Internet of Things (IoT) Based Modeling for Dynamic Security in Nuclear Systems with Data Mining Strategy

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데이터 마이닝 전략을 사용하여 원자력 시스템의 동적 보안을 위한 사물 인터넷 (IoT) 기반 모델링

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Abstract The data mining design incorporated with big data based cloud computing system is investigated for the nuclear terrorism prevention where the conventional physical protection system (PPS) is modified. The networking of terror related bodies is modeled by simulation study for nuclear forensic incidents. It is needed for the government to detect the terrorism and any attempts to attack to innocent people without illegal tapping. Although the mathematical algorithm of the study can't give the exact result of the terror incident, the potential possibility could be obtained by the simulations. The result shows the shape oscillation by time. In addition, the integration of the frequency of each value can show the degree of the transitions of the results. The value increases to -2.61741 in 63.125th hour. So, the terror possibility is highest in later time.

Key Words : Internet of Things (IoT), Nuclear power plants, Big data, Cloud computing, Data mining, System dynamics

요 약 원자력 테러 예방을 위해 기존의 물리 보호 시스템(PPS)를 수정한 빅데이터 기반의 클라우드 컴퓨팅 시스템과 통합된 데이터 마이닝 디자인이 조사됩니다. 원자력 범죄사건에 대해 시뮬레이션 연구에 의해 테러 관련 기관의 네트워킹이 모델링됩니다. 불법 도청 없이 무고한 사람들을 공격하려는 시도와 테러리즘을 정부가 탐지할 필요가 있습니다. 이 연구의 수학적 알고리즘은 테러 사건의 정확한 결과를 제공할 수 없지만, 시뮬레이션을 통해 잠재적 가능성을 얻을 수 있습니다. 본 결과는 시간에 따른 모양 진동을 보여줍니다. 또한 각 값의 빈도를 통합하면 결과의 전환 정도를 알 수 있습니다. 값은 63.125 시간에 -2.61741로 증가합니다. 따라서 테러 가능성은 나중에 가장 높습니다.

주제어 : 사물 인터넷 (IoT), 원자력 발전소, 빅데이터, 클라우드 컴퓨팅, 데이터 마이닝, 시스템 역학

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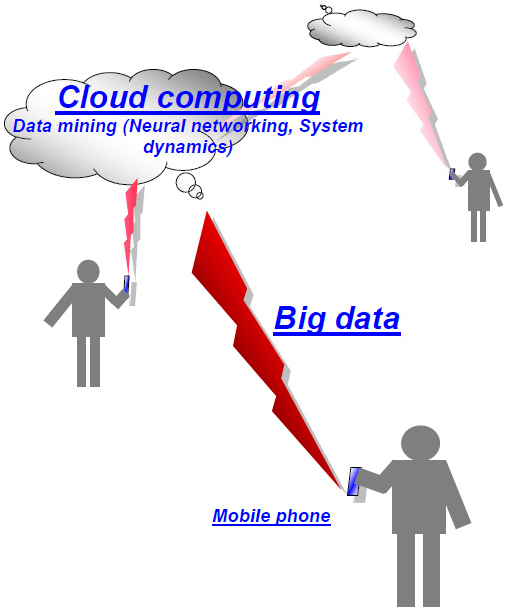
1. Introduction

It is very difficult to find out the terror conspiracy before the incident happens, especially for the aspect of nuclear forensic incident. There is a tendency to communicate for the plot of the terror among the terrorists which could be done by the telecommunication system like the mobile phone. However, the tapping is illegal in the normal situations. Hence, it is needed to make a system to detect the possible terror conspiracy without the tapping. The social networking related algorithms have been developed for efforts to prohibit the terror. It should be very reasonable in using the private communications for the nuclear industry. This paper would like to investigate for the systematic analysis in the social networking related terror prevention strategy where the internet of thing (IoT) is incorporated with the mobile phone. [Fig. 1] shows the configuration for the communications between individuals by the mobile phones where the cloud computing system is used for the communication processing. Data mining is a major function for the algorithm, which is composed of neural networking and systemic dynamics methods and big data are used in the processing. Usually terrorists make the terror incident after expressing and communicating with other companions. Terror happens by terrorists and they are connected by a mobile phone based communications. So, the detection of terror incident could be done from the communications modeling without illegal tapping. In the study, the exact tapping is replaced with the random number generated quantity and its modifications. Hence, the result would be compared each other with the dimensionless numbers.



