International Journal of Smart Home
Vol. 10, No. 1, (2016), pp. 89-100
http://dx.doi.org/10.14257/ijsh.2016.10.1.10

A Novel Measurement of Events for the Awareness of Danger in the Residential Condition

You Jeong-Bong, Si-kyung Kim, Ho-ik Jun* and Seo Dong-Hyeok

Kongju National University, ChenanCity Korea
*Hyejeon College, Chungchengnamdo Korea**
{jbyou, Skim}@kongju.ac.kr, report@hj.ac.kr, absuh@nsu.ac.kr*

Abstract

In living environments, abnormal and unusual situations should be quickly recognized. This can be said to be a study regarding secure safety. The purpose is to prepare measures for quick recognition and the avoidance of risk factors in residential environments. To intellectually recognize living spaces, measures to recognize various risks quickly are necessary. In the present study, factor extraction and situation detection measures necessary for space intellectualization for recognizing unusual situations in advance in urban spaces are proposed. Unusual situation occurrence factors in living environments were classified, and risk elements by factor were derived. The risks were calculated utilizing the extracted unusual situation elements to show the actual utilization.

Keywords*: situation inference, situation, context awareness*

1. Introduction

Recently, studies on the Internet of things have been actively in progress. Previously, wireless sensor networks were used to attach sensors to objects in the real world and surrounding environments and to report measurement data sent by the sensors to the host using wireless networks, such as Zigbee. On the other hand, the Internet of things connected mobile radio communication networks to existing local area wireless networks so that the sensor data transmitted could stably arrive at the server or host located at a long distance, thereby enhancing the stability and the utility of network systems[1]. Both ubiquitous sensor networks and the Internet of things technologies aim at recognizing situations and implementing intelligent services by attaching sensors to many objects in the real world and their surrounding environment to obtain the related information. In this case, among the measured values obtained through sensors, the sensor measured values with aspects of changes that have been judged to be reportable are called event information. Estimation techniques should be used for real world situations when recognizing targeted situations is difficult or sufficient positive proofs cannot be obtained, which is called situation inference. Situation recognition thus far has been implemented by constructing data models based on prior information and applying the data obtained from the sensors thereafter to the data models. Recently, to supplement situation recognition for situations that are not in the category of prior modeling, new situation inference techniques have been introduced.

An area in which these techniques are used to infer real world situations using sensors is space intellectualization for crime prevention and danger avoidance. Diverse studies intended to prevent crime occurrences in modern society and secure safety in living spaces have been in progress in many areas [9-11]. Studies for living safety are conducted in terms of utilizing the areas of construction, public administration, and IT technologies. In the area of construction, studies focus on the design of spaces in which crime occurrence can be prevented. The studies attempt to find ways to control crime occurrences through the redesign of urban environments and residential spaces. In the

ISSN: 1975-4094 IJSH

area in which IT technologies are utilized, studies to enable recognizing dangerous situations and avoiding dangers by utilizing sensors and surveillance cameras and constructing and utilizing data warehouses have been in progress. Problems in studies that aim to redesign urban spaces for crime prevention include not applying recent intelligent technology functions so that intelligent functions cannot be applied. In addition, those studies have limitations in the diverse prediction of crime occurrence and in risk measurement. Living security systems that use human body sensors, surveillance cameras, and data mining technologies are limited to only recognizing situations in which various dangers or crime occurrences are imminent. In addition, these systems' low rates of recognition of various dangers and crimes that are still not higher than 70% are also a matter that should be supplemented. An alternative that can overcome these problems is space intellectualization. Through space intellectualization, functions to prevent/suppress the occurrence of accidents or crimes can be reinforced further, the time to predict the occurrence of accidents or crimes can be advanced, and risks in real life can be measured more details. In the present study, measures to sense unusual situations are proposed for space intellectualization. The factors involved in unusual situations are extracted, and circumstances in which abnormal situations can be inferred using the factors are examined [2, 3].

The present paper consists of five chapters. In Chapter 2, the theoretical background and related studies are described, and in Chapter 3, measures to extract unusual factors from situation inference for space intellectualization are proposed. In Chapter 4, the contents of the evaluation through experiments are described, and in Chapter 5, the conclusions are drawn.

