**DATES**

2nd, 3rd, 5th, and 9th of September 2024.

**ASSEGNISTA**

Verónica Henao Isaza

**SEMINAR**

First Seminar

# Python Machine Learning Techniques for Classifying Patients with Neurodegenerative Disorders and Controls based on EEG, MRI, and Clinical Markers

4 Hands-on Seminars:

SAPIENZA
UNIVERSITÀ DI ROMA

# Table of Contents

# I Self-Introduction & Motivation

I Self-Introduction & Motivation

# Verónica Henao Isaza

MSc in engineering, Date: Dec 15, 2023
Bioengineering, Date: Sept 11, 2020

Age: 29
Colombian

I would like to pursue a career in research and development, focusing on creating innovative solutions for applied engineering within academic health centers.

## ACADEMIC WORK EXPERIENCE

Approx. 2 years (27 months) of academic experience to date.

**Sapienza Università di Roma, Italy, Research Fellow (2024)**
**Universidad de Antioquia, Lecturer (2023)**
**Sapienza Università di Roma, Italy, Internship (2022)**
**Universidad de Antioquia, Instructor student (2021-2022)**

## INDUSTRY WORK EXPERIENCE

Approx. 2 years (27 months) of industry experience to date

**Gropius Innovación S.A.S, Director of innovation and development (2020-2022)**
**Meridiano S.A.S, Technical advisor in the development of medical devices (2020)**

# I Self-Introduction & Motivation

## EXPLORING THE VISUAL CORTEX (PORTABLE DEVICES)

### SSVEP study in monocular and binocular vision

Daniela Ortega, Verónica Henao Isaza, and John Ochoa-Gómez

### Captura y análisis de potenciales visuales en estado estacionario usando tecnología portable y de bajo costo

Valeria Cadavid, Eliana Salas, Santiago González,Verónica Henao Isaza, and John Ochoa-Gómez

### Development of a tool for the acquisition of SSVEP using portable and low-cost electroencephalography

Verónica Henao Isaza, Eliana Salas, Valeria Cadavid, and John Ochoa-Gómez

### Unveiling Visual Physiology and Steady-State Evoked Potentials using Low-Cost and Transferable Electroencephalography for Evaluating Neuronal Activation

Verónica Henao Isaza, Valeria Cadavid, Eliana Salas, Santiago González, and John Ochoa-Gómez

# I Self-Introduction & Motivation

## ALZHEIMER'S AND PARKINSON'S DISEASE RISK

### Spectral features of resting-state EEG in Parkinson's Disease: A multicenter study using functional data analysis

Alberto Jaramillo-Jimenez; Verónica Henao Isaza; Valeria Cadavid Castro; Yorguin-Jose Mantilla-Ramos; John Fredy Ochoa Gómez; ...

CLINICAL NEUROPHYSIOLOGY
OFFICIAL JOURNAL OF THE INTERNATIONAL FEDERATION OF CLINICAL NEUROPHYSIOLOGY

### Tackling EEG test-retest reliability with a pre-processing pipeline based on ICA and wavelet-ICA

Verónica Henao Isaza; Valeria Cadavid Castro; Luisa María Zapata Saldarriaga; Yorguin-Jose Mantilla-Ramos; Jazmin Ximena Suarez Revelo; Carlos Andrés Tobón Quintero; John Fredy Ochoa Gómez.

Biomedical Signal Processing and Control

Preprint – In Review

### Reproducible Neuronal Components found using Group Independent Component Analysis in Resting State Electroencephalographic Data

Ochoa-Gómez, J. F., Mantilla-Ramos, Y. J., Isaza, V. H., Tobón, C. A., Lopera, F., Aguillón, D., & Suárez, J. X.

Brain Topography
A Journal of Cerebral Function and Dynamics

Preprint – In Review

### Comprehensive Methodology for Sample Augmentation in EEG Biomarker Studies for Alzheimer's Risk Classification

Verónica, Henao Isaza; David, Aguillon; Carlos Andrés, Tobón Quintero; Francisco, Lopera; John Fredy, Ochoa Gómez.

JOURNAL OF NEURAL ENGINEERING

Unsent – In Review

# II Objectives

## II Objectives

1. **Introduction and Application of Basic Machine Learning Techniques** for Neuropsychological and Neurophysiological Data Classification

2. **Optimization and Validation of Machine Learning Models** for Classification and Predicting Cognitive Markers

3. **Analysis and Visualization of Machine Learning Results** for the Association Between Telemonitoring Markers and Clinical Data

# III Methodology

# III Methodology

**4 Hands-on Seminars:**
**Python Machine Learning Techniques for Classifying Patients with Neurodegenerative Disorders and Controls based on EEG, MRI, and Clinical Markers**

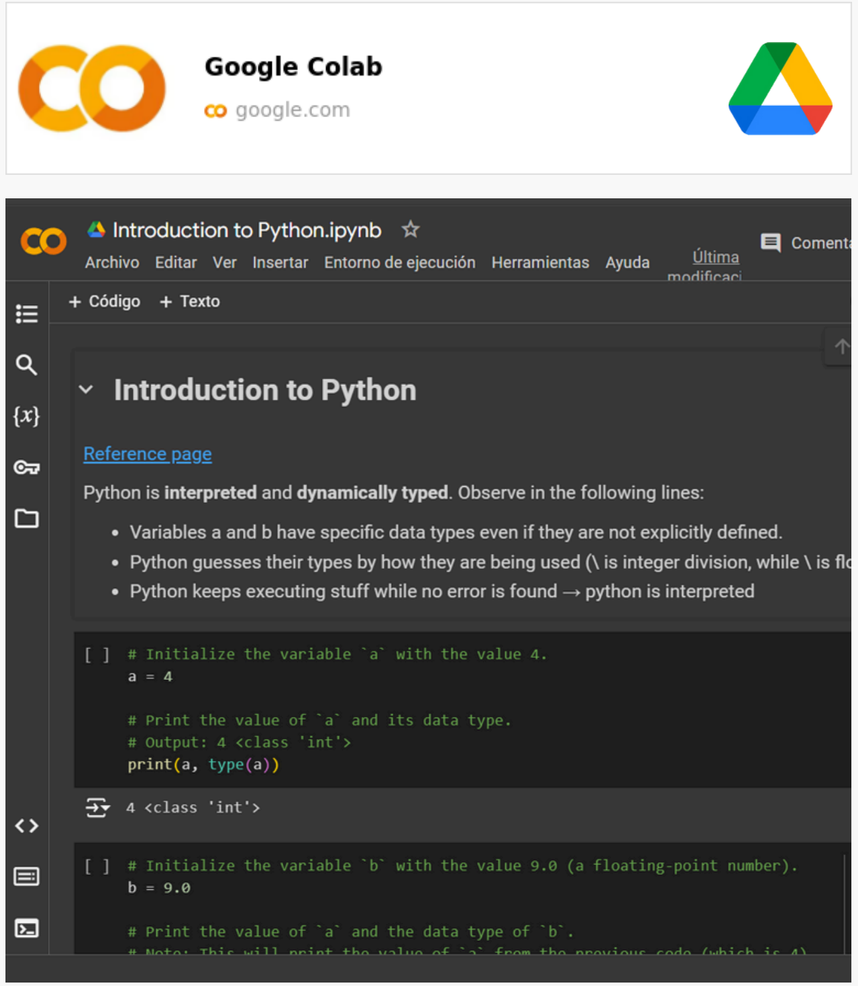
**Responsible**

Verónica Henao Isaza,
MSc in engineering, BSc Bioengineering
Emphasis on Neurosciences
Grupo Neuropsicología y Conducta GRUNECO
Universidad de Antioquia
Medellín, Colombia.

