HUMAN DATA ANALYTICS PROJECT (A4)

“EVALUATING 1D VS 2D CONVOLUTION IN DEEP NEURAL NETWORKS FOR THREE-CLASS EEG SIGNAL CLASSIFICATION”

By
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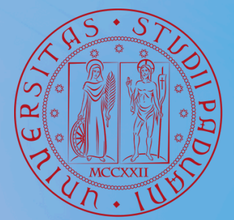

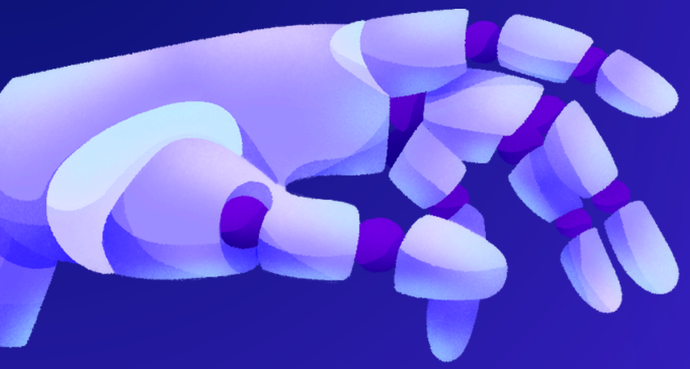

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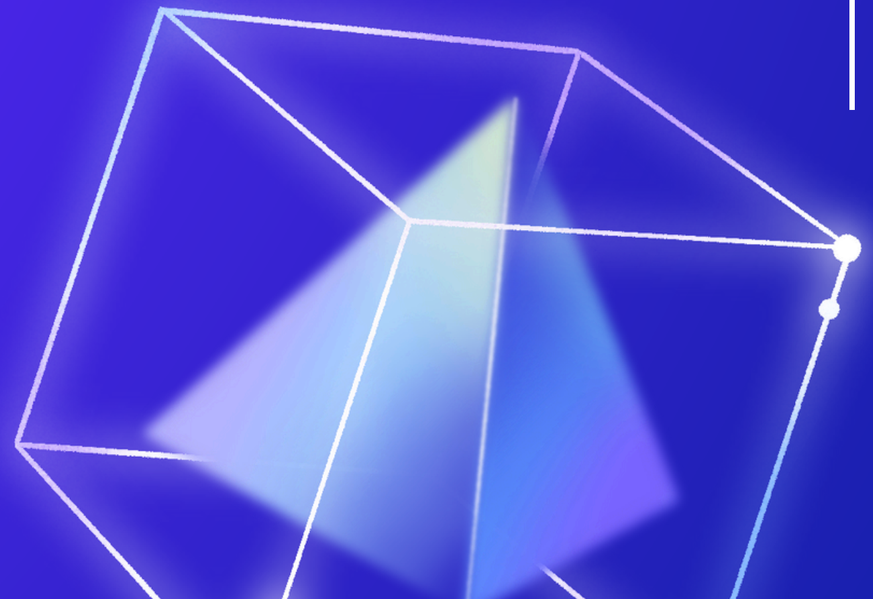