2. Context Inference and Living Security

2.1. Context Inference Using Data Streams

As studies on sensor networks and the Internet of things have been actively conducted, the interest in situation inference has increased. Situation inference in a sensor network and the Internet of things environments can be said to be situation inference in data stream environments because the data produced and distributed in these environments are not in conditions for storage and analysis over a sufficient time with existing data. The data produced in sensor networks and the Internet of things are measured by sensors, transmitted through networks, filtered or removed based on redundancy, fused in middleware, and used in the host for the provision of application services. Situation inference in data stream environments generally undergoes the preprocessing of sensor data and the fusion of heterogeneous data. For the fusion of heterogeneous data, methods using Bayes' theorem, methods using the fuzzy theory, methods using artificial neural networks, and methods using Kalman filters have been used [4, 5]. These data fusion technologies are used to obtain more accurate situation information using the values sensed by the diverse sensors. Through data fusion, situation information can be extracted based on the event information obtained by individual sensors through their unique functions, and the situation information obtained using many types of sensors can be higher in quality compared to situation information obtained using single sensors. It should be noted that unlike existing data processing, the processing methods of data streams should consider the high capacity, continuity, and variability of processing objects. Since situation inference in data stream environments should consider these characteristics, it should be differentiated from previous situation inference [6-8].

2.2. Design of Urban Spaces for Crime Prevention

This concept is based on the premise that city structures and space arrangement act as a factor for crime occurrence and the belief that the rate of crime occurrence can be reduced by improving city structures, space division, and utilization. The basic principles are natural surveillance, access control, reinforcement of territoriality, activation of activities, and maintenance. It has been proven that when cities, buildings, and spaces were redesigned based on the results derived through related studies, crime occurrences were suppressed. This can be applied to urban space design, residential environment structure improvement, and the utilization and improvement of spaces in schools to ensure safety.

Attempts to improve residential environments and reduce crime occurrences through Ansim Village projects implemented in individual regions in South Korea are being made. Studies to prevent school violence through the improvement of school spaces have also been conducted [9].

2.3. IT Fusion Systems for Living Security

Efforts to apply IT technologies that are continuously developed, such as high-performance sensor technologies, networking technologies, image processing technologies, and database analysis technologies, to diverse areas in real life have been continuously applied. Many studies are in progress that aim to introduce IT technologies to diverse areas, such as environment monitoring, production site management, and building safety management, to upgrade the information required in relevant areas further to provide high-level services. Studies to implement living security systems utilizing IT fusion technologies are also being conducted with the aim to sense signs of accident occurrences or accident occurrences utilizing sensing technologies, networking technologies, and computing technologies to respond to accidents quickly. There are studies being conducted to recognize the fright and fear experienced by residents in real life through body sensors to transmit the information to the server through the network as well as studies to recognize strangers loitering and trespassing through surveillance cameras. Studies to model situation information on various dangerous situations to construct data warehouses and recognize dangerous situations utilizing the data warehouses have also been conducted.

3. Risk Factor Extraction Measures for Space Intellectualization

3.1. Necessity of Space Intellectualization

To reduce the dangers in various living environments, there is a necessity to improve urban environments and change building structures, thereby expanding natural surveillance against dangers. The principle of natural surveillance is changing the structures of relevant regions and structures to connect the life and movement of users and residents to the surveillance of spaces and environments; however, natural surveillance cannot be done permanently. That is, even if spaces have been changed so that the spaces can be surveilled, surveillants, or users, that participate in surveillance or residents that should participate in surveillance activities may not exist in the relevant time and spaces in some cases. Therefore, measures to maintain natural surveillance permanently are necessary, and one way could be attaching sensors to the relevant spaces and installing data transmission networks to achieve space intellectualization. These space intellectualization measures can secure permanent natural surveillance as well as expand the area of natural surveillance further. That is, space intellectualization can enable implementing natural surveillance for dangers existing in hidden spaces that cannot be identified by the human naked eye or wide spaces that cannot be easily recognized. The necessity to implement space intellectualization is also because in real life, space intellectualization can allow for finding elements of unusual situations in advance and quickly notifying the elements to those that may be damaged to avoid or bypass the dangers. Services to indicate that the elements may be damaged and to notify the police would relieve the prospective victims from the dangers when guardians, or those who can respond to requests for protection, are required.

The necessity of space intellectualization measures to recognize unusual situations can be examined from the following five aspects.

