International Journal of Control and Automation
Vol.7, No.7 (2014), pp.55-64
http://dx.doi.org/10.14257/ijca.2014.7.7.05

# A Hierarchical Architecture for Semantic Representation of Sensing Information in Pig Farm

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***Abstract***

*Wireless sensor networks are used in various applications in several domains for measuring and determining physical phenomena and natural events. Wireless sensor networks can support to observe characteristics of physical objects and features of natural incidents. This paper proposes a hierarchical architecture of semantic information for heterogeneous sensor data representation in the pig farm. This architecture provides various real-time sensing data such as pigs environment of piggery using temperature sensor, humidity sensor, wind speed sensor, etc. Information of this architecture supports to develop Sensor web for effective pig keeping in ecological pig farm environment.*

***Keywords:*** *Information modeling, Sensor web, Pig farm*

## 1. Introduction

Recently, sensor networks are used in various applications and several domains for measuring and determining the physical phenomena and natural events. Sensor web enablement is used to capture and observe the characteristics of physical objects and features of natural incidents. Sensor networks have been increasingly used for monitoring and assessing environmental changes and impacts on vegetation and fauna as they offer a number of advantages over conventional methods. Large amounts of data can be captured with minimal disturbance of the environment. Many low level environmental characteristics such as temperature, humidity and pressure can be easily monitored. A Sensor web refers to web accessible sensor networks. Archived sensor data can be discovered and accessed using standard protocols and application program interfaces (APIs).

Context awareness is one of the key features for pervasive middleware. In regions of intensive pig farming and other risks of pollution (losses of air and accumulation of nutrients in soils) are also sources of concern. Context is defined as information used for identifying the status of an entity. An entity can become a place, pigs, or physical or computing object [1]. This context includes a user and application, and reflects the relationship of interactions between a user and an application. Based on this, entity in ubiquitous learning environments means users, position, activity, computing device of the environments. Schilit defines that context-aware computing is not only adaptable according to a place, a person and a group of objects, but also it is a software which can accept changes of objects as time goes by [2]. In the context of the knowledge management, ontology is referred as the shared understanding of some domains, which is often conceived as a set of entities, relations, functions, axioms and instances [3]. Through this ontology, the vocabularies of a specific domain can be defined in a common way, and thus knowledge can be shared [4].

ISSN: 2005-4297 IJCA

In this paper, we propose a hierarchical architecture for sensor information description using sensor data so that it becomes meaningful. We describe each information of layers using sensor data representation and attached semantics to it. The rest of this paper is organized as follows: In Section 2, Sensor web and Semantic Sensor web is introduced. In Section 3, we describe the hierarchical data Model for Sensor web in pig farm. Finally, we make a conclusion in Section 4.

## 2. Related Work

A sensor network is a computer accessible network of many spatially distributed devices, using sensors to monitor conditions at different locations such as temperature, sound, vibration, pressure and pollutants. The sensor web is a special type of web-centric information system for collecting, modeling, storing, retrieving, sharing, manipulating, analyzing, and visualizing information of sensors, sensor observations, and associated phenomena. Lack of standardization is the primary barrier to the realization of a progressive sensor web. Also, Sensor web is an emerging trend which makes various types of web-resident sensors, instruments, image devices, and repositories of sensor data, discoverable, accessible, and controllable via World Wide Web.

The OGC Sensor Web Enablement Standards are discovery of data sets from registers, the heterogeneity of descriptions and the lack of semantics or reasoning [9]. SWE services based infrastructures lack semantically rich discovery mechanisms. Search algorithms facilitating semantically enhanced queries from users would be retrieving useful information out of sensor web registers and services. Also, related concepts, subgroups of sensor types and integration of domain ontology, semantic queries and semantic transformations in sensor web infrastructure have to be addressed. Ontology of sensors has the potential to be a key component of semantic sensor webs.

