Deep Learning for Medical Imaging School 2025

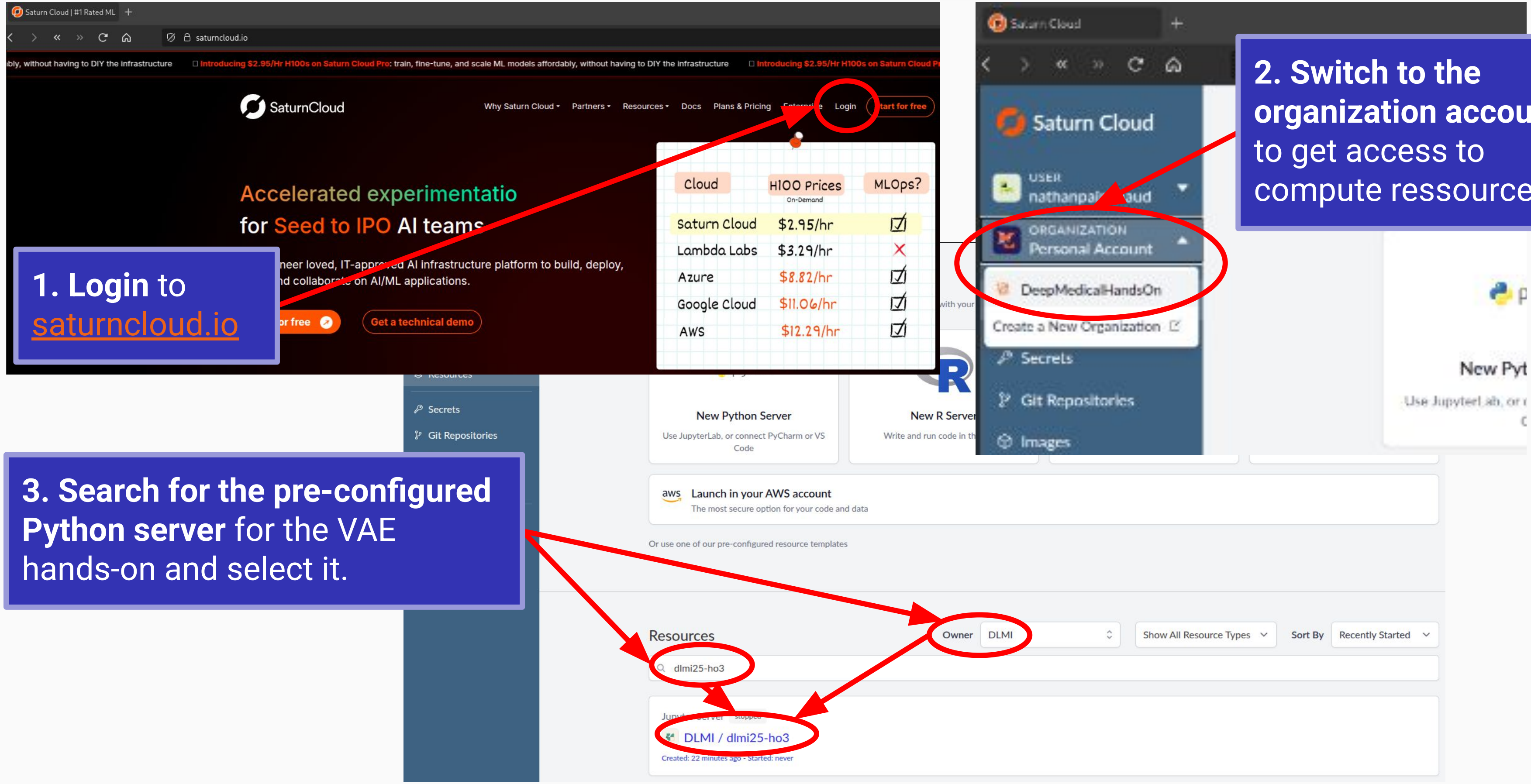
Autoencoders

by Nathan Painchaud and Pierre-Marc Jodoin

with the help of Thomas Grenier and Olivier Bernard

Set-up a SaturnCloud Server

SaturnCloud Environment Setup

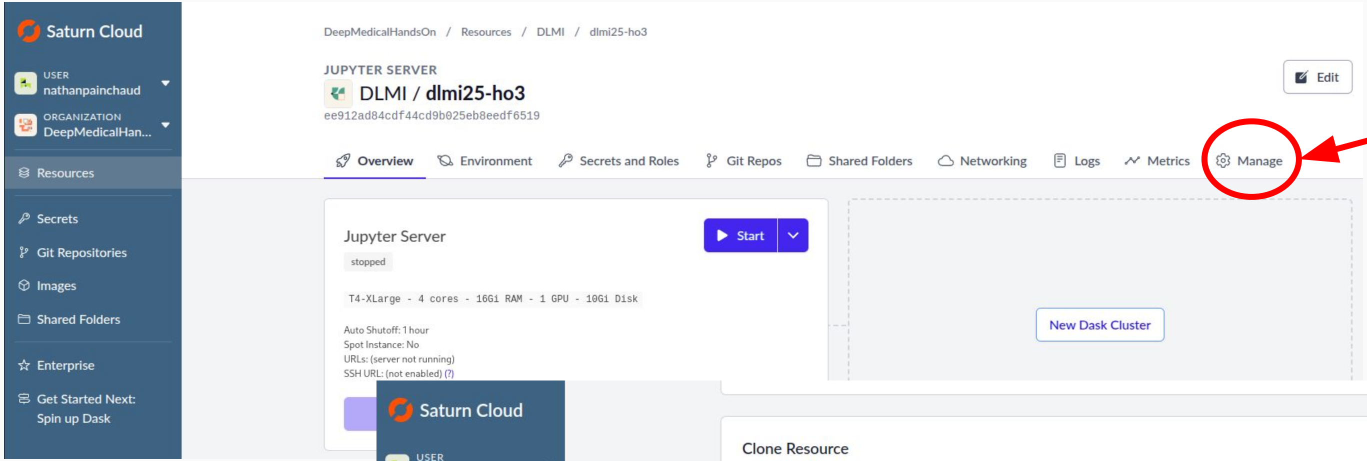


1. Login to saturncloud.io

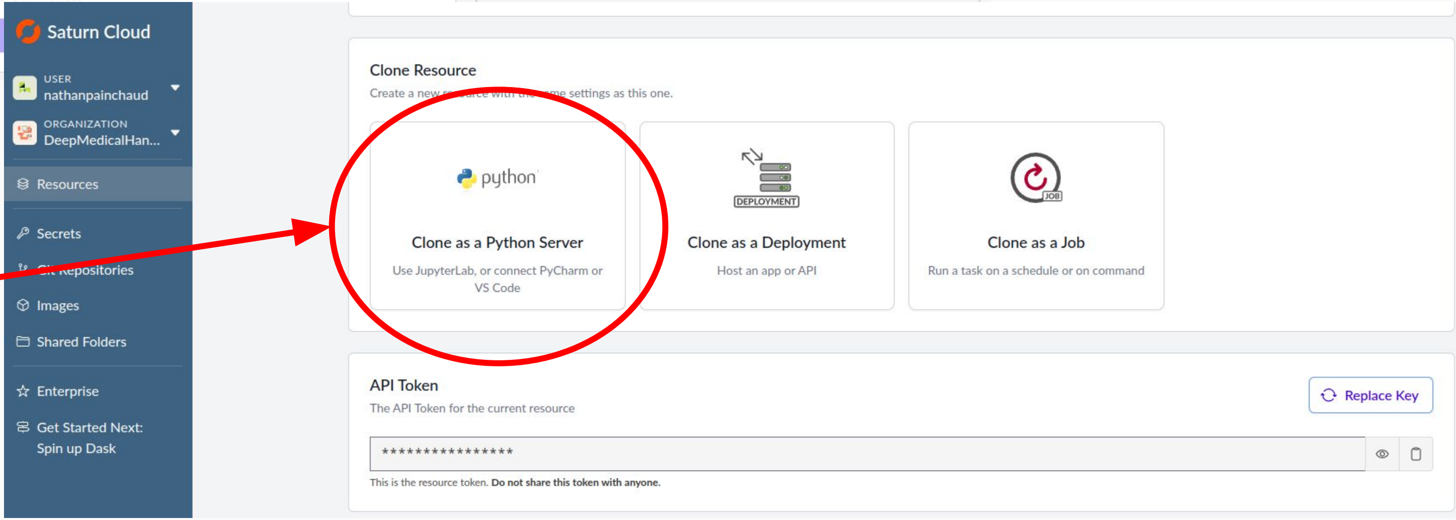
2. Switch to the organization account to get access to compute ressources.