Related Project (Thesis):
Machine Learning model for the classification of individuals at risk of Alzheimer's dementia from multimodal databases of EEG and clinical information.

https://veronicahenaoisaza.my.canva.site/

Seminar Guide


Workshops on web-based interactive computing platform

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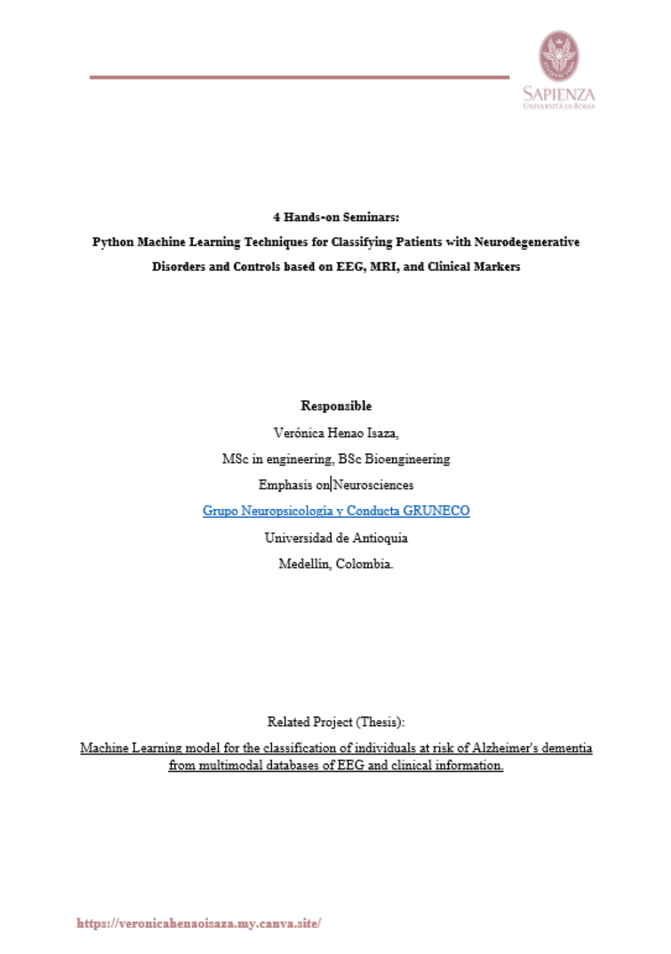
# III Methodology



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Seminar Guide

**Concepts**

**Examples**

**Types of AI**

**Workshops**

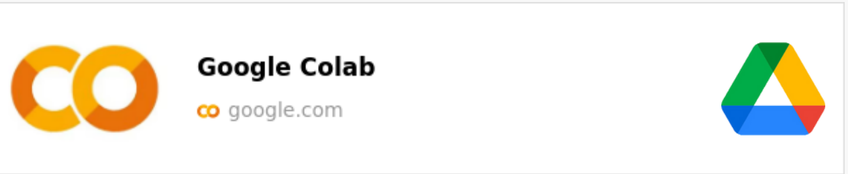
**Results**

**Final activity**

# III Methodology

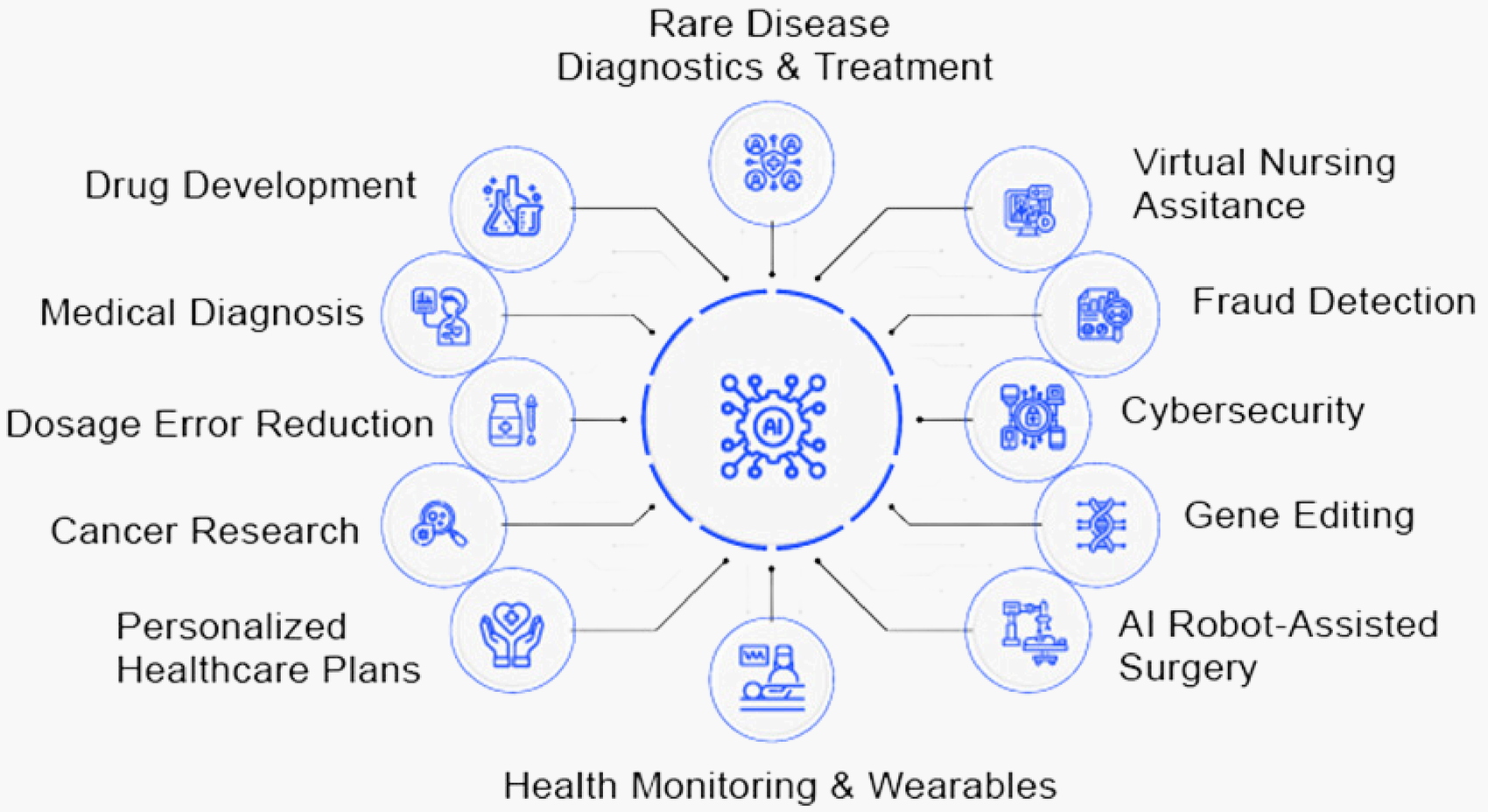

GitHub is a web-based platform that allows developers to store, share, and collaborate on code projects. It's built around Git, a version control system that tracks changes in code over time.

