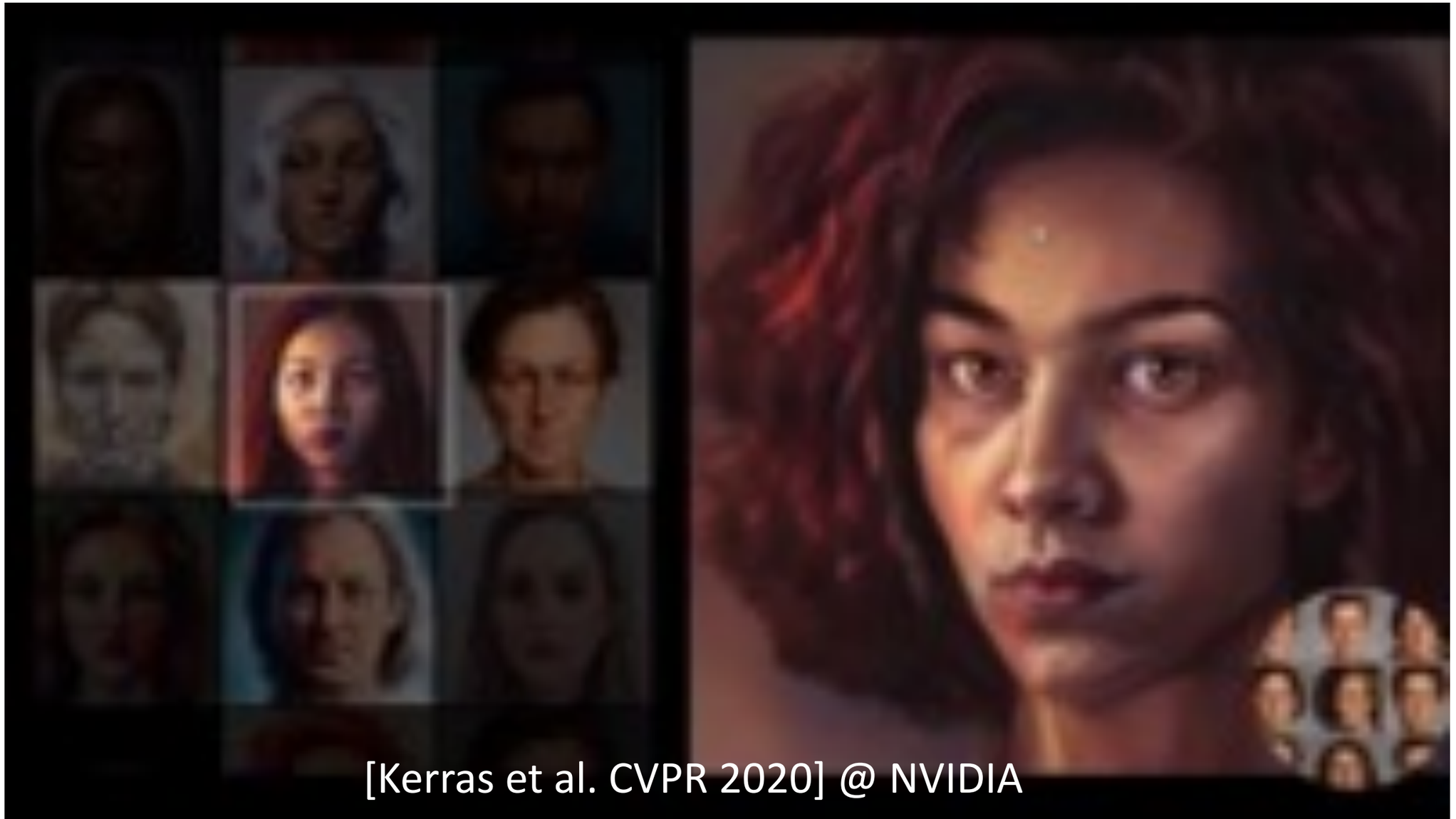
<not_an_ads

Photoshop 2021 “Neural Filters”

