

V. Mazur, O. Strilka  
Lviv Polytechnic National University,  
Computer-Aided Design Department

## RESEARCH OF AUTOMATIZATION AND FORMATION OF COMFORT ZONES

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**The results of experimental research and approaches to automated formation of comfort zones discussed in this article.**

**Key words: comfort zone, automatic measurements.**

**Розглянуто результати експериментальних досліджень та підходи до автоматизованого формування зон комфортності.**

**Ключові слова: зона комфортності, автоматизація вимірювань.**

### Introduction

Further improvement of human life conditions in the workplace, in schools, in vehicles and at home is an urgent task. Today, it is a very promising approach, based on the intellectual way of obtaining the necessary environment's parameters, which surrounds a person, using microcontrollers and radio – the design and application of so-called "smart home" [1]. In publications is widely covered issue of the SMART- technical systems, the choice of controllers and sensors, design of the management and controls [2]. However, some methodological issues of development of such systems researched and designed, in our opinion, aren't properly.

**The aim** is the research of experimental parameters of human comfort zones, development and implementation of some approaches for its support.

In this paper, as a measure of comfort, numerical values of such parameters were examined and investigated: temperature, humidity, air velocity, lighting, level of noise, thermal and electromagnetic radiation. Traditionally, a room is the main object for which the parameters of comfort are provided. In this paper we propose a more generalized concept - a comfort zone for which the required levels of the parameters described above are provided. It is in due to the fact that the concept of zone better reflects the distributed nature of the human environment (in a room can often be several zones for which you want to ensure different comfort options, such as lighting, etc.). A zoning process allows the identification and accounting conditions, aims, and a time of human presence in these areas. In general, offering of the necessary parameters in the local area may be less costly in a comparison to a whole room.

### Comfort zones parameters discovering for a university

Although experimental studies were conducted for house rooms, in this paper the results of complex research areas in the premises of the university, especially in the department of CAD were provided and this cause much greater practical interest. Processing of the results of these studies makes possible assessing the comfort level of the learning environment of students and lectures, in order to develop a series of natural and mathematical models, created to describe and form of comfort zones on the stage of aided design, offer a list of measures for ensuring and improving parameters of selected comfort zones.

A set of measuring instruments was used, consist of: Multi-Function Environment Meter DT- 8820, Electronic Digital Thermometer WSD-10, Infrared Pyrometer TLD 100. These instruments provide measurements of air and solid surface temperature with an accuracy of  $\pm 1^\circ\text{C}$ , humidity up to  $\pm 5\%$ , light to  $\pm 5\%$ , sound level to  $\pm 5\%$ . Obtained measurements were evaluated with respect to such parameters values: Temperature - 20-24  $^\circ\text{C}$  (PHS 3.3.6.042-99); Light - 500 lux (ISO 8995 , PHS 3.3.6.042-99); Humidity -

40-60 % ( PHS 3.3.6.042-99 ); Air Velocity - 0.2 m/sec (PHS 3.3.6.042-99); Sound Level - 40-50 dB (PHS 5.5.6 009-98 ); The Level of High-Frequency Electromagnetic Radiation - 2.5 mW/m<sup>2</sup> (PHS, Ministry of Health decree № 239 of 01.08.96 ).

### Temperature and humidity changes in the classroom during a class

The aim of this study was to determine temperature and humidity changes in the classroom during class in a deterioration of the functioning of forced ventilation provided by sealing windows. The measurement was conducted at 12.00. The outside air temperature was 13.9°C, humidity - 54%. Before the class, the classroom had ventilated during 10 min. At the beginning, the classroom temperature was - 19.3°C, humidity - 55.9%. The room area was 70 m<sup>2</sup>, number of students - 40. Measurements were carried out in the center of the room at a height of 1 m. The temperature changes in the classroom during the class are shown in Fig. 1.

