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DEMAND CONTROLED VENTILATION (DCV) : CASE STUDY IN ROOMS

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SYNOPSIS

DCV systems have proved to be energy saving with correct IAQ in previous studies. In order to achieve correct performance, these systems must be properly designed and tested.
The purpose of this study is to identify the possibility of using presence sensors based on movement detection to evaluate the number of people present in a room, and also gather some more information about the real occupation rate of meeting rooms. For that, an experiment in several kind of meeting rooms, located in different buildings and having different uses has been run.
The study is not finshed yet, but the analysis of the first results allow to have a good adequation between the informations given by the sensors and the effective number of people present in the room. It also shows with quantitative informations, how the occupation rate of meeting rooms is low, and the potentiel of energy savings that is possible to realise by adaptating the room ventilation flow rate to the real occupation rate.

1- INTRODUCTION

This paper deals with a study which aim is to experiment a system allowing to follow the occupation of meeting rooms, in order to have reliable informations about the number of people present.

2- DESCRIPTION OF THE EXPERIMENT METHOD

2.1 Typology of the rooms

Three rooms have been tested during this experiment. They take place in buildings of three different companies. They are all of medium size, dedicated for meetings with a maximum number of people included in the range ten to fifteen seated people.

The following table gives the characteristics of the rooms.

Room	Length (m)	Width (m)	Height (m)	Size (seated people)
A	6,2	5	2,5	10
B	8,5	6,1	2,5	15
C	7,5	5,4	2,5	12

Table 1 : Rooms dimensions

The uses of these rooms are for working meetings and trainings, with room A and B which are mainly used for meetings, and room C both for meetings and trainings. The behavior of the people in the room differs according to these two activities. During meetings, people are seated most of the time and their movements mainly concern their arms and their hands, and have a limited extent. Furthermore, the layout of the room is hardly changed during a meeting. During trainings, it is a bit different. At least one people, the teacher, keeps standing up and has to make movements to write or show documents on the blackboard or to go around trainees during exercises. Some of the trainees have sometimes also to deplace themselves in the room, like going to the blackboard or again modifying the layout of the tables to make little working groups. In these conditions, the quantity and the amplitude of the movements are both increased.

The rooms are presented in the figures 1 to 3. The usual location of the table corresponds to the orange rectangles. The seats are located around these tables.

2.2 Control of the occupation

Two detection systems have been tested. They both use the same sensors, and differ only by the repartition of the sensors. One concerns four sensors distributed near the corners of the ceiling, and the other four sensors gathered near the middle of the ceiling. For each of this combination, the location and the orientation of each sensor is defined to cover a quarter of the occupied surface of the room. The sensors used detect the movements in the room which are strongly linked to the presence of the people. As the experiment is intending to validate and calibrate the informations given by the sensors, we have used an other mean of control of the presence, that is a web camera.

The experiments have been run over near four months. Of course, only working days are concerned during this period and for each day, the test is ran from 9:00 to 19:00, which represents a 10 hours test period per day. The eight sensors are connected to a PC via a data acquisition facility. The web camera is also connected to the PC. Informations given by the sensors are stored every two seconds, and a picture of the room is recorded every minutes.

