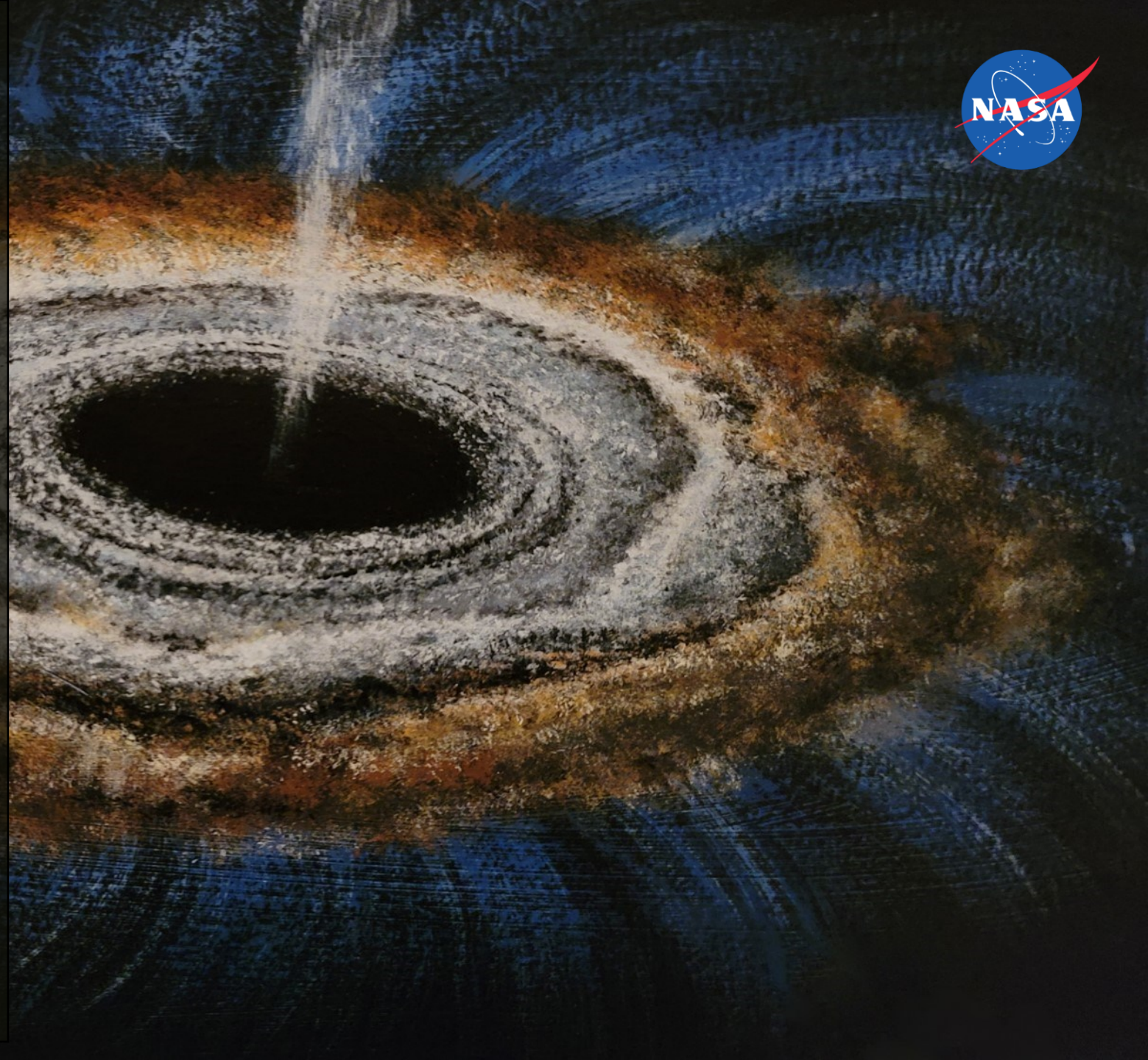
Practical Uses of AI in your Lab



Mona Matar, PhD
Research Mathematician
NASA Glenn Research Center

70th Annual Meeting of the Radiation Research Society
Sept 17, 2024 - Tucson, AZ

Introduction



What are AI and ML?

Artificial Intelligence (AI): simulation of human intelligence in machines that are programmed to think and learn

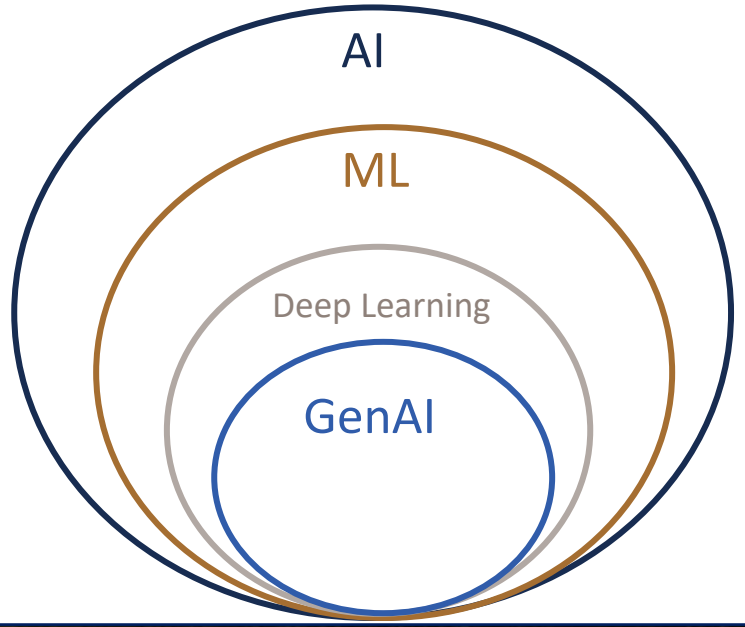
Machine Learning (ML): a subset of AI that involves training algorithms to make predictions or decisions based on data



What are AI and ML?

Artificial Intelligence (AI): simulation of human intelligence in machines that are programmed to think and learn

Machine Learning (ML): a subset of AI that involves training algorithms to make predictions or decisions based on data





What are AI and ML?

Artificial Intelligence (AI): simulation of human intelligence in machines that are programmed to think and learn

Machine Learning (ML): a subset of AI that involves training algorithms to make predictions or decisions based on data

Why it Matters in Labs:

- Streamlining data analysis
- Automating repetitive tasks
- Enhancing predictive modeling and simulations
- Facilitating decision-making processes



What AI can do in Laboratories

Diagnostics

- AI algorithms analyze lab results to assist in diagnosing diseases
- Example: In oncology, IBM Watson



What AI can do in Laboratories

Diagnostics

Automation

- Automating repetitive tasks such as sample analysis and data entry
- Example: Roche's Cobas 8000



diagnostics.roche.com

What AI can do in Laboratories

Diagnostics

Automation

Error Detection

- Identifying and correcting errors in lab processes
- *Example*: Siemens Healthineers

SIEMENS Healthineers
siemens-healthineers.com/en-us

What AI can do in Laboratories

Diagnostics

Automation

Error Detection

Forecasting

- Predicting trends and outcomes based on historical data
- Example: AI-driven systems in pharmaceutical labs like those used by Novartis

What AI can do in Laboratories

Diagnostics

Automation

Error Detection

Forecasting

Image Analysis

- Enhancing the analysis of medical images and slides
- *Example*: Google's DeepMind AI

Google DeepMind

deepmind.google

What AI can do in Laboratories

Diagnostics

Automation

Error Detection

Forecasting

Image Analysis

Genomics



illumina.com

- Analyzing genetic data to identify mutations and patterns
- *Example*: Illumina's AI-powered software

What AI canNOT do in Laboratories

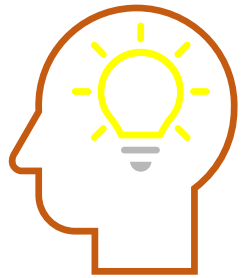
- Be used as a “**magic bullet**” vs. a tool



What AI canNOT do in Laboratories

- Be used as a “**magic bullet**” vs. a tool

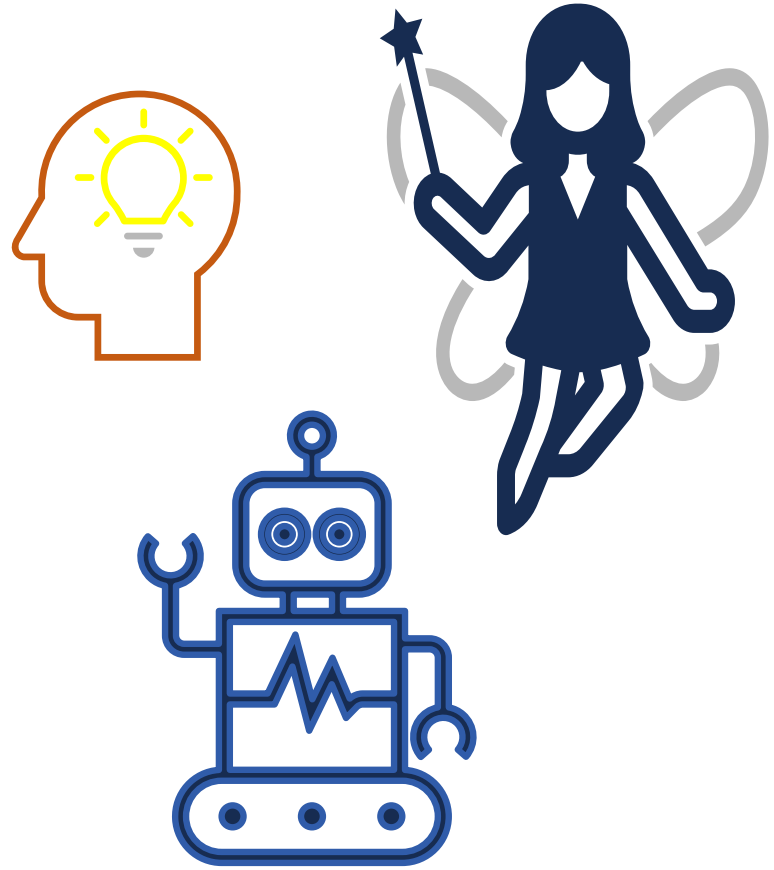
- Generate **creative** solutions for a problem





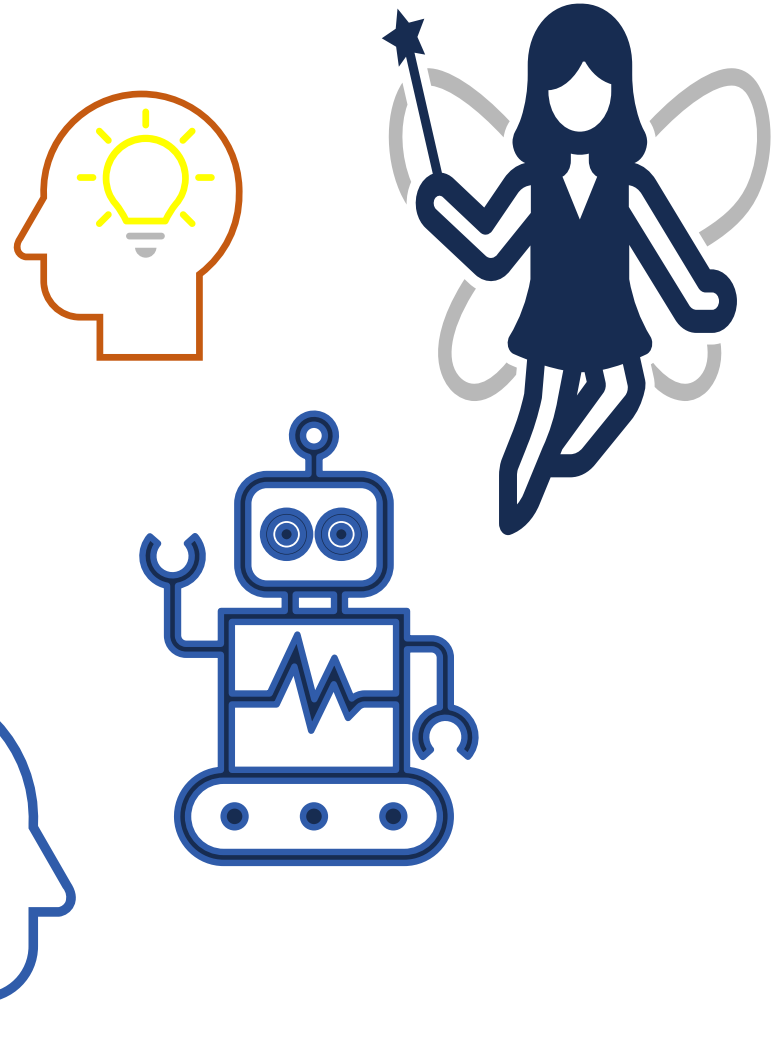
What AI canNOT do in Laboratories

- Be used as a “**magic bullet**” vs. a tool
- Generate **creative** solutions for a problem
- Produce reliable results if input **data** is not robust

