A Study on Development of Simple Energy Assessment Model for Building User based on Augmented Reality

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Abstract

Recently, the digitization brought the significant changes in aspects of life due to the advances in technology and the universalization of equipment is becoming increasingly, giving of affects much influencing in building related fields. The concept of the Augmented Reality as a technology for the representation by overlapping the information generated by computer in real-world images has begun to be introduced, and also in the field of architecture in the 2000s, began to take attention on the potential of augmented reality, but it is the fact that yet the researches involved in the field of built environment remains in its early stages. Therefore, this study has intended to help understanding on the building energy of general users as well as the architectural experts by conducting the basic research for the development of energy-assessment model to briefly evaluate the building energy assessment and performance using Augmented Reality Technique.

Keywords: Augmented Reality, Building Energy Performance, Energy Saving, Low Carbon Building

1. Introduction

1.1. Background and Purpose

Recently, the digitization brought the significant changes in aspects of life due to the advances in technology and the universalization of equipment is becoming increasingly, giving of affects much influencing in building related fields. The concept of the Augmented Reality as a technology for the representation by overlapping the information generated by computer in real-world images has begun to be introduced, and also in the field of architecture in the 2000s, began to take attention on the potential of augmented reality, but it is the fact that yet the researches involved in particularly the field of built environment in comparison with other sectors remains in its early stages. Building energy consumption is gradually increasing interest in energy savings, as well as experts to the public growing. Therefore, in the field of the building energy that can be accessed more easily by digitizing using augmented reality study is needed. Therefore, this study has intended to help understanding on the building energy of general users as well as the architectural experts by conducting the basic research for the development of energy-assessment model to briefly evaluate the building energy assessment and performance using Augmented Reality Technique.

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1.2. Methods and Scope of the Study

In this study, the authors have built the process for the development of application using Augmented Reality, and then have analyzed the design techniques for the energy conservation of building to be applied in the process. The energy performance assessment model by energy consumption, and the energy performance assessment model by building DB information for the development of building energy assessment models based on the above results were suggested, and the basic research preparing the process of energy performance assessment model through case study was progressed.

2. Design Technique for Building Energy Conservation and Process for Development of Augmented Reality Application

2.1. Process for Development of Augmented Reality Application

It was assumed that the objects for this application are the complex (e.g. College campus, Apartment Housing) constructed with the multiple buildings group. Building's energy performance

evaluation is divided into two areas, and these assessments make of the assessment by building DB and by energy consumption. User can determine the energy level of the building by easily evaluating the energy levels of the building and comparative analysis with similar buildings and by providing of the information in the form of the application using Mobile. This study is the contents corresponding to the first stage in three stages of application development, and is the brief evaluation stage by building DB and energy consumption. The scope of this research and the future research direction shows as Fig 1.

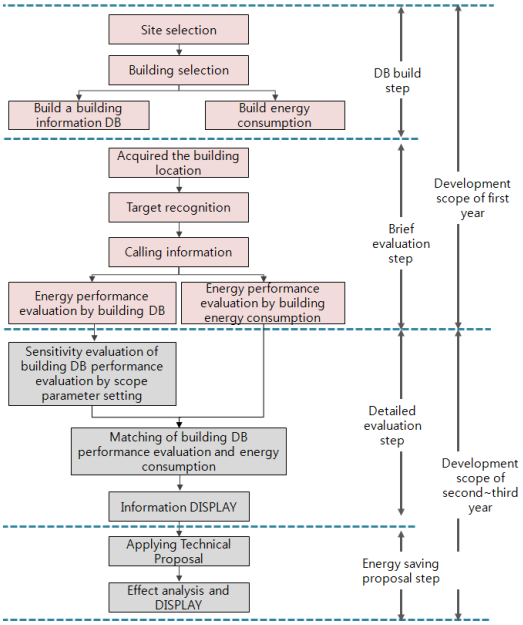

Fig 1. Process for Application Development

2.2. Building design techniques for energy conservation

As the results investigated through the building's domestic and international cases, applied technology elements can be divided into three elements technologies, that is, architectural planning, facilities planning and renewable energy technology. The main technologies of architectural planning elements are the direction of building, the U-value of building envelope and the window, window to wall ratio, S/V ratio and so on. The facility planning element technologies are the responsible for the energy load of lighting, appliances, heaters, etc. and the renewable energy is the clean natural energy replacing the existing fossil fuels, and the renewable energy being applied to building are solar energy, wind, geothermal and bio-energy.

3. Energy Assessment Model of Building

3.1. Energy Assessment Model by Energy Consumption

In this study, the evaluation criteria of building energy consumption level proposed by integrating the domestic and international energy reduction targets and energy reduction likelihood, as shown in Table 1. Normal step (current consumption level) was set to ±10% range of the average consumption, and good step was the case of 10~30% reduction, and the best step was set to more than 30% reduction.

