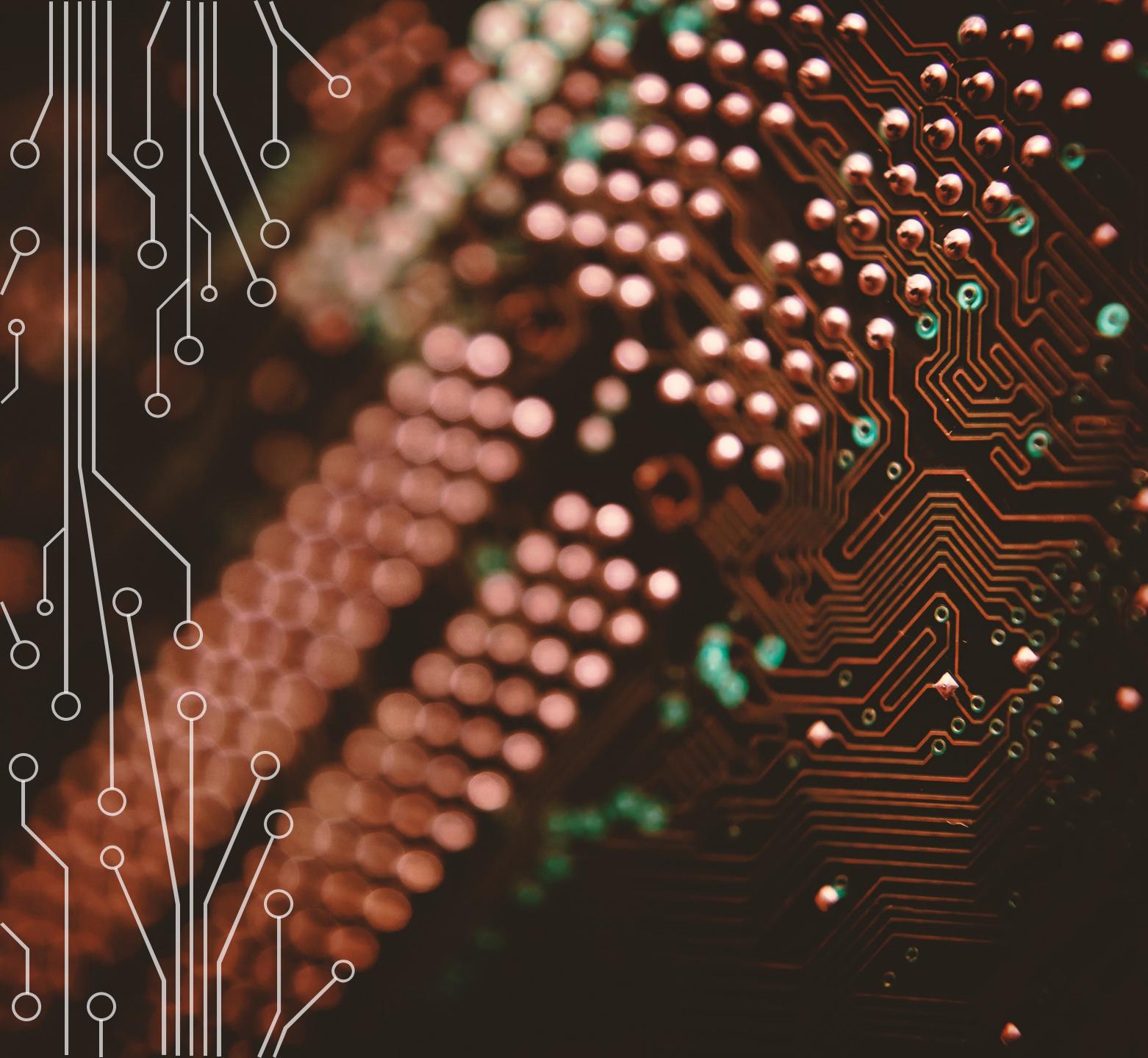


SMART PHYSICAL THERAPY

LET'S HELP PT PATIENTS TO IMPROVE THEIR
CONDITION BY THEMSELVES





TONIGHT'S AGENDA

 WHO

 WHAT

 WHY

 HOW

 NEXT

 CONCLUSIONS

 BIBLIOGRAPHY



WHO?
**ALVARO
RAMIREZ**





WHAT?
SMART PHYSICAL
THERAPY





WHAT? EXERCISE 1



WHAT? EXERCISE 2



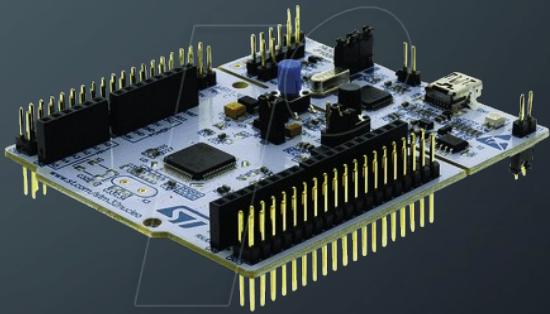
WHAT? EXERCISE 3



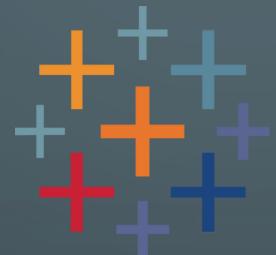
WHY? ERWIN FLORES



HOW? EQUIPMENT



HOW? SOFTWARE





HOW?
FROM 3
SENSORTILE
S...





HOW?
...TO **1**
SENSORTILE

HOW? CAPTURING DATA



<input type="checkbox"/>	Name	Status	Date modified	Type	Size
	211212_194743_01_01.csv	🕒	12/12/2021 8:38 PM	Microsoft Excel C...	1 KB
	211212_194743_01_02.csv	🕒	12/12/2021 7:47 PM	Microsoft Excel C...	4 KB
	211212_194743_01_03.csv	🕒	12/12/2021 7:48 PM	Microsoft Excel C...	5 KB
	211212_194743_01_04.csv	🕒	12/12/2021 7:48 PM	Microsoft Excel C...	4 KB
	211212_194743_01_05.csv	🕒	12/12/2021 7:48 PM	Microsoft Excel C...	4 KB
	211212_194743_01_06.csv	🕒	12/12/2021 7:48 PM	Microsoft Excel C...	4 KB
	211212_194743_01_07.csv	🕒	12/12/2021 7:48 PM	Microsoft Excel C...	4 KB