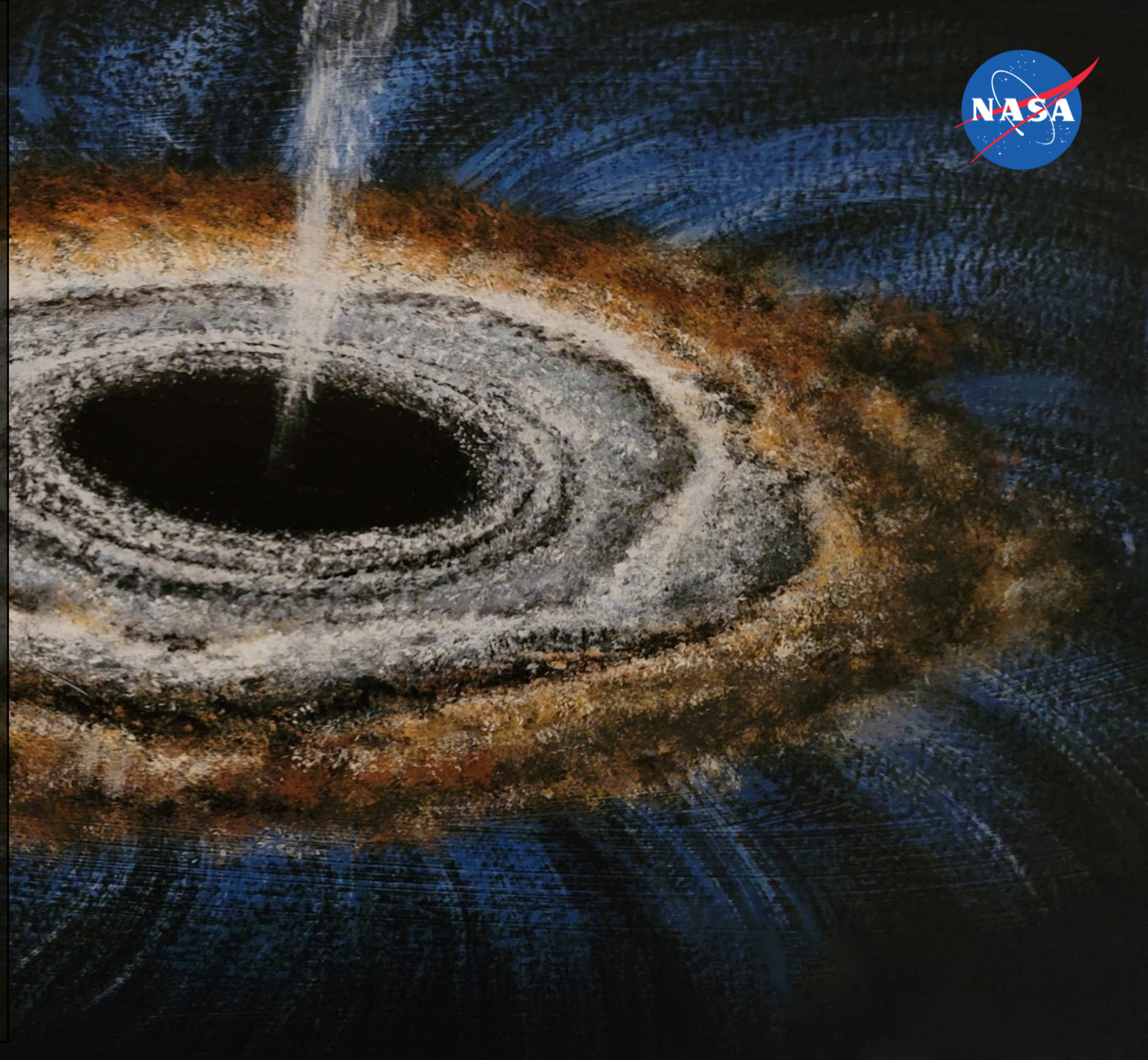


What AI canNOT do in Laboratories

- Be used as a “**magic bullet**” vs. a tool
- Generate **creative** solutions for a problem
- Produce reliable results if input **data** is not robust
- **Ethical** judgments and decision-making



Machine Learning



Types of Machine Learning

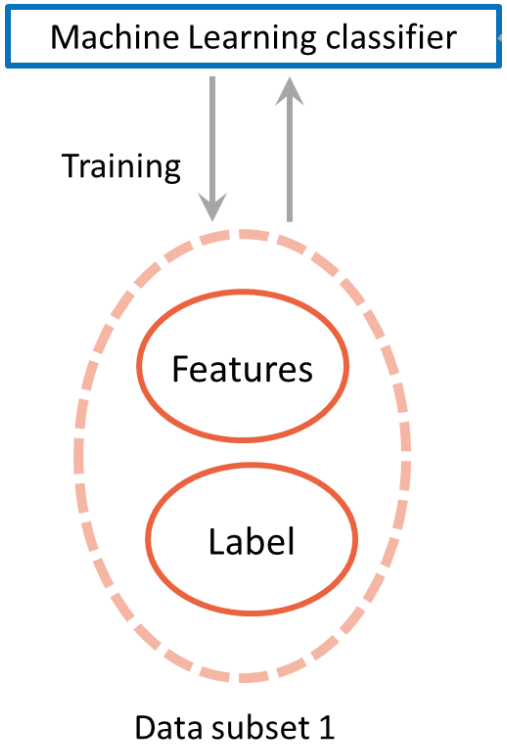
Supervised Learning (learning from **labeled** examples)



Supervised Machine Learning

Supervised Learning (learning from **labeled** examples)

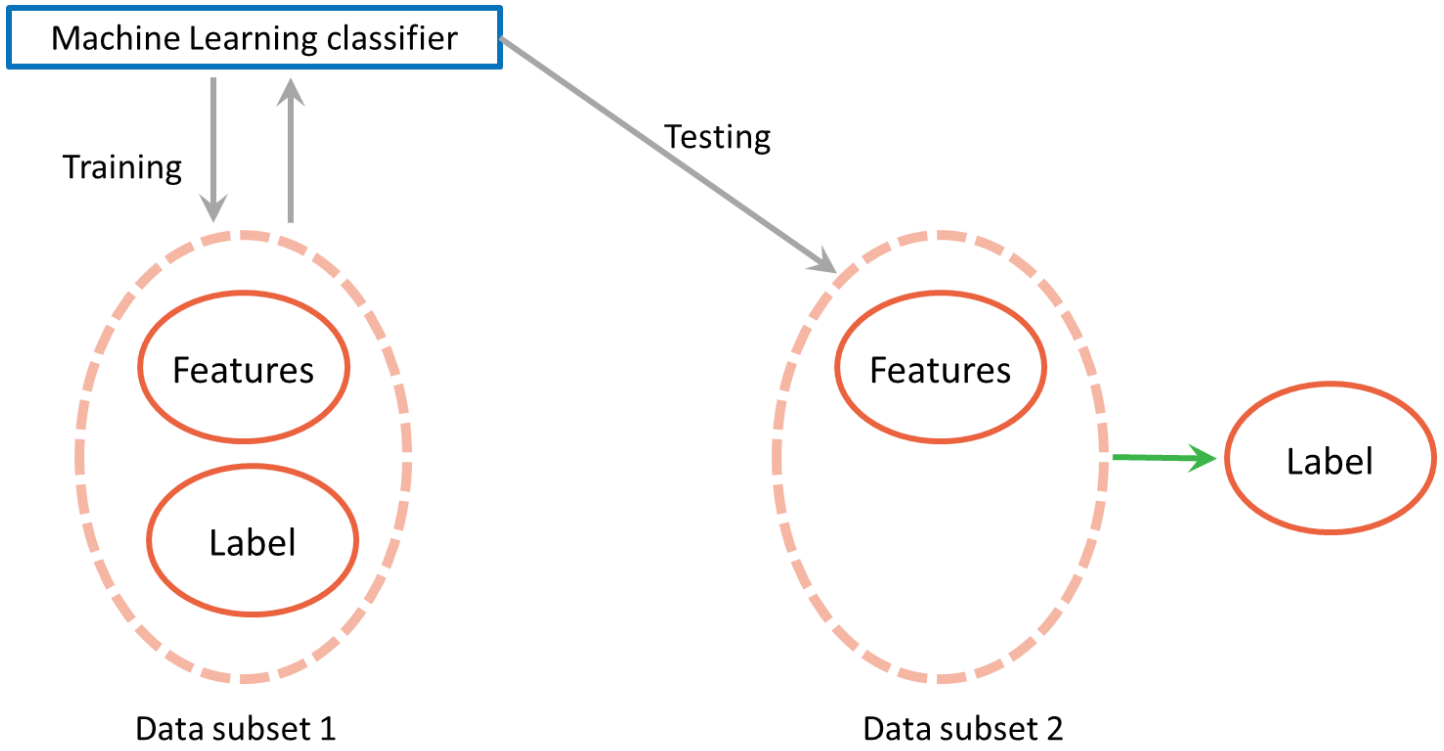




Supervised Machine Learning

Supervised Learning (learning from labeled examples)

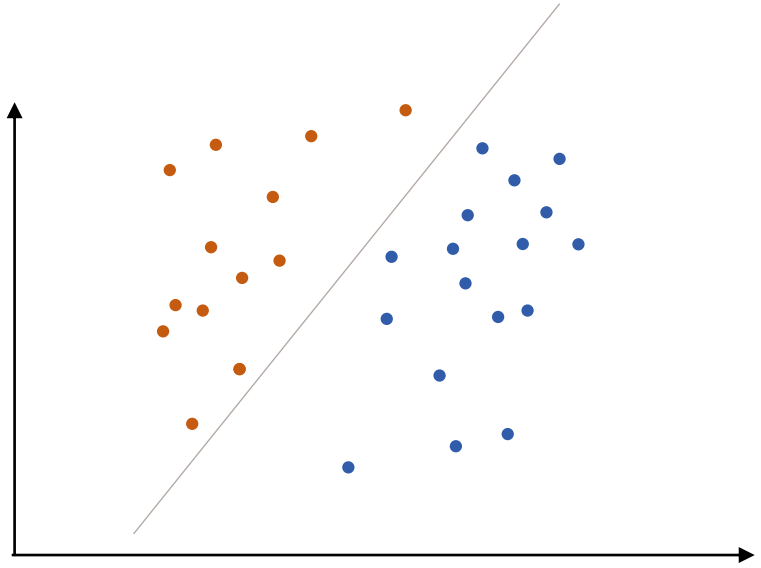




Supervised Machine Learning

Supervised Learning (learning from labeled examples)

- Support Vector Machines

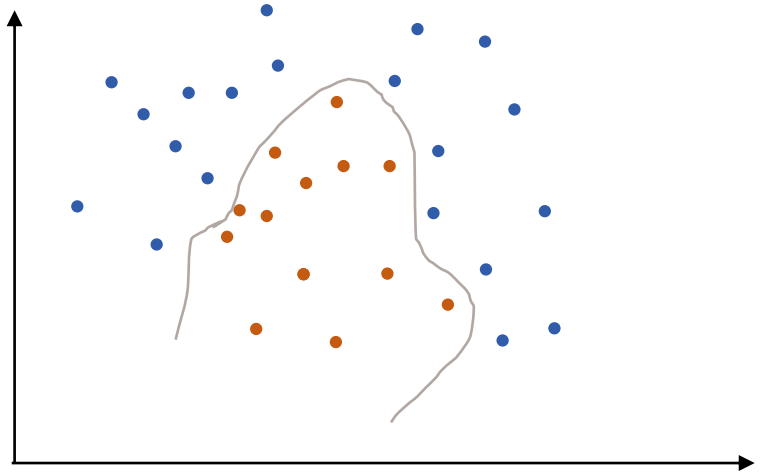


Supervised Machine Learning

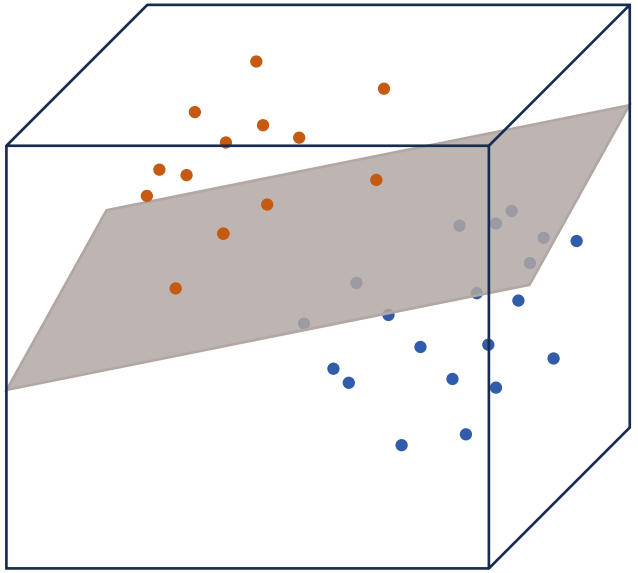


Supervised Learning (learning from labeled examples)

- Support Vector Machines



Data in 2D
non-separable

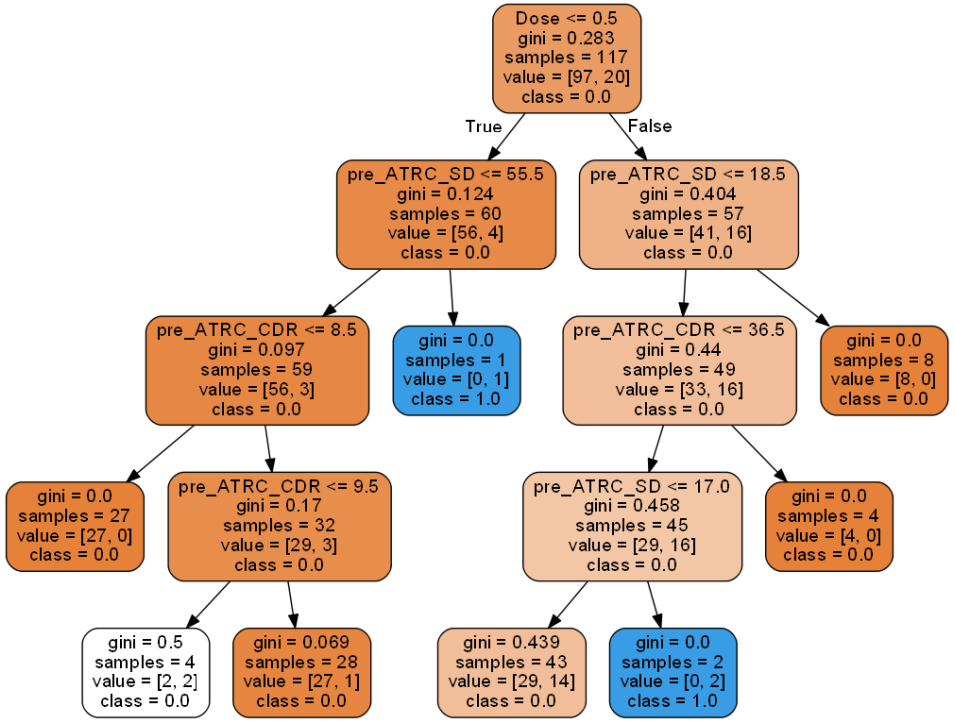


Data transformed in multi-dimensional space
(separable)

