

# Toward Knowledge-Aided Design & Manufacturing (KAD/KAM)

Kyung Ho Lee<sup>1</sup>

Department of Naval Architecture and Ocean Engineering, Inha University, Incheon, Korea;

Corresponding Author: kyungho@inha.ac.kr

## Abstract

The purpose of this paper is to define the concept of KAD/KAM, furthermore is to establish my own idea on the knowledge related works in engineering domain for a next decade ahead. KAD/KAM is represented as “Knowledge Everywhere” based on the concept of ubiquitous computing in engineering domain. At the beginning of the paper, the definition of KAD/KAM is described. And the related technologies to realize KAD/KAM, such as augmented reality, ontology, data mining, and knowledge management, are introduced. The concept of KAD/KAM is still immature. But this will be a new paradigm to change entire engineering environment in near future.

**Keywords: knowledge-aided engineering, augmented reality, ontology, data mining, knowledge management**

## 1 Introduction

For the past several decades, most of the computer applications in engineering design have been focused on Computer-Aided Design (CAD) and Computer-Aided Engineering (CAE). But currently computer applications are diverse by the help of the growth of information technologies. That is, the development of information technologies has changed the environments of industry rapidly as distributed and globalized.

Especially, the information technologies in shipbuilding industry, in which global market is formed, are regarded as not merely automation tools but strategic tool to secure international competitiveness for next decade.

For many years, there have been many knowledge related researches in all engineering fields including shipbuilding industry, especially in design and manufacturing (Bronsart 2002, Lee et al. 1994, Lee et al. 1992, Lee et al. 1996, 1998, Lee et al. 2002).

Recently the significance of knowledge is increasing as a way to manage the intellectual capitals for the improvement of enterprise competitiveness. The factors to evaluate the competitiveness of enterprises or nations are moved from visible assets, such as land, plant and equipment, to invisible intellectual capitals such as knowledge and capability of service (Yoo 1999).

That is, knowledge became the origin of competitiveness.

At this point of time, this paper presents the new concept of knowledge-aided design & manufacturing (KAD/KAM) differing from traditional CAD/CAM. The purpose of this paper is to define the concept of KAD/KAM, furthermore is to establish my own idea on the knowledge related works in engineering domain for a next decade ahead.

## **2 The definition of KAD/KAM**

It is not easy to define the concept of KAD/KAM in a word. But it is different from the existing knowledge-based engineering (KBE) concept. An existing KBE in design and manufacturing field has treated a visible knowledge, which is formal and structured. As a rule, a visible knowledge is represented by If-Then rule or case. On the contrary, KAD/KAM interests in the applications of invisible knowledge or pervasive knowledge. Herein, invisible knowledge depends on human. Usually, knowledge in human expert's brain, such as know-how, experience, and so on, conforms to this knowledge. Especially, pervasive knowledge focuses on existing data, in which expertise, know-how, experience and intuition are melted into them.

Recently, an ubiquitous computing, which is the center of attention as a hot issue in information and communication field, is linked by a wire/wireless network among a number of computers, sensors and related softwares, and exists in our life environment. But it can help us by offering all sorts of information and services without our awareness like water or air. So we call it as "Everyday Computing", "Computers Everywhere" (Kim 2003).

In the same manner, the new concept of KAD/KAM is defined as it helps a designer's decision-making and knowledge sharing/utilizing among designers through pervasive computing. Designer cannot be aware of the utilization of knowledge. So it is called as "Knowledge Everywhere".

Lampson (2003) described the developing steps for computer application techniques as followings. (1) 1960's simulation, (2) the middle of 1980's communication, (3) 2010's embodiment

At first, difficult problems in engineering fields are resolved by simulation. After that, a new typed cyber world or virtual world is formed by the advent of Internet. In near future, cyber world will be merged into the real world.

The concept of KAD/KAM in this paper is to make substantial based on ubiquitous computing in engineering environment. Current representative words denoting the trend of engineering are **collaboration**, **knowledge** and **virtual**. KAD/KAM is to treat the unification of these concepts on the whole as smooth as possible.

## **3 Related technologies**

The described technologies in this chapter are some of related ones to realize "everywhere knowledge", which is the main concept of KAD/KAM. Of course, there can be other technologies to do this, but only the knowledge related technologies are introduced in this paper.