1) Making natural surveillance permanent and expanding it
2) Danger sensing and avoidance
3) Cooperation for danger prevention and continuing the cooperation
4) Reducing space redesign costs
5) Active living security

Dangers can be recognized, and damage can be permanently prevented only when continuous and permanent sensing of dangers is possible whether or not people are gathered and whether or not human surveillance is implemented. In addition, cost effectiveness should be also discussed. Compared to the costs of facility remodeling or building structure changes, such as marking boundary areas and installing benches in urban residential environments, the costs to attach low-priced sensor and configure networks can be lower. Low cost, high efficiency systems can be configured by introducing space intellectualization. In addition, a problem appearing in previous studies on surveillance using sensors and surveillance cameras is that the time to recognize crime occurrences is too imminent. Systems in previous studies had to rely on body sensors to sense the fear felt by the prospective victims of crimes after feeling the risk of crimes. In the case of these systems, the time to respond to dangers may be too brief. A problem is that the time when dangers have been sensed through bio-signals is highly likely to be the time when the crime has already begun, and the dangers cannot be sensed through bio-signals in many cases. That is, since victims cannot predict or forefeel dangers in many cases, the function to recognize dangers and respond to the dangers may not operate at all. Rather than having prospective victims recognize dangers in residential environments, intellectualizing residential spaces and spaces surrounding residential areas through sensors and networks can reinforce the function to recognize dangers in advance and secure sufficient time to avoid the risk of the occurrence of crimes or respond to the risk of the occurrence of crimes.

3.2. Space Intellectualization

Measures to intellectualize residential spaces and living spaces can be approached from two aspects. The first is a system in which the user actively obtains information on surrounding spaces. This is based on the premise that the user has high-performance sensors and data processing equipment that enable judgment on situations or access to the host through the networks. The second is a system in which information provided by intellectualized spaces is obtained, utilized, and relayed to sensors and networks attached to or distributed in surrounding spaces. In the present study, unusual situation factors will be extracted from general environment information using measures that can be applied to both of the two systems, and how the extracted factors can be used for the prediction of danger will be shown.

The implementation processes for space intellectualization can be described as follows.

1) Sensor selection: Sensors should be selected for space intellectualization. Selecting sensors that can provide the appropriate information necessary for the recognition of situations is the first step toward space intellectualization. The first consideration in sensor selection is whether or not the sensor can provide information on the targeted situation or clues to the inference of situations.

2) Sensor attachment/distribution: Methods of sensor attachment/distribution should be considered. Sensor attachment/distribution should ensure sensors' survivability, guarantee

sensors' sensing activities, and enable a smooth acquisition of information for the recognition of situations.

