

SUPPLEMENTARY MATERIAL

Hybrid Digital Twin Framework for Real-Time Indoor Air Quality Monitoring and Filtration Optimization

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Table S1. Sensor placement in the room

Type of Sensor	X	Y	Z
Wings 316	115	137	100
Wings 4	115	137	13
Wings 7	310	225	100
Wings 13	310	225	145
Labservice Analytica 68	310	225	13
Labservice Analytica 69	115	137	145

Table S2. Sensor Accuracy of Wings devices

Type of Sensor	Parameter	Accuracy R ²
Wings Indoor	CO ₂	0,41
	TVOC	0,40
	PM ₁	0,98
	PM _{2,5}	0,98
	PM ₁₀	0,98
	Temperature	0,75
	RH	0,93
	Pressure	1,0
Wings Outdoor	NO ₂	0,66
	O ₃	0,83
	SO ₂	0,80
	CO	0,91

	PM ₁	0,97
	PM _{2,5}	0,98
	PM ₁₀	0,95
	NO	0,92
	Temperature	0,90
	RH	0,96

Table S3. Sensor Accuracy of Labservice Analytica devices

Type of Sensor	Parameter	Accuracy
Labservice Analytica	CO ₂ (ppm)	+/- 30 ppm
	O ₃ (ppb)	5 ppb
	CO (ppb)	20 ppb
	PM ₁₀ (µg/m ³)	+/- 25 µg/m ³
	PM _{2.5} (µg/m ³)	+/- 10 µg/m ³
	TVOC (ppm)	0.5 ppb
	NO ₂ (ppb)	5 ppb

Table S4. List of all measured parameters

Type of Sensor	Measurement	Description
Xiaomi Door/window	str	state of doors/windows, on opened, off closed
Labservice Analytica 68 and Labservice Analytica 69	timestamp	timestamp in UTC
	NetCO ₂ -CO ₂ (ppm)	CO ₂ in ppm
	NetCO ₂ -CO ₂ ug	CO ₂ in ug
	NetADC O ₃ -O ₃ ug	O ₃ in ug
	NetADC O ₃ -O ₃ (ppb)	O ₃ in ppb
	NetADC CO-CO ug	CO in ug
	NetADC CO-CO(ppb)	CO in ppb
	NetPM-PM ₁₀ (µg/m ³)	PM ₁₀ in (µg/m ³)
	NetPM-PM ₂₅ (µg/m ³)	PM _{2,5} in (µg/m ³)
	NetPid P ₁ -PPB(ppm)	TVOC in ppm
	NetPid P ₁ -PPB ug	TVOC in ug
	NetBME280-PERC(%)	Relative humidity in %
	NetBME280-TEMP EXT(°C)	Temperature in °C
	NetBME280-HPA(hPa)	Atmospheric pressure in hPa
	NetADC NO ₂ -NO ₂ ug	NO ₂ in ug
	NetADC NO ₂ -NO ₂ (ppb)	NO ₂ in ppb
Wings 13, 4, 7 and 316	timestamp	Timestamp in zagreb time
	timezone	Timezone
	CO ₂	CO ₂ in ppm
	TVOC	TVOC in ppb
	CO	CO in ppm
	PM ₁	PM ₁ in (µg/m ³)
	PM ₂₅	PM _{2,5} in (µg/m ³)
	PM ₁₀	PM ₁₀ in (µg/m ³)
	temperature	Temperature in °C
	humidity	Relative humidity in %

Wings outdoor device	atmospheric pressure	Atmospheric pressure in hPa
	timestamp	Timestamp in zagreb time
	timezone	Timezone
	NO2	NO ₂ in ppb
	O3	O ₃ in ppb
	SO2	SO ₂ in ppb
	CO	CO in ppb
	PM1	PM ₁ in (µg/m ³)
	PM25	PM _{2.5} in (µg/m ³)
	PM10	PM ₁₀ in (µg/m ³)
	NO	NO in ppb
	temperature	Temperature in °C
	humidity	Relative humidity in %
	atmospheric pressure	Atmospheric pressure in hPa
	noise	Noise in dB
	CO2	CO ₂ in ppm
Traffic	timestamp	Timestamp in zagreb time
	car	Number of cars that passed by in a minute
	truch	Number of trucks that passed by in a minute
	bus	Number of buses that passed by in a minute
	motorcycle	Number of motorcycles that passed by in a minute

