



# Artificial Creativity

What is creativity?  
How can computers expose it?

Benjamin Eckhardt, 24.01.2022

- Creativity
- Latent space
- AI enhanced creativity

# Creativity

"The true sign of intelligence is not knowledge but imagination."

— Albert Einstein

"Creativity is intelligence having fun."  
— Albert Einstein

"There is no such thing as a failed experiment, only experiments with unexpected outcomes."  
— R. Buckminster Fuller

"The chief enemy of creativity is good sense."  
— Pablo Picasso

"Creativity is allowing yourself to make mistakes.  
Art is knowing which ones to keep."  
— Scott Adams

"The truly creative mind [...] has] the overpowering necessity to create [...], without the creating of music or poetry or books or buildings or something of meaning, his very breath is cut off from him. He must create, must pour out creation [...] by] some strange, unknown, inward urgency [...]"  
— Pearl S. Buck

"If you can dream it, you can do it."  
— Walt Disney

"I do not seek. I find."  
— Pablo Picasso

"I never made one of my discoveries through the process of rational thinking"  
— Albert Einstein

"Creativity is the expression of lived experience."  
— Fridtjof Hansen

"The inner fire is the most important thing mankind possesses."  
— Edith Södergran

"Creativity is an act of defiance."  
— Twyla Tharp

"Invention, it must be humbly admitted, does not consist in creating out of void but out of chaos."  
— Mary Shelly

"Creativity has much to do with experience, observation and imagination, and if any one of those key elements is missing, it doesn't work."  
— Bob Dylan

# Defining Creativity

## Measures

- novel
- surprising
- valuable (useful, beautiful, ...)
- transformative

## Creative impulse

- external inspiration
  - complex *interaction* between subjects
    - *emotions, sympathy*
  - *association*
    - *experience*
    - *cross-domain*
- **Self emergence**
  - inexplicable? complexity
  - unpredictable / uncontrollable
  - continuity?

## Cognitive exploration of conceptual space

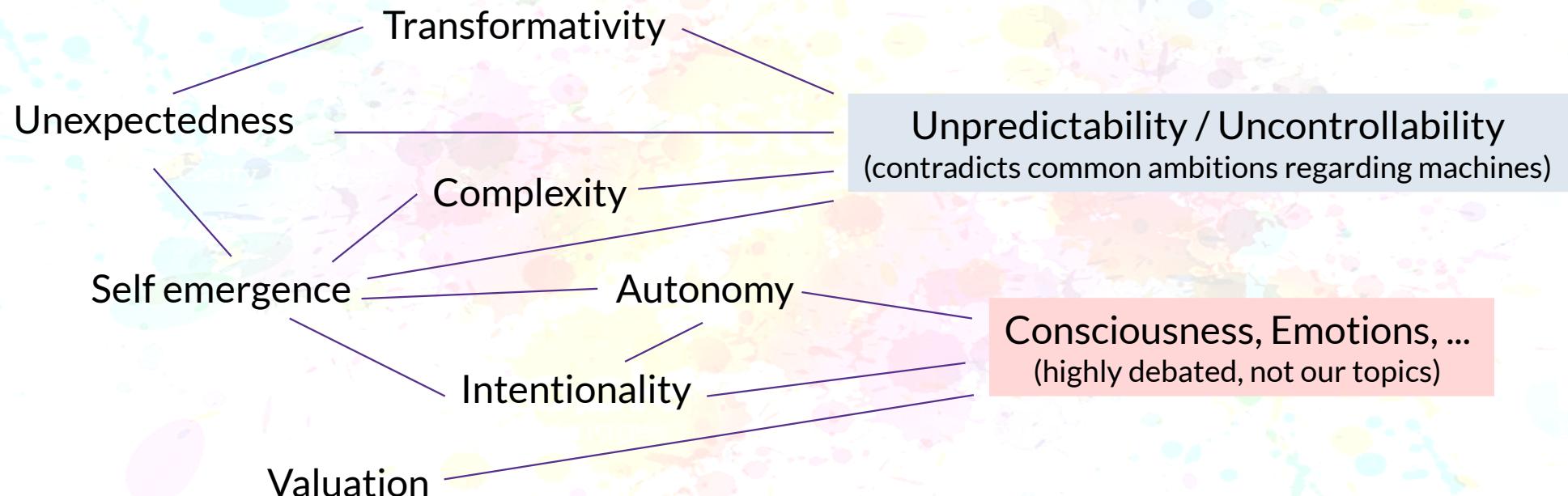
- Directed by intention
  - for a solution to have a particular shape
  - to expand the conceptual space  
(discover something completely new)
- Orientation in that space
  - recombination
  - breakout
- Evaluation

