Mini Project - analysis of the level of discomfort in a given smart home

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Abstract

In a world facing climate change it is important to reduce the use of energy to minimize its environmental impacts. Since the building sector takes up a great share of the energy use it is important to make energy reducing measurements there. One key player in energy use reducements is smart sensors. Smart sensors can also be used to create a better indoor environmental quality which is important to take into consideration. In this project, the level of discomfort in a given house with given data has been examined. The given data showed that there are many parameters in the house that reach the thresholds for discomfort.

Contents

1. Introduction

In the U.S, buildings consume 41% of the total energy. To be able to increase this amount one important part is to optimize the control of building environmental variables. These variables can be measured with smart sensors and can be temperature, humidity, CO2-level etc. Since the energy consumption in a building is directly connected to the occupants behavior, it is also important to take them into consideration while trying to reduce the energy use to minimize the building sector's environmental impact. The smart sensors can be used to create a better indoor environment quality and to better control the energy usage. Furthermore, the indoor environmental quality influences the occupants health as well as the building. Therefore, the aim in this project is to, by using data from smart sensors, analyze the level of discomfort in a given smart home. (Dong, B., et al., 2019)

2. Data collection

The data was collected from Grafana (Ferrari, J., 2022). We used a Python code to extract it and each data was then available in a csv file. Since the sensors were not the same for each data, we had different time steps. This is why we standardized the data by taking the mean value of each sensor for a time step of 30 minutes. Then we merged all the data into one unique excel file, which allows us to analyze them. See figure 1 for an example of the data set with the meshed data and the same time step.

datetime	CO2 chambre hiver	CO2 salon hiver	T salon hiver	T chambre hiver	H salon hiver	H chambre hiver	noise hiver
2021-12-24 00:00:00	1987	570,5	21	22,46	45	54,21	37
2021-12-24 00:30:00	1787,896552	553,25	21	22,57	45	52,66	36,5
2021-12-24 01:00:00	1704,733333	547	21	22,695	45	52,63	36,75
2021-12-24 01:30:00	1764,724138	524,5	21	22,82666667	45	53,37	37
2021-12-24 02:00:00	1787,241379	521,25	20,95	22,98	44,5	53	36,5
2021-12-24 02:30:00	1799,642857	506	20,9	23,07	44	52,985	36
2021-12-24 03:00:00	1804,846154	491	20,9	23,16	44	52,87	37
2021-12-24 03:30:00	1827,296296	483	20,9		44	52,95	37
2021-12-24 04:00:00	1838,125	478	20,9	23,25	44	53,01	37
2021-12-24 04:30:00	1849,185185	475,6666667	20,85		44		36,5
2021-12-24 05:00:00	1846,137931	486,75	20,8	23,38	44	52,73	36,33333333
2021-12-24 05:30:00	1842,481481	482	20,9		44		37
2021-12-24 06:00:00	1853,366667	487,5	20,9	23,485	44	52,71	37
2021-12-24 06:30:00	1393	529	20,95	23,235	44	46,745	42,5
2021-12-24 07:00:00	1093,035714	683,5	21,125	23,15	44,5	45,92	48,5
2021-12-24 07:30:00	789,5925926	827,5	21,4	22,1	45	33,535	48,75
2021-12-24 08:00:00	460,7586207	879,75	21,6	20,486	45	34,554	53,5

Figure 1: Showing an extraction of the data set structure.

As can be seen in figure 1, data is missing for some time steps. The missing data was assumed to not affect the trend. There were however not considered to be any outliers that needed to be managed. That is to say, no data points that were considered to have been collected incorrectly and would have had higher and lower values than normal and would have distorted the results if they were not to be deleted.

The data was collected for one week during the summer, 19/7-21 - 25/7-21, and one week during the winter, 24/12-21 - 30/12-21. The data for the following parameters were collected for both the summer and the winter week: the CO2 level in the bedroom number 1, the CO2 level in the living room, the temperature in the living room, the temperature in the bedroom number 1, the humidity in the living room, the humidity in the bedroom number 1 and the noise in the house (living room).