/not_an_ads>

Research Highlight

Synthesizing High-res Portraits

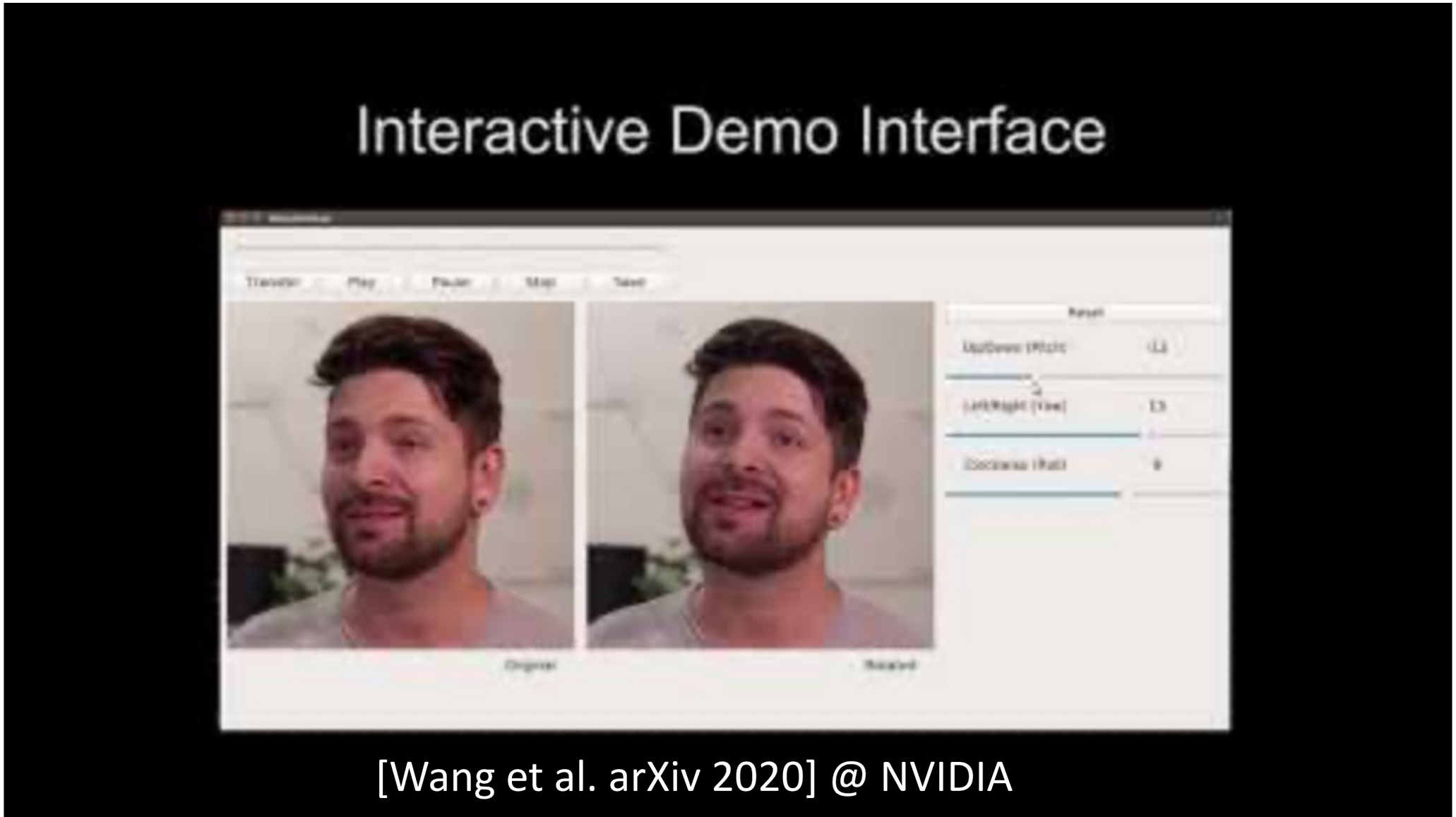


[Kerras et al. CVPR 2020] @ NVIDIA

Everybody Dances Now

[Zhou et al. ICCV 2019] @ UC Berkeley

Neural Talking-Head Synthesis

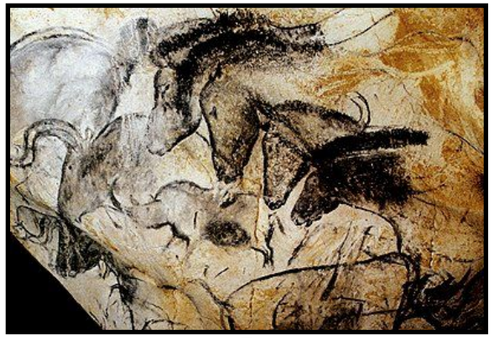


[Wang et al. arXiv 2020] @ NVIDIA

NeRF in the Wild

[Martin-Brualla et al. arXiv 2020] @ Google

Cave art

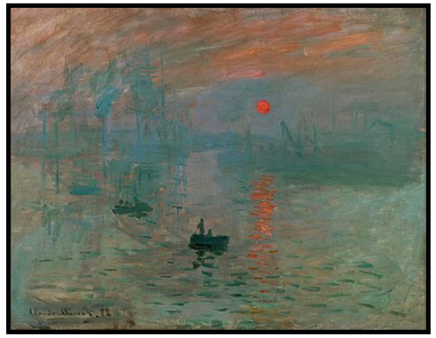


32,000 BC

Sculpture

1498

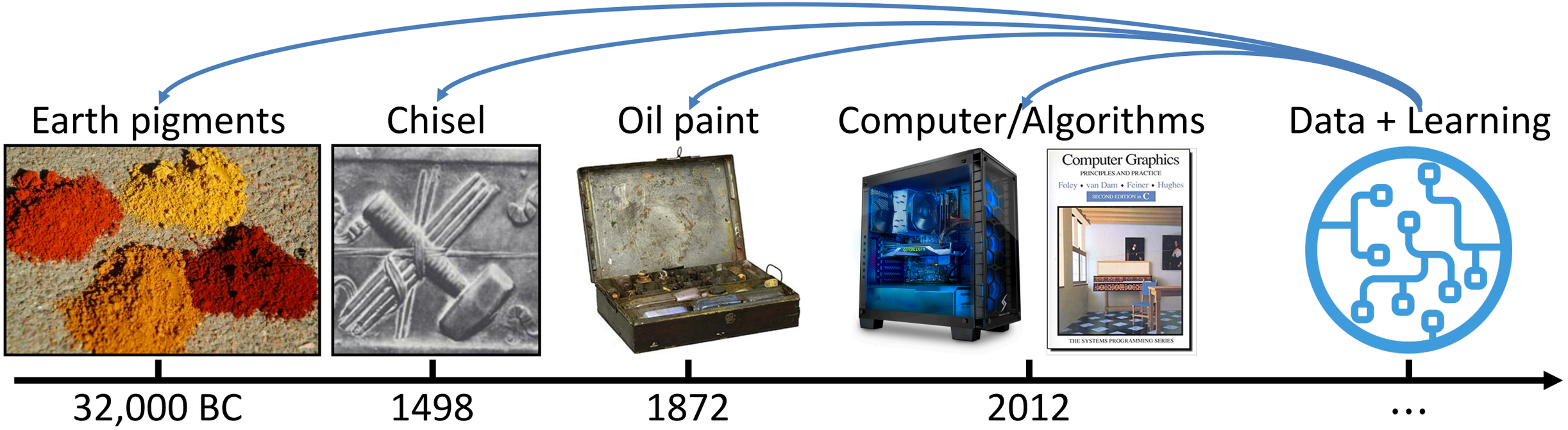
Painting



1872

Computer Graphics

2012