3. Search for the pre-configured Python server for the VAE hands-on and select it.

SaturnCloud Environment Setup

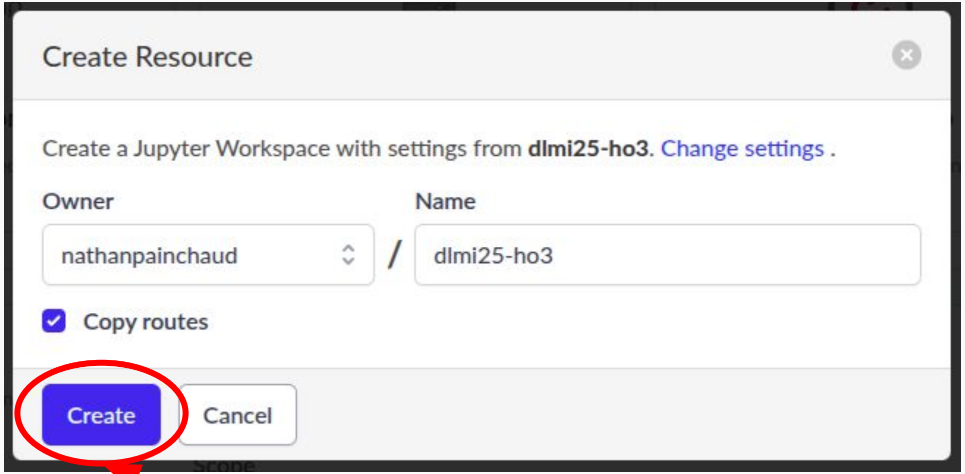


Navigate to the *Manage* menu of the pre-configured server



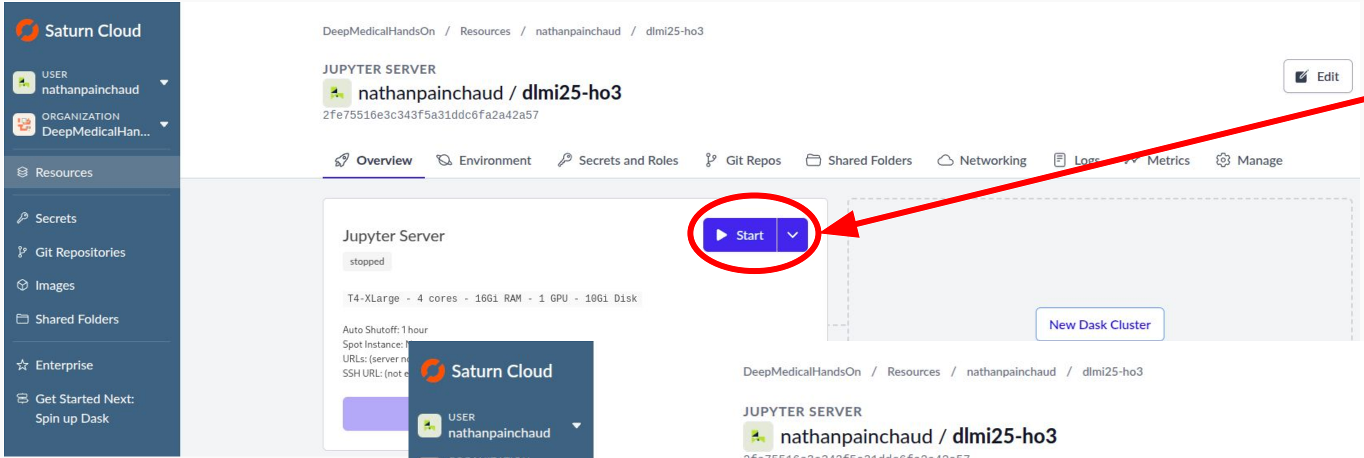
Scroll down and **select the *Clone as a Python Server* option**

SaturnCloud Environment Setup

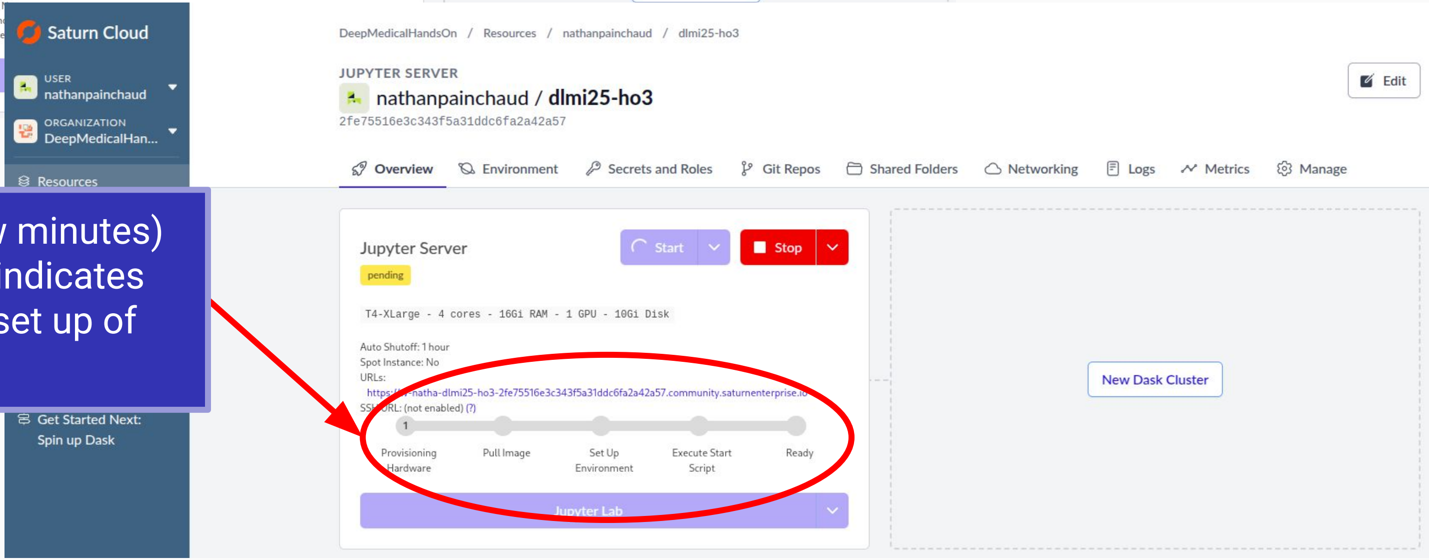


In the pop-up that appears, keep the default options (to create a clone of the resource for which you are the owner) and simply ***click Create***

SaturnCloud Environment Setup

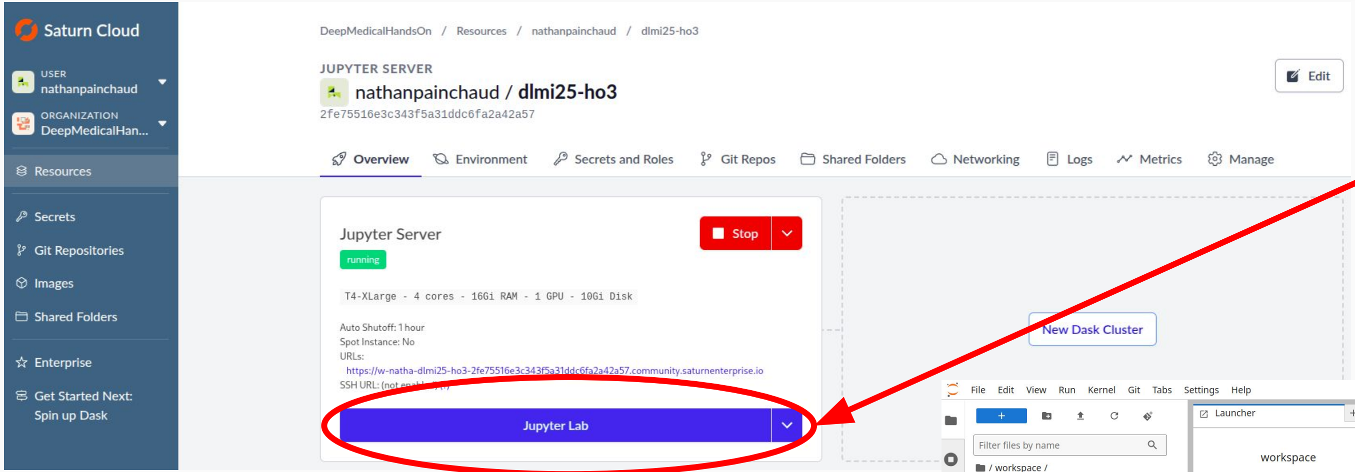


Start the server

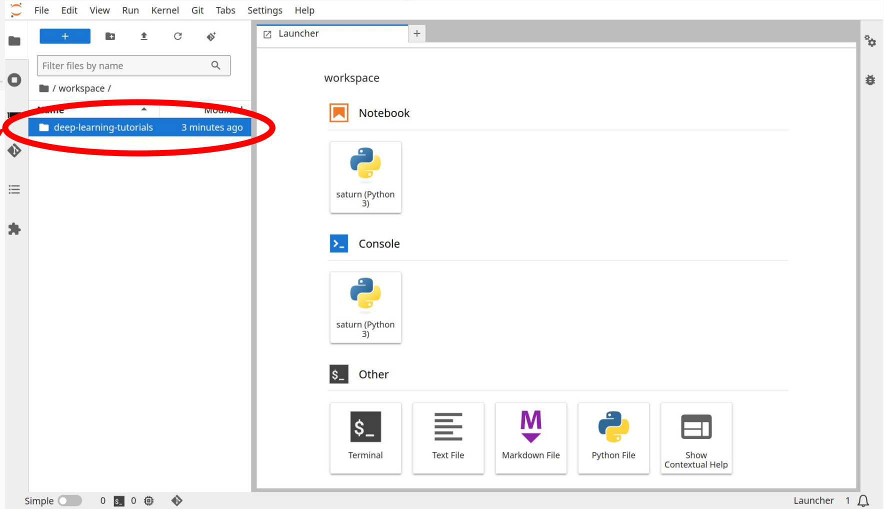


Wait (possibly for a few minutes) while the progress bar indicates the progression of the set up of the environment