### **3.1 Augmented reality**

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Augmented Reality (AR) means the world that real world is combined by the computer generated virtual world. Until now, Virtual Reality (VR) used in a design and manufacturing domain helps designers to perform his/her task by an experience of simulated situation in computer generated virtual space. But AR, the combination of real and virtual world, can be an important technology toward KAD/KAM. Figure 1 shows an example of AR system, from which game player can enjoy the game by moving around in the real world combined with computer-generated virtual environment. The left hand side of the figure denotes the devices, such as HMD (Head Mounted Display) and so on. The right hand side is computer-generated image visualized on HMD.

In contrast to VR, AR adds virtual world into real world, and offers some information or knowledge that is not easy to get through designer's physical sense. That is, designers can perform his/her task effectively by supporting related knowledge through AR.

In a word, AR is combined technique with VR, knowledge, and sense. AR is one of the important technologies to construct advanced knowledge related work in real world with virtual environments.

There can be diverse applicable areas in shipbuilding, especially in KAM. For examples, assisting manufacturing processes, fault diagnosis for assembly, maintenance of complicated structure or machine, etc. are included. This technology can bring dramatic changes in design and manufacturing process of ships.



**Figure 1:** Hardware and immersion in Augmented Reality (Piekarski and Thomas 2002)

### **3.2 Semantic web and ontology**

Semantic web is a new paradigm to build an intelligent e-design and e-manufacturing system for a global information/knowledge sharing system to acquire or share related knowledge/information on web. That is, semantic web, which adopts the concept of metadata, is an extended concept of existing web.

In a semantic web, the agents share their knowledge each other, large-scaled agents interact with human (designer), and heterogeneous systems are worked with mutual relationship. This is the same with a computer window system, in which agents perform their own roles, and make an interaction each other without user's awareness.

The core technology for a sharing of knowledge is ontology. Ontology is a formal and explicit specification of a shared conceptualization of a domain of interest (Gruber 1993, Maedche and Staab 2001).

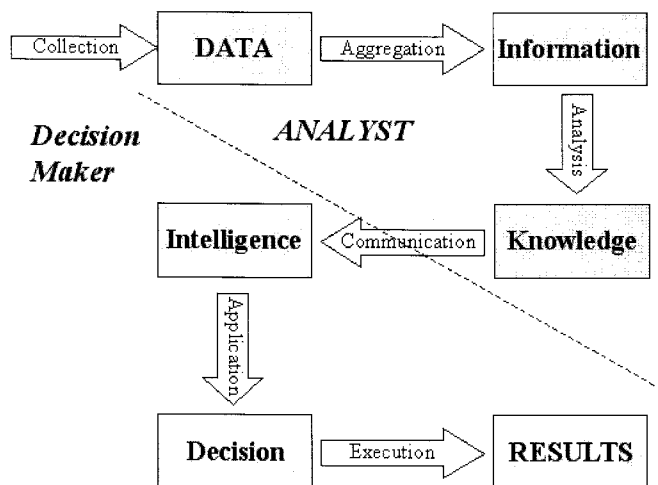
And also there is a new research field called ontological engineering, in which the effective development of ontology and its applications occurred in the overall life cycle of ontology, such as its design, evaluation, test, modification, maintenance, integration, and application, are studied (Gruninger and Lee 2002). In engineering domain, some practical researches are being tried. Lee et al. (2004) built feature ontology for CAD system interoperability, and Kim and Suh (2004) implemented product ontology for knowledge representation in CPC(Collaborative Product Commerce) environment.

Ontology has been a core research field in knowledge representation since the starting time of artificial intelligence. Knowledge in engineering is very important element in a viewpoint of innovation based on the creation of new concept. Semantic web will play an important role to realize KAD/KAM through knowledge standardization and utilization.

### 3.3 Business intelligence

Business intelligence (BI) is to create new knowledge for establishing management strategy of enterprise by gathering and analyzing of data. So it is called as knowledge engineering. From a view point that how to create knowledge, BI is one of important essential technologies to establish the concept of KAD/KAM.

Figure 2 denotes the value chain in BI.



**Figure 2:** Business Intelligence value chain

In Figure 2, the dashed line divides the role between analyst and decision maker. If the generated knowledge as a result of analyzing is transferred to decision maker, it becomes intelligence. This intelligence can be used to resolve some problems or to formulate future management strategies.

