Quantifying nitrogen oxides and ammonia via frequency modulation in gas sensors

Master Thesis - Mid term seminar

Marcos F Mourão

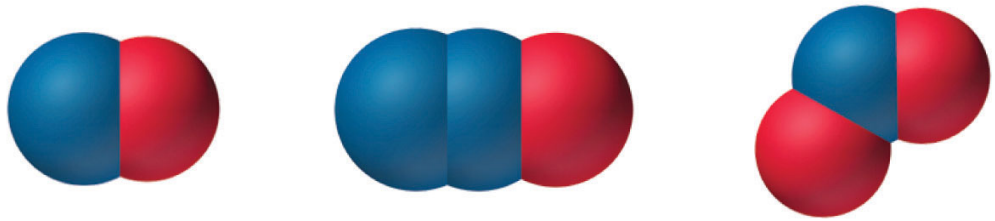
March 25, 2021

Outline

Problem in a nutshell

Motivation

NO_x[1]:



NO N_2O NO_2

[1] Image source: ENVIS Centre on Plants and Pollution

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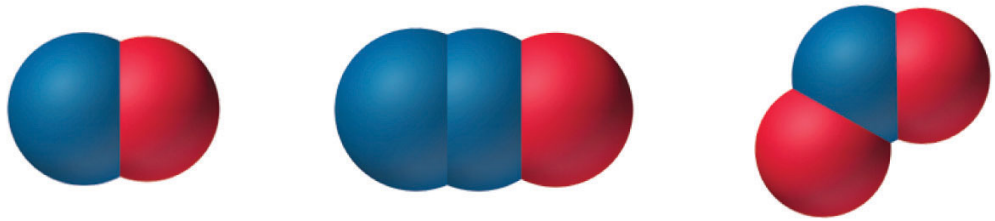

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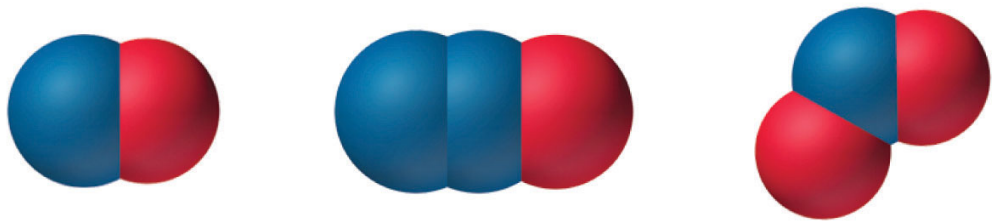

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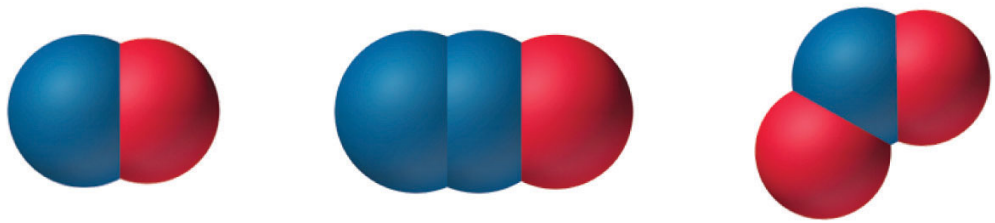

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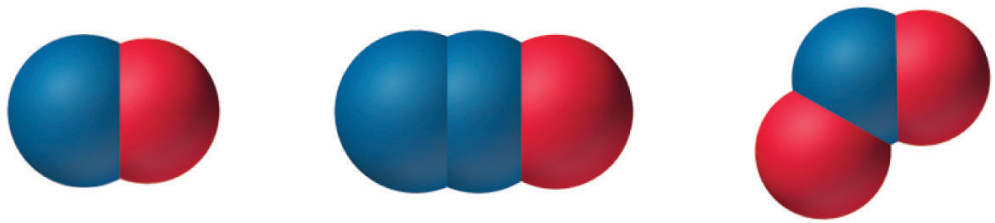

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- Ammonia can "neutralize" NOx, producing water (H_2O) and nitrogen gas (N_2). Both harmless! - Selective catalytic reduction (SCR).
- But ammonia is also hazardous to the environment/humans.