SaturnCloud Environment Setup

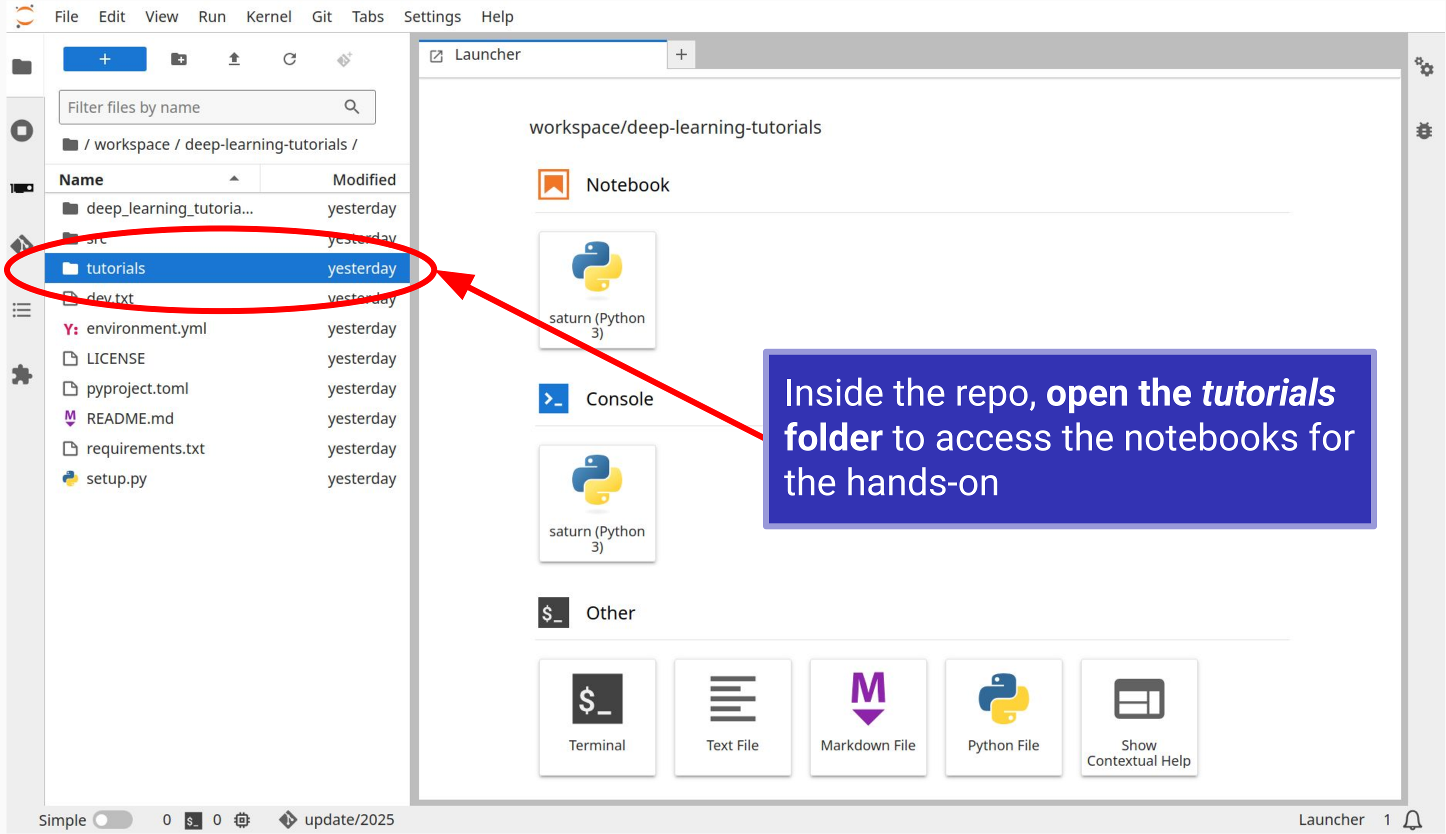


Once the server is ready, **click on the *Jupyter Lab* button** to launch it



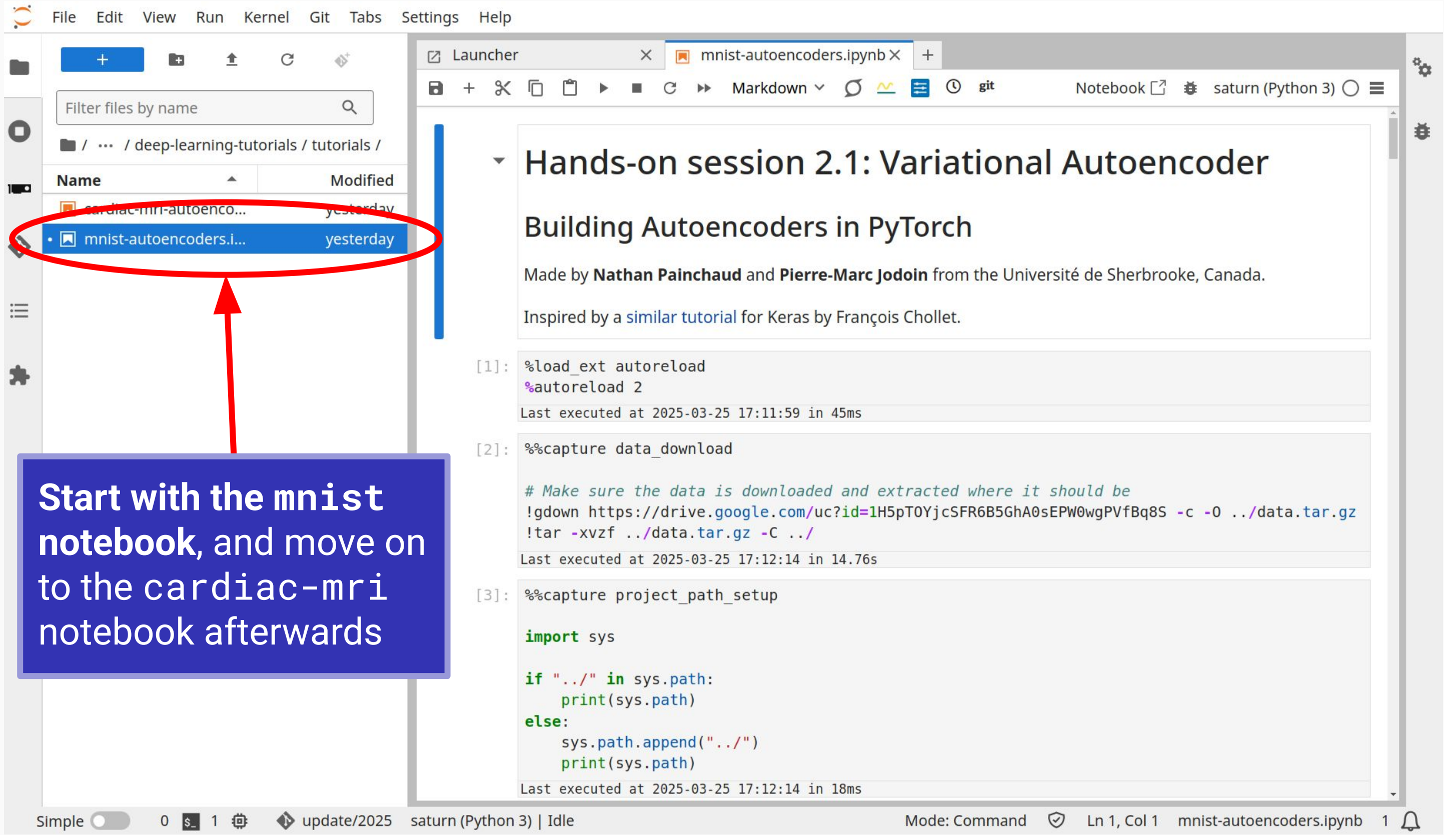
In *Jupyter Lab*, navigate through the file explorer in the left panel to **get to the code**