Course preview

- A modern machine learning perspective
- Widely-used learning algorithms
- Interactive content creation tools

Logistics

Course objectives

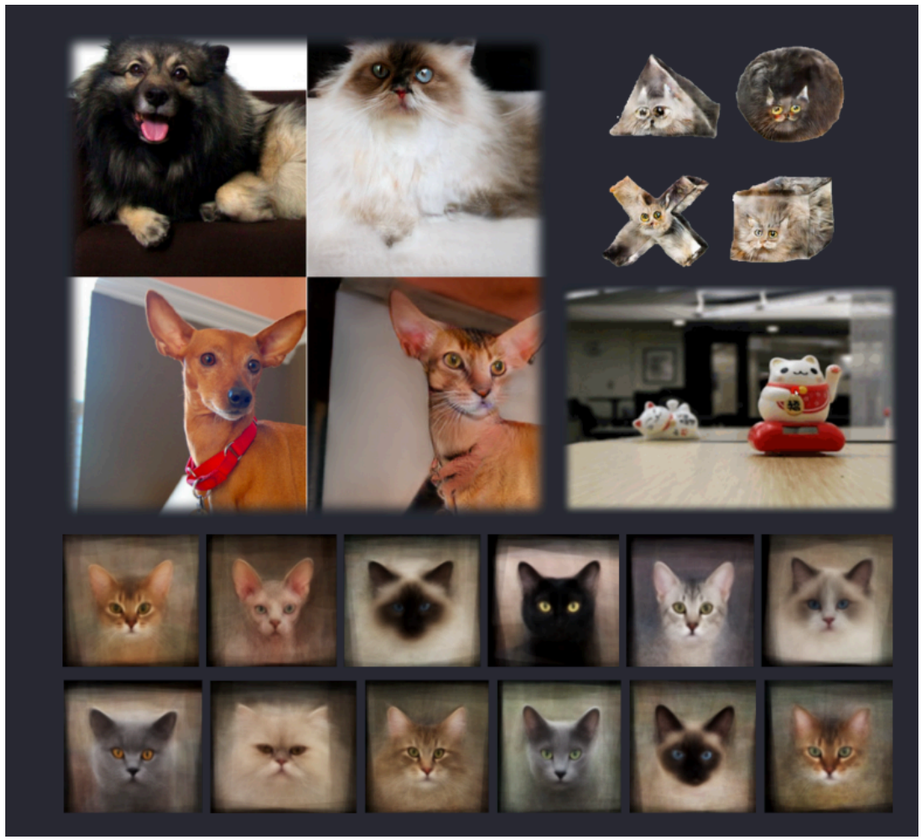
1. You will get a foundation in image editing and synthesis.
   - Texture synthesis and style transfer.
   - Face modeling and synthesis.
   - Image colorization and inpainting.
   - Video generation and editing.
   - Image-to-image translation.
   - Image and video editing. (warping, morphing, compositing)
   - Image and video forensics.