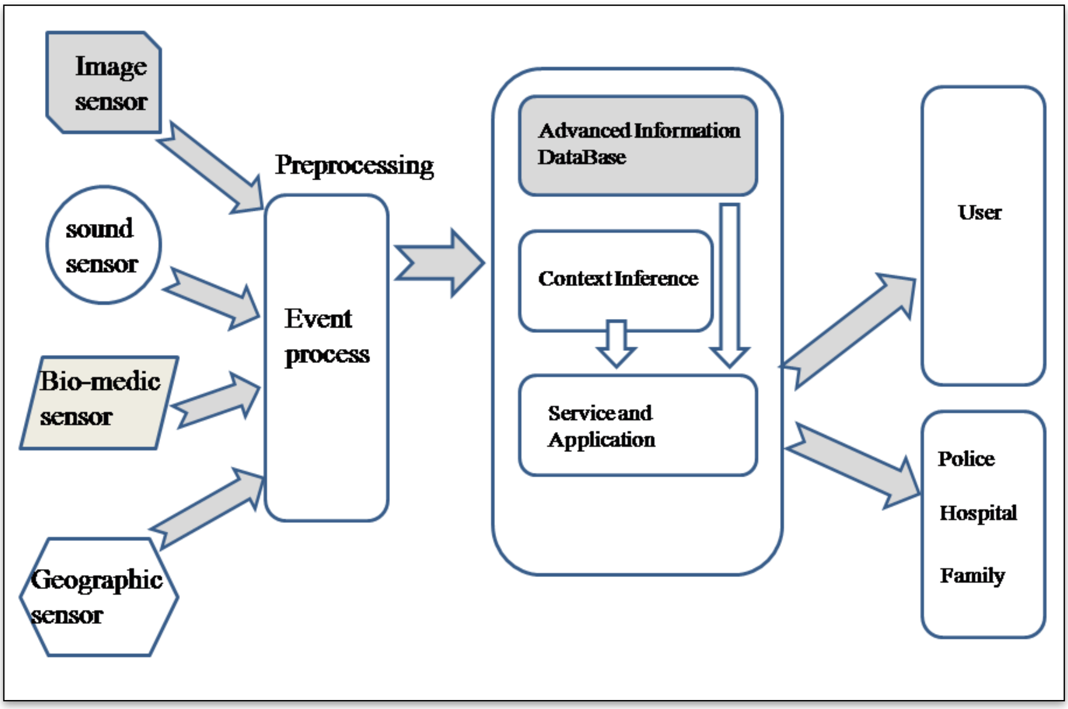

Figure 1. The Implementation Processes for Space Intellectualization

3) Data processing: Measures to process the data sensed and reported by sensors are important. The data sensed and reported by sensors are continuously obtained and reported over long periods of time. Sensors send measured values from targeted objects as signals, and these values should be pre-processed before being stored. In addition, the data are continuously obtained over time, and how these data should be processed should be determined. Whether all data would be processed or sample data would be selected and analyzed based on certain rules should be determined. Redundancy should be removed, and processing measures should be determined by considering how the data is sensed and reported by the heterogeneous sensor, which should be integrated into mutually related pieces of information.

4) Recognition of situation: Space intellectualization aims at recognizing what situations occur in the relevant space, and its ultimate goal is to provide services that are appropriate and suitable for situations in the space. Since situations occur in very diverse forms in the real world, accurately recognizing the situations through several devices is difficult. Measures to organize prior information to construct data models and utilize the data models are the most frequently used, and alternatives should be established for situations that are out of the range of the prior information. The pattern of changes in signal values from the sensors that are continuously received over time is noteworthy.

5) Information delivery and personalization service: Space intellectualization should ultimately be capable of delivering situation information in the space to the demander accurately and quickly. Information corresponding to situations occurring and progressing in the space should be distributed and delivered, and appropriate services corresponding to the situations should be realized. Services corresponding to situations should follow the functions and drive targets of individual application software programs, and the propagation of situation information can be implemented through auto-matching functions.

3.3. Risk Factor Extraction in Space Intellectualization for Living Security

The purpose of the present study was to seek space intellectualization measures that will sense the risk of occurrence of crimes in advance and enable response actions or danger avoidance. In particular, it focuses on how to extract factors related to situations in utilizing the Internet of things technologies.

To implement space intellectualization for living security, the factors involved in unusual situations are classified into three types:

1) Individuals' conditions
2) Changes in environmental factors
3) Spatiotemporal factors

Individuals' conditions refer to conditions in which the users of living spaces should not walk or show vulnerability to attacks. For instance, there was a case in which a woman who was sitting and crying on the stairs in front of a subway station was kidnapped. There was a case in which a drunken woman in her fifties was kidnapped in front of a bank on the roadside, and there was another case in which a drunken woman in her twenties was walking on the roadside and was kidnapped by car. She became a victim of a crime. These cases show that individuals' conditions are associated with the risk of crimes.

Individuals' conditions can be divided into stationary conditions and moving conditions. Estimating conditions that can be targets of crimes, measuring the risk levels of the individual conditions, and scoring the risk levels are necessary for risk level estimation.

Changes in environmental factors refers to changes in environments from places with high levels of illumination to dark places, from places with large floating populations to places with small floating populations, and from places where spaces are monitored and controlled to places where spaces are not monitored or controlled. These changes can be said to be made by users' movements in many cases. The risk levels can be said to rise in situations in which the environment is changed from places with high levels of illumination to dark places, from places with large floating populations to places with small floating populations, or from places where many windows or verandas face the moving path to places where no window or veranda faces the moving path.

The spatiotemporal factors were determined by referring to the analysis of crime occurrence statistics announced by the Public Prosecutors Office of South Korea indicating that crimes occur the most frequently between 21:00 and 01:00. In addition, the South Korean Police analyzed places where crimes are committed frequently based on statistics and made safety maps based on the results. According to the maps, it can be said that risks increase in places where crimes occur frequently. Time and spaces are associated with the risk of crimes.

3.4. Unusual Situation Detection Measures

To detect unusual situations, converting the heterogeneous factors into values in the same format that can be calculated is important. The individuals' conditions, the changes in environmental factors, and the spatiotemporal factors were divided as follows.

1) Individuals' Conditions

Individuals' conditions were divided as follows. Individual's conditions are to be evaluated according to the criteria set forth in the following table.