[Fig. 1] Simplified configuration of cloud computing strategy

Terror could happen by intentional ways of terrorists. This is different from the general accident which can give damages to humans. A general accident happens without any notifications, although there are several causes. Before the accident happens, it is difficult to stop an accident. That is, it is not called as an accident before the incident of accident is realized. The causes of many accidents are related to the human errors. The prediction of any accident is very difficult before it happens, especially in the nuclear power plants (NPPs) accident. In the case of the Fukushima, Chernobyl, and Three Mile Island accidents, even though the causes of the cases are related to the human errors, it was not to be notified to operator before the incident. By the way, the terror incident happens by somebody, namely, terrorist. The terror case happens by any human intention. Hence, the detection of the attempt of the terror attacks is a way for the data mining design. Once the symptom of the terror incident is notified, the terror can be stopped by a relevant agency. That is to say, the method to detect the terror incident is to find out the information from the communications around the possible terrorist. If it is known that the

specified terror would happen, the enforcement is done easily by the security personnel. The prior notifications are hardly detected in the accident. Otherwise, in terror incident, the terrorist has a tendency that the information is communicated with others by the telecommunication systems like the mobile phone and wired-networking systems. Frequencies for accident in nuclear industry have been counted quite many times including core melting accident. The nuclear terror was not done in the massive scale, although the radioactive material poison attack happened using the polonium-210 [1]. The safety systems are equipped well in the commercial NPPs. However, the physical protection system (PPS) for the possible terror incident is not prepared comparatively much. There are some PPS like the barricade, security guard, and some more security procedures. 〈Table 1〉 shows the comparisons between accident and terror incident. In accident, the cause and result are variable. Otherwise, those are human and terrifying respectively in terror case. The notifications of incident are possibly recognizable in terror case. Although the PPS in new plant are equipped, it is not well constructed comparing to the safety systems in which the emergency coolant carry systems are most important facilities like the high pressure safety injection system or some other coolant injection systems. Fortunately, the terror attempts against the NPPs are very few until now. But, this could be happened easily due to the political or some other matters.

The conventional PPS is composed of detection, delay, and response [2]. Each stage has particular characteristics where the detection state is to find out the intrusion and unauthorized behavior by some devices, the delay stage is to slow the malicious acts by some barriers, and finally the response stage is to interrupt the actions by several kinds of methods like the arms response [2]. So, this PPS is effective when the terror attack is realized around the nuclear facilities. There is no function to detect or delay before the terror attack. So, it is reasonable to make the new concept to treat the prognostic situations. The data mining can be made for the purpose of the predictive evaluations, which has been used in many areas including the security aspect. [Fig. 2] shows the modified concept for the PPS where the data mining performs as a role of a function like detection, delay, and response in PPS [3].

〈Table 1〉 Comparison between accident and terror

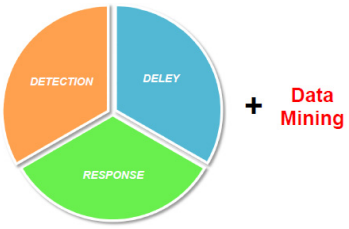
	Accident	Terror
Cause	Variable	Human
Result	Variable	Mostly very terrifying
Symptom	Yes	Yes
Notice	None	Could detect
Frequency in NPPs	Sometimes	Very few until now
Preparation in NPPs	Many systems from construction	Comparatively few in the construction stage

There are some data mining activities by the department of homeland security in the United States. The Automated Targeting System (ATS) compares several factors like traveler, cargo, and conveyance information against intelligence and other enforcement data, which is managed by U.S. Customs and Border Protection (CBP) and includes modules for inbound (ATS-N) and outbound (ATS-AT) cargo, land border crossings (ATS-L), and passengers (ATS-P) [4]. The Data Analysis and Research for Trade Transparency System (DARTTS) analyzes possible data like the trade and financial stuff, which is administered by U.S. Immigration and Customs Enforcement (ICE) [4].

2. Methods

In the modeling, the data mining is performed with the neural network incorporated with system dynamics (SD) method where the data feedback is applied to the neural network algorithm. This data mining technology is widely used in our lives for the commercialization,

safety, security, and so on. The application in nuclear industry could give the reliability of the NPPs operations for the stable electricity supply.