Table S5 Filtering unit placement in the room

X	Y	Z
45	90	50
45	90	150
90	45	50
90	45	150
90	270	50
90	270	150
200	90	50
200	90	150
270	45	50
270	45	150
270	270	50
270	270	150
330	90	50
330	90	150

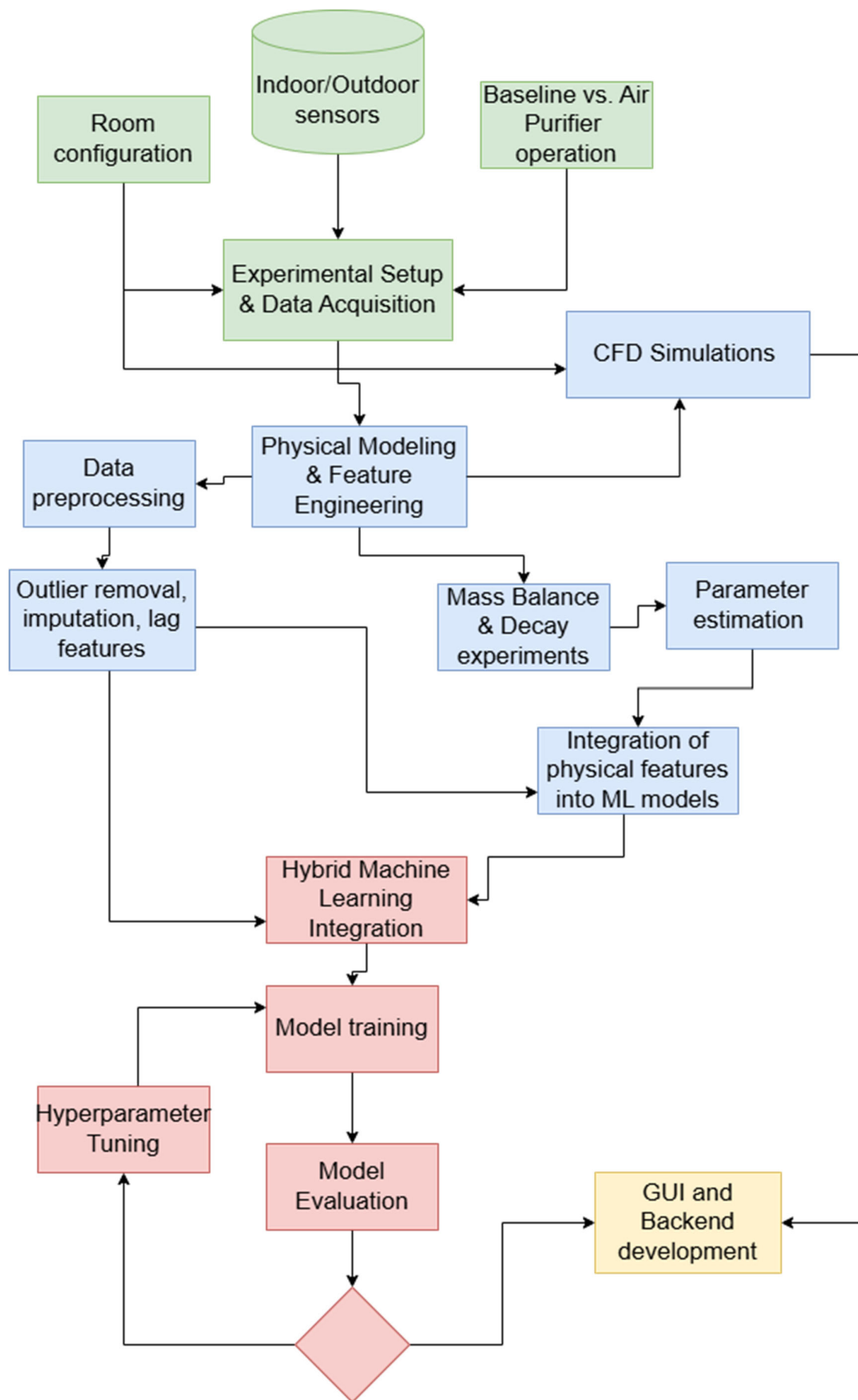


Figure S1: Flowchart of the study phases



Figure S2: Satellite and street view of the study location and photographs of the test site.