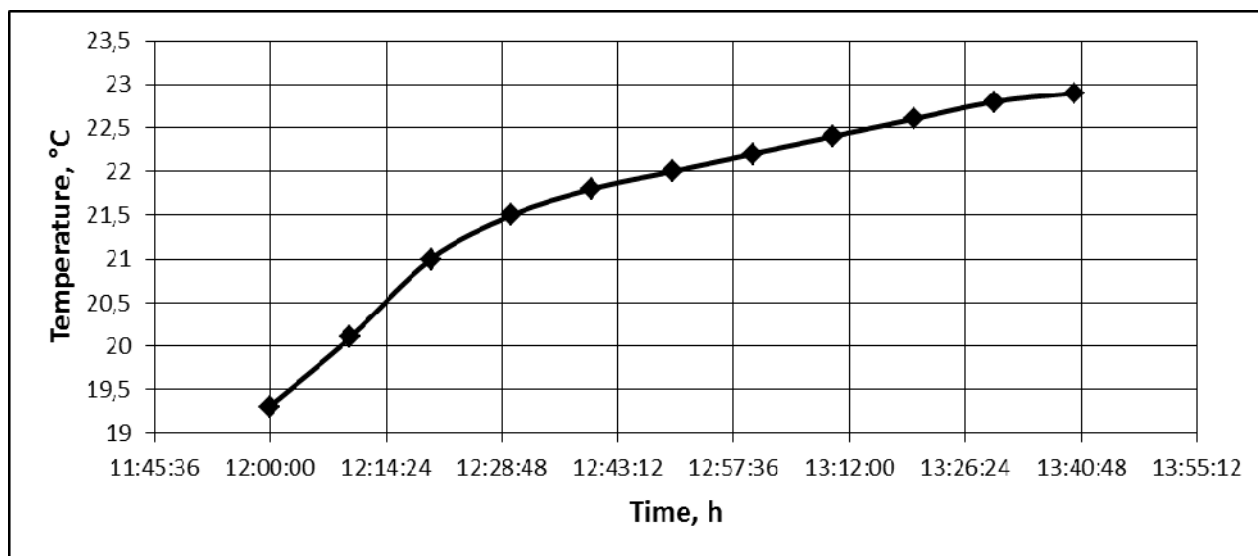


Fig. 1. Temperature changes in the classroom during the class

The increasing of temperature from the floor to a height of 2 m on average is 2 ° C and humidity increase is 1.5%. The experimental data provide approximation models, which are linking the point of temperature sensor placement and points of comfort zone.

Change of humidity in the classroom during the class is shown in Fig. 2.

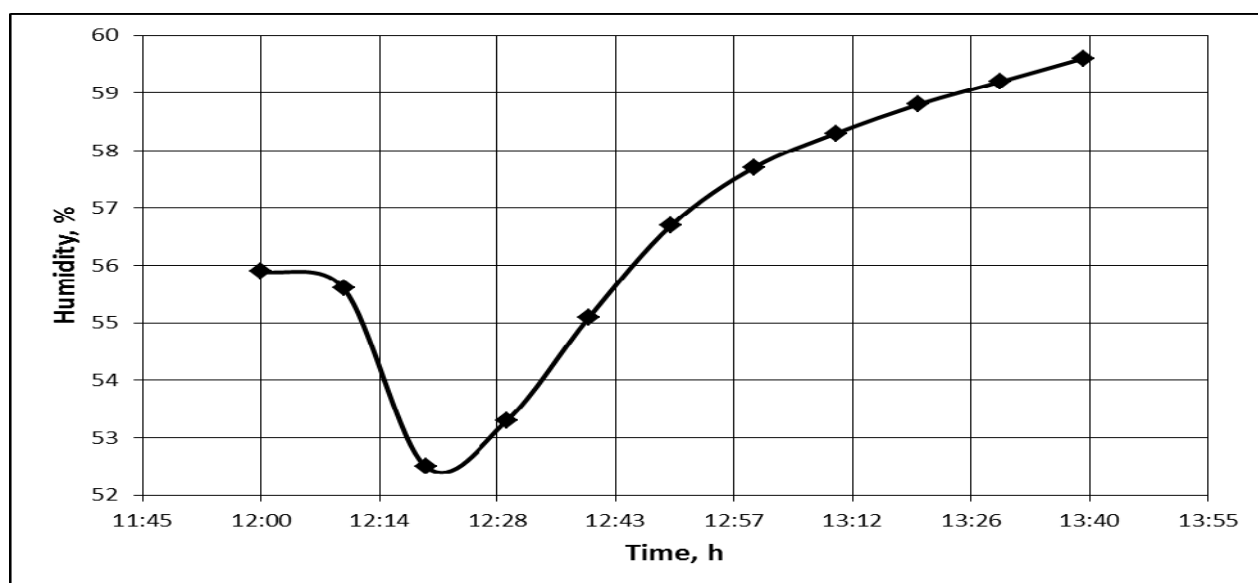


Fig. 2. Changes of humidity in the classroom during the class

Given that the temperature and humidity are approaching to the boundary of limit values, there is a necessity of ventilation of the classroom. It is implemented by using transoms that are at the bottom of the window. The resulting temperature distribution for zone near the windows is represented in Fig. 3. It allows an investigation of the effect of a cold air flows. Based on the temperature distribution analysis, the system of micro ventilation is proposed, which is using a microcontroller ES-ForthLogic.