[Fig. 2] Modified physical protection system (PPS)

2.1 Big data

Modern networking has been developed by the computer related systems like personal computer, mobile phone, and some other social networking systems. The processed data has increased in the human life following the system development. Big sized data processing is examined for the preventing nuclear terrorism in the NPPs. Highly developed networking system in current technology is utilized in this study. The social networking is used as a major role in simulating the nuclear accident. The big data mean the data more than terabytes in the computing memory [5]. That is, this is same to 1,000 times 1 gigabyte USB (Universal Serial Bus) flash drive, which is currently used everywhere. However, the characteristics are more important than quantity, because the complexity and variety of data are much more implied for the future incident [6].

In the previous work, Steed et al. studied for Exploratory Data analysis ENvironment (EDEN) in which the visual analytic system is performed for the analysis of complex earth system simulation data sets [7]. Also, Fiore worked the Ophidia in which the efficient data analysis for scientific array-based data was analyzed [8].

2.2 Cloud computing

Cloud computing is defined as a variety of computing concepts which are connected with many user's receiving systems like the mobile phone, personal computer, notebook, networking system and so on in the real-time communications [9]. Therefore, the database role is performed in the cloud computing platform which is installed in several areas. It is very convenient to use any data in the cloud computing platform. The business, education, social networking and much active management are possible with the cloud computing technology.

There are some studies for the cloud computing. Seddon and Currie [10] worked that a health market is investigated for the politician, health care managers and some more using the cloud computing data processing. Sakellari and Loukas [11] studied the cloud computing platform for the research promotions with some simulation modeling.

2.3 Neural network

There is one of important and famous algorithm in the networking quantification which is the neural networking system. This is a networking for an algorithm mimicking of biological neurons. Dr. Robert Hecht-Nielsen defines a neural network as [12],

> "...a computing system made up of a number of simple, highly interconnected processing elements, which process information by their dynamic state response to external inputs."

Historically, a computational model for neural networks based on mathematics and algorithms were created by Warren McCulloch and Walter Pitts [13]. Then, Farley and Clark [14] had used the calculator to make the simulations of Hebbian network at MIT.

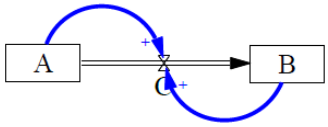
In the previous work, Li et al. studied a Back-Propagation neural network prediction model using the Levenberg-Marquardt algorithm for prediction of non-linear system [15]. In

addition, Bayram et al. worked that for taking the binding energies of nuclei based on the data calculated from Hartree-Fock-Bogolibov method, artificial neural network (ANN) was used [16].

2.4 System dynamics (SD)

The SD is applied for modeling in the study. After developing by Jay Forrester in MIT, the algorithm has been used in the many fields of social humanities as well as science and technology. That is to say, SD is the application tools for the dynamic matters in the complex and non-linear systems [17]. In the modeling, the interested variables can be connected in a feedback loop for the goal, which are applicable in the economy, social matter, science-technology and many other areas [18]. The line connections show the event flows with the quantity. [Fig. 3] shows the example of the modeling where the variables with the quantity are calculated with designed equations. The event flow can show feedback oriented algorithms in this example.

There are some publications for the SD related works. The cyclical patterns since deregulation in 1978 has been investigated as Markov chain Monte Carlo methods applied with maximum likelihood methods [19]. In addition, the medical matters are estimated with social science aspects of some theories and data [20].



[Fig. 3] Example of modeling for the study of system

2.5 Data mining

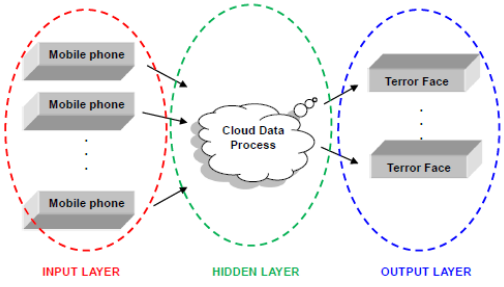
The data mining means the analyzing of collected information in the arbitrary data for the interested goal [21]. The data mining has focuses on the financial, marketing, communication, and many more where the data make the operator decide the satisfactions of customers in marketing [21]. For example, the route of customer in department store could give a hint of increasing the selling. Also, the communications in the website can give the data regarding the attractions of the customer. One can find out the merit of the goods after checking the clicking count in the website. In the security research, the pattern of the communications could make the possible next behaviors. If the potential terrorist makes a phone in the night around military facility, the security related matter in military actions or national defenses could be imagined. There are many kinds of possibilities which are guessed in the behaviors of somebody, although there is no illegal tapping. In the quantification, some non-linear and complex algorithm could be applicable.