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- **Frequency cycling**.

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Research questions

- Can frequency cycling be used to simultaneously quantify NOx and ammonia concentrations?
- Which method yield best prediction of gas concentrations?

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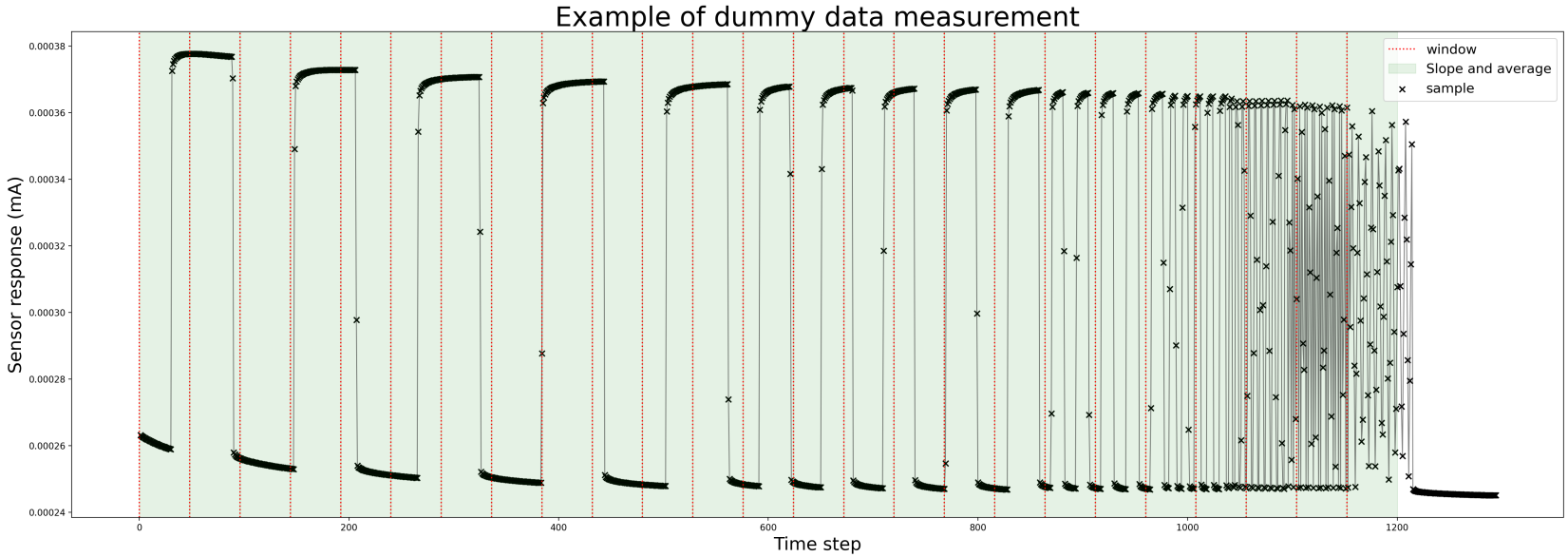
(Dummy) data


Example of dummy data measurement
Sensor response (mA)
Time step
window
Slope and average
sample
0.00038
0.00036
0.00034
0.00032
0.00030
0.00028
0.00026
0.00024
0
200
400
600
800
1000
1200