Normal condition
Conditions in which the individual requires attention
Conditions in which the individual requires help
Conditions in which the individual is exposed to dangers

2) Changes in Environmental Factors

Information on environmental factors can be obtained through sensors. One fact that is important when selecting sensors is that a large quantity is necessary because the sensors should be distributed in or attached to living environments. Therefore, sensors should not be expensive. Since the sensors are not expensive with a high performance, to obtain high grade information, different types of sensors with different functions should be used. In this case, measures to process the heterogeneous measurement signals are needed to recognize unusual situations. In the present study, since movements from bright places to dark places and movements from places with large floating populations to places with small populations were regarded as important factors for situation changes to be recognized, illumination sensors and sound sensors were employed to detect the factors. These sensors were distributed in the space, and the patterns of changes were evaluated. When the environment factors showed noteworthy patterns, the patterns were utilized as grounds for the calculation of risk levels.

3) Spatiotemporal factors

Spatiotemporal factors were given different weights according to time zones. The factors were divided according to time zones as follows.

Sound data(D_1)

$$D_{1\cdot t} = \begin{cases} 1 - \frac{S_{1\cdot t}}{\delta_1} & , \wedge S_{1\cdot t} < \delta_1 \\ 0 \quad , \quad \wedge S_{1\cdot t} \geq \delta_1 \end{cases} \quad (1)$$

Illuminancedata(D_2)

$$\Delta_{2\cdot t} = S_{2\cdot t} - S_{2\cdot(t-1)} \quad (2)$$

$$D_{2\cdot 1\cdot t} = \begin{cases} 1 - \frac{1}{\Delta_{2\cdot t}}, & 1 < \Delta_{2\cdot t} \\ 0 \quad , & 1 \geq \Delta_{2\cdot t} \end{cases} \quad (3)$$

$$D_{2\cdot 2\cdot t} = \begin{cases} 1 - \frac{S_{2\cdot t}}{\delta_1} & , \wedge S_{2\cdot t} < \delta_2 \\ 0 \quad , \quad \wedge S_{2\cdot t} \geq \delta_2 \end{cases} \quad (4)$$

$$D_{2\cdot t} = \frac{D_{2\cdot 1\cdot t} + D_{2\cdot 2\cdot t}}{2} \quad (5)$$

Spatial data(D_3)

$$D_t = \frac{D_{1\cdot t} + D_{2\cdot t} + D_{3\cdot t}}{3} \quad (6)$$

Spatial factors are to be evaluated by referring to the frequency of the occurrence of dangerous situations in the relevant place based on the location information. In the present study, expert evaluations were obtained.

4. Detection of Unusual Situations and Results

Using the unusual situation recognition elements proposed in the previous chapter, whether or not unusual situations were actually recognized was evaluated. Individuals' condition values and spatiotemporal factors were selected from the above table of criteria, and illumination sensors and sound sensors were examined in the experiment.

Through the experiment, the following results were obtained.

Table 1. Condition 1

Noise (dB)	Illumin-ance(lx)	Illumin-ance_pr(lx)	gps_x	gps_y	Danger _sound	Danger _light	Danger _map	danger
50	38	38	5	1	0	0	0.1	0.0333
53	36	38	5	1	0	0.25	0.1	0.1166
60	37	36	5	2	0	0	0.1	0.0333
54	38	37	5	2	0	0	0.1	0.0333
48	36	38	5	3	0	0.25	0.1	0.1166
49	35	36	5	3	0	0	0.1	0.0333
52	36	35	5	3	0	0	0.1	0.0333
46	34	36	4	3	0	0.25	0.3	0.1833
43	36	34	4	3	0	0	0.3	0.1
46	34	36	4	3	0	0.25	0.3	0.1833

The concrete contents of the process used to obtain the results are as follows.

Table 2. Condition 2

Noiese (dB)	Illumin-ance(lx)	Illumin-ance_pr(lx)	gps_x	gps_y	Danger _sound	Danger _light	Danger _map	danger
3	46	47	5	1	0.85	0	0.1	0.3166
4	44	46	5	1	0.8	0.25	0.1	0.3833
2	47	44	5	2	0.9	0	0.1	0.3333
3	45	47	5	2	0.85	0.25	0.1	0.4
5	46	45	5	3	0.75	0	0.1	0.2833
4	45	46	5	3	0.8	0	0.1	0.3
3	47	45	5	3	0.85	0	0.1	0.3166
2	46	47	4	3	0.9	0	0.3	0.4
4	45	46	4	3	0.8	0	0.3	0.3666
3	47	45	4	3	0.85	0	0.3	0.3833

Table 3. Condition 3

Noiese (dB)	Illumin-ance(lx)	Illumin-ance_pr(lx)	gps_x	gps_y	Danger _sound	Danger _light	Danger _map	danger
49	8	6	5	1	0	0.3	0.1	0.1333
48	5	8	5	1	0	0.7083	0.1	0.2694
52	6	5	5	2	0	0.35	0.1	0.15
48	8	6	5	2	0	0.3	0.1	0.1333

46	5	8	5	3	0	0.7083	0.1	0.2694
48	9	5	5	3	0	0.275	0.1	0.125
47	6	9	5	3	0	0.6833	0.1	0.2611
48	7	6	4	3	0	0.325	0.3	0.2083
46	8	7	4	3	0	0.3	0.3	0.2
49	6	8	4	3	0	0.6	0.3	0.3

The procedures for the evaluation of the patterns of changes detected by the sensors are as follows.

