ScaDS.AI
DRESDEN LEIPZIG

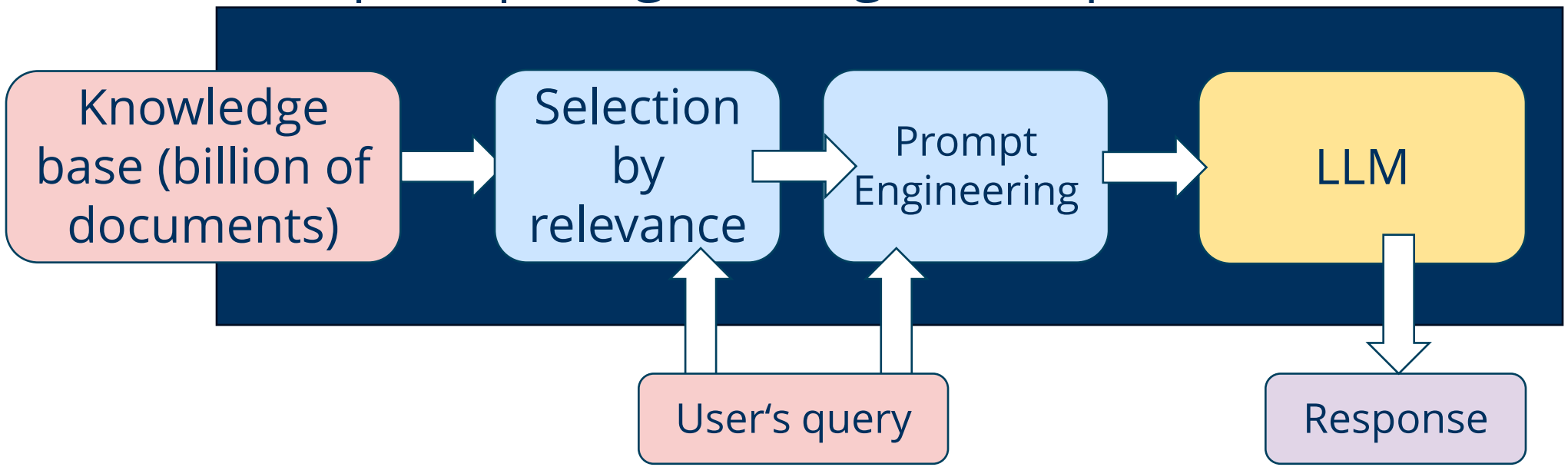
CENTER FOR SCALABLE DATA ANALYTICS AND
ARTIFICIAL INTELLIGENCE

Multi-modal Language Models

Robert Haase

Quiz

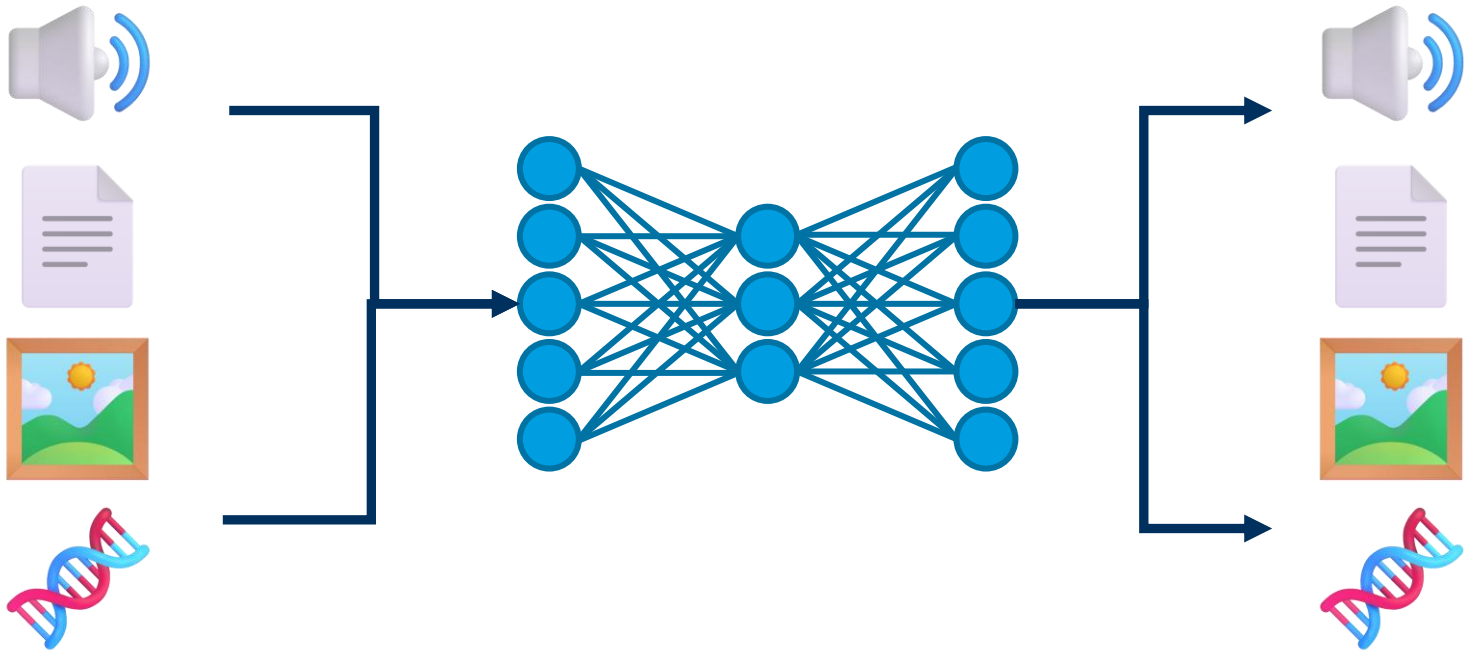
How is this prompt engineering technique / architecture called?



- Reflection
- Long-context propmpting
- Retrieval augmented generation
- Knowledge distillation

Multi-modal LLMs

Combining image, text and [...] data



Multi-modal LLMs

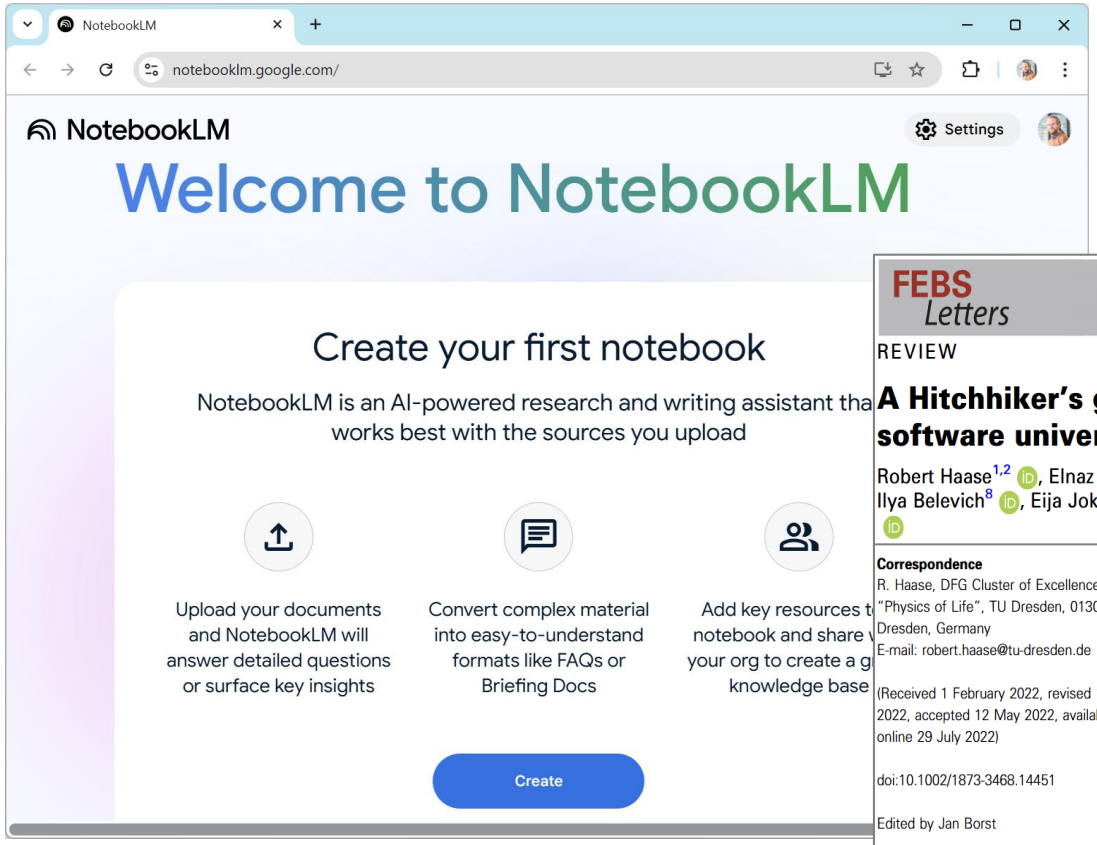
Combining image, text and [...] data, to gain new [biological] insights.

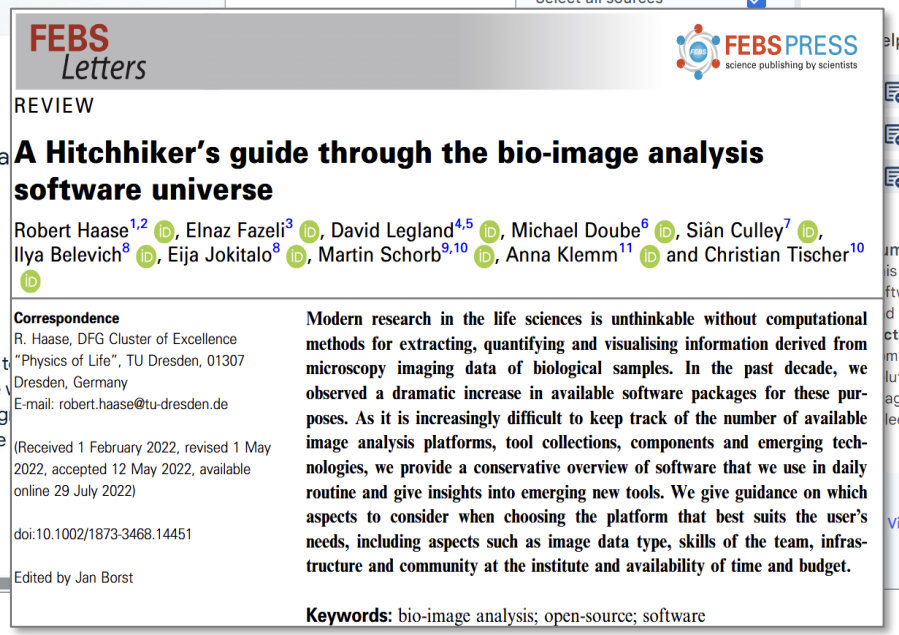
- Chat / translation / text-generation: 📄 -> 📄
- Voice-chat / -translation: 🔊 -> 🔊
- Text-to-speech (TTS): 📄 -> 🔊
- Speech to text (STT): 🔊 -> 📄
- Vision / image classification / image description / image-to-text: 🖼️ -> 📄
- Image generation, text-to-image: 📄 -> 🖼️
- Image variation, inpainting, image segmentation: 🖼️ -> 🖼️
- Genotype-phenotype translation: 🧬 -> 📄
- Sequence-prediction / protein design: 📄 -> 🧬

Focus of today's lecture

Use case: Paper to Podcast

Text to audio conversion: Google NotebookLM ->




FEBS Letters

FEBS PRESS science publishing by scientists

REVIEW

A Hitchhiker's guide through the bio-image analysis software universe

Robert Haase[1,2], Elnaz Fazeli[3], David Legland[4,5], Michael Doube[6], Siân Culley[7], Ilya Belevich[8], Eija Jokitalo[8], Martin Schorb[9,10], Anna Klemm[11] and Christian Tischer[10]

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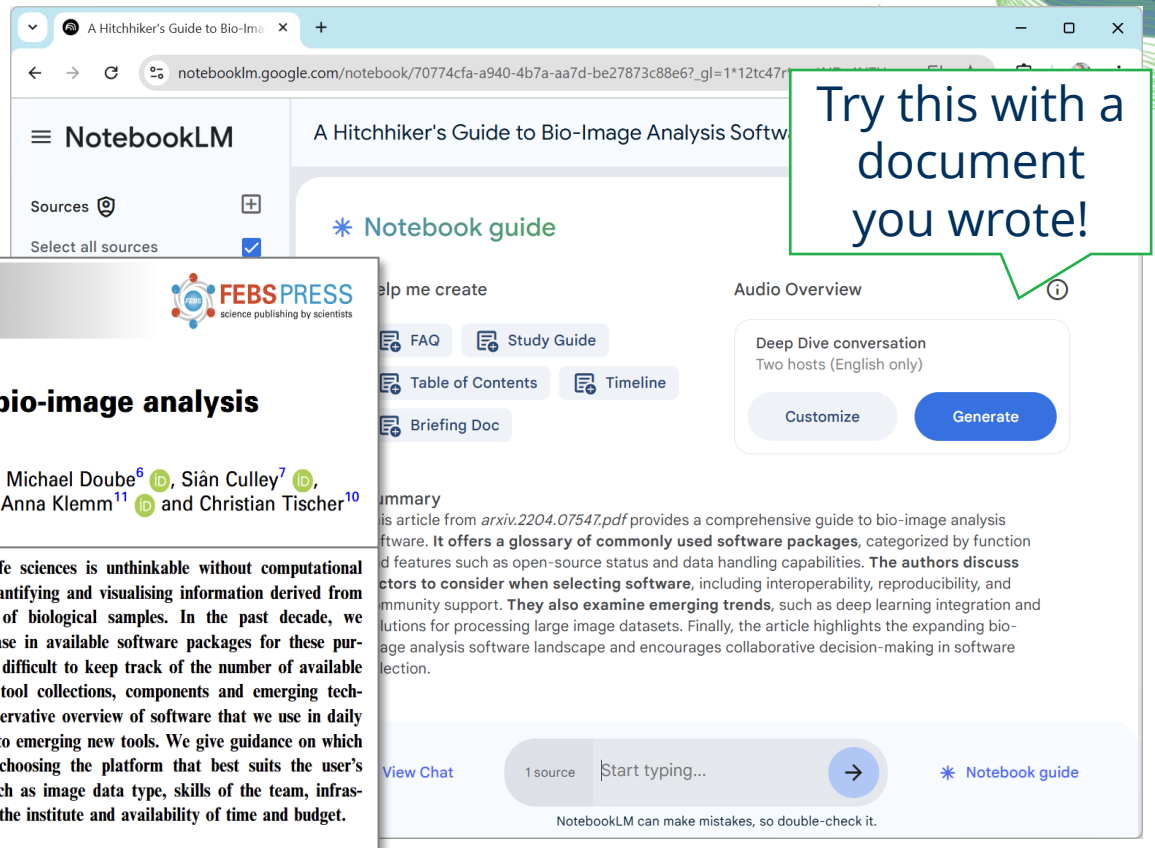
Edited by Jan Borst

Modern research in the life sciences is unthinkable without computational methods for extracting, quantifying and visualising information derived from microscopy imaging data of biological samples. In the past decade, we observed a dramatic increase in available software packages for these purposes. As it is increasingly difficult to keep track of the number of available image analysis platforms, tool collections, components and emerging technologies, we provide a conservative overview of software that we use in daily routine and give insights into emerging new tools. We give guidance on which aspects to consider when choosing the platform that best suits the user's needs, including aspects such as image data type, skills of the team, infrastructure and community at the institute and availability of time and budget.

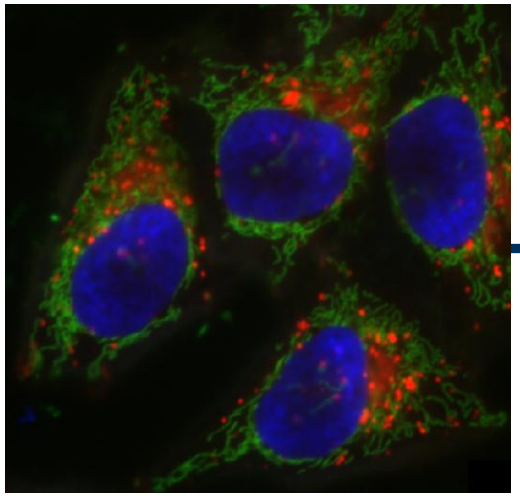
Keywords: bio-image analysis; open-source; software



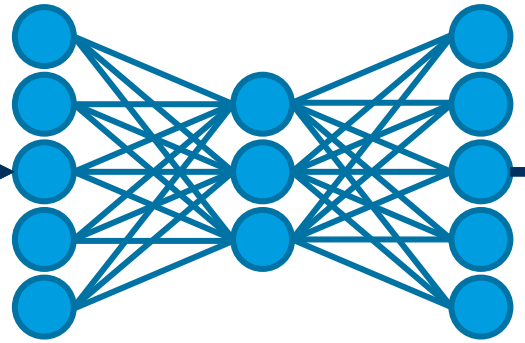
Try this with a document you wrote!

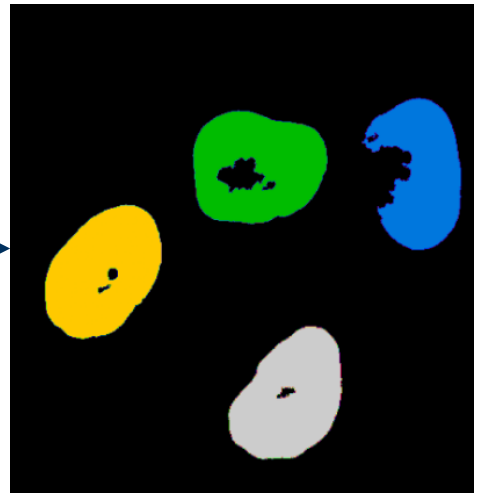
Multi-modal LLMs

Combining image, text and [...] data, to gain new [biological] insights.



How many cells are there?



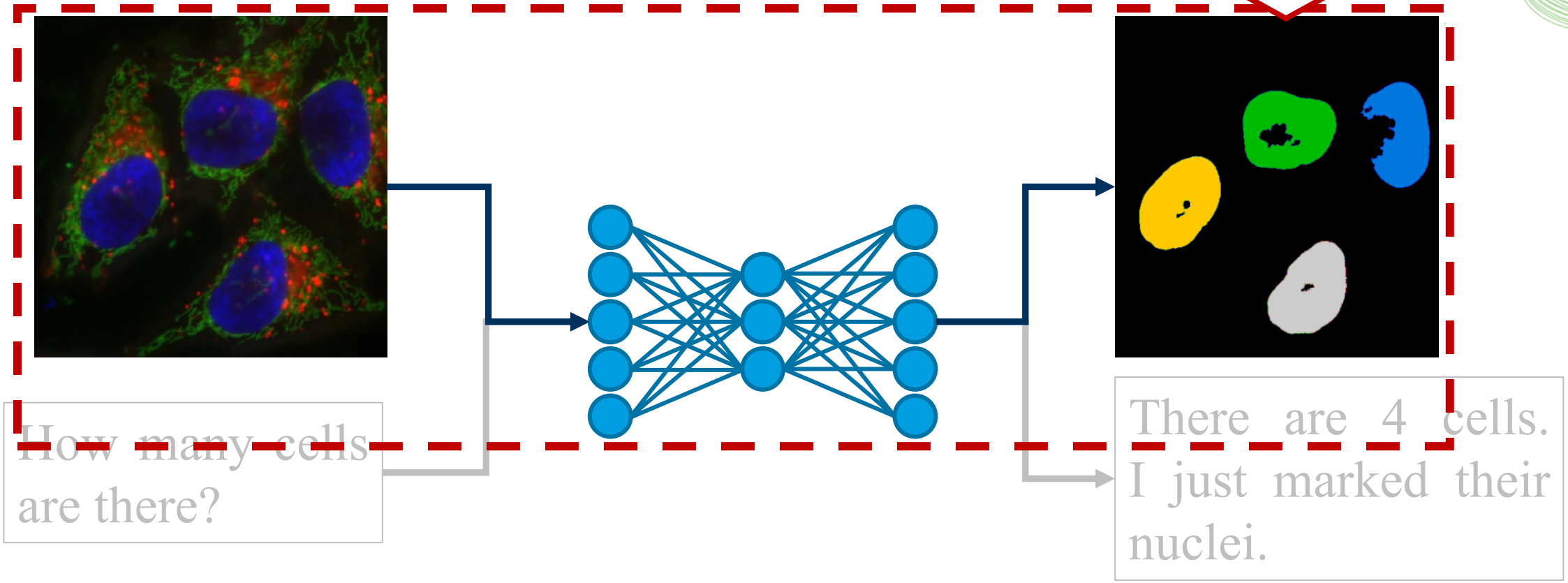


There are 4 cells. I just marked their nuclei.

Multi-modal LLMs

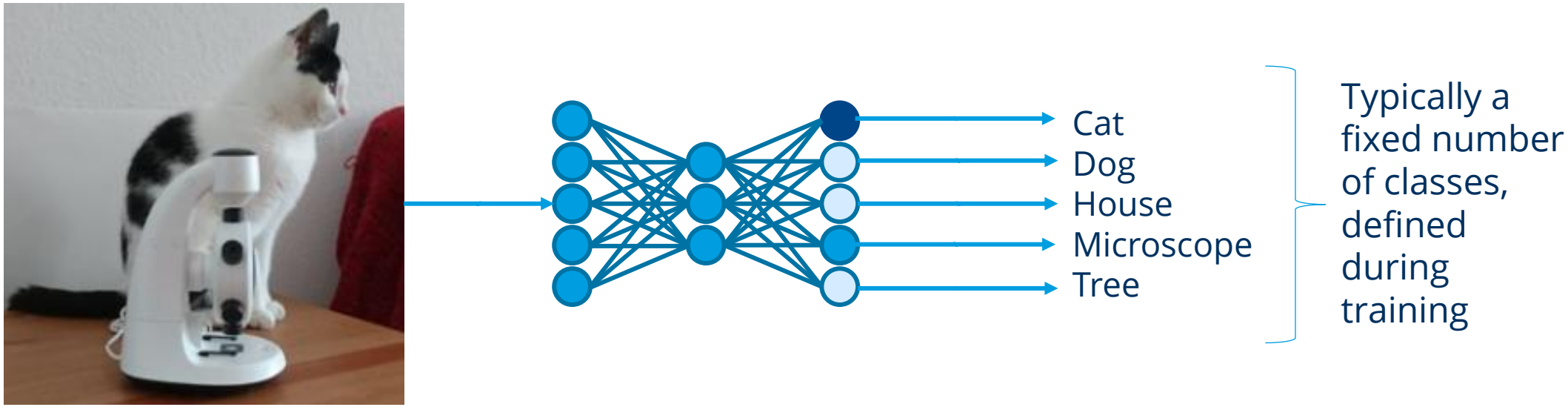
Combining image, text and [...] data, to gain new [biological] insights

Quiz: Could a neural network predict an instance label image directly?



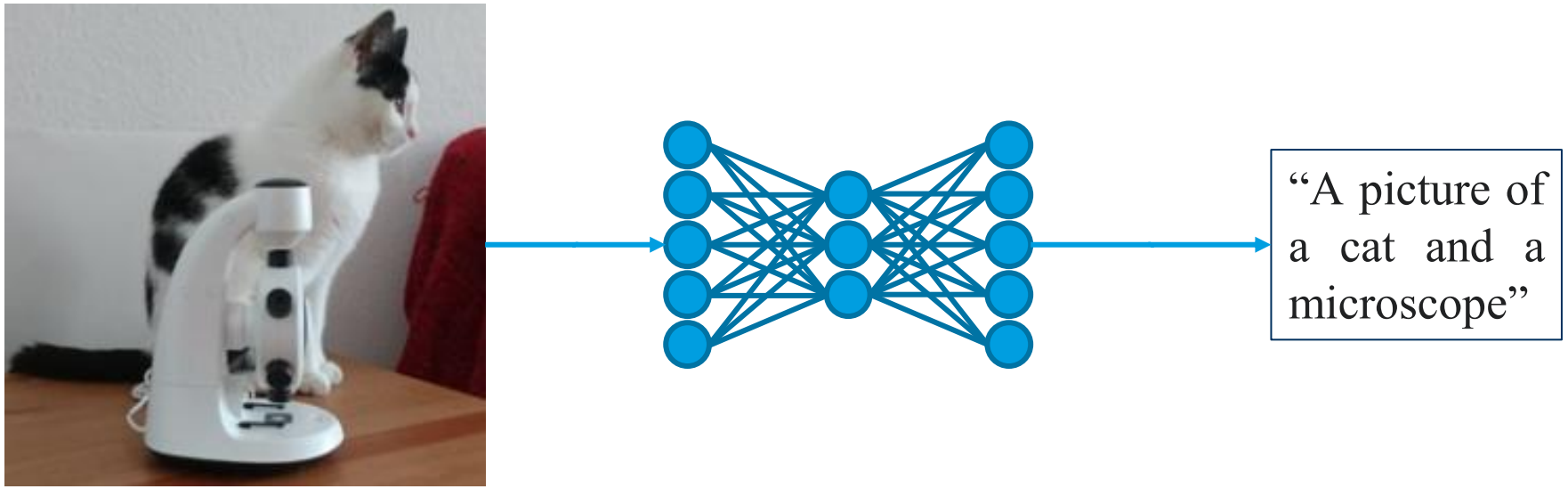
Vision Models

- Classifying images (decades old research field 🤭)

