한국산학기술학회논문지
Vol. 8, No. 4, pp. 853-860, 2007

Simulation platform for living environment to ensure quality life

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쾌적한 생활 설계를 위한 주거 및 사무실 시뮬레이터개발

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Abstract In this modern era, human beings lead their life in complex environment where there are lots of parameters such as temperature, light, smell, sound, visual stimulus etc. that play important role for quality life. These parameters affect physical and mental behavior of a human being immensely. To ensure quality life the demand for quality products is always associated with human emotion and sensibility. Due to human sensibility and emotion involvement with quality life, the design stages of any kind of product must include some certain features related with emotion and sensibility. The cues for optimizing artificial environment are the physiological responses of human in that environment. The conventional approach of environmental physiology is to measure the relationship between environmental physical parameters and human psychological parameters under artificial conditions. Using that approach we tried to design an artificial environment for our daily lives and activities associated with both physiological and psychological behavior. We developed the technique to present the mock environment and software to measure and evaluate sensibility physiologically or psychologically and a simulator to measure and evaluate sensibility that can be utilized for large scale industrial production and design of environment. Simulator to measure and analyze human sensibility (SMAS) was constructed, which was utilized to estimate human sensibility and to simulate living and office environment

Key words : Sensitivity, Physiological, Psychological, Environment and Simulation.

요 약 현대 인간이 삶을 영위하며 대부분의 시간을 소비하는 주거환경과 사무환경은 다양한 요소인 온습도환경, 시각환경, 음환경으로 구성 되어있으며 이들 환경 요소가 쾌적한 생활요소 설계의 주요 요소로 대두되고 있다. 특히, 인간에게 주는 영향 즉 "인간과 주거환경", "인간과 직장의 사무환경"간의 상호영향은 인간의 쾌적한 생활환경의 매우 중요한 요소이다. 사무환경의 경우 직장에서는 쾌적한 직장환경, 피로나 스트레스 적은 근무 및 작업환경을 만듦으로서 업무능률의 향상, 생산성 향상을 기할 수 있으며, 이를 위해서는 사무용 건물을 지을 때부터 이러한 점들을 고려한 건축물의 설계가 이루어져야 한다. 또한 주거환경은 하루 중 절반 이상의 시간을 보내며, 직장이나 가사로부터 쌓인 피로를 풀면서 다음날을 준비하는 장소이며, 수많은 가정용 가전기기들로 채워지고 있어, 개인 기호에 따른 다양한 공산품들을 소비하고 사용하는 곳이다. 따라서 이러한 두 환경에서 생활하는 인간이 건강하고 쾌적한 생활을 유지하기 위해서는 이들 환경과 제품 자체가 가능한 인간에게 피로나 스트레스를 유발시키지 않도록 감성적으로 설계되어야 한다. 동시에 외부에서 쌓인 피로나 스트레스를 빨리 회복할 수 있도록 설계되고 유지되어야 할 뿐만 아니라 개인적인 기호도 동시에 만족시킬 수 있어야 하며 최종적으로 이들 환경 안에서 생활하는 인간에게 쾌적하고 감성적인 환경, 인간 친화적인 제품을 제공할 수 있도록 하여야 한다.
본 연구에서는 온열환경, 시각환경, 음환경 제시가 가능한 시뮬레이터 공간으로서의 주거/사무환경의 시험평가시설을 구축하였고 이 환경에 필요한 각종 자극의 제시와 측정 및 평가를 위해 온습도, 조명, 색채, 음향 등의 제시환경기술을 통합한 기본적인 시설을 구축하고, 구축된 시설과 각 제시자극의 측정 및 평가지표를 통합하여 종합적인 감성측정 및 평가 가능한 주거 및 사무실 시뮬레이터를(Simulator to measure and analyze human sensibility ,SMAS) 개발하였다. 본 연구에서 구축한 시스템을 통하여 종합적인 주거/사무 환경에 대한 감성측정/평가 시스템 및 환경 시험평가 및 감성평가 지원기술 및 시스템을 통합 하여 감성정보 종합관리 시스템을 구축하였으며 이를 통하여 인간의 환경 시설에 대한 감성 평가 표준 데이터포맷을 제시하였다. 이러한 종합적인 감성측정 및 평가 가능한 주거 및 사무실 시뮬레이터 시스템은 실험을 통하여 그 효용성을 입증 하였다.