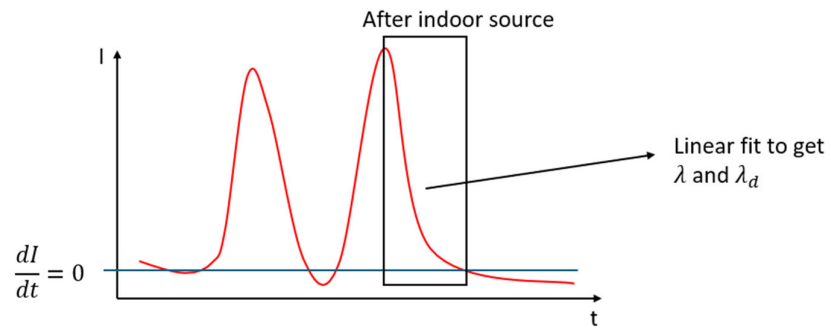


Figure S3. Calculation of λ and λ_d

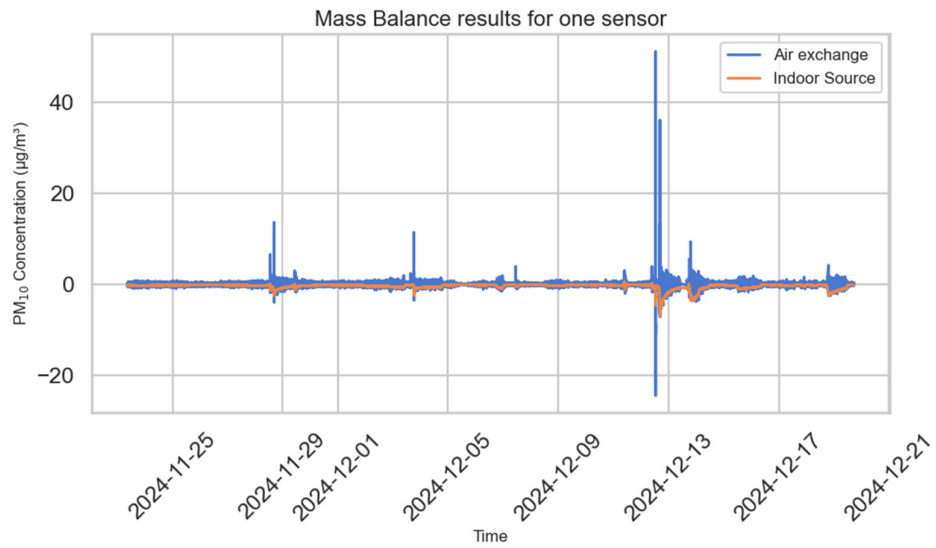


Figure S4. Mass Balance results for one sensor

