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Context Awareness of Smart Space for Life Safety

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Abstract

This study aimed at preventing crimes and various accidents. The space of residential environment provides service of preventing and avoiding various risks by demonstrating the function of being aware of various risks in advance. This study proposed a plan that guaranteed concealment in the environment which used cheap small sensor and enabled advance awareness even for a risk which deviated the range of advance information-based data modeling. Risk context reasoning was made to become clear through repeatedly checking a risk factor to be identified, as a multi-sensor data fusion-based risk awareness scheme which used DST.

Keywords: *Context Awareness, Data Fusion, Multi-sensor, Stream Data Mining*

1. Introduction

An interest in the study of guaranteeing life safety is increasing. There are various factors that threaten inhabitants' safety in the present living environment. Each municipality all over the country is devising measures for guaranteeing and improving life safety through the improvement of facilities in the vulnerable area for the structural vulnerability of residential environment.

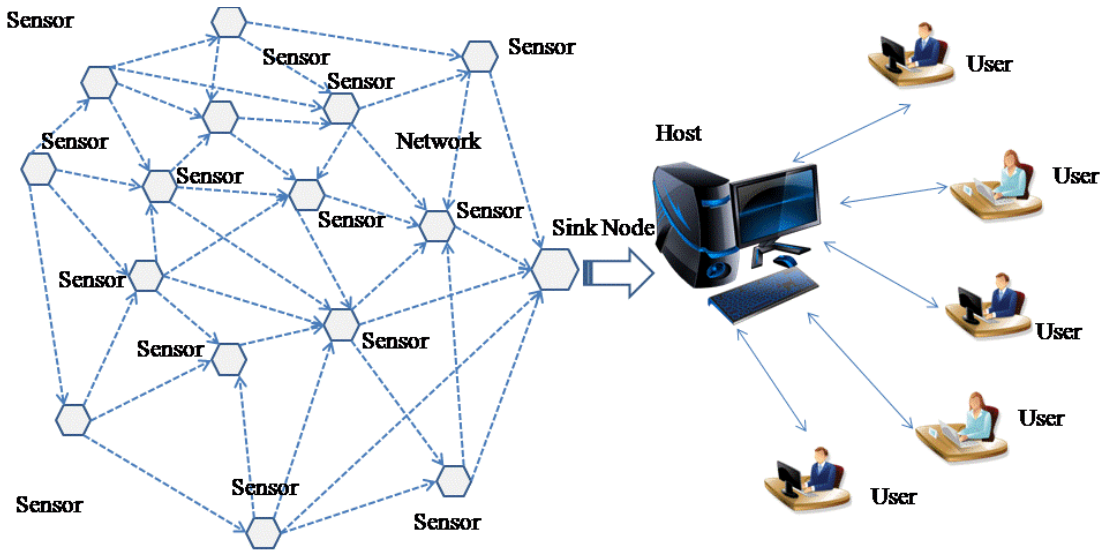

Fig. 1 Sensor Data Processing

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However, the actual condition is that environmental improvement for safety has restrictive factor due to the high renovation costs and structural problem of various kinds of social infrastructure.