In the literature study, Alsultanny worked for the prediction of the labor market using a kind of decision tree [22]. Peña-Ayala used the chronicles of recent educational data mining (EDM) for the twofold goal of education data mining [23].

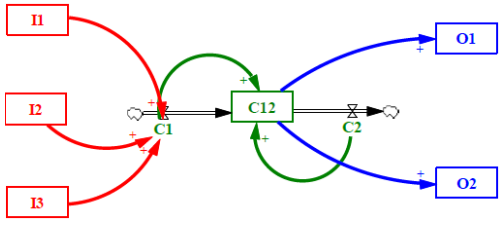
2.6 Modeling

The modeling is constructed by the combinational algorithm of data mining based neural networking and SD methods where the nonlinear complex algorithm is incorporated with artificial intelligence (AI). [Fig. 4] shows the data flows from input layer to output layer via the hidden layer presenting the cloud data computing in the neural network system. There is a diagram for the neural network where the big data are processed. The data mining is performed by neutral networking with feedback logic of SD where the feedback algorithm is mixed in hidden layer-output layer loop of neural network system. The data numbers could exceed terabyte in the interested information processing. In this study, the terror related matters would be included. The SD diagram in given in [Fig. 5] in which there are 3 kinds of input data and hidden layer is shown

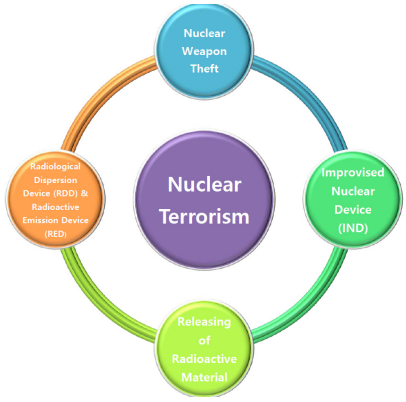
as the processing of input and output data. The output data are written as 2 kinds of data. The output data mean as 4 kinds of faces which could happen as the nuclear terror incidents in [Fig. 6] which could be processed by the mobile phone for the practical purposes [24]. Main characteristics of nuclear terrorism are the theft and releasing of radioactive nuclear material which are accomplished by intrusion or sabotage of matters in PPS. So, these faces reflect nearly whole aspects of nuclear terror. 〈Table 2〉 shows the comparisons for raw score, banded system in Global Terrorism Index (GTI) 2011 [25], and new index in which the raw data are given by weighting factor multiplied by case numbers [24]. The cases are classified as incidents, fatalities, injuries, and property damages [24]. This means the tapping including the communications of possible terrorists is replaced with the random number generated quantity and its modifications. The quantified numbers are decided by the experts



[Fig. 4] Data mining systems by cloud computing strategy



[Fig. 5] Diagram by data mining of neural network incorporated with system dynamics



[Fig. 6] Four faces of nuclear terrorism for the securities

〈Table 2〉 Comparisons of raw score, banded system in Global Terrorism Index (GTI) 2011, and new index

Raw score	Global Terrorism Index (GTI) 2011	New index
0	0	0
.	.	.
.	.	.
6,000	5	0.5
.	.	.
.	.	.
12,000	10	1

by subjective decisions. 〈Table 3〉 is the classification of input and output data using a new index. In I1, the random number is generated between 0 and 1 for a normal distribution as mean of 0.3 and standard deviation of 0.3. Otherwise, the I2 gives as the conditional statement. If the random number between 0 and 1 is lower than 0.5, the value is 0, otherwise it is 1. Following the mean and standard deviation values, the terror possibility could be changed. So, the higher mean and its related narrow standard deviation can show a higher possibility of terror incident. The I3, C1, and C2 are done in similar ways. C12 is C1 - C2 which means that the input data of C1 are compared with the experts' values of C2. If C1 is higher than C2, the output is positive. This expresses the tendency of terror incident would be higher than lower values or minus values. In O2, the values of C12 are integrated numerically

with initial value of 0. So, this shows the accumulated terror possibilities. The meanings are explained in each case on 〈Table 4〉. That is to say, the random number is generated by the mean and standard deviation in which the terror possibility is obtained by the manipulations of mean and standard deviation. Otherwise, the conditional number is generated by the conditional equation. This means the political situation of the society is oscillating in which some social conditions exist. In hidden layer, the C1 is decided by the comparisons among the input data. C2 is made by the expert's judgment. Then, this is compared each other. So, the C2 could mean the current situation of terror incident. In output layer, the discrete value in O1 shows just each result of the situation. However, the accumulated value in O2 is the trend of the event frequency.