Google Colab is a cloud-based development environment that allows users to write and run Python code directly in their web browser. It's popular for data science, machine learning, and data analysis projects, offering free access to powerful computational resources like GPUs and TPUs.

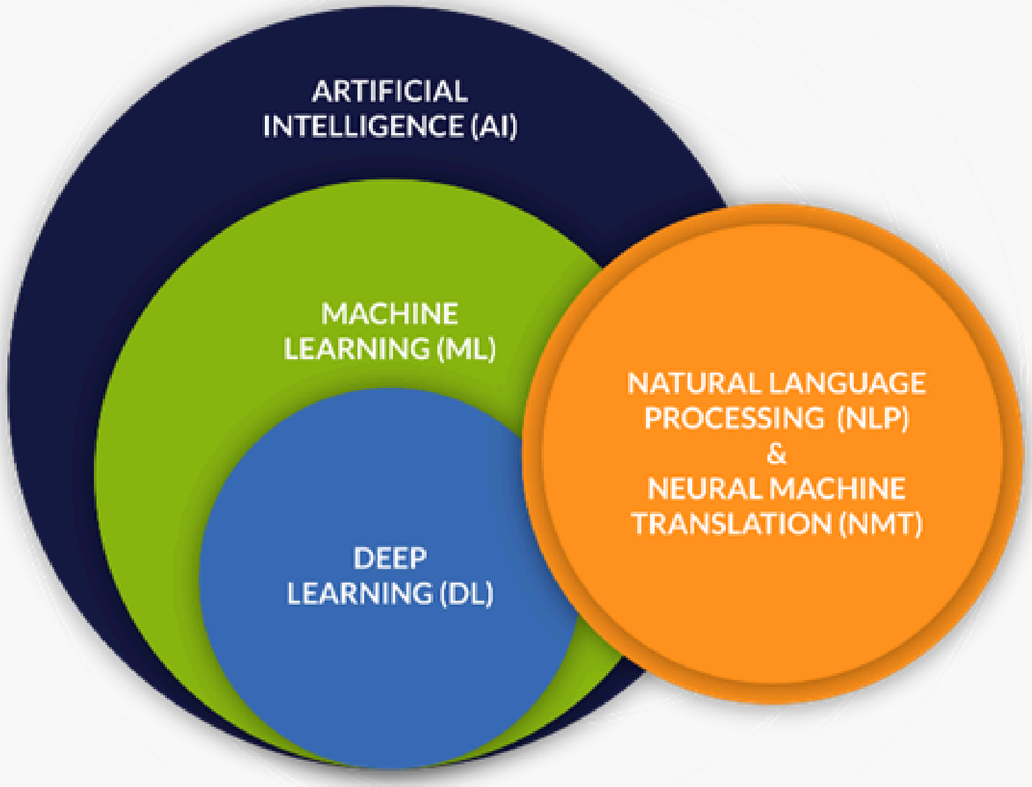


# IV Concepts

# Applications of AI in Healthcare



# Types of AI in health care




**Linear Models**

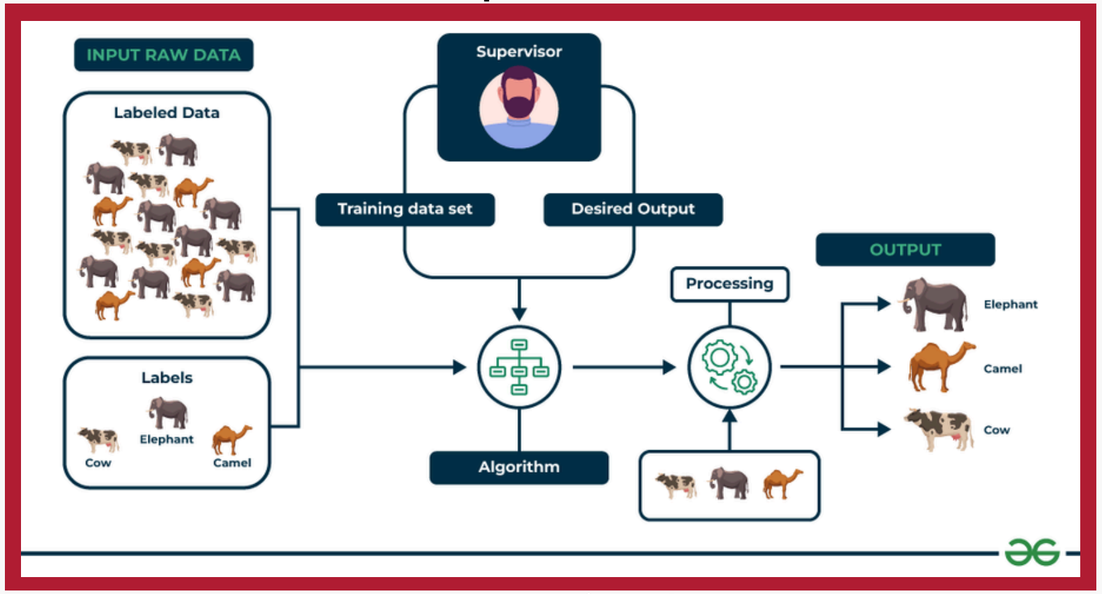
- Logistic Regression
- SupportVectorMachines (SVM)

**Non-Linear Models**

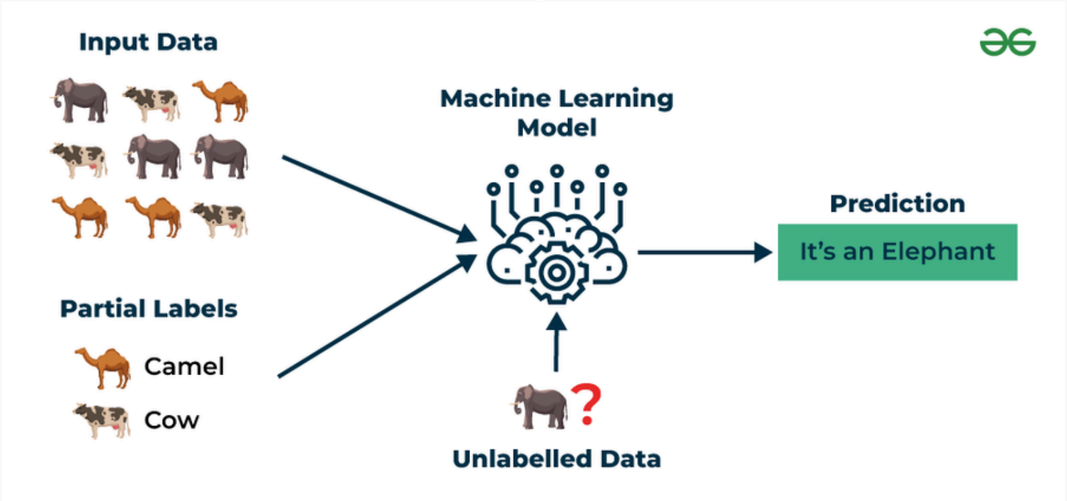
- k-Nearest Neighbors
- Kernel SVM
- Bayesian Classification
- Decision Trees
- RandomForestClassification