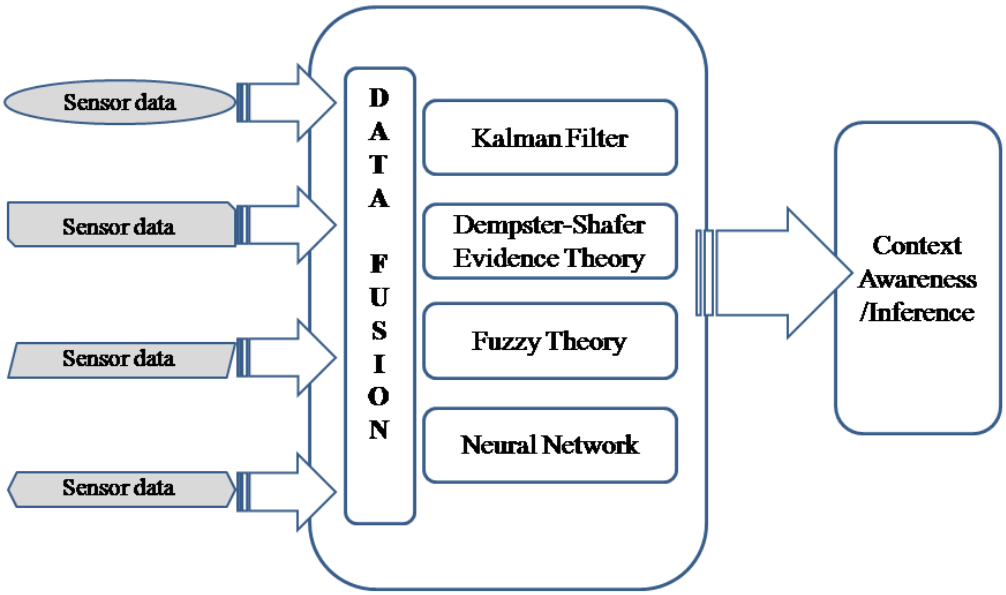

Fig. 2 Data Fusion for Context Awareness and Inference

Hence, studies of guaranteeing life safety by utilizing various kinds of smart technologies are increasing. It is expected that solution through the application of smart technology rather than the improvement of infrastructure is considerably effective in the improvement of vulnerable footway environment and residence of densely built-up old downtown with low costs. Technologies utilized for guaranteeing life safety around residence include context awareness technologies utilizing various kinds of network systems, image processing technology, and various kinds of sensing technologies. These are technologies for devising a plan of perceiving a threatening factor that may occur around residence and for protecting a user from danger.

What should be significantly examined in these studies is whether there is sufficient function of preventing various kinds of crimes and accidents. There are many cases the damage is fatal even though a crime and accident occurs just once. It is the best that crime and accident never occurs. Nevertheless, the actual condition is that technology developed for the objective of preventing a crime and accident has progressed in the direction of crime/accident awareness rather than preparation function and crime/accident avoidance. A plan of preventing a crime/accident and avoiding a crime/accident in advance is absolutely necessary.

This study aims at preventing crimes and various accidents. The space of residential environment provides service of preventing and avoiding various risks by demonstrating the function of being aware of various risks. There were many methods where advance information about crime and accident was acquired, and context data was modeled in advance on the basis of this, and then context was reasoned by comparing the acquired data in the conventional studies. However, the problem is that there is a case a crime or accident deviate from the range of information acquired in advance. In addition, a crime becomes more astute, and an example where suspects evade or disable various sensors such as CC camera appears. Therefore, now is a time when a system covertly distributed and installed, of which the advance prevention performance is strengthened is necessary.

Multi-sensor data fusion technology is useful in order to enable this objective. Lots of small sensors are attached to various kinds of space of residential environment, and are enabled to operate covertly. Though these sensors have simple functions, context can be precisely grasped through data fusion when these are various kinds of sensors complementary to each other. Expensive sensors have good performance. However, distribution in the wide area is a burden on the aspect of cost and there is difficulty in distributing and attaching a large quantity in extensive area. Cheap sensor itself is insufficient because there is functional limit and error. However, it is possible to acquire context information of high level through data fusion processing.

This study proposes a plan that guarantees concealment in the environment which uses cheap small sensor and enables advance awareness even for a risk which deviates from the range of advance information-based data modeling. Risk context reasoning was made to become clear through repeatedly checking a risk factor to be identified, as a multi-sensor data fusion-based risk awareness scheme which used DST.

This paper is composed as follows. Background technology and precedent research was arranged in chapter 2. Chapter 3 proposes multi-sensor data fusion and risk awareness scheme of smart space proposed in this paper.

An experiment and assessment is described for the proposed method in chapter 4. And it is finished with a conclusion in chapter 5.

2. Related Research

Physiological response recognition technology: It is a technology of recognizing various responses of body and the condition of body through sensors attached to the body. It is utilized as technology for perceiving the condition of being confronted with danger besides the purpose of health care. Equipment for checking the irregular pulse of heart, blood sugar check, etc. are technologies for monitoring the condition of health. Sensors measuring the exercise volume are technologies utilized for health care, weight management etc. after checking activity. Recently, they are developing a technology intended to perceive that someone is confronted with danger by developing a sensor that recognizes the emotional condition such as surprise and excitement [1,2,3].

Image processing technology: Image recognition enables various kinds of services. Pornographic video detection, existence or non-existence of person, fire occurrence recognition, etc. is enabled by image processing technology. Image processing technology that enables the awareness of risk factor is developed in order to safely protect a user against a crime/accident [4-7].

Context awareness technology: There are various context awareness technologies. However, the most widely used method is a scheme where data is modeled on the basis of advance information, and then the acquired data is referred to this. Methods using Ontology have been mainly studied a lot [8-12].

Point at issue in the conventional studies:A crime and accident in the residential environment brings about serious consequences. Therefore, the damage can be fatal even though only one accident occurs. The conventional studies propose an effective alternative plan for crime and accident awareness. However, fatal damage cannot be prevented by a scheme of being aware of context just before an accident occurs or of being aware that an accident has already occurred.