Supervised Machine Learning

Supervised Learning (learning from **labeled** examples)

- Support Vector Machines
- **Tree-based methods**

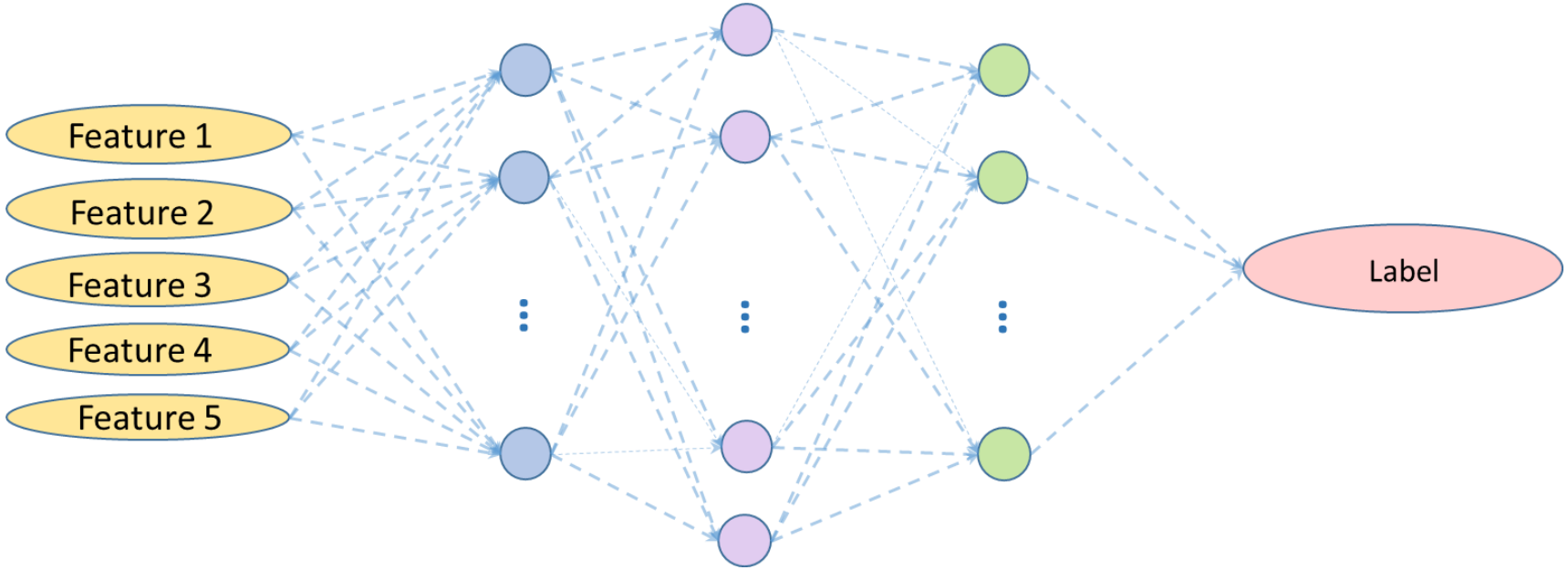


Supervised Machine Learning

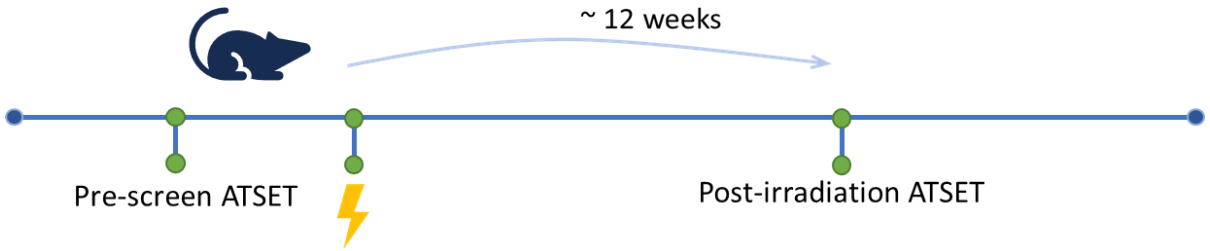
Supervised Learning (learning from **labeled** examples)



- Support Vector Machines
- Tree-based methods
- **Neural networks**



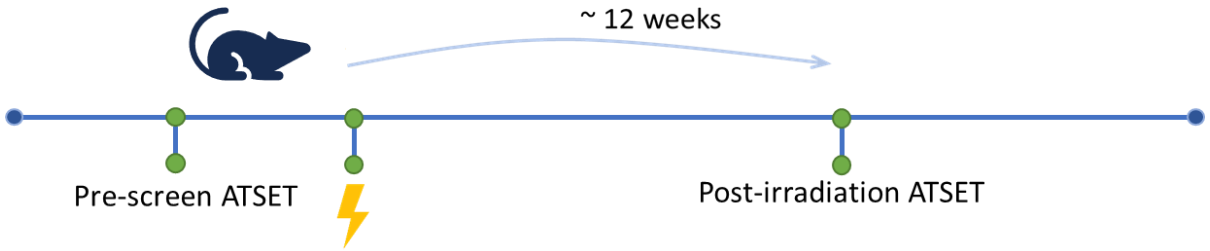
Supervised Machine Learning in Our Lab



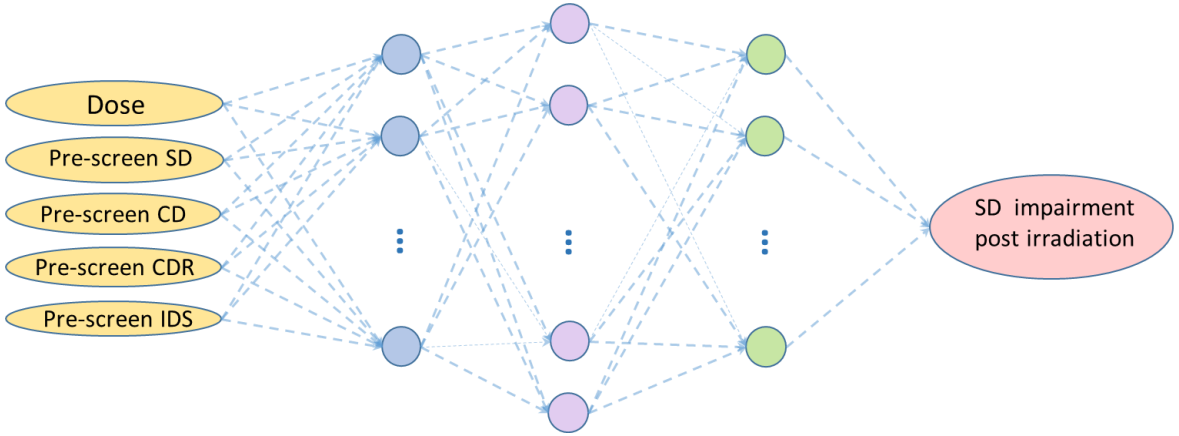
- Supervised ML was used to **predict** task impairment of rats after irradiation
- Requires labeled data

mona.matar@nasa.gov

Supervised Machine Learning in Our Lab

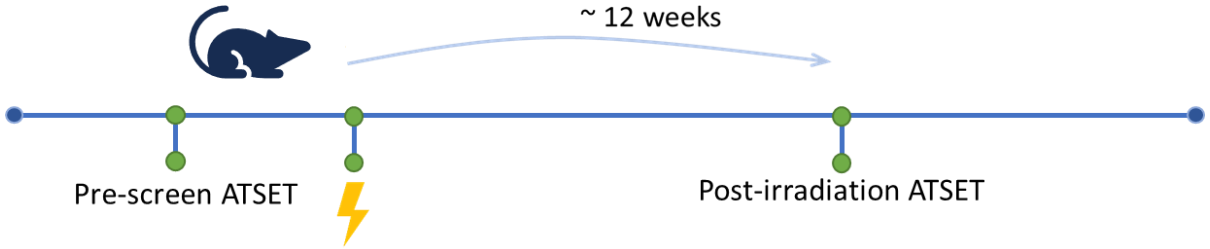


- Supervised ML was used to **predict** task impairment of rats after irradiation
- Requires labeled data
- Artificial Neural Networks (ANNs)

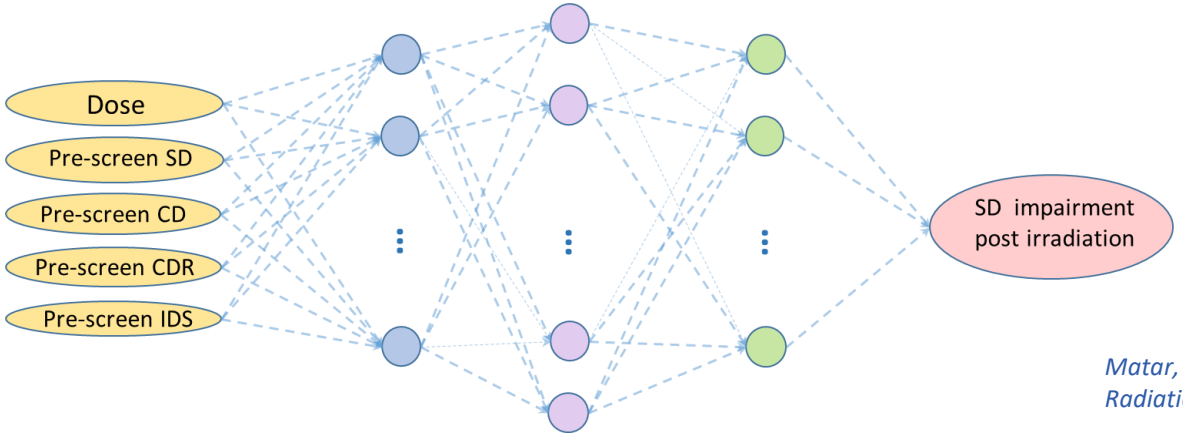


mona.matar@nasa.gov

Supervised Machine Learning in Our Lab



- Supervised ML was used to **predict** task impairment of rats after irradiation
- Requires labeled data
- Artificial Neural Networks (ANNs)



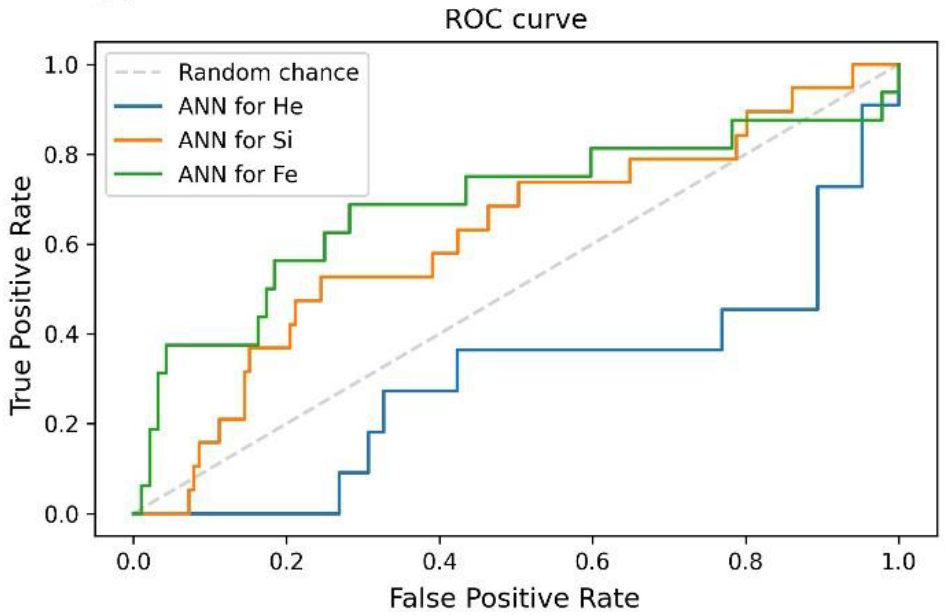


Figure: Impairment prediction in the SD stage using the ANN classifier Each line corresponds to sham rats and those irradiated with 4 He, 28 Si or 56 Fe ion at any of the given doses 1, 5, 10 cGy. The ROC curve of the neural network. The dotted diagonal represents random chance. A "better than chance" prediction translates into an AUC above 0.5.