## Intention

- External
  - *optimize* for specific requirements
- Internal
  - *consciousness*
  - *expand* the conceptual space with something completely new
  - *express one self*
  - *communicate / provoke* deep feelings and emotions

# Can Machines be creative?

*Some notions of machine creativity are speculative or contradictory*



⇒ If a machine where to mimic human creativity, it could imply the same 'disadvantages' humans have regarding simpler machine (limited harnessability, willfullness)

# Possibilities for Artificial Creativity

Thus ideal genuine creativity like attributed to Picasso, Mozart, Bob Dylan, ...

- remains unlikely to be artificially recreated
- and would likely contradict the common purposes of machines

What remains:

- Domain specific problem solving?
  - intention is external ⇒ to find some specific solution
  - may still posses other notions of creativity
- Randomization
- Cooperative creativity / Human computer interaction
  - will need to define *meaningful human control*, so that
  - difficult notions of creativity will be backed by human

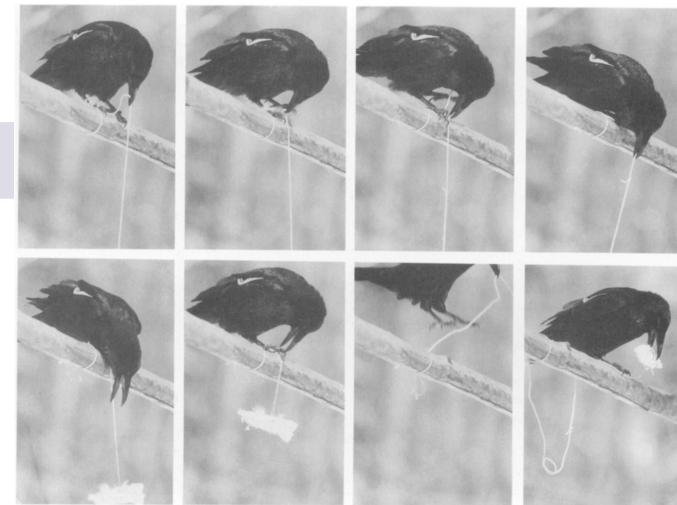
*Order of our considerations*



# Creative Problem Solving

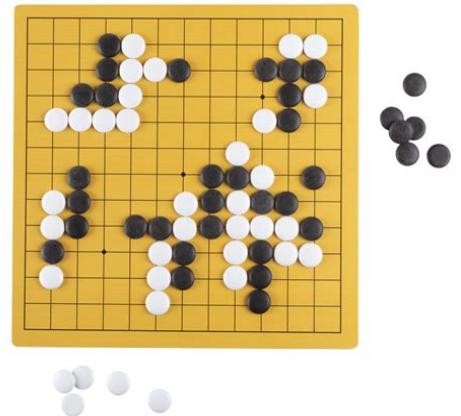
*AlphaGo vs insightful animals*

- Mental Scenario Building
  - AlphaGo does Monte Carlo Tree Search (MCTS)
  - *Explores* new moves
- Domain-General Reasoning
  - Knowledge about domain-general properties
  - Enables for discovering new functions for objects
- Experts describe AlphaGo's play as creative
- Moves were *novel, valuable* and *transformative*
- AlphaGo's world is very limited
- AlphaGo's capabilities are very domain-specific