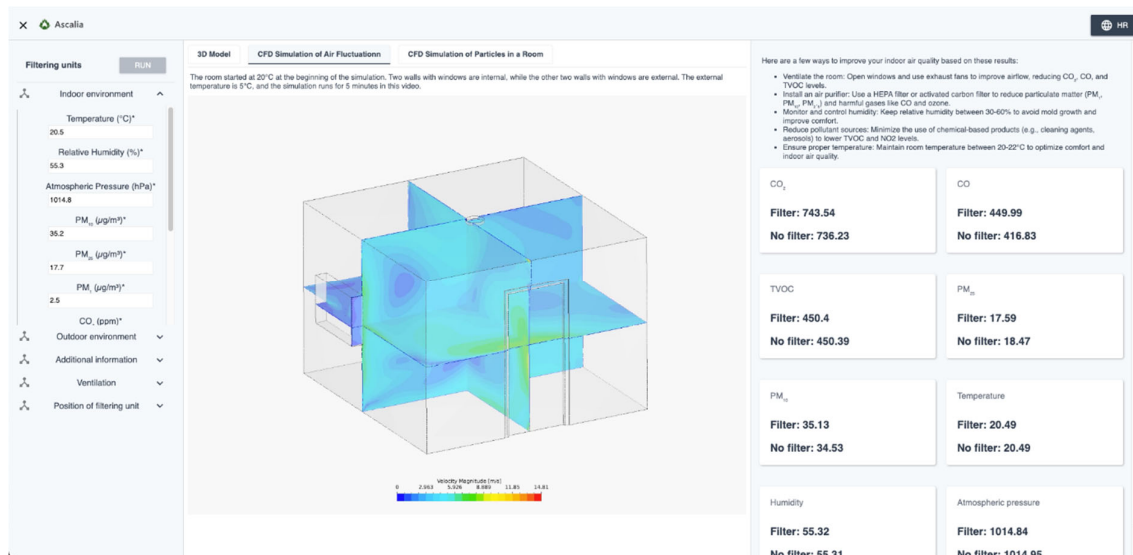


Figure S5. GUI with tab CFD Simulation of Air Fluctuation

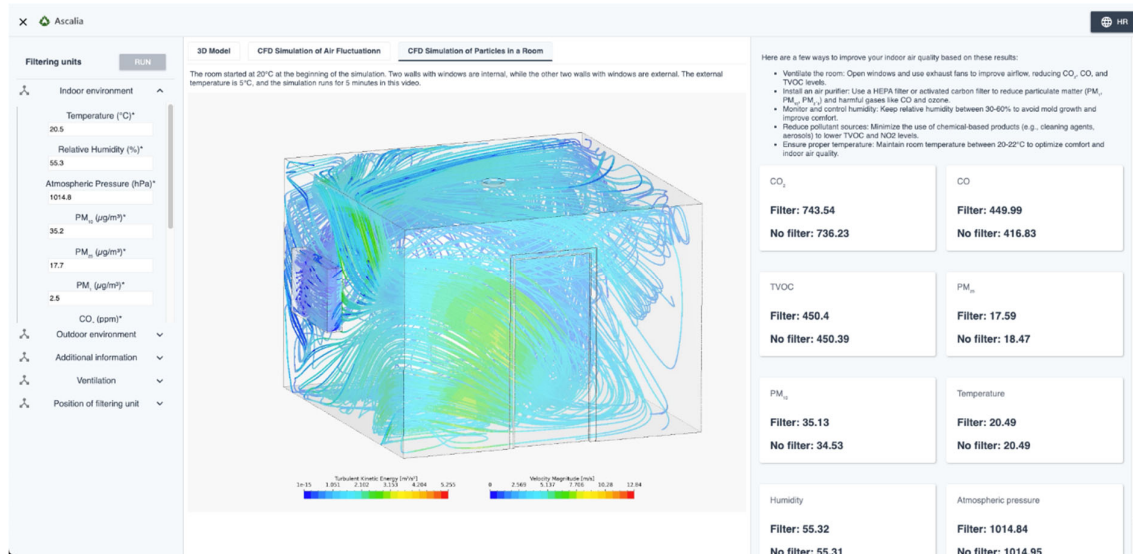