Matar, Mona et al. "Machine Learning Models to Predict Cognitive Impairment of Rodents Subjected to Space Radiation." Frontiers in systems neuroscience vol. 15 713131. 13 Sep. 2021, doi:10.3389/fnsys.2021.713131

mona.matar@nasa.gov

Unsupervised Machine Learning

Supervised Learning (learning from **labeled** examples)



Unsupervised Learning (**no label** for data, goal to model/discover)



Unsupervised Machine Learning

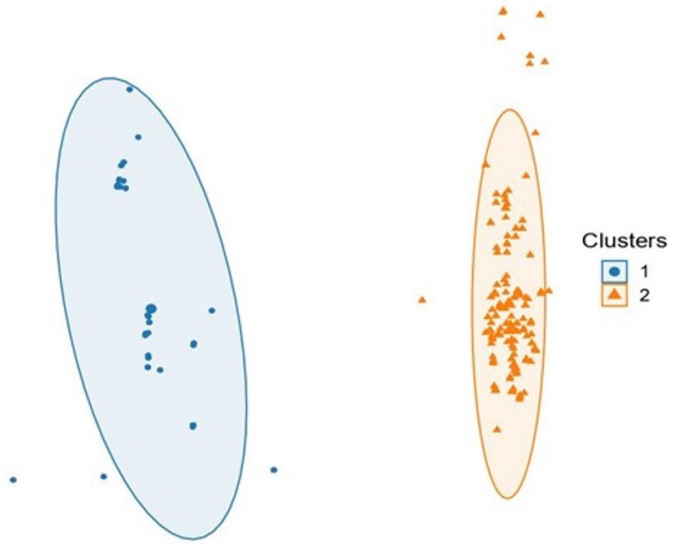
Supervised Learning (learning from **labeled** examples)



Unsupervised Learning (**no label** for data, goal to model/discover)



- Clustering (KMeans, …)



Unsupervised Machine Learning

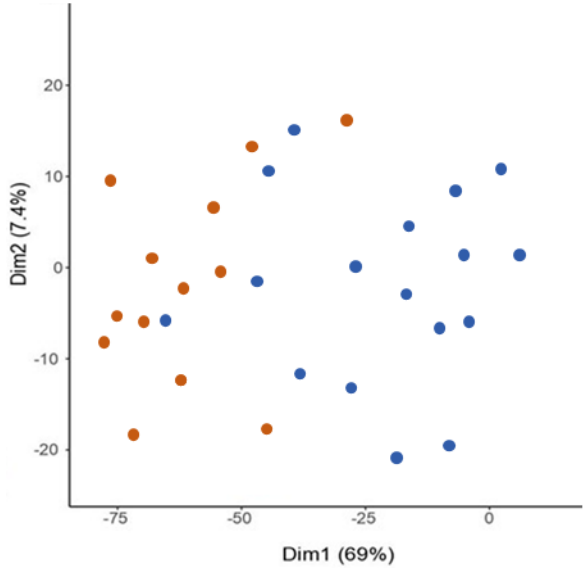
Supervised Learning (learning from **labeled** examples)



Unsupervised Learning (**no label** for data, goal to model/discover)



- Clustering (KMeans, …)
- Matrix Decomposition (PCA, …)



Unsupervised Machine Learning in Our Lab

- Analyze the **visuomotor network** in hypogravity

Unsupervised Machine Learning in Our Lab

- Analyze the **visuomotor network** in hypogravity

- Soft **k-means** two cluster of dominant frequencies of visuomotor networks

Unsupervised Machine Learning in Our Lab

- Analyze the **visuomotor network** in hypogravity
- Soft **k-means** two cluster of dominant frequencies of visuomotor networks
- 3 **PCA** dimensions

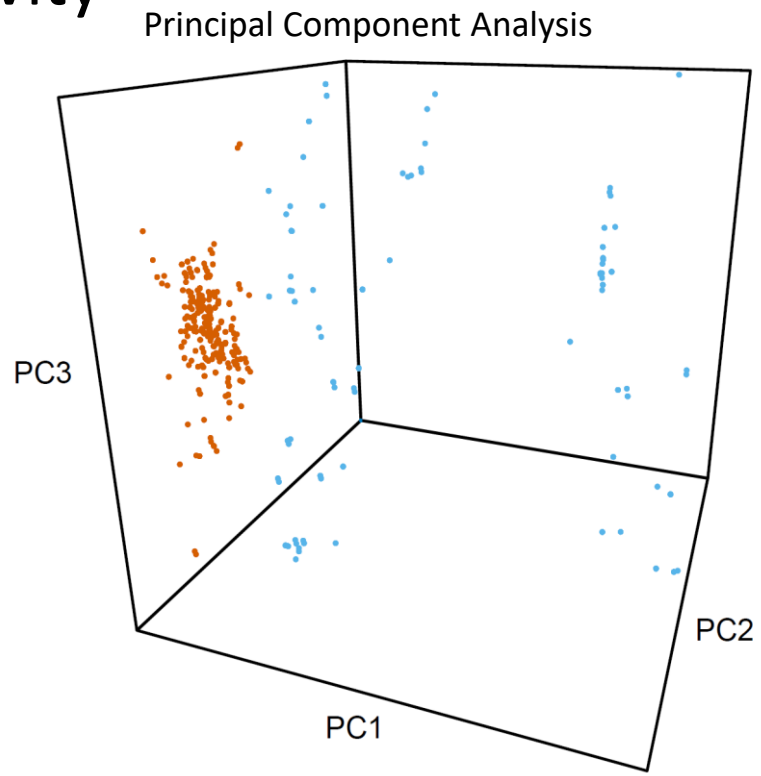


*Figure: S*oft k-means two cluster analysis of dominant frequencies of visuomotor networks, fifty of which with 1G parameters and 3,150 with hypogravity parameters. Plotted against first three PCA dimensions.

Unsupervised Machine Learning in Our Lab

- Analyze the **visuomotor network** in hypogravity
- Soft **k-means** two cluster of dominant frequencies of visuomotor networks
- 3 **PCA** dimensions
- Clustered samples with 1G parameters **separately** from those with hypogravity parameters

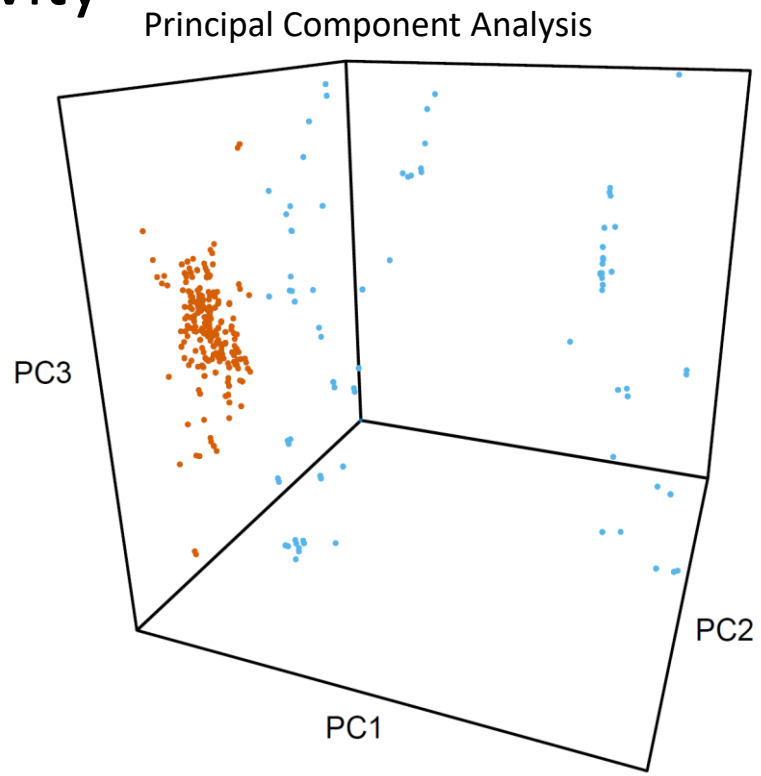


*Figure: S*oft k-means two cluster analysis of dominant frequencies of visuomotor networks, fifty of which with 1G parameters and 3,150 with hypogravity parameters. Plotted against first three PCA dimensions.

Reinforced Machine Learning

Supervised Learning (learning from **labeled** examples)



Unsupervised Learning (**no label** for data, goal to model/discover)



Reinforcement Learning (learning to act, not just predict; based on **feedback** or reward)



Generative AI

Supervised Learning (learning from **labeled** examples)



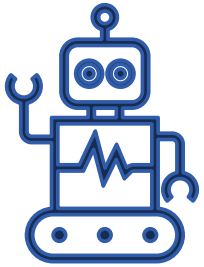
Unsupervised Learning (**no label** for data, goal to model/discover)



Reinforcement Learning (learning to act, not just predict; based on **feedback** or reward)



Generative AI (GenAI)



Generative AI

Supervised Learning (learning from **labeled** examples)



Unsupervised Learning (**no label** for data, goal to model/discover)

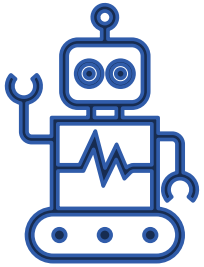


Reinforcement Learning (learning to act, not just predict; based on **feedback** or reward)



Generative AI (GenAI)

- ChatGPT
- Ollama



GenAI Benefits

- Potential for extracting meaningful insights from large text datasets

GenAI Benefits

- Potential for extracting meaningful insights from large text datasets

- Automating the categorization of lab reports, publications, or experimental results

GenAI Benefits

- Potential for extracting meaningful insights from large **text** datasets
- **Automating** the categorization of lab reports, publications, or experimental results
- Secret in giving the optimal "**prompt**": Crafting inputs to optimize GenAI outputs

GenAI in Our Lab

- Use of **GenAI** to analyze astronaut **tasks**

- ”Carry harvested plant material from greenhouse to surface habitat galley, manually while wearing EVA suit, to prepare for crew consumption”

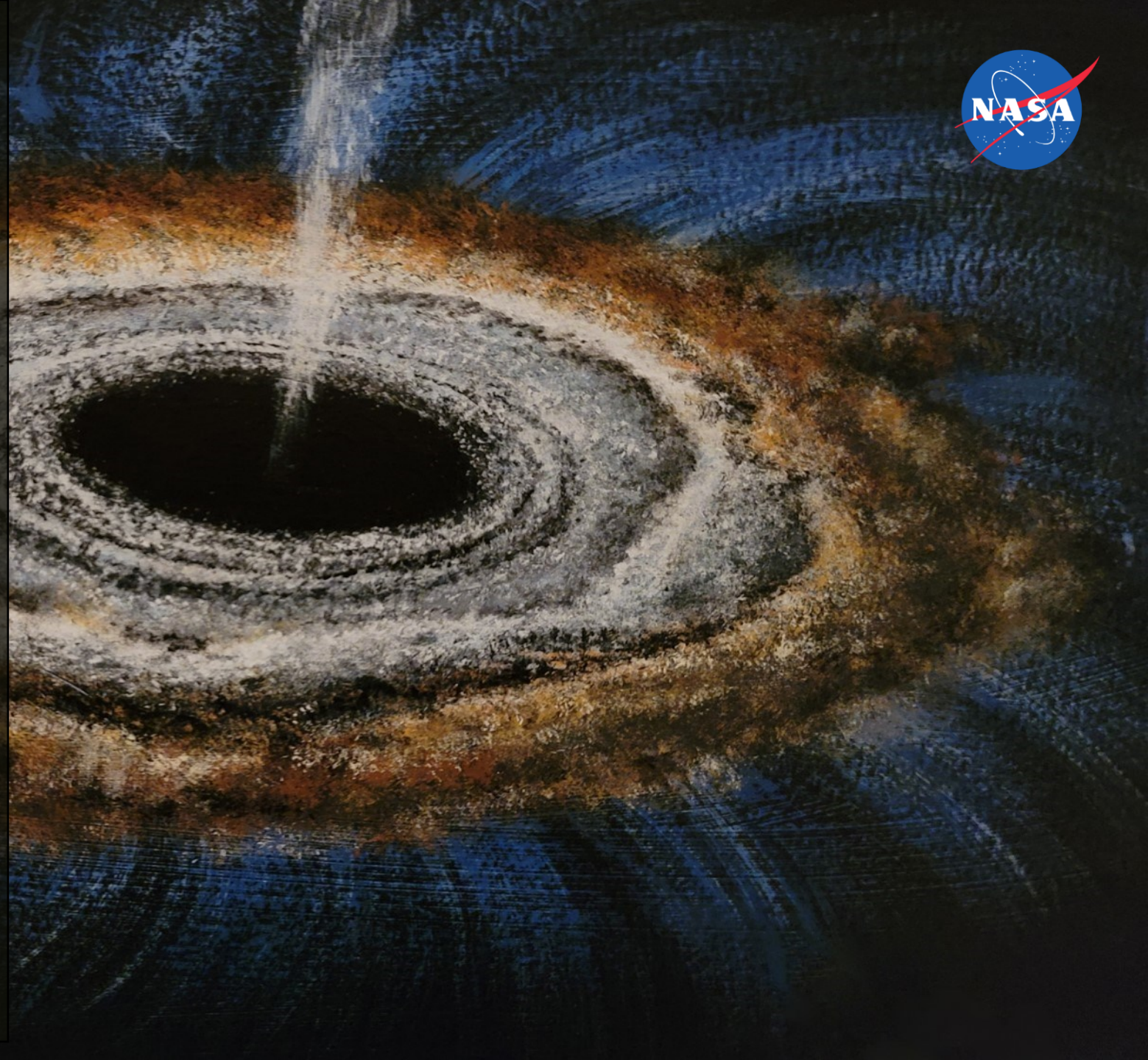


GenAI in Our Lab

- Use of **GenAI** to analyze astronaut **tasks**
- ”Carry harvested plant material from greenhouse to surface habitat galley, manually while wearing EVA suit, to prepare for crew consumption”
- Used **Ollama** to generate the involvement of the human systems in a task



Challenges with GenAI



Challenges/Ethical Considerations of GenAI

- **Bias:** May unintentionally learn and propagate biases from training data

Challenges/Ethical Considerations of GenAI

- **Bias:** May unintentionally learn and propagate biases from training data
- **Hallucination**: Can generate incorrect information

Challenges/Ethical Considerations of GenAI

- **Bias:** May unintentionally learn and propagate biases from training data
- **Hallucination**: Can generate incorrect information
- **Lack of Transparency:** backend process is opaque, difficult to explain outputs