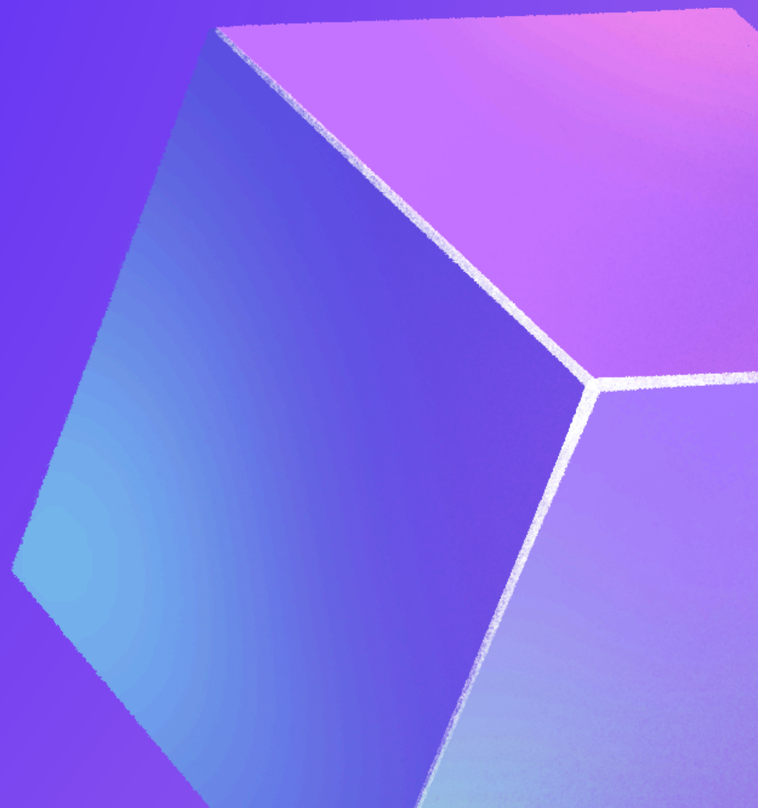
INTRODUCTION

OUR TASK (A4):

EEG Signals

Three Class Classification (LH - RH - N)

Neural Networks



PROJECT SCOPES

1. CLASSIFICATION

- Left Hand
- Right Hand
- Neutral state

2. Temporal vs Spatial Convolution

- Conv1D
- Conv2D

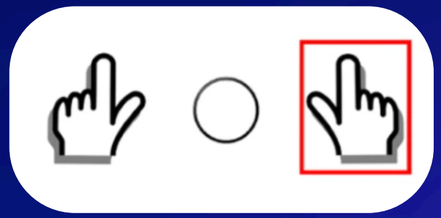
DATASET

EEG SINGALS

Data Descriptor: A large electroencephalographic motor imagery dataset for electroencephalographic brain computer interfaces

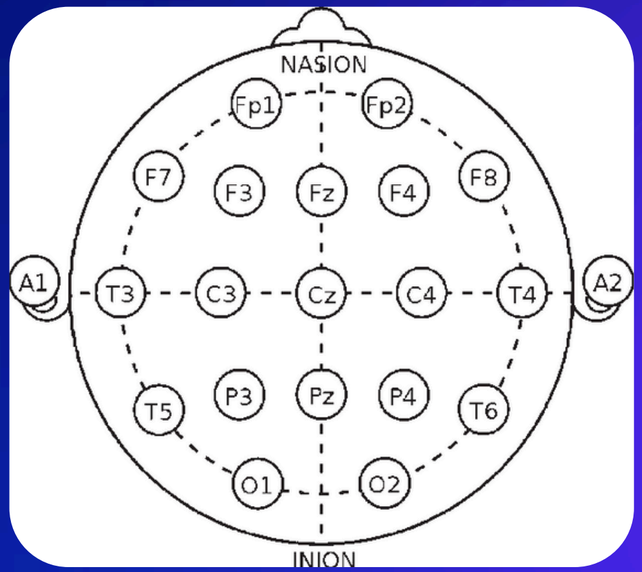
Murat Kaya[1], Mustafa Kemal Binli[2], Erkan Ozbay[1], Hilmi Yanar[1] & Yuriy Mishchenko[2]

DATA ACQUISITION



CLA PARADIGM

- An action signal indicating left hand, right hand or circle (for passive response) was shown for 1 s.
- Participants implemented the selected motor imagery, (remained passive for passive imagery)
- Next signal after ~3 Sec on average



22 EEG CHANNELS

- 200 Hz Frequency
- 7 Participants
- Participant J better quality

LABEL ASSIGNMENT

- Label 1 : Left Hand
- Label2: Right Hand
- Label3: Passive State
- Label 99: Initial Relaxation
- Label 91: Pause inter trial
- Label 92: End experiment

DATA PREPROCESSING

01

PCA

- Principal Components Analysis with 12 Principal Components

02

ICA

- (FastICA) Indipendent Components Analysis with 11 Components

03

FREQUENCY FILTERING

- Alpha + Beta waves range (8-30Hz)

04

NORMALIZATION

- Z-Score Normalization

LEARNING FRAMEWORKS

CNN CONV_1D

- Started form a very basic CNN with conv1D
- Experimented adding different layers
- Experimented with different configurations