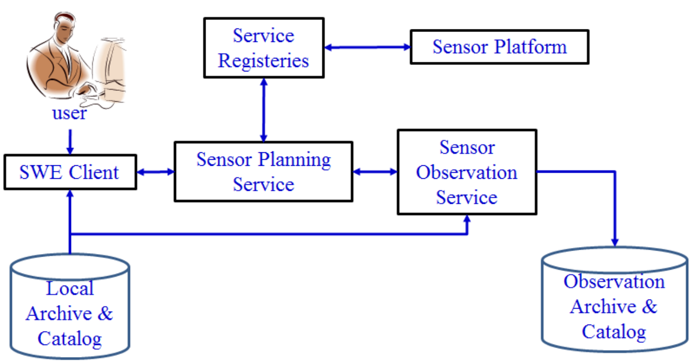


**Figure 1. Sensor Web Configuration in OGC**

Currently, the framework defines catalog services for discovering sensors and sensor data, collection services for accessing real-time or achieved observation data, planning services for tasking sensors, and notification services for providing users the results of task requests or for alerting users of other services observed.

 

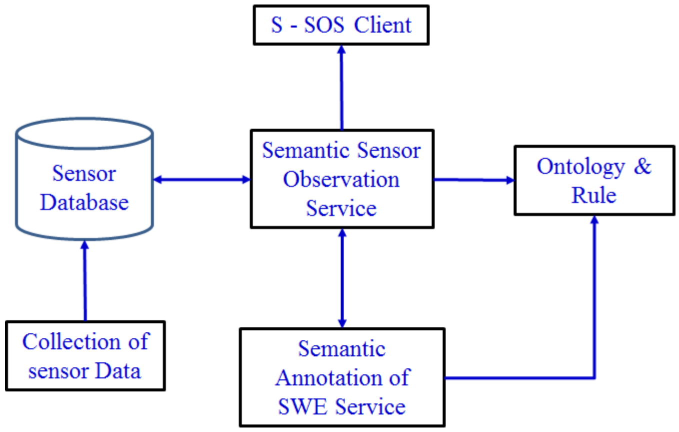


**Figure 2. Semantic Sensor Web Configuration**

The semantic web was introduced for automated programs or agents as well as humans to read and process documents on the web and produce knowledge from the information. Agents' understanding of a web document is quite different from that of human. Since agents such as computers have no imagination, it is impossible to teach them words expressing emotions. The ontology was developed by considering the fact that computers can recognize logical relations such as opposite (↔), equality (=), and inclusion (ε). The ontology is effective in having agents recognize the contents of documents by inputting relationships between words.

The semantic sensor web initiative was taken by World Wide Web consortium. The semantic sensor web provides a common framework that allows data to be shared and reused across application, enterprise, and community boundaries. The semantic web extends the idea of web applications to an integrated web of data, which can be effectively shared by different users and can be easily processed by machines as well. The semantic sensor web is based on the Resource Description Framework (RDF). Semantic web allows people to express in a machine process form, the relationship between different sets of data and their properties. Thus, establishing a "Semantic Link" between data from difference sources, this allows machines to automatically understand data from many heterogeneous sources and thus be able to process and infer new information.

## 3. A Hierarchical Architecture for Semantic Sensor Information in Pig Farm

A pig farm in sensor networks is a group of specialized transducers with a communication infrastructure intended to monitor physical phenomena like temperature, wind speed, gas and humidity, location, motion of objects and so on. Each sensor network is deployed to serve a specific purpose and uses its own protocols. This heterogeneity in sensor networks makes it impossible to communicate with each other or to reuse and share their data with different applications. The term sensor networks is used since most sensors are connected using several sensor technologies. Sensor nodes are responsible for detecting and monitoring of certain phenomena and sending the raw measurement data to an end user. Further analysis and processing of sensor data is application dependent.

The environment of the pig farms context provides sensing capabilities including light sensors, temperature sensors, humidity sensors, wind sensors, and gas sensors. The temperature sensors sensing the pig body temperature and room temperature data. If the room temperature is high or low, it depends on the pig condition such as healthy, sick, and stressed. Figure 3 shows the four layers hierarchical data modeling for pig farms. The data modeling architecture has been divided into physical layer, semantic layer, awareness layer and service layer. The obtained objects from the physical layer are to make the semantic layer with the context-awareness layer and transfer that information latter to the service layer. Moreover, the context awareness layer guarantees the independence of a service, device and mediates the context information provided by the sensor to a service. If the user turns on the sensing devices, the context provides suitable information from the device.

The variable physical sensing devices of temperature, wind, gas and humidity sensors are used for measuring the information such as wet and dry bulb temperature, humidity and CO2 *etc*. The sensing device senses the physical raw data information of a user and then transfers those raw data to the semantic layer. The context-awareness layers receives raw data from the semantic information and then generate to the context model, after that produces the context delivers to services. The semantic database manages context store and context query because the system environment is restrictive of the environments. The pig situation monitoring service is automatically stored by the context-aware framework or is selected by the user using the user interface.