(Dummy) data

	NO2	NO	NH3	avg0	avg1	avg2	avg3	avg4	avg5	avg6	...	slope15	slope16	slope17	slope18	slope19
0	50	100	25	-0.076323	0.915652	-0.970946	0.999202	-0.363800	-0.026400	0.603117	...	-11.274687	-10.370948	3.966974	-0.479340	-0.897105
1	100	25	100	-0.352834	0.854548	-0.934629	0.984386	-0.188594	0.027784	0.792582	...	-11.287665	-11.421536	1.860088	-2.393667	-3.398451
2	25	100	50	-0.141720	0.874015	-0.959047	0.999862	-0.352600	0.027594	0.561209	...	-4.754586	-11.580877	-3.583086	-3.218467	-1.802992
3	50	25	100	-0.249815	0.890990	-0.850049	1.123559	-0.242452	0.254415	0.645449	...	1.367344	-11.669267	-6.962770	2.391163	3.753269
4	100	100	25	-0.188844	0.765447	-1.026246	0.960545	-0.511767	0.027451	0.372231	...	1.599057	-10.410155	-6.444129	3.060615	4.349158

5 rows × 50 columns

Methods

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1. Linear Regression

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2. Principal Component Regression

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5. Some non-parametric regression - tbd

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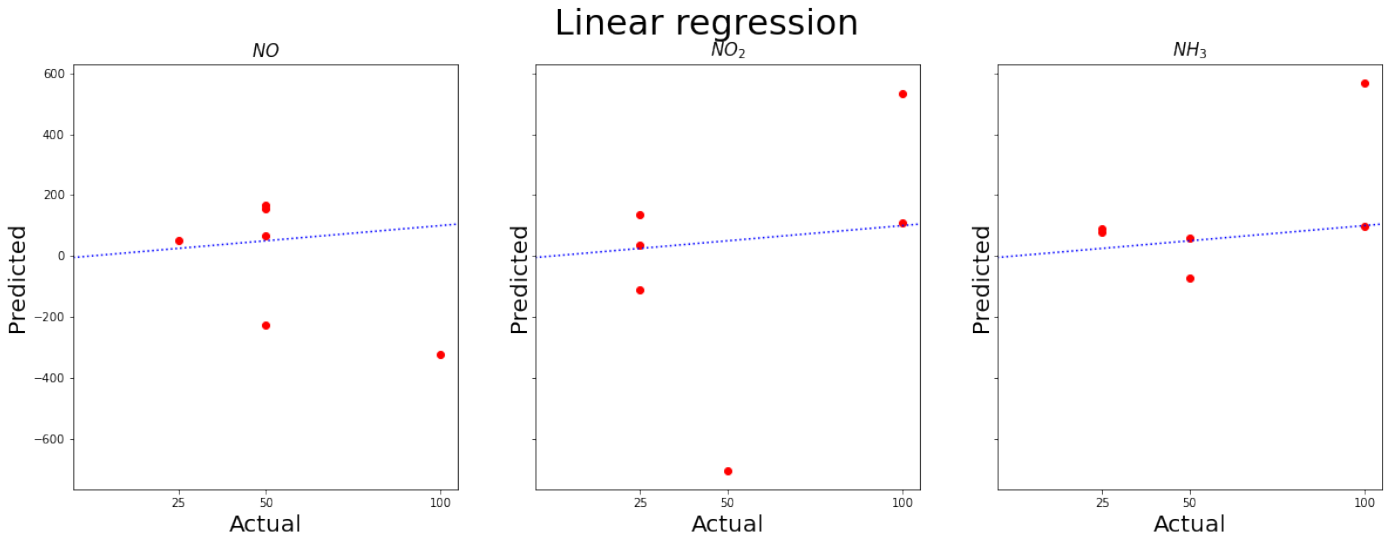