Individuals' conditions, changes in environmental factors, and spatiotemporal factors were regarded as multiple factors, and heterogeneous values were fused.

As a result, the results as set forth in the following table could be obtained.

Table 4. As the Results, Belief and Plausibility of Each Focal Elements

Condition 1	h1	h2	h3	h1+h2	h1+h3	h2+h3	h1+h2+h3
bel	0	0.4798	0.1049	0.5998	0.1312	0.7710	1
pl	0.2289	0.8687	0.4001	0.8950	0.5201	1	1
pl-bel	0.2289	0.3889	0.2951	0.2951	0.3889	0.2289	0
Condition 2	h1	h2	h3	h1+h2	h1+h3	h2+h3	h1+h2+h3
bel	0.0004	0.5967	0.0489	0.7455	0.0622	0.7791	1
pl	0.2208	0.9377	0.2544	0.9510	0.4032	0.9995	1
pl-bel	0.2204	0.3410	0.2058	0.2054	0.3410	0.2204	0
Condition 3	h1	h2	h3	h1+h2	h1+h3	h2+h3	h1+h2+h3
bel	0	0.2120	0.4313	0.2650	0.5391	0.7789	1
pl	0.2210	0.4608	0.7349	0.5686	0.7879	1	1
pl-bel	0.2210	0.24881	0.3036	0.3036	0.2488	0.2210	0

As can be seen in the table, unusual situations could be recognized. The result is available to infer the context of real world. The comparison of each belief of focal elements make use of distinguish the most critical factor of unusual event. The uncertainty can derive from the plausibility and belief. The uncertainty reveals which is the most certain or uncertain. They can get rid of the ambiguous factor of the real context.

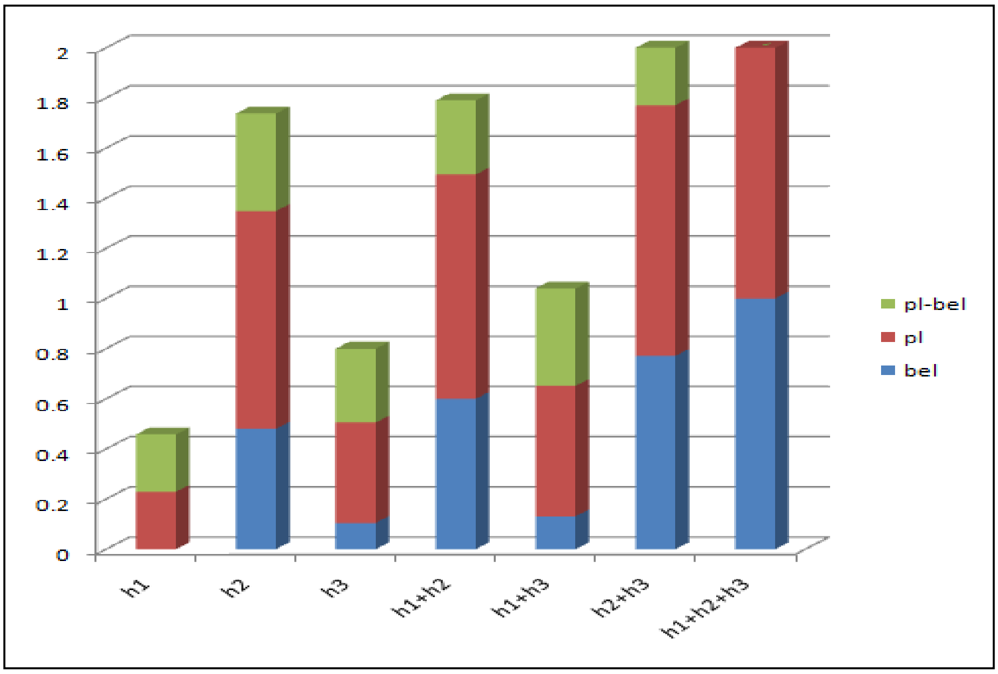

Figure 2. ***Belief*** **and** ***Plausibility*** **of Each Focal Elements(Condition 1)**