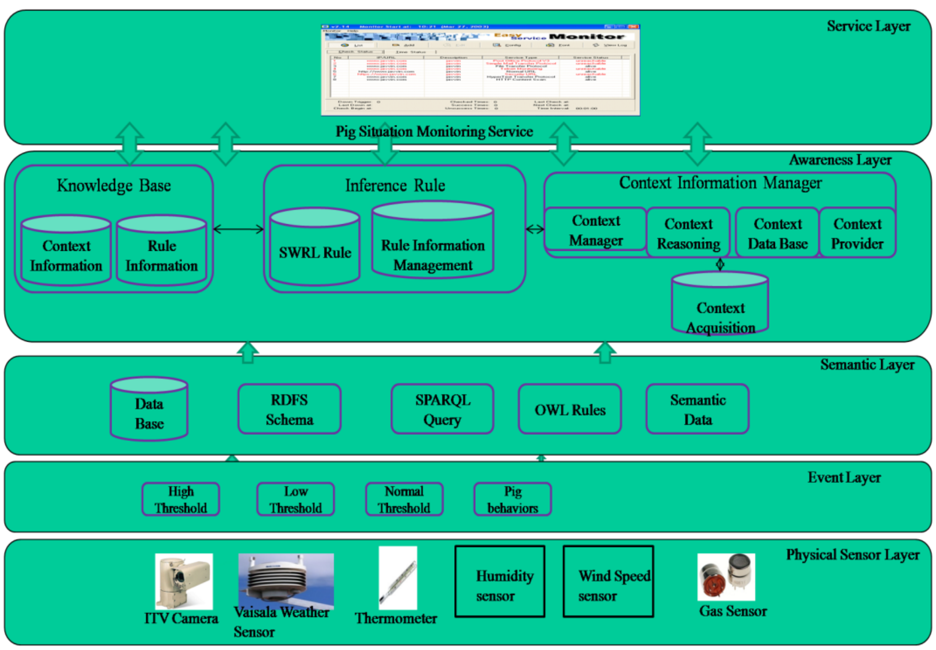


**Figure 3. Hierarchical Architecture of Semantic Sensor Information for Pig Farm**

The physical layer is the data source layer which consists of sensors. The data from sensors are collected and accessed by semantic layer. The data can have any proprietary format. For example, the physical sensor layer has various kinds of sensors such as gas sensor, humidity sensor, thermometer, temperature sensor, wind sensor. Those kinds of sensors collect the data and store it the database.

The event layer describes the information of sensing data and performing the required event description. For example, the event layer access the data from each sensors through database and apply various formula such as upper bound threshold and lower bound threshold. These threshold values are stored in the database.

Once the sensor data is available, it needs to describe the semantics of those data. Therefore, the third layer of this architecture consists of semantic layer. The data can be processed after defining semantics of sensor data in this layer. For example, the semantic layer getting the upper bound and lower bound threshold values from database, which depends on the pig health condition and its behavior. If the room temperature is high then it depends on the pig's health condition.