3. Results from the sensor data

In this section the results of the collected data will be presented, which then can be used to evaluate the level of comfort in the house during summer and winter.

3.1 CO2-levels

The CO2 level in the bedroom varies between 500 ppm to around 3400 ppm during the summer and between 500 ppm to around 3000 ppm during the winter week, see figure 2.

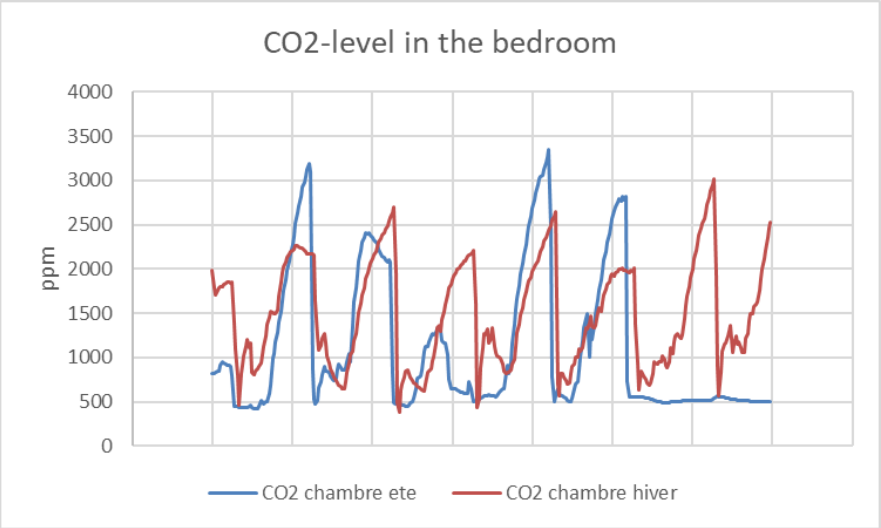

Figure 2: Showing the CO2 level in the bedroom during the summer and the winter week.

The CO2 level in the living room during the summer week is however lower than in the bedroom and varies between around 400 ppm to 1600 ppm. The CO2 level in the living room during the winter week shows similar values as during the summer week and varies between around 400 ppm to 1600 ppm, see figure 3.

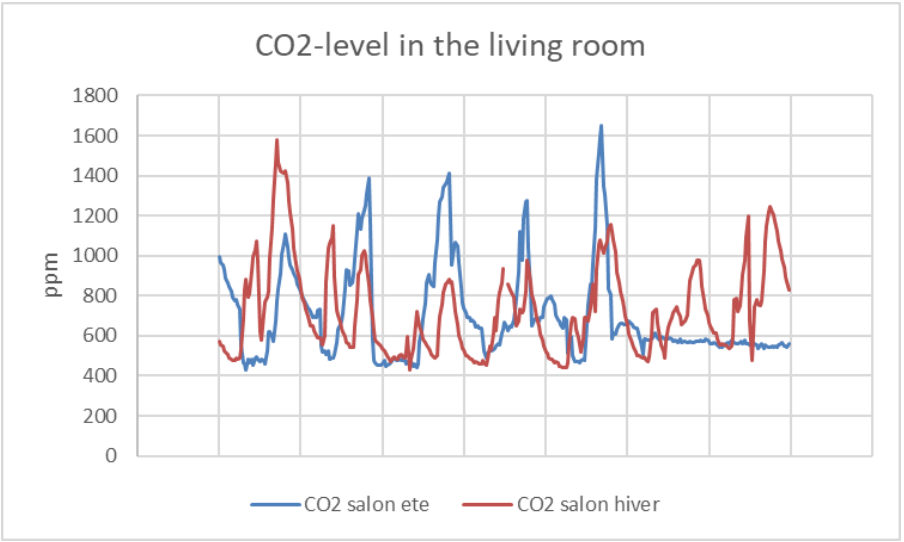

Figure 3: Showing the CO2 level in the living room during the summer and the winter week.

3.2 Temperatures

When it comes to temperatures, the temperature in the living room during the summer week varies between 23℃ - 27℃ and between 20,3℃ - 22,5℃ for the winter week, see figure 4.