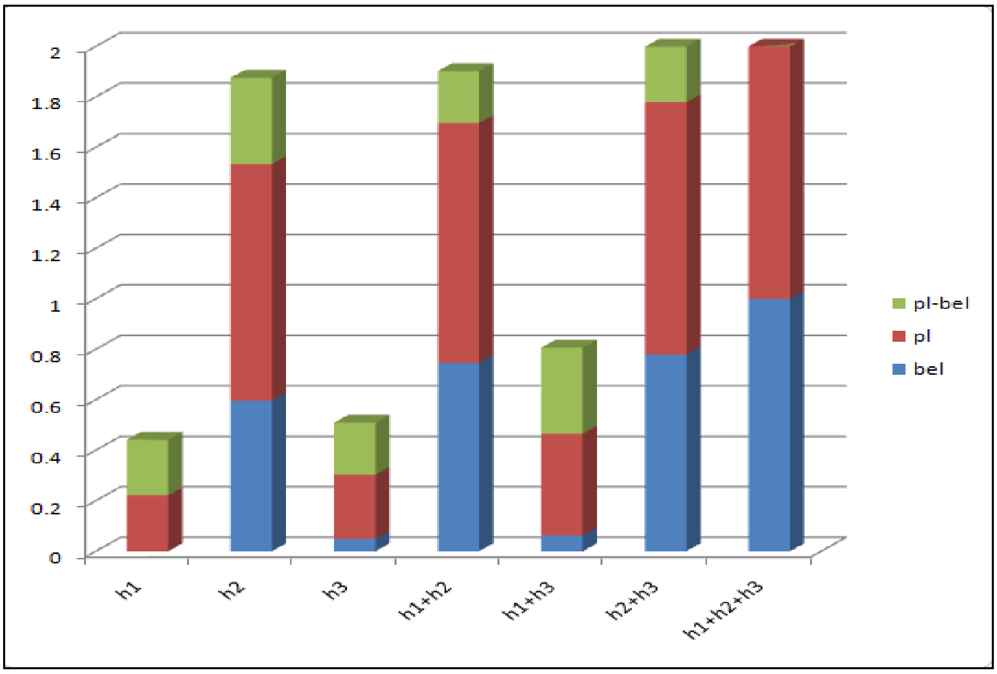

Figure 3. ***Belief*** **and** ***Plausibility*** **of Each Focal Elements(Condition 2)**

These graphs are derived from the Table 4 above. These graphs show that the most crucial factor of them. We can simply get the one that the blue bar the longest of them all. The blue bar means the belief. The largest belief says that the most important role in this unusual situation. The experiment of this chapter shows how to get the most important factor of real world context and the way of calculate the risk factor is useful.