	211212_194743_01_08.csv	🕒	12/12/2021 7:48 PM	Microsoft Excel C...	5 KB
	211212_194743_01_09.csv	🕒	12/12/2021 7:48 PM	Microsoft Excel C...	4 KB
	211212_194743_01_10.csv	🕒	12/12/2021 7:48 PM	Microsoft Excel C...	4 KB
	211212_194743_01_11.csv	🕒	12/12/2021 7:48 PM	Microsoft Excel C...	4 KB
	211212_194743_01_12.csv	🕒	12/12/2021 7:48 PM	Microsoft Excel C...	4 KB
	211212_194743_01_13.csv	🕒	12/12/2021 7:48 PM	Microsoft Excel C...	4 KB
	211212_194743_01_14.csv	Type: Microsoft Excel Comma Separated Values File Size: 3.59 KB Date modified: 12/12/2021 7:48 PM Availability status: Available on this device		Microsoft Excel C...	4 KB
	211212_194743_01_15.csv			Microsoft Excel C...	4 KB
	211212_194743_01_16.csv			Microsoft Excel C...	4 KB
	211212_194743_01_17.csv			Microsoft Excel C...	4 KB
	211212_194743_01_18.csv	🕒	12/12/2021 7:49 PM	Microsoft Excel C...	4 KB
	211212_194743_01_19.csv	🕒	12/12/2021 7:49 PM	Microsoft Excel C...	4 KB
	211212_194743_01_20.csv	🕒	12/12/2021 7:49 PM	Microsoft Excel C...	4 KB
	211212_194743_01_21.csv	🕒	12/12/2021 7:51 PM	Microsoft Excel C...	1 KB