On the contrary, for the building having much energy consumption, the building using more 10 to 30 percent than average was set the insufficient grade, and the building using more than 30% compared to average consumption was set as the bad grade. Details are shown in Table 2.

3.2. Energy assessment model by building DB

To propose the energy assessment model by building DB, the energy parameters used to building energy analysis were drawn by investigating and analyzing for the energy analysis method calculating the load directly affected to energy consumption of building and the energy analysis tool using the method, the variables of building energy assessments were chosen as the center of the essential and direct variables.

The assessment model by building DB presented the assessment method of assessment variables of building energy consumption previously given. Each variable secures the building DB through the drawings of building and related documents as the element that affects directly or indirectly to energy consumption. However, each assessment grade per variable was evaluated in the three grades considering whether the secure of DB. The user's convenience, and assessment grade are divided to low energy, average, energy guzzling. Low energy means less than the amount of energy consumption of existing buildings and average means average energy consumption of existing buildings. The detail assessment items are followed in Table 3.

Table 1. Rating by Building type (unit: Mcal/㎡·yr)

Building type		Office	University	Apartment house
Average Energy consumption		211	181	125
Grade	Best (Over-30%)	Below147.7	Below126.7	Below84.7
	Good (-10~-30%)	147.7~189.9	126.7~162.9	84.7~108.9
	Average (-10~+10%)	189.9~232.1	162.9~199.1	108.9~133.1
	Insufficient (+10~+30%)	232.1~274.3	199.1~235.3	133.1~157.3
	Bad (Exceed+30%)	Exceed274.3	Exceed235.3	Exceed157.3

Table 2. Building Energy Assessment Variables

Section	Parameter
Design parameter	Direction of the building
	S/V Ratio(%)
	Envelope insulation(W/㎡ k)
	Window insulation(W/㎡ k)
	Window wall Ratio(%)
	Presence of open window
Facilities parameter	Light fixtures
	Heating/Cooling equipment

4. CASE STUDY

In the case study, the energy assessment model was applied by conducting energy consumption and building DB assessment as the center on complex constructed with multiple building groups. The target buildings selected the college campus constructed of multiple buildings. The college campus basically consists of the building groups having various characteristics such as Educational facility or Dormitories, Lecture, Researching Building, and the energy consumption. In the case study, the energy assessment model was applied by conducting energy consumption and building DB assessment as the center on complex constructed with multiple building groups. The target buildings selected the college campus constructed of multiple buildings. The college campus basically consists of the building groups having various characteristics such as Educational facility or Dormitories, Lecture, Researching Building, and the energy consumption Educational facility or Dormitories, Lecture, Researching Building, and the energy consumption in most of building was reduced, while the energy consumption of college campus was increase.

Table 3. Assessment of Building DB Level Thus, this campus was selected as the object of the case study under judgment that will be required the induction of evaluation and energy-saving for energy consumption of university campus. Overview of case study of building group is shown in Table 4.

4.1. Evaluation of Energy Consumption

The average of total energy consumption per unit area of Case Building was 182.9Mcal/㎡, a nd this value was investigated as being similar to the average energy consumption of 180.8Mca l/㎡ in building for education. It was evaluated as Table 5. that there were best grade of 4 pla ces, good grade of 1 place, Average grade of 3 places, insufficient grade of 2 places and bad g rade of 2 places among 12 building groups. It is expected that the energy building was reduce d, while the energy consumption of college ca mpus was increase The consumption of Univers ity building will be significantly changed accordi ng to the practical usage pattern rather than the architectural planning elements because the usag e pattern is changed depending on academic sc hedule.

4.2. Building DB Evaluation

The building information DB every target buil ding of case study is various level because whe ther the drawings of building can be obtained o r not according to construction year is different. Therefore, the case study of building assessment conducted the building evaluation selecting the b uilding which the obtaining of drawings and DB are easy among building groups. The sample bu ilding(Building 10) summary are show in Table 6.

Assessment	Low-Energy Level	Average Level	Energy-guzzling Level
Direction of the building	S/SSE/SSW	SE/SW/ESE/WSW	E/W
S/V Ratio(%)	Under10	Over10~Under20	Over20
Exterior wall insulation (W/㎡ k)	Over0.15~Under0.47	Over0.47~Under0.58	Below0.58
Roof insulation (W/㎡ k)	Over0.15~Under0.29	Over0.29~Under0.41	Below0.41
Floor insulation (W/㎡ k)	Over0.15~Under0.35	Over0.35~Under0.58	Below0.58
Window insulation (W/㎡ k)	Over1.8~Under2.3	Over2.3~Under3.4	Below3.4
Window Wall Ratio(%)	Below50	Over50~Under70	Over70
Presence of open window	Have	-	None
Light fixtures	LED Lamp/Dimming Control	A fluorescent lamp within ballast stabilizer	Incandescent lamp/ Halogen lamp/ A fluorescent lamp
Heating/Cooling equipment	Ground Source Heat Pump	EHP/GHP/ Absorption Chiller-Heater/ Radiant floor	Steam Boiler/ Gas Furnace/ Packaged air conditioner