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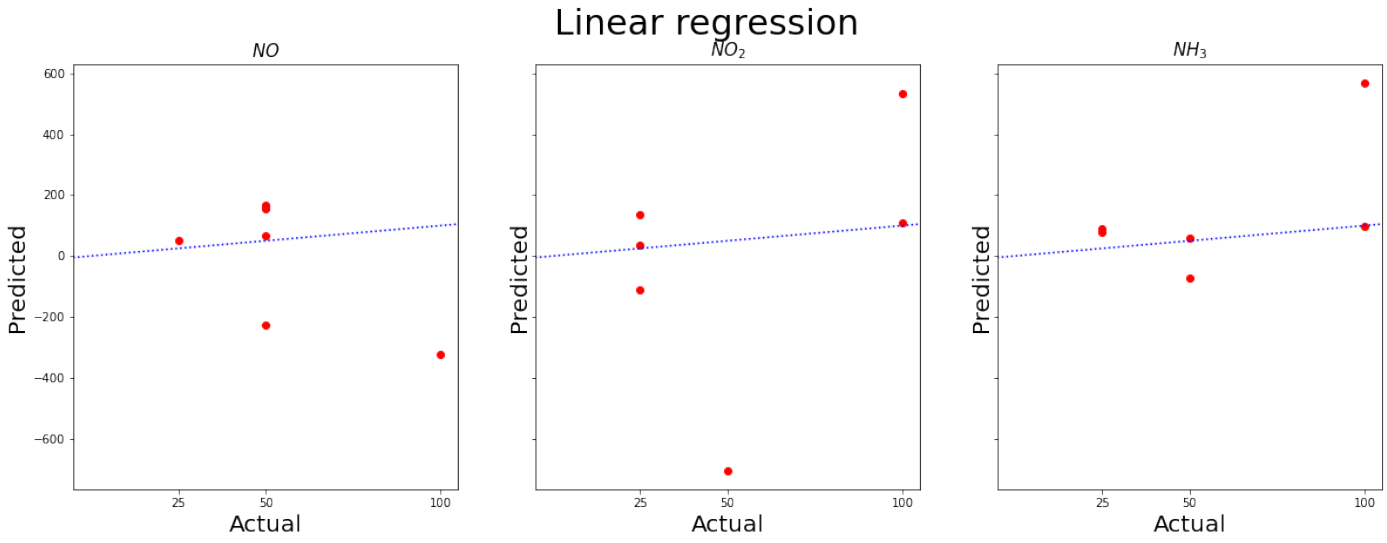