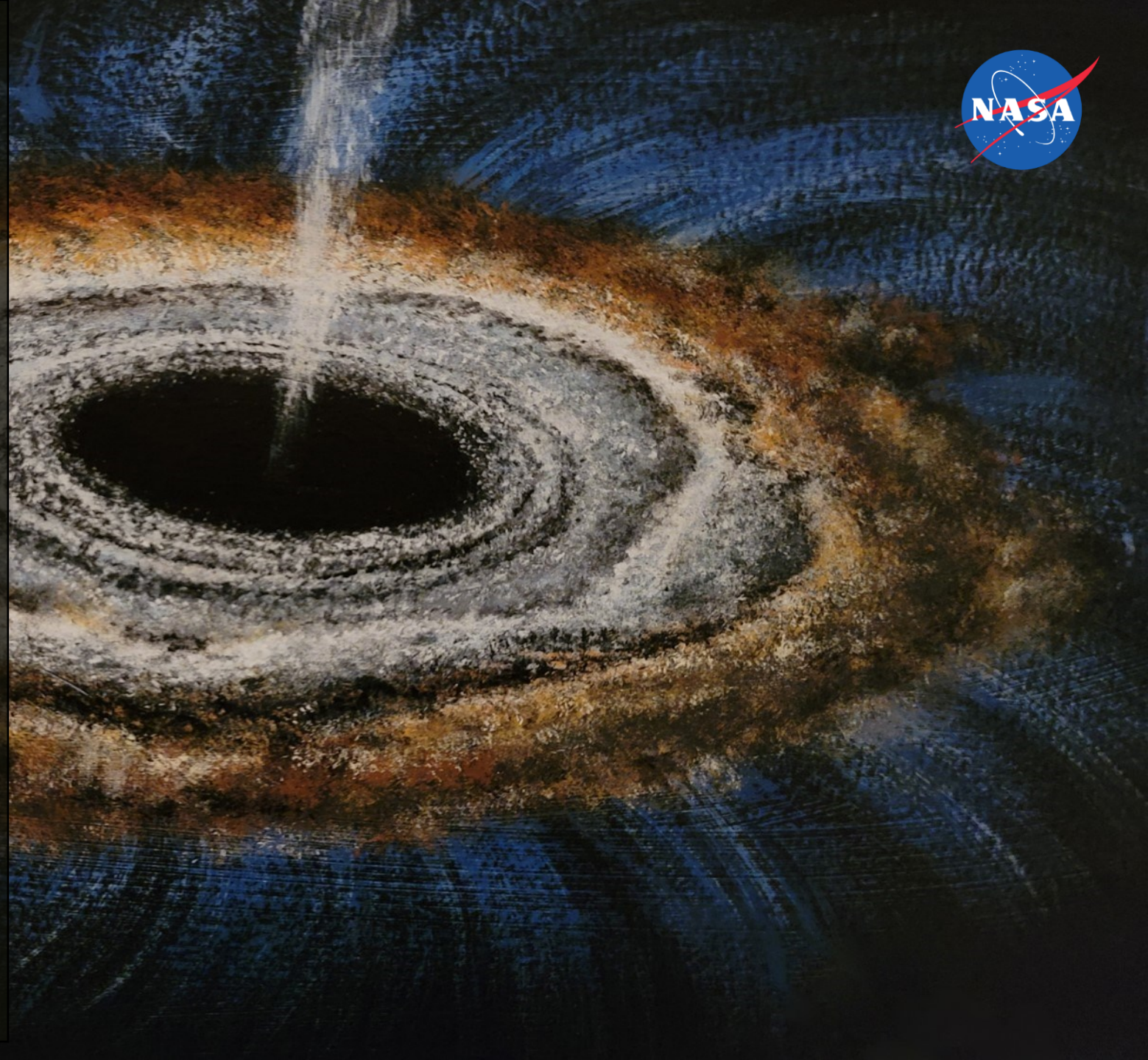
Challenges/Ethical Considerations of GenAI

- **Bias:** May unintentionally learn and propagate biases from training data
- **Hallucination**: Can generate incorrect information
- **Lack of Transparency:** backend process is opaque, difficult to explain outputs
- **Privacy** and **Security:** May rely on datasets with sensitive personal data

Challenges/Ethical Considerations of GenAI

- **Bias:** May unintentionally learn and propagate biases from training data
- **Hallucination**: Can generate incorrect information
- **Lack of Transparency:** backend process is opaque, difficult to explain outputs
- **Privacy** and **Security:** May rely on datasets with sensitive personal data
- Needs **regulation** and **compliance** as it grows

Starting with Python



Anaconda



Open Source

- Software openly available, for data visualization to robotics

User-friendly

- Easily search and install packages and create, load, and switch between environments

Trusted

- Tested and regularly updated

Anaconda

ANACONDA.
anaconda.com

Data Exploration & Transformation:

- NumPy
- Pandas
- Jupyter

Visualization:

- Matplotlib
- Seaborn
- Plotly

Statistics:

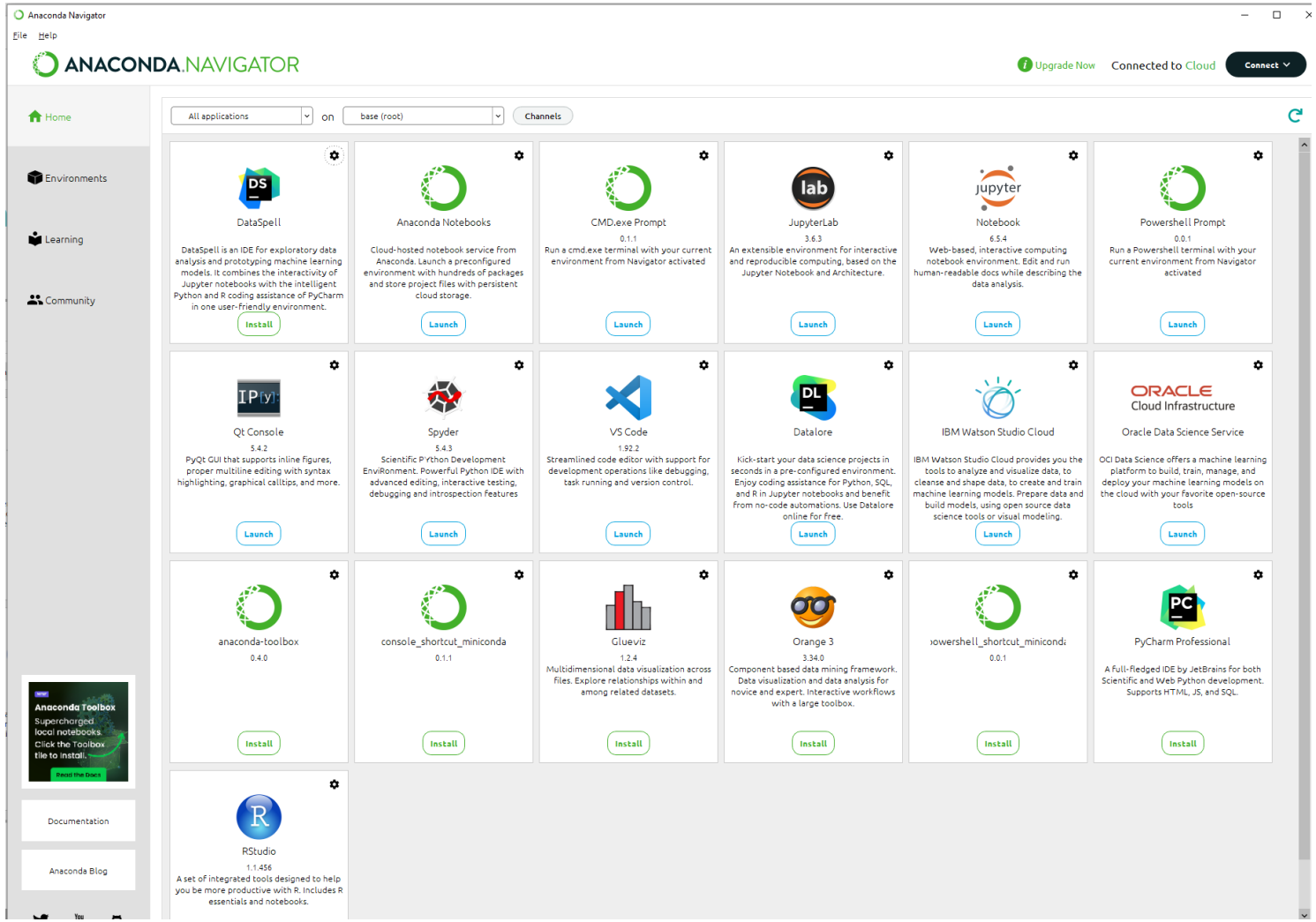
- Scipy

AI and ML

- scikit-learn
- TensorFlow
- Keras

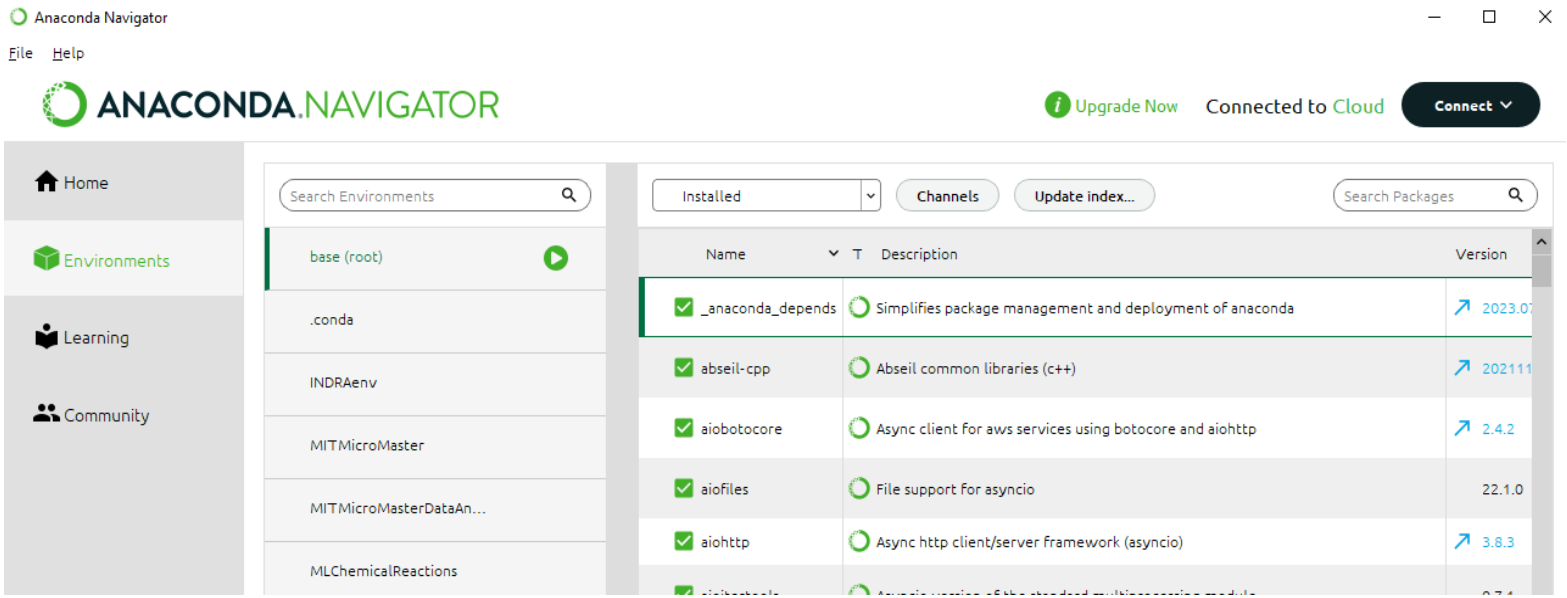
Anaconda Navigator

- Go to Anaconda Navigator
- “Home” tab



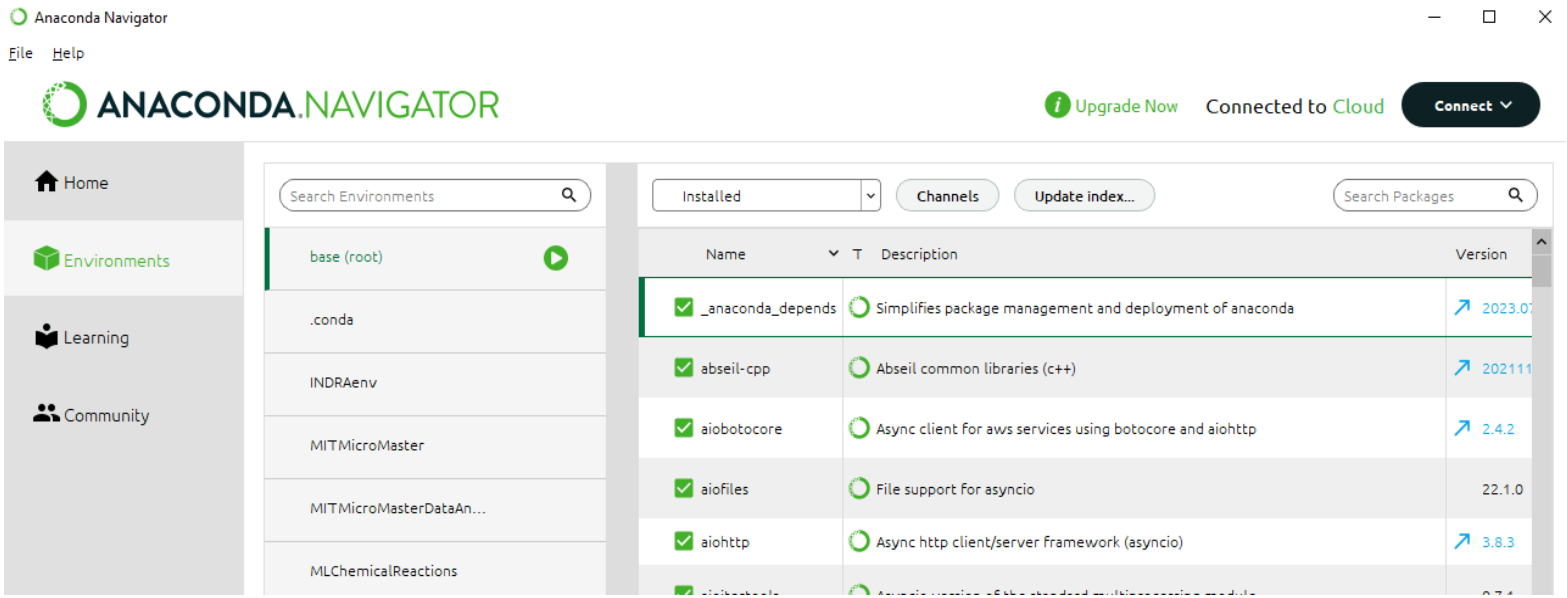
Python Packages

- Go to Anaconda Navigator
- Click “Environments” tab



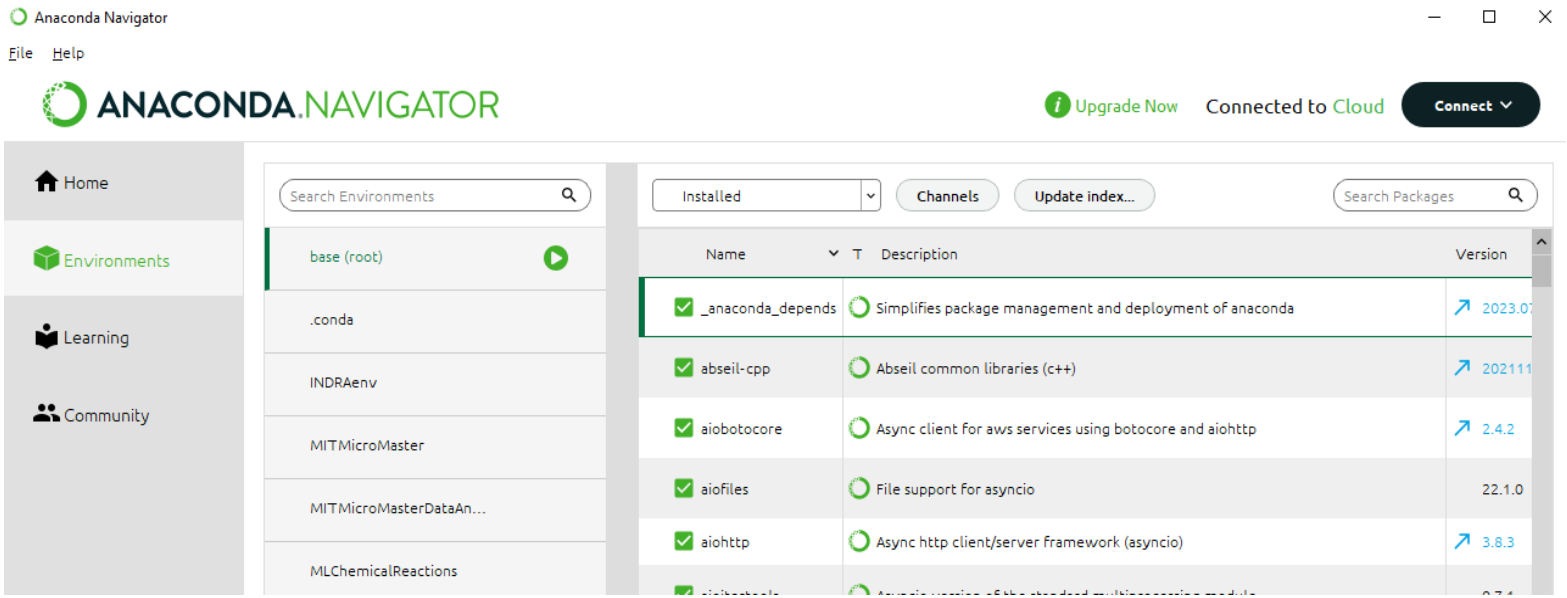
Python Packages

- Go to Anaconda Navigator
- Click “Environments” tab
- Check installed packages



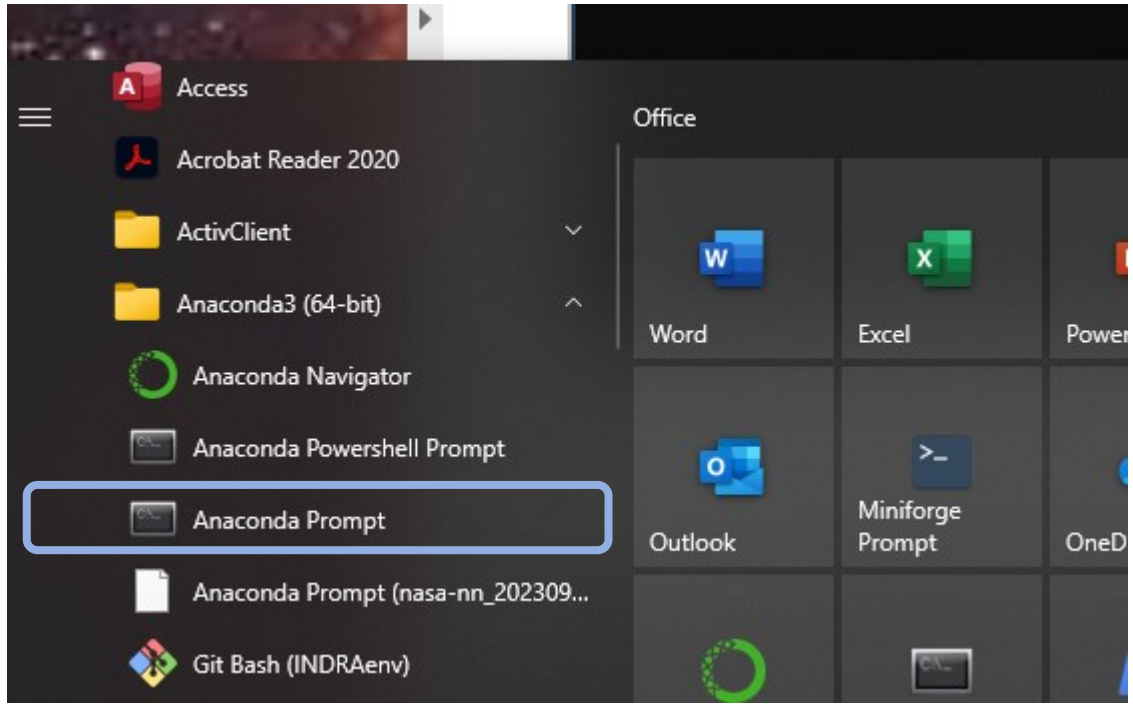
Python Packages

- Go to Anaconda Navigator
- Click “Environments” tab
- Check installed packages
- Some packages are downloadable from “Anaconda Navigator”