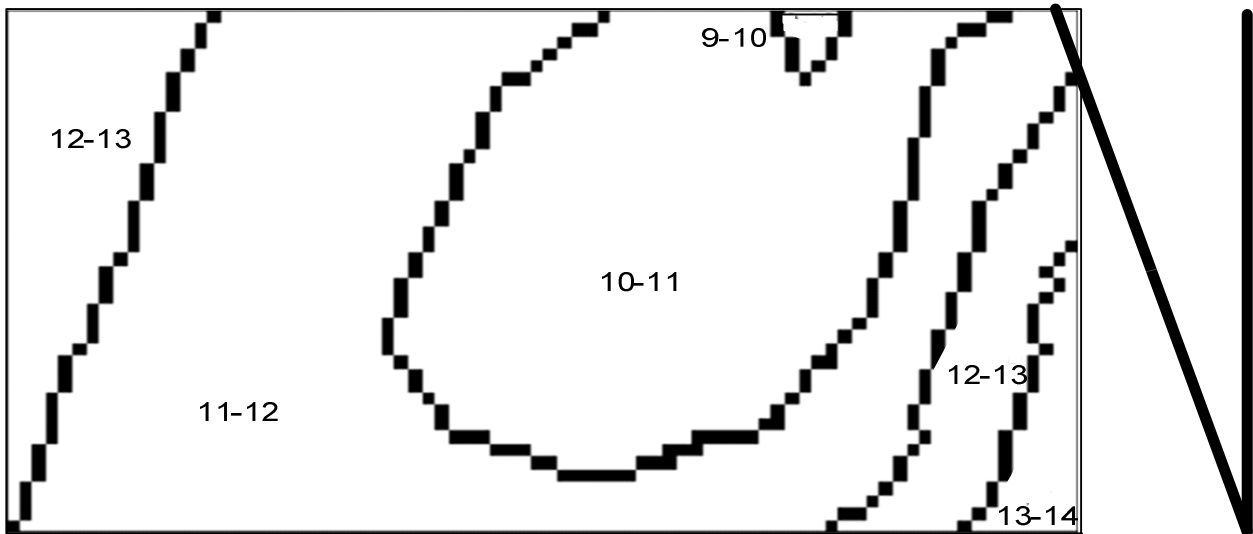


Fig. 3. Temperature distribution results for zone near windows

#### Automatized process of temperature measurement

Determination of temperature fields for a zone is time consuming task, because it requires a large number of measurements. The automated measurement system was suggested and it's is shown in Fig. 4.

The fast-response thermistors are used as sensors, which placed on measuring rack (height of 2 m in steps of 25 cm) and in nodes of measuring frame (size 100 \* 60 cm in increments of 20 cm). The voltage obtained from the divider is formed by loading impedance and thermistor, applied to analog electronic switch. The signal from the switch is fed to the analog-to-digital converter, and digital value of the temperature is transferred to the digital display, computer or written to a nonvolatile memory. Calibration is performed using a digital thermometer. The accuracy of temperature measurement is at level of  $\pm 5\%$ . Based on these values the temperature field distribution is plotted by a special program.

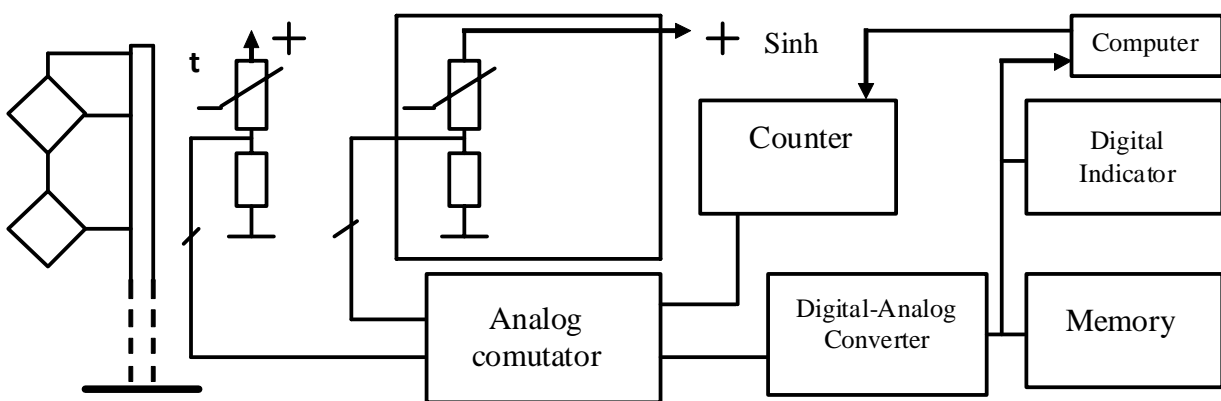


Fig. 4. Structure of an automated system for measuring temperature

The thermistor measures the air temperature in the set of points. Objects with a significant level of the temperature in the comfort zone can be affected by sunlight (insolation). To investigate this factor in the measurement points, on measuring rack square aluminum plates are located, which are heated by sunrays during the measurements. The temperature of these plates is measured by the infrared pyrometer. It allows building a more accurate temperature model of a comfort zone.