〈Table 3〉 Classification of input and output

Variable	Quantification
I1	Random # normal [0.3, 0.3]
I2	If random # < 0.5 [0, 1]
I3	Random # normal [0.6, 0.3]
C1	If random # < I1[if random # < I2 [0, 1], I3]
C2	Random normal [0.6, 0.3]
C12	C1-C2
O1	C12
O2	INTEG [C12, 0]

〈Table 4〉 Meaning of classification

Variable	Meaning
I1	Randomly happening event with specified mean and st. deviation
I2	Conditionally happening event
I3	Randomly happening event with specified mean and st. deviation
C1	Conditionally happening event (Input data are compared)
C2	Randomly happening event with specified mean and st. deviation (Expert's decided standard data are produced)
C12	Compared between C1 and C2
O1	Discrete output data
O2	Accumulated output data

3. Results

The quantification of the terror possibility is performed by the non-linear complex algorithm incorporated with the SD and neural network with big data. In the calculations, the data are processed in every 7.5 minutes in which this means the calculation is done as 8 times in one hour. Hence the graph has 100 hours with 800 times data processing. This means that 35,673.516 graphs are available by the big data processing. That is,

1 terabyte = 1,000,000,000,000 bytes = 800 × 2,500,000,000 bytes

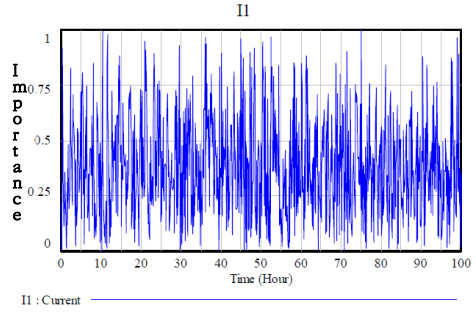
So, it is needed to process 2,500,000,000 bytes more for 1 terabyte.
In the similar way,

2,500,000,000 bytes are done for 8 times in 1 hour, then,
312,500,000 bytes are done for 24 hours in 1day, then,
13,020,833.33 bytes are done for 365days in 1 year, then,
35,673.516 years are done.

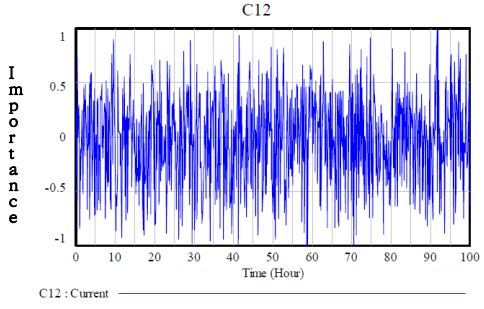
Therefore, about 35,673 years' data could be processed for the security. Input data are obtained by the random numbers in which the [Fig. 7] shows one of input data. Y-axis is the dimensionless importance number where it is compared each other. The higher values give the higher possibilities of terror incidents. [Fig. 8] is the cloud computing data in which the values are C1 minus C2 in each time. [Fig. 9] is the output data of the processing in the cloud computing. Fig. 10 is the cumulative values for the expressed security. The value increases to -2.61741 in 63.125^{th} hour. So, the terror possibilities would be highest in later time. In examination of the result, the graph of [Fig. 9] shows the shape oscillates by time. However, the integration of the frequency of each value can show the degree of the transitions of the results. So, as it is seen in [Fig. 10], terror possibility will be decreased as time goes on.