SaturnCloud Environment Setup



Inside the repo, **open the *tutorials* folder** to access the notebooks for the hands-on

SaturnCloud Environment Setup



Start with the `mnist` notebook, and move on to the `cardiac-mri` notebook afterwards

Autoencoders Recap

Summary

Note: If you are familiar with AEs and VAEs, you may skip the rest of the slides

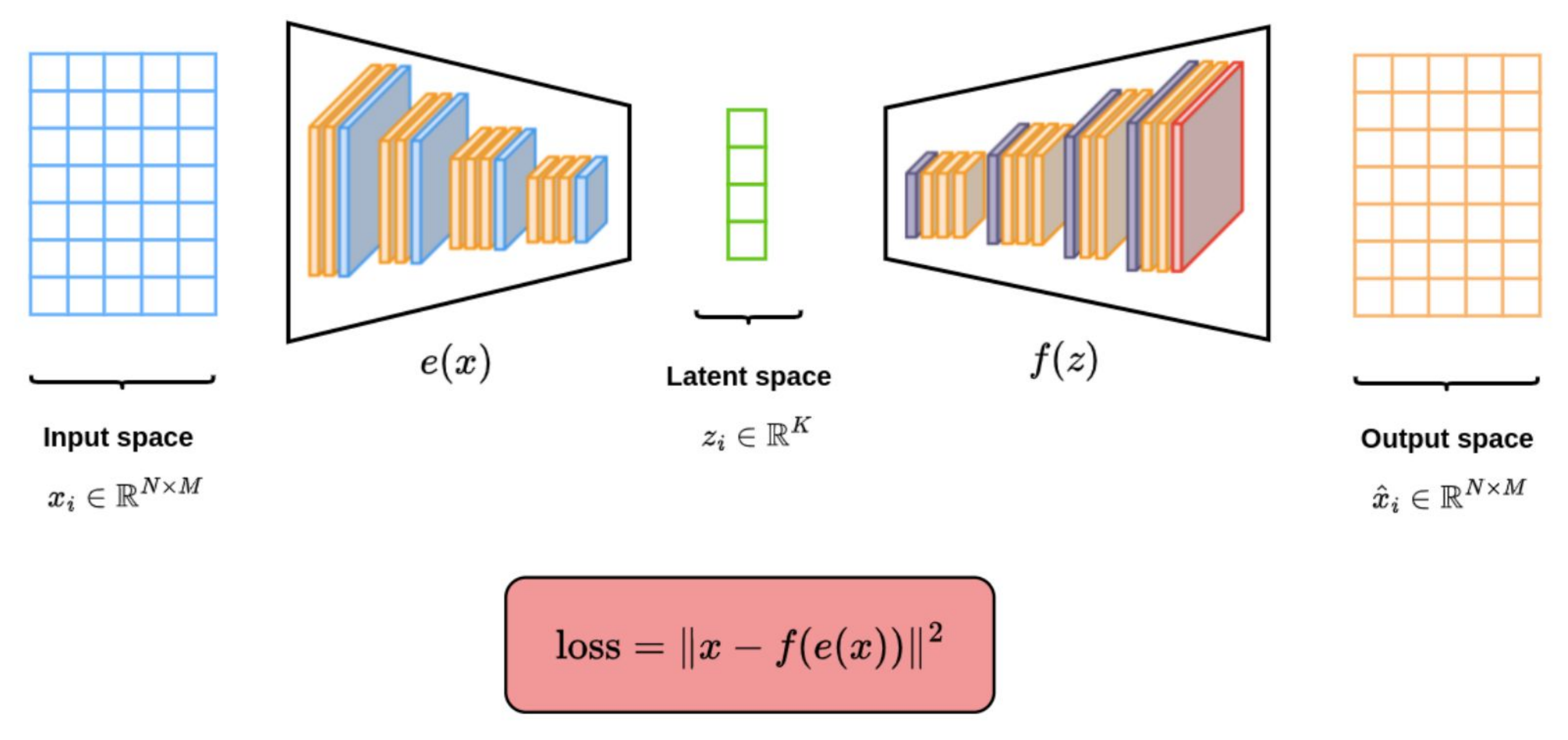
- What are autoencoders
- How are they implemented
- How do they apply to MNIST (grayscale images)
- How do they apply to ACDC (cardiac segmentation maps)

What are autoencoders?

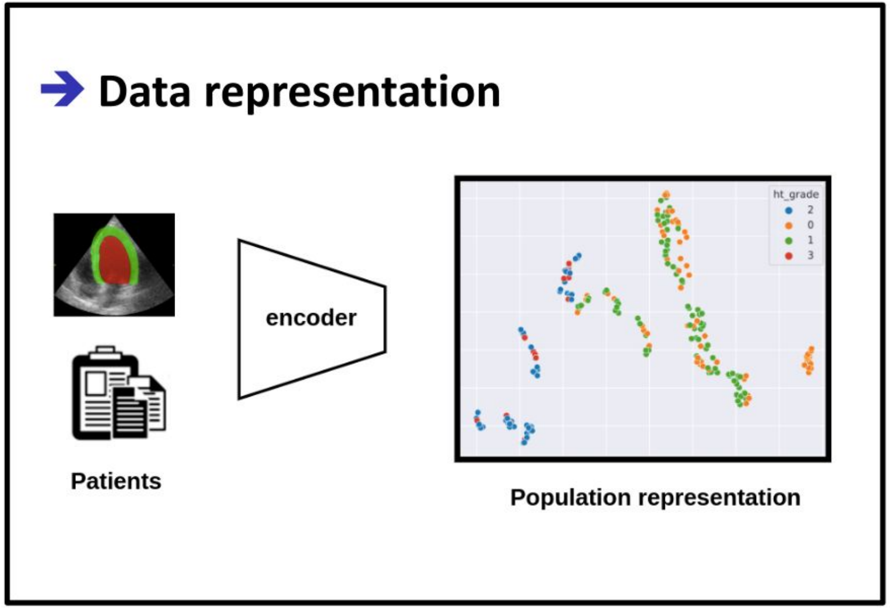
Problem: Learn the distribution of a set of data

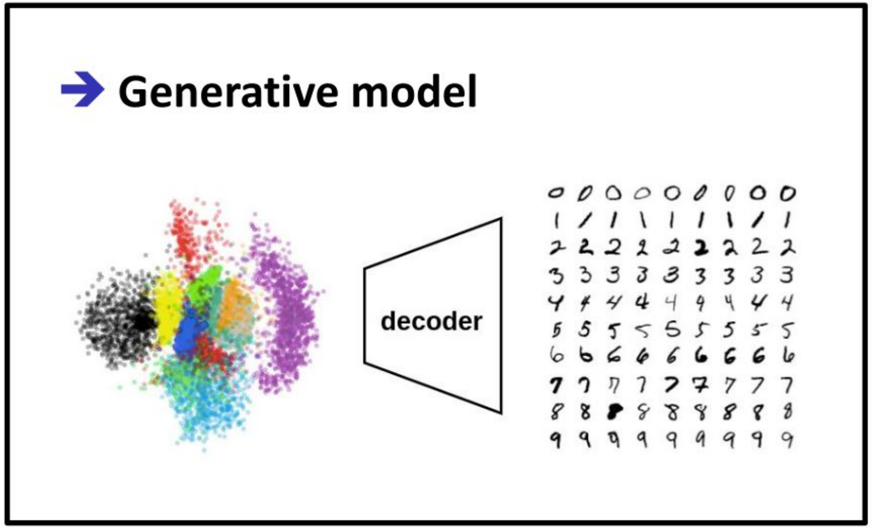
Method: Train a neural network to output… its own input!