A	B	C	D	E	F	G	H	I	J	K	L	M
	exercise	Sample	ACC X	ACC Y	ACC Z	GYR X	GYR Y	GYR Z	MAG X	MAG Y	MAG Z	raw
152	1	1	-923	-133	-346	-5	-26	0	-307	304	469	bytearray(b'\xfb9e\xfc\xff\xa6\xfe\xfb\xff\xe6\xff\x00\x00\xcd\xfe0\x01\xd5\x01')
153	1	1	-922	-132	-345	-4	-27	0	-306	306	469	bytearray(b'\x01:f\xfc\xff\xa7\xfe\xfc\xff\xe5\xff\x00\x00\xce\xfe\x01\xd5\x01')
154	1	1	-923	-132	-349	-6	-24	0	-300	309	462	bytearray(b'\x07:e\xfc\xff\xa3\xfe\xfa\xff\xe8\xff\x00\x00\xd4\xfe5\x01\xd5\x01')
155	1	1	-923	-132	-345	-5	-29	1	-306	306	463	bytearray(b'\r:e\xfc\xff\xa7\xfe\xfc\xff\xe3\xff\x01\x00\xce\xfe2\x01\xd5\x01')
156	1	1	-923	-131	-347	-4	-35	0	-304	315	468	bytearray(b'\x14:e\xfc\xff\xa5\xfe\xfc\xff\xdd\xff\x00\x00\xd0\xfe\x01\xd4\x01')
157	1	1	-922	-131	-344	-5	-28	0	-304	309	463	bytearray(b'\x1a:f\xfc\xff\xa8\xfe\xfb\xff\xe4\xff\x00\x00\xd0\xfe5\x01\xcf\x01')
158	1	1	-923	-132	-347	-4	-25	0	-307	301	471	bytearray(b'\e\xfc\xff\xa5\xfe\xfc\xff\xe7\xff\x00\x00\xcd\xfe-\x01\xd7\x01')
159	1	1	-923	-131	-343	-4	-28	0	-300	309	456	bytearray(b'&:e\xfc\xff\xa9\xfe\xfc\xff\xe4\xff\x00\x00\xd4\xfe5\x01\xc8\x01')
160	1	1	-923	-132	-345	-4	-26	0	-307	306	468	bytearray(b'-:e\xfc\xff\xa7\xfe\xfc\xff\xe6\xff\x00\x00\xcd\xfe2\x01\xd4\x01')
161	1	1	-919	-135	-353	-2	-37	7	-306	303	468	bytearray(b'3:i\xfcy\xff\x9f\xfe\xfc\xff\xdb\xff\x07\x00\xce\xfe/\x01\xd4\x01')
162	1	1	-922	-136	-350	-5	-60	27	-304	307	460	bytearray(b'9:f\xfcx\xff\x2\xfe\xfh\xff\xc4\xff\x1b\x00\xd0\xfe3\x01\xcc\x01')
163	1	1	-951	-134	-393	4	-174	59	-315	310	459	bytearray(b'?:\xfcz\xffw\xfe\x04\x00R\xff\x00\xc5\xfe6\x01\xcb\x01')
164	1	1	-920	-104	-286	4	-250	63	-316	310	453	bytearray(b'F:h\xfc\x98\xff\xe2\xfe\x04\x00\x06\xff?\x00\xc4\xfe6\x01\xc5\x01')
165	1	1	-925	-123	-289	-10	-150	51	-313	300	477	bytearray(b'L:c\xfc\x86\xff\xdf\xfe\xfb\xff\xff\x00\xc7\xfe')
166	1	1	-949	-114	-291	0	-112	42	-306	310	439	bytearray(b'R:K\xfc\x8e\xff\xdd\xfe\x00\x00\x0f\xff*\x00\xce\xfe-\x01\xb6\x01')
167	1	1	-950	-97	-281	-16	-37	8	-324	318	438	bytearray(b'X:J\xfc\x9f\xff\xe7\xfe\xf0\xff\xdb\xff\x08\x00\xbc\xfe<\x01\xb7\x01')
168	1	1	-944	-119	-289	-11	-79	11	-306	310	439	bytearray(b'8:\xfc\x89\xff\xdf\xfe\xf5\xff\x1d\x00\xf0\xff\xce\xi\x01\x01\xb7\x01')
169	1	1	-936	-125	-307	30	-11	11	-304	311	431	bytearray(b'k:Y\xfc\x8f\xff\xde\xfe#\x00\x0e\x00\xd2\xff\xca\xfe6\x01\xb9\x01')