Figure S6. GUI with tab CFD Simulation of Particles in a Room

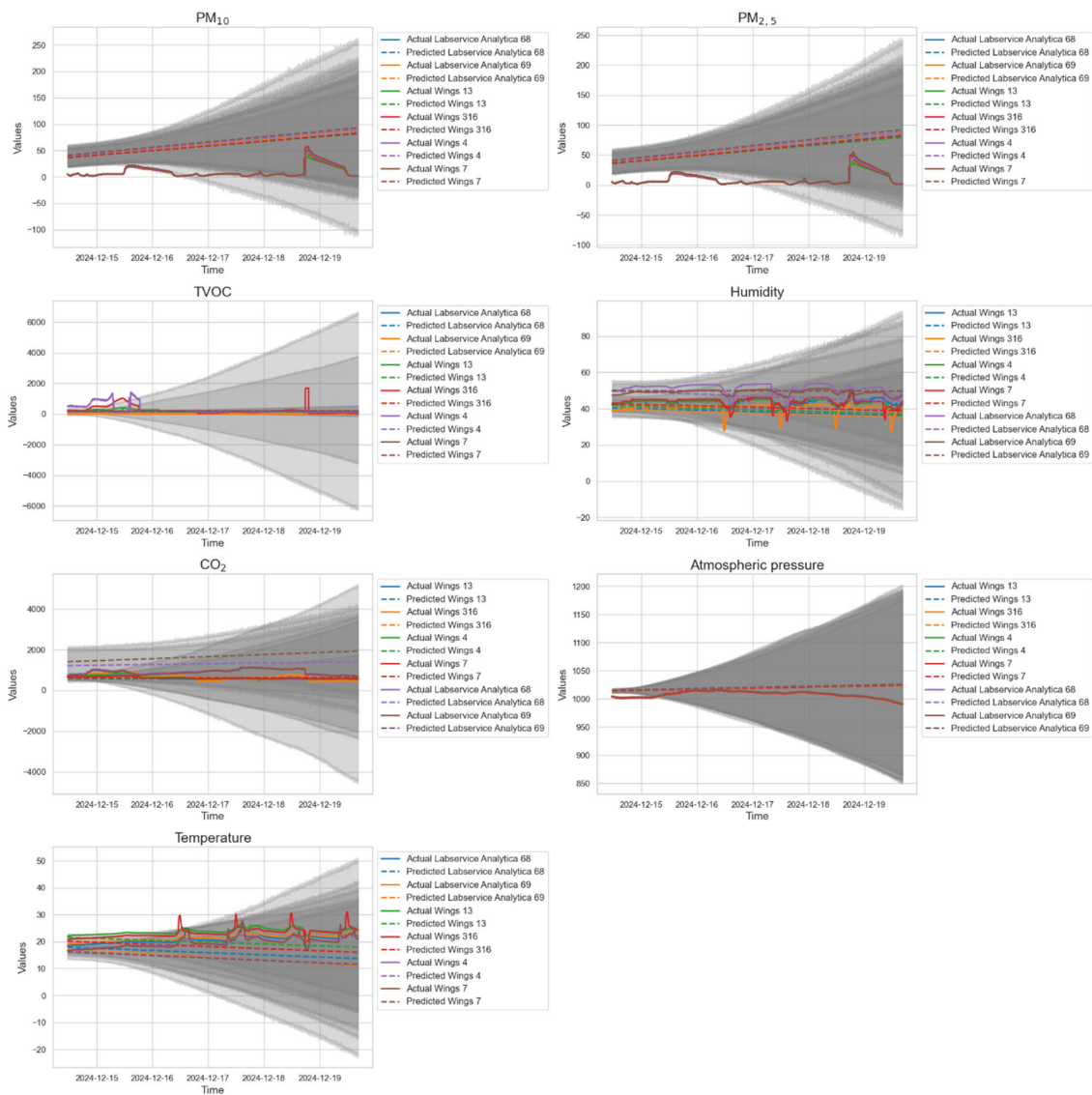


Figure S7. Results of the Prophet model on the test set