RNN CONV_1D

- Recurrent version of CNN with conv1D
- GRU (Grated Recurrent Unit)

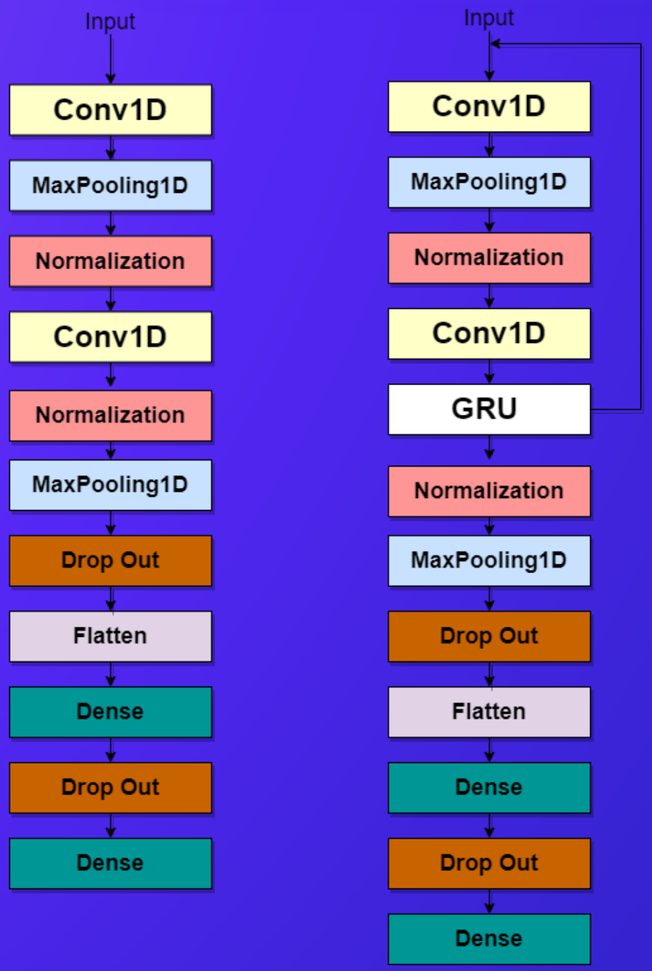
RNN CONV_2D

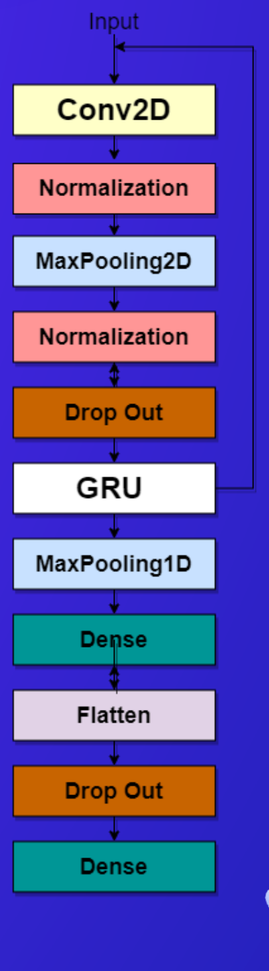
- Reccurent Network with Conv2D Layers
- Builded from the 1D version
- Experimented with different configurations

EEGNET

- Network used as reference tester
- Temporal Convolution Layer, Depthwise Convolution Layer, Separable Convolution Layer:

OUR NETWORKS





RESULTS AND ACHIEVEMENTS

01

- Tested several cofigurations with different hyperparameters and networks configurations

