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Effects of building parameters on occupant's window opening behaviour

Youngmin An¹, Bomin Ko¹, Sungwon cho¹, Junseok Park^{1,*}, Jinhwa Jeong¹, Youngtae Chae¹

¹Dept. of Architectural Engineering Hanyang University, Seoul 04763, Republic of Korea

* junpark@hanyang.ac.kr

Abstract. Nowadays a large portion of energy consumption is depends on Residential Building. For these reasons Mechanical ventilation, colling, heating such things also be improved. But Occupants take action to control their indoor environments to adjust their individual flavour. Window Opening & closing If this result is universally applicable most preferred behaviour to adjust their indoor environment. However these behaviour causes an increase in energy consumption in the building. Therefore, if the window opening and closing behavior can be predicted, it will lead to an increase the comfort in the building and a decrease in the energy consumption. Previous studies have confirmed that window opening and closing behavior is significantly affected by ambient temperature. This also indicates that the season also affects window opening. It can be seen that the machine learning algorithm has better prediction than the traditional regression model. The purpose of this study is to investigate the effects of building information (location, number of floors, area, completion year) and human characteristic for indoor environmental control(heating setting temperature), not on the environmental parameters(temperature, humidity, fine dust, etc.) applied to previous machine learning models in the prediction of window opening and closing behavior. If this result is normally applicable, it will make more realistic predictions possible than when predicting with existing environmental parameters alone. This will give a plausibility to the results of simulations on actual buildings.

1. Introduction.

Occupants act as active actors to adjust their living conditions to the comfort conditions their needs. Opening and closing a window is an easy and frequent method of use. These behaviour's tendency can be expected to be influenced by the characteristics of individual people, and also by the information of the residential buildings. The air entering through an opened window has the added advantage of changing indoor air quality in a positive direction. However ambient air entering through the window opening causes a change in energy use. Therefore, if we can predict and understand the window opening and closing circumstance under certain conditions, it can have a positive effect on energy consumption. For the purpose of this study, we conduct a comprehensive analysis of the importance of environmental variables in window opening and closing, the differences in the building information.

2. Method

2.1. Building parameters of the samples

The individuality of the housing units makes a difference in opening and closing the windows. Because there are many differences in characteristics such as location characteristics, air-conditioning system, ventilation equipment, construction year, etc. so grouped and analyzed them.

First of all, since the equipment aspect is commonly applied to A, B, and C apartments, it was judged to be difficult to analyze the tendency. For this reason, we tried to proceed based on the data that are considered to have significant values for each housing units, such as area, number of floors, and location. Since the measurements were carried out in all three apartments, we divided them into three according



to the apartments as a primary classification. Also we proceeded in the same apartment and analyzed the tendency of opening frequency based on building characteristics such as number of floors, area, and housing unit in the same apartment.

Table 1. Housing units information

Sample ID	Housing units	Floor area [m ²]	Floor level ^a	Location Within the building	Heating set Temperature [°C]	Opening frequency (heating)
a	A1	109	4/20	Inner	21.5	14
b	2	109	8/20	Outer	20.6	54
c	3	129	14/26	Outer	22.9	41
d	4	171	8/20	Outer	23.2	4
e	5	109	16/24	Inner	24.5	30
f	6	109	5/24	Inner		
g	B1	145	4/19	Outer	23	18
h	2	135	2/19	Inner	20.9	24
i	3	145	13/19	Inner	21.2	35
j	4	162	12/14	Outer	22.4	83
k	5	162	4/15	Outer		18
l	6	163	10/15	Outer		
m	7	163	6/14	Inner		
n	8	163	5/14	Inner		
o	9	163	1/19	Inner		
p	C1	73	14/21	Inner	22.9	60
q	2	79	9/25	Outer		
r	3	109	9/25	Outer	19.8	34
s	4	79	19/25	Outer	22.9	38
t	5	79	6/20	Outer	18.5	196
u	6	72	7/23	Outer	19.3	121
v	7	79	25/25	Outer		
w	8	163	15/25	Outer		

a floor number/Total Number of floors

In this case of a residential building, several houses are arranged in series on one floor. Therefore, one side of the house may be in contact with the outside air, and may be in contact with the house only. The former case was called Outer and the latter was called inner.