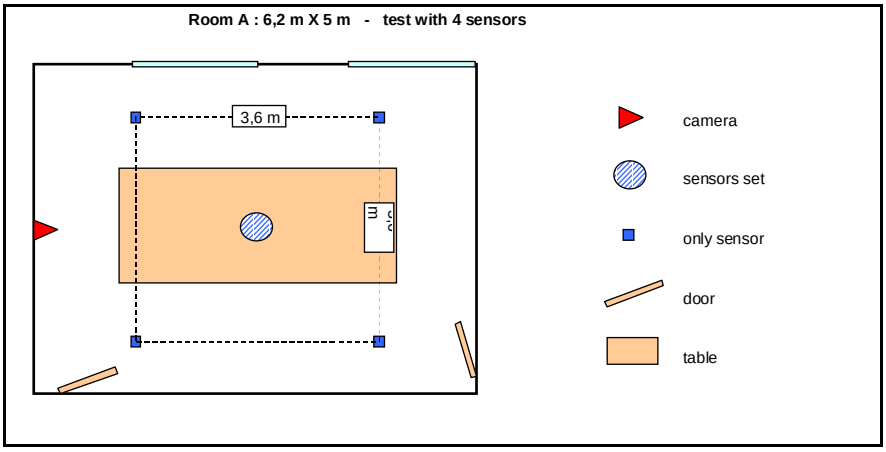

Figure 1 : Scheme of the room A

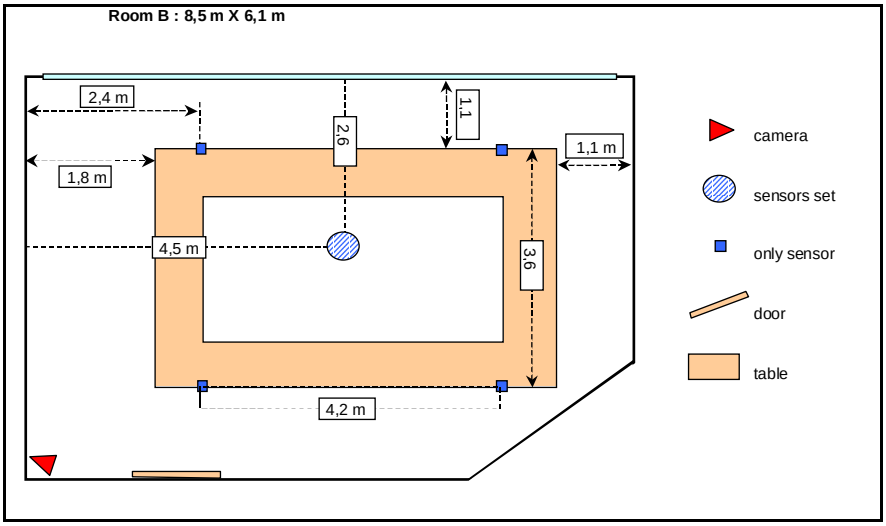

Figure 2 : Scheme of the room B

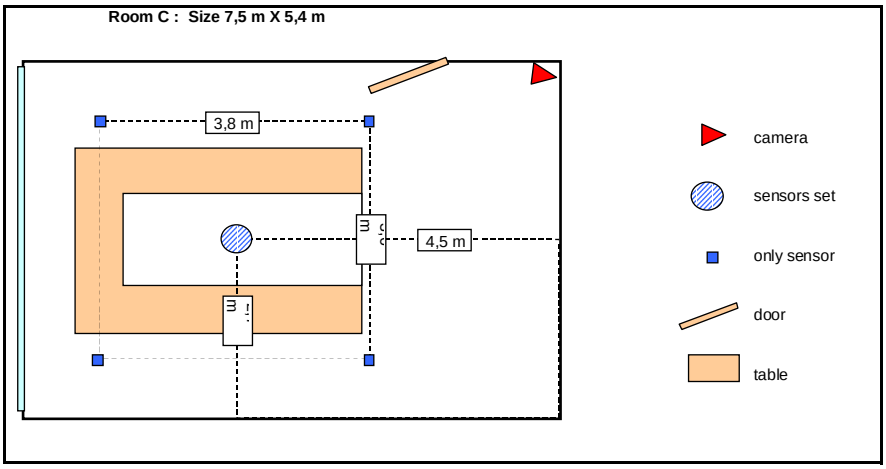

Figure 3 : Scheme of the room C

3- DATA ANALYSIS

The analysis of the results consists, in parallel, for each working day:

- to visualize the pictures given by the camera and pick up the number of people present during which period;
- to process the detection files by gathering the detections given by the sensors located in the corners and the sensors located in the middle. These informations are gathered over ranges of three minutes length.

At the end of this process, we can obtain a diagram giving for each set of sensors, the variation of the number of detections during the day by ranges of three minutes, and also the variation of the number of people present.