02

- Applied configuration with best results to analyze single Partecipant

RESULTS

Understanding Best over All Configurations

Net	Channels	Length	Subjects	# Epoch	Normalize	Filter	IC	# Accurancy
RNN	22	600ms	All	20	Yes	No	No	82.02%
CNN	22	600ms	All	20	Yes	No	No	81.9%
CNN	22	600ms	All	20	Yes	Yes 8-30	No	77.3%
CNN	22	600ms	All	20	Yes	No	ICA11	74.7%
CNN	22	600ms	All	20	Yes	No	PCA11	74%
RNN	22	600ms	All	20	Yes	Yes 8-30	No	72%
EEGNet	22	600ms	All	200	Yes	No	No	67.89%
CNN	22	600ms	All	20	Yes	Yes 8-30	ICA11	67%
EEGNet	22	600ms	All	200	No	No	No	65.72%
EEGNet	22	600ms	All	200	No	No	PCA22	64%
RNN	22	600ms	All	20	Yes	Yes 8-30	ICA11	64%
RNN-2D	22	600ms	All	20	Yes	Yes 8-30	No	60%
RNN-2D	22	600ms	All	20	Yes	No		59%
RNN-2D	22	600ms	All	20	Yes	Yes 8-30	PCA12	58.2%
EEGNet	22	600ms	All	200	Yes	Yes 8-30	No	56%
RNN	22	600ms	All	20	Yes	Yes 8-30	PCA12	55.3%
CNN	22	600ms	All	20	Yes	Yes 8-30	PCA12	54.6%
EEGNet	22	600ms	All	20	Yes	Yes 8-30	PCA12	53.5%
RNN-2D	22	600ms	All	20	Yes	Yes 8-30	ICA11	53%
EEGNet	22	600ms	All	20	Yes	Yes 8-30	ICA11	51%
EEGNet	22	600ms	All	200	No	Yes 8-30	No	50%