Necessity of smart space awareness: The awareness of accident and risk in the residential environment by perceiving that a person is aware of risk and is personally surprised or screams has high possibility of being a context where the occurrence of damage is imminent. Being aware that a person who appears on the screen is a criminal or attempts to commit a crime also means that a suspect already has appeared, and time may be insufficient to avoid a crime. Therefore, it is necessary to secure sufficient time to perceive a risk and to avoid a risk in advance through making the space that constructs the residential environment become smart.

3. Context Awareness of Smart Space for Life Safety

Problem of method that uses a signal sent by a sensor attached to a person or the image of surveillance camera operating in the fixed position so as to find out a factor that threatens safety in the residential environment is about recognition timing, not the problem of recognition. It is very important to be more rapidly aware of risk factor of residential environment and to enable a user to avoid a risk for guaranteeing the safety of residential environment.

Smart space awareness technique is necessary for satisfying this necessity.

This study proposes a scheme where space itself is aware of risk context that deviates from the range of advance information in order to judge a factor which threatens the safety of residential environment. To this end, it proposes a scheme to repeatedly check the change of *belief* value calculated by using BPA importantly utilized in DST according to time interval and to be aware of risk context through the change.

Smart space awareness for guaranteeing life safety progresses in accordance with the following procedure.

STEP 01) Risk factor establishment
STEP 02) Risk factor information gathering sensor
STEP 03) Element awareness data filtering
STEP 04) Element awareness data deduplication
STEP 05) Risk context hypothesis formulation
STEP 06) Basic probability assignment calculation according to each risk context
STEP 07) Belief and uncertainty calculation according to each risk context
STEP 08) STEP 2 is repeated,
STEP 09) Comparison with and judgment of belief according to each risk context in the previous time slot
STEP 10) When a increase in the belief of risk context is shown, time interval is adjusted.
STEP 11) STEP 2 is repeated.
STEP 12) Comparison with and judgment of belief according to each risk context in the previous time slot
STEP 13) When a increase in the belief of risk context continues, measures of informing and avoiding are taken.
STEP 14) STEP 2 is repeated.
STEP 15) Judge whether risk context continues or is removed. A increase in the belief of risk context → Continue, A decrease in the belief of risk context → Remove
STEP 16) STEP 2 is repeated.

The belief of risk context means the value of probability that an accident relating to specific evidence occurs when the evidence is shown. Uncertainty means a difference between probability and belief, and may be called an uncertain and obscure area. And in other meaning, it may be called a variable section where a certain accident may or may not occur according to the condition. What is proposed in this study is that in order to

assess risk context according to event information perceived by various sensors and risk factor established at the beginning, each risk context is first classified, and various acquired evidences are connected to these risk contexts, and then basic probability assignment of each risk context is calculated. Then, belief calculated on the basis of this is judged according to each time slot. And in case there is what increases in belief among risk factors, time interval is adjusted, and the belief of risk context corresponding to the next time slot is compared with that of previous time slot again. At this time, if it is verified that the belief of the corresponding risk context increases, time is adjusted, and the belief of risk context corresponding to the next time slot is compared with that of previous time slot. And if belief increases, a user is informed of risk without delay, and follow-up measures are made to be taken so as to avoid the risk factor. The procedure like this is illustrated in following Fig.3

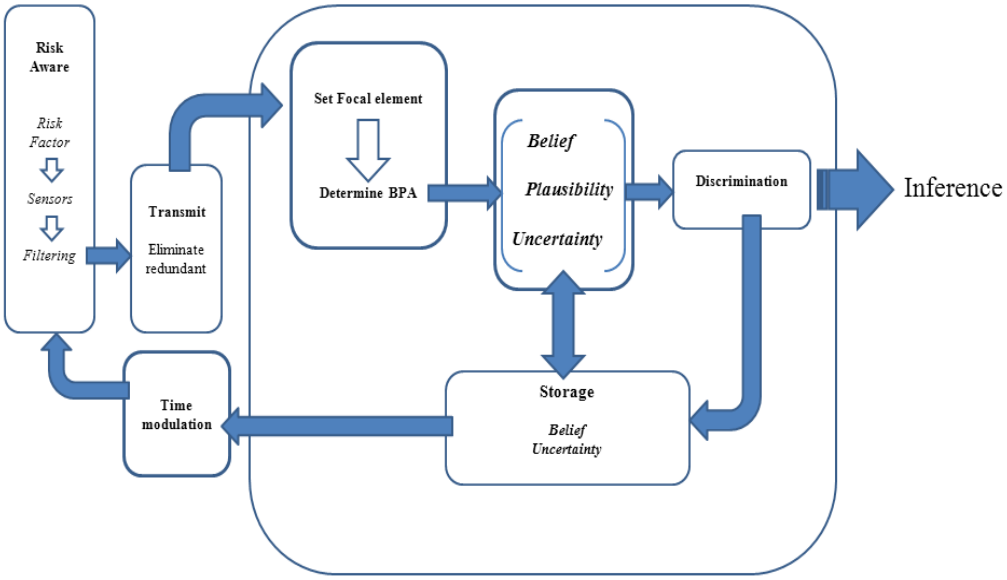

Fig. 3 Risk Context Awareness Process

The advantage of scheme like this is that it is possible not only to be promptly aware of a certain risk context but also to tell whether the belief of a certain risk context increases, therefore the related proof is presented so that measures against that can be taken.