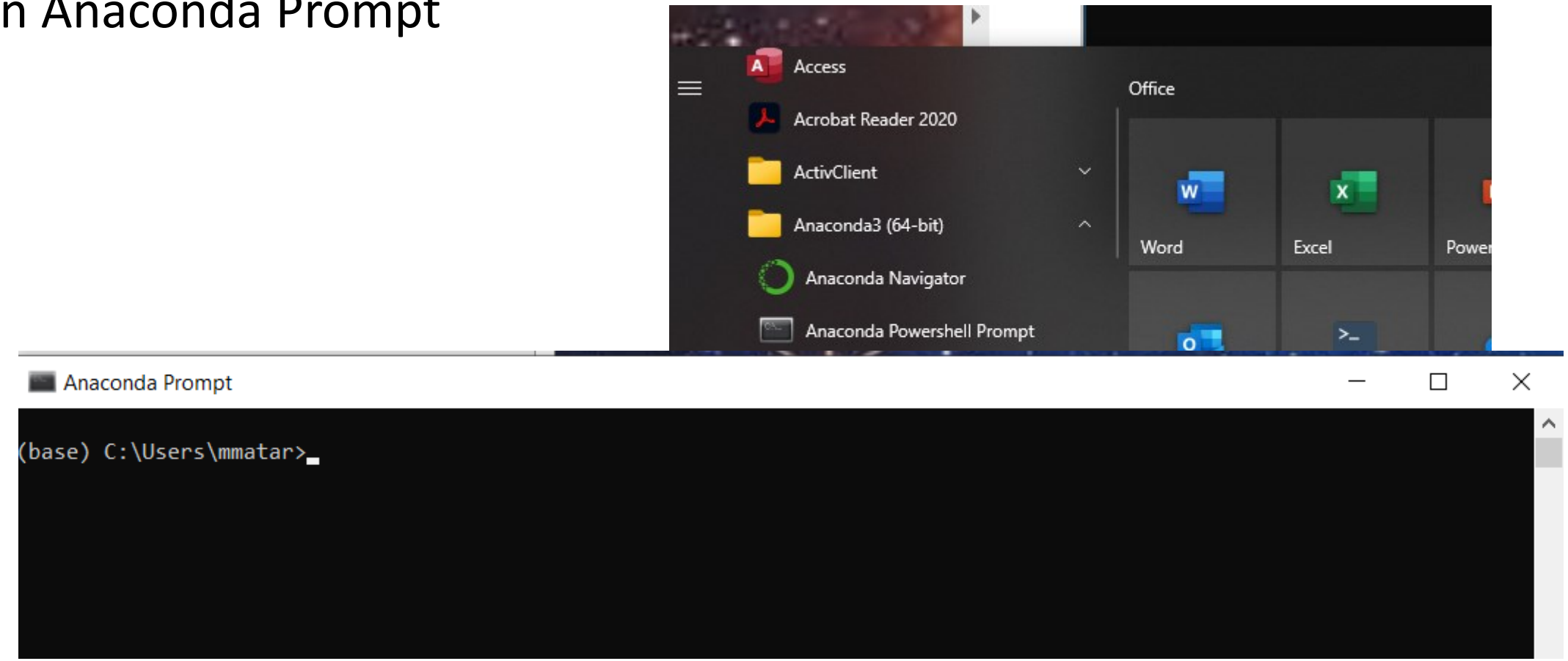
Python Packages

- Open Anaconda Prompt



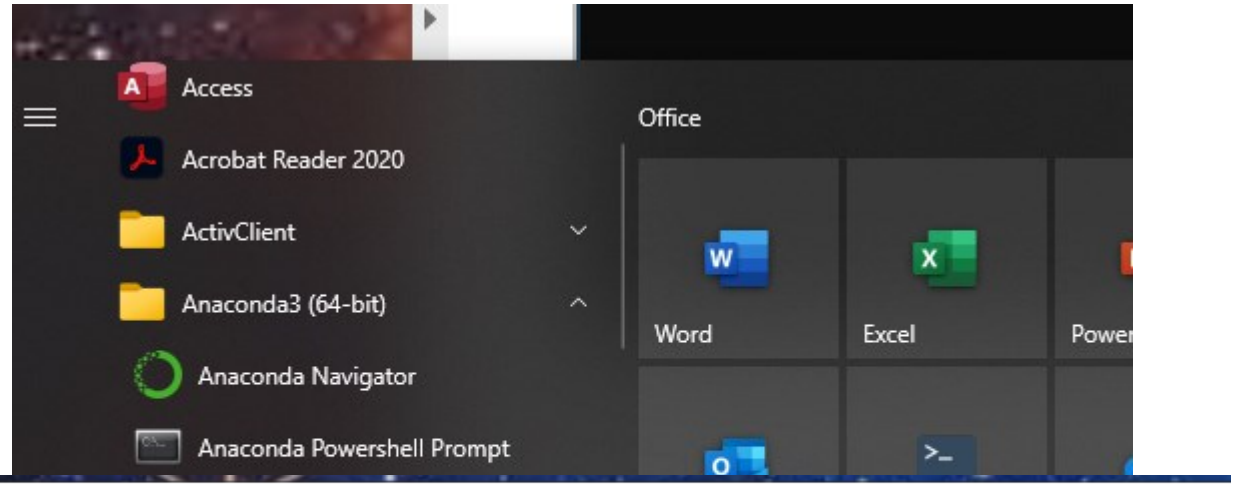
Python Packages

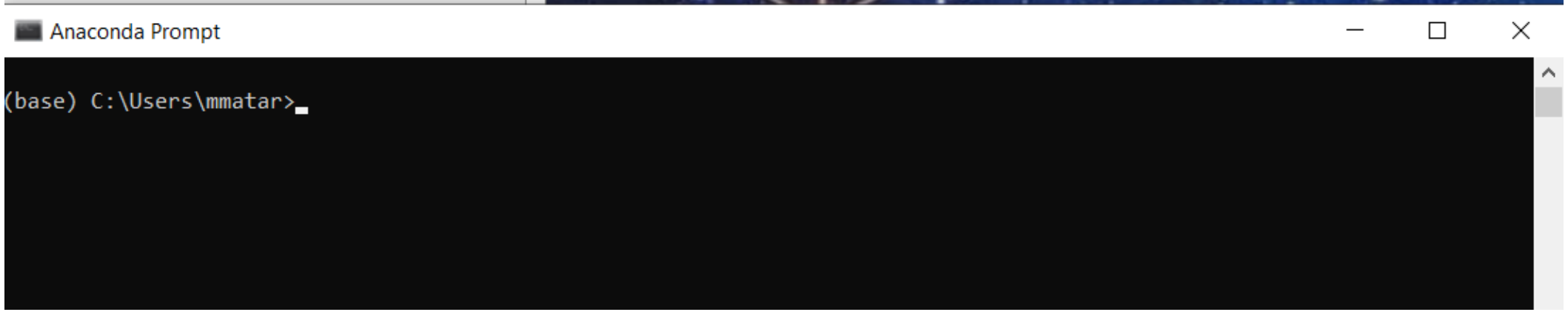
- Open Anaconda Prompt



Python Packages

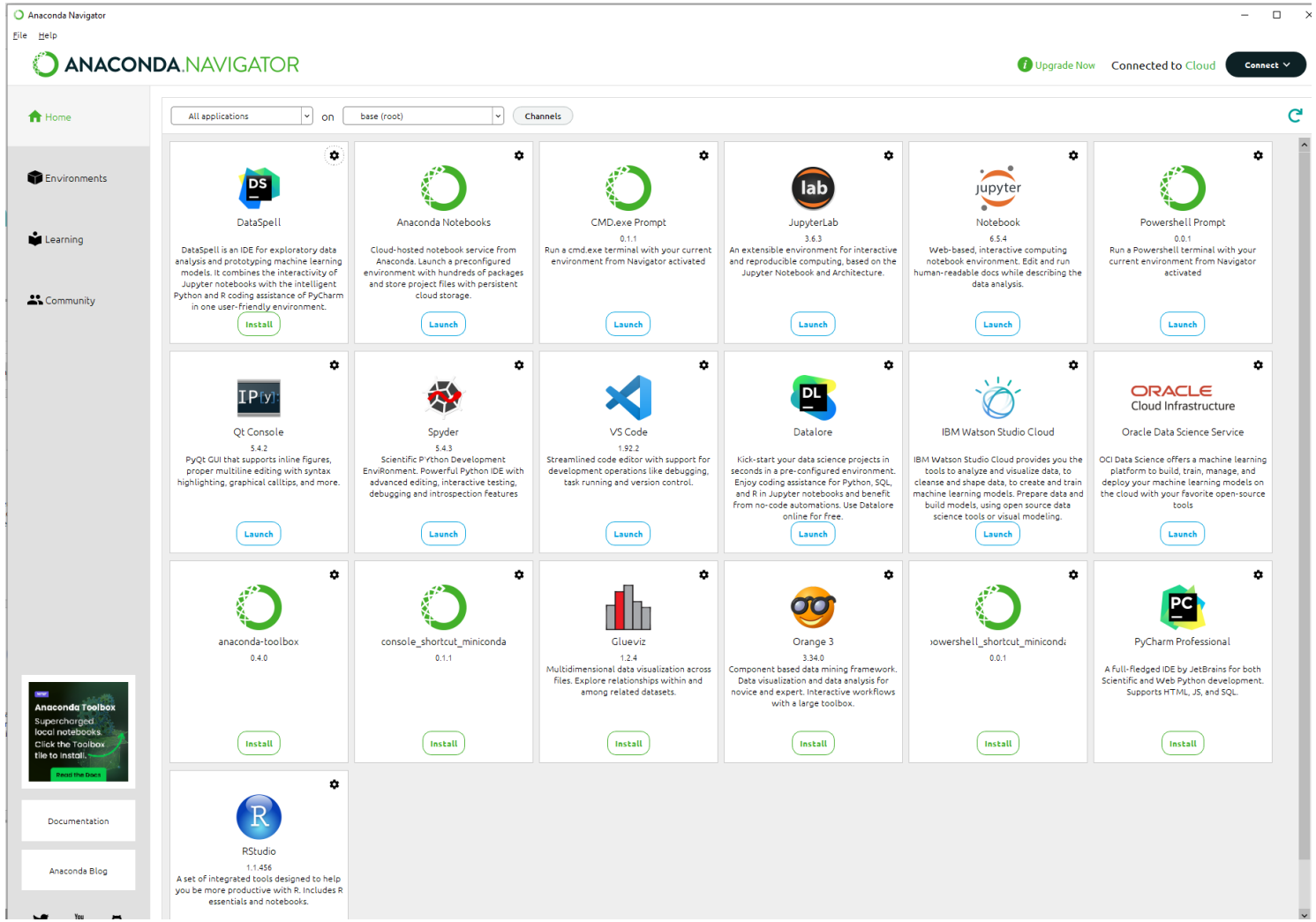
- Open Anaconda Prompt
- Command:
  pip install [package_name]





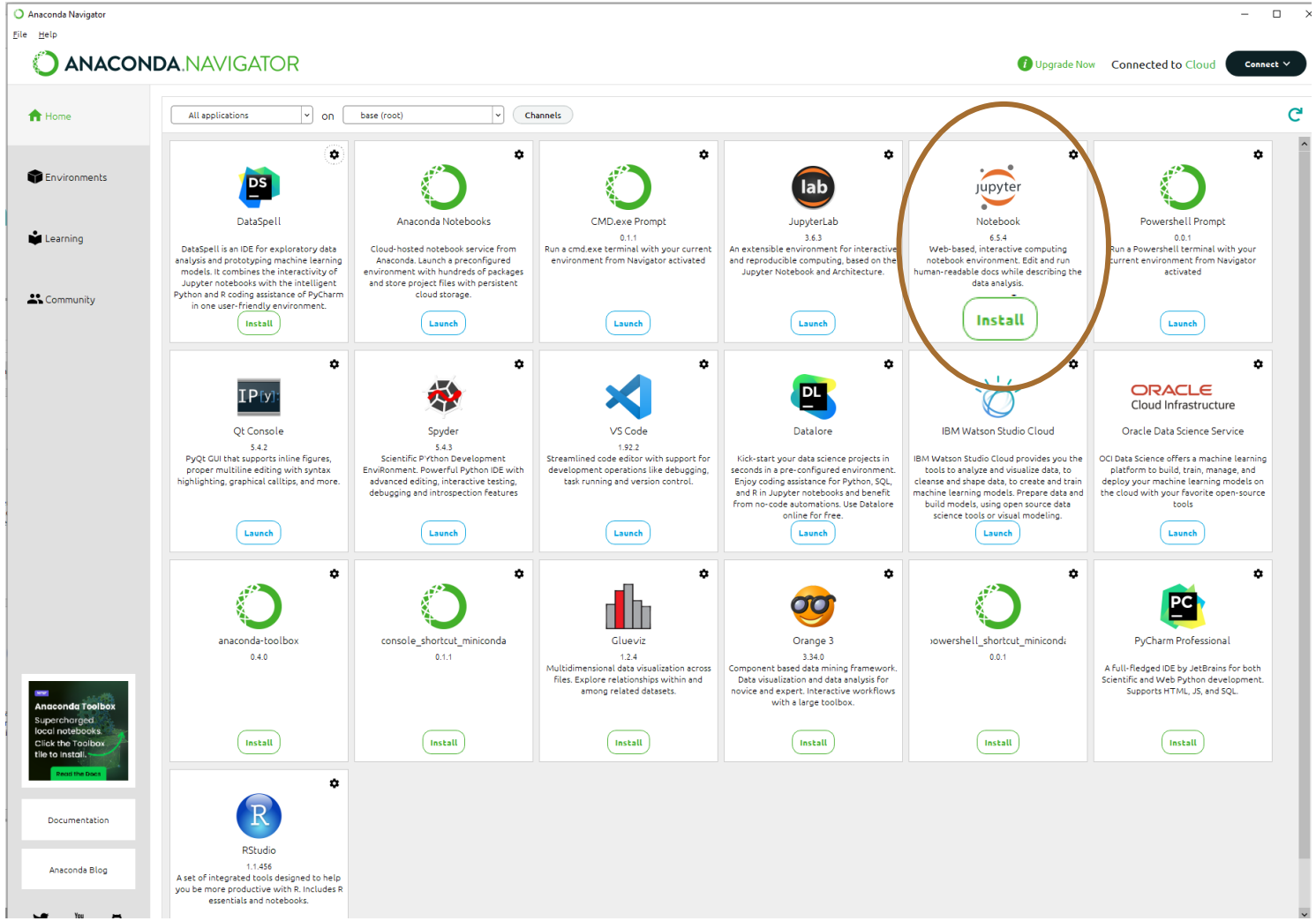
Jupyter Notebook

- Go back to Anaconda Navigator
- “Home” tab



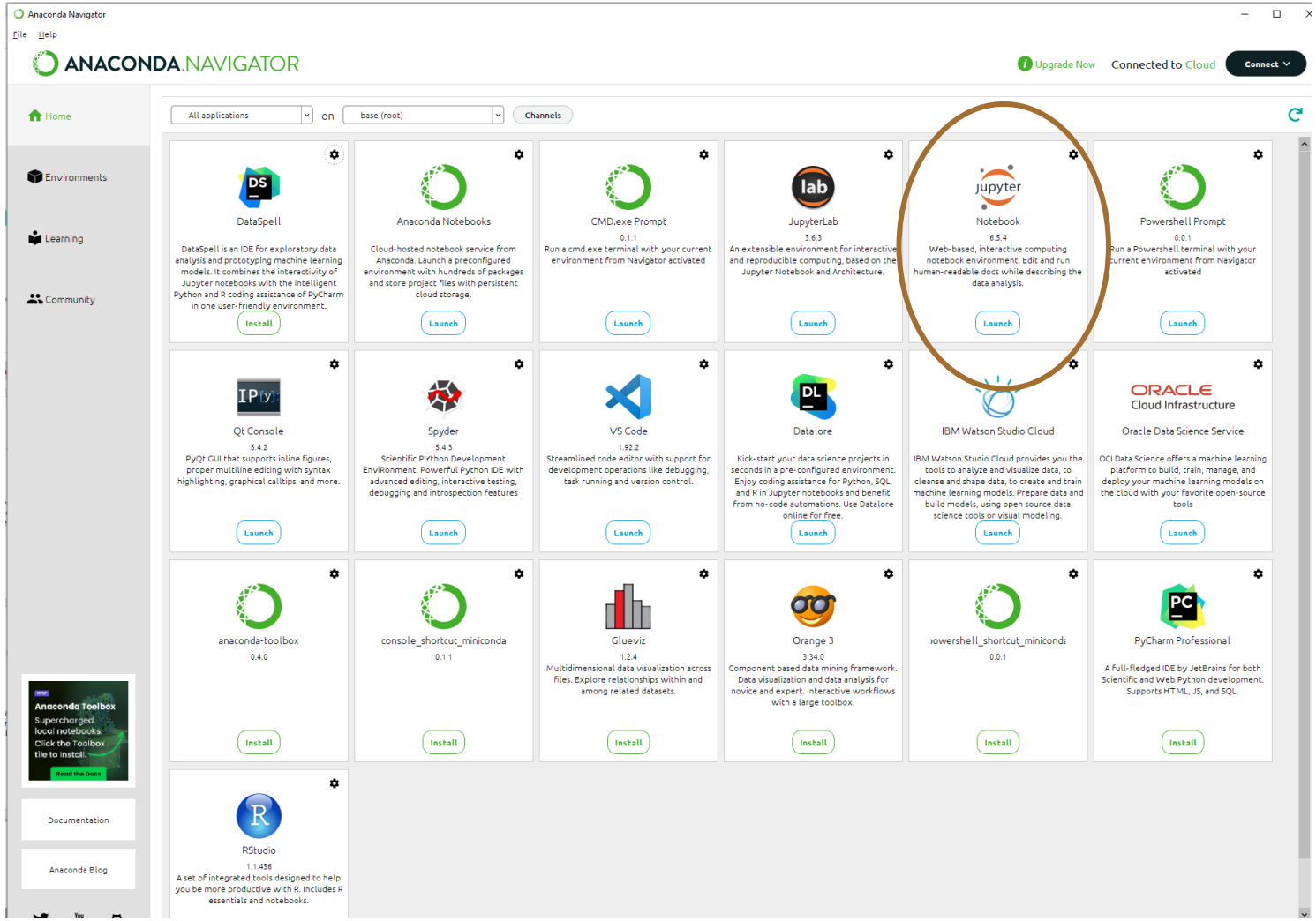
Jupyter Notebook

- Go back to Anaconda Navigator
- If Jupyter Notebook is not installed, click “Install”



Jupyter Notebook

- Go back to Anaconda Navigator
- If Jupyter Notebook is not installed, click “Install”
- Click “Launch”