4. Conclusions

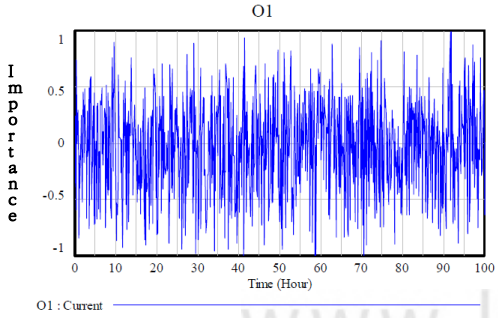
The quantification of the nuclear terror assessment has done for the security aspect. The conventional PPS is modified with data mining algorithm where the symptom of terror incident could be predicted. The nuclear system is very dangerous in the case of non-control state. Hence, the mathematical investigation is important of the preparations for the possible terror incidents. Data mining has been developed in many areas of our lives. Especially, the commercialized activity needs the predictive customer's behaviors.



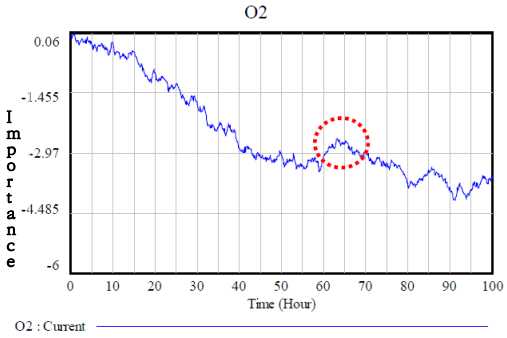
[Fig. 7] Diagram of I1



[Fig. 8] Diagram of C12



[Fig. 9] Diagram of O1



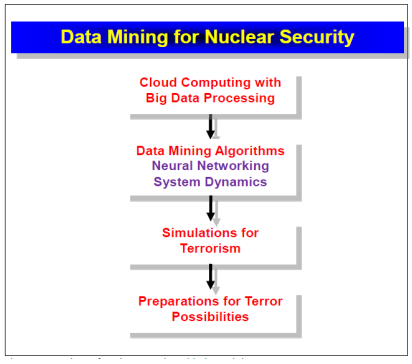
[Fig. 10] Diagram of O2

Likewise, the investigations of terrorist behaviors are inevitable to begin the terror defense system constructions. Almost all communications of the terrorist could be done by the telephone system like the mobile phone. Therefore, the systematic research of the mobile phone based social networking service (SNS) as IoT is effective to prepare against the conspiracy of the terrorists. Iot has been applied in many areas recently [26-27]. [Fig. 11] is the procedure of nuclear security with data mining. In the last stage of this diagram, the international cooperation is suggested. The networking reaches to every country without interruption in which the effective performance can be accomplished by the multi-national information exchanges. There are some findings in this study as follows;

- The big data are used for the data quantifications in nuclear forensic incidents.
- Data mining algorithm is performed incorporated with non-linear algorithms.
- The neural network with SD is used for the calculations.
- Social networking is investigated with cloud computing.

The importance of this study is from the possible illegal tapping in the governmental agency. The most civilian could make a legal action against the tapping. Hence, without the illegal work, the government should detect the

terrorism and any attempts to attack to innocent people. Although, this mathematical algorithm can't give the exact result of the terror incident, the potential possibility could be obtained by the simulations. The exactness could be increased as the data increase. The big data concept is useful to treat this non-linear algorithm based detecting strategy. Until recent year, it is impossible to make any processes in huge data using small sized computing system of personal computer or mobile phone based smart phone. But, nowadays, the mobile phone oriented cloud computing is operated very easily in the portable state. The cloud computing platform supplies the database equipment. Without the tapping of the voice and image of the communicators, it could be constructed to detect any kinds of terrorism conspiracy.



[Fig. 11] Procedure of nuclear security with data mining

Considering conventional approach to nuclear security, the practical method such as the mobile phone usage could enhance the integrity of the plant operations. Hence the networking based characteristics would be significantly useful in the terrorism prevention. The networking algorithms of SD and neural system are performed easily in the calculations of the prediction for the possible terror incident in nuclear industry. This algorithm can be used in other industry and could be used for prevention of the possible disasters. For example, the airplane terror could be stopped by the algorithm of this study where the pattern of the terrorist behavior is could be detected by security systems. In addition, the preparations for the possible terror attacks are simulated by the relevant variable. This is not possible in the conventional PPS concept, because this is just for processing of the realized terror attacks, namely, the time scale is a 'current' state. By the way, this new algorithm of the present work can see the future possibility using dynamic strategy. So, the prediction based terror prevention planning can be done successfully in the general industries.

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