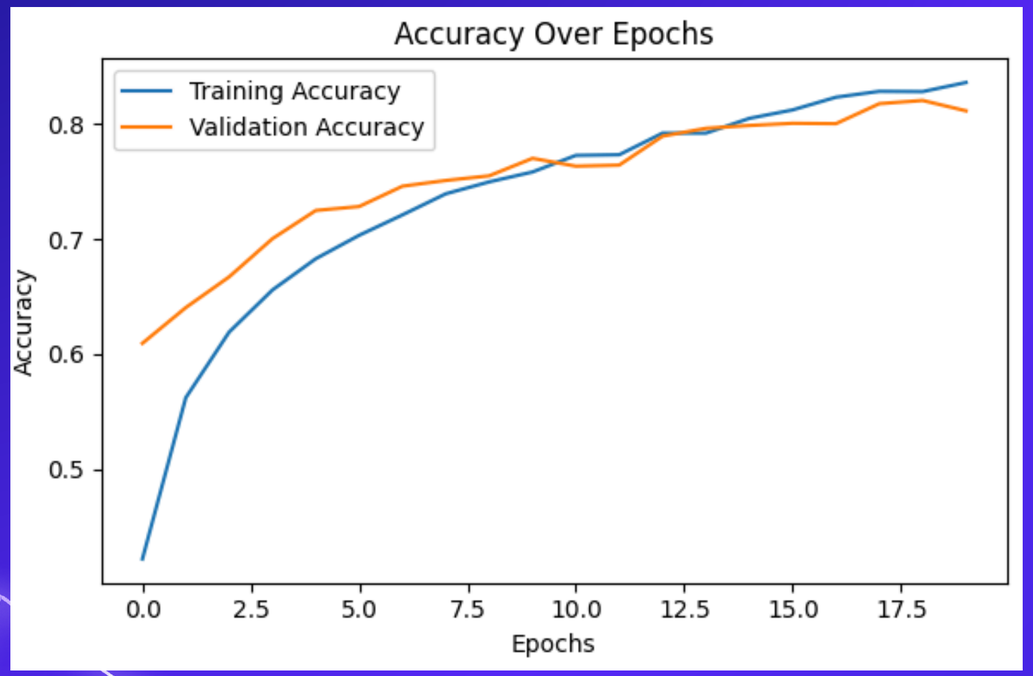
RESULTS

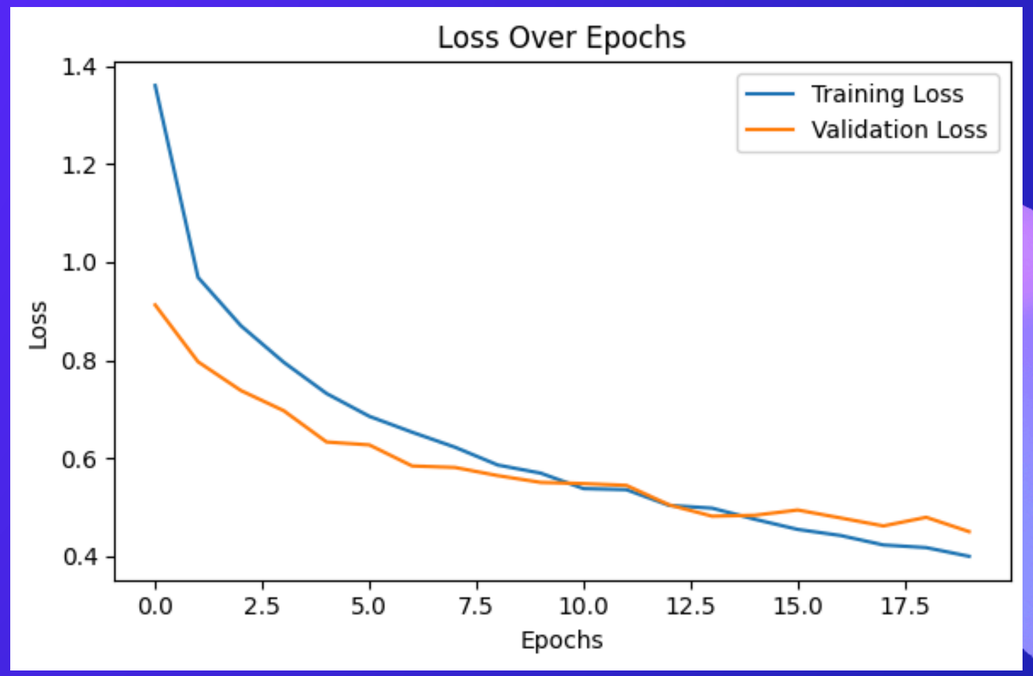
Testing the best emerged configurations for every Network on Dataset with ALL Participants

Net	Channels	Length	Subjects	# Epoch	Normalize	Filter	IC	# Accurancy
RNN	22	600ms	All	20	Yes	No	No	82.02%
CNN	22	600ms	All	20	Yes	No	No	81.9%
EEGNet	22	600ms	All	200	Yes	No	No	67.89%
EEGNet	22	600ms	All	200	No	No	No	65.72%
RNN-2D	22	600ms	All	20	Yes	No	No	59%