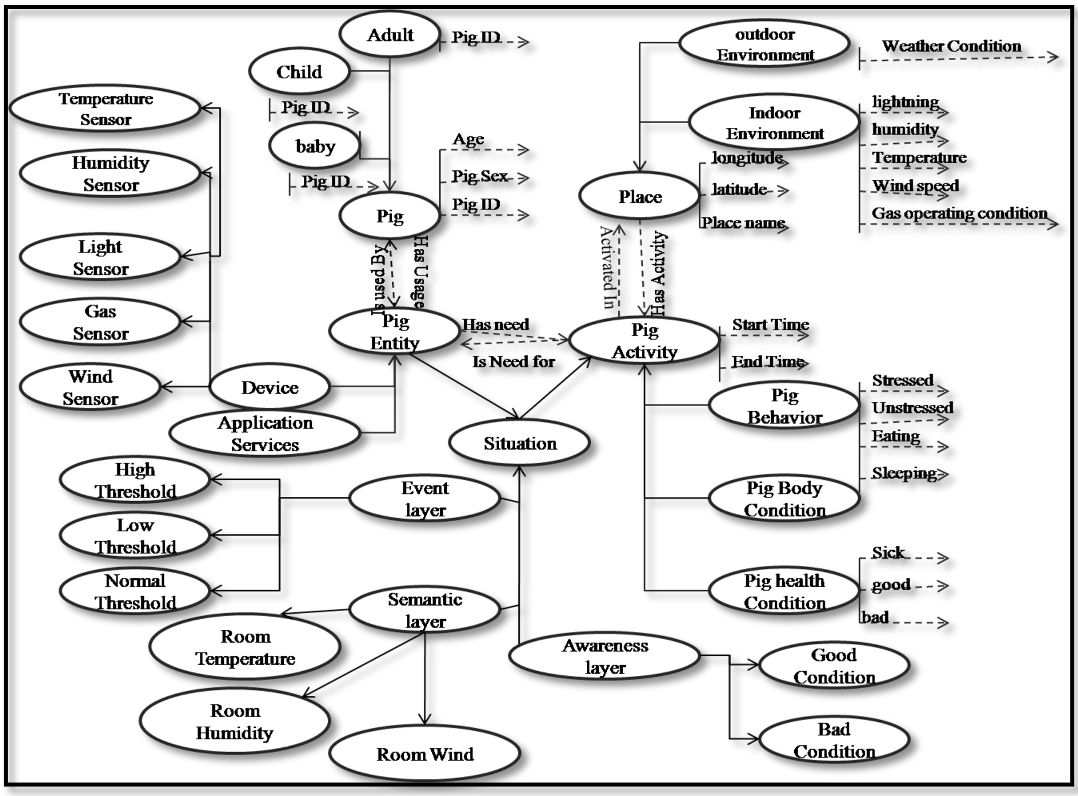


**Figure 4. Context Information Modeling Based on Ontology in Pig Farms**

Context awareness layer supports events, rules and persons ontology to realize context awareness. The syntax diversity of context and personal profile descriptions can be solved by ontology techniques. We are involving the use of SWRL (Semantic web rules Language Combining OWL and Rules). For example, pigs are relatively sensitive to high environmental temperatures because they cannot sweat and are relatively poor at panting. Reduction in the associated thermal effect of feeding is an efficient mechanism to reduce the heat load. Generally it is recommended to raise pigs at temperature 30C to ambient conditions. Evaporative heat loss might cause respiratory evaporation from the wet body surface of pigs. Air temperature as critical environmental factor is influenced by relative humidity and air flow velocity. Air humidity level is very important in cooling process. Higher temperatures and lower relative humidity is noticed as optimum range for pigs, in summer period. The service layer provides various services that the user requires.

## 4. Context Information Modeling Based on Ontology for Thermal Comfort in Pig Farm

Context is any information that can be used to characterize the situation of an entity, and context-aware computing is the use of context to provide relevant information and services to the pig recognition. A context-aware system should automatically recognize the situation based on data from various sensors. Context modeling is very important in context-aware systems to provide context for intelligent services. Therefore, context modeling is a key feature in the context-aware system.