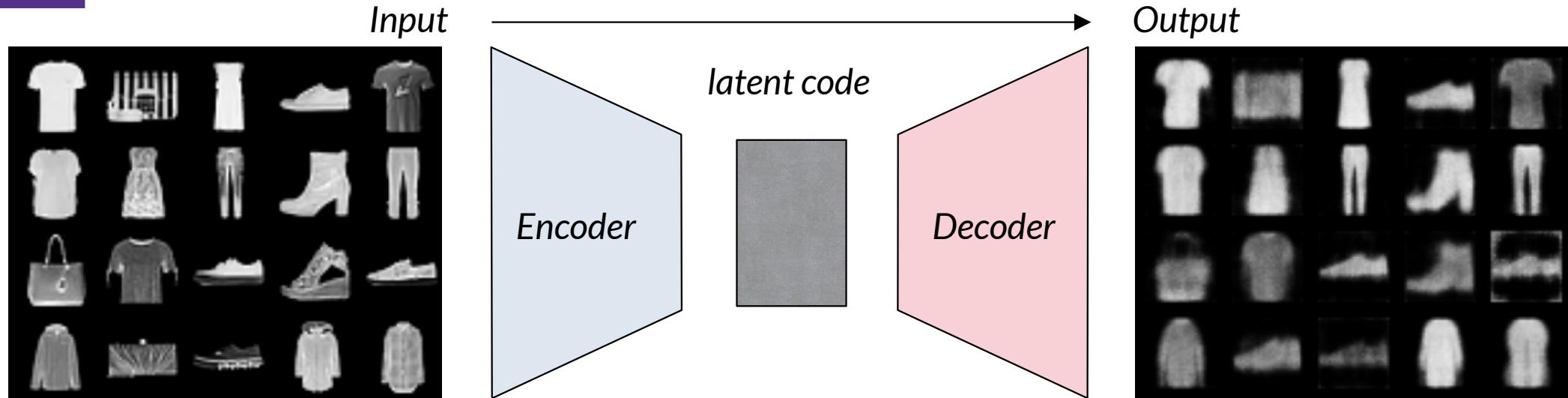


*A crow solving a new task without apparent trial-and-error-learning*

*The world of Go*



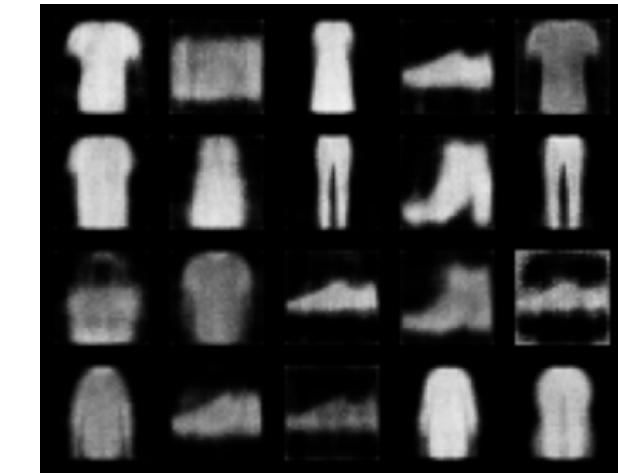
# Variational Autoencoders



- 2 (convolutional) neural networks:  
*Encoder* and *Decoder*
- trained to find an optimal compact representation for data: *latent code* and mappings between it and *data*
- for *data* with complex hidden structure



**Output**



**Encoder:** high dimensional data  
→ low dimensional latent code

**Decoder:** low dimensional code  
→ plausible reconstruction

**Training Objective:** Maximize similarity between input and output

# Latent Space

Directions in latent space often correspond to *meaningful* properties

- Helps for explainability of AI
- Can extract and separate abstract features
  - ⇒ Like `intended` image content from `unintended`  
(enables restoration, super-resolution, semantic filtration, ...)
- Allows for powerful semantic manipulation
  - ⇒ Thus easily enabling meaningful control
- Empirically justifies common human terms
  - ⇒ As they emerge as sensible representations for data
  - ⇒ Common ground for human and AI understanding
- Depending on data, model and training procedure  
any high degree of abstraction may be employed

Interpolation / Traversal



# Random Sampling

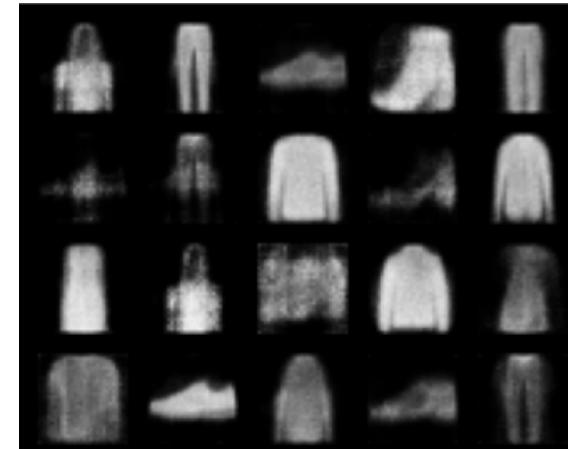
*Autonomously generate novel content by sampling randomly from latent space*

*Variational autoencoders also learn the distribution of data in latent space*

- We can sample from this to generate plausible latent codes
- The generated data resembles the structure of the known data  
(structure may be defined at arbitrary abstraction levels)
- Thus it may have the same *valuable* properties

Is this a creative entity: *Random-Sampler + Latent-Decoder* ?