170	1	1	-935	-113	-290	35	14	-46	-310	310	441	bytearray(b'q:[\xfc\x82\xff\xd2\xfe]\x02\x00\x06\x00\xe9\xff\xd0\xfe2\x01\xc5\x01')
171	1	1	-933	-126	-302	2	54	-23	-304	305	453	bytearray(b'q::\xfc\x89\xff\xb0\xfe\xf0\xff\x00\xe4\xff\xd0\xfe3\x01\xc8\x01')
172	1	2	-966	-119	-336	-16	56	-28	-304	307	456	bytearray(b'":N\xfcy\xff\xa5\xfe\x13\x00\x8f\xff\xe6\xff\xcb\xfe0\x01\xc9\x01')
173	1	2	-946	-133	-347	19	-113	-26	-309	304	457	bytearray(b'84:\xfc(\x00\xd1\xfe\x1c\x00\xfe\xee\xff\xd3\xfe2\x01\xc2\x01')
174	1	2	-931	-133	-303	28	-135	-18	-301	306	450	bytearray(b'8a:\xfcw\xff\xd7\xfe\x14\x00\x93\xff\xf7\xff\xd0\xfe6\x01\xc6\x01')
175	1	2	-961	-131	-297	20	-109	-9	-304	310	454	bytearray(b'91:<\xfc\x84\x11\xd2\xfe\x00\x9c\xff\xf7\xff\xcd\xfe0\x01\xb7\x01')
176	1	2	-964	-124	-302	15	-100	-9	-307	304	439	bytearray(b'97:H\xfcv\xff\xca\xfe#\x00\xff\xe9\xff\xd3\xfe0\x01\xb6\x01')
177	1	2	-952	-138	-310	35	-150	-23	-301	304	438	bytearray(b'9d:6\xfc\xff\xfe\xfe3\x00\xbf\xff\xe3\xff\xcd\xfe9\x01\xbc\x01')
178	1	2	-970	-152	-258	51	-65	-29	-307	313	444	bytearray(b'a3:B\xfc\xff\xe0\xfe*\x00\xed\xff\xe7\xff\xce\xfe;\x01\xbf\x01')
179	1	2	-958	-141	-288	42	-19	-25	-306	315	447	bytearray(b'aa:6\xfc\xff\xb4\xfeA\x00\xe4\xff\xdb\xff\xd6\xfe5\x01\xb9\x01')
180	1	2	-970	-158	-332	65	-28	-37	-298	309	441	bytearray(b'xb0:\x10\xfcP\xff\xde\xfeO\x00\xa2\xff\xc9\xff\xd3\xfe2\x01\xb6\x01')
181	1	2	-1008	-176	-290	79	-94	-55	-301	306	438	bytearray(b'xb6:\xfc\xff\xed\xfeU\x00\x89\xff\xc3\xff\xd7\xfe<\x01\xb6\x01')
182	1	2	-932	-154	-275	85	-119	-61	-297	316	438	bytearray(b'bc:*:\xfcA\xff\xfeZ\x00\xff\xe9\xff\xd4\xfeA\x01\xaa\x01')
183	1	2	-982	-191	-257	90	-151	-23	-300	321	426	bytearray(b'c3:)\xfcM\xff\x10\xff\x00\xc3\xff\xa5\xff\xd6\xfe9\x01\xb0\x01')
184	1	2	-983	-179	-240	74	-61	-91	-298	313	432	bytearray(b'c9:)\xfcM\xff\xff3\x00\xf2\xff\x9e\xff\xd4\xfe3\x01\xb3\x01')
185	1	2	-966	-179	-186	51	-14	-98	-300	307	435	bytearray(b'xcf:-\xfcF\xff;\xfc1\x00\xf8\xff\x9b\xff\xd9\xfe8\x01\xb0\x01')
186	1	2	-979	-186	-197	49	-8	-101	-295	312	432	bytearray(b'xd5:\xfcD\xff;\xfcD\xff\x1e\x00\xf9\xff\x9f\xff\x8f\xff\xd3\xfeB\x01\xb6\x01')
187	1	2	-962	-188	-176	30	-7	-113	-291	322	438	bytearray(b'xd5:\xfcD\xff;\xfcD\xff\x1e\x00\xf9\xff\x9f\xff\x8f\xff\xd3\xfeB\x01\xb6\x01')