# Machine Learning

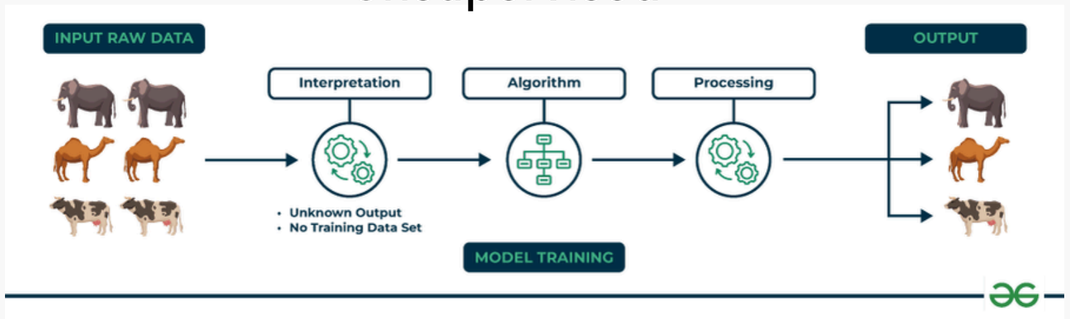
## Supervised



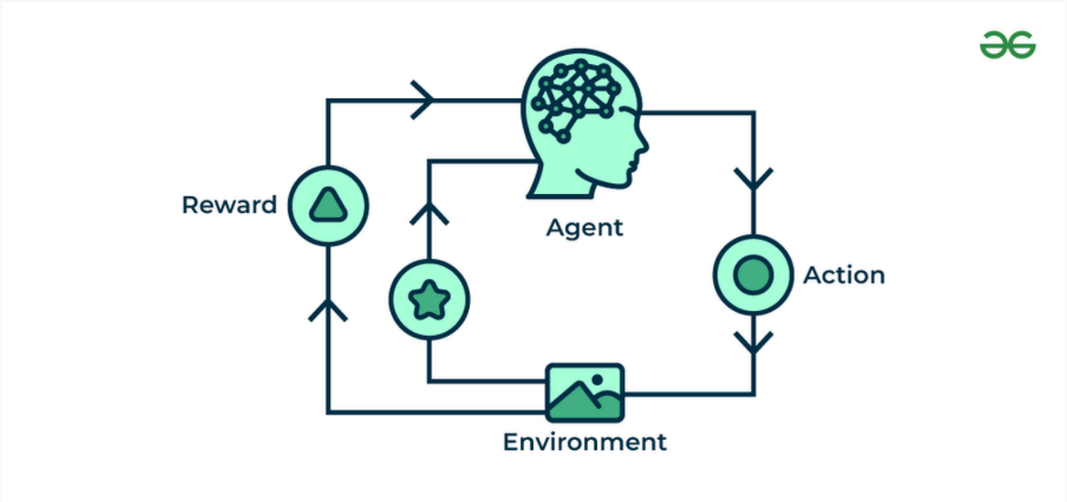

## Semi-Supervised




## Unsupervised




## Reinforcement



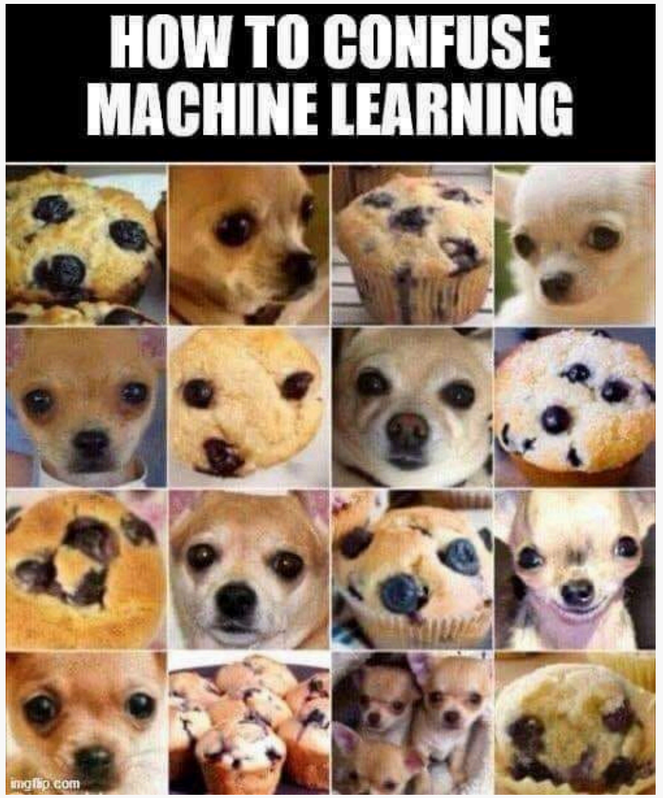

https://www.geeksforgeeks.org/types-of-machine-learning/

# Importance of data quality

| | | Actual Values: Positive (1) | Actual Values: Negative (0) |
|---|---|---|---|
| Predicted Values | Positive (1) | TP | FP |
| | Negative (0) | FN | TN |

Performance, overfitting, generalization, evaluation.