### The lighting level measurement and ensuring

A set of measurements was carried out by the device DT-8820 at 14.00 during a sunny weather. The windows of the room are placed to the north-west side of the build, without direct sunlight. The size of the classroom is 6 by 6 m. The level of lighting was determined for natural lighting, artificial lighting and combined lighting on the table surface (height - 75 cm) from the window to the wall at the points in increments of 25 cm. Three lamps with shades (power lamps - 3 \* 60 W) are placed at a distance of respectively 1.5 and 4.5 m. The measurement results are presented in Fig. 5.

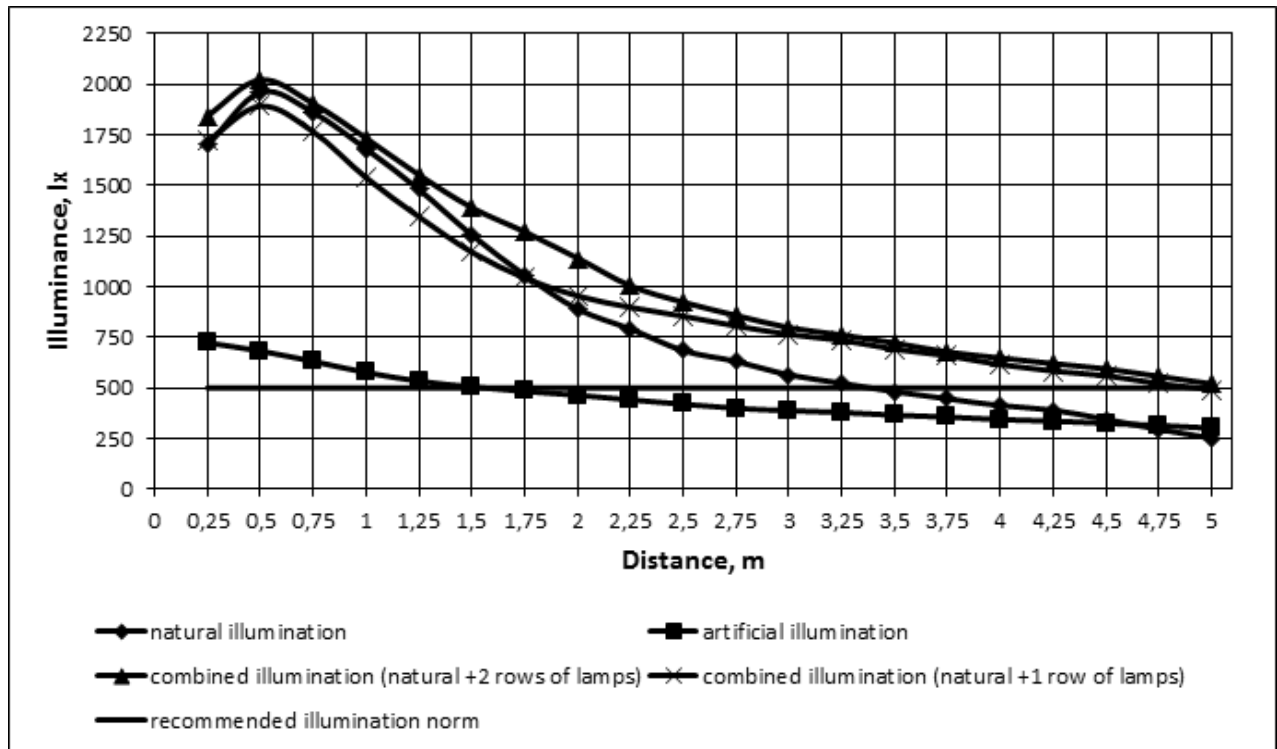


Fig. 5. The light level measurement results

As can be seen from the presented graphs, about 60% of the room's square is lighted by a natural lighting in accordance to the recommended standard (500 lux). The lighting level for the part of a room is below the recommended, because they are out the distance from windows and some part of a light is absorbed by furniture wall. It is important to note a significant level of non-uniform lighting (the difference in work areas 4 times).