Then, a second step consists in a statistical analysis to know for each set of sensors and each number of people, what is the most probable corresponding number of detections. This analysis is performed using all the datas obtained over the experiment period. For each number of people, an histogram is plotted giving the statistical weight of each detection number obtained. Then an interpolation of this histogram using a Gaussian curve is made. The abcsissa of the peak of the Gaussian curve is corresponding to the most probable detections number that can be obtained over 3 minutes. To realise this interpolation, we have used all the available datas or only these corresponding to a sufficient high statistical weight, in order to take into account more representative datas. This sceening of the datas has been realised by setting at 20% of the maximum statistical weight, the threshold of tolerance. An example of this statistical analysis is given by the figures 4 and 5, for the room C. It corresponds to a number of 8 present people. We can see that the most probable detection number is lightly shifted. In this case, it is towards the higher values, when using screening, but this is not a general tendancy.

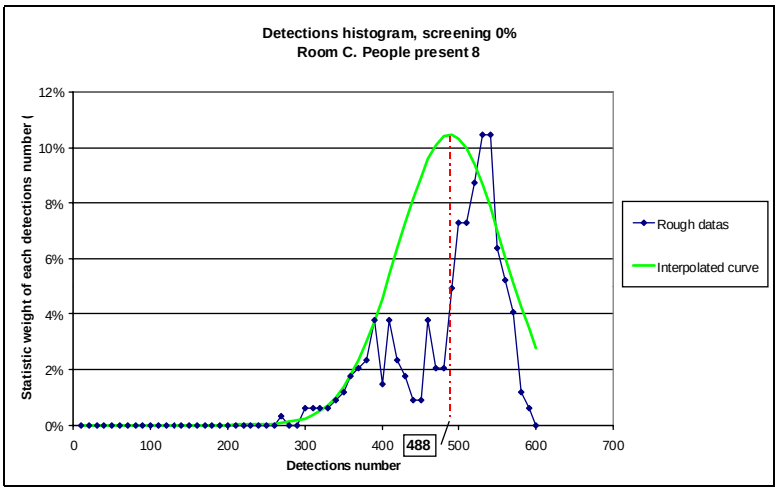

Figure 4 : Histogram of detections for room C, without screening

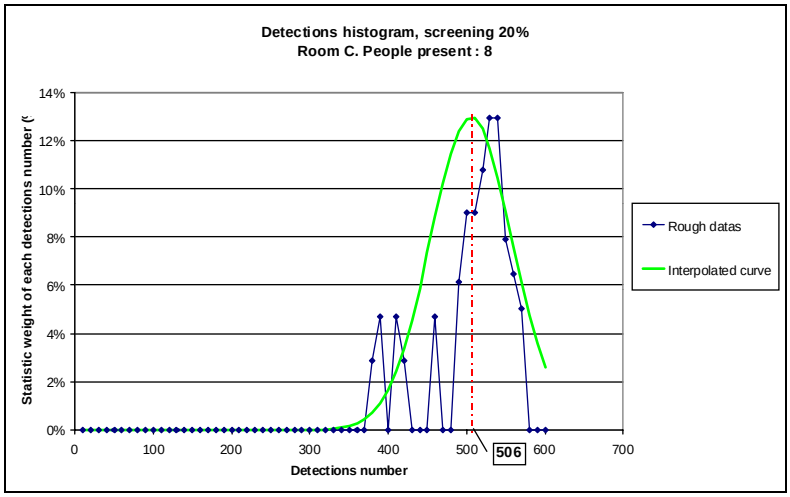

Figure 5 : Histogram of detections for room C, with a 20% screening

4- ANALYSIS OF THE RESULTS

4.1 Occupation of the rooms

One of the important results of this study is the possibility to obtain quantitative informations about the occupation times of the rooms. As we can see on the pictures 6 to 8, the proportion of time where the rooms are not occupied is always strongly majoritary. The room A, that is the most occupied one, is not used more than 45% of time.