Autoencoder Framework



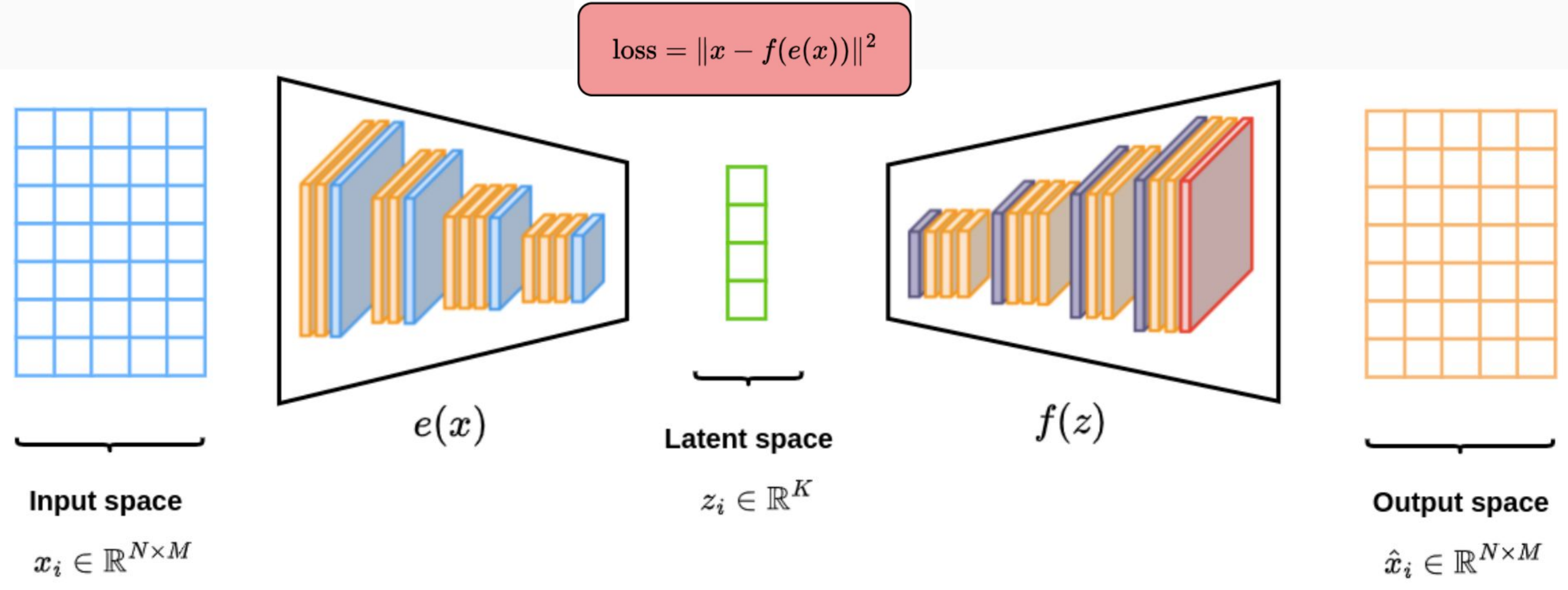
Applications of Autoencoders





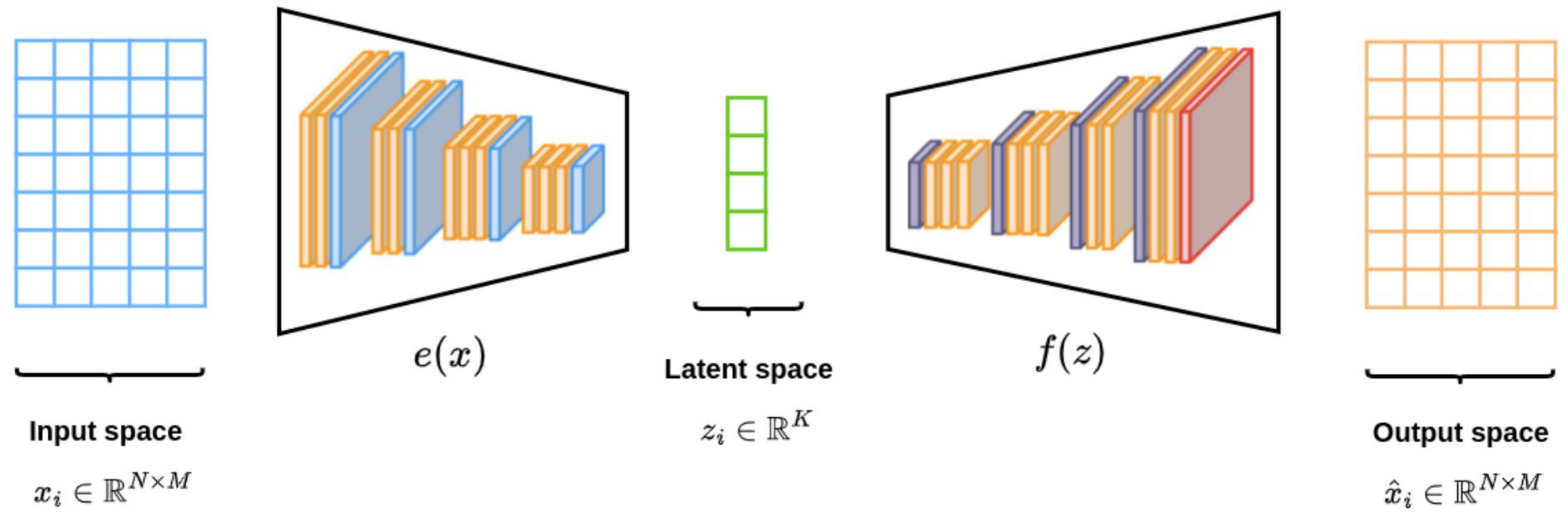
Key Concepts

- Loss **minimizes reconstruction error** of the output, e.g.