2.2. variable importance outdoor and indoor parameters

In the previous study, we derived the importance of each environment variable (Table 2) through Random Forest (RF) method. Based on these results, we could divide 23 housing units into three groups and proceeded with research based on these three groups. Group_1 is a group with 13 housing units, PMA and Daily OT as main parameters, Group_2 is a group with 6 housing unit as carbon dioxide as a main parameter, Group_3 has indoor relative humidity as a main parameter, and time and carbon dioxide concentration as a subsequent parameter. Try to find what affected the Importance index by comparing the opening time, building degree and human behavior characteristics between groups.

Table 2. Variable importance of the parameters using Gini importance

Subjects	Outdoor			Wind speed (m/s)	PM10 (µg/m ³)	Daily OT (°C)	PMA (°C)	Indoor			CO ₂ Concentration (ppm)	Difference		Time
	Temperature (°C)	RH (%)	Sr (MJ/m ²)					Temperature (°C)	Daily OT (°C)	RH (%)		Out/In temperature	Out/OT	
a	0.11	0.01	0.01	0.01	0.01	0.19	0.16	0.12	0.15	0.08	0.04	0.03	0.05	0.01
b	0.07	0.02	0.02	0.02	0.03	0.17	0.17	0.11	0.11	0.05	0.05	0.04	0.07	0.05
c	0.06	0.02	0.02	0.02	0.04	0.17	0.19	0.05	0.06	0.08	0.06	0.10	0.11	0.02
d	0.11	0.02	0.02	0.04	0.03	0.15	0.20	0.06	0.06	0.04	0.07	0.08	0.08	0.04
e	0.12	0.02	0.02	0.03	0.03	0.17	0.20	0.07	0.06	0.04	0.06	0.07	0.1	0.03
f	0.08	0.06	0.06	0.05	0.06	0.06	0.06	0.05	0.05	0.14	0.08	0.08	0.08	0.09
g	0.04	0.05	0.04	0.04	0.04	0.12	0.17	0.08	0.11	0.08	0.06	0.05	0.05	0.05
h	0.10	0.03	0.06	0.02	0.02	0.07	0.06	0.05	0.06	0.05	0.08	0.14	0.18	0.08
i	0.11	0.02	0.01	0.02	0.04	0.21	0.21	0.08	0.11	0.04	0.03	0.05	0.05	0.02
j	0.07	0.02	0.01	0.01	0.02	0.14	0.26	0.14	0.16	0.05	0.03	0.04	0.04	0.01

k	0.06	0.04	0.03	0.04	0.04	0.13	0.16	0.05	0.05	0.11	0.11	0.07	0.06	0.05
l	0.07	0.07	0.06	0.05	0.06	0.05	0.05	0.07	0.07	0.14	0.09	0.07	0.07	0.08
m	0.04	0.04	0.03	0.03	0.06	0.11	0.16	0.06	0.05	0.09	0.16	0.05	0.05	0.05
n	0.09	0.05	0.07	0.03	0.05	0.12	0.13	0.05	0.05	0.07	0.07	0.07	0.07	0.08
o	0.07	0.05	0.04	0.03	0.05	0.11	0.10	0.04	0.05	0.1	0.14	0.08	0.08	0.05
p	0.10	0.03	0.02	0.02	0.03	0.18	0.17	0.11	0.09	0.04	0.05	0.06	0.08	0.02
q	0.03	0.11	0.03	0.03	0.03	0.12	0.11	0.06	0.06	0.08	0.23	0.04	0.04	0.03
r	0.12	0.05	0.06	0.04	0.05	0.07	0.06	0.04	0.05	0.1	0.12	0.09	0.09	0.07
s	0.13	0.02	0.01	0.01	0.02	0.09	0.12	0.02	0.06	0.02	0.21	0.12	0.14	0.02
t	0.09	0.03	0.04	0.02	0.03	0.12	0.16	0.13	0.09	0.04	0.08	0.06	0.07	0.03
u	0.05	0.05	0.07	0.05	0.05	0.07	0.08	0.08	0.07	0.09	0.13	0.06	0.06	0.1
v	0.03	0.05	0.02	0.05	0.04	0.18	0.23	0.05	0.06	0.17	0.05	0.03	0.02	0.02
w	0.08	0.06	0.06	0.05	0.05	0.04	0.04	0.05	0.05	0.14	0.11	0.08	0.08	0.12
Me														
an	0.08	0.04	0.04	0.03	0.04	0.12	0.14	0.07	0.08	0.08	0.09	0.07	0.07	0.05

Dat = Daily average temperature, Rh = relative humidity, OT = Operative temperature, SR = Solar radiation

3. Results and discussion

3.1. Window opening hours

Group1 with PMA and Daily OT as the main index was compared with other groups. In the information of buildings (layers, areas, etc.) the difference was not evident. However, based on the window opening time compared to the measurement period, we found that Group1 is significantly higher opening time.