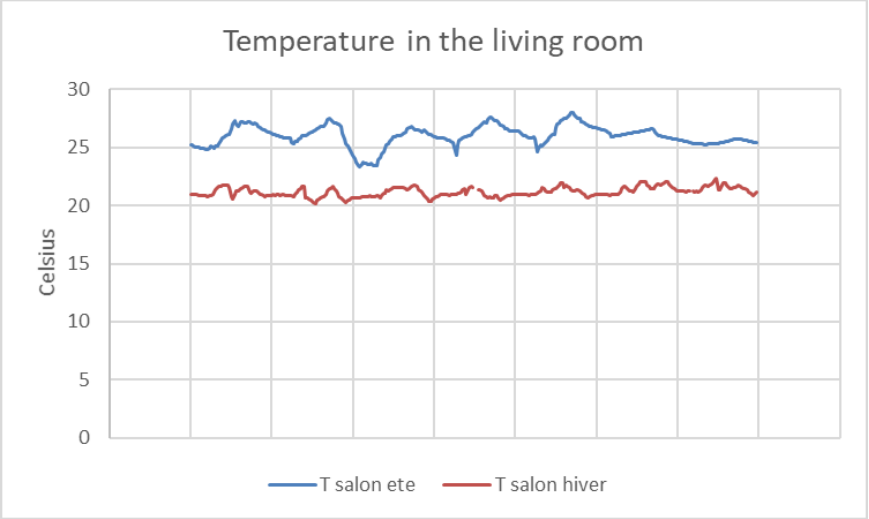

Figure 4: Showing the temperature in the living room.

The bedroom has similar temperatures during the summer week, around 24℃ - 26,5 ℃. The temperature in the bedroom during the winter week varies around 19℃ - 24 ℃, see figure 5.

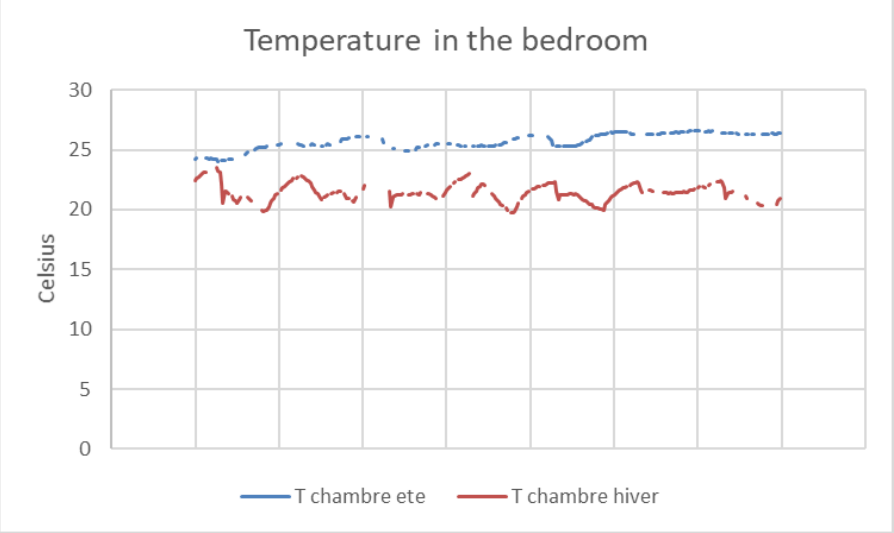

Figure 5: Showing the temperature level in the bedroom during the summer and winter week.

3.3 Humidity

The humidity in the living room varies between 55-65 % during the summer week and between 42-58 % during the winter week, see figure 6.