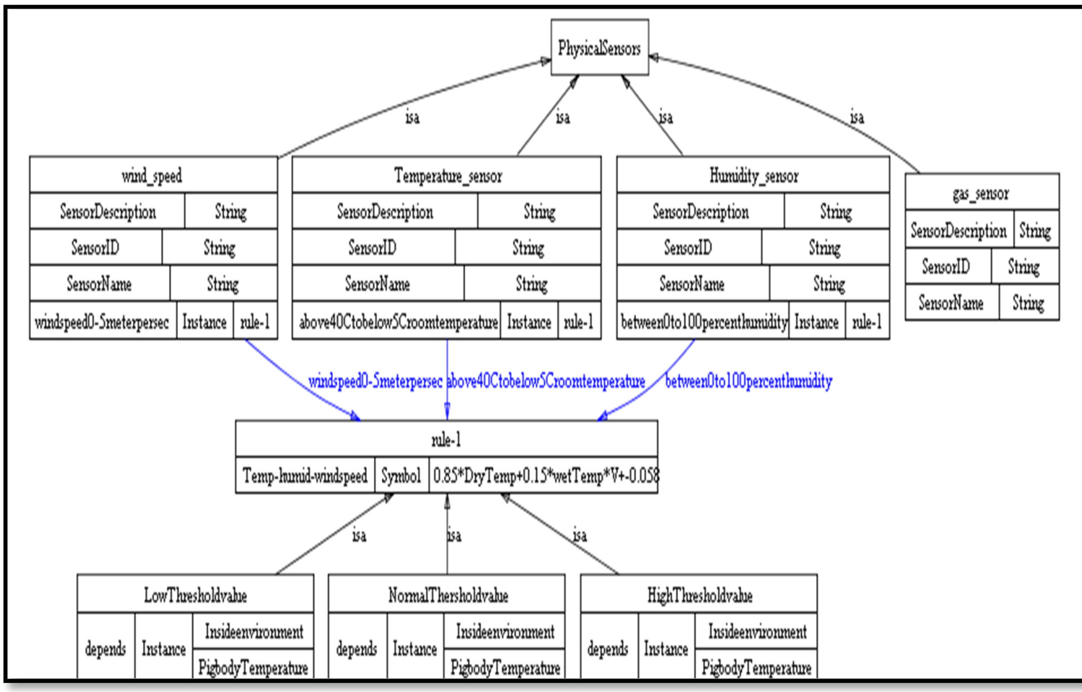


**Figure 5. Context Information Modeling based on Ontology of Physical Sensor and Event Layer for Thermal Comfort**

Ontology is used in order to make explicit assumptions and to separate domain knowledge from operational knowledge. Ontology has the advantage of sharing of knowledge, logic inference and the reuse of knowledge. If any system uses ontology, the system can provide a general expressive concept and offer syntactic and semantic interoperability. Ontology is a good candidate for expressing context and domain knowledge.

As shown in Figure 4, we show the classification and the relation between context information in pig farm based on ontology model and major properties. Most of the physical information for sensor networks is focused on humidity sensor, thermometer, temperature sensor, wind sensor for thermal comfort. The event layer presents upper bound and lower bound threshold based on thermal comfort. The awareness layer describes pig’s state based on upper bound and lower bound threshold. In Figure 5, we explain the context ontology of physical sensors and event layer. The physical sensors have wind speed, temperature, humidity, and gas sensors. This figure is applied the rule such as thermal comfort index (temperature-wind speed-humidity) and conditions. If the rule satisfies, then it provides lower, upper or normal threshold values depends on the pig body temperature in environments.

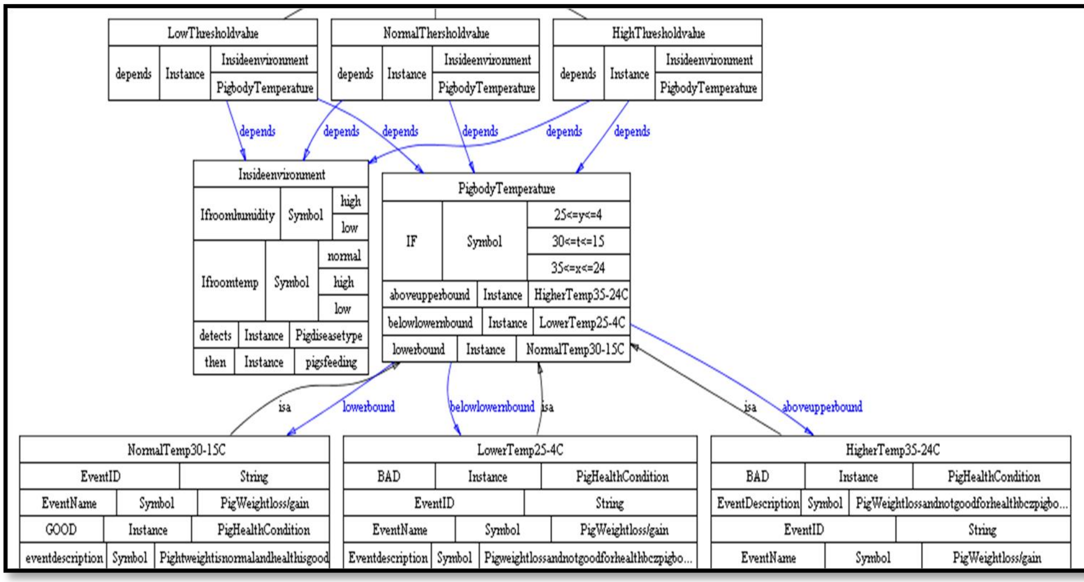


**Figure 6. Context Information Modeling based on Ontology for the Event and the Semantic Layer based on Thermal Comfort**

As shown in Figure 6, we describe context information based ontology between the event layer and the semantic layer. If the room temperature is lower than the specified normal temperature (150C-300C), the pig body temperature shows lower. Similarly, if the room temperature is higher than the specified normal temperature (150C-300C), the pig body temperature shows higher.