- + Novel and (sometimes) valuable results
- + Autonomy
- No intention
- No directed exploration (Though Picasso also “do[es] not seek. [He] find[s].”)

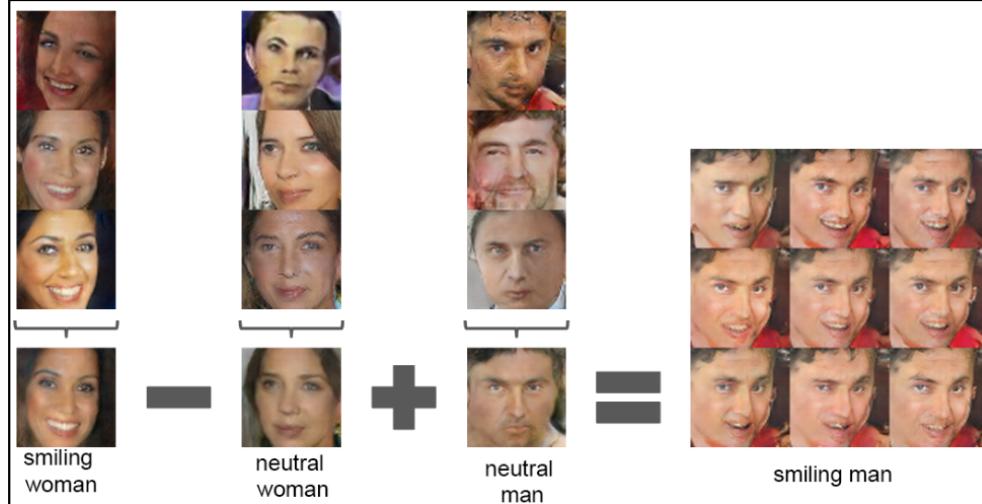


*random samples including novel fashion-hybrids like shirt-bags, unseen pants, skirts...*

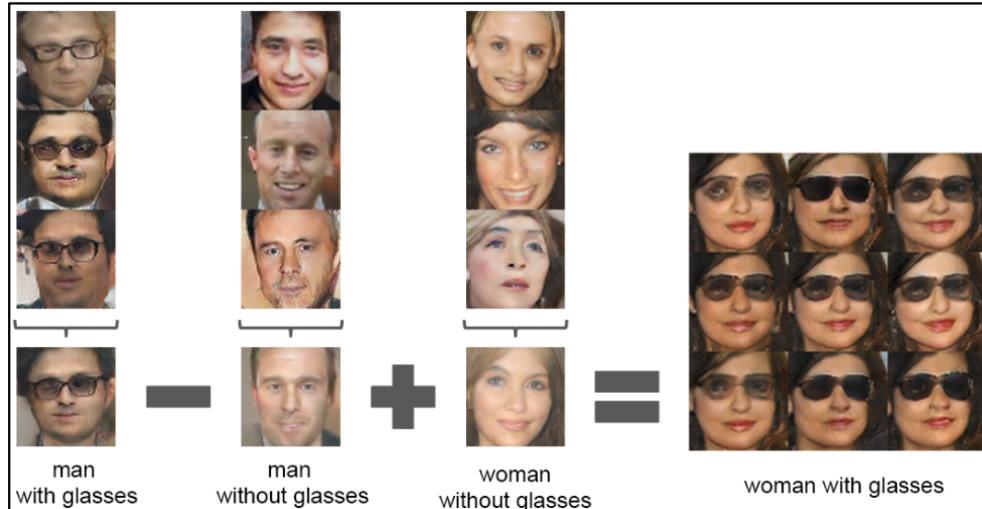
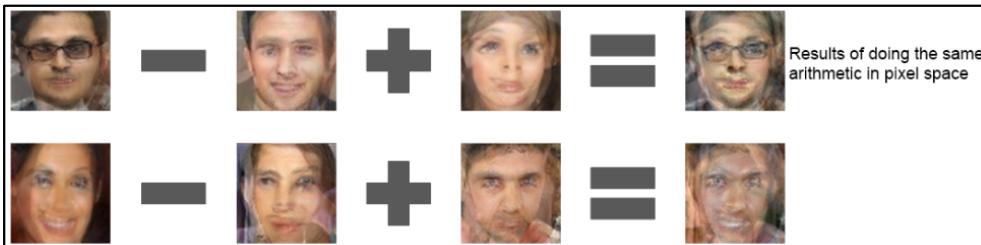
# Latent Arithmetic

Latent space allows for:

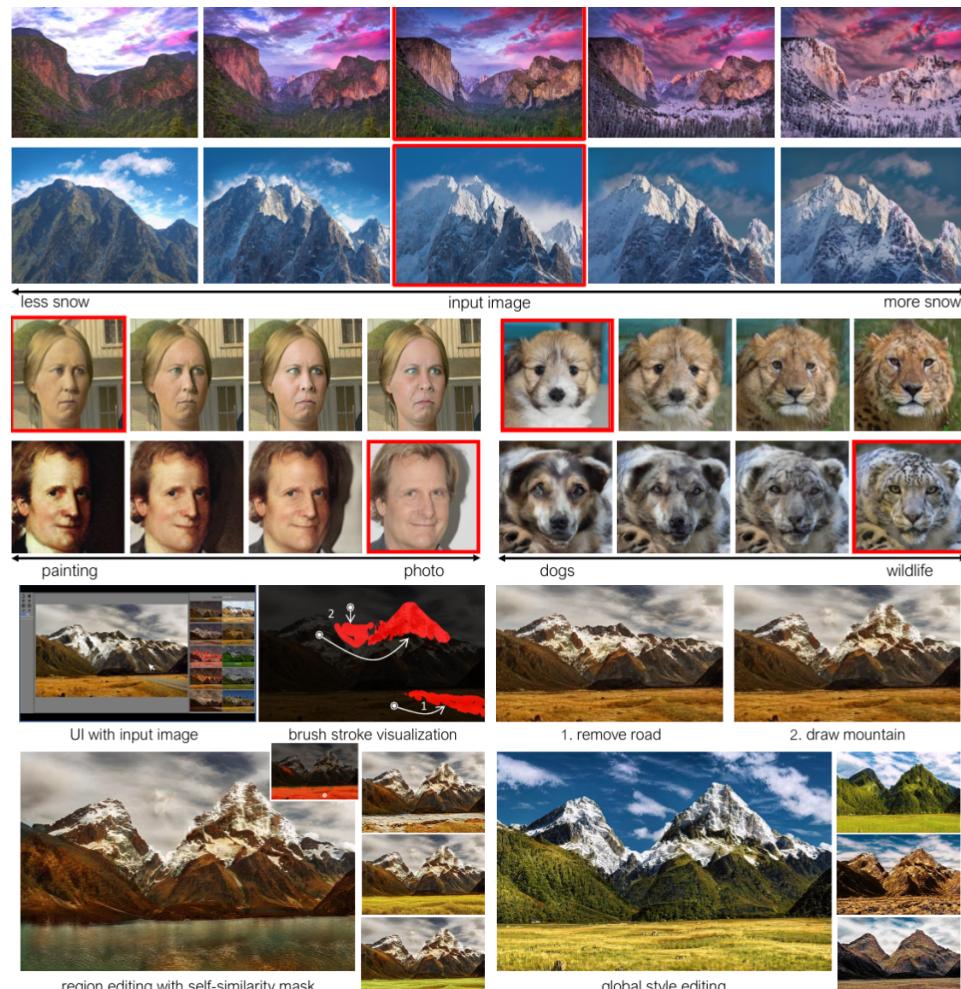
- Extracting directions corresponding to a semantic properties (calculating averages)
- Adding and subtracting those properties
- More elaborate manipulations (see e.g. Li (2020))



This is not possible in the data's original space:



# Example Inventions



texture

## structure



Park (2020)

# DALL-E: Creating Images from Text

TEXT PROMPT

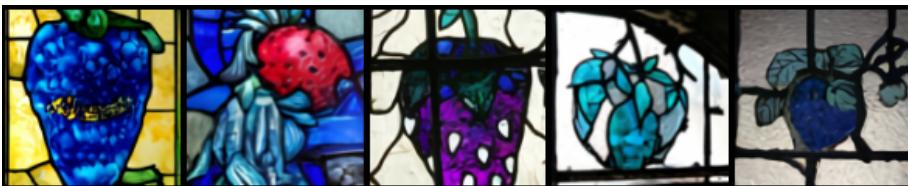
an armchair in the shape of an avocado....

an illustration of a baby daikon radish in a tutu walking a dog

AI-GENERATED  
IMAGES



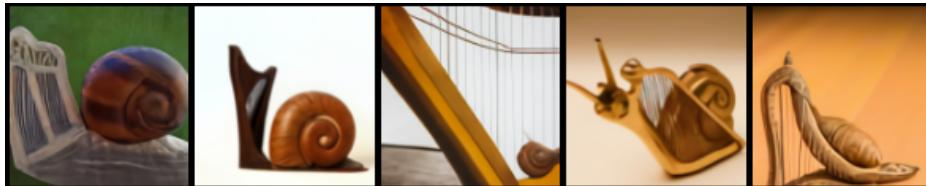
a stained glass window with an image of a blue strawberry



a cube made of cloud. a cube with the texture of cloud



a snail made of harp. a snail with the texture of a harp.