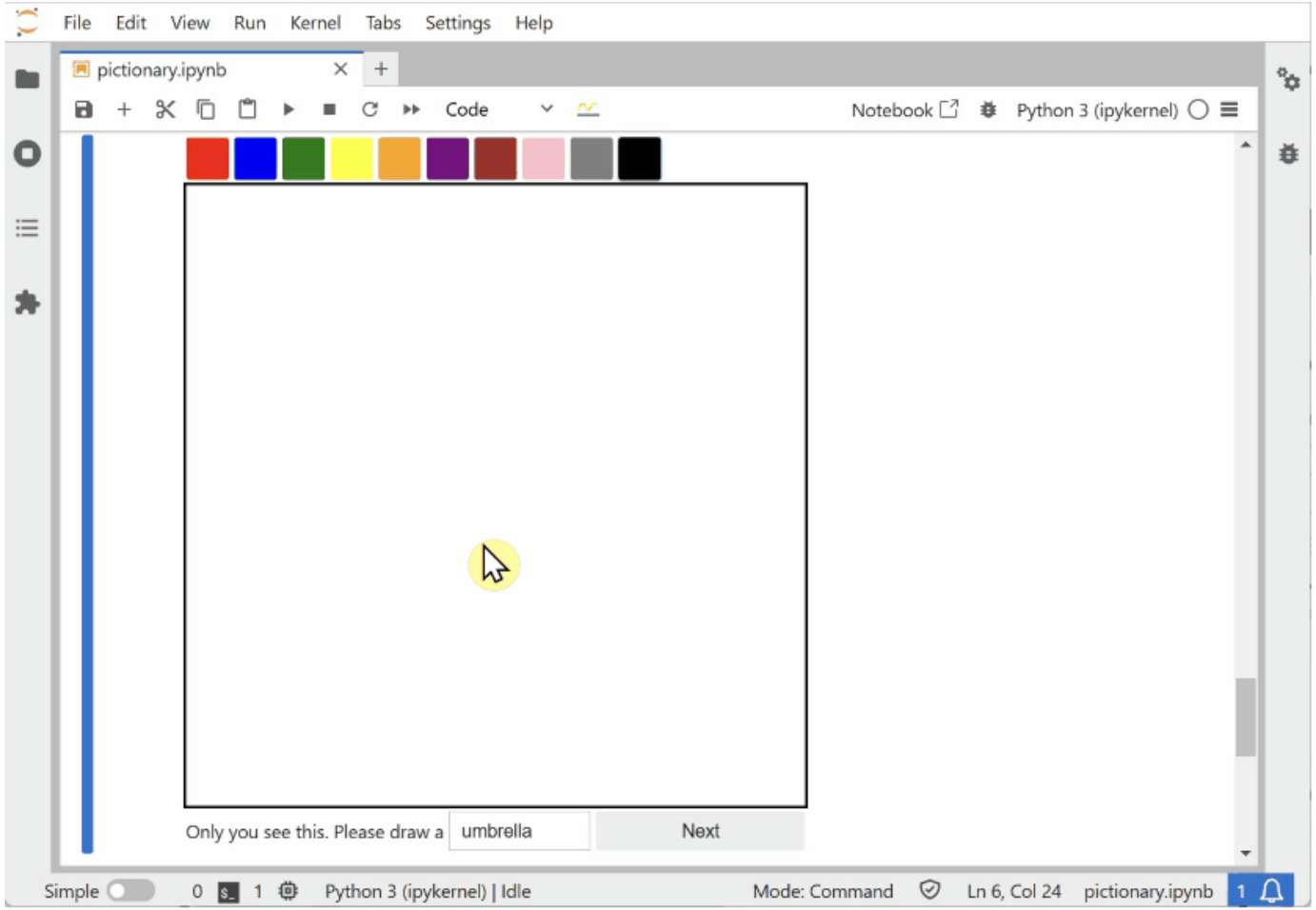


Vision Language Models

- Classifying images
- Describing images



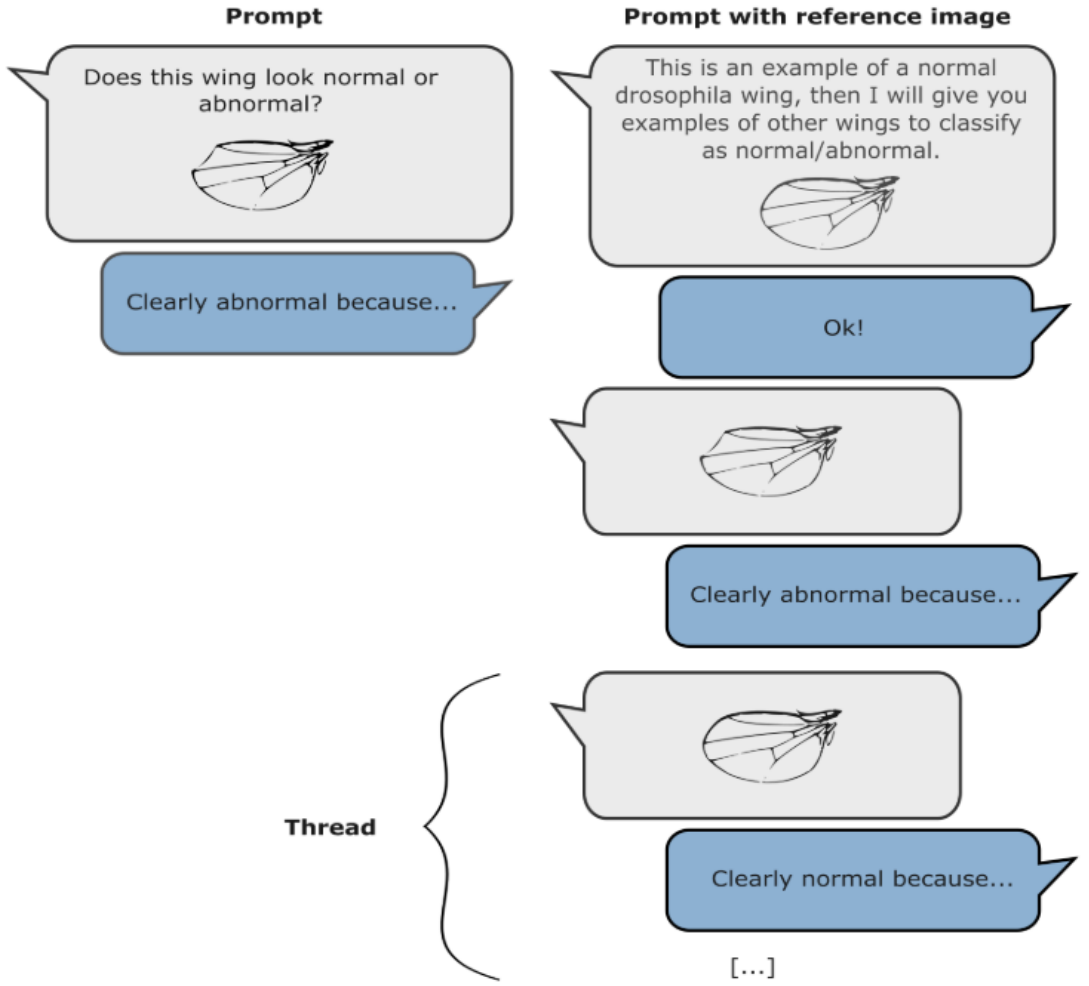
Gamification: VLM-Pictionary



Use case: Descriptive biology

Table 1. Dataset: phenotypes analyzed and example images.

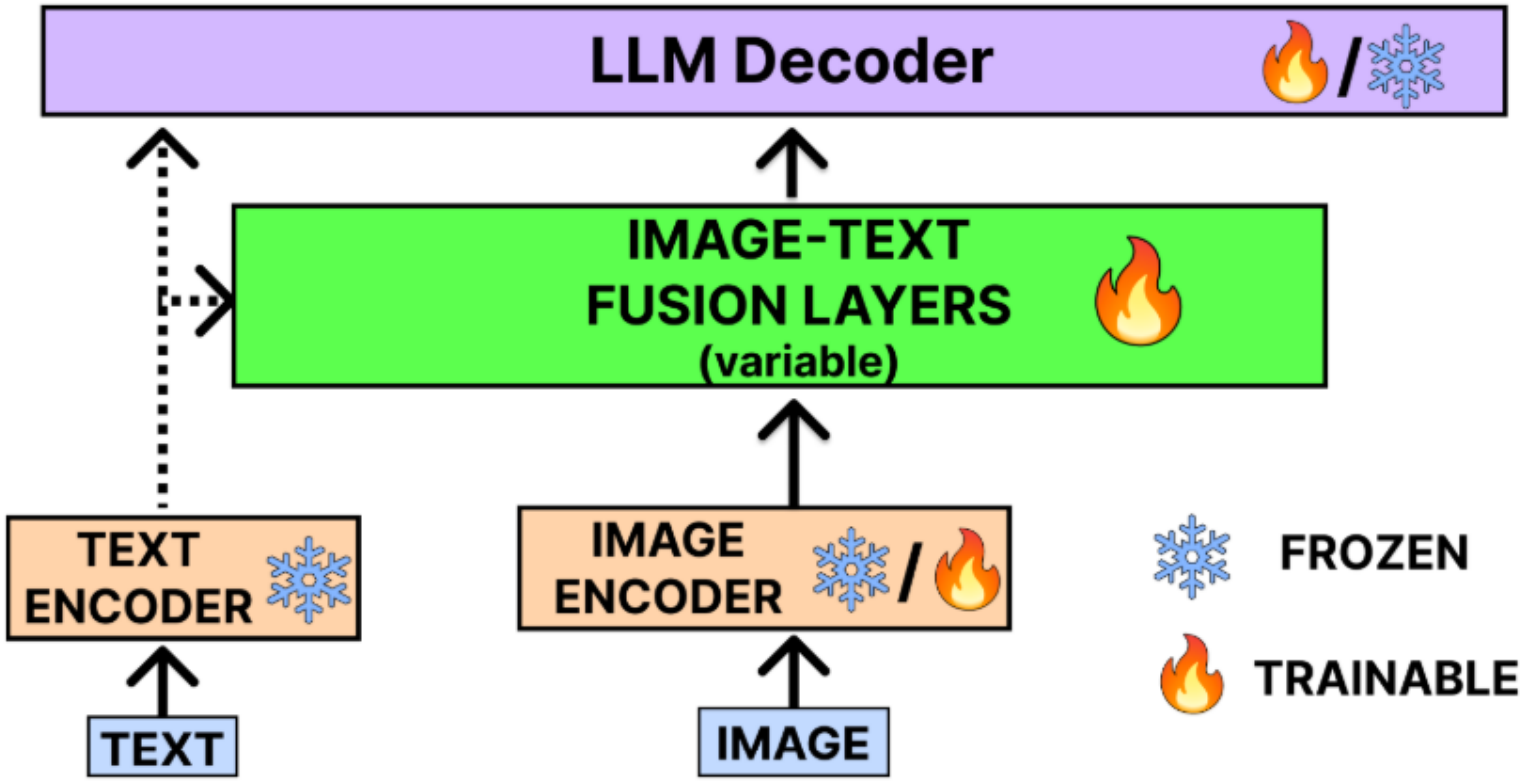
Phenotype	# Imgs	Example
Loss of wing veins (V-)	10	
Ectopic wing veins (V+)	20	
Integrity of wing margin (WM)	23	
Wing surface adhesion (WA)	27	



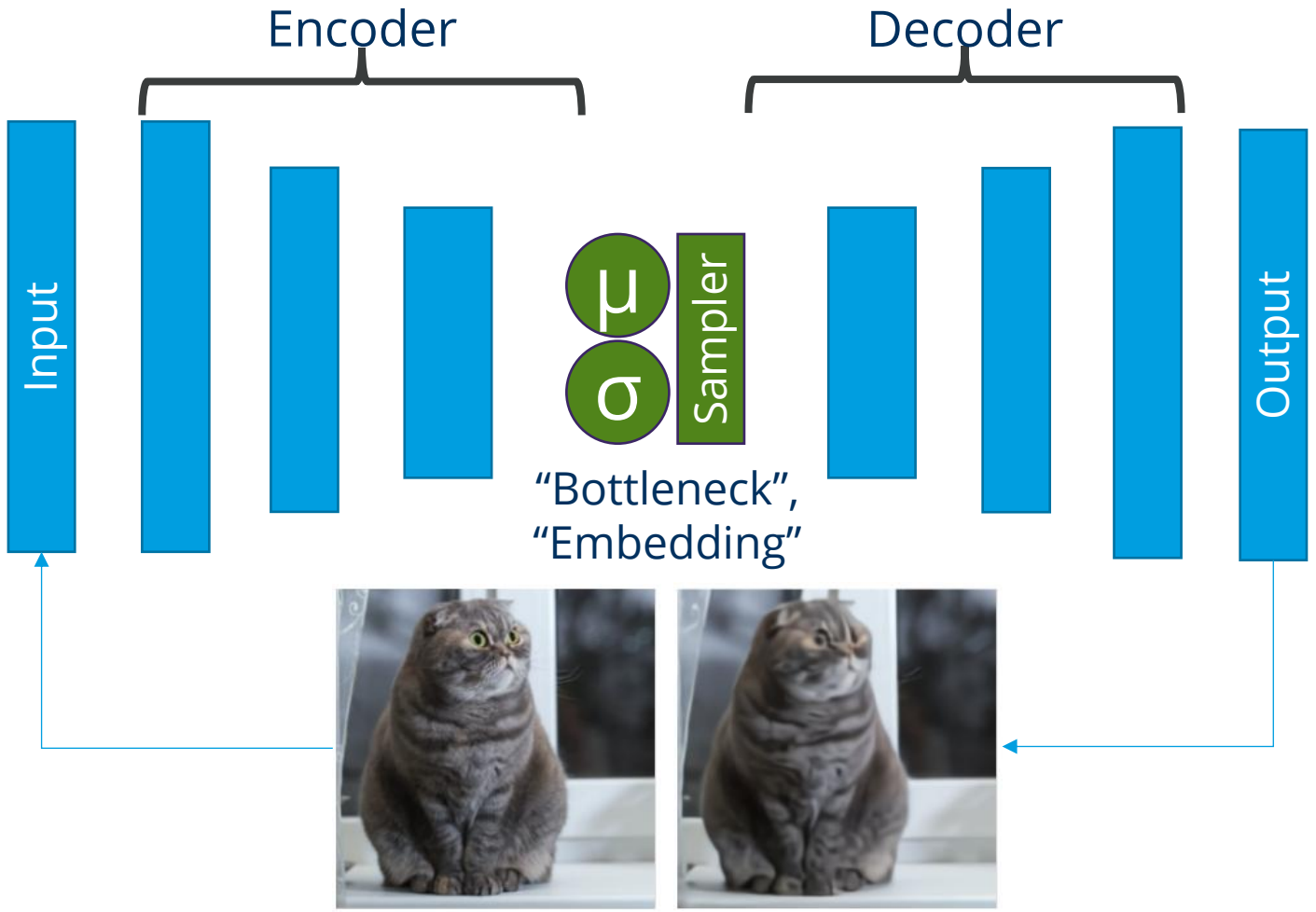
"… while visual language models are in their infancy, they already show potential for multiple applications in automated phenotyping studies. We encourage the community to carefully test them… "

Vision Language Models (VLMs)

Goal: Describe images



Variational Auto-Encoder



Cat picture source: Ramesh et al. 2021, licensed CC-BY 4.0 https://arxiv.org/pdf/2102.12092.pdf

Image classification -> image describing

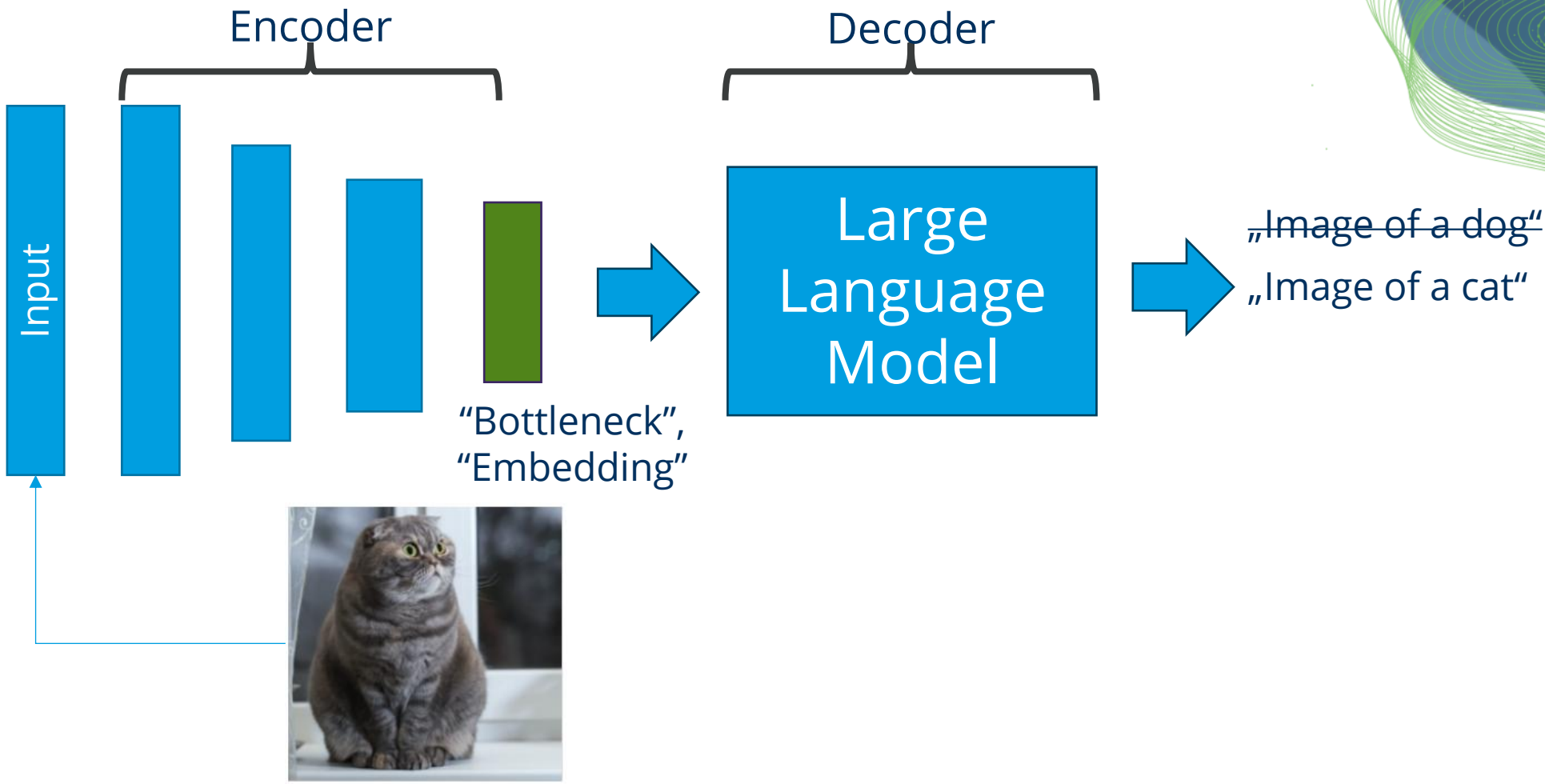
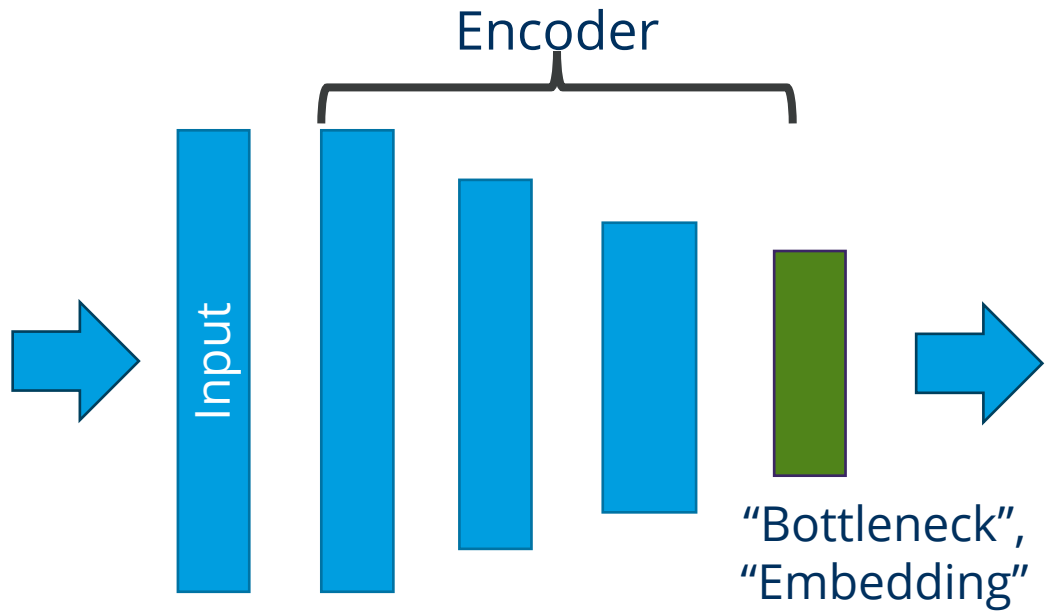


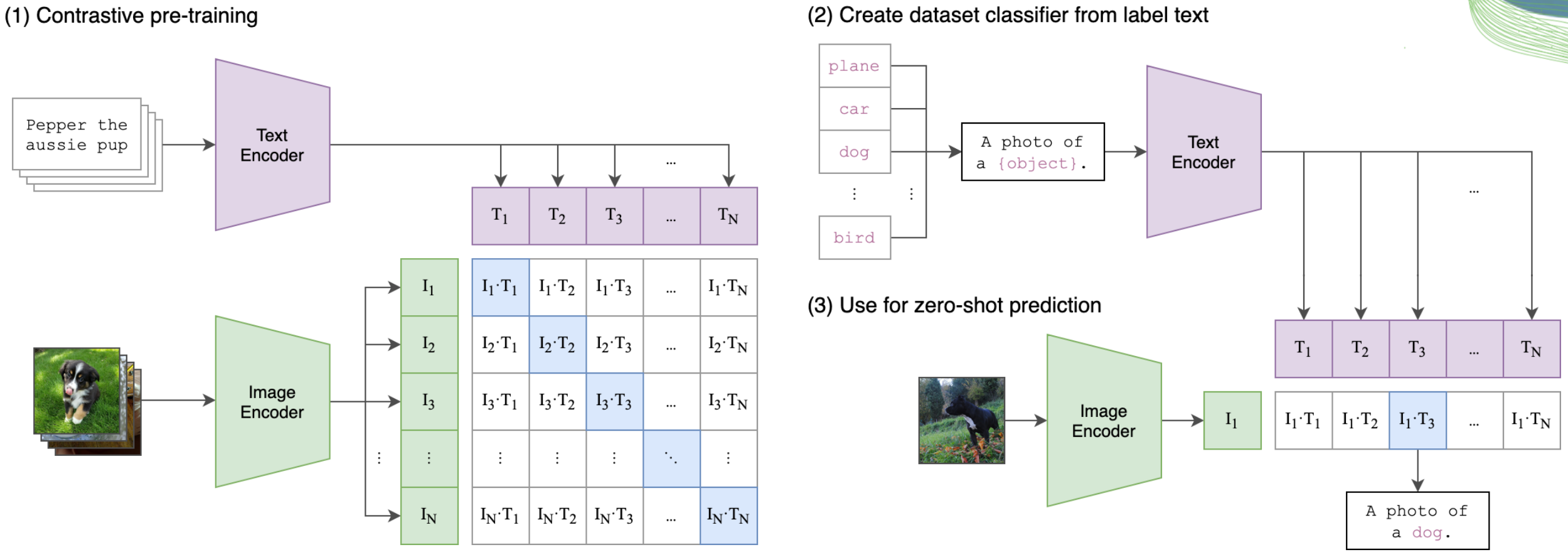
Image classification -> image describing



VLMs can only know terms which were in the training data.

Contrastive Language-Image Pre-Training

„CLIP“ Transformers



Source: Radford et al 2021, License MT
https://arxiv.org/abs/2103.00020
https://github.com/OpenAI/CLIP

CLIP transformers in Python

Using huggingface 🤗

Downloads 500 MB

```
model = CLIPModel.from_pretrained("openai/clip-vit-base-patch32")
processor = CLIPProcessor.from_pretrained("openai/clip-vit-base-patch32")
```

```
options = ["a photo of a cat",
           "a photo of a dog"]
```

```
options = ["a photo of a cat",
           "a photo of a dog",
           "a photo of a microscope"]
```

```
inputs = processor(text=options, images=image, return_tensors="pt", padding=True)
outputs = model(**inputs)
```

...

```
label_probabilities
```

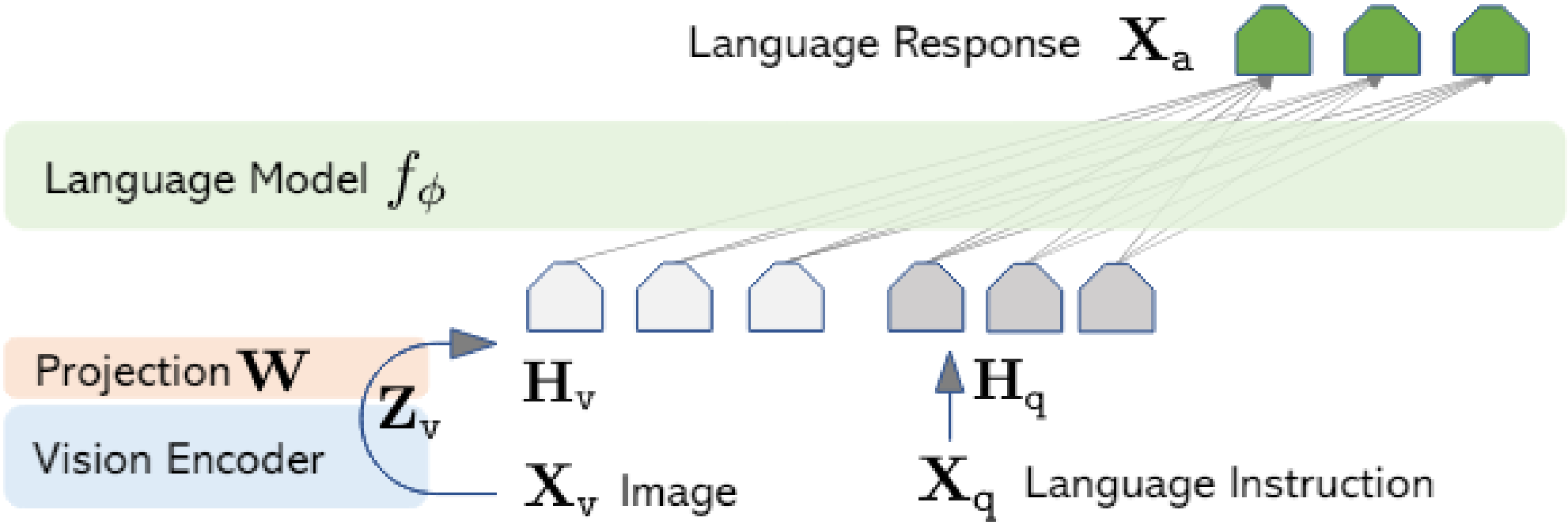
```
{'a photo of a cat': 0.9907298684120178,
 'a photo of a dog': 0.009270114824175835}
```

```
label_probabilities
```

```
{'a photo of a cat': 0.1352911740541458,
 'a photo of a dog': 0.0012659047497436404,
 'a photo of a microscope': 0.8634429574012756}
```