The context information is described in the semantic, awareness and service layer based on ontology in pig farm is shown in Figure 7. Such as pig health condition (Good/Bad) and pig behavior, which is supported by the pig situation monitoring service. The context data analysis and ontology-based reasoning to extract additional knowledge from the data only occurs in processing nodes which have more processing capabilities.

## 4. Conclusion

The animal production is an important factor to supply the population with vital foodstuffs and to deliver raw materials for various branches of industry. This research attempts to build pig ecological environments from the view of Sensor web. We propose a hierarchical architecture for data modeling using the temperature sensor, the humidity sensor, the wind speed sensor in pig ecological sensor networks. The propose architecture support to identify pigs, position of the pig and health status of the pig. Accordingly, the context ontology model is related to physical environments and includes the description of pig's presence, absence, health condition, *etc.*

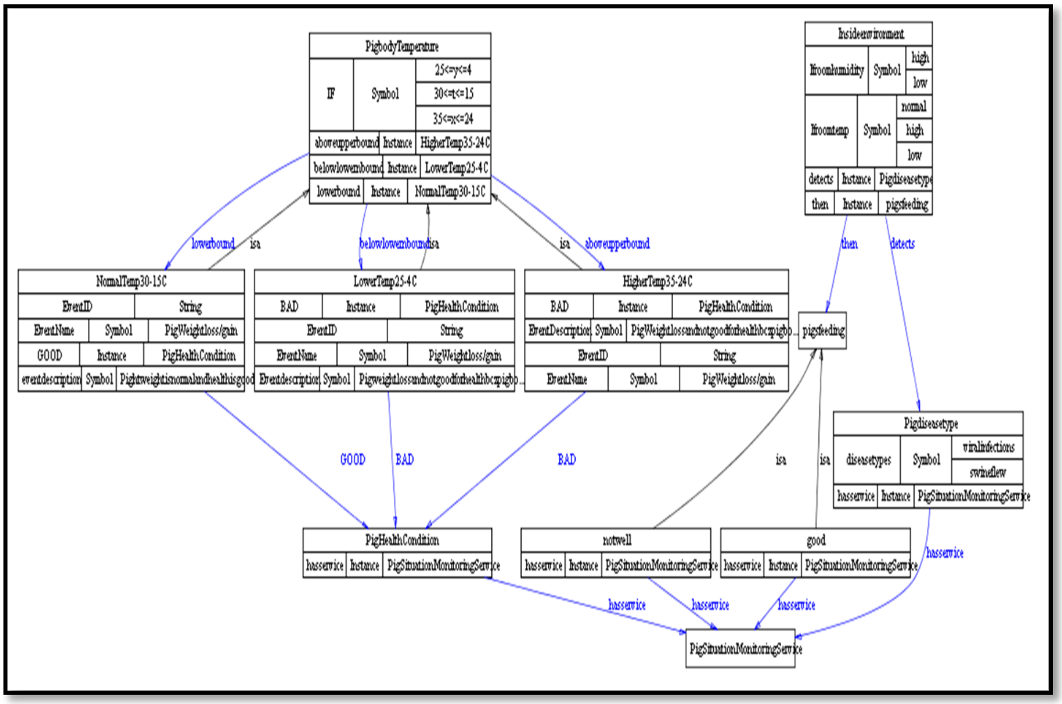


**Figure 7. Context Information Modeling based on Ontology for Semantic, Awareness and Service Layer**

## Acknowledgements

This work was supported by ETRI(Korea) [Development of USN/WoT Convergence Platform for Internet of Reality Service Provision (13ZC1130)]."Corresponding author; DoHyeun Kim (e-mail: kimdh@jejunu.ac.kr).

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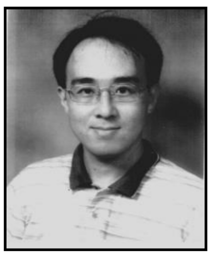

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