a professional high quality illustration of a jellyfish bat chimera. a jelly fish imitating a bat. a jellyfish made of bat



# Meaningful Human Control

- Term adapted from autonomous weapons systems
  - Needed for performativity and expressivity
  - no threshold but continuum
  - Aim to maximize meaningful control
- 
- Different things to control:
    - Learning (Hyperparameters, Data)
    - Motives
    - Feature-parameters (in latent space)
- Realtime Continuous Control
    - User = performer that *plays* the system like an instrument
    - Live feedback for assessing models capabilities / understanding it
- Non-realtime, non continuous
    - Like video editing, writing a score
    - Designs trajectory through latent space

# Controlling the Learning

## Live feedback

- Provides intuitions for performer / trainer
- Systems throughput
- Anticipated live metrics
  - predictive performance
  - knowledge gain

## Learning from live data

- Gaining intuition for the learning of DNNs
- Dynamically expand models conceptual space
- Customizing the `instrument` live

## Hyperparameter manipulation

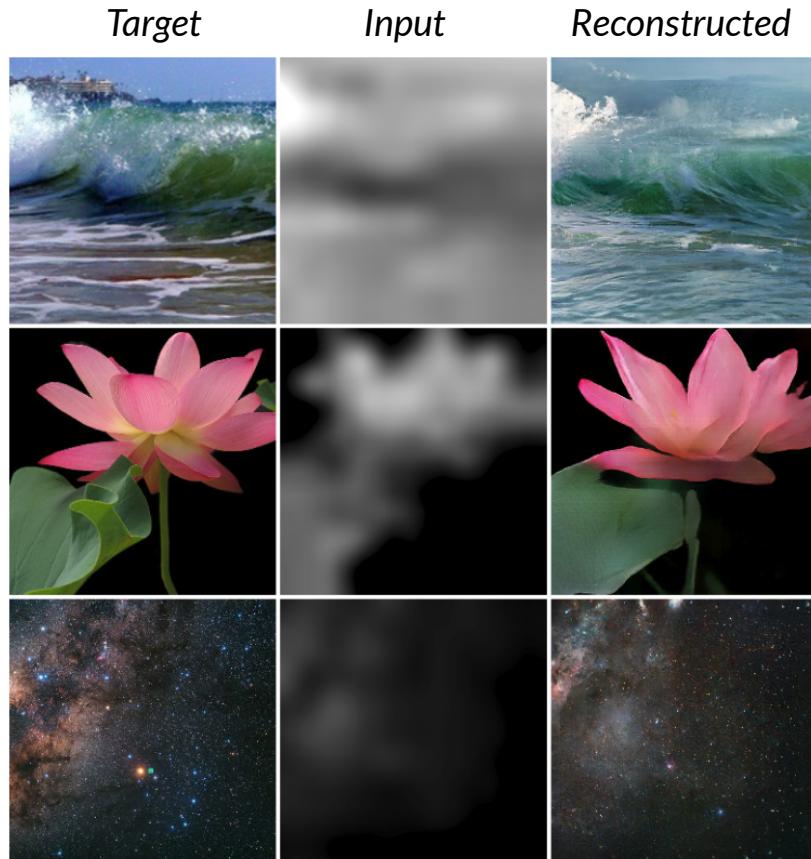
- Useful for intuitive hyperparameter search
- Control for the way the model adapts to new input
- Thus further customize the `instrument`