#### 3.3.1 DM (Data Mining)

Data Mining (DM) is a technology to capture useful knowledge from accumulated data (Berson et al. 2000). As we can see from the terminology ‘mining’, DM focuses on the knowledge capturing from the vast amount of accumulated data gathered from enterprise activities. This is similar to Online Analytical Processing (OLAP), but has some

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conceptual differences. OLAP generates a framework to analyze large amount of data, and to present knowledge as a meaningful type. On the other hand, DM added some functions of artificial intelligence, such as decision tree, rules, associations, deviations, correlations, and so on. Through a DM, it is possible to extract useful knowledge from existing data by the help of artificial intelligence.

DM will be one of key technologies in KAD/KAM as a part of knowledge generation/creation mechanism.

### **3.3.2 Knowledge management**

Knowledge fusion that linked among the distributed designers, or between designer and manufacturer, or within inter-organization, or with global suppliers, is impossible without infrastructure based on information technology. Knowledge management (KM) is a solution to realize these concepts.

In this paper, the meaning of KM is regarded as knowledge resource management. That is, KM is a systematic and organizationally specified process for acquiring, organizing, and communicating both tacit and explicit knowledge of employees so that other employees may make use of it to be more effective and productive in their work.

The followings are KM related technologies.

#### 1) Knowledge Creation/Generation

- Manipulation of large amount of data and cases  
(Case-Based Reasoning, Neural Network, Data Mining)
- Knowledge resource (External DB, Internet, etc.)

#### 2) Knowledge Storing/Sharing

- Communication channel and Knowledge Interchange  
(Video Conference, Remote education, Groupware)
- Knowledge Reuse (Knowledge repository, Knowledge Map)

#### 3) Knowledge Utilization

- Interface with decision-making and analyzing tool (Decision Making System etc.)
- Integration of distributed Knowledge Resources (EDMS, Workflow Management, etc.)
- Knowledge Representation (Rule Base, Object-Oriented, etc.)

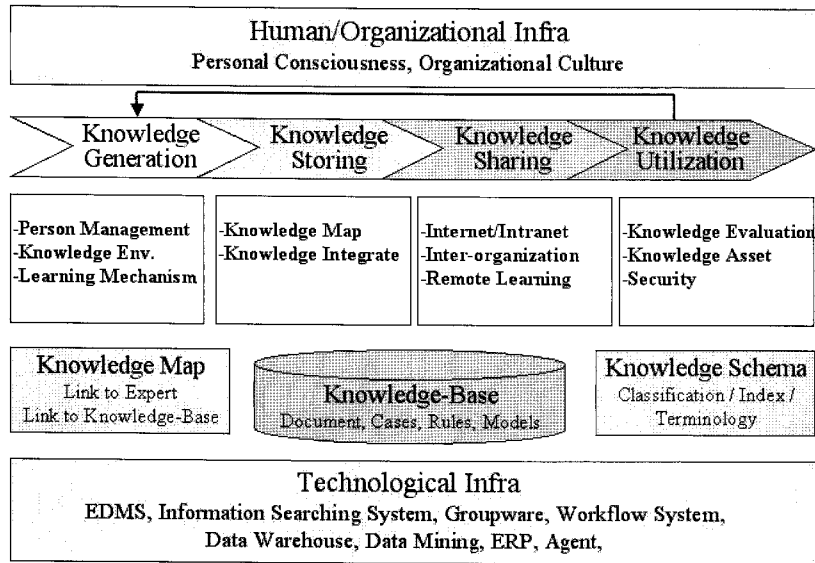
Knowledge Management System (KMS), an information system based on KM, can be used as a tool for knowledge creation/generation, sharing, and utilization in constructing KAD/KAM.

Figure 3 represents the concept of KM for an engineering domain (Lee 2003).

## **4 Conclusions**

The aim of this paper is to set up the knowledge utilization in engineering domain by presenting a new concept of KAD/KAM. As mentioned before, the concept of KAD/KAM is to make substantial based on ubiquitous computing in engineering environment. Ubiquitous computing is a hot issue in information communication domain. In a word, "Knowledge Everywhere" is a phrase pregnant with meaning of KAD/KAM.

The concept of KAD/KAM is still immature and rudimentary. But this will be a new paradigm to change engineering environment in near future.



**Figure 3:** The configuration of knowledge management system

## Acknowledgements

This work is supported by Advanced Ship Engineering Research Center (R11-2002-104-08002-0).

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