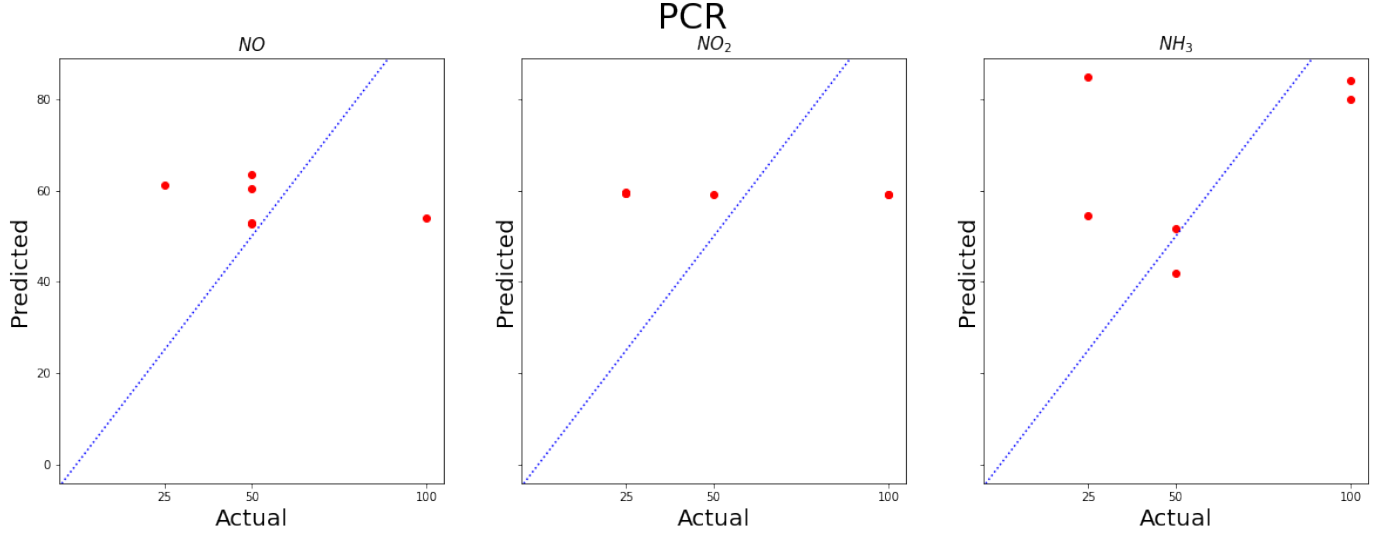

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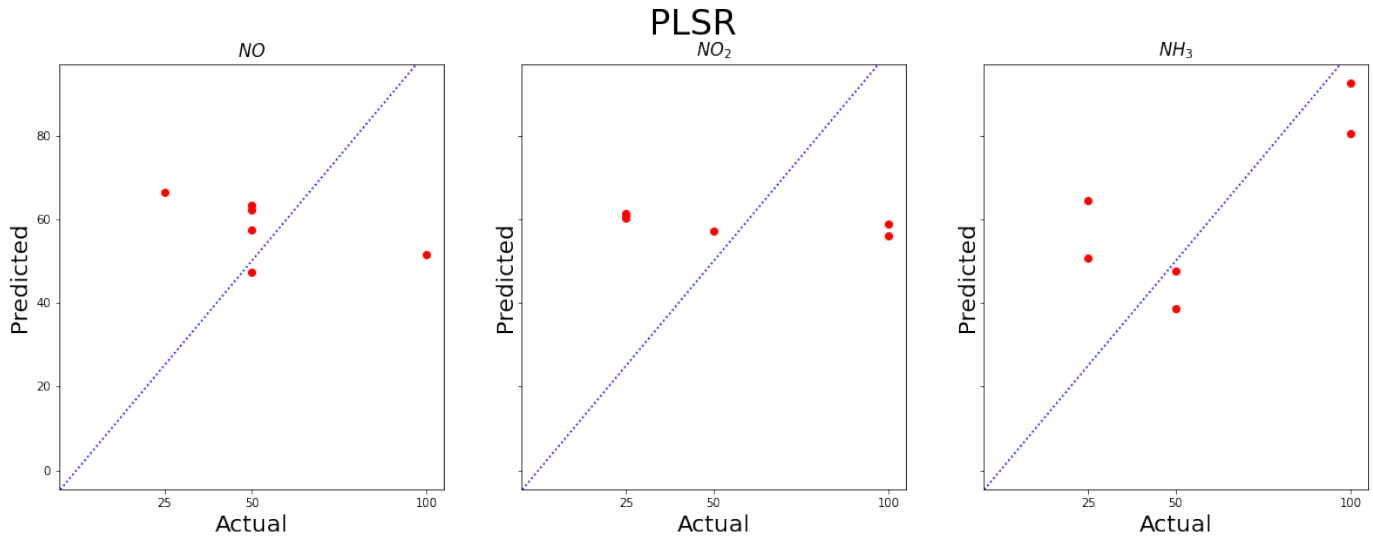