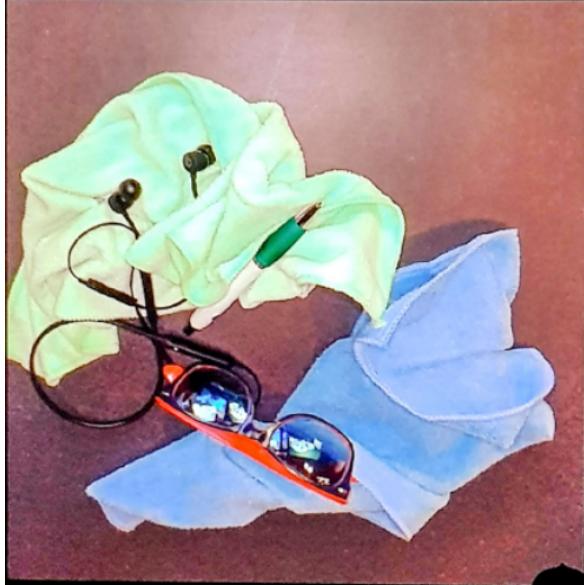


# Controlling the Motive: *Digital Puppetry*

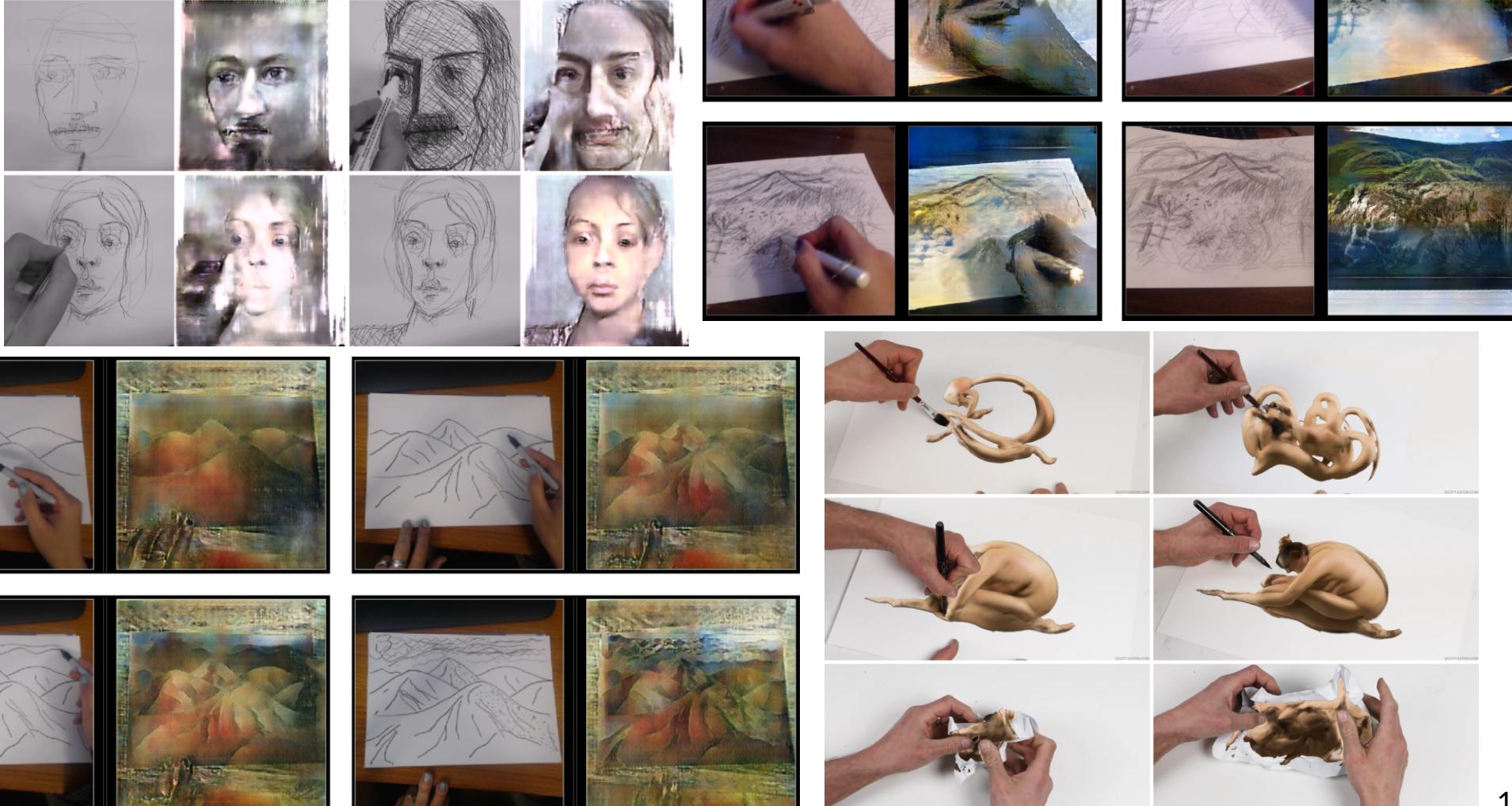
AI enhanced live performances

- Pretrained image to image model  
(here *pix2pix* conditional GAN)
- Reconstruct *target* given an abstracted version as *input*
- Model specialized to specific motive
- Abstraction
  - Different techniques possible
  - Allows for arbitrary motives
  - Training data for free
  - Exposes powerful parameters  
(semantic brightness, ...)
- Live interaction through a video-feed