Measurements for artificial lighting were carried out for windows covered with shutters (imitation twilight). Although the lighting is much more even, but not enough for today's standards (500 lux).

In order to ensure the necessary level of lighting it is using a combined lighting. As can be seen from the graph, the default option (natural lighting and two rows of lamps) ensures the necessary level of lighting in all work areas of the room. However, it is economically inefficient for the area which provided by natural light. It was studied the variant in which the lamps only work in the area there is an insufficient natural light (natural and one row of lamp). As can be seen from the corresponding graph, it leads not only to save an energy (up to two times), but also aligns the lighting. Therefore, in future, for the lighting in the classrooms of the university has recommended separate switching of lamps along the rows of windows for a combined coverage of remote areas.

Further improvements to the working area lighting can be based on a determination of the level of lighting directly in a work area and use local fixtures to ensure compliance with the standards. In publications, it is offered to use a microcontroller in the "smart home". However, in our opinion, such excessive centralization of control has several disadvantages. First, the most common controllers have a limited number of relevant inputs for connecting sensors (e. g., ES-ForthLogic - 4 analog inputs [3]).

Secondly, there is the problem of wire communication between sensor and controller. Using a wireless connection of sensors based on wireless communication leads to increased levels of electromagnetic radiation in the room. Therefore, this paper proposes a decentralized control, which is based on the "intellectualization" of lamp for artificial or combined lighting. The scheme, equipped with sensors, for autonomous control of lamp is shown in Fig. 6.

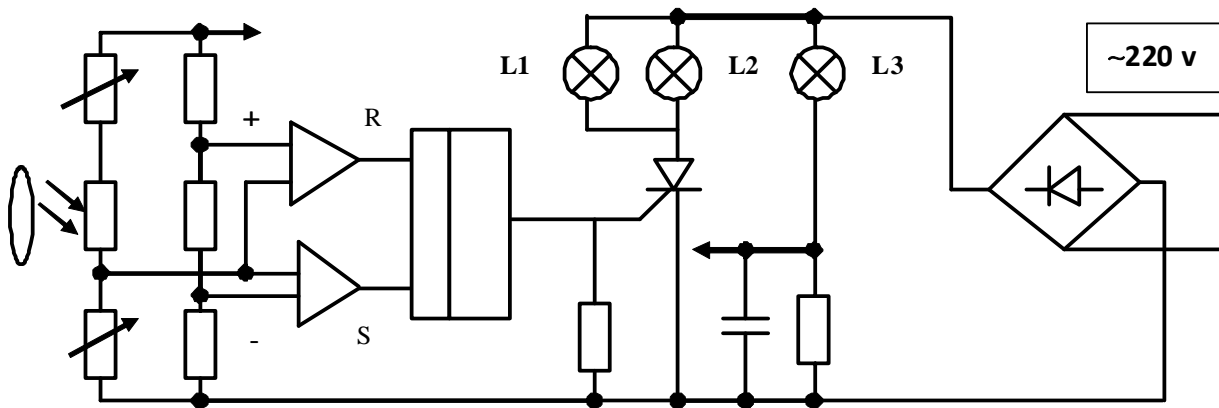


Fig 6. The scheme for lamps adaptive control

The light output, which reflected from the table surface and focuses by a lens is perceived by photo resistor. Information signal from the voltage divider, which is composed photo resistor fed to the inputs of comparators, connected to trigger. At a low level of lighting the lower comparator toggles and switches the trigger. The extra bulb lamp L2- L3 is turned on by thyristor. At increasing of light levels and increasing voltage from the divider the upper comparator turns on, switches the trigger and turns off additional lamps by means of thyristor. Lamp L1 is turned by a common switch in the room. It defines the initial level of lighting and is the part divider for powering the circuit. Installation of lighting levels and prevent the relaxation regime (eliminated due to hysteresis) are carried out by the selection of regulatory resistors. The sensor and the control circuit placing in the lamp housing eliminate the problem of connecting wires.

### Conclusions

Experimental temperature and humidity result specified the models which provide formation concerning comfort zones. The proposed measurement system simplifies the measurement process for the identification and analysis of temperature fields in the selected areas. The results of lightning measurements and the proposed scheme for adaptive lamp control may be used in the design and implementation of an effective system for a distributed lighting.

1. Дерев'янюк Ю.В., Краснікова О.Л. Дослідження можливостей "Інтелектуального будинку". – Харків, 2010. 2. Умный дом // [ht tp://intellecthouse.com.ua](http://intellecthouse.com.ua). 3. Вільнопрограмований логічний контроллер ES-ForthLogic // Електросвіт. 2009.