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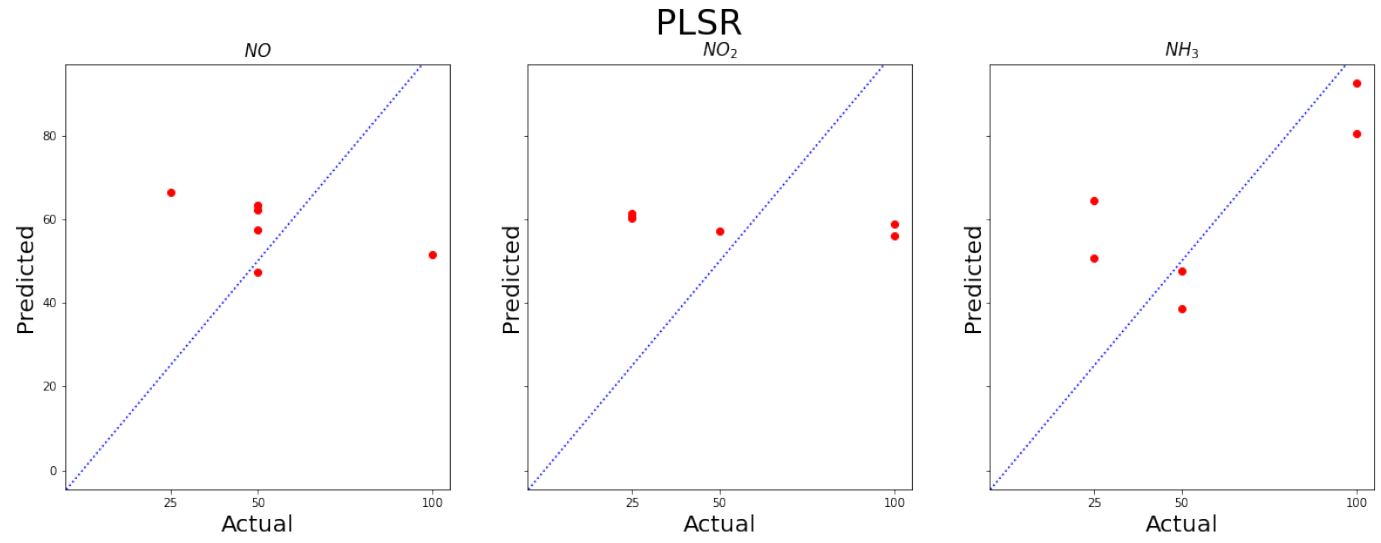

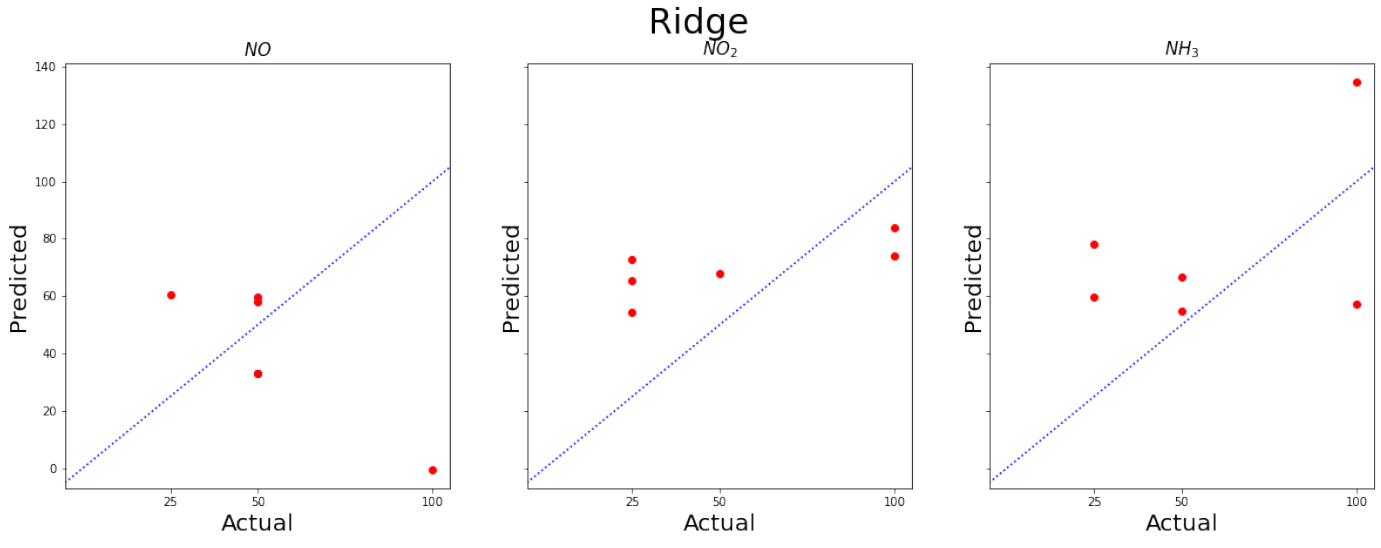

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- Shape features directly measured