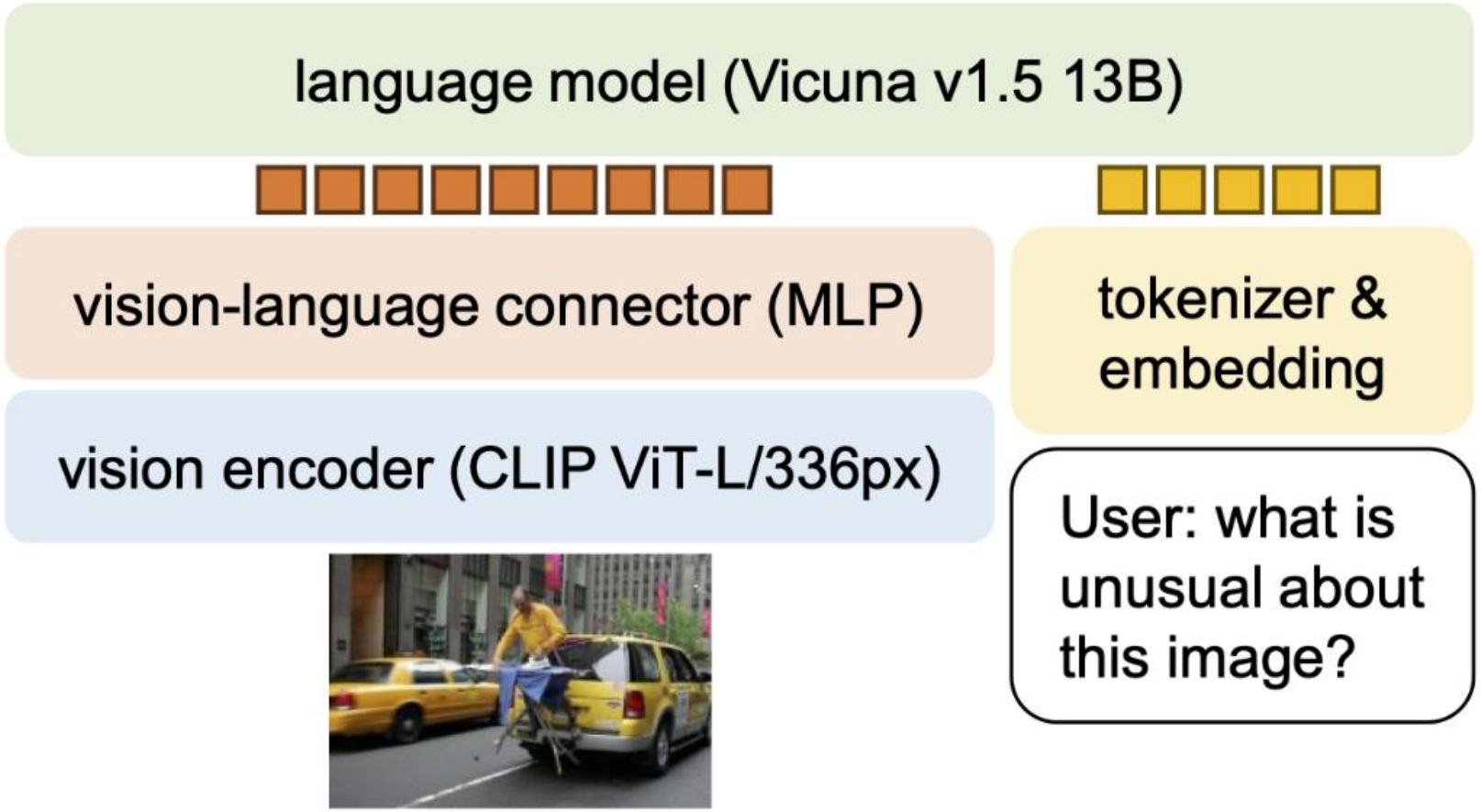
LLAVA

Large Language and Vision Assistant



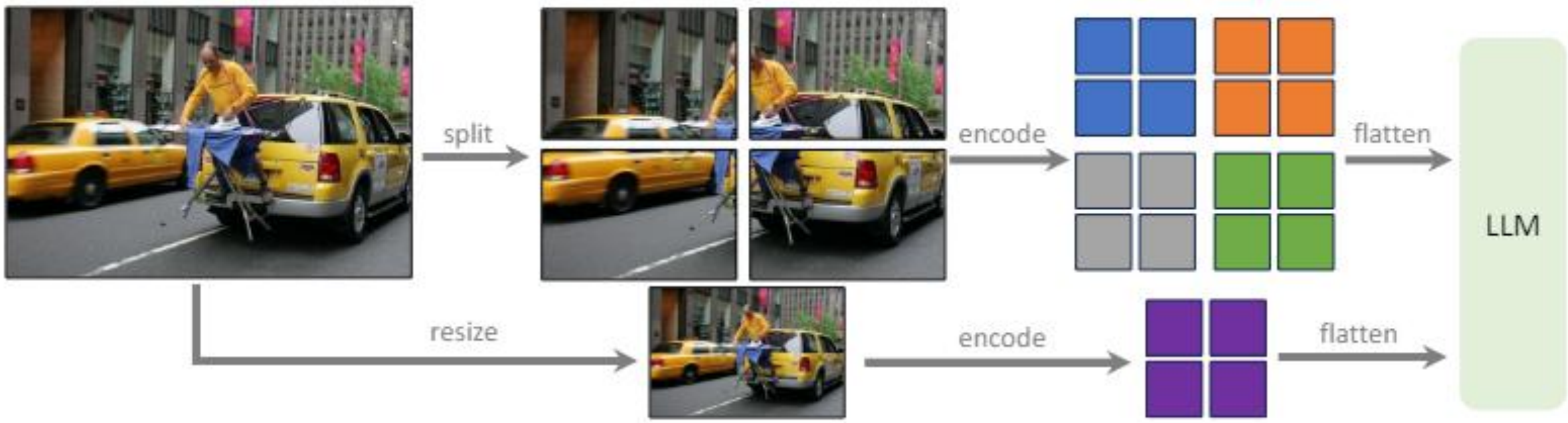
LLAVA 1.5

Combining LLAVA with CLIP

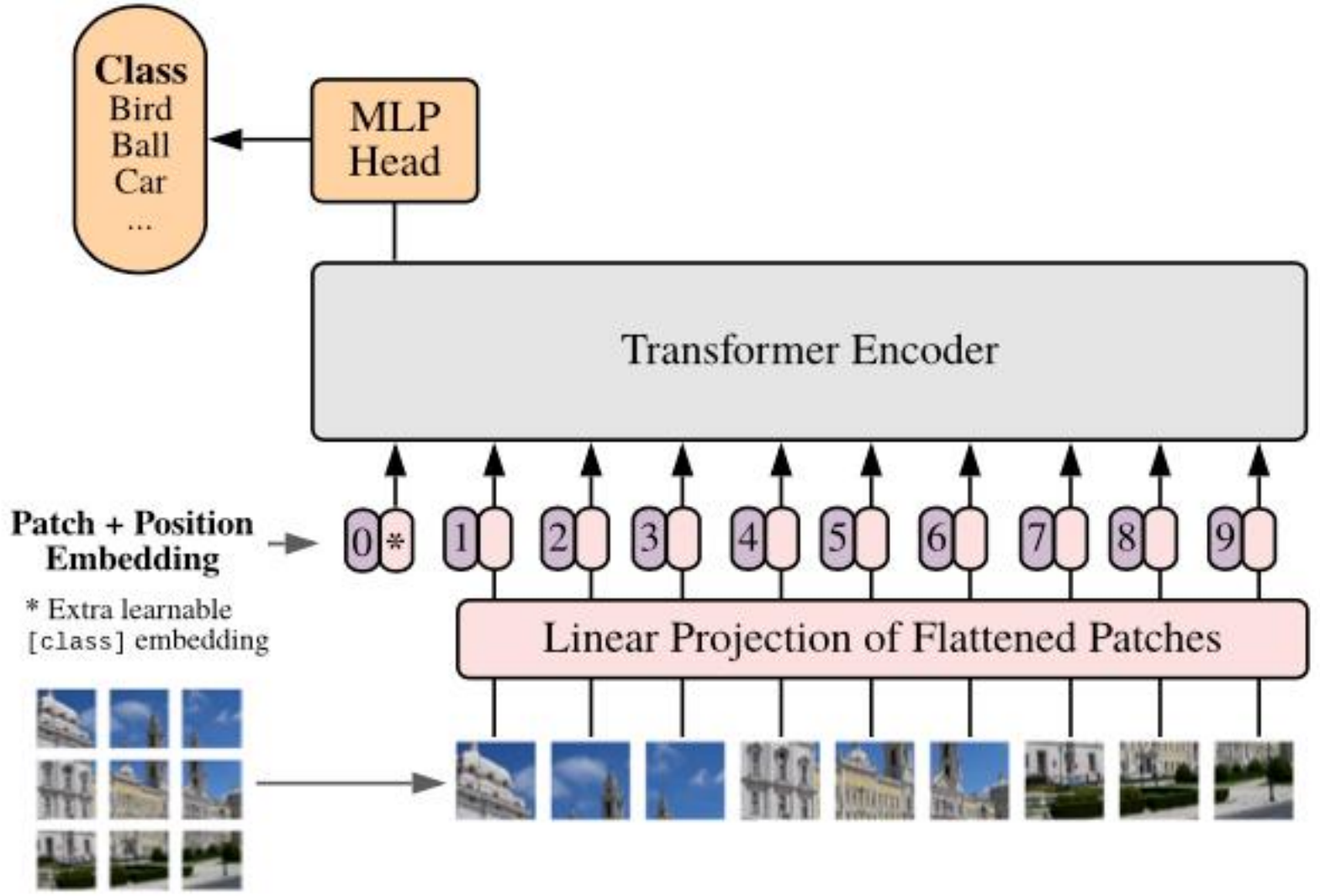


LLAVA 1.5 HD

Giving the model multiple perspectives on the same scene



Vision-Transformer (ViT)

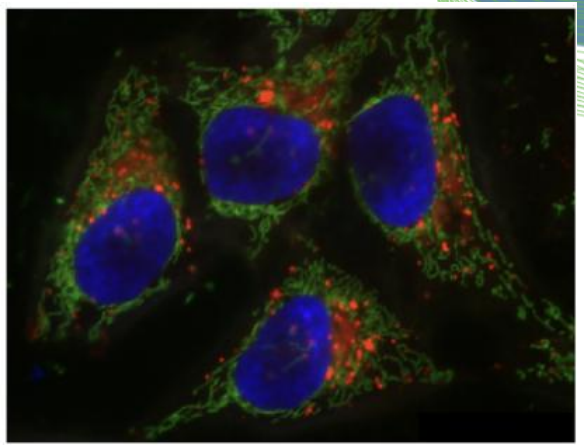


Source: Cropped from Dosovitskiy et al 2021.
https://github.com/google-research/vision_transformer, license Apache 2
See also: https://arxiv.org/abs/2010.11929

Accessing VLMs using Python

E.g. using ScaDS.AI's openai-compatible LLM Server

```python
def prompt_qwen(prompt:str, image, model="Qwen/Qwen2-VL-7B-Instruct"):
    """A prompt helper function that sends a message to the server
    and returns only the text response.
    """
    rgb_image = _img_to_rgb(image)
    byte_stream = numpy_to_bytestream(rgb_image)
    base64_image = base64.b64encode(byte_stream).decode('utf-8')

    message = [{"role": "user", "content": [
        {"type": "text", "text": prompt},
        {
        "type": "image_url",
        "image_url": {
            "url": f"{base64_image}"
        }
    }]}]

    # setup connection to the LLM
    client = openai.OpenAI(base_url="https://llm.scads.ai/v1",
```



```python
res = prompt_qwen("what's in this image?", hela_cells)

display(Markdown(res))
```

Accessing VLMs using Python: No common API

```python
if image is None:
    message = [{"role": "user", "content": message}]
else:
    encoded_image = image_to_url(image)
    message = [{
        "role": "user",
        "content": [
            {
                "type": "text",
                "text": message
            },
            {
                "type": "image",
                "source": {
                    "type": "base64",
                    "media_type": "image/png",
                    "data": encoded_image
                }
            }
        ]
    }]
```

Anthropic / claude

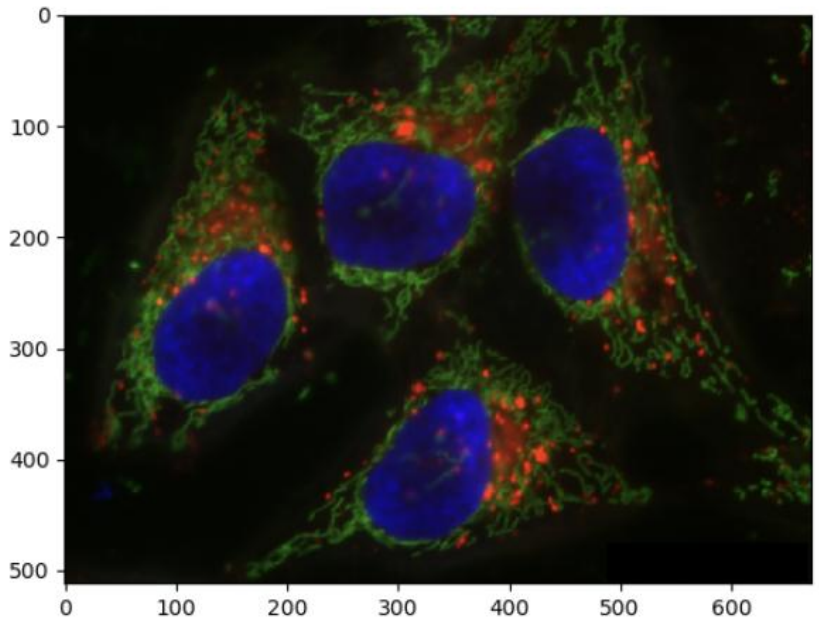
```python
if image is not None:
    response = client.generate_content([image, request])
else:
    response = client.generate_content(request)
```

Google / Gemini

Structured output

Ask VLMs to describe an image and pre-define a structure

```
hela = imread("data/hela-cells-8bit.tif")
stackview.insight(hela)
```



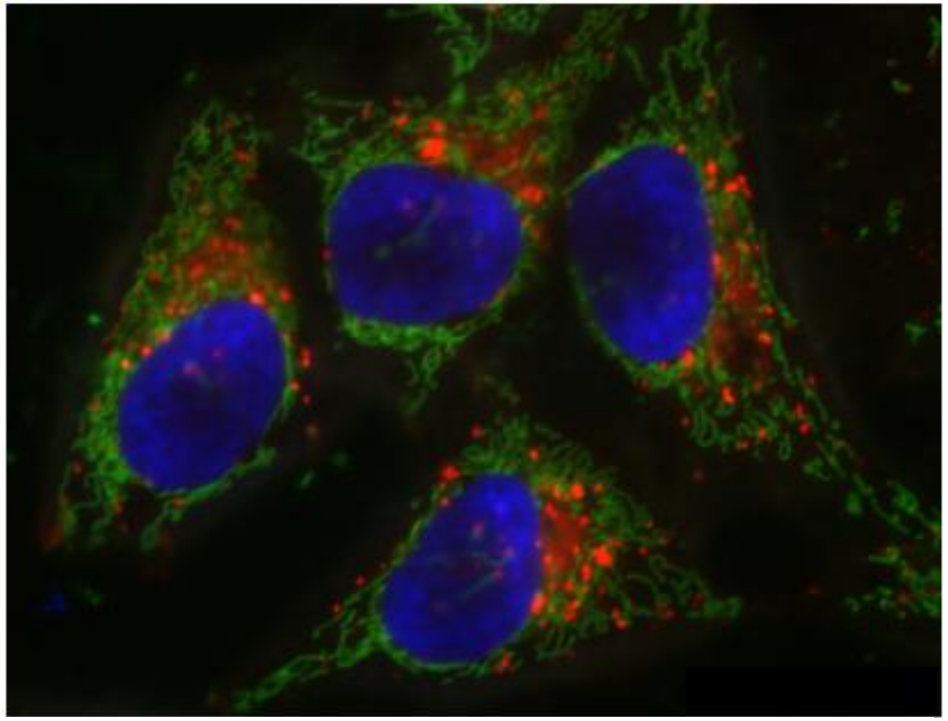

```
result = prompt_chatGPT("""You are a highly experienced biologist with advanced microscopy skills.

# Task
Name the content of this image. Answer for each channel independently.

# Options
The following structures could be in the image:
* Nulcei
* Membranes
* Cytoplasm
* Cytoskeleton
* Extra-cellular structure
* Other sub-cellular structures

# Output format
* Red channel: <structure>
* Green channel: <structure>
* Blue channel: <structure>

Keep your answer as short as possible.
Only respond with the structres for the three channels in the format shown above.
""", hela)

Markdown(result)
```

- Red channel: Other sub-cellular structures
- Green channel: Cytoskeleton
- Blue channel: Nuclei

Benchmarking vision models

Single attempts… are a trap

You



How many blue nuclei are in this image?

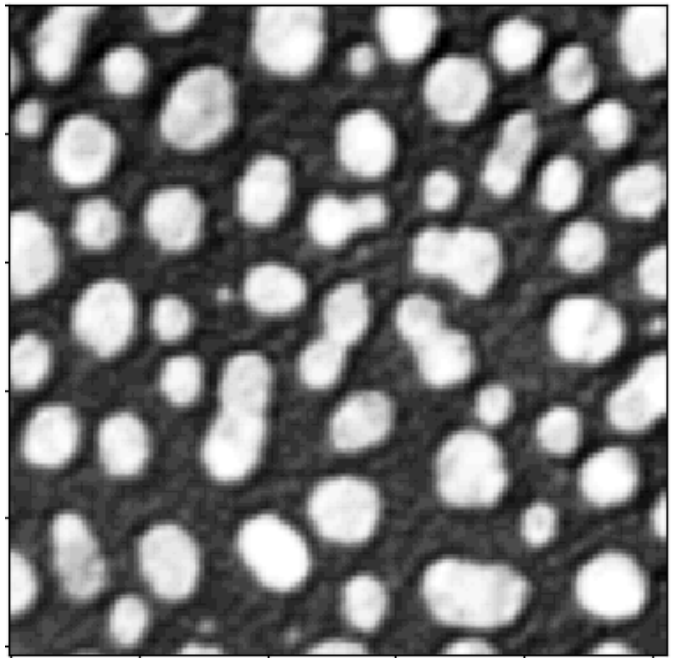
ChatGPT

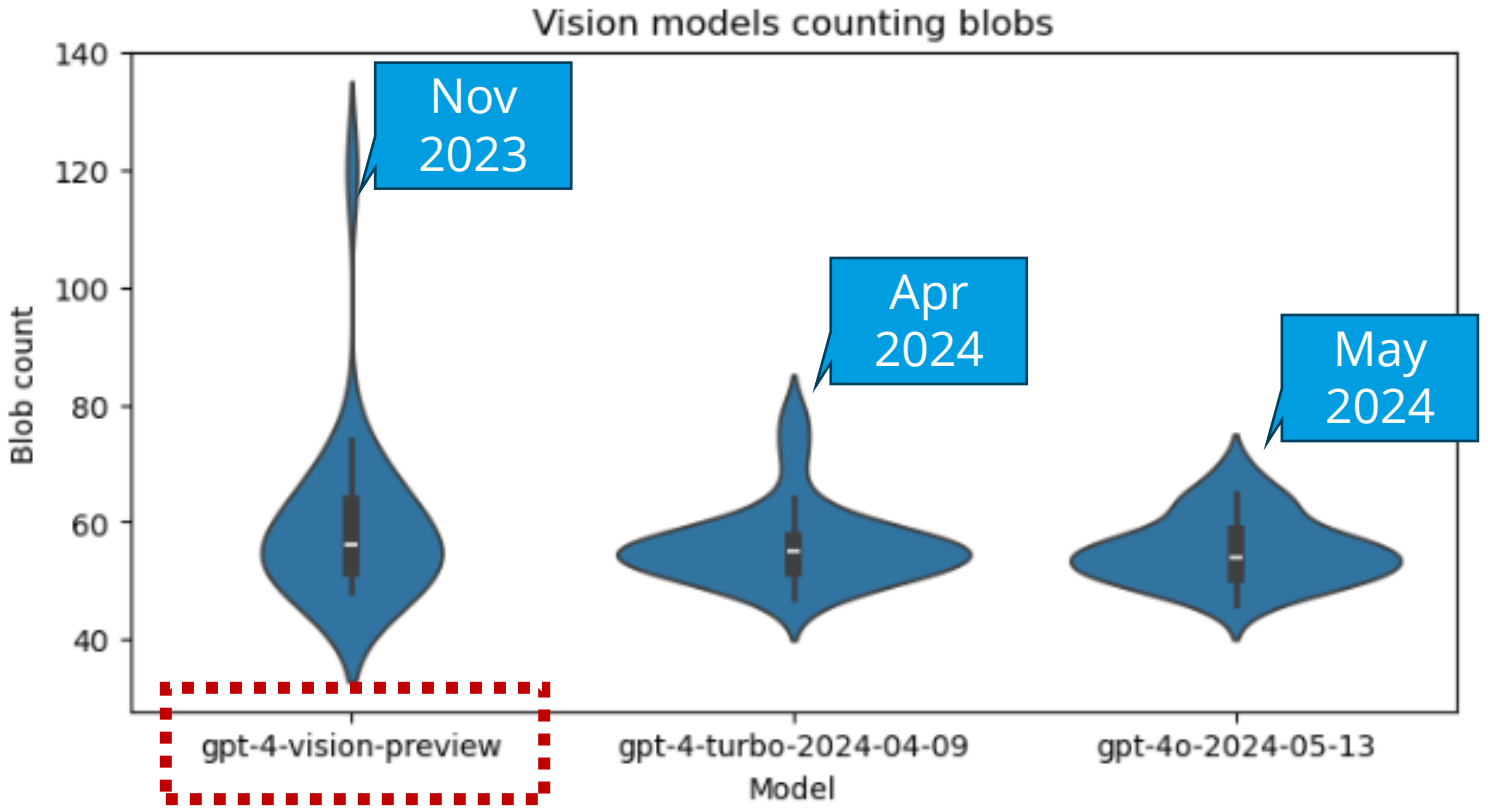
There are three blue nuclei visible in this image.

n=1

Vision language models for counting objects

Prompt: „Analyse the following image by counting the bright blobs. Respond with the number only. “ (n=25)





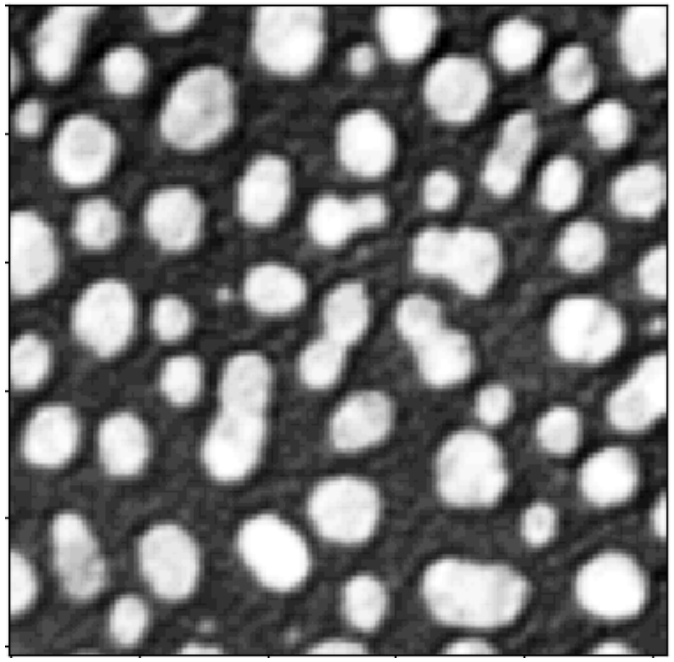
Model no longer available (Apr. 2025)

https://scads.github.io/generative-ai-notebooks/80_benchmarking_llms/20_vision_models.html

Vision language models for counting objects

Experiment reproduced June 24th 2025

Lesson learned: We need physical control of models and infrastructure to secure reproducibility!

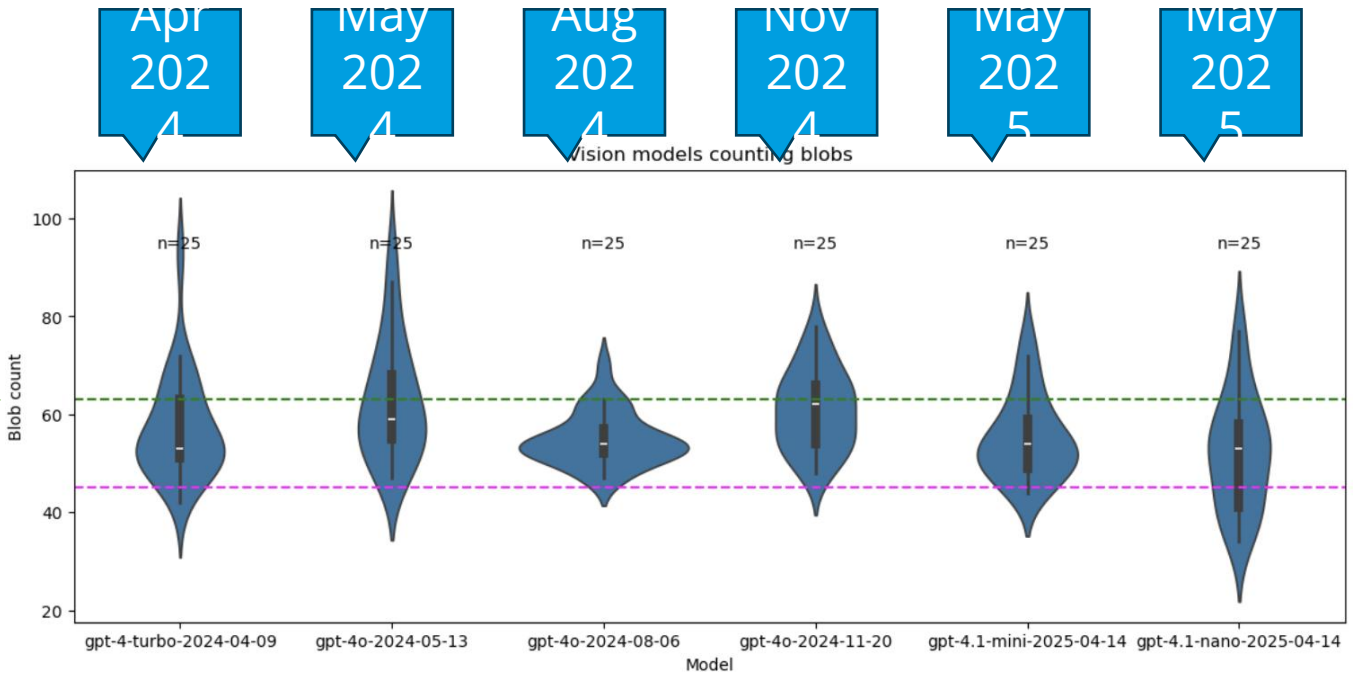


Nov 2023

Model no longer available (Apr. 2025)

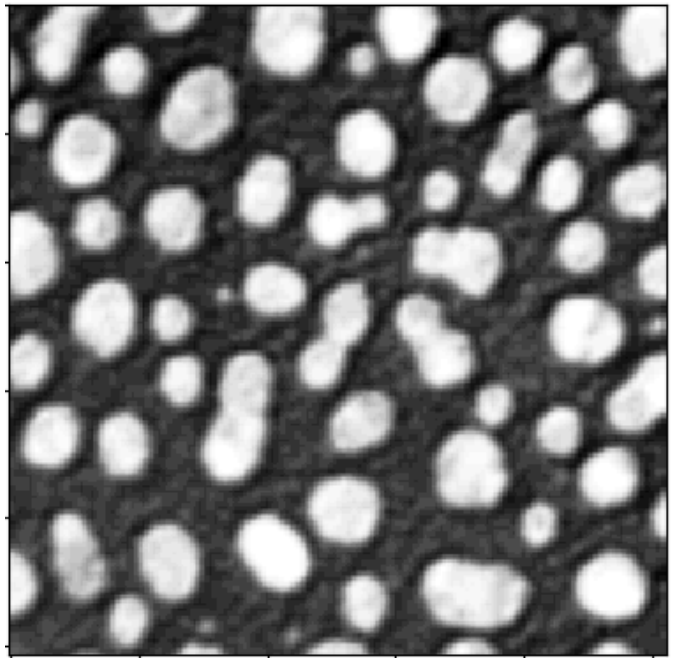
Baseline: Otsu-threshold

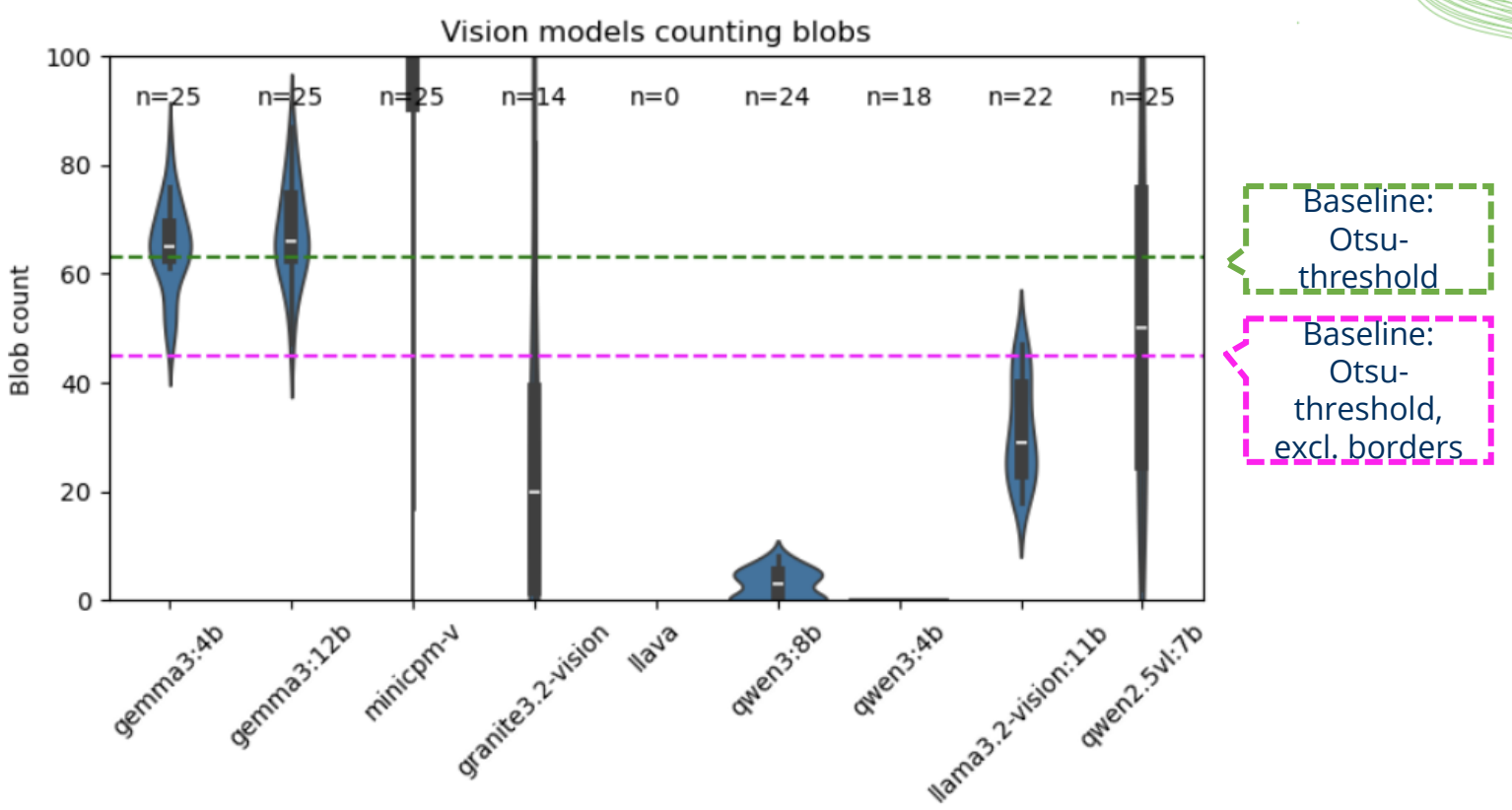
Baseline: Otsu-threshold, excl. borders



Vision language models for counting objects

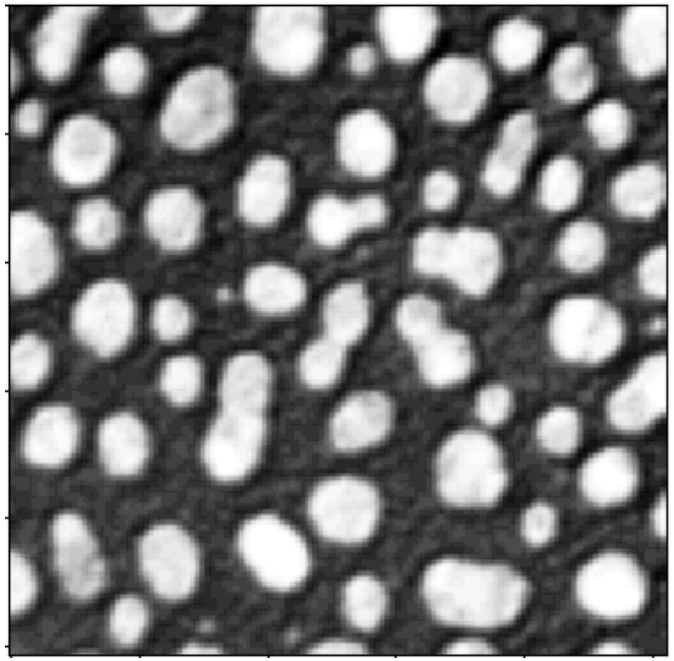
Now also possible using open-weight models (via ollama)