HOW? DATA CLEANING

[Training data](#) | [Test data](#) | [Export data](#)

Did you know? You can capture data from any device or development board, or upload your existing datasets - [Show options](#)



X

DATA COLLECTED
18sTRAIN / TEST SPLIT
70% / 30% 

Record new data

[Connect using WebUSB](#)

Collected data

SAMPLE NAME LABEL

211211_160916_01_17.csv.2mid2hi8 Ex 1

ADDED LENGTH

Dec 11 2021, 17:04:51

1s

211211_160916_01_15.csv.2mid2h4g Ex 1

Dec 11 2021, 17:04:51

1s

211211_160916_01_14.csv.2mid2h... Ex 1

Dec 11 2021, 17:04:51

1s

211211_160916_01_13.csv.2mid2gr1 Ex 1

Dec 11 2021, 17:04:51

1s

211211_160916_01_12.csv.2mid2gh0 Ex 1

Dec 11 2021, 17:04:50

1s

211211_160916_01_10.csv.2mid2g6p Ex 1

Dec 11 2021, 17:04:50

1s

211211_160916_01_09.csv.2mid2g4q Ex 1

Dec 11 2021, 17:04:50

1s

211211_160916_01_40.csv.2mid2g2t Ex 1

Dec 11 2021, 17:04:50

1s

211211_160916_01_39.csv.2mid2g28 Ex 1

Dec 11 2021, 17:04:50

1s

211211_160916_01_37.csv.2mid2fvf Ex 1

Dec 11 2021, 17:04:50

1s

211211_160916_01_34.csv.2mid2fsj Ex 1

Dec 11 2021, 17:04:50

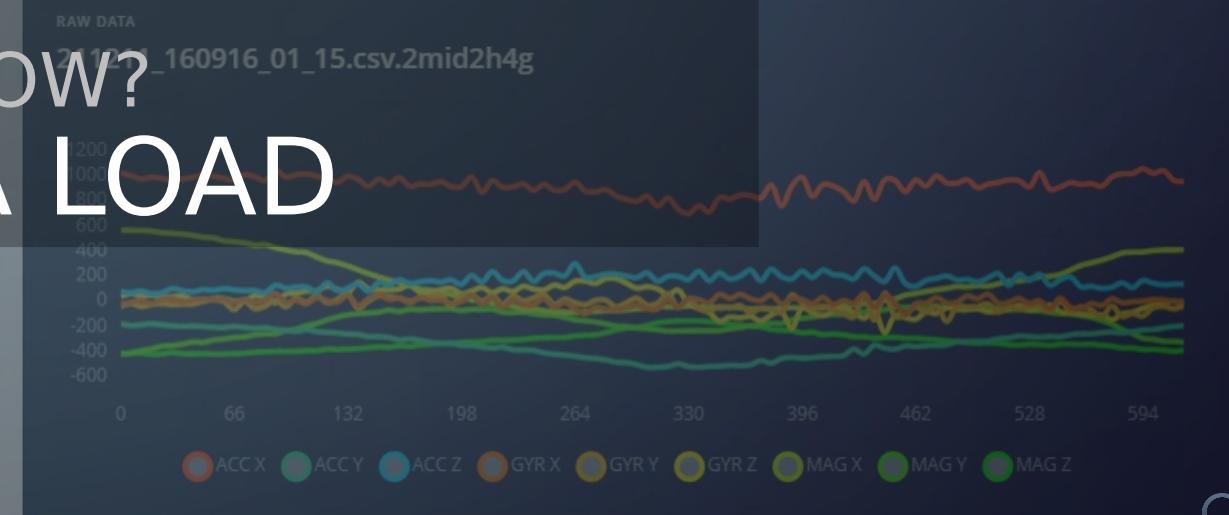
1s

211211_160916_01_33.csv.2mid2frg Ex 1

Dec 11 2021, 17:04:50

1s

HOW? DATA LOAD



EDGE IMPULSE

CREATE IMPULSE (PROJECT EX 2)