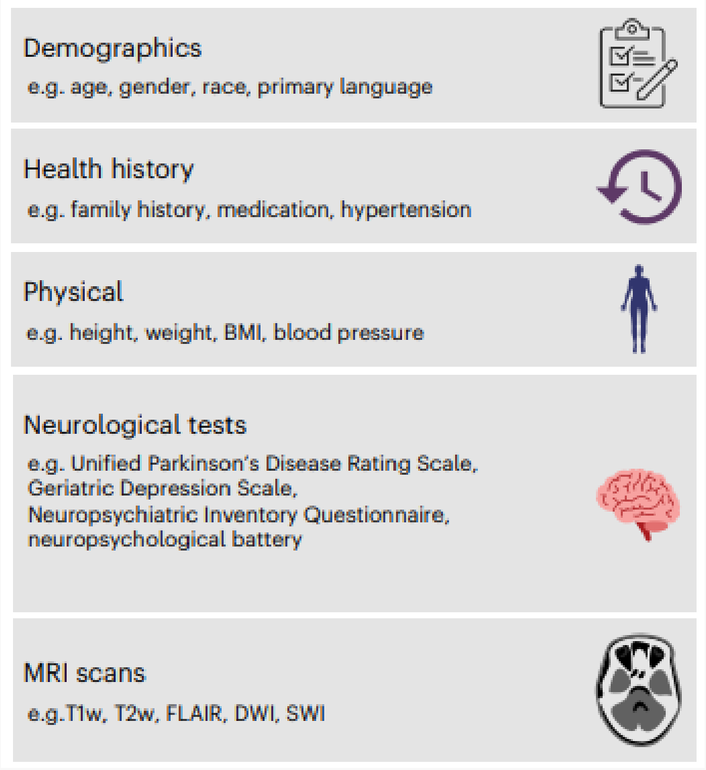
20-80
30-70

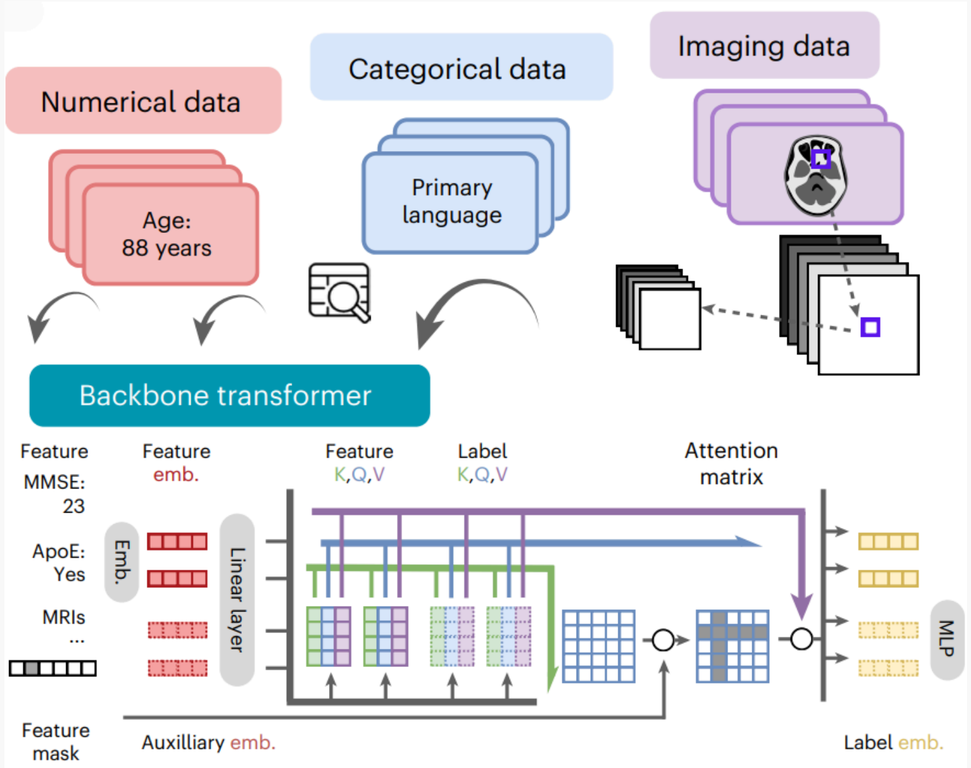


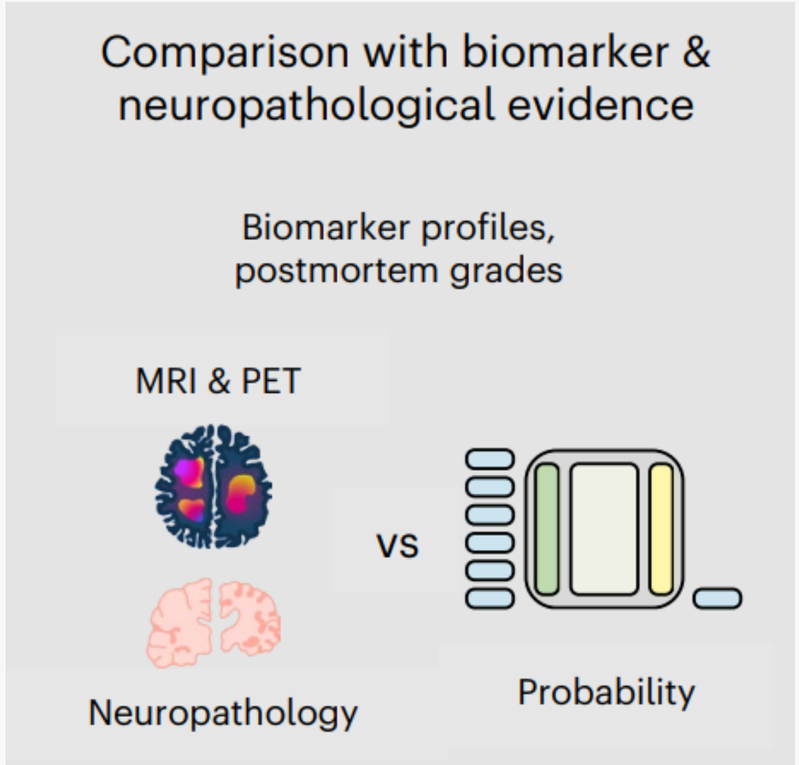

Adversarial Examples, Data Poisoning,
Bias and Imbalanced Data,
Limited Training Data

# V Relevance in Neurosciences

# Relevance in Neurosciences



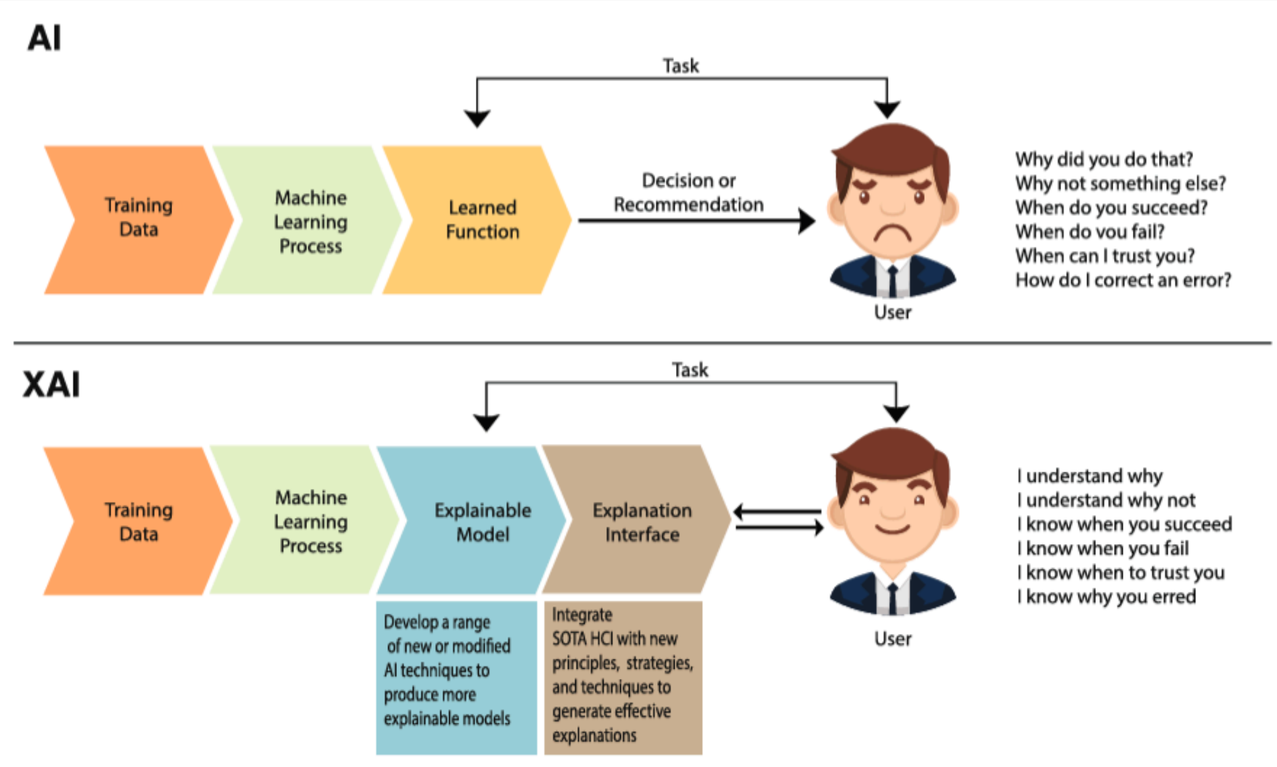




Xue, C., Kowshik, S.S., Lteif, D. et al. AI-based differential diagnosis of dementia etiologies on multimodal data. Nat Med (2024). https://doi.org/10.1038/s41591-024-03118-z