Course objectives

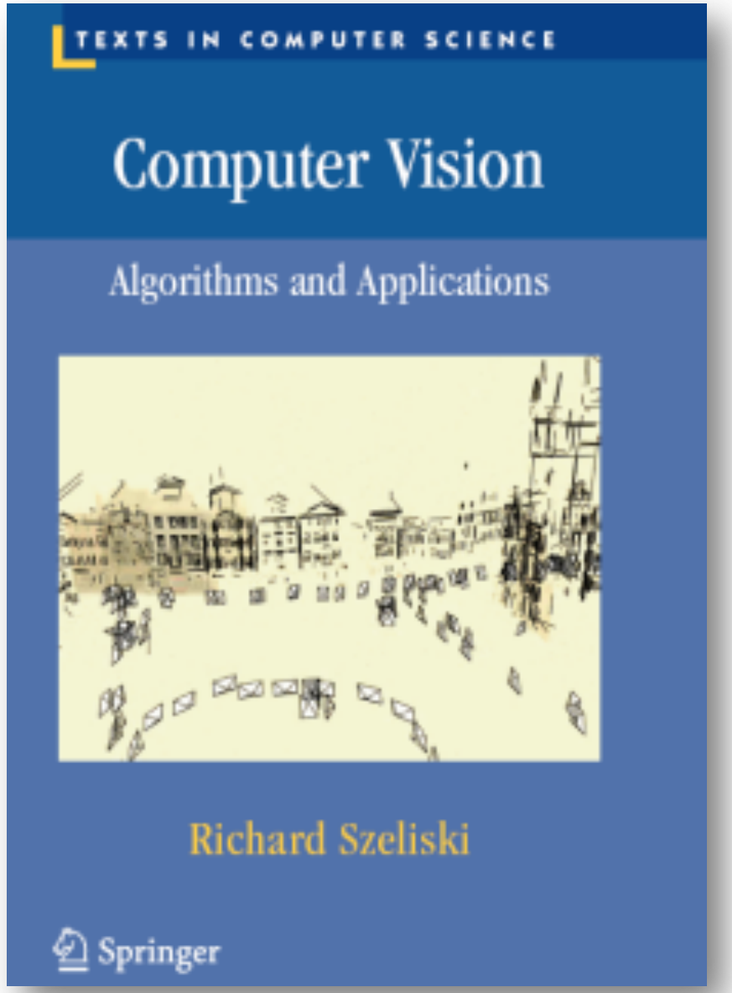
2. You will get a foundation of machine learning concepts
   - (fast) Nearest neighbor search.
   - Principal component analysis, Gaussian Mixture model. Markov Random Field (MRF)
   - Convolutional neural networks.
   - Deep generative models: Auto-encoder, Generative Adversarial Networks, Flow-based models, Variational Auto-encoder, PixelCNN, Energy-based models.
   - Conditional generative models.