An impulse takes raw data, uses signal processing to extract features, and then uses a learning block to classify new data.

Time series data

Axes: ACC X, ACC Y, ACC Z, GYR X, GYR Y, GYR Z, MAG X, MAG Y, MAG Z

Window size: 1000 ms

Window increase: 1000 ms

Frequency (Hz): 166.66666666666667

Zero-pad data:

Spectral Analysis

Name: Spectral features

Input axes: ACC X, ACC Y, ACC Z, GYR X, GYR Y, GYR Z, MAG X, MAG Y

Anomaly Detection (K-means)

Name: Anomaly detection

Input features: Spectral features

Output features: 1 (Anomaly score)

Output features

1 (Anomaly score)

Save Impulse

HOW? MODEL SETUP



HOW? PARAMETERS DEFINITION

EDGE IMPULSE

SPECTRAL FEATURES (PROJECT EX 2)
#1 ▾ Click to set a description for this version

Parameters Generate features

Training set

Data in training set	11s
Classes	1 (Ex 2)
Window length	1000 ms.
Window increase	1000 ms.
Training windows	0

Generate features

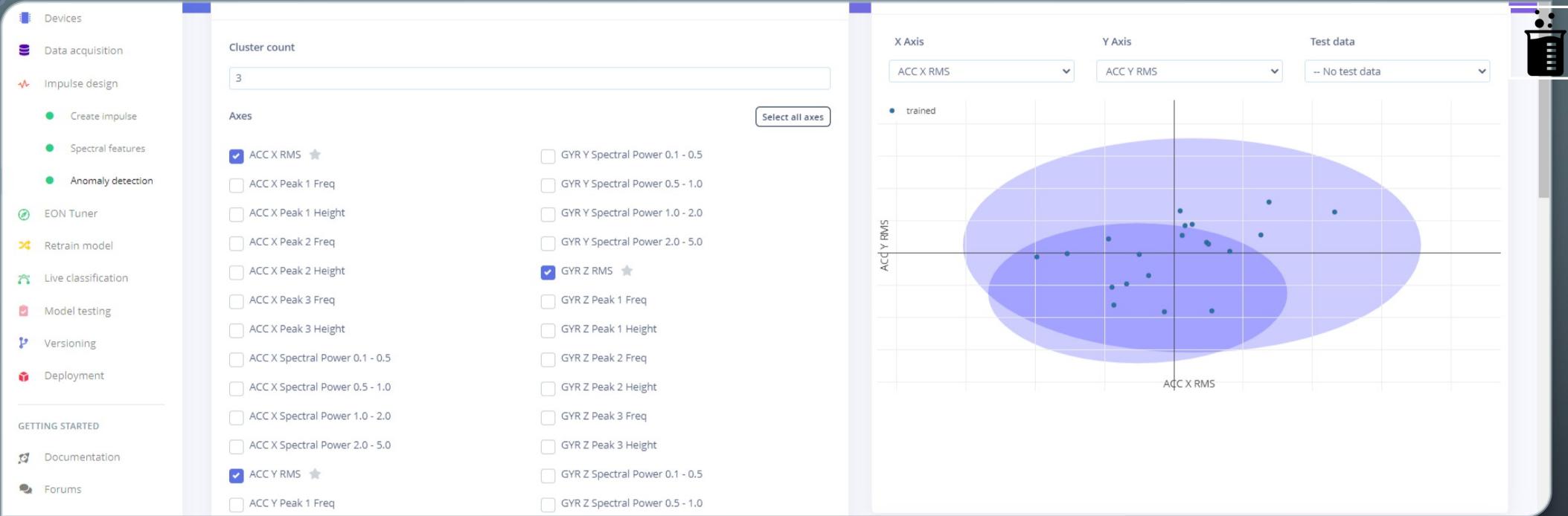
Feature explorer (20 samples)