Vision language models for counting objects

Prompt-engineering also works with VLMS



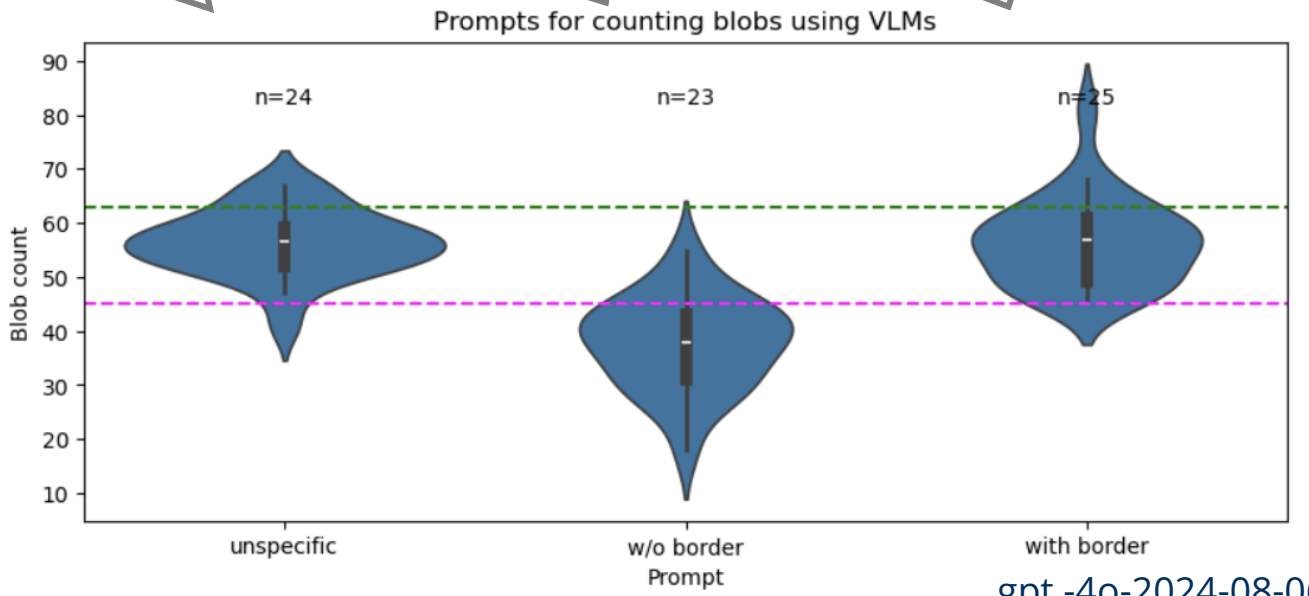
Baseline: Otsu-threshold

Baseline: Otsu-threshold, excl. borders

"Analyse the following image by counting the bright blobs. Respond ONLY the number."

"Analyse the following image by counting the bright blobs. **Ignore the objects touching the image border.** Respond ONLY the number."

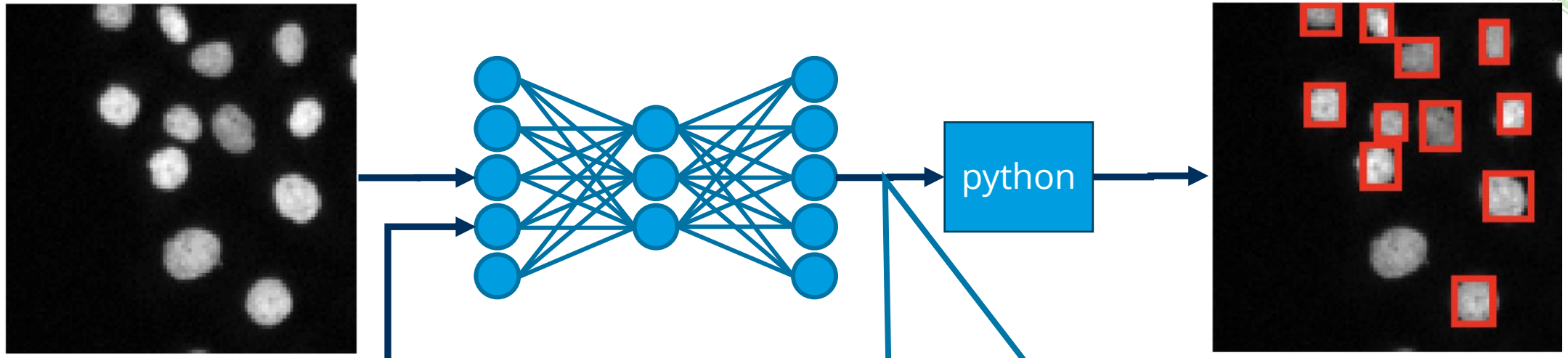
"Analyse the following image by counting the bright blobs**, including the objects touching the image border.** Respond ONLY the number."



gpt -4o-2024-08-06

VLMs for bounding box segmentation

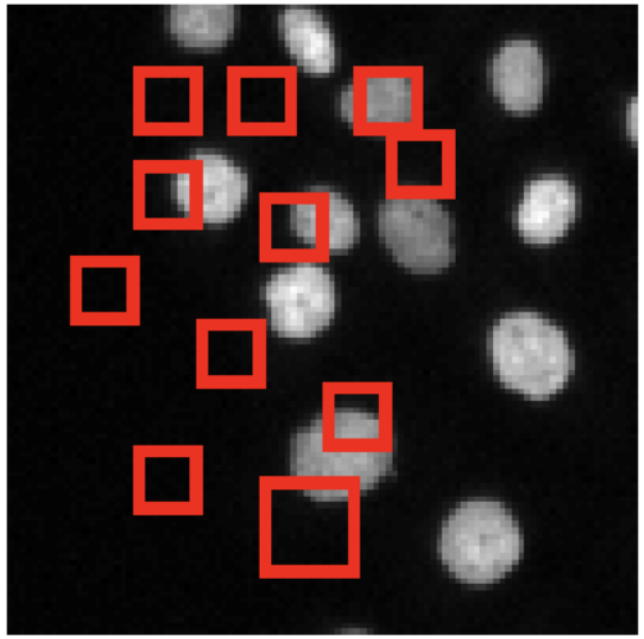
Recap: VLMs combine images + text to produce text



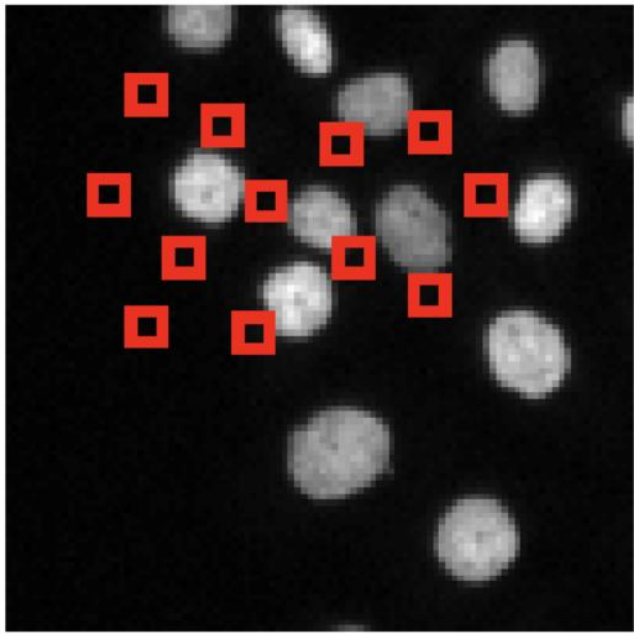
Give me a json object of bounding boxes around ALL bright blobs in this image…

[{"x": 0.191, "y": 0.111,...},
{"x": 0.313, "y": 0.161,...},...]

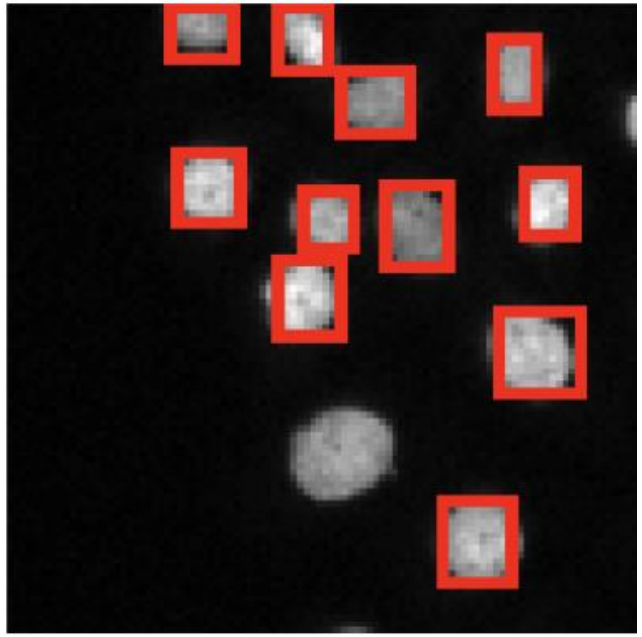
VLMs for bounding box segmentation



GPT-4o



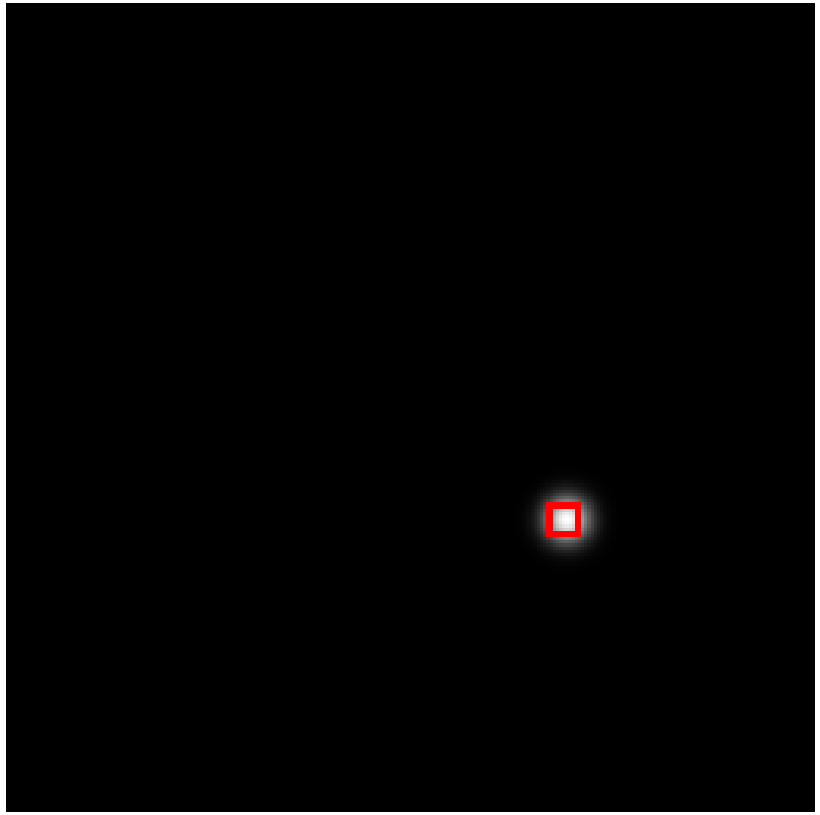
Claude 3.7 Sonnet

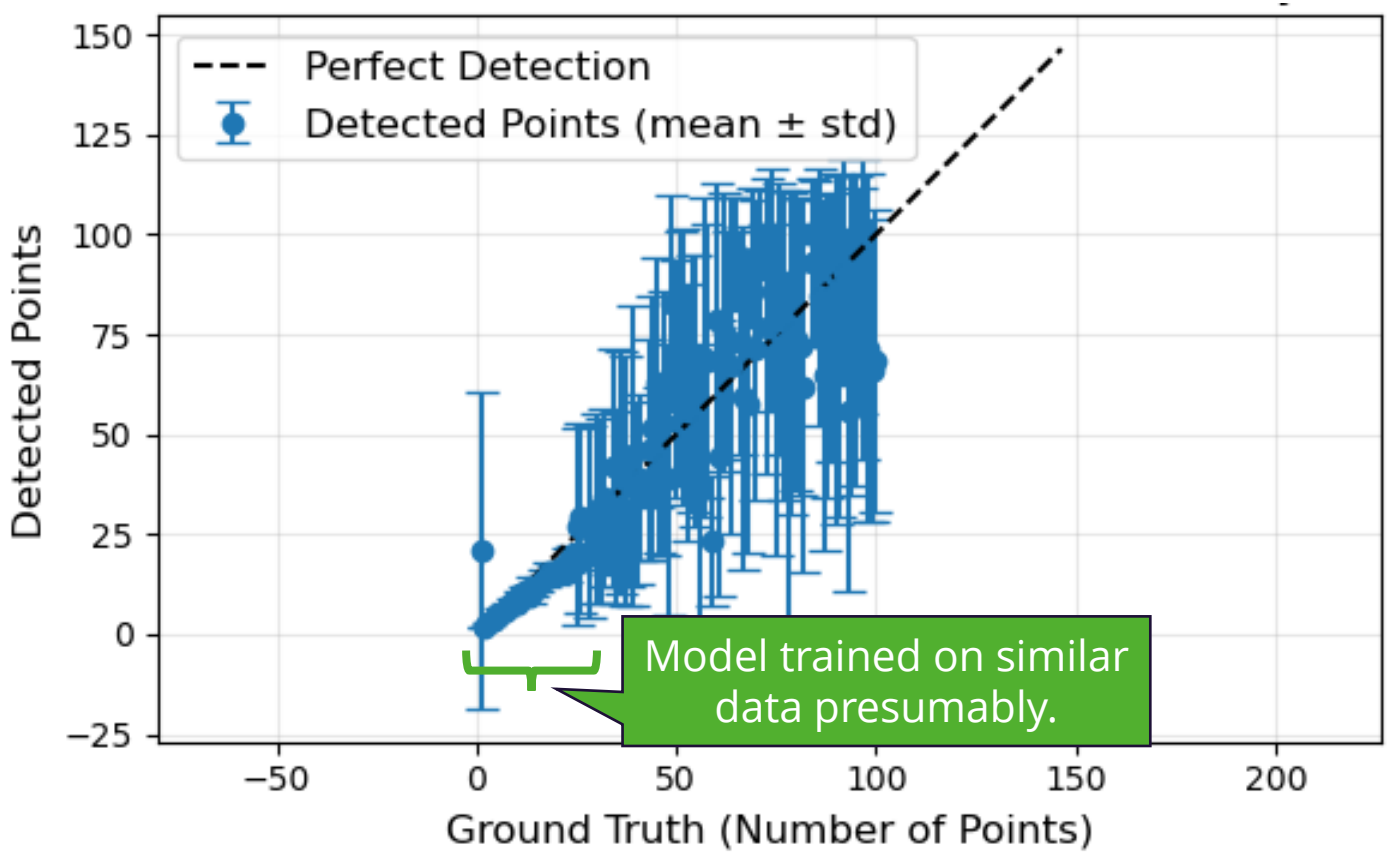


Moondream 2B

Limits of VLMs

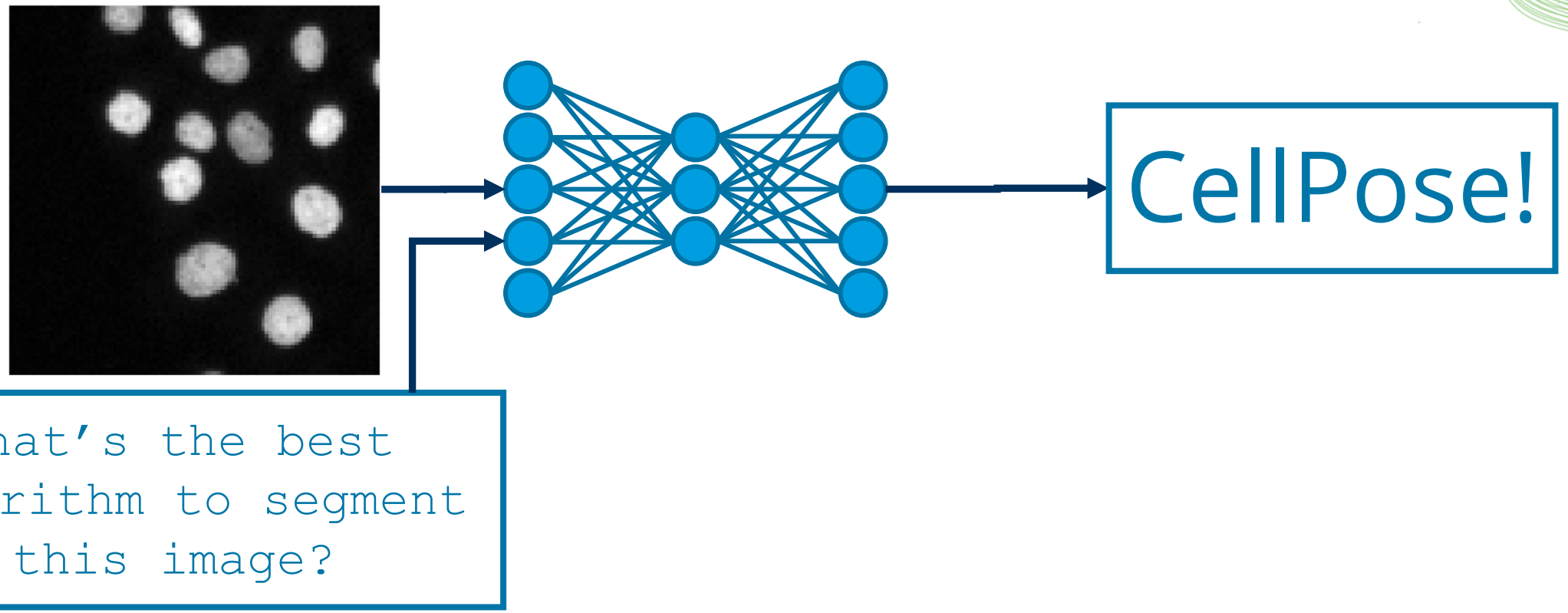
Example: Moondream 2B applied to simulated data





VLMs *guessing* segmentation algorithms

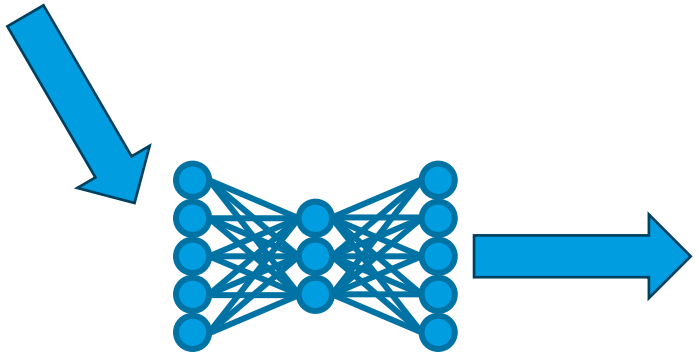
Combine image + text to generate text



LLMs *guessing* segmentation algorithms

```
prompt = """You are a bioimage-analysis expert.
What is the best image processing algorithm to segment microscopy images?
Answer the algorithm name only. No explanations.
"""
```

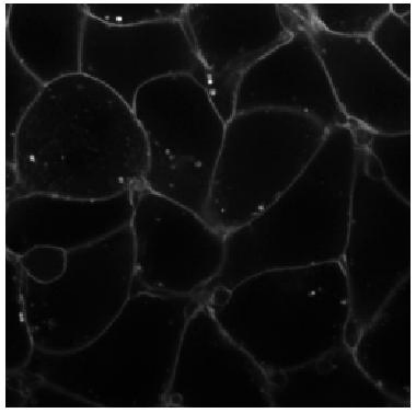
+ no image



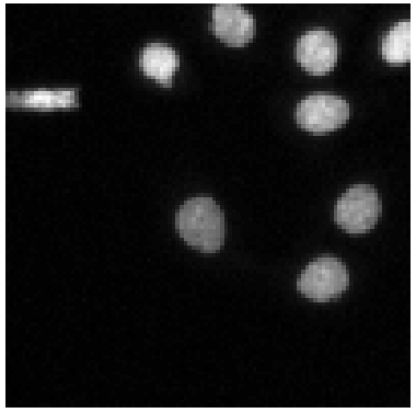
VLM: gpt-4o-2024-11-20, n=25
https://scads.github.io/generative-ai-notebooks/47_vision/40_vlms_guessing_segmentation_alg.html

VLMs guessing segmentation algorithms

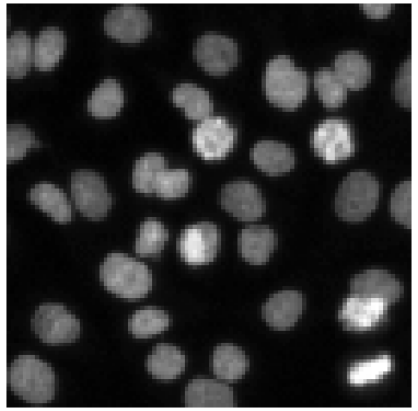
```
prompt = """You are a bioimage-analysis expert.
What is the best image processing algorithm to segment this microscopy image?
Answer the algorithm name only. No explanations.
"""
```



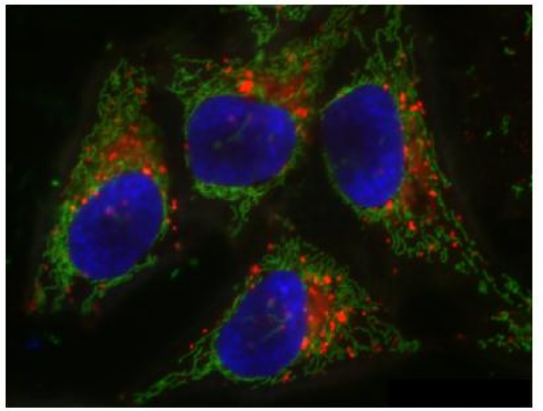
watershed



otsu thresholding
watershed



watershed
otsu thresholding

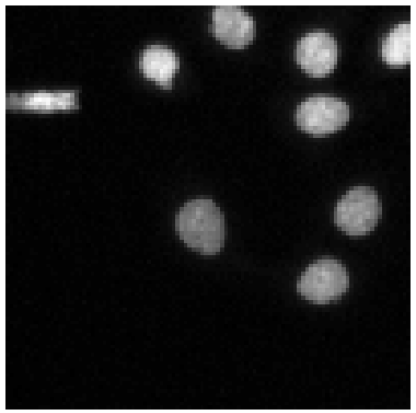


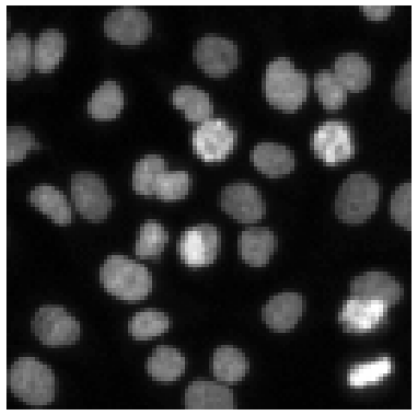
otsu thresholding
learning deep u
cellpose
e watershed
g

VLM: gpt-4o-2024-11-20, n=25
https://scads.github.io/generative-ai-notebooks/47_vision/40_vlms_guessing_segmentation_alg.html

Quiz

You have two images and two segmentation algorithms. Assign the algorithms to the images. Explain your choice.