A parameter that is very representative of the occupation of the rooms is the occupation rate τ. This parameter takes into account both the ratio between the time where the room is occupied over the working period and also the ratio between the effective number of people present to the maximum capacity of the room.

$$\hat{o} = \frac{(\text{real amount of hours x real number of occupants})}{(\text{total amount of hours x maximum number of occupants})}$$

The values calculated for the occupation rate are given in the table 2. Examining these results, it is obvious that there is a considerable potentiel of energy savings by adaptating the ventilation rate to the real occupation of the rooms.

ROOMS	A	B	C
OCCUPATION RATE (%)	14	11	4

Table 2 : Occupation rates

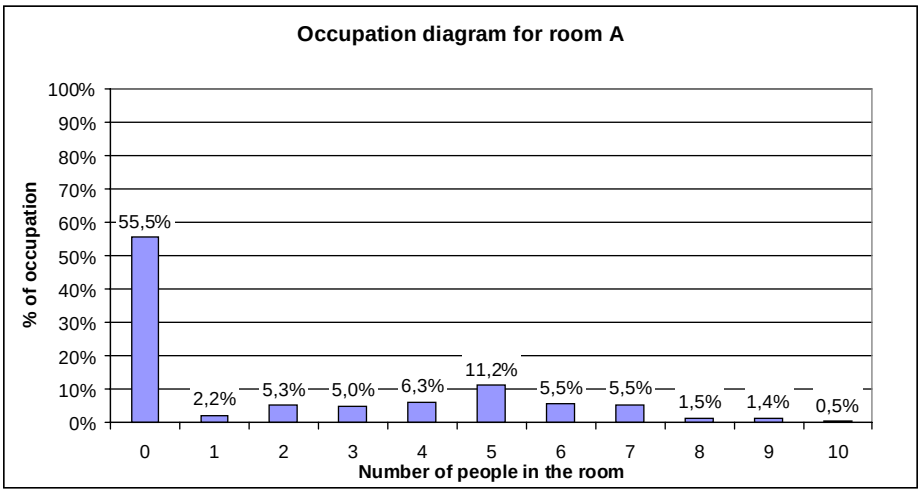

Figure 6 : Occupation diagram for room A

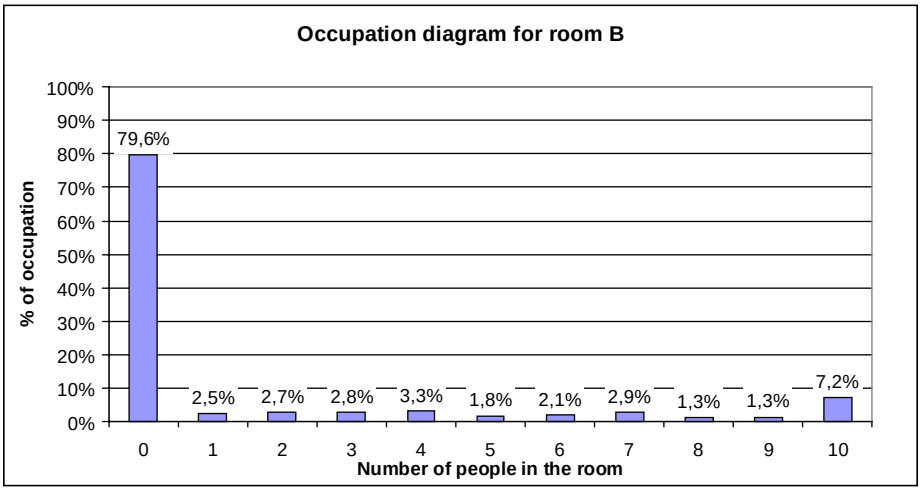

Figure 7 : Occupation diagram for room B

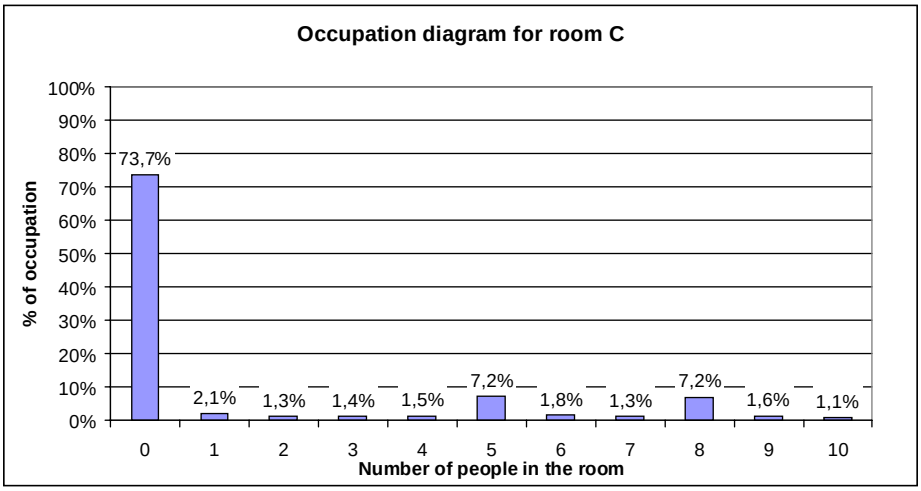

Figure 8 : Occupation diagram for room C

4.2 Relationship between detections and presence of the people