X Axis: ACC X RMS
Y Axis: ACC Y RMS
Z Axis: ACC Z RMS

Ex 2

The figure is a 3D scatter plot titled "Feature explorer (20 samples)". It has three axes: X Axis (ACC X RMS), Y Axis (ACC Y RMS), and Z Axis (ACC Z RMS). The X-axis ranges from 1050 to 1200, the Y-axis from 100 to 450, and the Z-axis from 200 to 450. The data points are blue spheres clustered in two main groups: one group is located around (1100, 400, 400) and the other is around (1150, 300, 300).

HOW? FEATURE EXTRACTION



HOW? MODEL TRAINING

HOW? MODEL TESTING



The screenshot shows the Edge Impulse web interface for live classification. At the top, there's a purple header bar with the title "LIVE CLASSIFICATION (PROJECT EX 2)". Below it, a blue banner displays a tip: "Did you know? Capture data from any device or development board into the testing category to live classify data - [Show options](#)". On the right side of the header, there's a user profile for "Alvaro" and a settings icon.

The main area is divided into two sections:

- Classify new data:** This section includes fields for "Device" (set to "No devices connected"), "Sensor" (dropdown menu), "Sample length (ms.)" (set to 10000), and "Frequency" (dropdown menu). It also features a "Start sampling" button at the bottom.
- Classify existing test sample:** This section shows a dropdown menu containing the file path "211212_203842_02_20.csv.2mlhqej0 (Ex 2 - Test - Wrong)" and a "Load sample" button.

At the bottom left, there's a copyright notice: "© 2021 Edgelimpulse Inc. All rights reserved".

HOW? LIVE CLASSIFICATION

The screenshot shows the Edge Impulse web interface for live classification. The top navigation bar includes the Edge Impulse logo, a user profile for 'Alvaro', and a notification icon. The main header 'LIVE CLASSIFICATION (PROJECT EX 2)' is displayed above two main sections: 'Classify new data' and 'Classify existing test sample'.
Classify new data: This section contains four input fields: 'Device' (set to 'No devices connected'), 'Sensor' (dropdown menu), 'Sample length (ms.)' (set to 10000), and 'Frequency' (dropdown menu). A green 'Start sampling' button is located at the bottom of this section.
Classify existing test sample: This section shows a dropdown menu containing the file path '211212_203842_02_20.csv.2mlhqej0 (Ex 2 - Test - Wrong)'. A blue 'Load sample' button is positioned next to the dropdown.
At the bottom left of the interface, there is a copyright notice: '© 2021 Edgelimpulse Inc. All rights reserved'.
A banner at the top of the page reads: 'Did you know? Capture data from any device or development board into the testing category to live classify data - [Show options](#)'.

HOW? PROOF OF CONCEPT: MODEL TESTING

HOW? PROOF OF CONCEPT

- With the power of an unsupervised neural network for anomaly detection, the system recognizes if the patient reached the goal or not allowing them to work out by themselves and get the notifications they need.
- With the proper data, the system can be used for other exercises.

HOW? ITEMS TO IMPROVE

- It is not clear how precise the response would be for exercises with little displacement of the leg.
- For a real implementation, the system shall:
 - Be wireless
 - Use a phone instead of a computer
 - Be trained with hundreds or thousands of samples from multiple patients

WHEN? IN THE FUTURE

The system could:

- Graphically show, in real time, how far or close the patient is from the goal.
- Share data in real time with the PT and the doctor.
- Keep the history of each session showing tendency charts to know if the patient is improving or not.
- Have a calendar to schedule work out sessions with the system.

CONCLUSIONS

- More sensors not necessarily are the best solution
- A lot of learning, a lot to learn
- Need to improve documentation and share it with the world to increase number of developments in this field

SOME BIBLIOGRAPHY





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