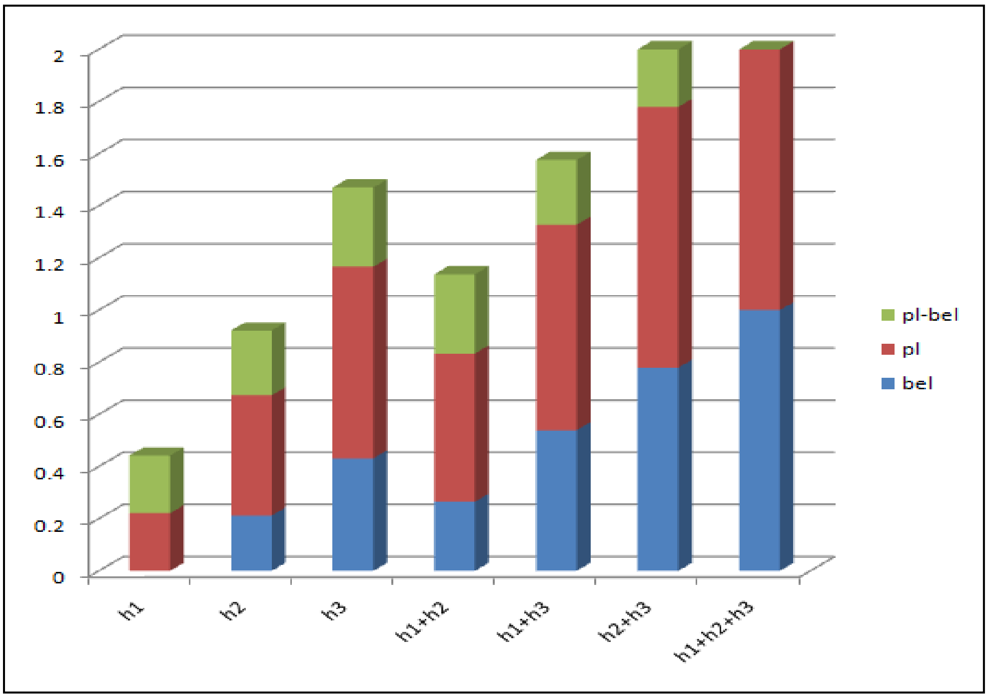

Figure 4. *Belief* and *Plausibility* of Each Focal Elements(Condition 3)

5. Conclusion

Recognizing and predicting unusual situations occurring in the real world is important. If such unusual situations are to cause damage or losses to humans, the sign of occurrence of such situations should be recognized, and prospective victims should be enabled to avoid the dangers.

The Internet of things was designed to enable information exchanges and situation recognition among devices without human intervention or management. In the present study, measures to detect unusual situations occurring in living environments based on the Internet of things technologies was proposed. Based on the present study, services to recognize and respond to dangerous situations can be developed, and advanced smart services for elderly persons and disabled persons can be developed

Acknowledgments

This work was supported by the research grant of the Kongju National University in 2015.

References

[1] Q. Chen, A. Whitbrook, U. Aickelin and C. Roadknight, "Data classification using the Dempster--Shafer method", Journal of Experimental & Theoretical Artificial Intelligence, vol. 26, no.4, **(2014)**, pp. 493-517.

[2] S. H. Lee, "Dempster-Shafer Fusion of Multisensor Imagery Using Gaussian Mass Function", Korean Journal of Remote Sensing, vol. 20, no. 6, **(2004)**, pp. 419-425.

[3] A. P. Dempster, "Upper and lower probabilities induced by a multivalued mapping", Ann. Math. Statist., vol. 38, **(1967)**, pp. 325-339.

[4] S. H. Lee, "Unsupervised Image Classification Using Spatial Region Growing Segmentation and Hierarchical Clustering", Proceedings of the KSRS Spring Meeting, **(2001)**.

[5] D. Suh and C. K. Ryu, "Multi-sensor Data Fusion Using Weighting Method based on Event Frequency", The Journal of The Korea Institute of Electronic Communication Sciences, vol.6, no. 4, **(2011)**, pp. 581-587.

[6] R. So and L. Sonenberg, "Situation awareness in intelligent agents: Foundations for a theory of proactive agent behavior", Proceedings of IEEE/WIC/ACM international conference on intelligent agent technology, **(2004)**.
[7] J. Thangarajah, L. Padgham and S. Sardina, "Modelling situations in intelligent agents", Proceedings of fifth international joint conference on autonomous agents and multiagent systems, **(2006)**; Hakodate, Japan.
[8] P. Urlings, J. Tweedale, C. Sioutis and N. Ichalkaranje, "Intelligent agents and situation awareness", Proceedings of the 7th international conference on knowledge-based intelligent information and engineering systems, LNCS 2774, **(2003)**.
[9] J. Lee, H. Park and S. Oh, "A Study on the Crime Prevention Through Environmental Design (CPTED) Strategy for the Application in Korea: A Preliminary Inquiry", Journal of The Korean Regional Development Association, vol. 20, no. 2, **(2008)**, pp. 213-232.
[10] D. B. Cornish and R. V. Clarke, "Theory for Practice in Situational Crime Prevention", Crime Prevention Studies, NY: Criminal Justice Pres., **(2003)**.
[11] G. Saville and G. Cleveland, "2nd Generation CPTED: An Antidoteto the Social Y2K Virus of Urban Design", 2nd Annual International CPTED Conference, **(1997)**; Washington, D.C.
[12] D. Suh and C. Ryu, "A Novel Weighting Method for Context Inference", International Journal of Multimedia and Ubiquitous Engineering, vol. 8, no. 1,**(2013)**, pp. 91-100.
[13] S. Yoon, C. Ryu and D. Suh, "A Novel Way of BPA Calculation for Context Inference using Sensor Signals", International Journal of Smart Home, vol. 8, no. 1, **(2014)**, pp. 1-8.
[i]

[i] This paper is a revised and expanded version of a paper entitled [A Novel Way of Recognition and Avoidance of Risk Factors in Residential Environments] presented at [FGCN2015, Jeju National University, Jeju Island, Korea, November 25 - 28, 2015].