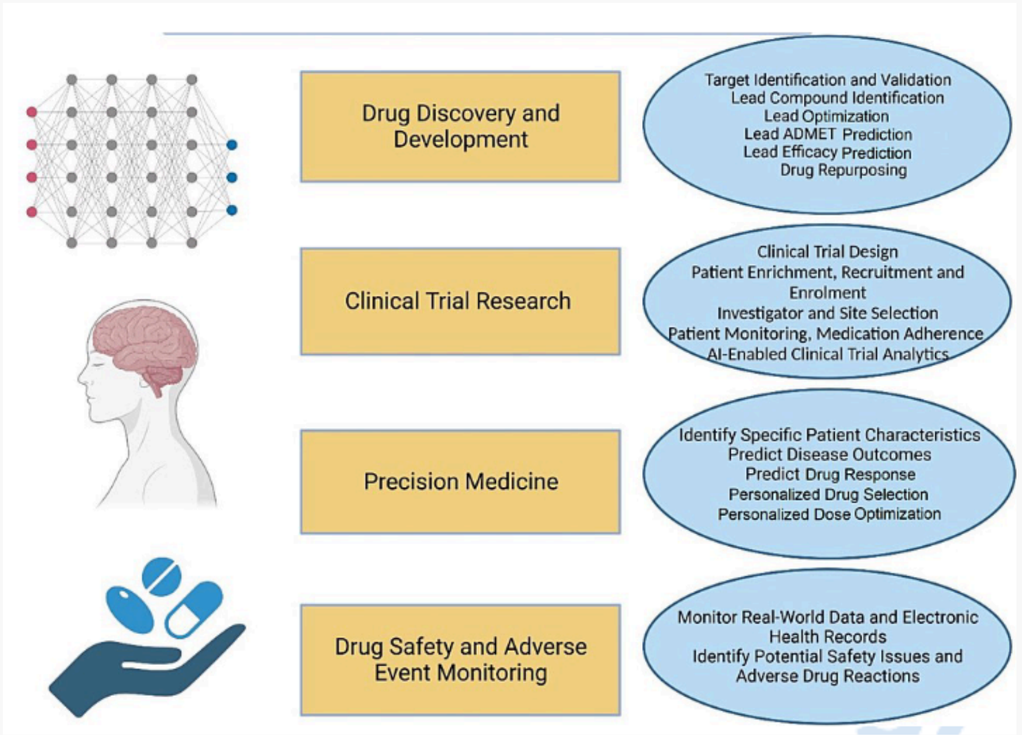
# Examples of Artificial Intelligence Applications

## AI in Clinical Decision-Making




https://link.springer.com/article/10.1007/s12559-023-10192-x

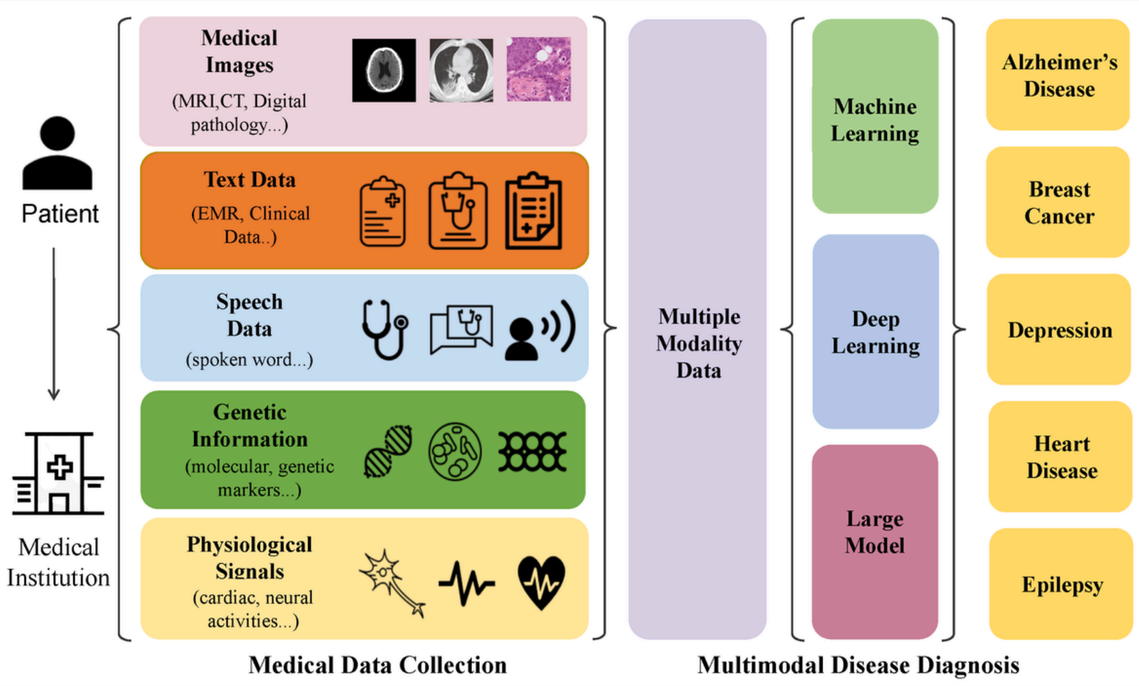
## AI in Personalized Medicine




https://thesciencebrigade.com/jst/article/view/124

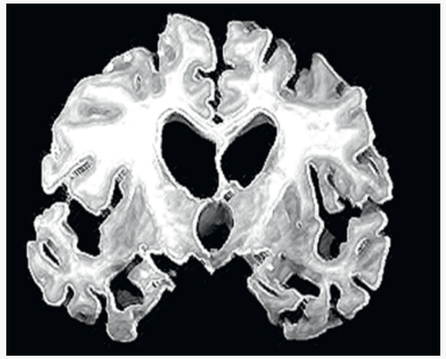
# Examples of Artificial Intelligence Applications

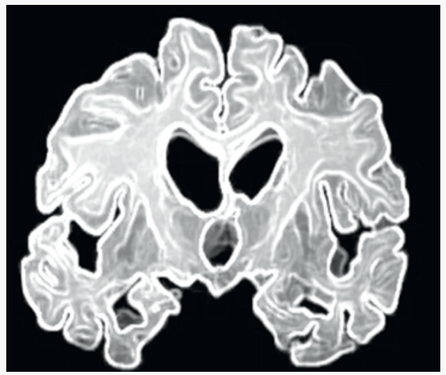
## AI in Medical Diagnosis




https://www.mdpi.com/2306-5354/11/3/219

## AI in Imaging Diagnosis





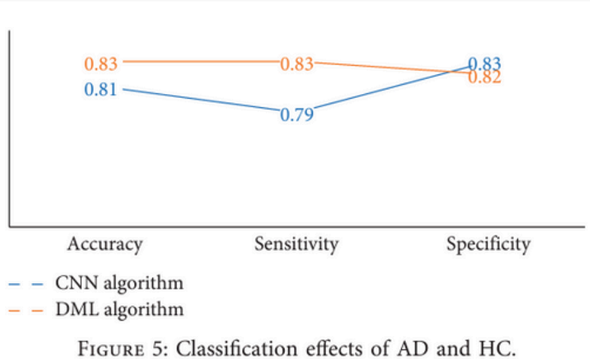



FIGURE 5: Classification effects of AD and HC.