This can affect the season or timing of measurement, so each monthly measurement ratio was compared between groups. The results showed that the houses in Group 1 were being measured monthly at a high rate overall. Overall, it was measured at a high rate. The differences between the groups analyzed earlier can be confirmed that window opening differences are not seasonal.

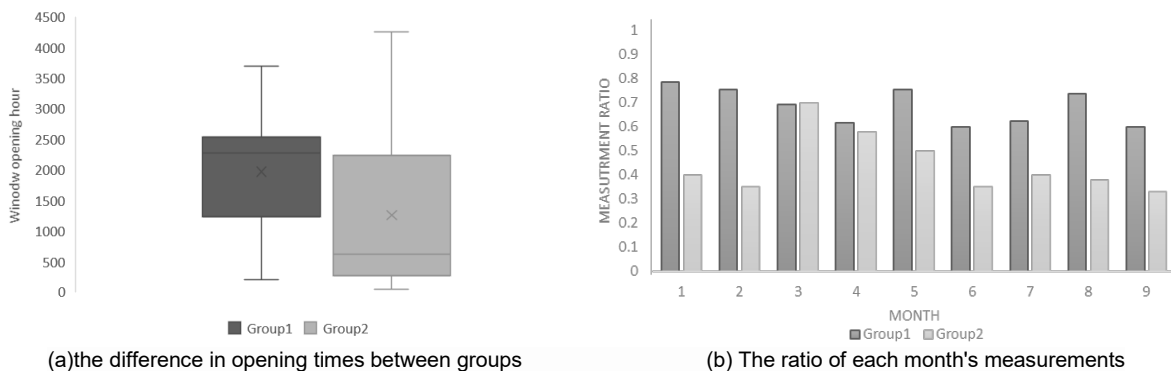


Figure 1. importance difference Group_1 case

3.2 Window opening frequency

Figure2 shows the correlation of the window opening frequency with the information of the apartment. The frequency of window opening showed a correlation with area and floor level in A apartment. In B apartment, it showed correlation with location and level of apartment. A and B apartments all showed a negative correlation with the floor level, and it can be confirmed that the area and position act as supplementary parameters. Therefore, it should be noted that the window opening behavior itself may indicate the frequency of other window opening even though the same environmental condition is predicted.

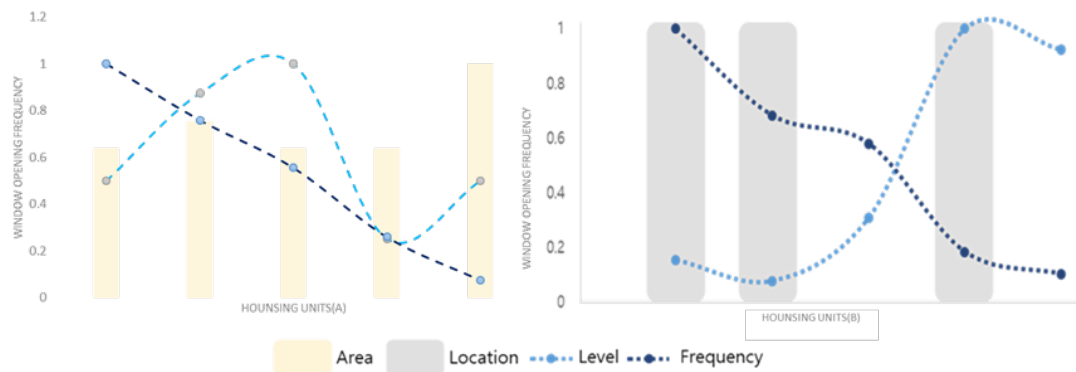


Figure 2. Window opening frequency

4. Conclusion

Previous studies have attempted to make predictions based on environmental factors (temperature, RH, CO₂, etc.) while excluding information on apartments and human behavior. Based on the results, we investigated the influence of apartments information and human behavioral characteristics. Also it was possible to verify that differences in groups based on importance were classified according to window opening time. In addition, the analysis of the influence of the building information on the window opening frequency itself was also carried out. We found that the tendency of variables varies according to building information and human behavioral characteristics, Through this, it can be confirmed that the information of the building and the behavioral characteristics of the human being should be reflected through the fact that the gini importance to predict the window opening and closing behavior of residents is similar but the overall tendency is different according In next studies, the same analysis is preferentially repeated for the additional housing units, and the explanatory power is enhanced based on sufficient data acquisition.

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