- Voronoi-Otsu-Labeling
- StarDist

VLMs guessing segmentation algorithms

```
prompt = """You are a bioimage-analysis expert. You have a rule-book what alogrithms to use for specific images.

## Rules

* If an image shows sparse objects such as nuclei, use Otsu-thresholding for segmenting them.
* If an image shows dense, partially overlapping objects such as nuclei, use StarDist.
* If an image shows large cell-like structures with bright membranes, use the Watershed algorithm.
* In case of doubt, use CellPose.

## The task

What is the best image processing algorithm to segment this microscopy image?
Answer the algorithm name only. No explanations.
"""
```

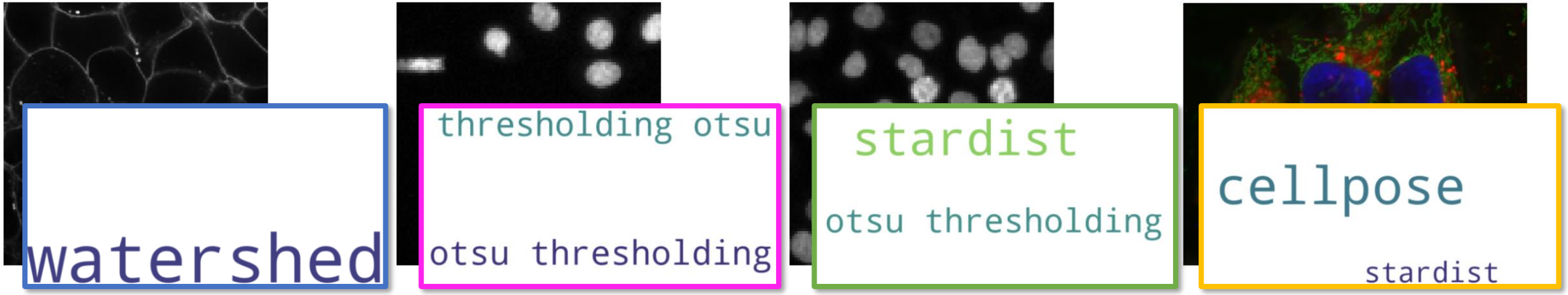
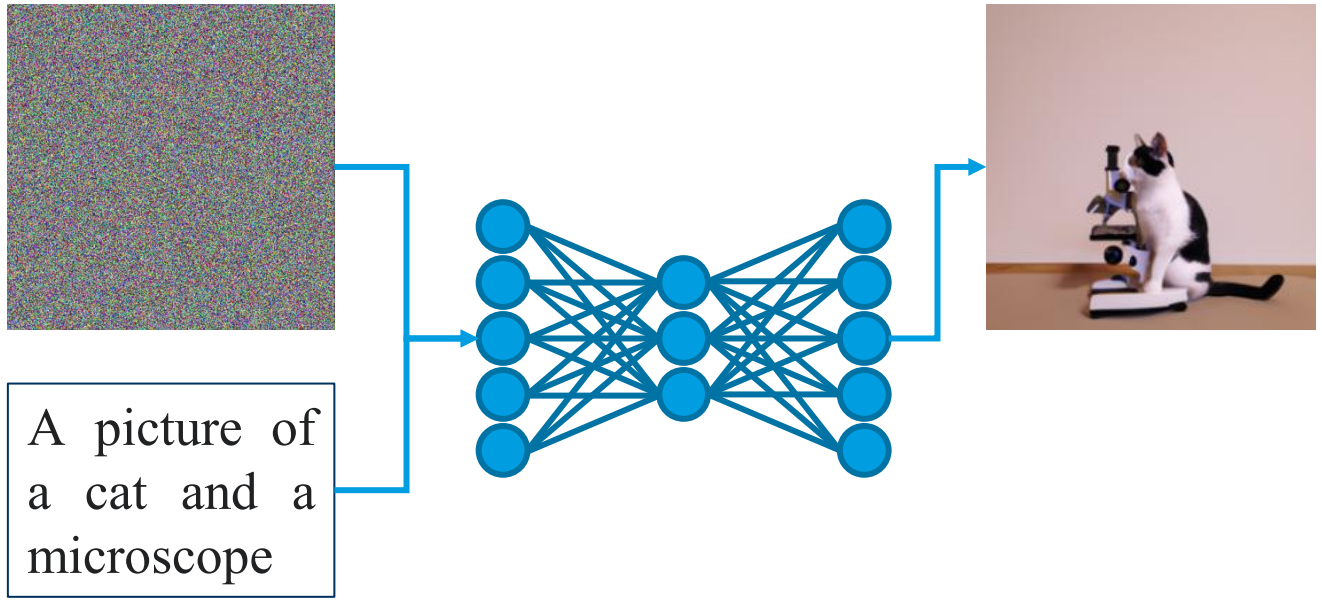


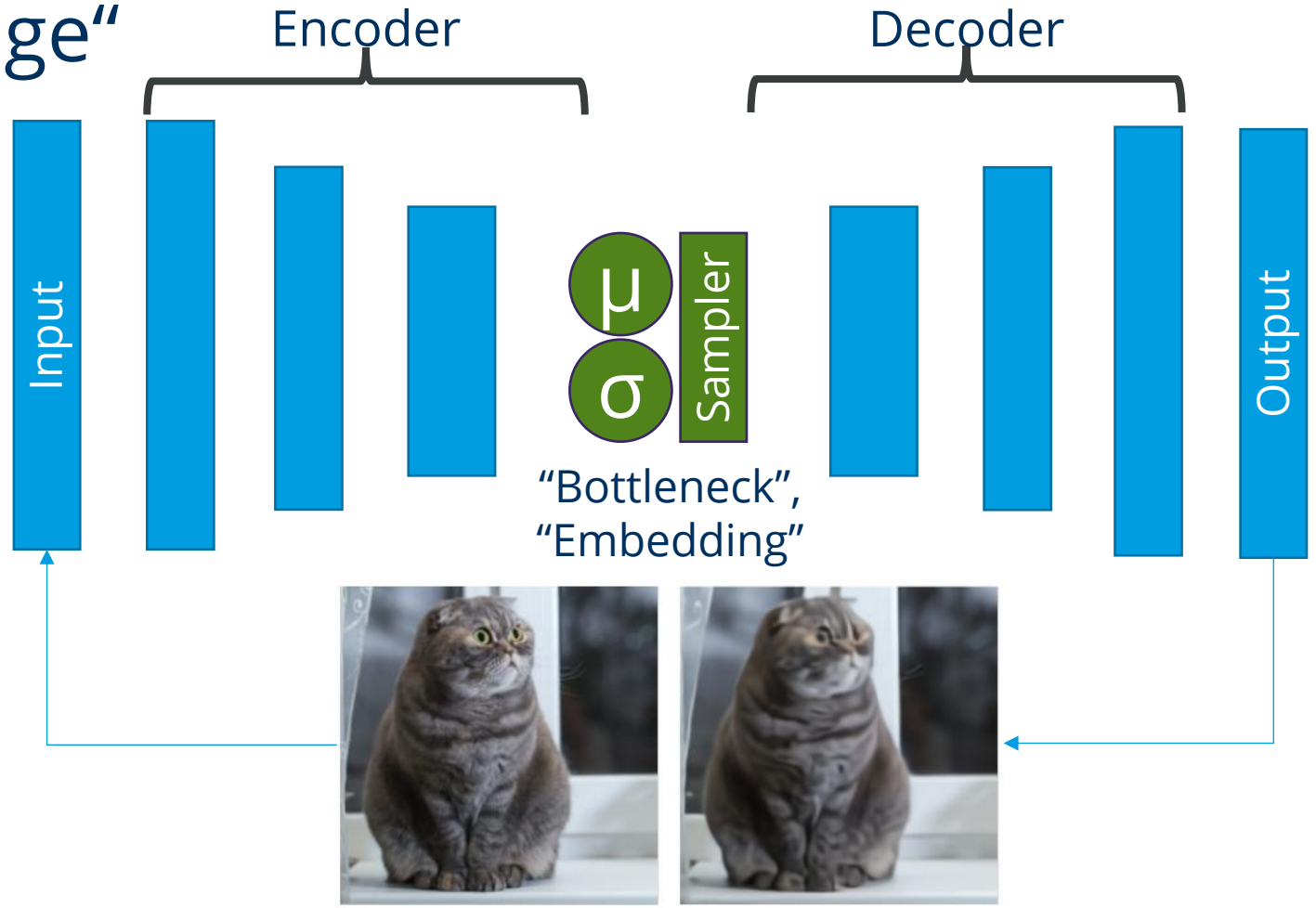
Image Generation

„text-to-image“



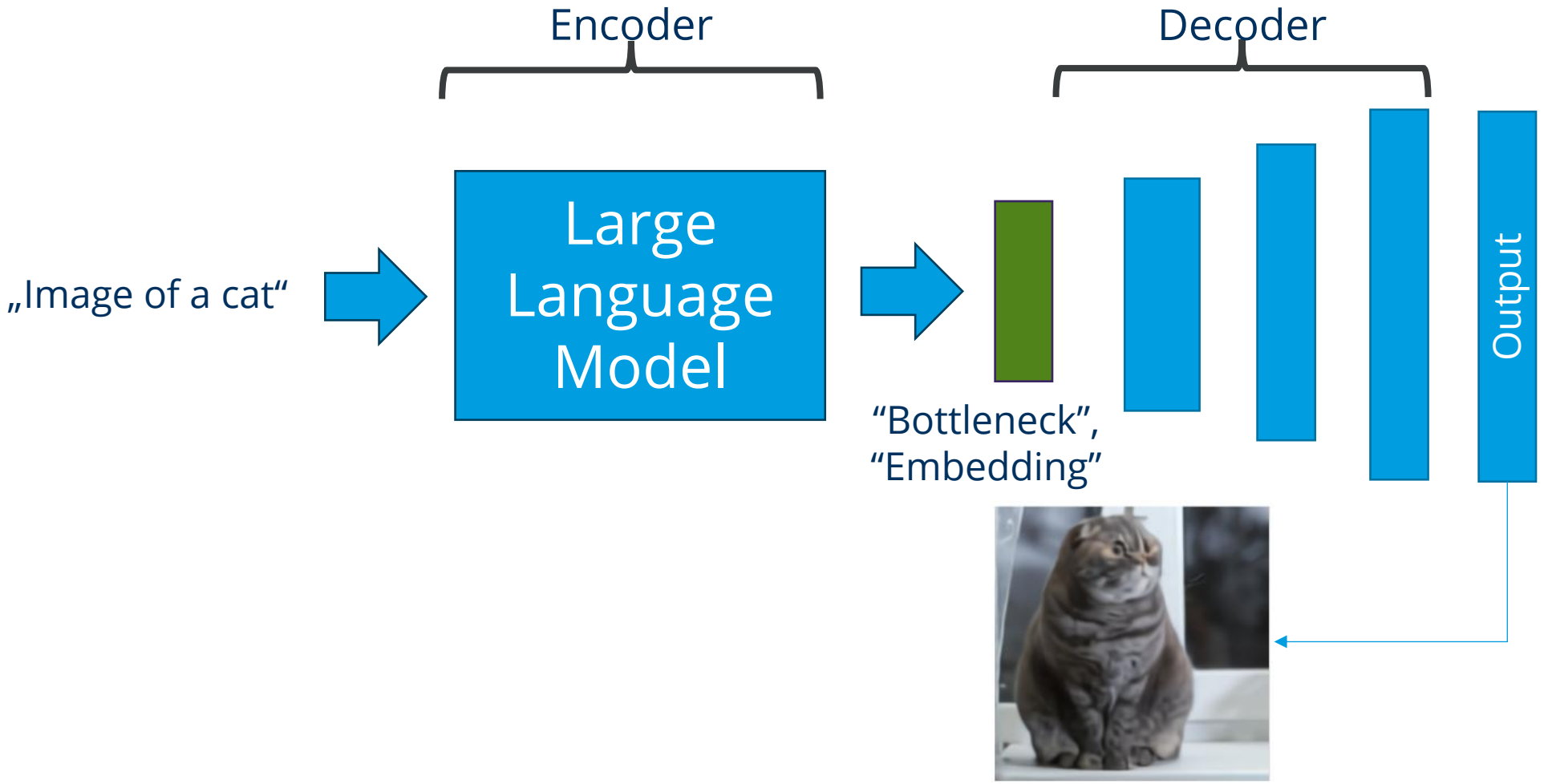
Variational Auto-Encoder

„image-to-image“



Cat picture source: Ramesh et al. 2021, licensed CC-BY 4.0 https://arxiv.org/pdf/2102.12092.pdf

Image Generation

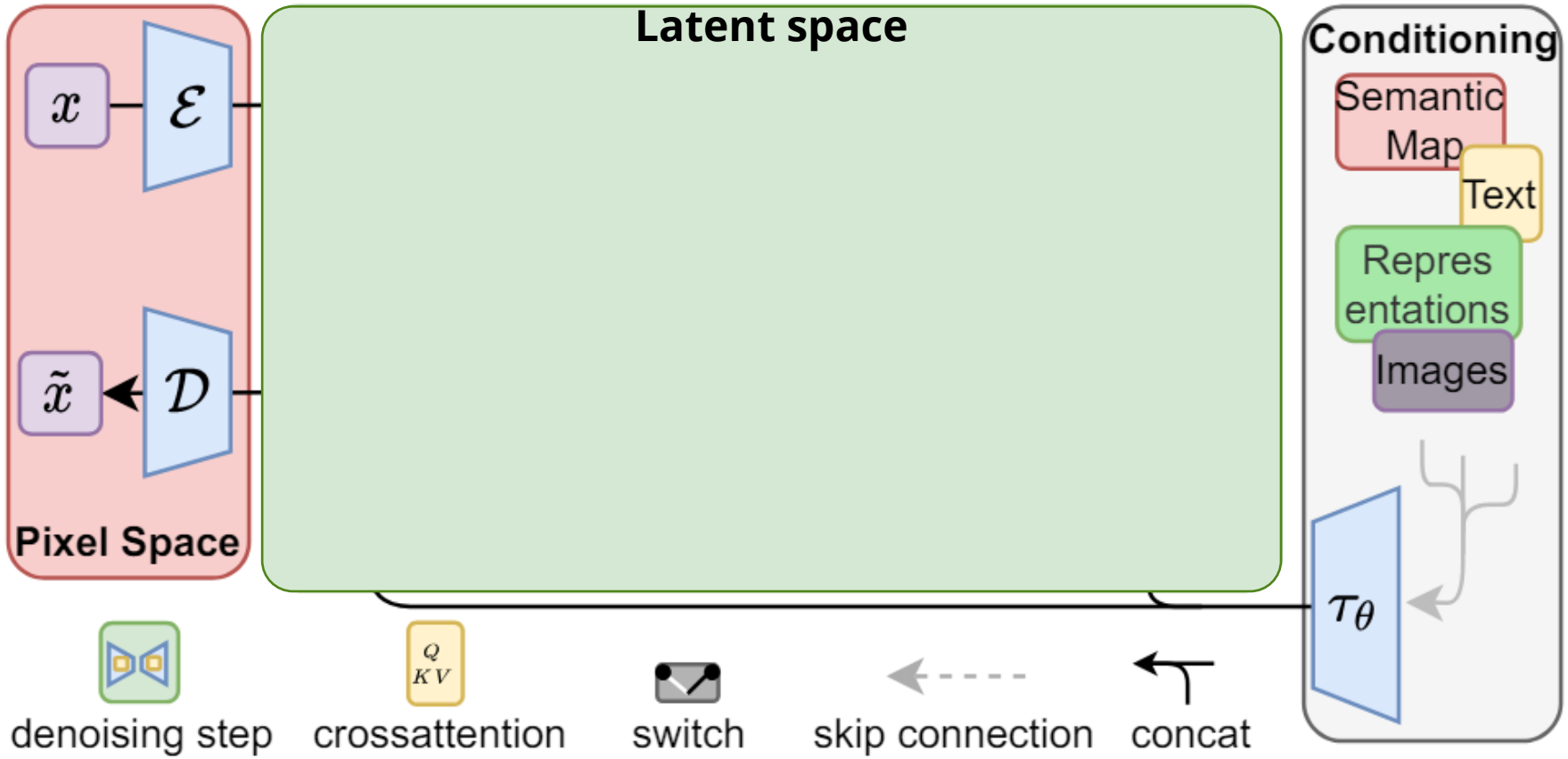


Cat picture source: Ramesh et al. 2021, licensed CC-BY 4.0 https://arxiv.org/pdf/2102.12092.pdf

Stable Diffusion

Diffusion: iterative, reverse denoising

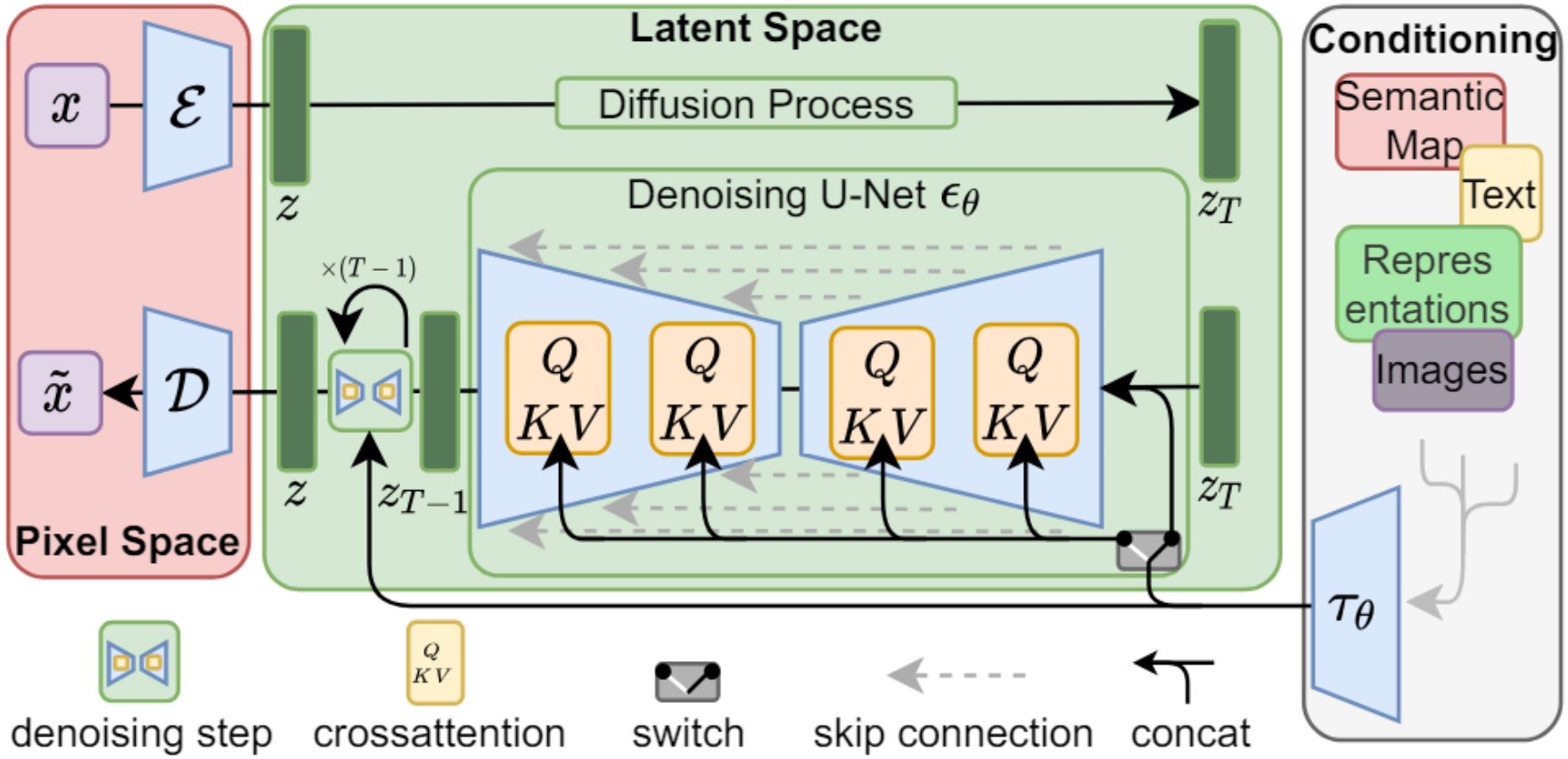
Quiz: What is a different word for “latent space”?



Simplified from: Rombach et al. 2021
https://arxiv.org/abs/2112.10752

Stable Diffusion

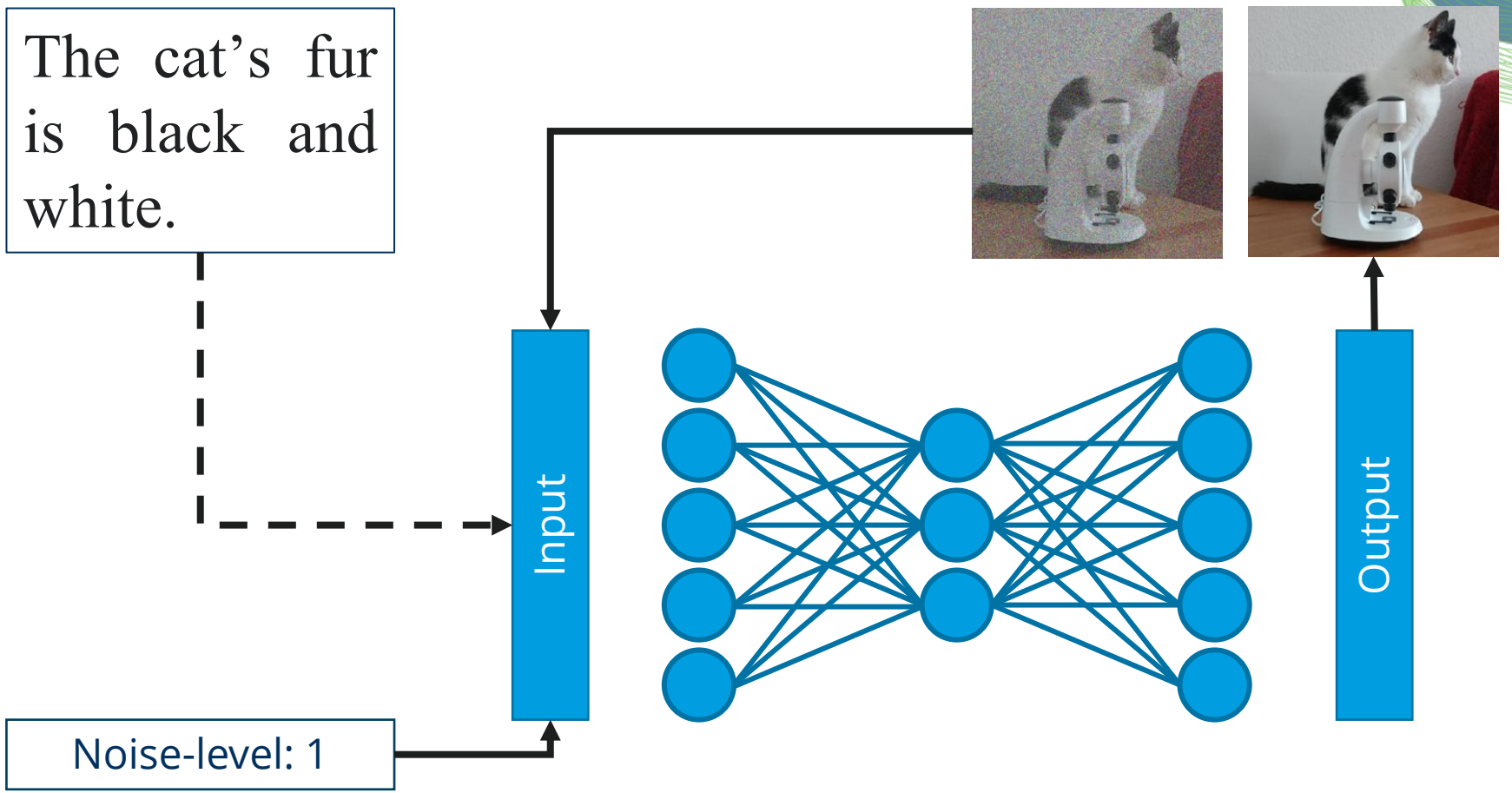
Diffusion: iterative, reverse denoising



Source: Rombach et al. 2021
https://arxiv.org/abs/2112.10752

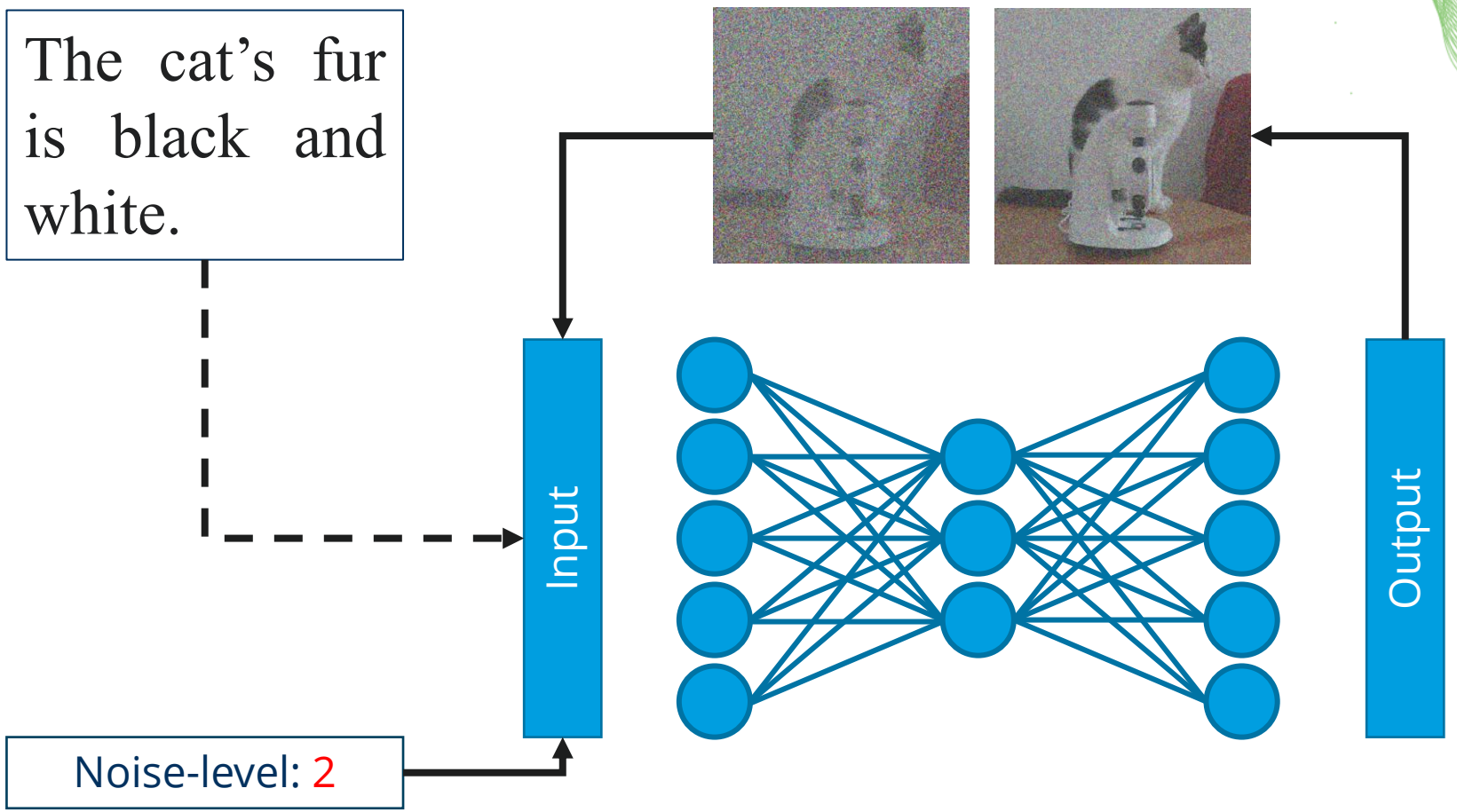
How does it work?

Train a U-Net on data: image + noisy image + description + noise-level



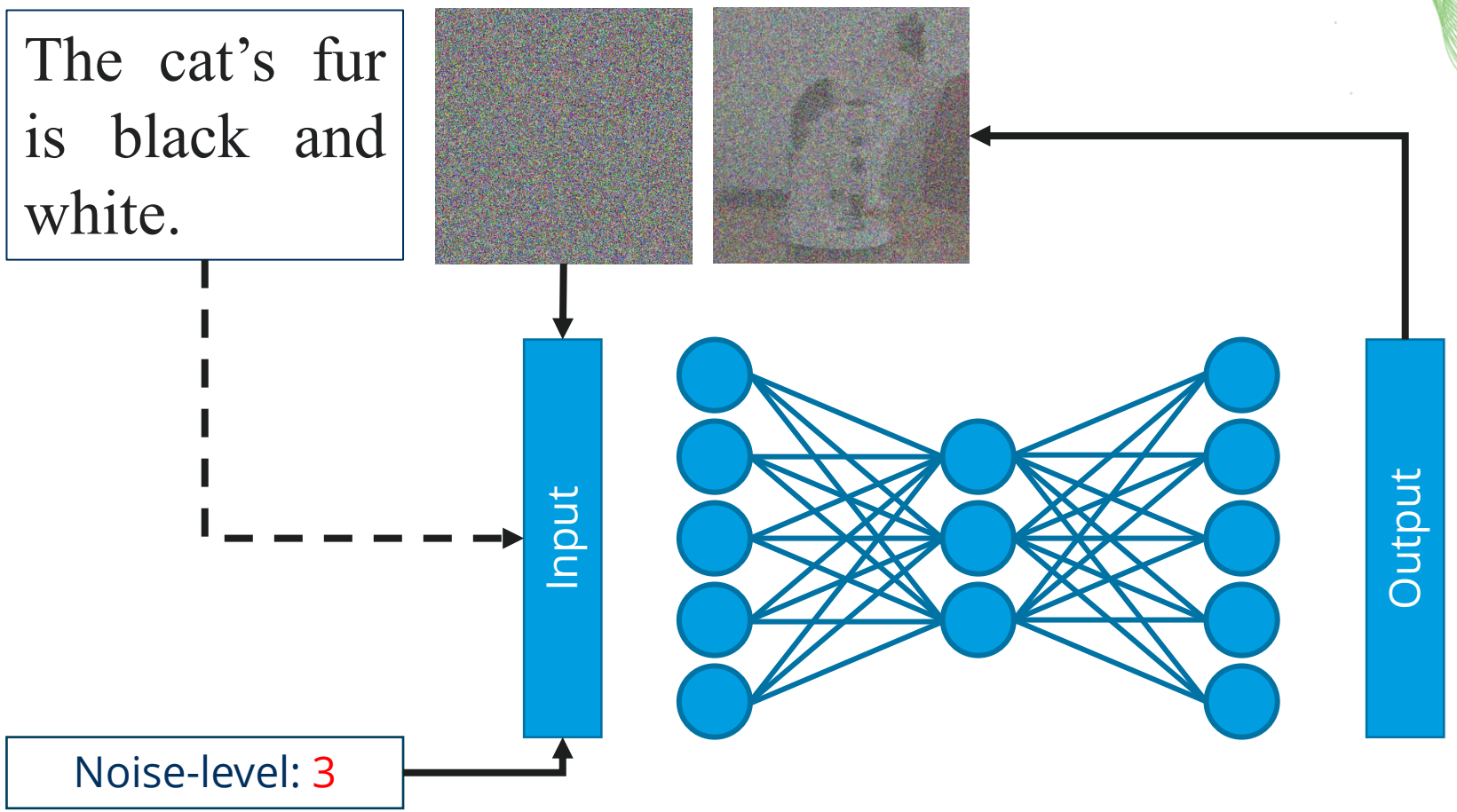
How does it work?