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Table: Data acquisition details

Parameter	**Value**
Factors (gases)	3
Levels (concentrations)	5
Frequencies	16
Features per frequency	4 (2 slopes and 2 averages)
Features per cycle	64
Number of cycles	5
Data points per mixture	320
Number of mixtures	125
Datapoints per experiment	40.000
Number of experiments	3
Total data points	120.000

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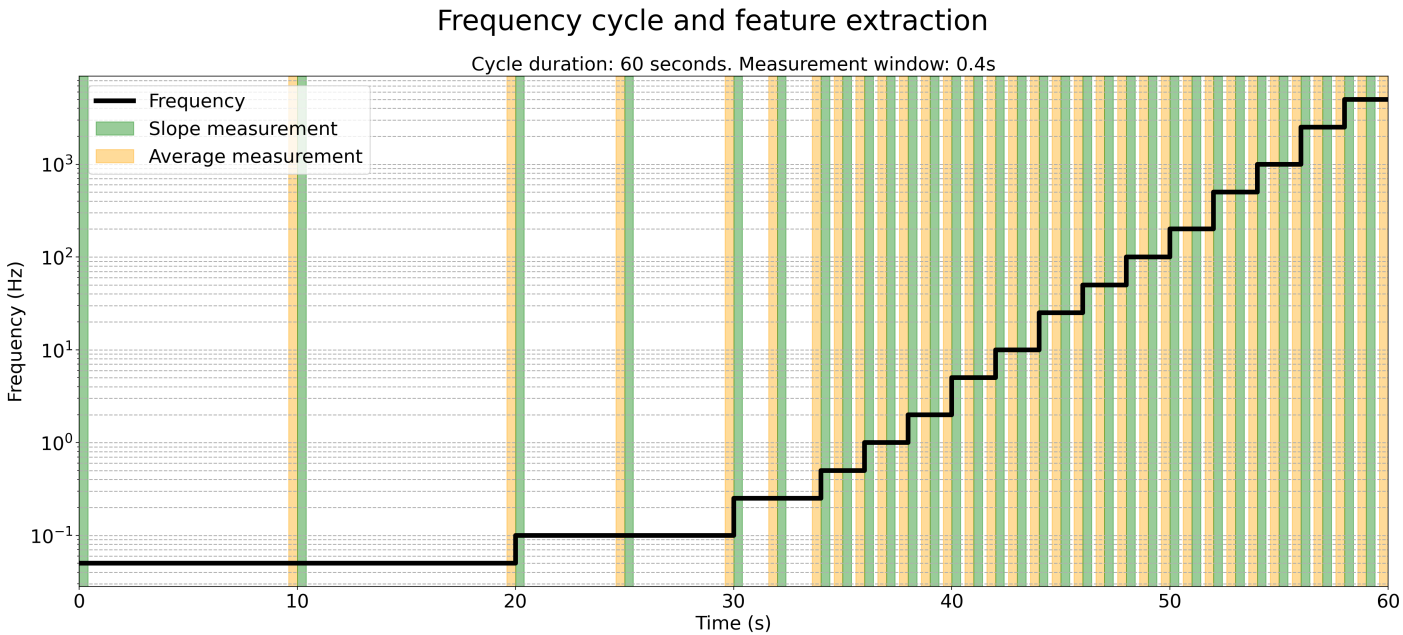

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5. Keep writing!

Thank you!