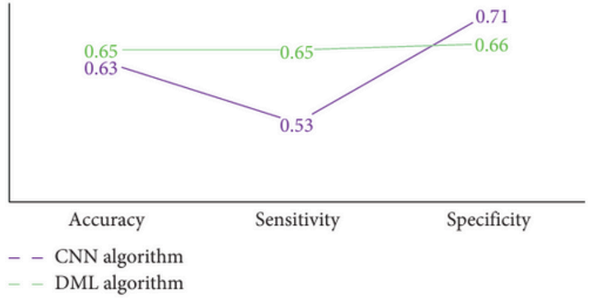



FIGURE 6: Comparison of classification effects between MCI and HC.

https://onlinelibrary.wiley.com/doi/10.1155/2021/8198552

# VI Example of a Personal Project

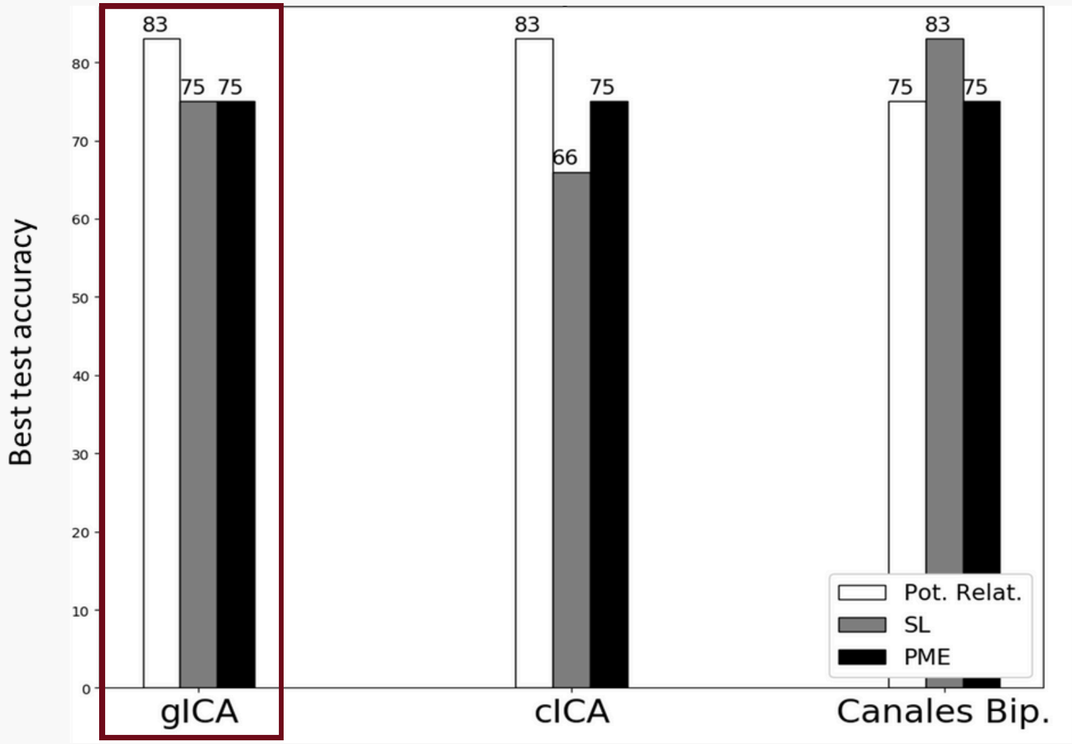
# Example of a Personal Project

## Automatic Classification of Subjects of the PSEN1-E280A Family at Risk of Developing Alzheimer's Disease Using Machine Learning and Resting State Electroencephalography

García-Pretelt FJ, Suárez-Relevo JX, Aguillon-Niño DF, Lopera-Restrepo FJ, Ochoa-Gómez JF, Tobón-Quintero CA.

Table I. Subjects demographics.

| | *ACr* | *NonCr* | *ACr vs NonCr (p-value)* | *Effect size (hedges)* |
|---|---|---|---|---|
| N | 27 | 33 | NA | NA |
| Age | 32.44 ± 5.800 | 32.70 ± 5.828 | 0.868 | -0.043 |
| Gender (M/F) | 11/16 | 13/20 | 1.000 | 0.020 (Cramer) |
| Education level (years) | 10.81 ± 2.936 | 13.21 ± 2.759 | 0.001 | -0.833 |
| Verbal Fluency | 21.74 ± 3.829 | 22.67 ± 3.688 | 0.346 | -0.244 |
| Boston Naming Test | 12.33 ± 3.101 | 13.61 ± 1.116 | 0.032 | -0.562 |
| MMSE | 29.30 ± 0.953 | 29.64 ± 0.822 | 0.044 | -0.38 |
| Word List Recall | 7.59 ± 1.551 | 8.39 ± 1.171 | 0.048 | -0.584 |
| Word List Recognition | 9.78 ± 0.506 | 10.00 ± 0.000 | 0.011 | -0.647 |
| Constructional Praxis | 9.96 ± 1.160 | 10.39 ± 0.827 | 0.171 | -0.43 |
| Delayed Constructional Praxis | 9.04 ± 1.720 | 9.82 ± 1.776 | 0.018 | -0.44 |




García-Pretelt FJ, Suárez-Relevo JX, Aguillon-Niño DF, Lopera-Restrepo FJ, Ochoa-Gómez JF, Tobón-Quintero CA. Automatic Classification of Subjects of the PSEN1-E280A Family at Risk of Developing Alzheimer's Disease Using Machine Learning and Resting State Electroencephalography. J Alzheimers Dis. 2022;87(2):817-832. doi: 10.3233/JAD-210148. PMID: 35404271.