Train a U-Net on data: image + noisy image + description + noise-level



How does it work?

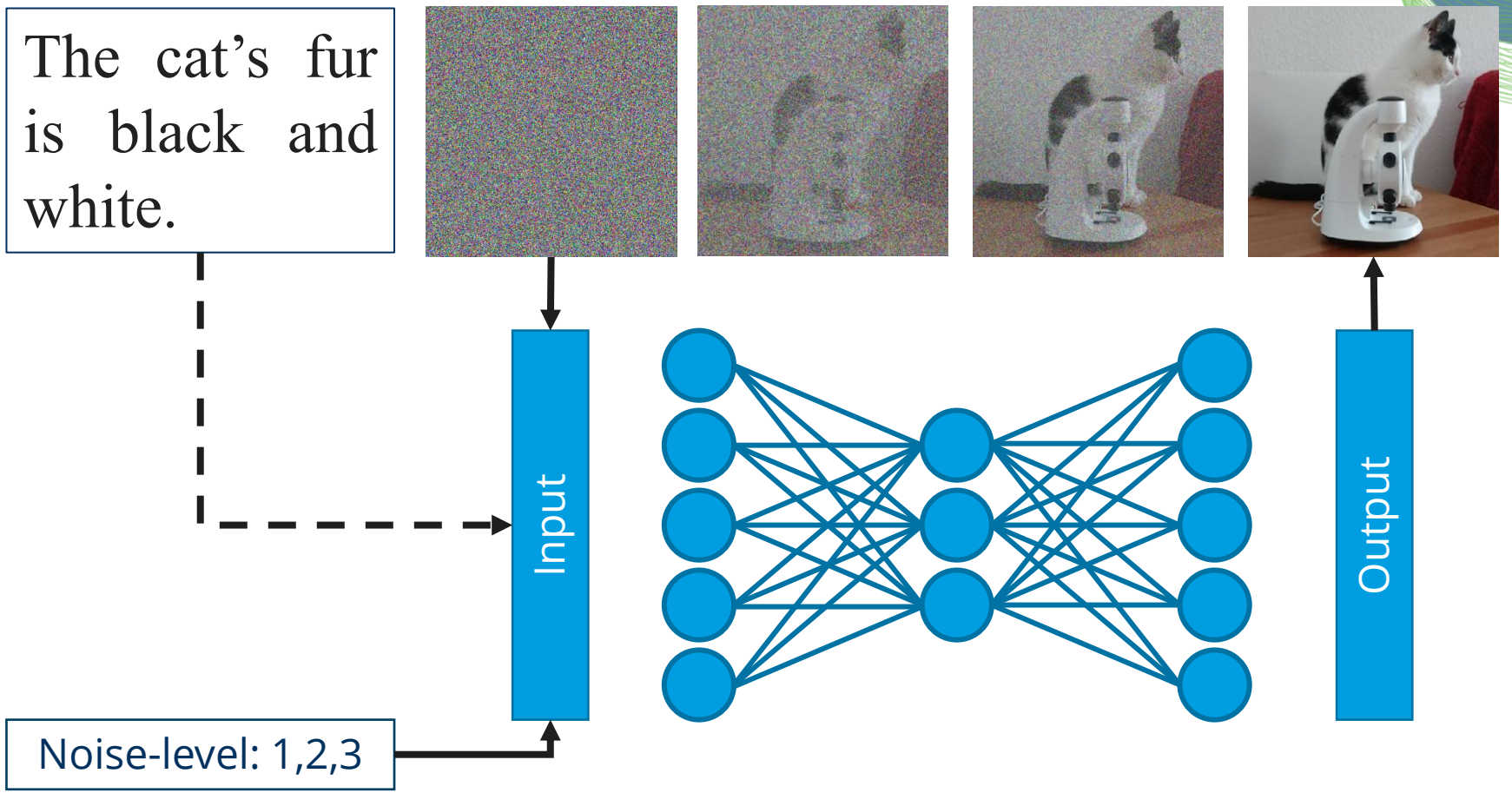
Train a U-Net on data: image + noisy image + description + noise-level



How does it work?

Prediction is iterative denoising of:

Pure noise + text prompt



How does it work?

Reminder:

- Word embeddings
- Attention

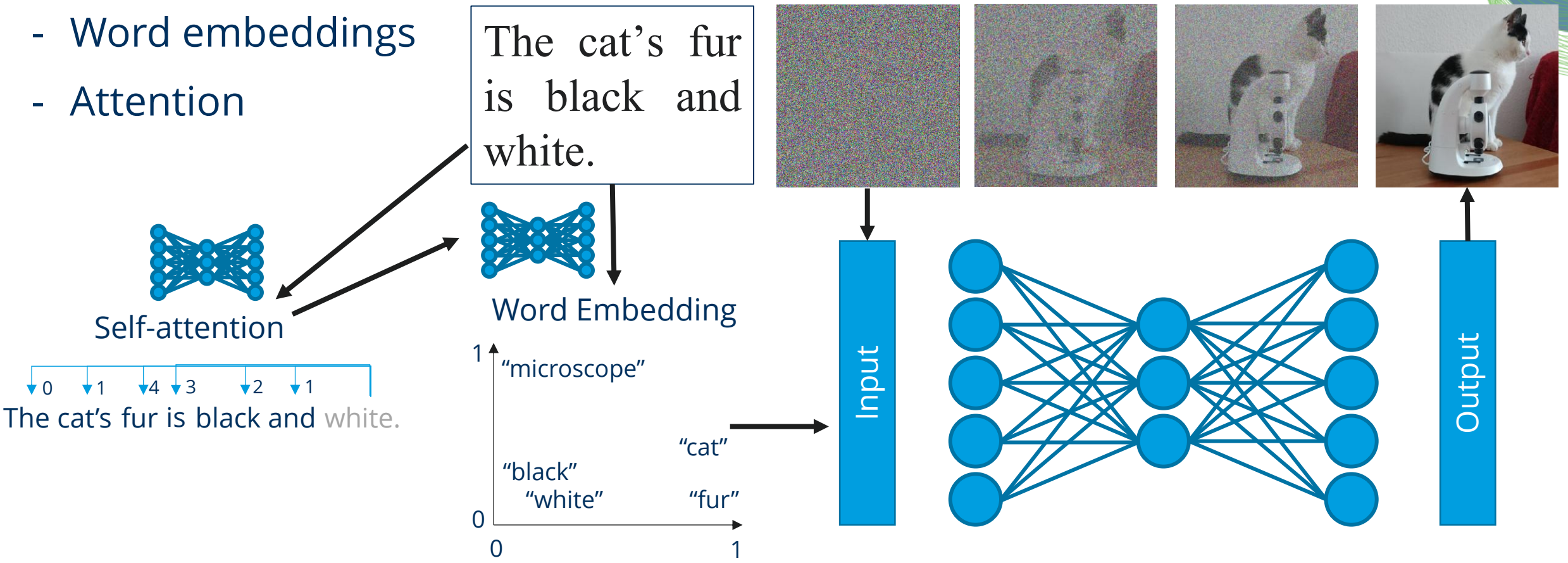


Image generation in Python: Huggingface

Most [Huggingface] image-generation models require a GPU.

```
pipe = DiffusionPipeline.from_pretrained(
    "stabilityai/stable-diffusion-2-1-base", torch_dtype=torch.float16
)
```

Downloads 4.8 GB

```
pipe = pipe.to("cuda")
```

Needs Nvidia GPU

```
prompt = """
Draw a realistic photo of an astronaut riding a horse.
"""

astronaut = pipe(prompt).images[0]
astronaut
```

Image generation in Python: Huggingface

Works well if the prompt overlaps with training data, potentially huge variation between attempts

```
prompt = """
Draw a realistic photo of an astronaut riding a horse.
"""

astronaut = pipe(prompt).images[0]
astronaut
```

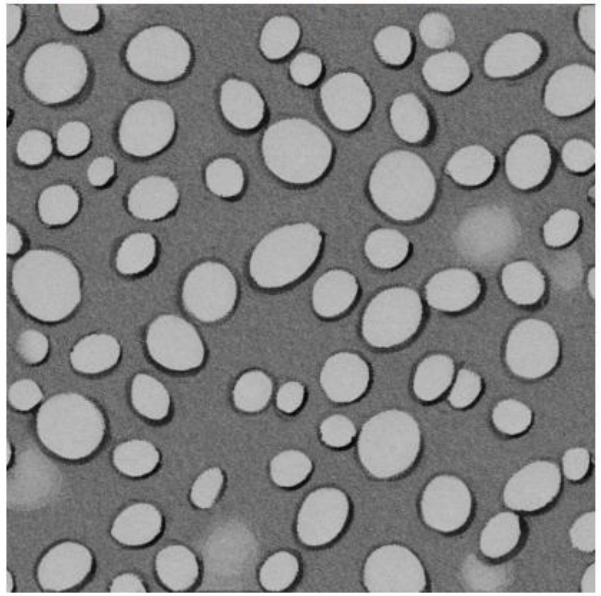
```
100%  50/50 [00:43<00:00,  1.24s/it]
```

```
prompt = """
Draw a realistic photo of a lecture hall with an
ongoing lecture about vision language models.
"""

photo = pipe(prompt).images[0]
photo
```

```
100%  50/50 [01:30<00:00,  1.40s/it]
```

```
prompt = """
Draw a greyscale picture of sparse bright blobs on dark
background. Some of the blobs are roundish, some are a
bit elongated.
"""

image = pipe(prompt).images[0]
image
```

```
100%  50/50 [01:16<00:00,  1.18s/it]
```



```
image = pipe(prompt,
             num_inference_steps=10,
             width=512,
             height=512).images[0]
image
```

```
100%  10/10 [00:17<00:00,  1.88s/it]
```

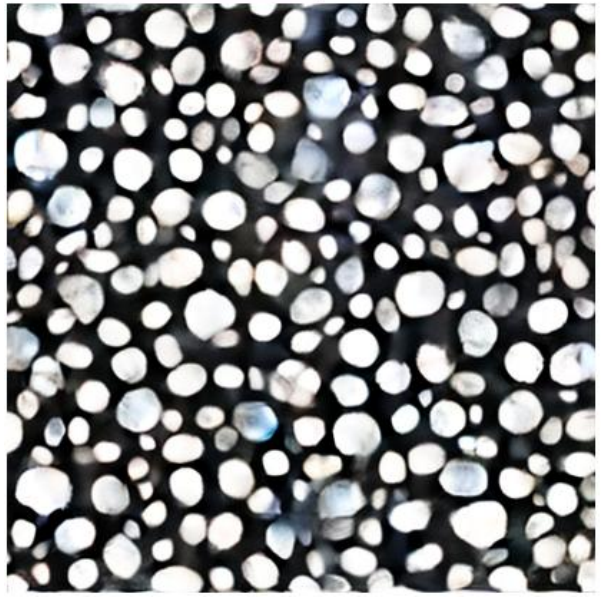


Image generation in Python: Dall-E

No need for a GPU, but costs 💸 💸 💸

```python
def prompt_image(message:str, width:int=1024, height:int=1024, model='dall-e-3'):
    client = openai.OpenAI()
    response = client.images.generate(
      prompt=message,
      model=model,
      n=1,
      size=f"{width}x{height}"
    )
    image_url = response.data[0].url
    image = imread(image_url)

    return image
```

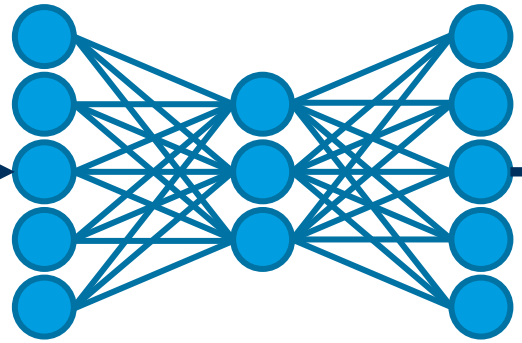
Works with Dall-E 2 and 3

Image Generation LLMs

Challenges: fake-images

Interesting challenges for our community ahead

a histology image of lung cancer cells and some healthy tissue



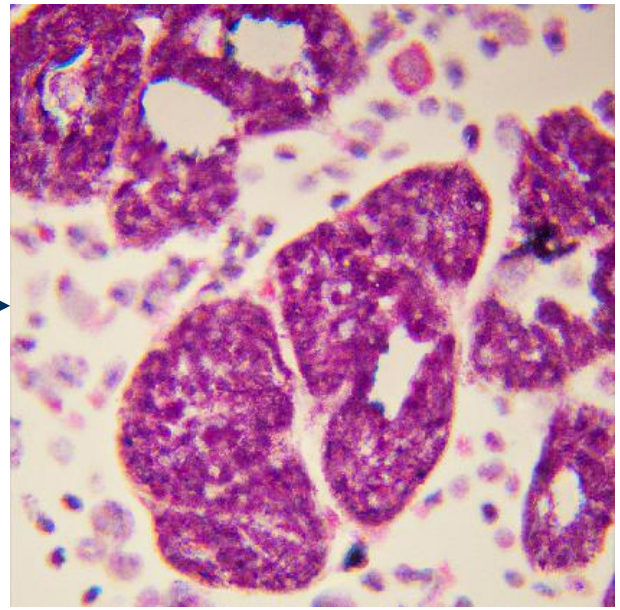
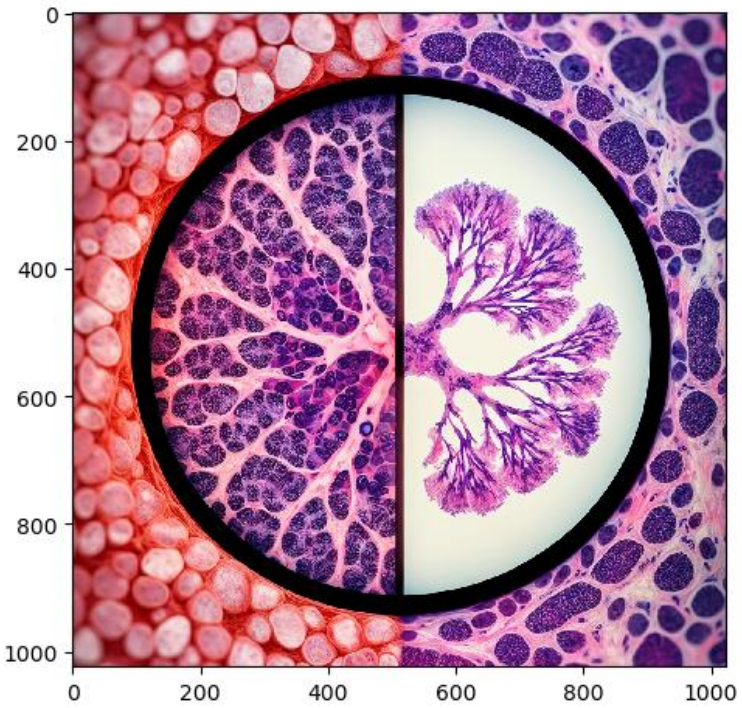


Image generation in Python: Dall-E

Is Dall-E 2 more capable of creating realistic microscopy images than Dall-E 3?

```
histology = prompt_image('a histology image of lung cancer cells and some healthy tissue')
imshow(histology)
```

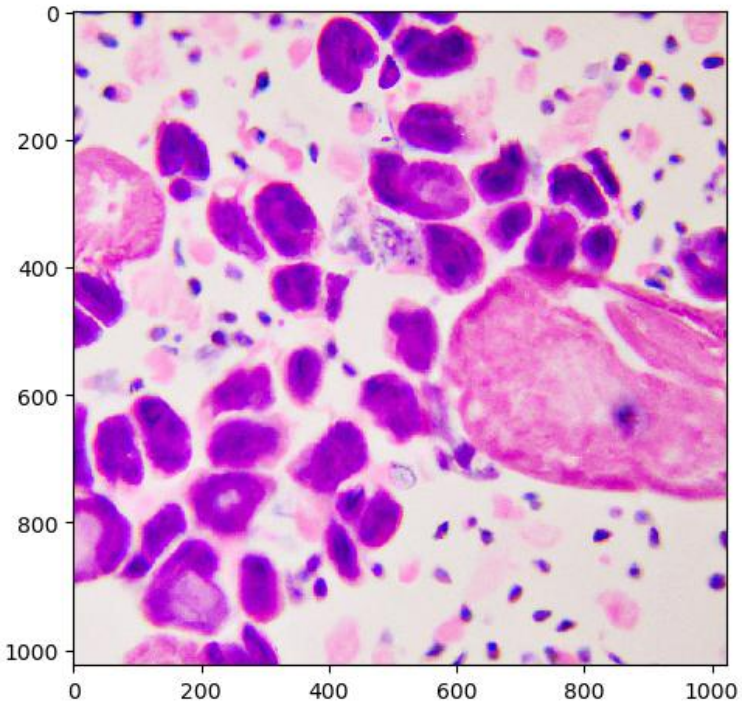
```
<matplotlib.image.AxesImage at 0x1d9eda5bd90>
```



Dall-E 3

```
histology = prompt_image('a histology image of lung cancer cells and some healthy tissue',
                         model='dall-e-2')
imshow(histology)
```

```
<matplotlib.image.AxesImage at 0x1d9edac6fd0>
```



Dall-E 2

Image Generation LLMs

Challenges: physical / physiological hallucinations

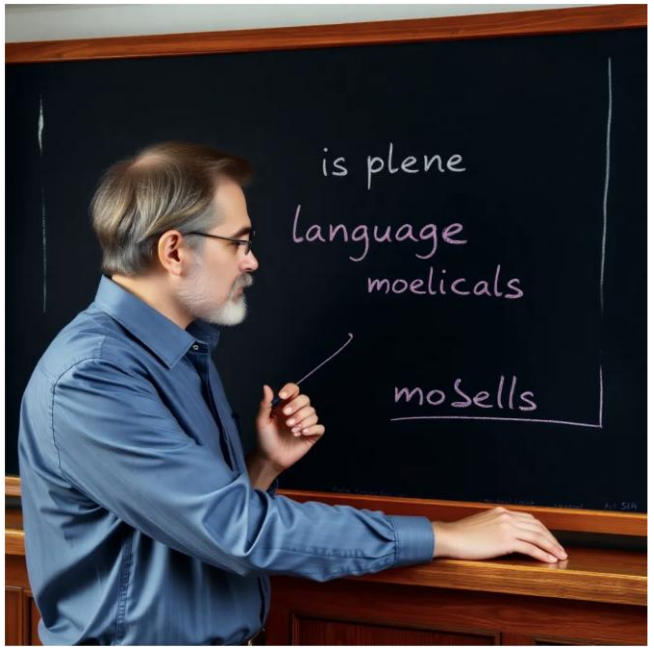
Prompt: “Draw a close-up picture of people's hands”

Source: https://replicate.com/black-forest-labs/flux-schnell-lora

Image Generation LLMs

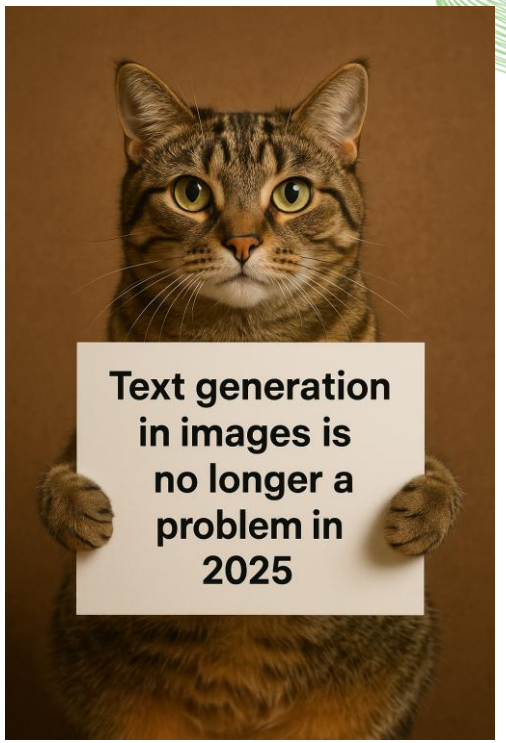
Challenges: Text in images

Prompt: ‘please draw a picture of a professor writing "large language models" on a blackboard’



Source: https://replicate.com/black-forest-labs/flux-schnell-lora

Prompt: ‘Please draw a picture of a cat holding a sign with the text "Text generation in images is no longer a problem in 2025".’



https://chatgpt.com/share/685e2ea5-42f4-8001-9c56-6e3c6de2464e

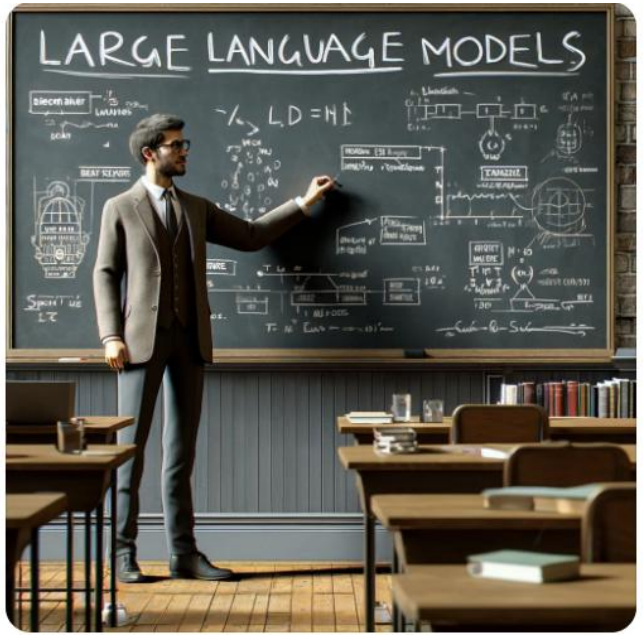
Image Generation LLMs

Challenges: Bias

Prompt: “a nice photo of a human”

Source: https://replicate.com/stability-ai/stable-diffusion

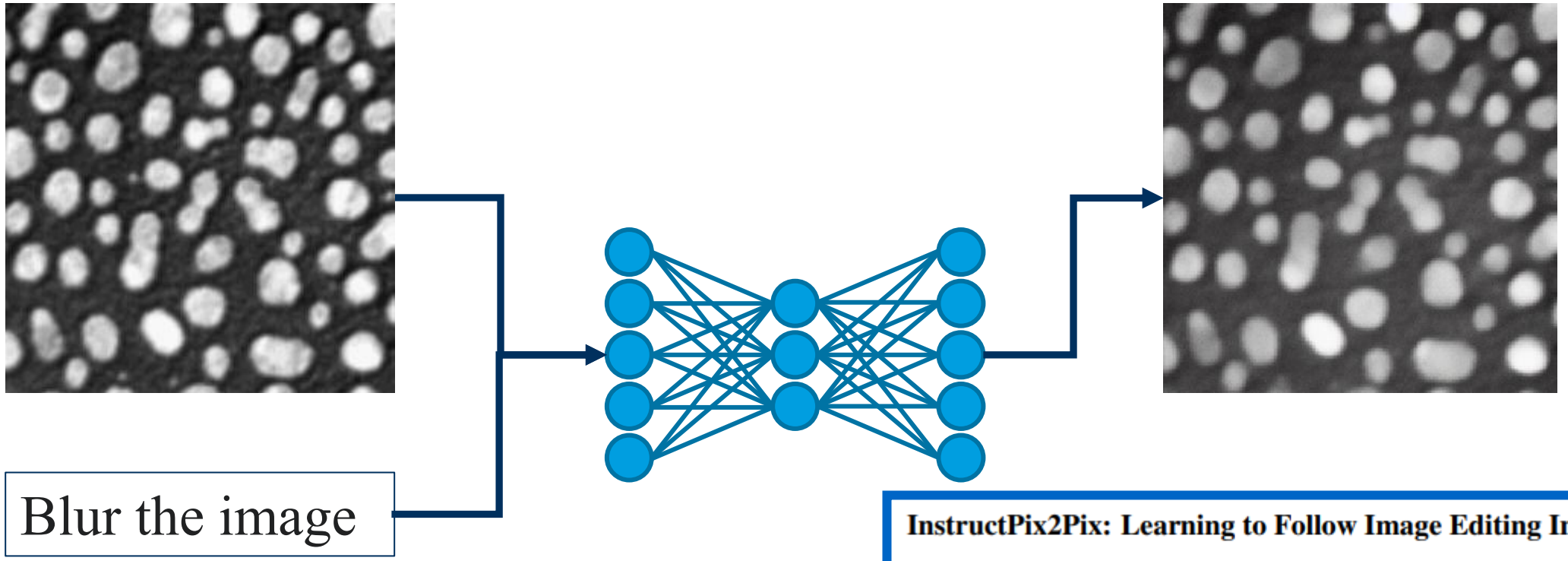
Prompt: ‘please draw a picture of a professor writing "large language models" on a blackboard’



Source: https://chatgpt.com/

Image Generation LLMs

Image-to-image prompting, image variations



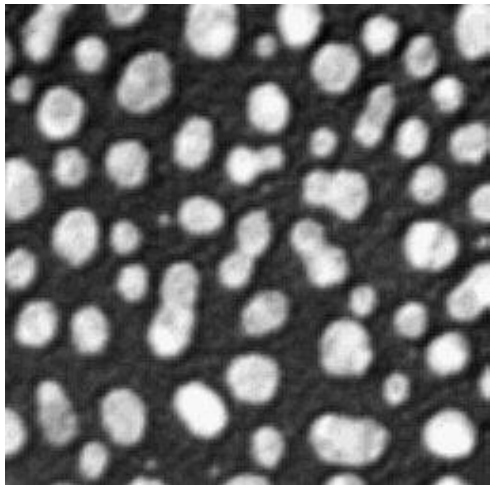
InstructPix2Pix: Learning to Follow Image Editing Instructions

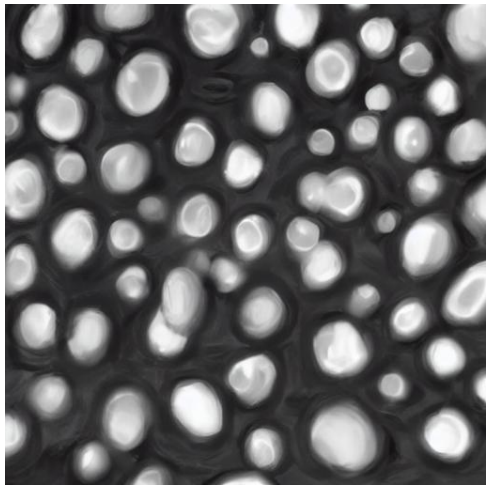
Tim Brooks* Aleksander Holynski* Alexei A. Efros
University of California, Berkeley

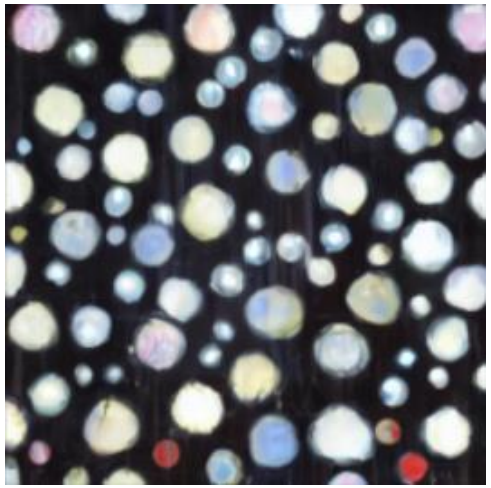
Image variation

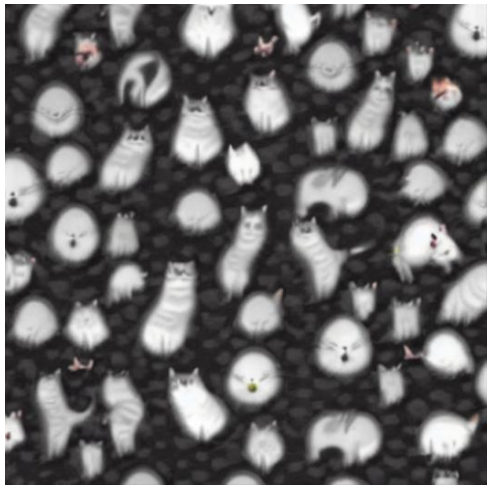
Generate images, e.g. for augmenting data