Course objectives

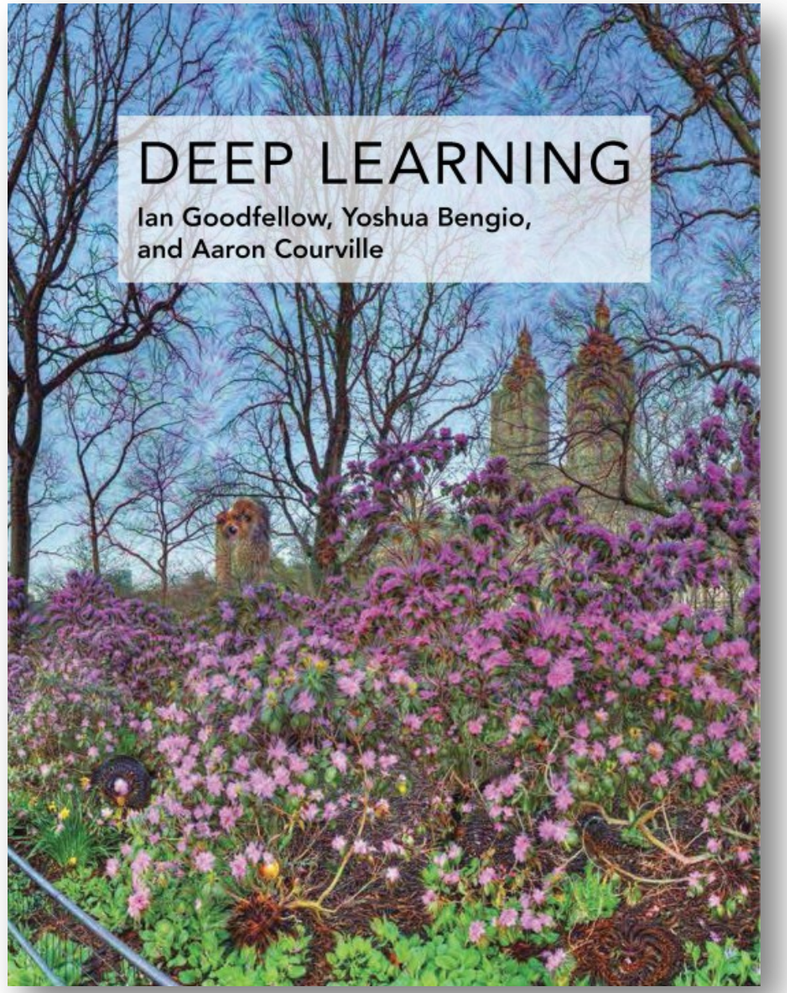
3. You will have some cool results using your own photos



Textbook



https://szeliski.org/Book/
(2021 edition")



https://www.deeplearningbook.org/
(2016 edition)

Grading

- Emphasis on programming projects (**65%**).
  - Classic: 1. image alignment. 2. image blending
  - Deep learning: 3. neural style transfer. 4. GANs and conditional GANs.
    5. reconstructing and editing an image with GANs.
- Late Policy for programming assignments.
  - Five (5) emergency late days for semester, to be spent wisely
  - 10% of penalty per day afterwards
- One paper presentation (**10%**):
  - 10-20 min, 1-2 people in a group.
  - Need to answer questions about this paper from now on.
- Final Project (**25%**)
  - A webpage-based report + a presentation.
  - No late day.
  - 2-3 people per group.

For each project

- Derive the math, implement stuff from scratch (+ starter code), and apply it to your own photos
- Every person does their own project (except final)
- Reporting via web page (+ submit code to Canvas)
- Afterwards, vote for class favorite(s)! Gift!
- Programming Language:
  - Python/PyTorch
  - you can use other languages, but you are on your own

Academic Integrity

- Can discuss projects, but don’t share code
- Don’t look up code or copy from a friend
- If you’re not sure if it’s allowed, ask
- Acknowledge any inspirations
- If you get stuck, come talk to us

Getting help outside of class

- Course Web Page
  - https://learning-image-synthesis.github.io/
- Discussion board:
  - Piazza.com
- Office hours (EST)
  - Viraj: 5:30-6:30 pm Monday [link]
  - Yufei: 9-10 am Tuesday [link]
  - Jun-Yan: 8-9 pm Wednesday [link]

Why you should NOT take this class

- Project-based class
  - No canned problem sets
  - Not theory-heavy
  - will read lots of research papers
  - Open-ended by design
- Need time to think, not just hack
  - **Creativity** is a class requirement
- Not worth it if you don’t enjoy it

Now… reasons TO take this class

- Not too many similar courses at other places.
- You get to create pictures, unleash your creative potential
- Interested in grad school and research? ☺
- Interested in industry jobs? ☺

Thank You!

16-726, Spring 2021

https://learning-image-synthesis.github.io/