Machine Learning - Software Project

Component 1

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1 Room occupancy estimation

1.1 Problem description

The addressed problem requires to estimate the number of people in a 6m x 4.6m room using the data provided by a set of sensors that measure light, temperature, sound, CO_2 and movements via infrared (a visualization of the scheme of the room can be seen in Figure 1). Table 1 lists the accuracy and resolution of each used sensor.

Table 1: Sensor Specifications [SJC+18]

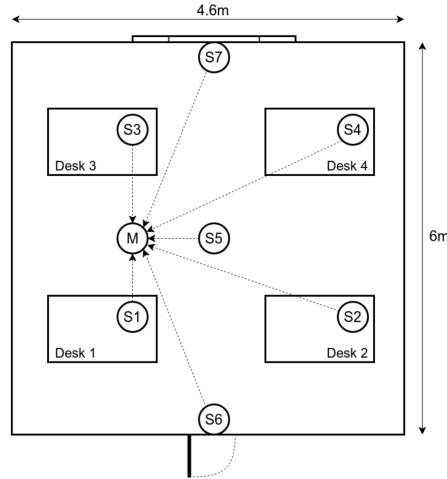| Sensor	Parameter	Resolution	Accuracy
BH1750	Light	1 Lux	1.2 times
MAX4466	Sound	0.01 V	-
MH-Z14A	CO2	5 ppm	±50 ppm
Digital PIR	Motion	-	-

Figure 1: The star-based scheme of the sensors where the data was obtained [SJC+18].

1.2 Problem specification

1.2.1 Variables Details

Variable	Description	Units
Input Data (Features)		
Date	Date of the recorded data	YYYY/MM/DD
Time	Time of the recorded data	HH:MM:SS
S1_Temp	Temperature reading from S_1	°C
S2_Temp	Temperature reading from S_2	°C
S3_Temp	Temperature reading from S_3	°C
S4_Temp	Temperature reading from S_4	°C
S1_Light	Light intensity reading from S_1	Lux
S2_Light	Light intensity reading from S_2	Lux
S3_Light	Light intensity reading from S_3	Lux
S4_Light	Light intensity reading from S_4	Lux
S1_Sound	Sound level from S_1 measured by ADC amplifier	Volts
S2_Sound	Sound level from S_2 measured by ADC amplifier	Volts
S3_Sound	Sound level from S_3 measured by ADC amplifier	Volts
S4_Sound	Sound level from S_4 measured by ADC amplifier	Volts
S5_CO2	Carbon dioxide concentration reading from S_5	PPM
S5_CO2_Slope	Slope of CO_2 concentration values (over a sliding window)	
S6_PIR	Binary indicator of motion detection from PIR S_6	
S7_PIR	Binary indicator of motion detection from PIR S_7	
Output Data (Target)		
Count	Number of people in the room	

1.2.2 Variables Constraints

Variable	Type	Domain
Input Data (Features)		
Date	Temporal	2017/12/22 - 2018/01/11
Time	Temporal	00:00:00 - 23:59:59
S1_Temp	Continuous	[1, 50] [Cho07]
S2_Temp	Continuous	[1, 50] [Cho07]
S3_Temp	Continuous	[1, 50] [Cho07]
S4_Temp	Continuous	[1, 50] [Cho07]
S1_Light	Integer	{0...500} [Bio21]
S2_Light	Integer	{0...500} [Bio21]
S3_Light	Integer	{0...500} [Bio21]
S4_Light	Integer	{0...500} [Bio21]
S1_Sound	Continuous	[0, 5] [Int10]
S2_Sound	Continuous	[0, 5] [Int10]
S3_Sound	Continuous	[0, 5] [Int10]
S4_Sound	Continuous	[0, 5] [Int10]
S5_CO2	Integer	{0...2000} [ZWETC15]
S5_CO2_Slope	Continuous	$\mathbb{Q}$
S6_PIR	Binary	{0, 1}
S7_PIR	Binary	{0, 1}
Output Data (Target)		
Count	Integer	{0...3}

Note: *Sensor x was denoted with either S_x or Sx_NAME.*

1.3 Learning tasks specification

1.3.1 Supervised Regression

- **Task**: Predicting a continuous non-negative variable that estimates the number of people in the room based on the sensors' measurements. This value is eventually rounded to the nearest integer in order to obtain the final result;

- **Performance measure**: Error-quantifying metrics: Mean Absolute Error, Mean Squared Error; Relationship metric: R-Squared score;

- **Experience**: Dataset of room ambient measurements collected over various time periods on different dates, corresponding to a number of people that occupy it.

1.3.2 Supervised Classification

- **Task**: Classifying room occupancy levels into four categories based on sensor measurements: 0 (empty), 1 (1 people), 2 (2 people), and 3 (3 people).

- **Performance measure**: Accuracy, Precision, Recall, F1 Score; Area Under the Receiver Operating Characteristic Curve (AUC-ROC).

- **Experience**: Dataset of room ambient measurements collected over various time periods on different dates, corresponding to the occupancy categories (0, 1, 2, 3).

References

[Bio21]   Biomaker. Lux light sensor (bh1750), 2021.

[Cho07]   Shein-Chung Chow. *Statistical design and analysis of stability studies.* Chapman and Hall/CRC, 2007.

[Int10]   Maxim Integrated. MAX4465–MAX4469 low-power, low-noise, op amps for microphone preamplifiers, 2010.

[SJC+18]   Adarsh Pal Singh, Vivek Jain, Sachin Chaudhari, Frank Alexander Kraemer, Stefan Werner, and Vishal Garg. Machine learning-based occupancy estimation using multivariate sensor nodes. In *2018 IEEE Globecom Workshops (GC Wkshps)*, pages 1–6. IEEE, 2018.

[ZWETC15] LTD. Zhengzhou Winsen Electronics Technology CO. Intelligent infrared carbon dioxide module (model: Mh-z14a), 2015.