1. INTRODUCTION

Simulation is an effective tool for analyzing a test bench frame. For instance it can be used for further analysis of any

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industrial design framework in reference to different applications such as design, control, safety etc. In fact recent development infrastructure indicate that human behavior should be considered when dealing with the design of living and office environment in order to evaluate certain several aspects such as safety, security and quality of life. Within such a design the simulation can be used to determine the process of improvement of quality of life with the advent of new technology which increases suitability of the living environment. Environment is surrounded by a wide range of factors such as auditory signal , temperature, light, can be taken as a challenging world to be assessed[1,2,3,4]; the goal is not concentrated not only on the functional organization and ergonomics features of such complex systems but also development of models of physiological and psychological human behavior, human interaction such as emotion and sensibility[5,6,7]. Human emotion and sensibility are beyond the scope of space and time. Human body contains lots of organs and cells. There is no such thing as a laughing cell or crying cell or angry cell in the human body. Apart from the physiological structures, a human being has psychological and emotional attributes[8]. Such attributes include our state of mind, ideas, ways of thinking and attitudes. These are the core factors that influence us in our daily life activities. So to design any kind of product the physiological and psychological behavior of human must be considered [9,10]. The cues for optimizing an artificial environment are the physiological or psychological behavior of human in that environment. The conventional approach of environmental physiology is to measure the relationship between environmental physical parameters and human psychological parameters under artificial conditions[11,12,13]. Using that approach we designed an artificial environment for our daily lives and activities associated with both physiological and psychological behavior. We developed the technique to present the mock environment and software to measure and evaluate the sensibility physiologically or psychologically and a simulator to measure and evaluate sensibility that can be utilized for large scale industrial production and design of environment. Simulator to measure and analyze human sensibility (SMAS) was constructed, which was utilized to estimate human sensibility and to simulate living and office environment.

The objectives of our designed simulation frame are:

- To suggest a new framework simulation for living and office environment to ensure quality of life
- To evaluate the proposed method through simulation.

The developed simulation system can provide the comprehensive assesment/measurement results for the living and office environments. Additionally, after integrating the sensibility evaluation and supporting technologies, a sensibility Information analyzing system is proposed. Through the information synthesis analyzing system, a standard data format for living environment accessories is presented based on the sensitivity evaluation. It is verified that the sensitivity measurement and estimation for living and office environments is effective through the experiments. Experimental facilities and results are shown in the later part of this paper. This paper contains the potential of simulation techniques in investigating creative design of living and office environment based on physiological and psychological behavior of human. In chapter 2, the structural frame for living and office environment simulator and experimental facilities are introduced. In chapter 3, evaluation of the system by experimental simulation is demonstrated. In chapter 4, in conclusion we have described what we have done.

2. STRUCTURAL FRAME FOR LIVING AND OFFICE ENVIRONEMNT SIMULATOR

In this paper, we have demonstrated a living and office environment simulator designed for the evaluation of physiological and psychological responses against various factors such as sound, visual, thermal, and light under the free conditions against external various sound, temperature, and electromagnetic wave. The designed simulator as shown in figure 1, is constructed on the technical support building in KRISS. The external size is a 3,600(W) x 5,400(D) x 2,950(H) M/M and internal size is 3,100(W) x 4,850(D) x 2,600(H) M/M. The constant temperature and EMI shield are guaranteed and the external noise is shielded less than 30(dB). The experimental subjects are monitored by the video camera installed in the external laboratory. Additionally the behavior and motions of the experimental subjects could be recorded by VCR. The systems designed to measure the sensitivity being involved with human's real life, are employed in the simulation. Typical experimental facilities include artificial living and office environment, temperature and humidity controller for providing constant temperature as well as soundproof and sound absorption design that is established for providing auditory stimulus generation and control. The illumination of the environment can be controlled by specially designed lighting appliance that can generate four different color temperature (2700/3000/4000/6500K) by directly and indirectness way. Figure 2 shows the photograph of the laboratory designed for the experimental environments.