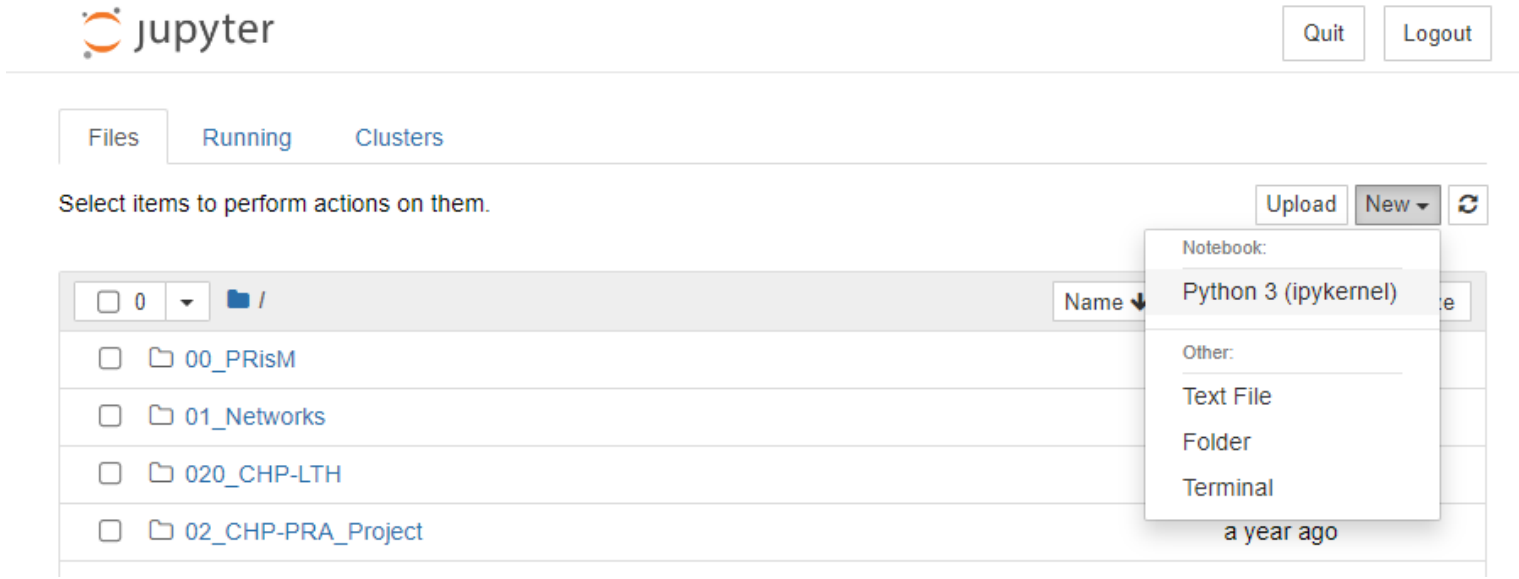
Jupyter Notebook

- A browser window opens



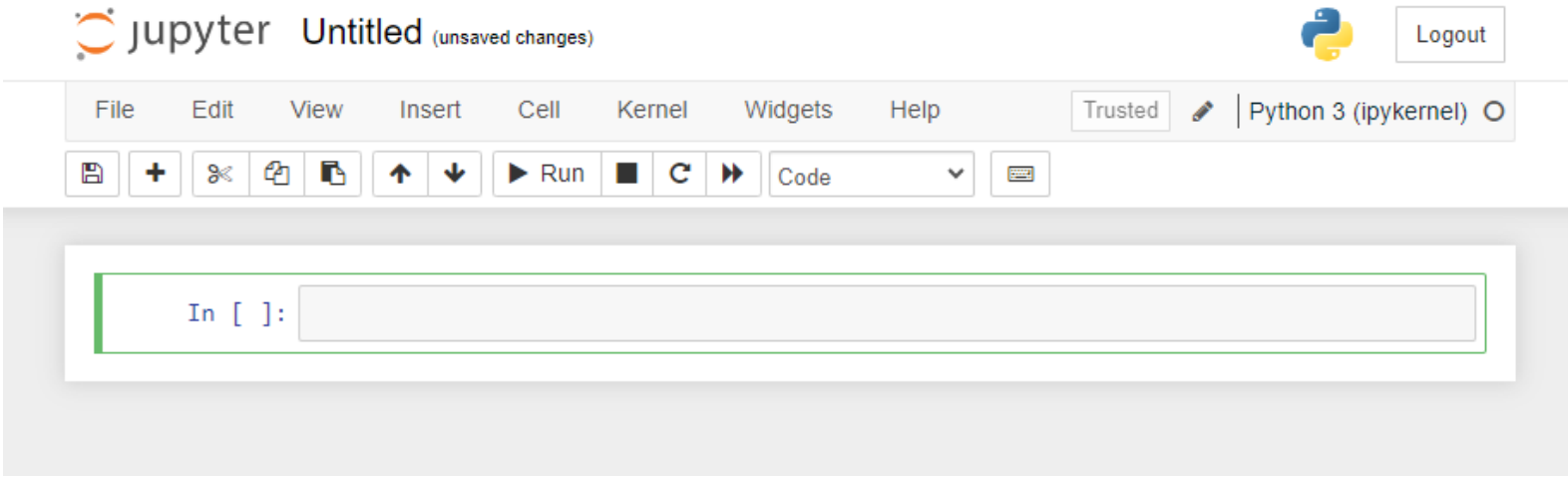
Jupyter Notebook

- A browser window opens
- Press “New” and choose “Python 3”



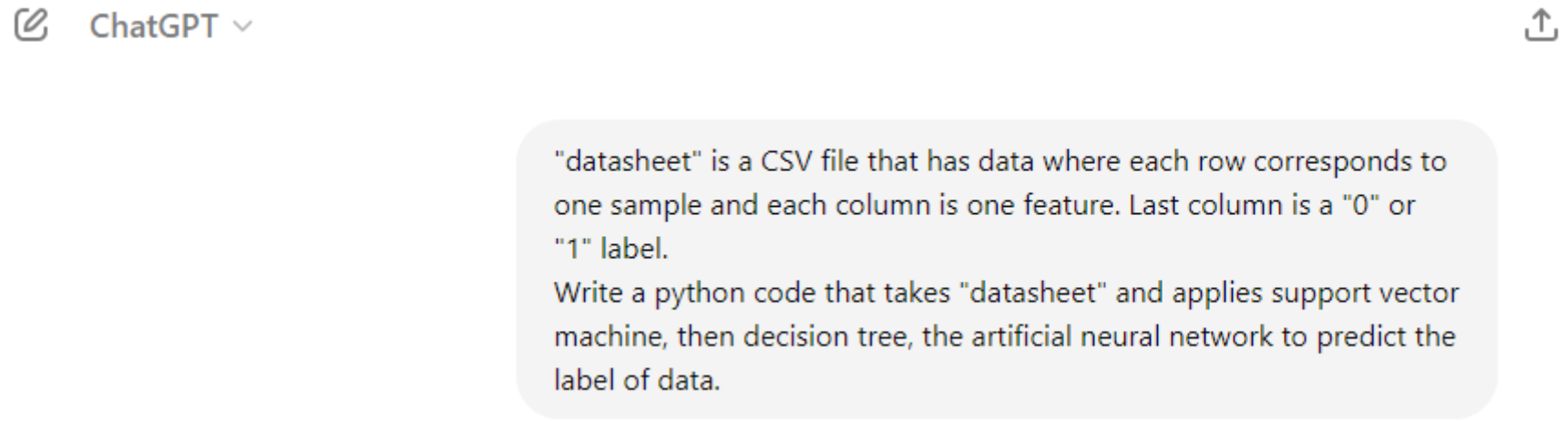
Jupyter Notebook

- A browser window opens
- Press “New” and choose “Python 3”
- A new script opens



ChatGPT

- A simple way to start your machine learning code as a beginner:
  - Ask ChatGPT
  - **Caution:** Do not input any data or information related to your project to prevent breech

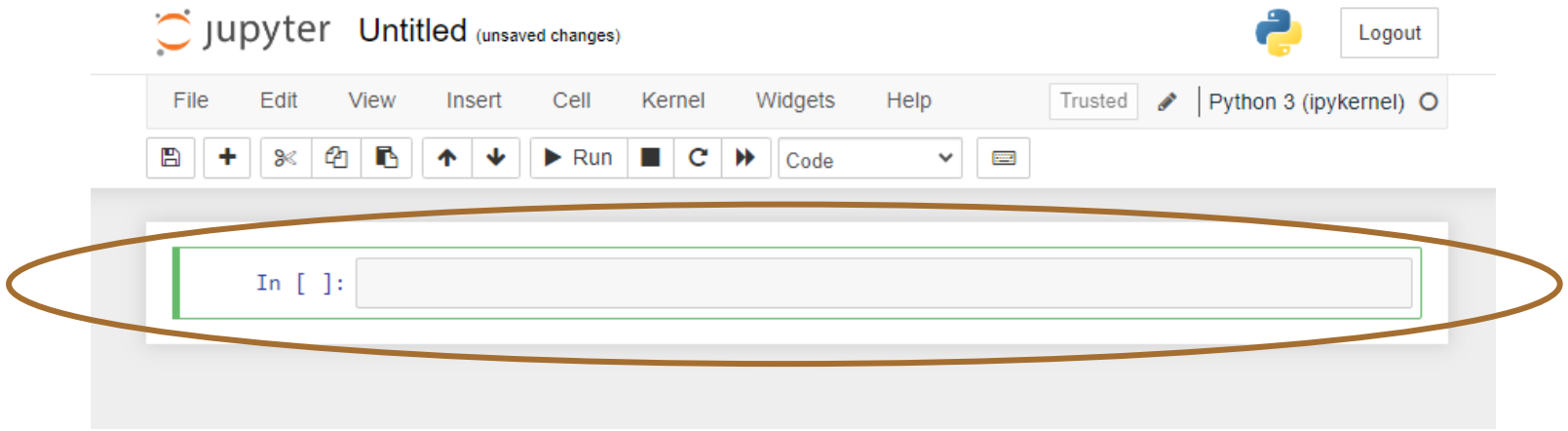


ChatGPT

- ChatGPT will give you a script with all python packages necessary

ChatGPT

- ChatGPT will give you a script with all python packages necessary
- You can put all the code in one Jupyter Notebook cell



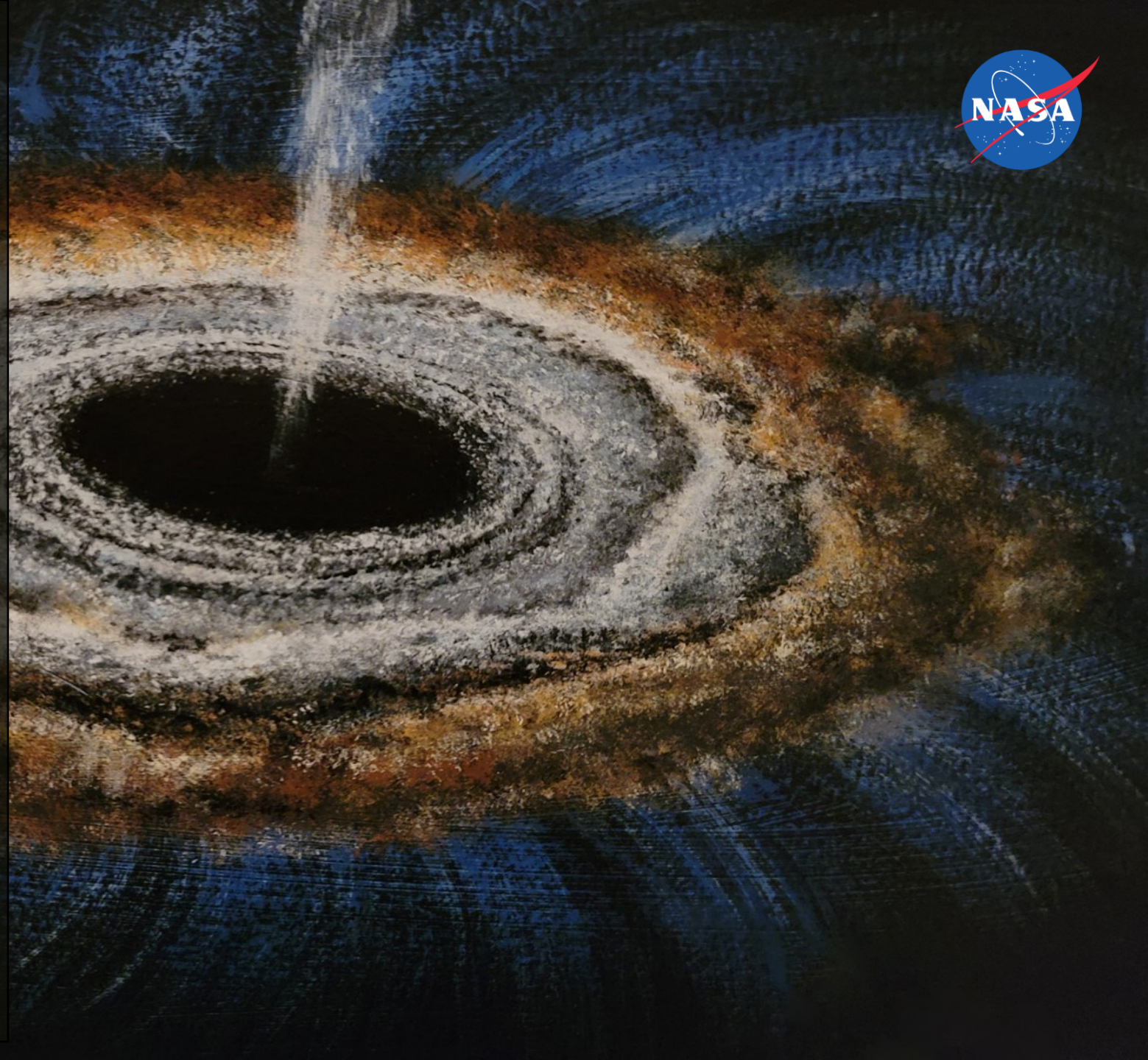
ChatGPT

- Or you want to be fancier and split the code into cells. All you have to do is ask

write it suitable for jupyter notebook

- ChatGPT gives the code split to be entered in multiple cells

Takeaways



Takeaways

AI/ML/GenAI help with

- **Efficiency:** Automates repetitive tasks, saving time and reducing human error
- **Scalability:** Processes vast amounts of data at scale, improving decision-making
- **Personalization:** Enhances customer experience by tailoring products and services
- **Innovation:** Enables discovery of new insights and novel solutions in various industries

You Can Start in Your Lab

- Organize and **clean** your data

You Can Start in Your Lab

- Organize and **clean** your data
- Streamline analysis **workflow** with code

You Can Start in Your Lab

- Organize and **clean** your data
- Streamline analysis **workflow** with code
- Harness **ML** models for insightful predictions

You Can Start in Your Lab

- Organize and **clean** your data
- Streamline analysis **workflow** with code
- Harness **ML** models for insightful predictions
- Establish robust **validation** methods

You Can Start in Your Lab

- Organize and **clean** your data
- Streamline analysis **workflow** with code
- Harness **ML** models for insightful predictions
- Establish robust **validation** methods
- Engage with **AI specialists**

You Can Start in Your Lab

- Organize and **clean** your data
- Streamline analysis **workflow** with code
- Harness **ML** models for insightful predictions
- Establish robust **validation** methods
- Engage with **AI specialists**
- Prioritize **data quality** and integrity

Additional Resources

Tutorials for Beginners

- AI for Beginners
  https://microsoft.github.io/AI-For-Beginners/
- Artificial Intelligence Tutorial for Beginners
  https://www.guru99.com/ai-tutorial.html
- Top Artificial Intelligence Courses for Beginners – Coursera
  https://www.coursera.org/courses?query=artificial%20intelligence&productDifficultyLevel=Beginner
- How to Learn Artificial Intelligence: A Beginner's Guide - Coursera
  https://www.coursera.org/articles/how-to-learn-artificial-intelligence
- 10 Best Free AI & Machine Learning Courses For Beginners
  https://www.scriptbyai.com/best-free-beginner-courses/

Thank You

mona.matar@nasa.gov