Potentially useful to make algorithms more robust





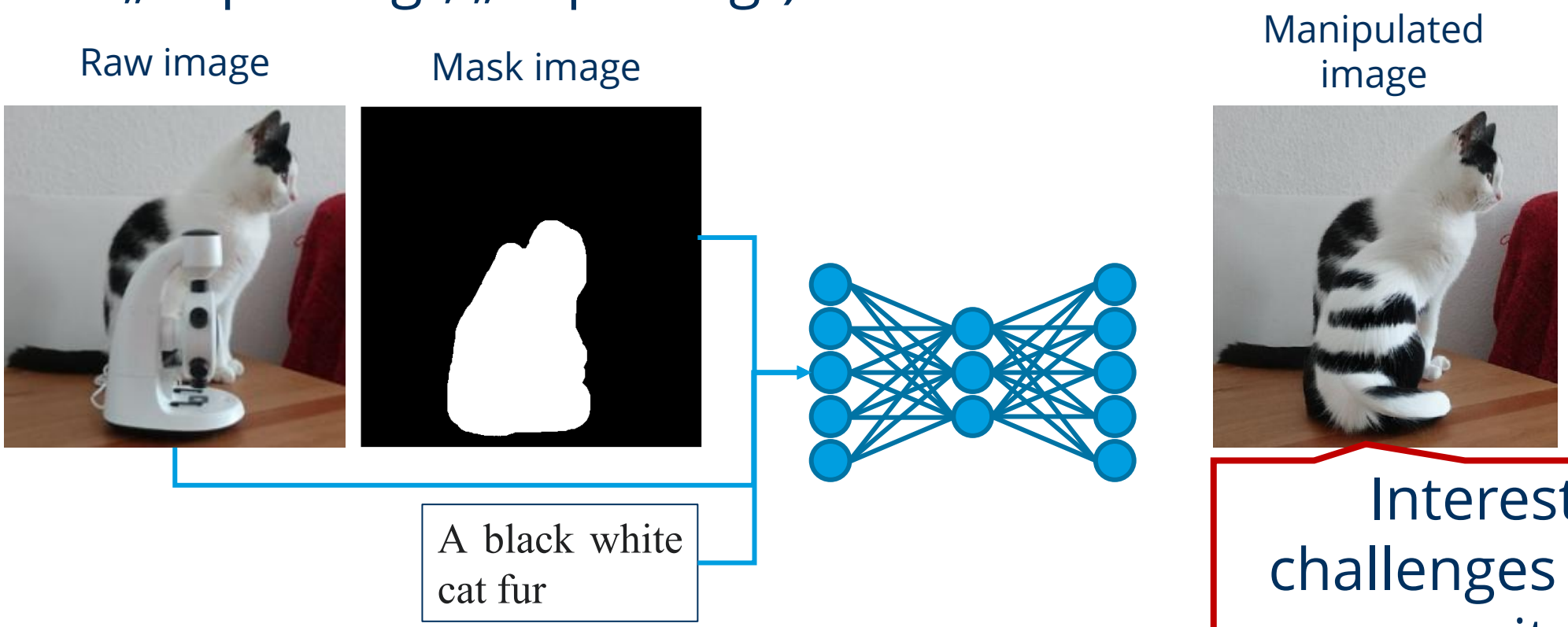




Inpainting

Replacing regions in images

(also „Gap-filling“, „Replacing“)



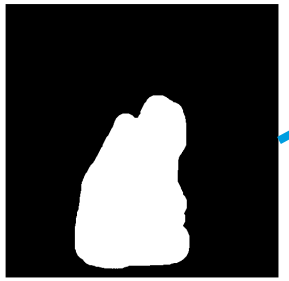
Interesting challenges for our community ahead

Inpainting in Python: Huggingface

```python
pipe = StableDiffusionInpaintPipeline.from_pretrained(
    "stabilityai/stable-diffusion-2-inpainting",
    torch_dtype=torch.float16
)
pipe = pipe.to("cuda")
```

Downloads 4.8 GB

Needs Nvidia GPU



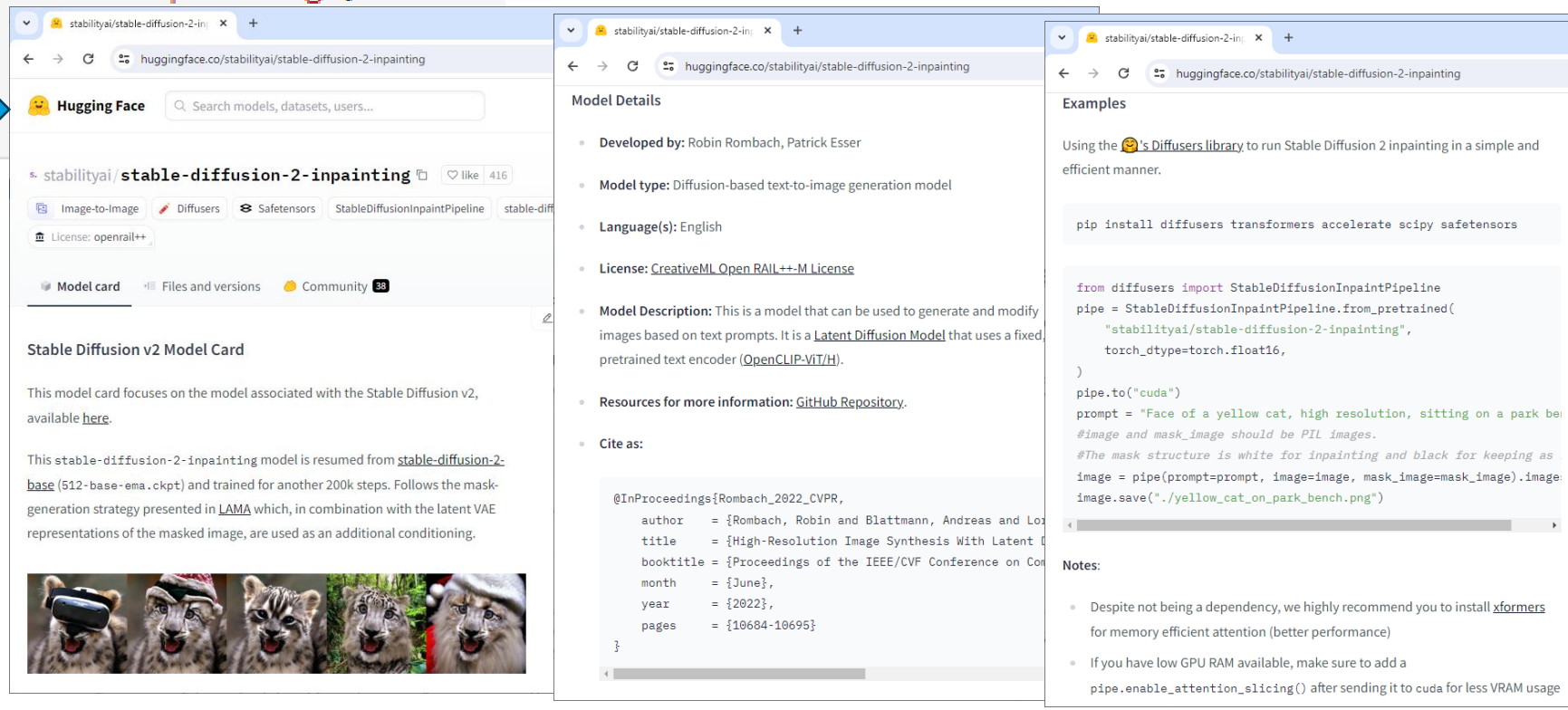
```python
prompt = "A black white cat fur"
image = pipe(prompt=prompt,
             image=init_image,
             mask_image=mask_image,
             num_inference_steps=50,
             width=512,
             height=512,
             num_images_per_prompt=1,
            ).images[0]
```

Read more:
https://huggingface.co/docs/diffusers/api/pipelines/stable_diffusion/inpaint

Inpainting in Python: Huggingface

Check out the *model cards* online in the Huggingface hub.

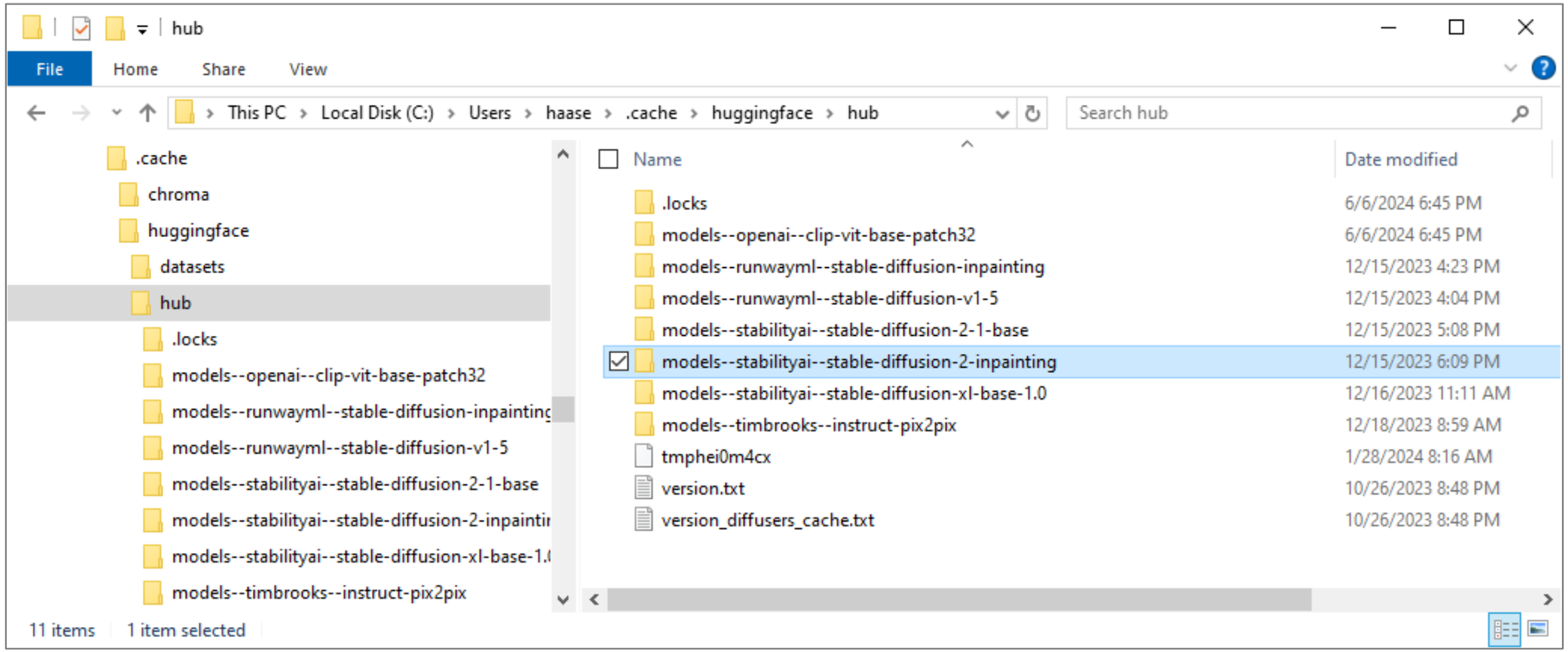
```python
pipe = StableDiffusionInpaintPipeline.from_pretrained(
    "stabilityai/stable-diffusion-2-inpainting",
    torch_dtype=torch.float16
)
pipe = pipe.to("cuda")
```



Inpainting in Python: Huggingface

You find the downloaded models cached in your home directory

They are big! Clean up here from time to time.



Inpainting in Python: Dall-E

No need for a GPU, but costs 💸 💸 💸

```python
client = OpenAI()

response = client.images.edit(
  image=numpy_to_bytestream(resized_image_rgb),
  mask=numpy_to_bytestream(masked_rgba),
  prompt=prompt,
  n=1,
  size=f"{image_width}x{image_height}",
  model=model
)
```

2D RGB images only

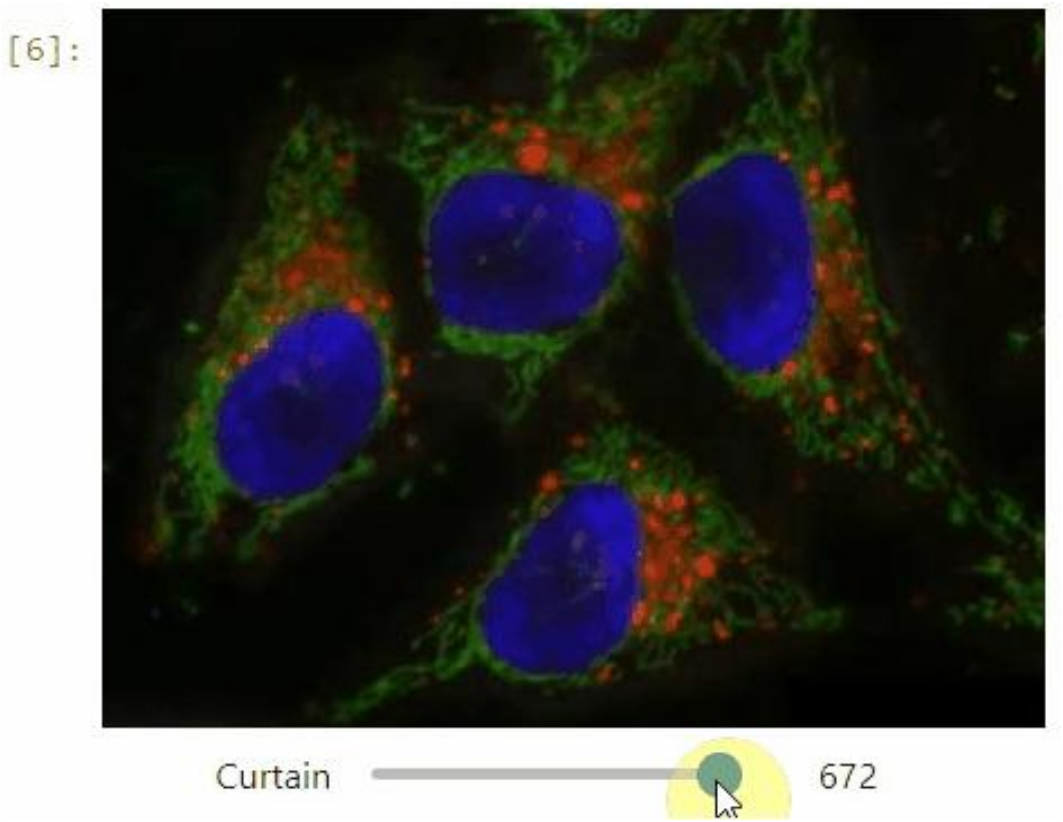
Size must match

Supported: 256, 512, 1024 pixels

Result: List of URL(s)

New technologies bring new risks...

If you can generate images,
you can also generate parts of images....



Interesting challenges for our community ahead

Image manipulation detection

The noise pattern differs between raw and processed images…

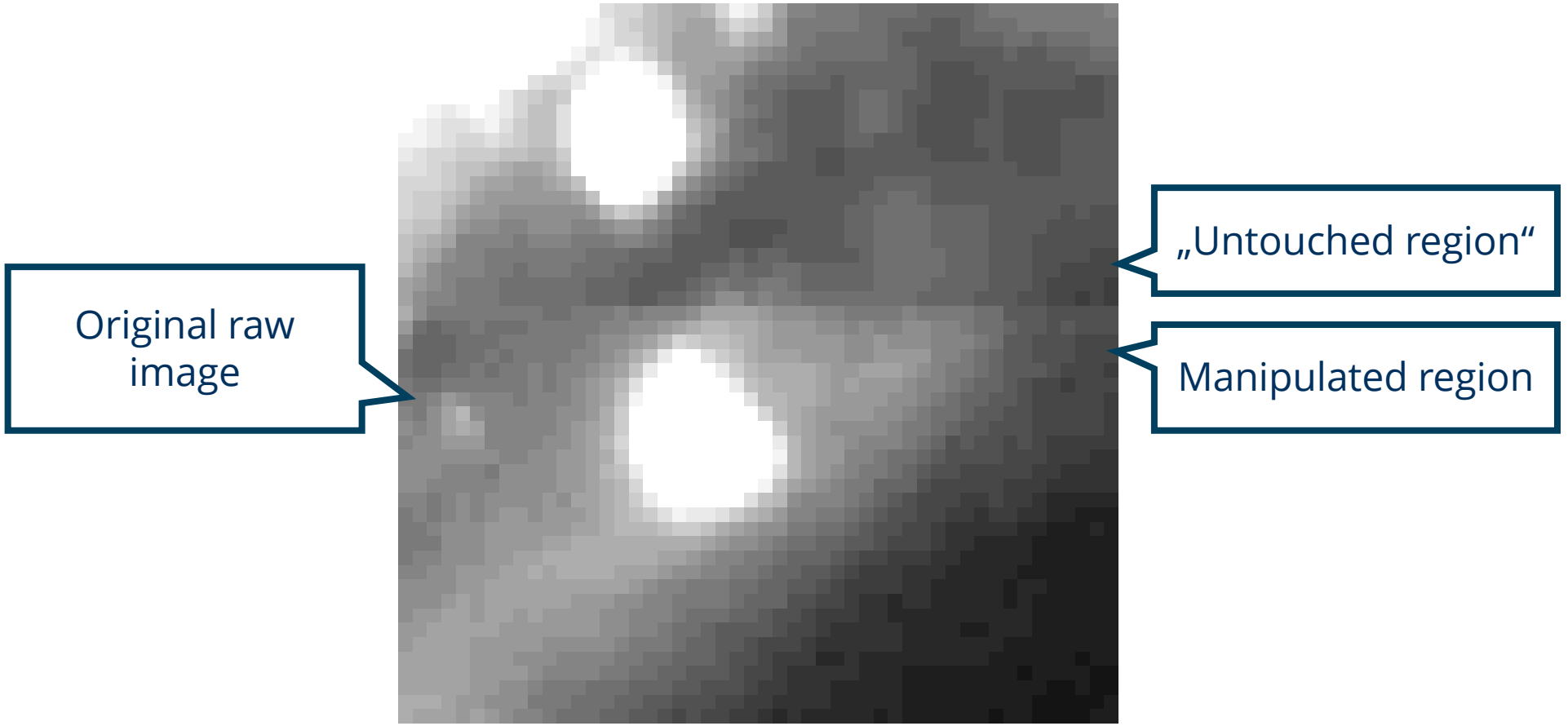
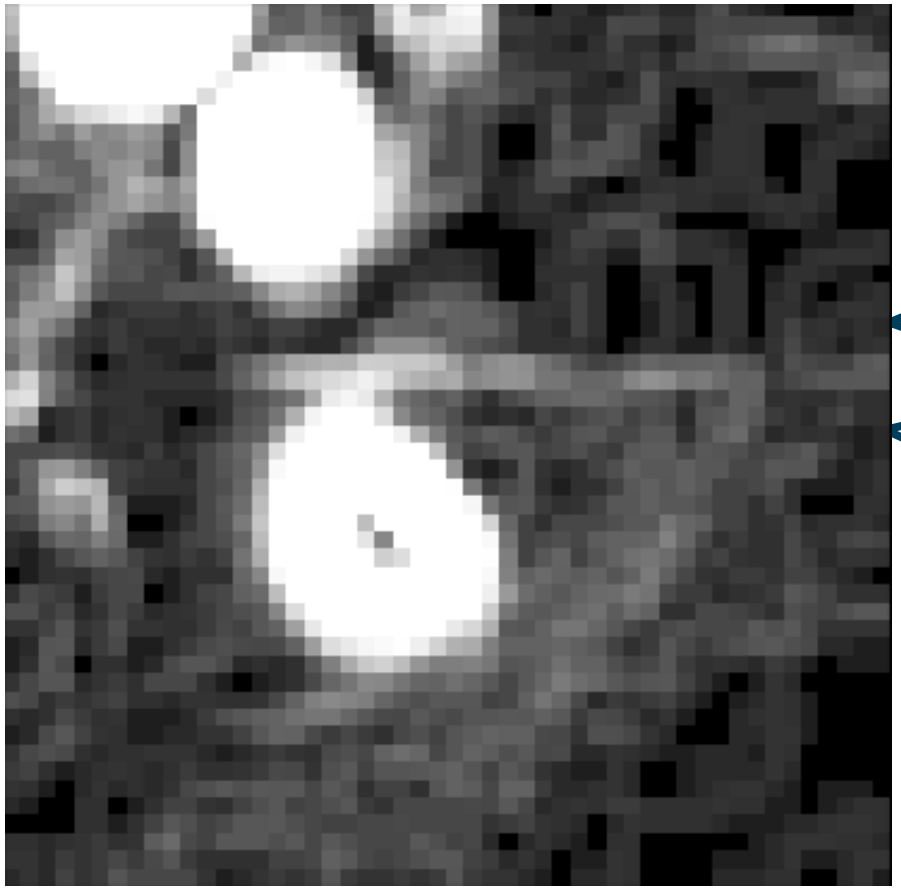


Image manipulation detection

e.g. by studying noise-patterns

Local standard deviation filter



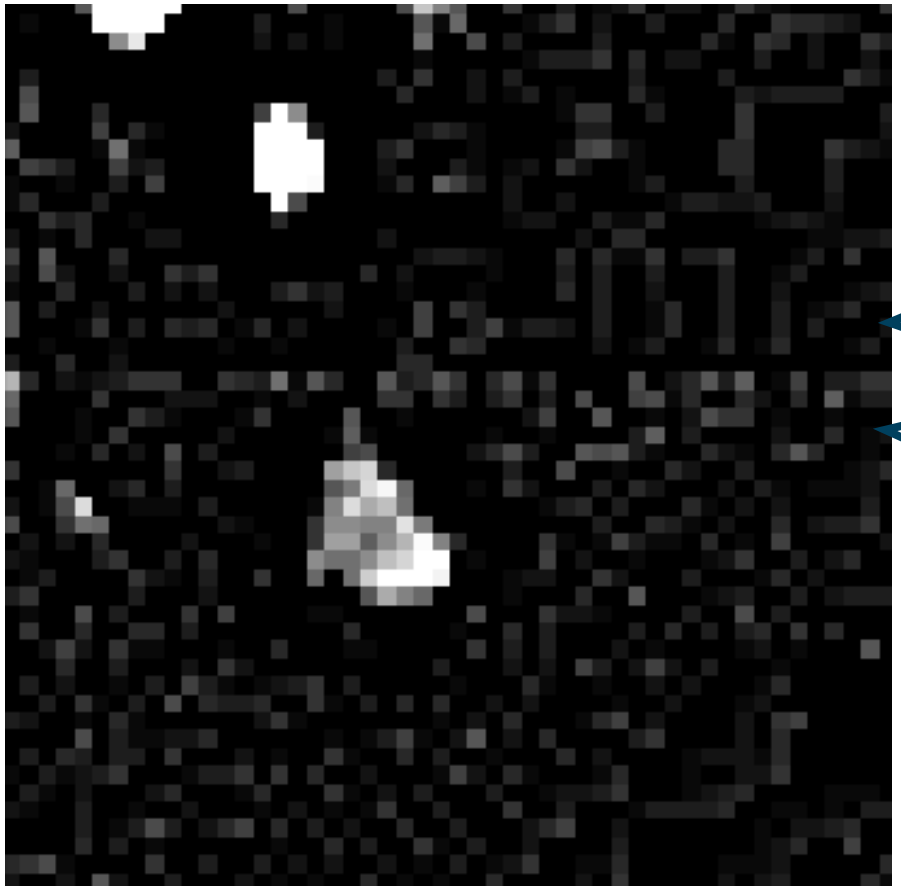
„Untouched region“

Manipulated region

Image manipulation detection

e.g. by studying noise-patterns

Sobel filter



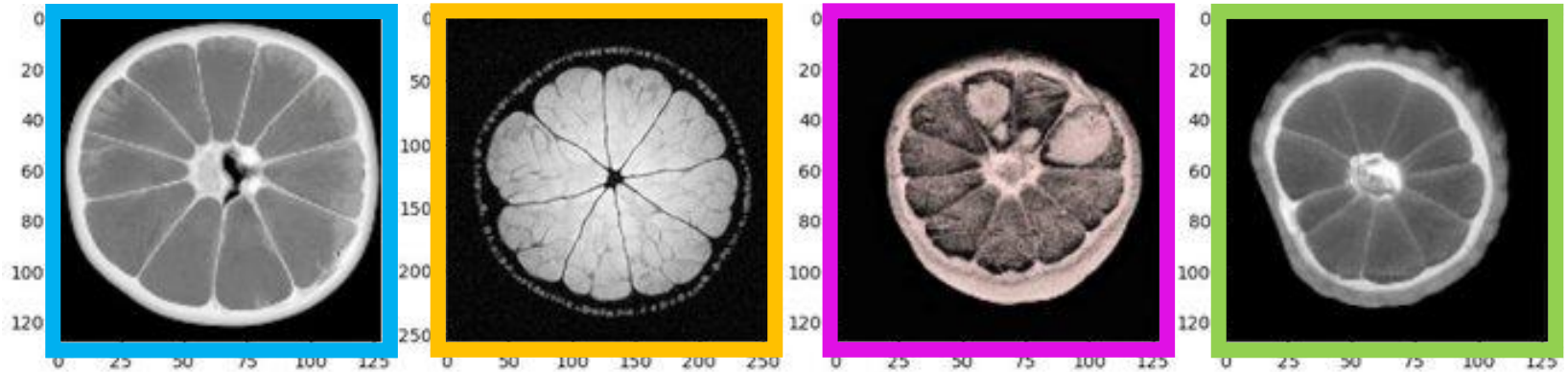
„Untouched region“

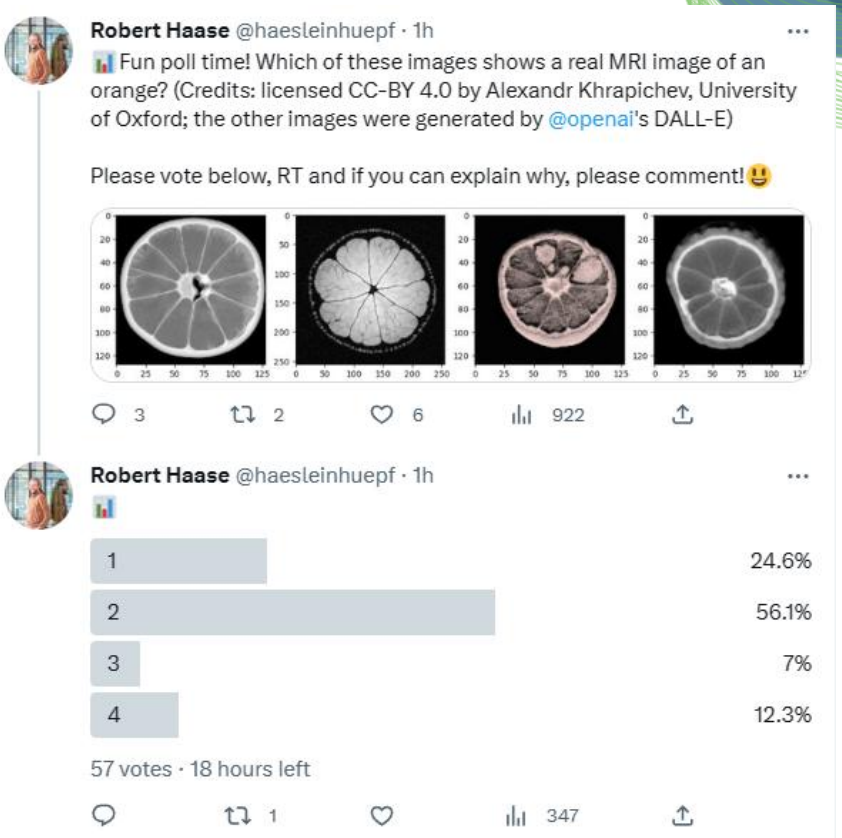
Manipulated region

Benchmarking image generation

When asking humans to evaluate results, make sure they are the right target audience

```
mri_prompt = """
A single, high resolution, black-white image of
a realistically looking orange fruit slice
imaged with T2-weighted magnetic resonance imaging (MRI).
"""
```





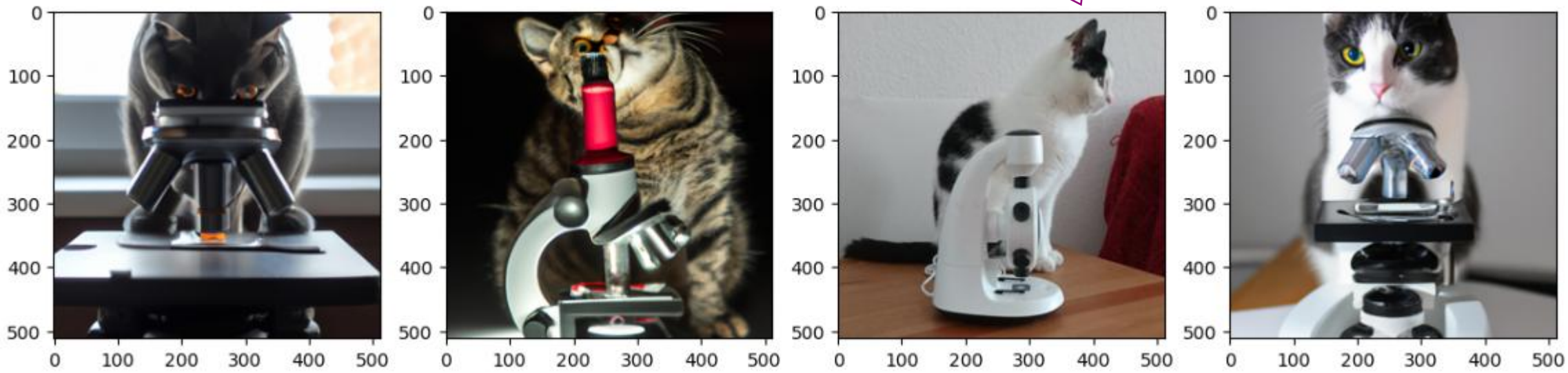
https://haesleinhuepf.github.io/BioImageAnalysisNotebooks/07_prompt_engineering/02_generating_mri_images.html
https://twitter.com/haesleinhuepf/status/1659138282641342466

Benchmarking image generation

Prompt engineering to optimize images

```
cat_microscope_prompt = """
Image of a cat sitting behind a microscope.
"""
```

One cat is real.