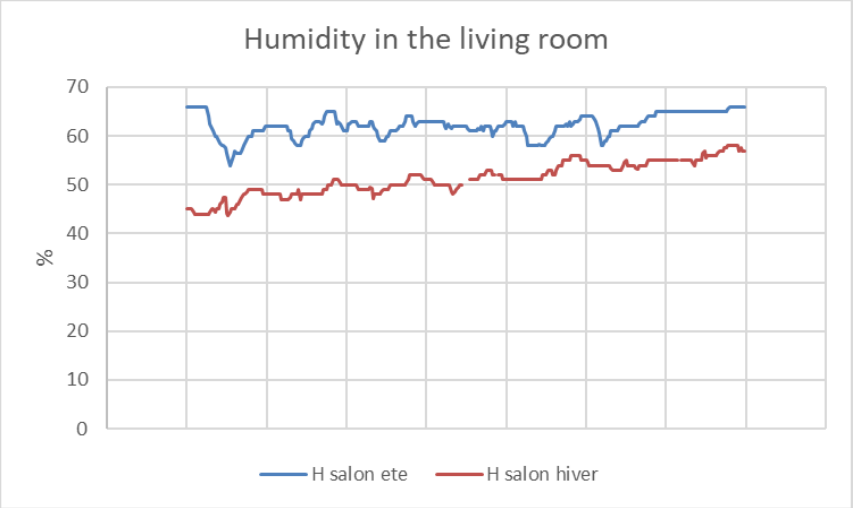

Figure 6: Showing the humidity level in the living room during the summer and winter week.

The humidity in the bedroom varies between 60-75 % during the summer week and between 35-65 % during the winter week, see figure 7.

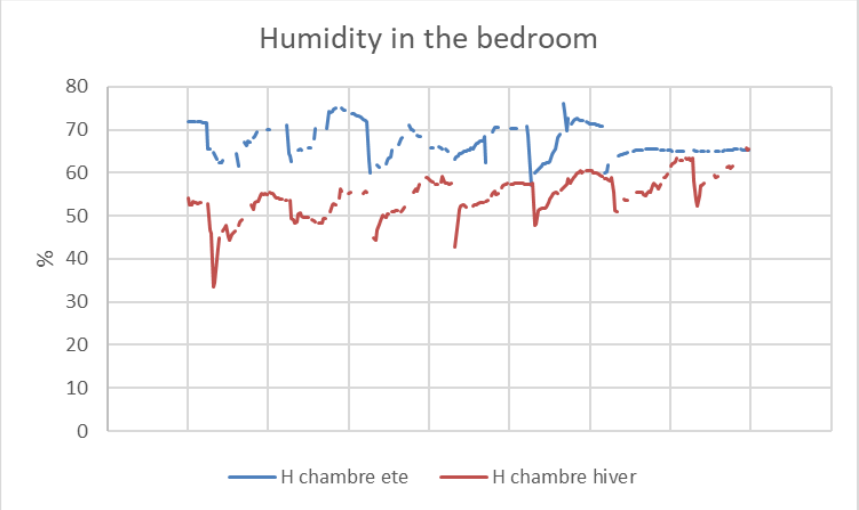

Figure 7: Showing the humidity level in the bedroom during the summer and winter week.

There is a lack of data for the humidity in bedroom number 1. However, it is not necessary to fill in data because the trend is not affected by these data lacking.

3.4 Noise

The level of noise in the house does not differ much between the summer and the winter. It varies between 38 - 62 dB for the summer week and between 38 - 68 dB for the winter week, see figure 8.

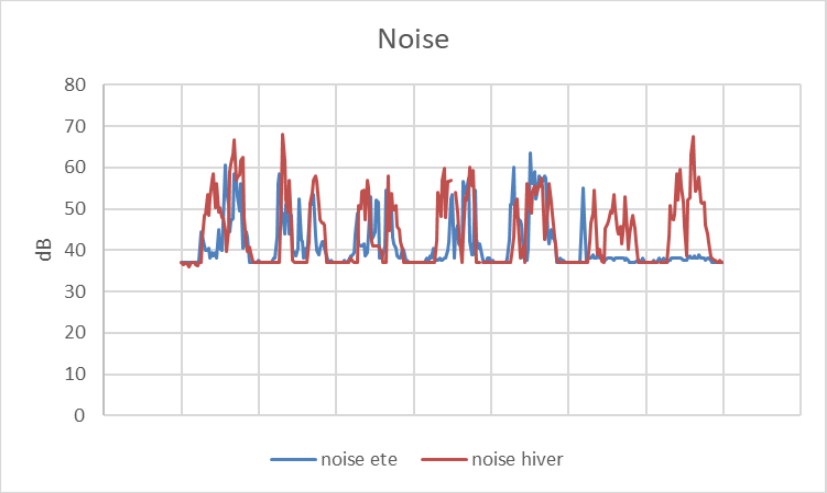

Figure 8: Showing the noise level in the house during the summer week.