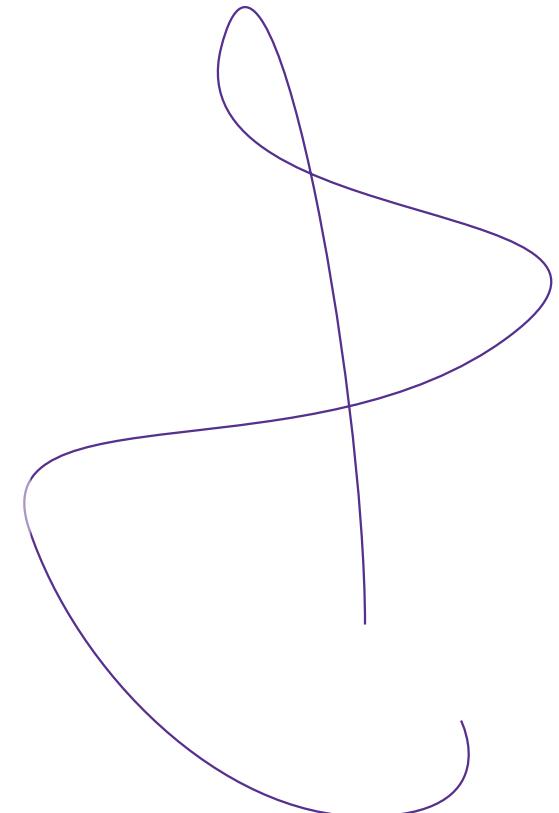
# Augmented Drawing



# Deep Meditations: Latent Storytelling

Long-form designed trajectories in latent space

- Very new, until this work<sup>(Akten 2018)</sup> only:  
single samples, random walks, short interpolations between points
- Explore full scope of latent space (hundreds of dimensions)
  - By composing from selected random samples and walks
- Keyframes: temporally sparse sequence of (time, image)-pairs
  - Correspondence to latent space keyframes
  - Idea common in video editing, animation, ...
- Trajectory design
  - Different ways to interpolate between keyframes
  - Generates temporally dense sequence for smooth transformations
  - Problem: Latent space is deformed:
    - Biased distribution, perceptual speed misaligns, weird interpolations



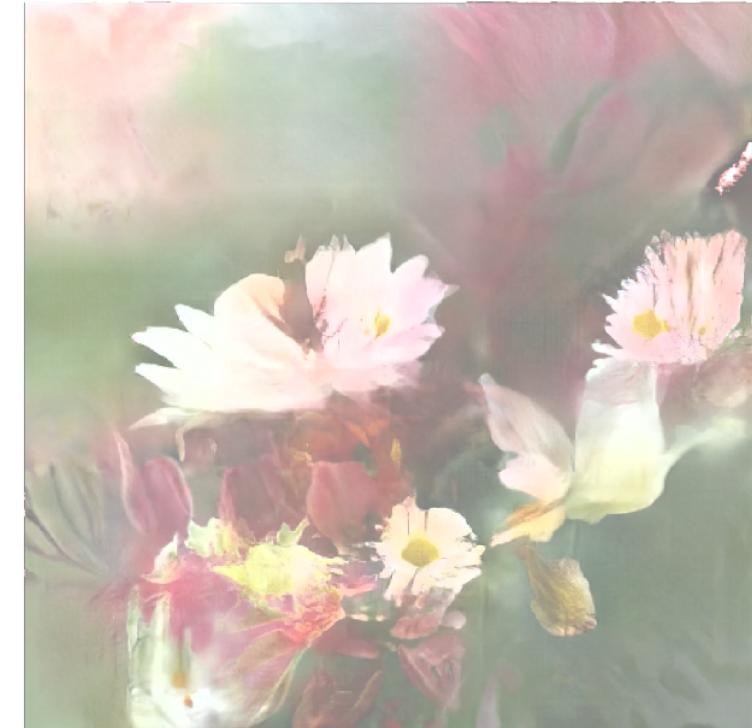
[video link](#)

# Thank you for listening!



Recommended reading:  
Akten (2020)

Further inspirational work:  
[Memo Akten's Website](#)



# References

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- [W2] <https://quotefancy.com/creativity-quotes>
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