4. An Experiment and Evaluation

In this paragraph, an experiment of scheme proposed by this study is carried out, and the assessment results are arranged. In the experiment, risk factor and risk context was defined as follows.

Risk Factor Definition Details

For risk factor relating to the risk context, factors were defined on the following three aspects.

1) Time factor: 6p.m.-10 p.m., 10-2a.m., 2a.m.-6a.m

2) Space factor: Distance from surveillance camera, distance from crime prevention guard checkpoint, and vulnerable area

3) Sensing factor: Luminance (luminance sensor), neighboring vehicle (ultrasonic sensor), neighboring active people (infrared sensor)

Risk Context Assessment and Results

BPA of each factor was made to be determined by a specialist in order to assess risk context.

BPA of risk factor in each time slot is shown in the following Table 1.

Table 1. Basic Probability Assignment According to Each Risk Factor

		BPA(t_0)	BPA(t_1)	BPA(t_2)	BPA(t_3)	BPA(t_4)
Space factor	18p.m.~10p.m.	0.063	0.057	0.036	0.031	0.025
	10p.m.~02a.m.					
	02a.m.~06a.m.					
Space factor	distance(cam)	0.063	0.080	0.107	0.094	0.100
	distance(patr.)					
	dang. area					
Sensing factor	Illuminations.	0.125	0.114	0.107	0.125	0.125
	Ultrasonics.					
	Infrareds.					
Time + Space		0.125	0.136	0.143	0.125	0.125
Time + Sensing		0.188	0.170	0.143	0.156	0.150
Space + Sensing		0.188	0.193	0.214	0.219	0.225
Time + Space + Sensing		0.250	0.250	0.250	0.250	0.250

If belief and uncertainty of each time slot is calculated on the basis of BPA in Table 1, it is as follows.

Table 2. Belief and Uncertainty of Risk Context in Each Time

	t_0		t_1		t_2		t_3		t_4	
	bel	*unc*	*bel*	*unc*	*bel*	*unc*	*bel*	*unc*	*bel*	*unc*
Time factor	0.063	0.563	0.057	0.557	0.036	0.536	0.031	0.531	0.025	0.525
Space factor	0.063	0.563	0.080	0.580	0.107	0.607	0.094	0.594	0.100	0.600
Sensing factor	0.125	0.625	0.114	0.614	0.107	0.607	0.125	0.625	0.125	0.625
Time + Space	0.250	0.625	0.273	0.614	0.286	0.607	0.250	0.625	0.250	0.625
Time + Sensing	0.375	0.563	0.341	0.580	0.286	0.607	0.313	0.594	0.300	0.600
Space + Sensing	0.375	0.563	0.386	0.557	0.429	0.536	0.438	0.531	0.450	0.525
Time + Space + Sensing	1.000	0.000	1.000	0.000	1.000	0.000	1.000	0.000	1.000	0.000

Risk Context Reasoning

Like the results shown in Table 2, the belief value of risk context on which space + sensing factor acted rapidly increased in t2. The belief value of risk context on which space + sensing factor acted was increasing in t3 again, and the increasing tendency

continued in t4. Therefore, it is judged that risk context is continuous in t4, and a user and safety worker is promptly made to be notified of risk context.

5. Conclusion

It is expected that solution through the application of smart technology rather than the improvement of infrastructure is considerably effective in the improvement of vulnerable footway environment and residence of densely built-up old downtown with low costs. What should be significantly examined in these studies is whether there is sufficient function of preventing various kinds of crimes and accidents. This study aimed at preventing crimes and various accidents. The space of residential environment provides service of preventing and avoiding various risks by demonstrating the function of being aware of various risks in advance. This study proposed a plan that guaranteed concealment in the environment which used cheap small sensor and enabled advance awareness even for a risk which deviated from the range of advance information-based data modeling.

As a multi-sensor data fusion-based risk awareness scheme which used DST, risk factor and risk context was defined, and the acquired data was identified, and the occurrence risk of risk context was rapidly calculated, and then it was made possible to provide a proof of getting a user to avoid risk context.

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