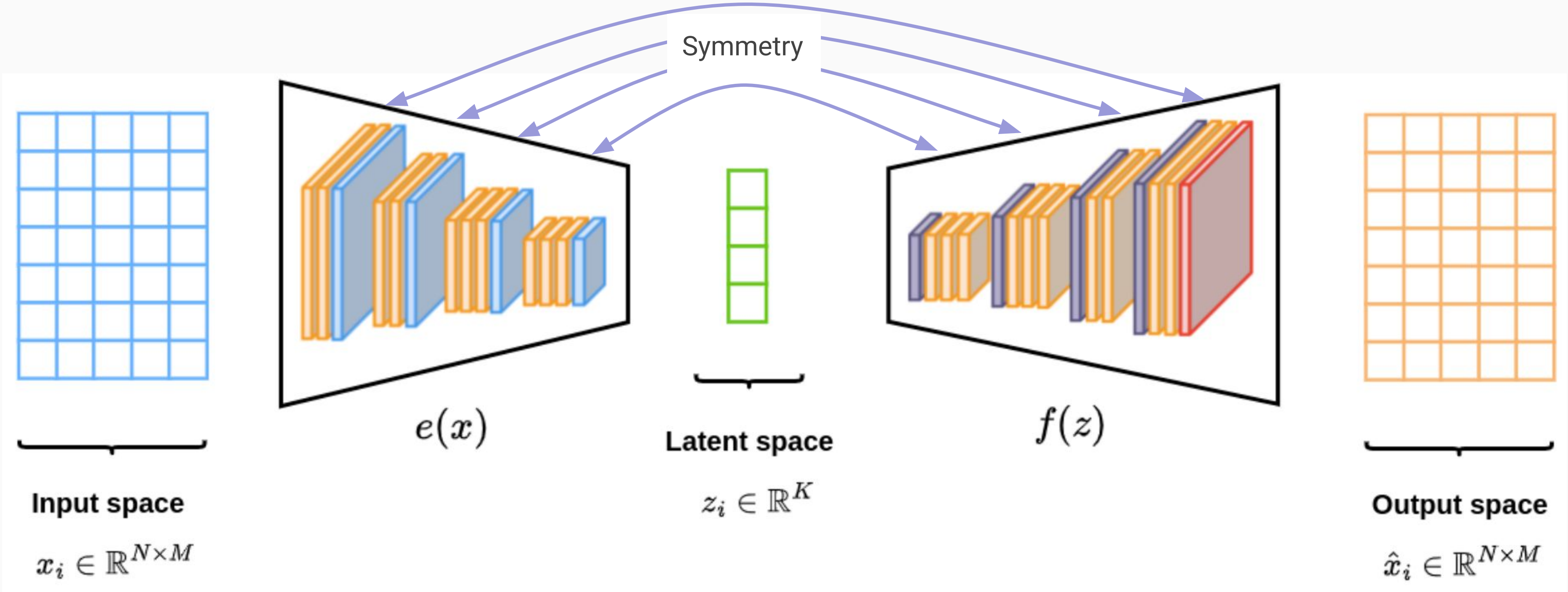
Key Concepts

- Encoder-decoder architecture to compress input, with ***K << N x M***



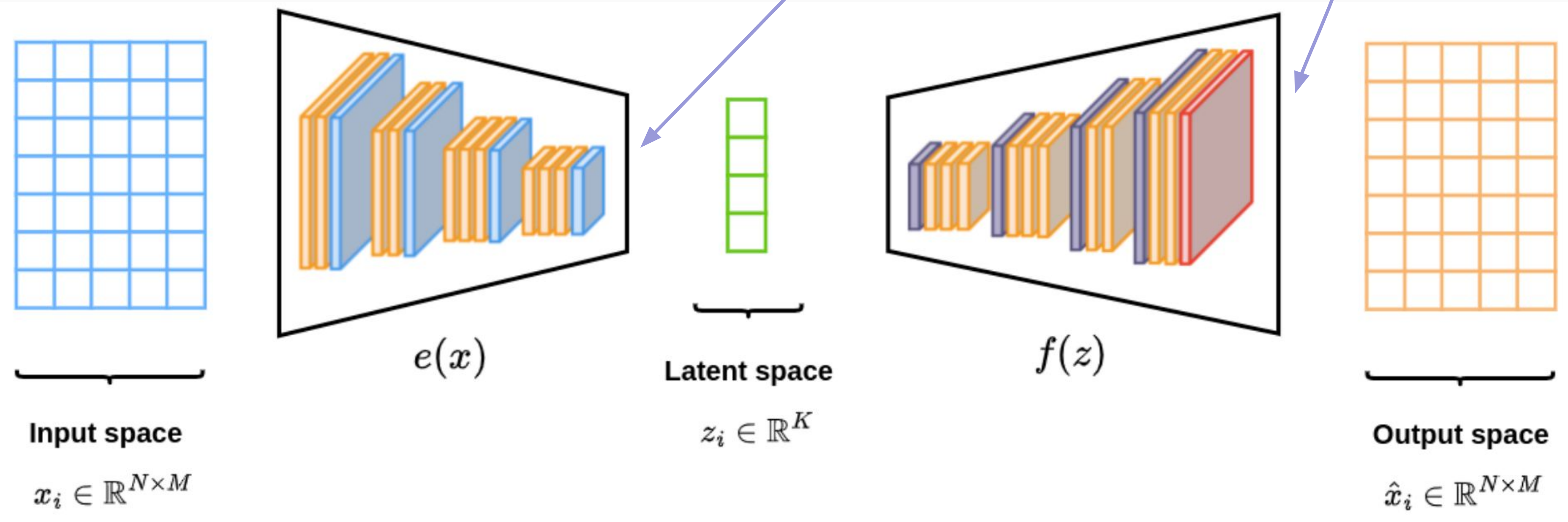
Key Concepts

- Generally, decoder is a **mirror** of the encoder



Key Concepts

- Mostly, **sigmoid/relu** at the output of the **decoder** + **no activations** at the output of the **encoder**

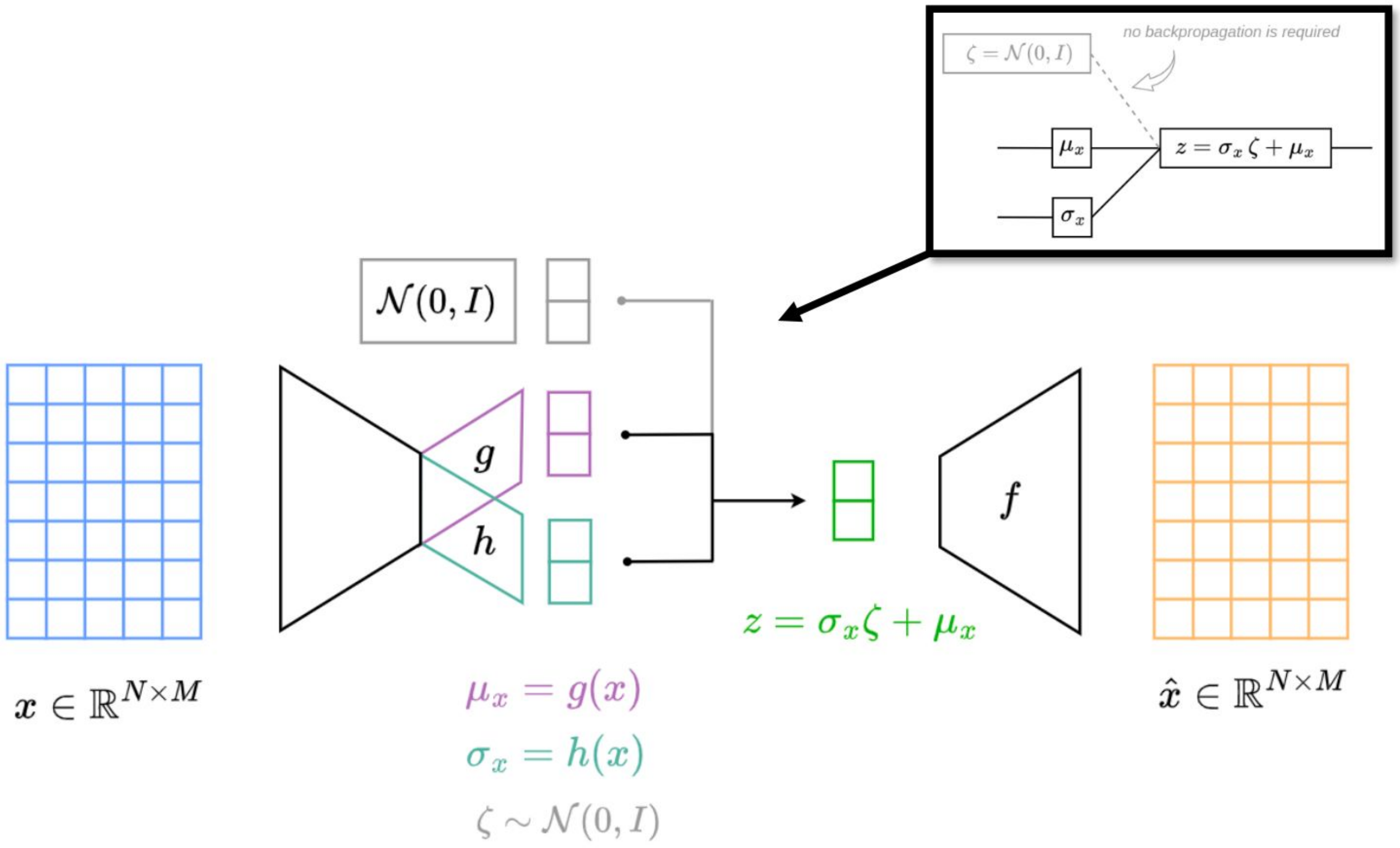


Variational Autoencoders

- Encoder output $\mathcal{N}(g(x), h(x))$ is a distribution instead of a precise point
  How does this affect the implementation?
  - 2 heads *g* and *h* at the end of the encoder (shared weights in previous layers)
  - Reparameterization trick (see next slide)

- $\mathcal{N}(0, I)$ prior on the encoder's predictions
  How does this affect the implementation?
  - Add a KL divergence term to the total loss

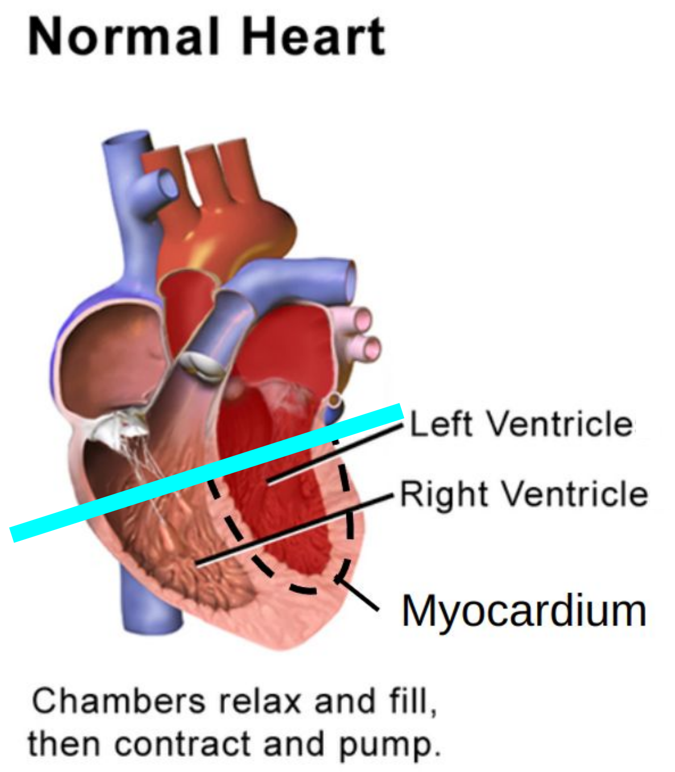
Reparameterization Trick

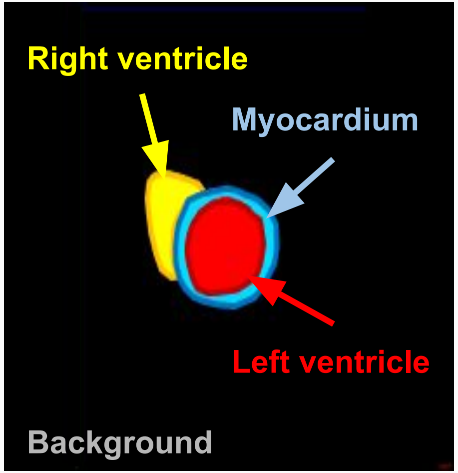


MNIST

- Handwritten digits
  - 60,000 images
  - 32x32 pixels
  - Website
- Simple images/distribution ->
  - Fully-connected AE
  - Interactive visualization of 2D latent space
- Test autoencoder vs. variational autoencoder