4. Comparison with the ideal values for comfort

High levels of CO2 concentrations, above 3000 ppm, indicates improper ventilation and poor air quality in bedrooms (P. Batoga, M. Badurab, 2013). Since there are collected values during the summer week that measure up to 3400 ppm in the bedroom, the bedroom has poor air quality which can disturb the sleep. However, the highest measured value in the bedroom during the winter week is 3000 ppm and the air quality can be assumed to be sufficient. The air quality is shown to be good in the living room during both the summer and the winter week (highest value measured 1600 ppm).

The indoor temperature should be at least 18℃ to avoid health risks (Public Health England, 2014) . Since the lowest measured temperature was 19℃ it is not too cold in the house even during the winter week. However the indoor temperature should not exceed 26 ℃ during the summer and there are both measurements over 26 ℃ in the bedroom and the living room (fastighetsagarna.se, 2022).

When it comes to the humidity, the recommended humidity indoors is 30-70%. Air indoors with a high humidity, humidity over 70%, can create problems (Folkhälsomyndigheten, 2005). Since the humidity varies between 60-75 % in the bedroom during the summer there could be problems.

According to WHO, the guideline values for annoyance when it comes to noise indoors are set to 50 or 55dB (WHO, n.d). Since there have been noise levels measured that are higher than 55dB there is a risk that the people living in the house are annoyed by the noise. This level of noise can be explained by the presence of children in the house, who may play together in the livingroom and by extension who create noise in this place of the house. Since the noise levels are the same in winter and in summer, there is no correlation between the noise in the living room and the season.

5. Conclusions

According to the literature and the data we extracted, we can say that there is a problem with discomfort in the house. The CO2 level in the bedroom number 1, the indoor temperature during the summer, the humidity in summer, and the noise level are too high. This can affect the occupants' health.

However, some of these parameters can be improved by the occupants, for instance the CO2 level in the bedroom thanks to a regular aeration of the room.

Moreover, if the bedroom is not used (children studying in another city, guest room …) that can explain the values of humidity and CO2 level and may not impact so much the comfort of the permanent occupants of the house.

References

- Batog, Piotr, and Marek Badura. “Dynamic of Changes in Carbon Dioxide Concentration in Bedrooms.” *Procedia Engineering*, Modern Building Materials, Structures and Techniques, 57 (January 1, 2013): 175–82. https://doi.org/10.1016/j.proeng.2013.04.025. [1]
- “Comnoise-4.Pdf.” Accessed January 31, 2022. https://www.who.int/docstore/peh/noise/Comnoise-4.pdf. [2]
- Dong, Bing, Vishnu Prakash, Fan Feng, and Zheng O’Neill. “A Review of Smart Building Sensing System for Better Indoor Environment Control.” *Energy and Buildings* 199 (September 15, 2019): 29–46. https://doi.org/10.1016/j.enbuild.2019.06.025. [3]
- “Grafana.” Accessed January 31, 2022. https://jarvis-oneforall.duckdns.org:3000/login. [4]
- “Hur varmt får det vara i lägenheten? - Fastighetsägarna.” Accessed January 31, 2022. https://www.fastighetsagarna.se/aktuellt/nyheter/sa-varmt-far-det-vara-i-lagenheten/. [5]
- Jevons, R., C. Carmichael, A. Crossley, and A. Bone. “Minimum Indoor Temperature Threshold Recommendations for English Homes in Winter - A Systematic Review.” *Public Health* 136 (July 2016): 4–12. https://doi.org/10.1016/j.puhe.2016.02.007. [6]
- “Temperatur inomhus (Handbok) — Folkhälsomyndigheten.” Accessed January 31, 2022. https://www.folkhalsomyndigheten.se/publicerat-material/publikationsarkiv/t/temperatur-inomhus/. [7]