RESULTS

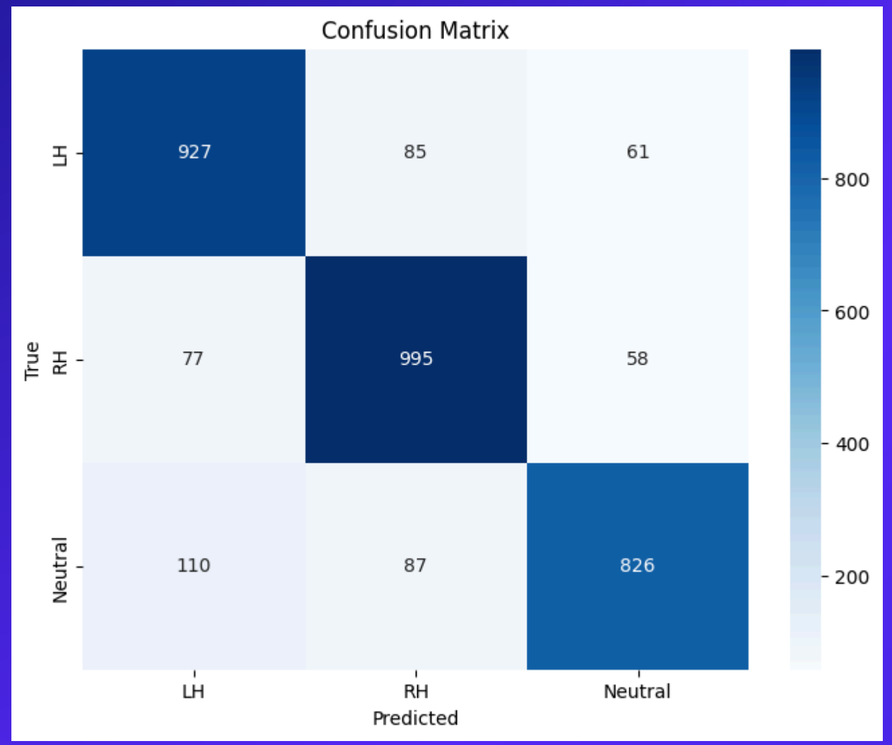
Metrics

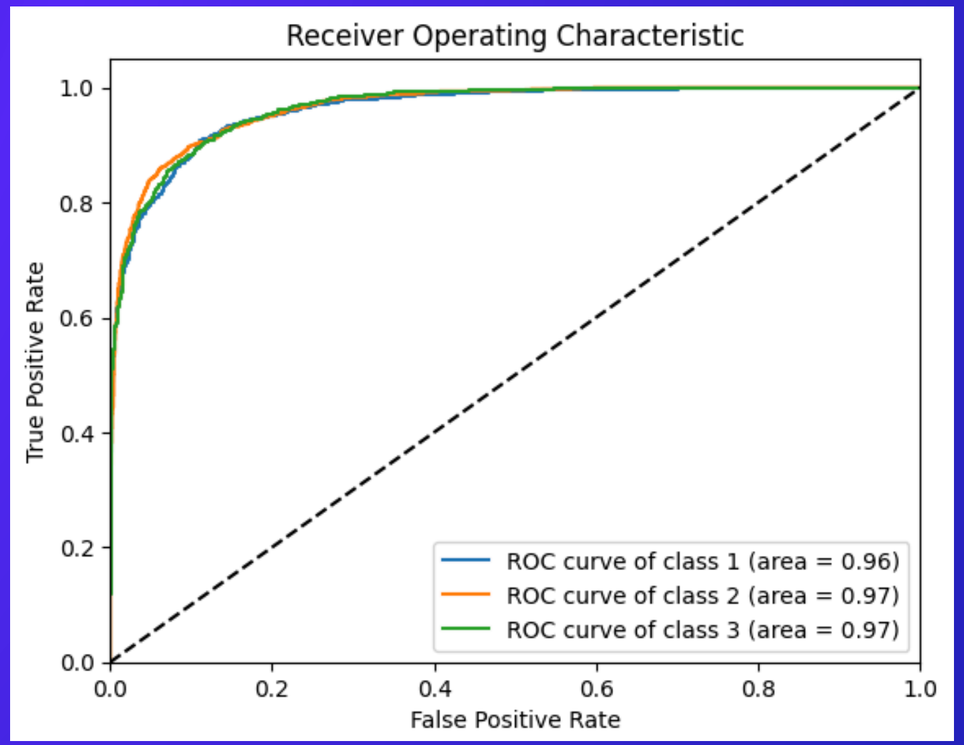




RESULTS

Metrics





F1 Score: 0.84

RESULTS

Testing best Network on Single Participant

Net	Channels	Length	Subjects	# Epoch	Normalize	# Accurancy
RNN	22	600ms	Sub J	20	Yes	97%
RNN	22	600ms	Sub C	20	Yes	93%
RNN	22	600ms	Sub F	20	Yes	84%
RNN	22	600ms	Sub E	20	Yes	81%
RNN	22	600ms	Sub A	20	Yes	72%
RNN	22	600ms	Sub D	20	Yes	69%
RNN	22	600ms	Sub B	20	Yes	63%

BEST

ACHIVEMENTS

1. CLASSIFICATION

- Left Hand
- Right Hand

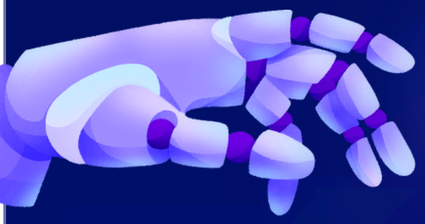
} Easier to detect

- Neutral state
- Single Participant much better than ALL

2. Temporal vs Spatial Convolution

- Conv1D is better when data saw as Time-Series both in terms of Accuracy and Speed
- Conv2D needs a more accurate preprocessing and/or more precise configurations