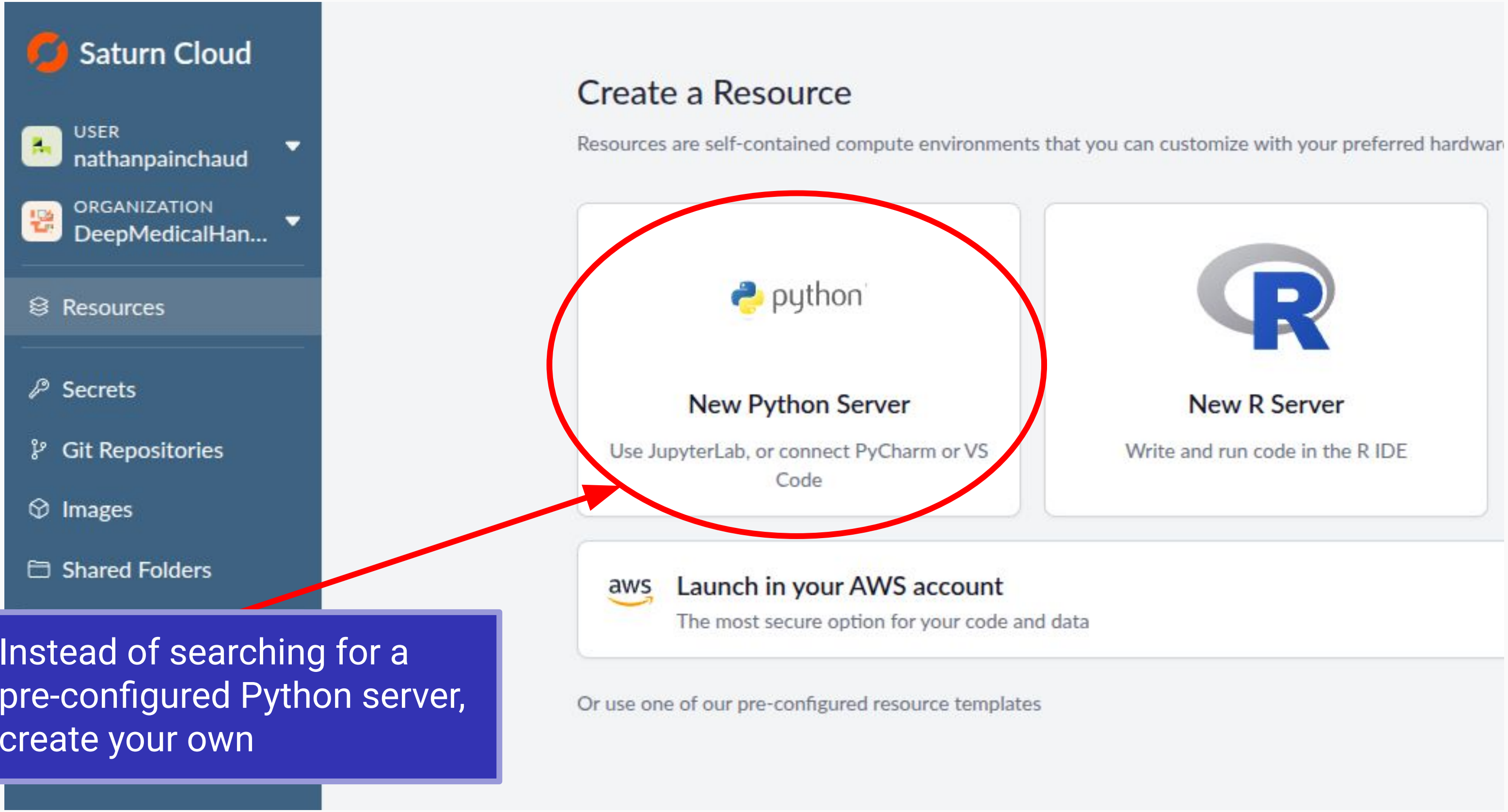
- Cardiac short-axis cine-MRI
  - 150 patients
  - 5 clinical groups
  - 256x256 pixels
  - Website
- Complex images/distribution ->
  - Convolutional AE/VAE
- Showcase AE/VAE on real-world problems