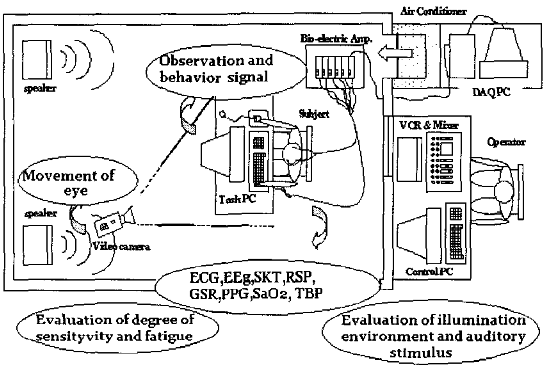


Figure 1. A schematic of designed simulation environment

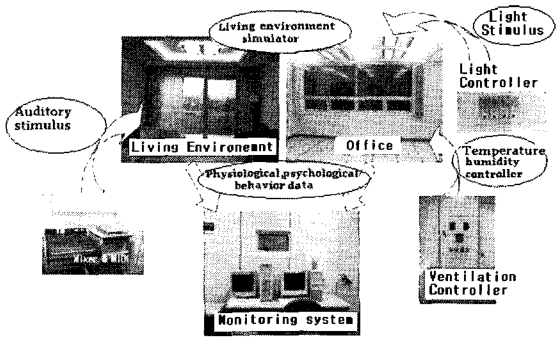


Figure 2. Overview of Living and office environment simulator

Moreover, the illuminations level, the artificial solar system and the auditory stimulus control system are established in such a way that the environment is quite similar with natural living environment. The sensitivity measurement system in this simulation environment is constructed in order to process the detection of physiological and psychological signals and at the same time the work environment data can be measured and to obtain a relationship between them if possible.

Our proposed framework for optimizing the physical parameters of an artificial environment based on the measured physiological data can be realized using the following procedure:

- An artificial space is created to form a living and office environment simulator
- A simulation software SMAS is designed to measure the sensitivity of the simulation environment.
- A control system is established to implement the whole system for the measurement and control of different parameters of human behavior in response to various factors such a light, auditory signal, temperature and humidity under the simulation environment.

2.1 Experimental facilities

Experimental facilities can be divided into the sensitivity measurement system, the auditory stimulus control and measurement system, the artificial light controller and the artificial sun room. Figure 3 shows a schematic of the experimental facilities in the simulation environment.

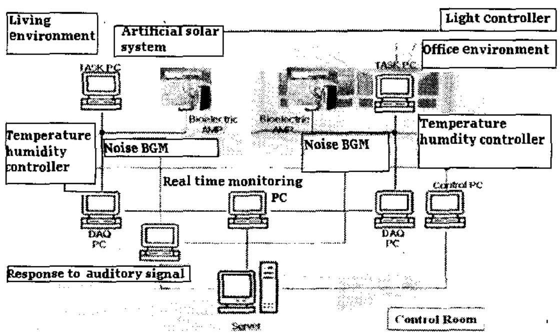


Figure 3. Living and office environment sensitivity measurement estimation system

2.1.1 Sensitivity measurement system

The living and office environment simulator has an integrated system along with the auditory stimulus providing system, the temperature and humidity control system, and the physiology signal controller so that the sensitivity measurement, estimation and analysis are possible in real time.

2.1.2 Auditory stimulus control and measurement system

The simulator consisting kitchen, bedroom and living room has a sound absorption wall and wall ceiling where internal type speaker is established for auditory signal controlling purpose. This system is also integrated with the central control system for the living and office environment simulator to have a complete idea about human behavior to auditory stimulus.

2.1.3 Artificial light controller

An illumination controller system is available which produces four kinds of color temperature (2700, 3000, 4000, 6500 K) with the help of lighting appliances according to requirement by adjusting luminance level between 10 ~ 100%.

2.1.4 Artificial sun room

As sunlight is an important factor in real life living and office environment, the simulator has an artificial solar system to implement sun light. Color temperature is taken into consideration to match up with the natural environment and the frame for the system is designed so that position transfer (150mm) may be possible. Moreover, there is a reflector available for angle adjustment. The whole facility has a surrounding environment presentation such that it gives a sense for the real natural environment in the sun.

3. EVALUATION OF THE SYSTEM BY THE EXPERIMENTAL SIMULATION

To measure and investigate the sensitivity, people are employed as experimental subjects in real environment. The environment simulator presents experimental results that are verified for various experiments, which can be used later for real time estimation comparison.

We evaluated the validity of our proposed framework through physiological simulation under the environment. The task was to estimate different parameters of living and office environment simulator. The characteristics of the parameters were then compared with the target design. The table1 below corresponds to the experimental results.