# Example of a Personal Project

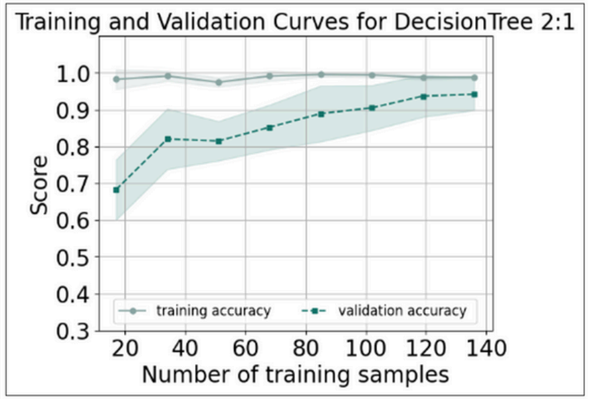
## Comprehensive Methodology for Sample Augmentation in EEG Biomarker Studies for Alzheimer's Risk Classification

Verónica, Henao Isaza; David, Aguillón; Carlos Andrés, Tobón Quintero; Francisco, Lopera; John Fredy, Ochoa Gómez.

**Table 1**. Summary characteristics of the databases

| | Database | Group | Count | Age (Mean ± SD) | Sex (F/M) |
|---|---|---|---|---|---|
| 2:1 | CHBMP | HC | 38 | 27.63 ± 6.67 | 13/25 |
| | SRM | HC | 31 | 30.77 ± 5.21 | 19/12 |
| | UdeA1 | ACr | 68 | 35.81 ± 4.36 | 49/19 |
| | UdeA1 | HC | 77 | 30.45 ± 4.81 | 47/30 |
| | UdeA2 | ACr | 11 | 33.45 ± 3.64 | 9/2 |
| | UdeA2 | HC | 12 | 31.42 ± 7.15 | 10/2 |
| | **Total** | | **237** | | **147/90** |
| 5:1 | CHBMP | HC | 38 | 27.63 ± 6.67 | 13/25 |
| | SRM | HC | 31 | 30.77 ± 5.21 | 19/12 |
| | UdeA1 | ACr | 30 | 39.78 ± 2.85 | 21/9 |
| | UdeA1 | HC | 77 | 30.45 ± 4.81 | 47/30 |
| | UdeA2 | ACr | 1 | 43.0 ± nan | 1/0 |
| | UdeA2 | HC | 12 | 31.42 ± 7.15 | 10/2 |
| | **Total** | | **189** | | **111/78** |
| 10:1 | CHBMP | HC | 38 | 27.63 ± 6.67 | 13/25 |
| | SRM | HC | 31 | 30.77 ± 5.21 | 19/12 |
| | UdeA1 | ACr | 14 | 41.86 ± 2.35 | 12/2 |
| | UdeA1 | HC | 77 | 30.45 ± 4.81 | 47/30 |
| | UdeA2 | ACr | 1 | 43.0 ± nan | 1/0 |
| | UdeA2 | HC | 12 | 31.42 ± 7.15 | 10/2 |
| | **Total** | | **173** | | **102/71** |

*HC: Healthy non-carrier subjects. ACr: Asymptomatic E280A mutation Alzheimer's disease carriers.*



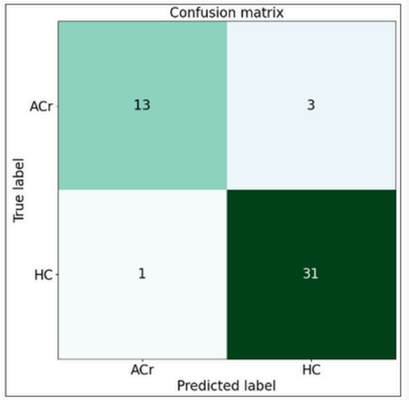




**Table 2.** Evaluation of Model Performance Using Computer Precision

| 2:1 | 5:1 | 10:1 |
|---|---|---|
| **Accuracy: 91%** | **Accuracy: 98%** | **Accuracy: 96%** |
| **Precision: 91%** | **Precision: 97%** | **Precision: 97%** |
| **Recall: 97%** | **Recall: 100%** | **Recall: 100%** |
| **F1-score: 94%** | **F1-score: 98%** | **F1-score: 98%** |
| **AUC: 92%** | **AUC: 99%** | **AUC: 93%** |

# VII Workshops 1

# VII Workshops 1

**4 Hands-on Seminars:**
**Python Machine Learning Techniques for Classifying Patients with Neurodegenerative Disorders and Controls based on EEG, MRI, and Clinical Markers**

**Responsible**

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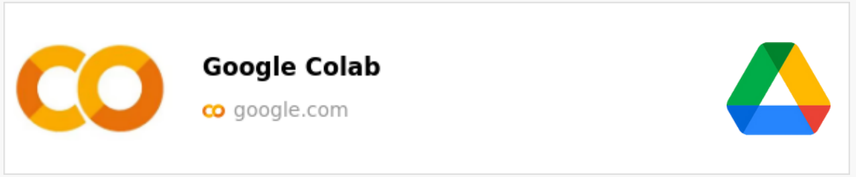
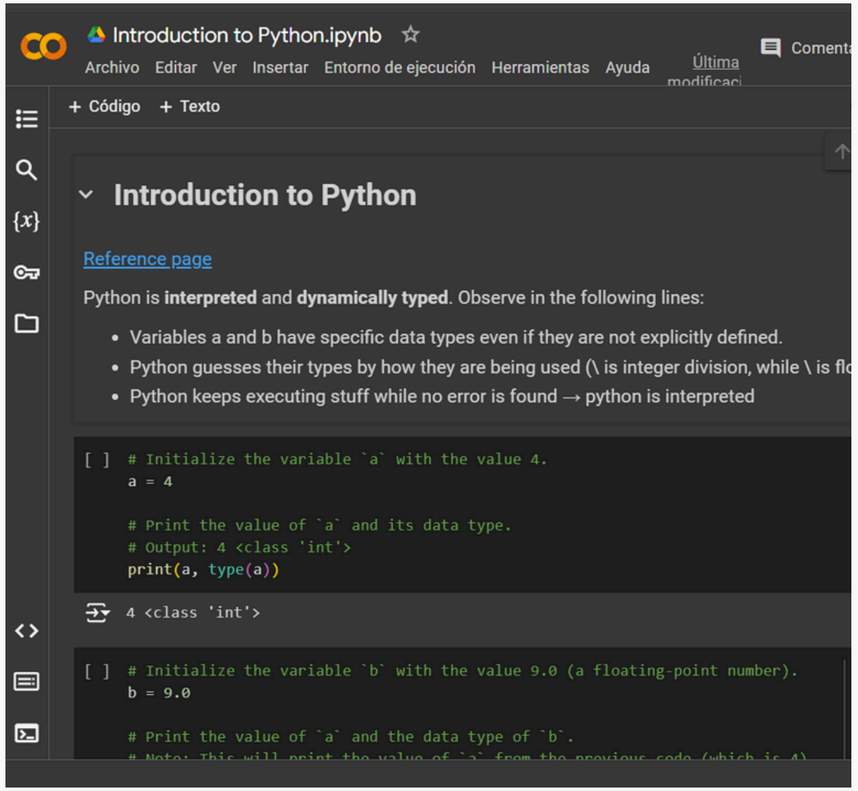
Seminar Guide


Workshops on web-based interactive computing platform

https://colab.research.google.com/drive/1_ILb-GESMlWyxtrCekn7gmekfK-sSQMW?usp=drive_link

**DATES**

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**ASSEGNISTA**

Verónica Henao Isaza

**SEMINAR**

First Seminar

# Thank you for listening!

About me