CONCLUSIONS

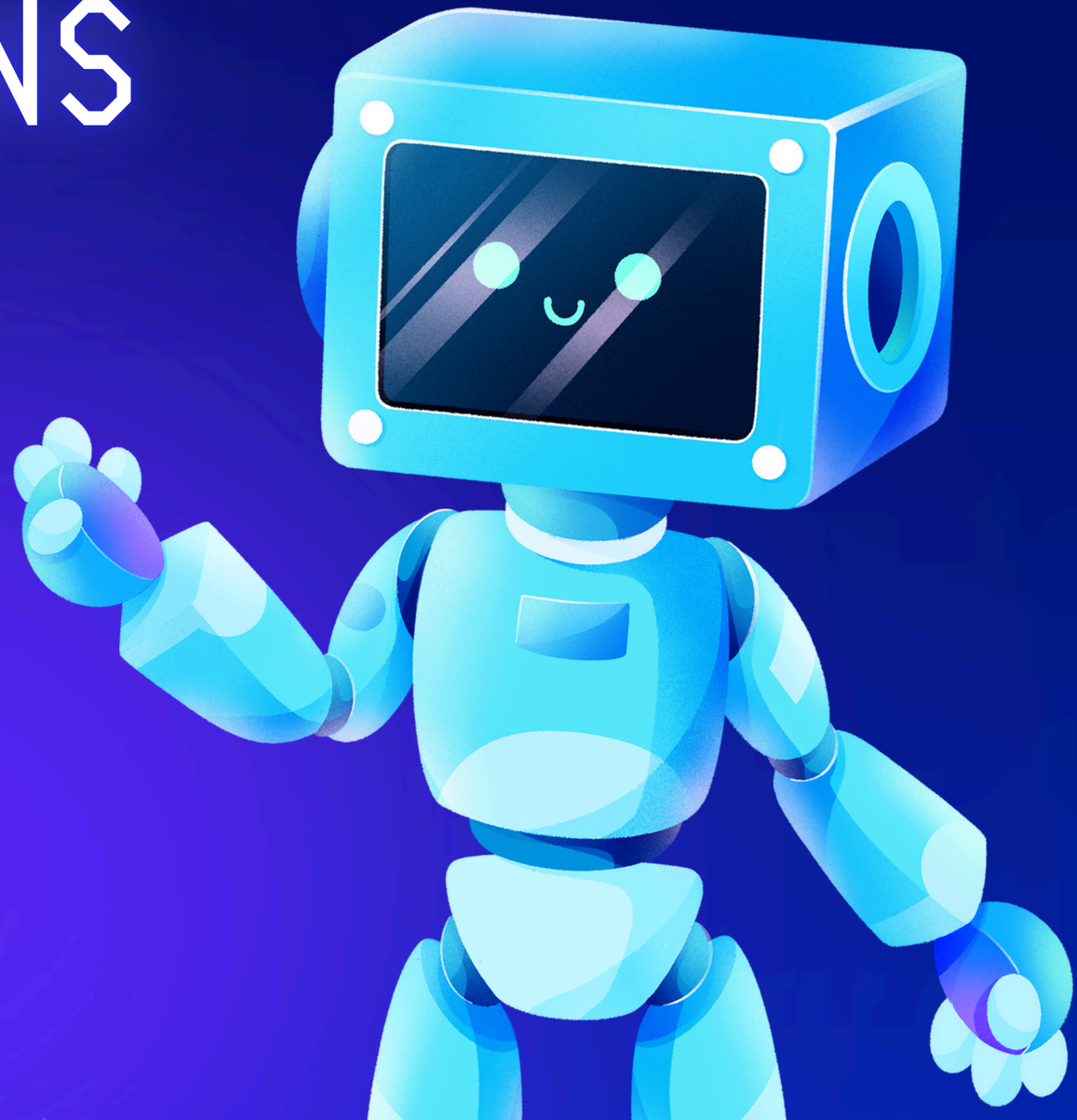


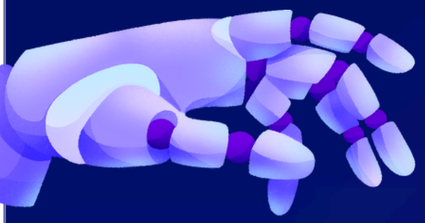
Future Developement:

- Use differnet Frequencies as dimension or as added columns
- Try with stream data for real world application

Challenge:

- Preprocessing is hard
- Syntetize in a Paper is hard





THANK YOU!