3.1 Auditory stimulus control and measurement experiment

To evaluate the auditory stimulus experiment, the six different spots were selected for the living room and offices under the same environment evaluation. Table 2 presents the average environment noise is less than 20 dB(A) except the office. Whenever the ventilation is turned on, the internal background noise of the simulator is less than 35 dB(A), meeting the designated specification of the overall system.

Table 2. Average background noise

Measurement position	Background noise(dB(A))	
	Ventilation off	Ventilation on
Living environment chamber	13.4	29.7
Office environment chamber	9.9	31.4
Artficial solar room	16.5	33.1
Control office	36.7	43.9

The figure 4 shows the setup of the measurement system to evaluate the indoor sound characteristics for the developed simulator. As shown in the figure, the sound is measured with the non-directional speaker, the non-directional microphone and sound analyzer. Figure 5

Table 1. Experimental simulation results

Items	Living Environment		Office Environment	
	Design Value	Measurement Value	Design Value	Measurement Value
Temperature	18 - 35∓1	18 - 35∓2	18 - 35	18 - 35∓2
Humidity %	40 - 80∓5	40 - 80∓6	40 - 80	40 - 80∓6
Lux. lx	0 - 750	10 - 100 %	0 - 1500	10 - 100 %
Color Temperature K	3000 - 6400	4 Different Values	3000 - 6400	4 Different Values
Indoor Noise dB	30	25	30	25
Air Current	N/A	N/A	0.1 - 0.5 m/s	0.1 -1

shows the evaluation results that represent the sound clearness degree under the different environment.

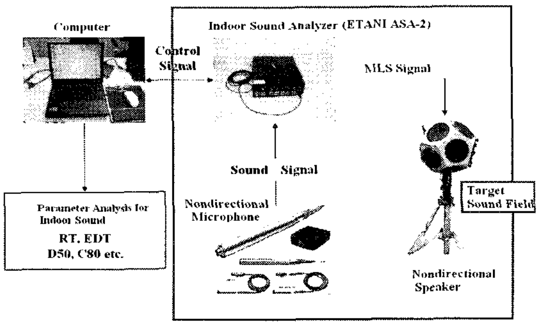
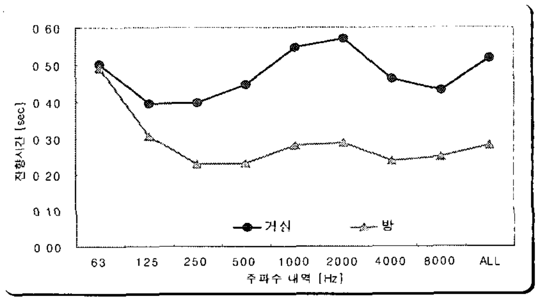
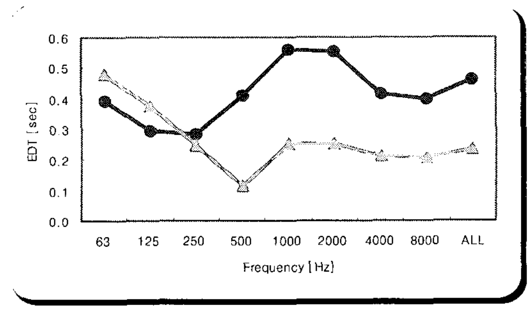


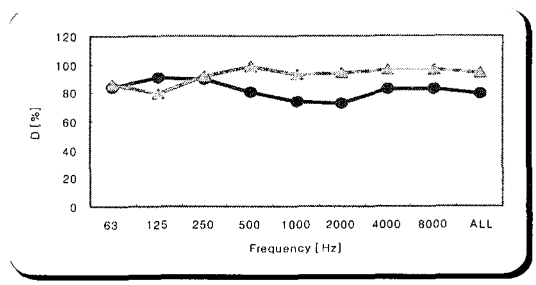
Figure 4. System configuration to measure the sound.