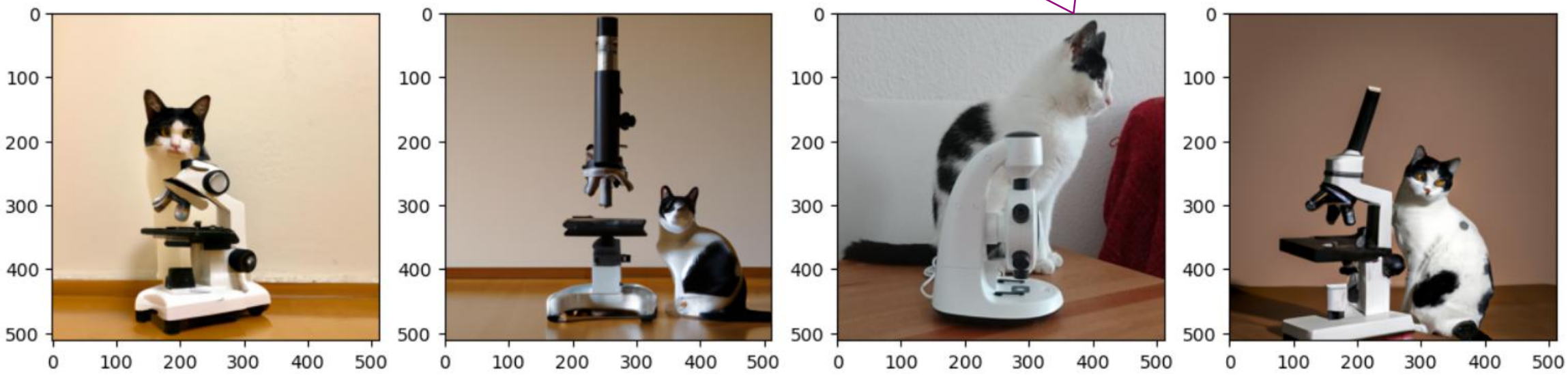


Benchmarking image generation

Prompt engineering to optimize images

[5]:
```
cat_microscope_prompt = """
Image of a cat sitting behind a microscope.
Both are on a brown floor in front of a white wall.
The cat is mostly white and has some black dots.
The cat sits straight.
The cat is a bit larger than the microsope.
"""
```

One cat is real.



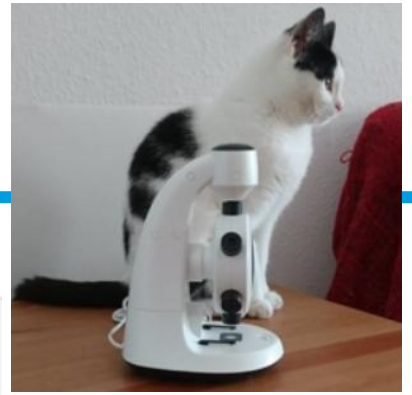
CLIP scores

Contrastive Language-Image Pre-Training (CLIP)

- For image describing

Here: Similarity between image and prompt

```python
from torchmetrics.multimodal.clip_score import CLIPScore
metric = CLIPScore(model_name_or_path="openai/clip-vit-base-patch16")
```



```python
score = metric(torch.as_tensor(image), "cat")
score.detach()
```

```
tensor(25.3473)
```

```python
score = metric(torch.as_tensor(image), "microscope")
float(score.detach())
```

```
30.786287307739258
```

CLIP scores

Example: Prompt optimization

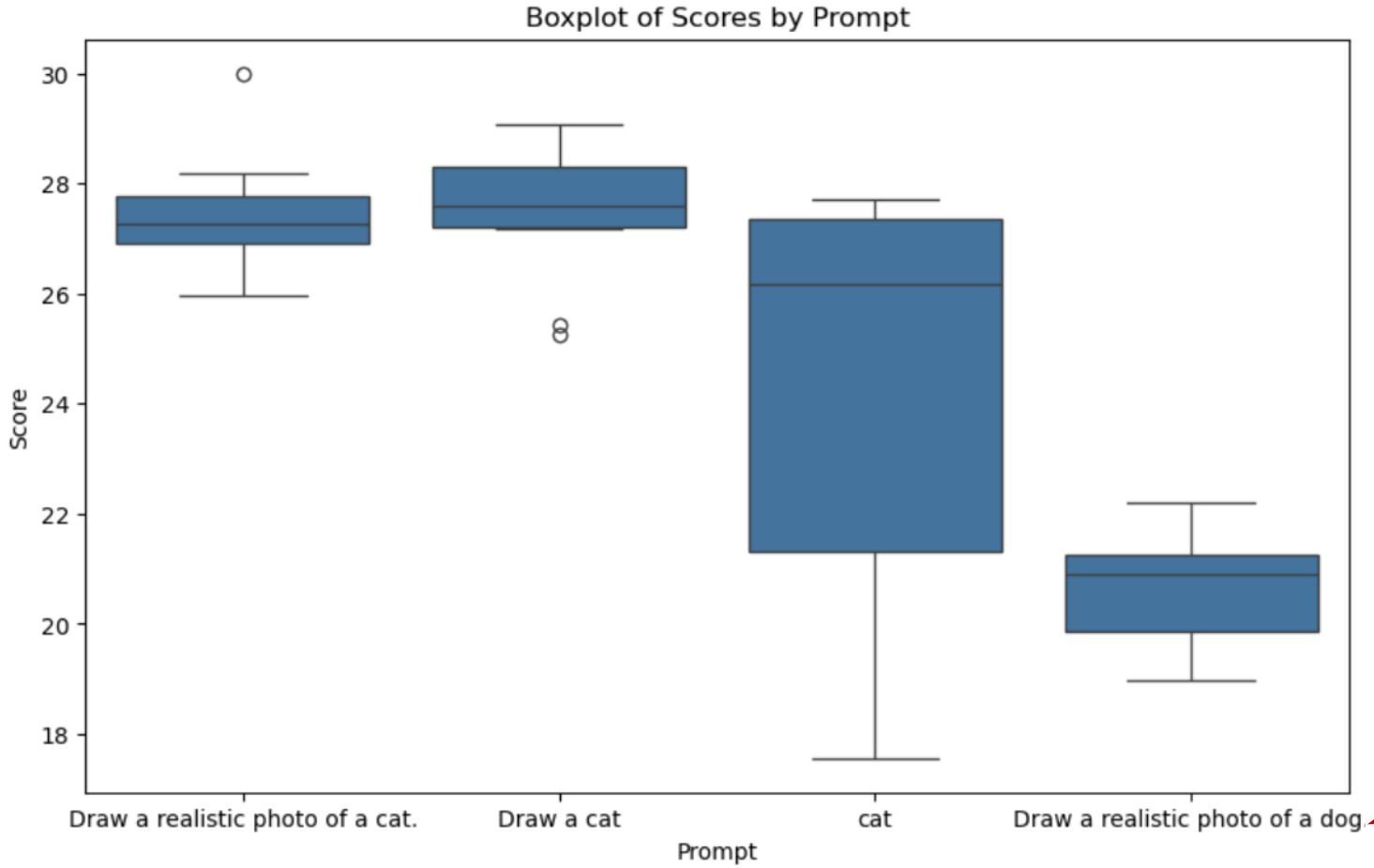
```
num_attempts = 10
prompts = ["Draw a realistic photo of a cat.",
           "Draw a cat",
           "cat",
           "Draw a realistic photo of a dog."]

data = {"prompt":[],
        "score":[]}
for prompt in prompts:
    for i in range(num_attempts):
        image = pipe(prompt, disable_tqdm=True).images[0]

        score = metric(torch.as_tensor(np.array(image)), "cat")
        data["score"].append(float(score.detach()))
        data["prompt"].append(prompt)
```

Image generation

Quality measurement

CLIP scores

Example: Prompt optimization



Always have a control experiment!

Summary

- Multi-modal models combine image, text and [...] data
- Combination of pre-existing model architectures
- APIs not standardized (yet)

Trade-off:

- LLM capacity / size limited
- Multi-modal LLMs presumably perform worse compared to more specialized models
  - Example: Ask a vision-language model to write code
- High potential for mixture-of-experts models and multi-agent systems using small specialized language models

ScaDS.AI
DRESDEN LEIPZIG

CENTER FOR SCALABLE DATA ANALYTICS AND ARTIFICIAL INTELLIGENCE

Funded by

Bundesministerium für Bildung und Forschung

SACHSEN

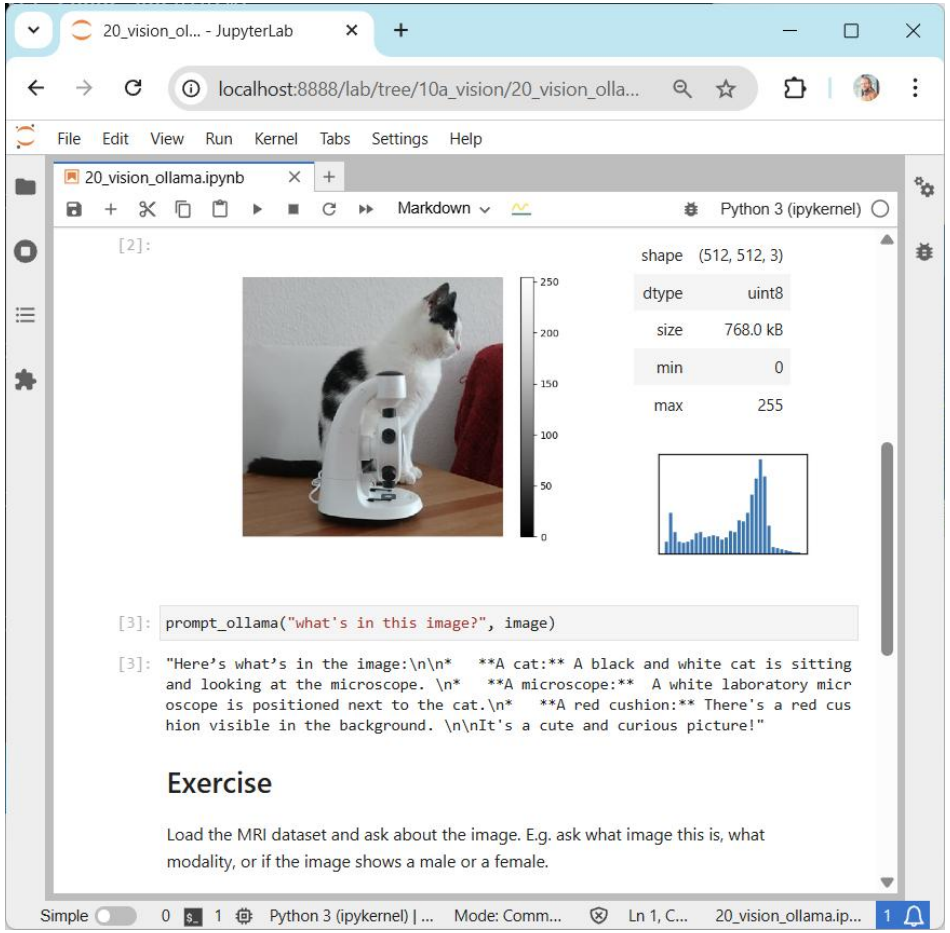
Diese Maßnahme wird gefördert durch die Bundesregierung aufgrund eines Beschlusses des Deutschen Bundestages. Diese Maßnahme wird mitfinanziert durch Steuermittel auf der Grundlage des von den Abgeordneten des Sächsischen Landtags beschlossenen Haushaltes.

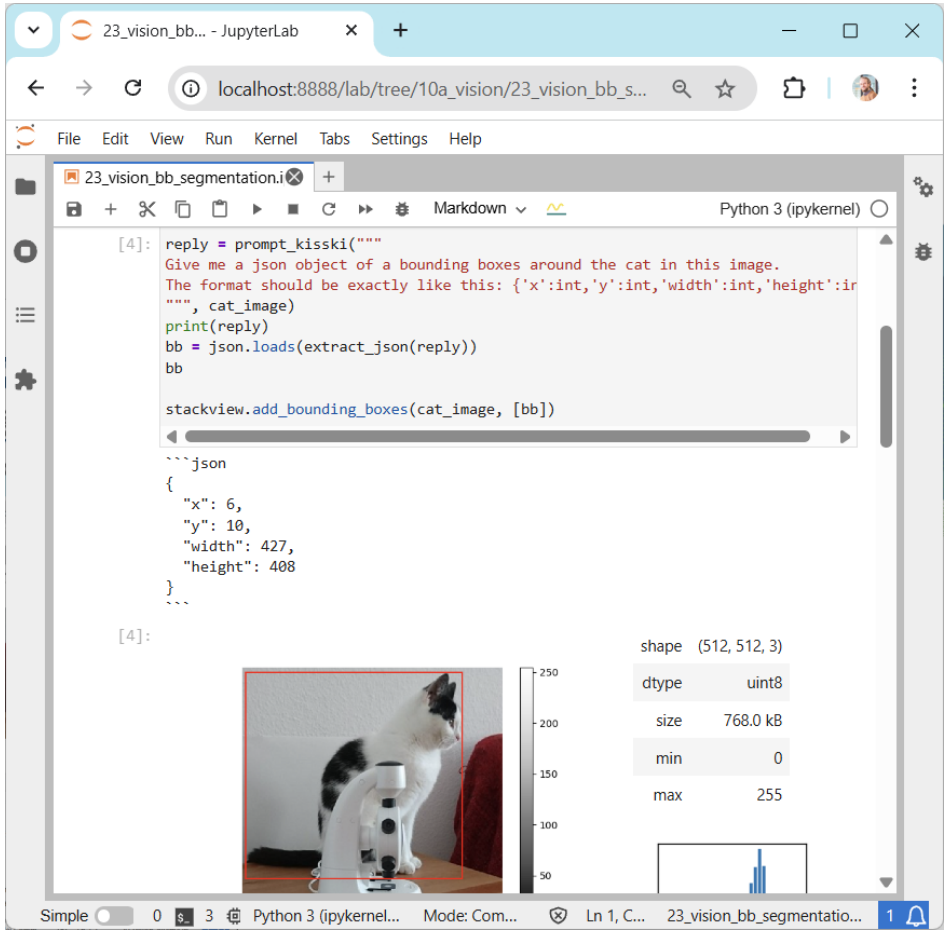
Exercises

Robert Haase

Vision language models

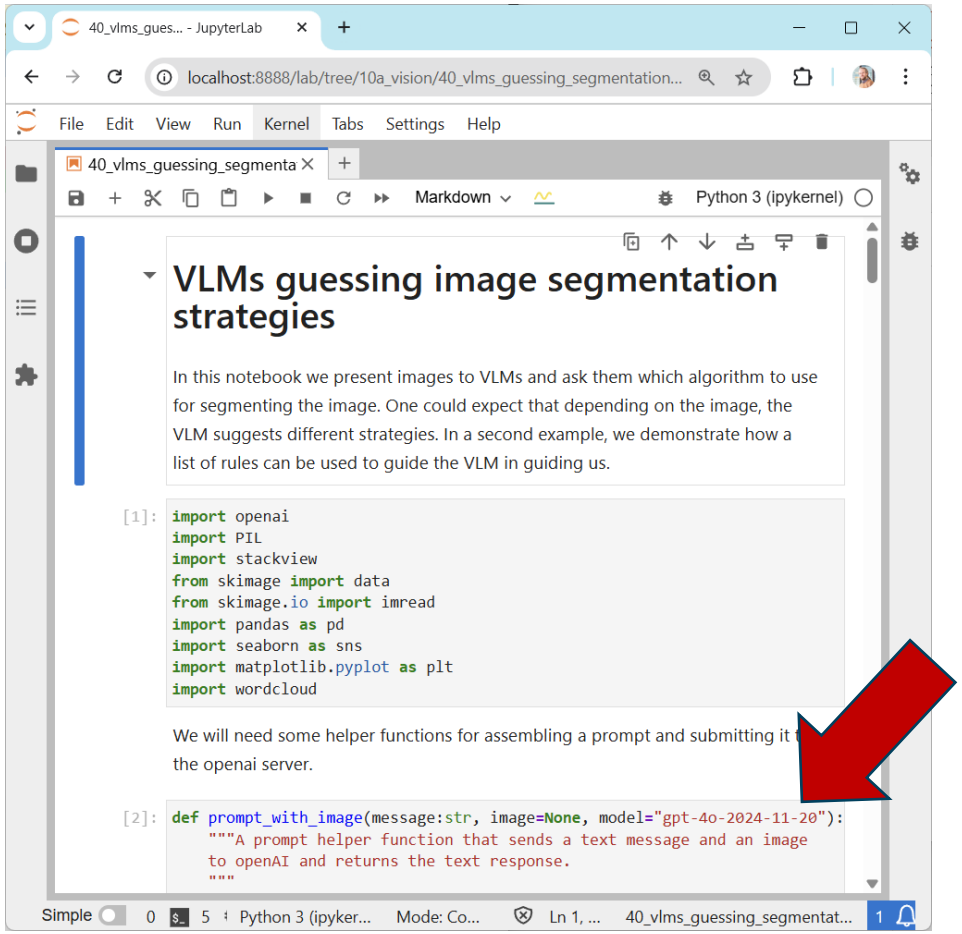
Elaborate on the limits of VLMs





Vision language models

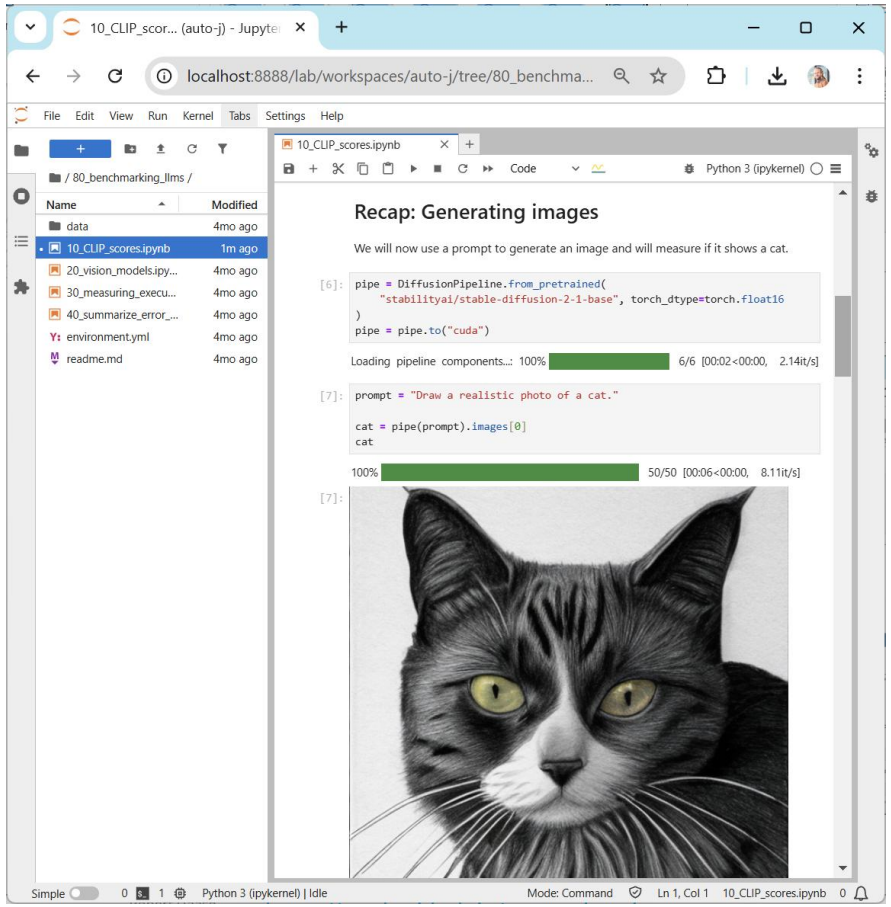
Elaborate on the limits of VLMs

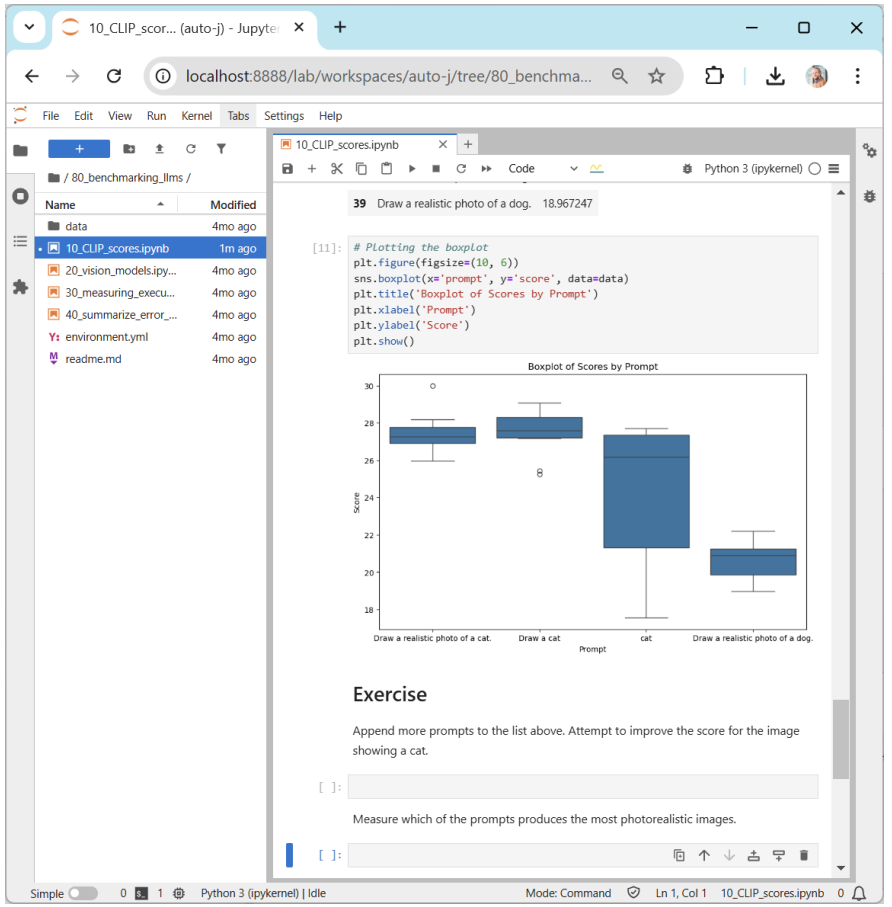


Try to do this with ollama or kisski instead.

CLIP Scores

Improve given prompts and measure the improvement





Exam preparation

Use the opportunity to try out this Vision-RAG system written by Lea Gihlein, who attended this course last year.

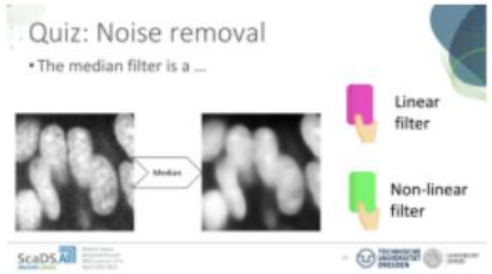
- Generate exam questions
- See related Slides

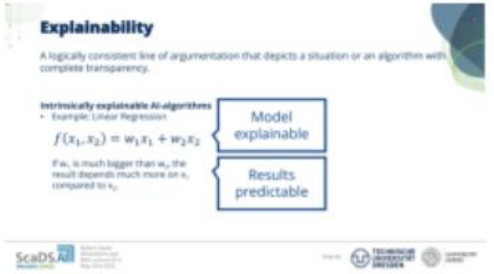
Beware, not all slides might be related to the question!

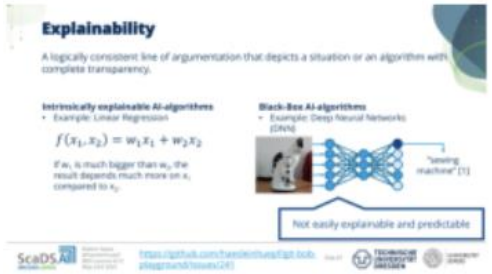
```
# Setting up the model
endpoint = "http://localhost:11434/v1"
token = "whatever"
model = "gemma3:4b"
```

```
question_topic = "Linear filtering"
```

```
1.  What is the core operation behind a linear filter, and how is it
mathematically described?
2.  Name three examples of linear filters presented in the slides.
3.  Explain the difference between intrinsically explainable and blac
k-box algorithms, using Linear Regression and Deep Neural Networks as
examples.
```







Preliminary schedule

April 11th 2025 – Introduction Microscopy, Bioimage Analysis, Research Software Management
~~April 18th 2025 – Good Friday (Karfreitag)~~
April 25th 2025 - Microscopy Image Processing
May 2nd 2025 – Segmentation of cells and nuclei
May 9th 2025 – Feature Extraction, Data Viz, Quality Assurance — Handout exam pre-requisite complex exercise
May 16th 2025 – Big data, parallel processing & tiled image computing
May 23th 2025 – Introduction to Machine Learning for bio-image analysis
May 30st 2025 – Deep Learning for image denoising + segmentation
June 6th 2025 – Large Language Models and Prompt Engineering
[June 13th 2025 – DevOps Hands-on tutorial @ Data Week, optional https://www.mathcs.uni-leipzig.de/veranstaltungsdetail/termin/data-week-leipzig-2025]
June 20th 2025 – Large Language Models for Code Generation
June 27th 2025 – Vision Language Models and Agents
July 4th 2025 – Research Data Management — Submission deadline complex exercise
July 11nd 2024 – Summary, exam preparation

8 weeks