Even if this study is not ended yet, and if we still run the experiment, we can give some of the first results of the statistical analysis performed to find a relationship between the detections signals and the effetive number of people present in the room. For instance, in the picture 9, we have plotted the variation of the number of detections versus the number of the people present, for the room B. It appears that there is a rather good correlation between these two parameters, and that the sensors used are able to follow the evolution of the number of people in meeting rooms. The use of screening does not affect sensitively the results, but it allows to obtain a more regular variation curve.

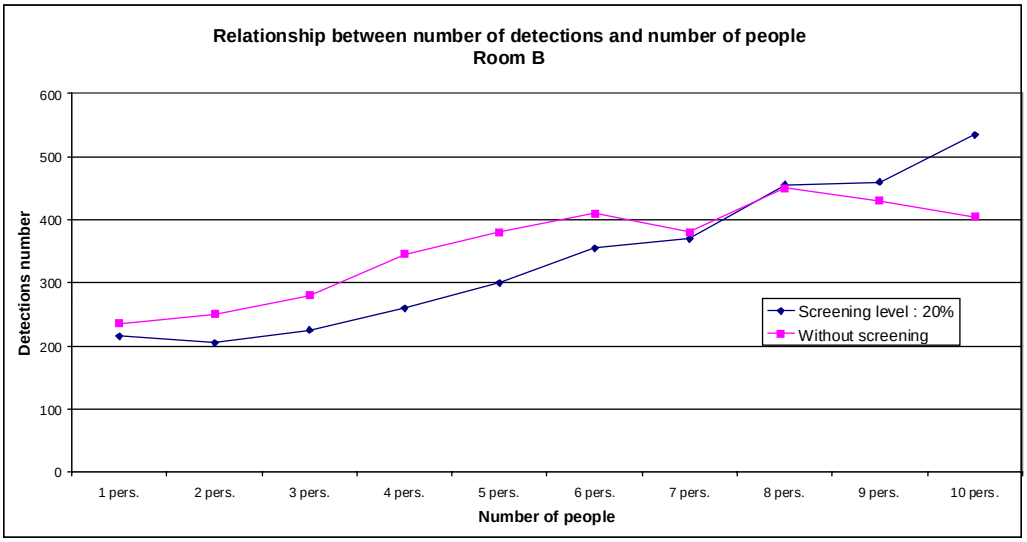

Figure 9 : Relationship between detections and people - Room B

5- CONCLUSION

The first results of the experiment described in this paper show that a system based on movements detection is able to give reliable informations on the occupation of a room. This kind of system can have a great interest to supply information in order to adapt the ventilation rate to the occupation rate. Moreover, statistics performed here about the occupation of meeting rooms show that there is a real potentiel of energy savings due to the real low effective occupation of meeting rooms.