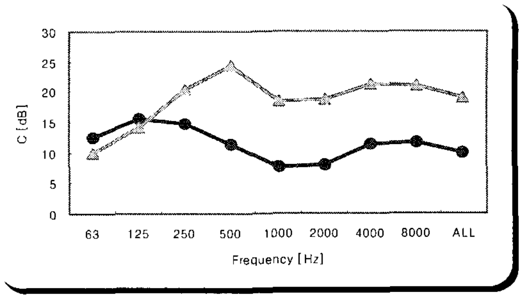
(a) RT(Reverberation Time)



(b) EDT (Early Decay Time)



(c) D50 (Definition)



(d) C80(Clarity)

Figure 5. Indoor sound characteristics for living and office environment (circle : living room, triangle: office)

3.2 Artificial light experiment

To evaluate the artificial light controller, the 24 light sources were placed on the 24 different spots for the living and office environment. Table 3 presents the average environment noise of the simulator where the noise is less than 20 dB(A) for living environment than the office. Figure 6 shows the onfigurations where the light source are placed. An illumination controller system is available which produces four kinds of color temperature (2700, 3000, 4000, 6500 K) with the help of lighting appliances according to requirement by adjusting luminance level between 10 ~ 100%.

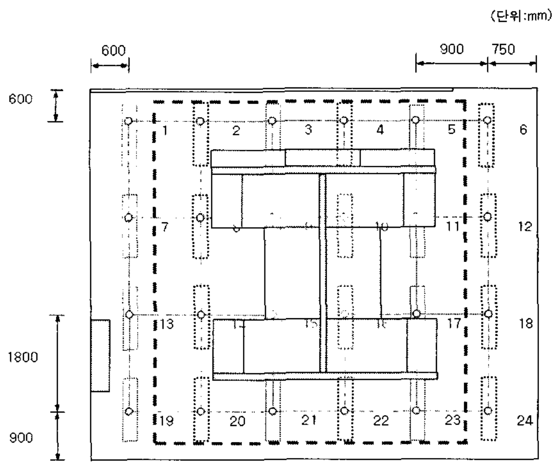


Figure 6. Artificial light location
(circle: measuring spot, solid box: direct illumination, dot box: indirect illumination)

Table 3. Illumination distribution in the office environment [Brightness(lx) Color Temperature((K)]

Item	Indirect illumination		Direct illumination		Indirect + Direct illumination	
	Brightness	Color Temperature	Brightness	Color Temperature	Brightness	Color Temperature
1	935	5300	520	5700	1530	5450
2	1080	5400	700	5700	1850	5550
3	1080	5450	1010	5800	2150	5600
4	1060	5450	810	5650	1950	5600
5	930	5450	1000	5750	2000	5600
6	780	5350	745	5650	1540	5500
7	1140	5350	640	5700	1810	5450
8	1300	5450	810	5700	2150	5500
9	1280	5450	1200	5800	2550	5600
10	1190	5500	925	5600	2000	5550
11	1090	5500	1200	5800	2300	5600
12	880	5450	870	5650	1720	5550
13	1080	5350	655	5700	1630	5450
14	1320	5350	780	5650	2100	5500
15	1330	5350	1200	5800	2550	5600
16	1350	5500	925	5600	2220	5500
17	1110	5450	1190	5800	2300	5600
18	860	5450	860	5650	1710	5550
19	1020	5250	525	5650	1660	5400
20	1140	5300	670	5650	1870	5450
21	1100	5300	995	5800	2150	5500
22	1100	5350	765	5600	1900	5450
23	950	5350	1000	5750	1960	5550
24	840	5350	760	5600	1550	5500

Table 4. Illumination distribution measurement for artificial solar system.[Illumination(lx) Color temperature(K)]

Item	Artificial Sun		General illumination + Artificial Sun	
	Illumination	Color temperature	Illumination	Color temperature
1	2800	4850	4550	4800
2	10000	6100	14500	6350
3	2900	5250	4650	4650

3.3 Artificial solar system experiment

As sunlight is an important factor in real life living and office environment, the simulator has an artificial solar system to implement sun light. As shown in the table 4, color temperature and illumination have been measured for the different illumination level. Moreover, the same analysis had been performed for surrounding environment which gives a sense for the real natural environment in the sun.

4. CONCLUSION

In this paper, we developed the technique to present the mock environment and software to measure and evaluate the sensibility physiologically or psychologically and a simulator to measure and analyze human sensibility (SMAS)that can be utilized for large scale industrial production and design of environment. The experimental results show that the proposed framework tries to reach the global optimum physical data that corresponding to the target physiological data. In conclusion, we can say that,

- The proposed framework exhibited the potential to design an artificial environment.
- It is necessary to prepare more pairs of physical and physiological data sets to show the effectiveness clearly.

The next steps are therefore to improve the evaluation simulation based on this discussion and to show the effectiveness of our proposed framework by using real physiological measurements to optimize an artificial environment.

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