Table 4. Overview of Case study of Building Group

Building	Gross area (m^2)	Floors	Operation control	Heating/Cooling equipment
1	10,093	3F, B1F	Personal	Packaged air conditioner
2	7,891	4F	Personal	EHP
3	3,707	6F, B2F	Personal	GHP
4	9,122	5F, B1F	Personal	Gas Furnace
5	3,674	6F	Personal	EHP
6	14,258	5F, B1F	Personal	EHP
7	22,145	7F, B1F	Central	Steam Boiler, EHP
8	11,894	7F, B1F	Central	Absorption Chiller-Heater, EHP
9	5,299	9F, B3F	Personal	GHP
10	35,119	5F, B3F	Central	Steam Boiler, GHP
11	1,616	14F, B3F	Central	GHP
12	19,164	10F, B3F	Personal	EHP, Radiant floor

Table 5. Energy consumption of Sample building (Unit : Mcal/㎡)

Building	Electricity	Gas	Total	Grade
1	44.58	66.61	112.19	Best
2	122.83	0	124.83	Best
3	145.35	230.77	379.12	Bad
4	33.95	41.65	79.60	Best
5	229.27	0	234.27	Insufficient
6	109.05	3.31	118.36	Best
7	106.58	129.89	243.47	Bad
8	63.76	118.69	190.45	Average
9	66.37	159.83	235.20	Insufficient
10	63.07	70.69	143.76	Good
11	25.05	169.63	205.68	Average
12	113.89	80.75	206.64	Average
Total	93.65	89.32	182.96	-

Table 6. Sample building(Building 10) Outline

Parameter	Value
Building Type	University
Location	Seoul
Building area	3,733 m^2
Gross area	35,119 m^2
Floors	14F, B3F
Completion of Year	2007
Operation control	Central
Heating/Cooling system	GHP
Assessment Energy consumption	Good

The sample of case was direction of the building was tilted 62° to southwest base On the south side. The shape of the building S/V ratio was calculated as 18 large building which is the energy-consuming due to the size of the building floor. This building has been completed in 2007, so the building envelope and the heat transmission coefficient of window applied 2001 standard. For the reason, the drawings of case building were obtained but the data on the detail combination of envelope structure was limited to obtain. In the plan of windows and in the east and the west, only at least window was planned, so the area ratio of full widow was 33%. The area of windows which open and shut are possible were planned for each room, and it was expected that natural ventilation was possible through the windows. The tubular 32 W grade florescent light was used in lighting, the user could control to turn on/off of lighting. Heating and cooling systems through the GHP was used for cooling and heating. As the results of evaluation of the variables of each item, were evaluated such as 7 items in normal, 2 items in low energy and 4 items in energy-consumption among total evaluation items of 13 items. The results are same as Table 7.

5. Conclusion

This study is the basic research to develop the energy assessment model being able to briefly evaluate the building energy and performance utilizing augmented reality techniques, and built the process for development of augmented reality application. After analyzing the design technique for building energy conservation to be applied in this process, the basic study preparing the process of the energy performance assessment model progressed dividing in two steps of Evaluation of Energy Consumption and Building DB Evaluation through Case Study for development of building energy assessment model was performed. In the case of the energy consumption evaluation, the authors measured the electricity and gas consumption selecting 12 target buildings in the campus, and set as the target the building which building information DB could be easily obtained among them. As the results of assessment of energy consumption, the average energy consumption of building groups was investigated as similar value(182.9Mcal/㎡) to energy consumption per unit area (180.8Mcal/㎡) presented in the standard, but were examined that deviations of energy consumption by buildings were large.

Table 7 Building energy assessment by building DB efficiency rating label system for the

Parameter	Value	Low-Energy Level	Average Level	Energy-guzzling Level
Direction of the building	SW		O	
S/V Ratio(%)	18		O	
Exterior wall insulation(W/ m^2k)	0.29		O	
Roof insulation (W/ m^2k)	0.47		O	
Floor insulation (W/ m^2k)	0.35		O	
Window insulation(W/ m^2k)	3.84			O
Window to Wall Ratio(%)	33	O		
Presence of open window	Have	O		
Light fixtures	A fluorescent lamp		O	
Heating/Cooling equipment	GHP		O	

This is because the pattern of building occupancy is different by building, so it is expected that in future evaluation of energy consumption of University building, the criteria on the pattern of building occupancy would be presented. The target building of building DB assessment was evaluated to consume less than average energy consumption of usual building for teaching as good grade in the assessment by energy consumption, but most results of the assessment were normal item that belongs to the majority. Energy consumption was divided into give stages by energy consumption per unit area, but the assessment by building DB for each item divided into three stages, so this matching was limited.

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