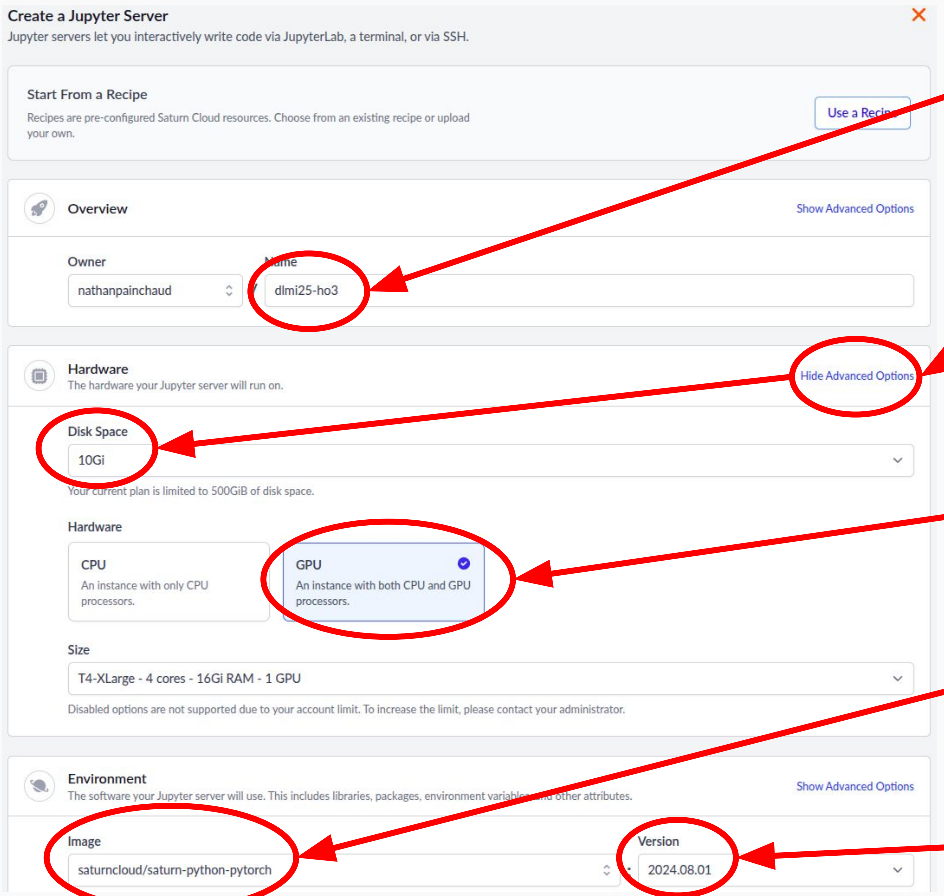
Set-up your own SaturnCloud Server

Create SaturnCloud Environment from Scratch



Instead of searching for a pre-configured Python server, create your own

Create SaturnCloud Environment from Scratch



Give a descriptive name to the server

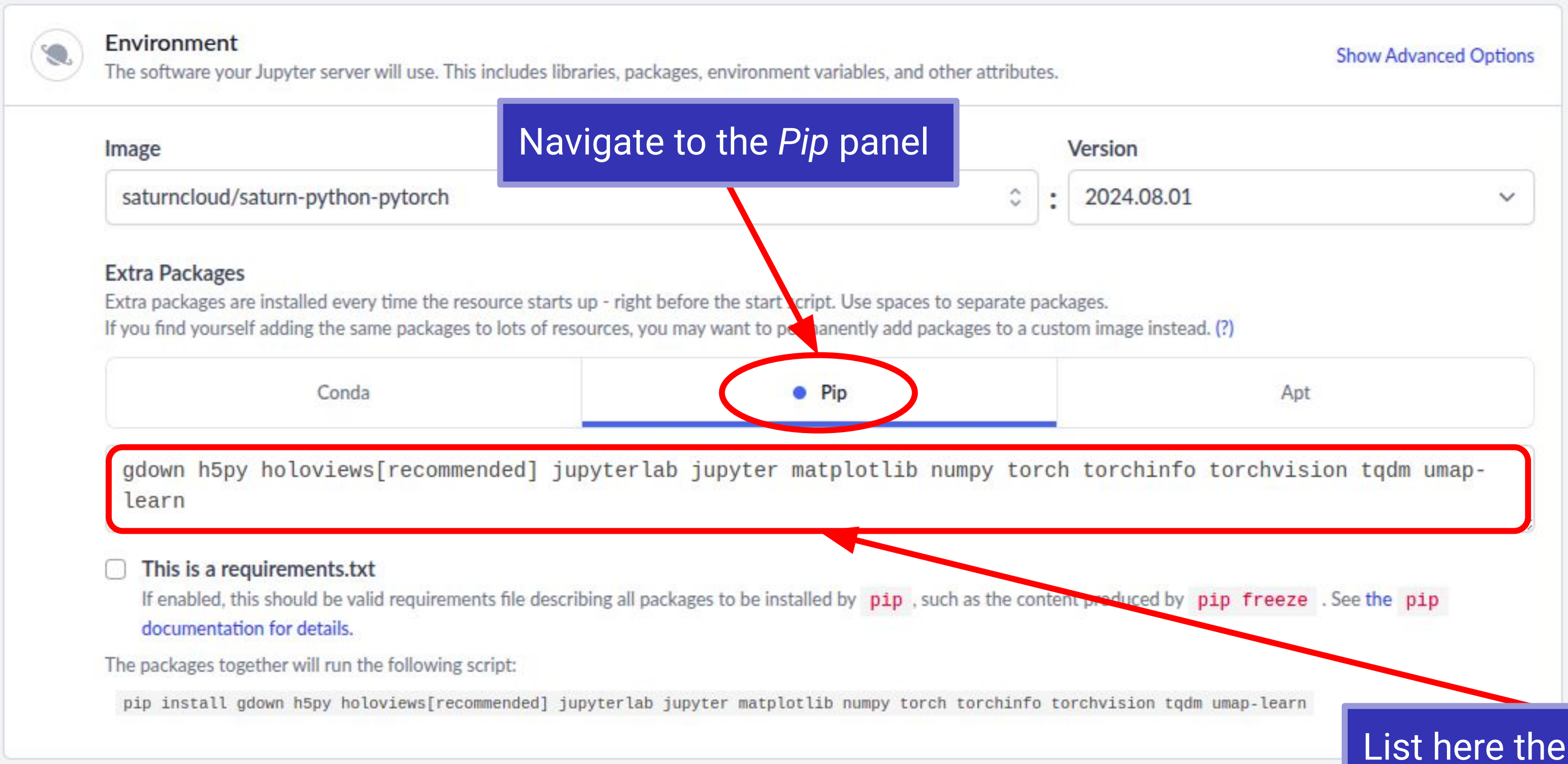
Click on *Show Advanced Options* in the *Hardware* box to reveal the *Disk space* menu and choose the 10Gi option

Select the GPU hardware

Select the *saturn-python-pytorch* image

Keep the default 2024.08.01 version

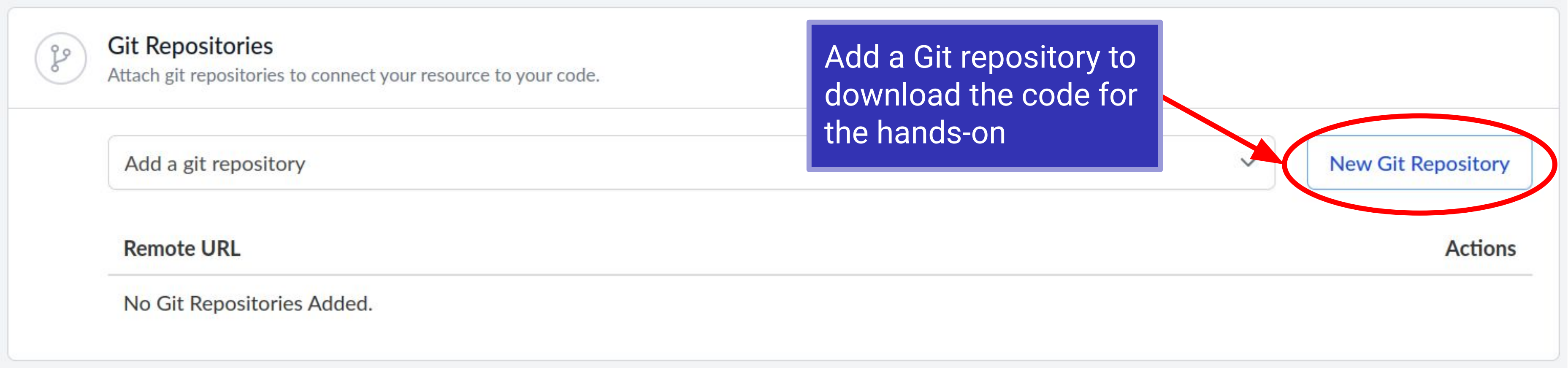
Create SaturnCloud Environment from Scratch



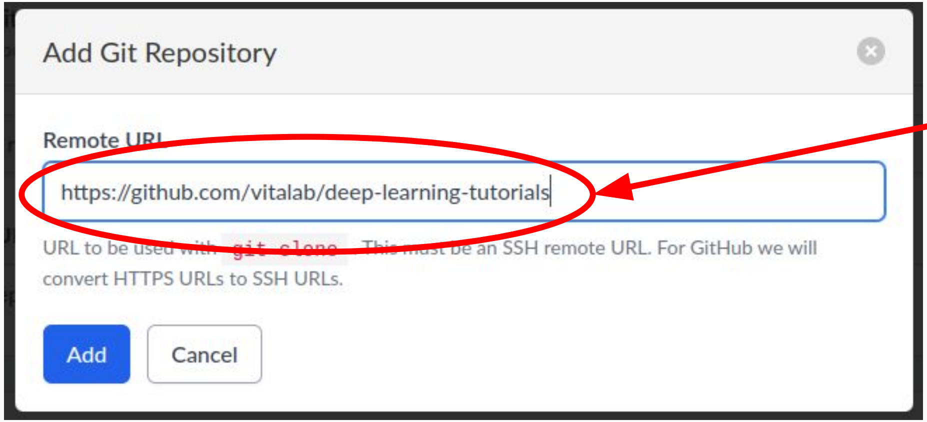
Navigate to the *Pip* panel

List here the packages to be `pip install`-ed

Create SaturnCloud Environment from Scratch

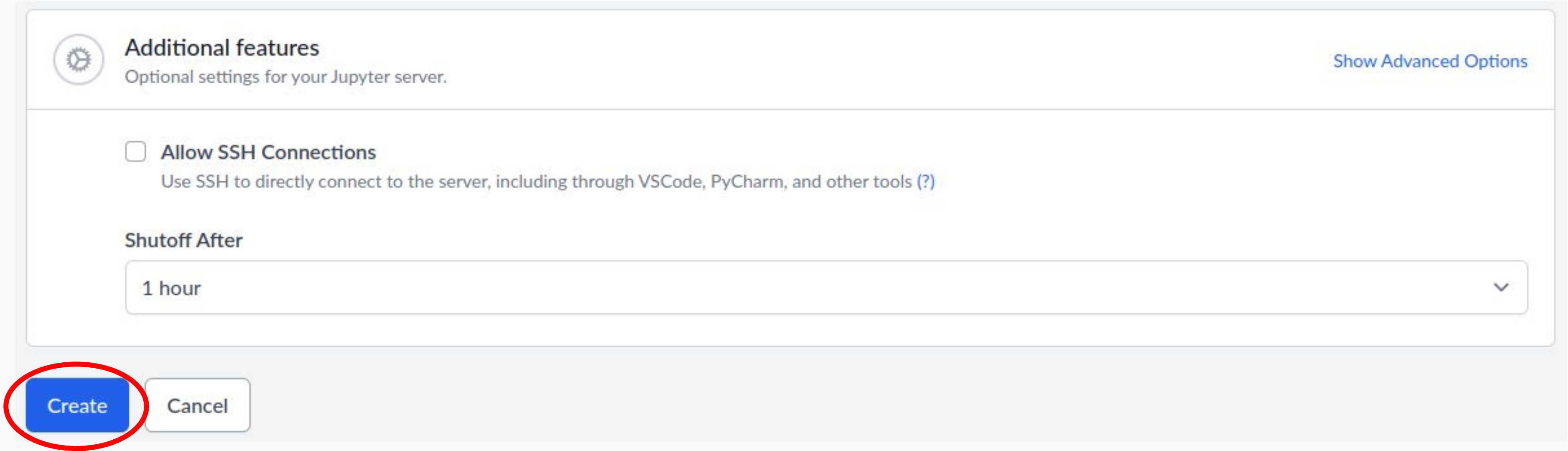


Add a Git repository to download the code for the hands-on



In the pop-up that appears, paste the following URL: https://github.com/vitalab/deep-learning-tutorials

Create SaturnCloud Environment from Scratch



Create the server