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# An intelligent insect search system based on observation of the insect's structure

Yong Sik Chang [a,1], Eung Sup Jun [b,*]

[a] Department of e-Business, Hanshin University, 137 Hanshindae-gil, Osan-si, Gyeonggi-do, Republic of Korea
[b] Department of Computer Software, Induk University, Wolgye-dong, Nowon-gu, Seoul, Republic of Korea

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ABSTRACT

In today's ecological environment, non-experts need insect search systems to identify insect species and to obtain its u-Learning contents. Even though non-experts have been assisted by the naïve web search system based on scientific names, it is very difficult for them to use the system effectively because they are laypersons of insects' scientific names. To assist them more effectively, the *ISBC* (Insect Search based on Biological Classification) method and *ISOBC* (Insect Search through Observation based on Biological Classification) method had been proposed. However, the *ISBC* method requires their time-consuming efforts to search insects because it is due to biological classification based on insects' Order-Family-Species and their scientific names. On the other hand, the *ISOBC* also gives them troublesomeness to observe insects because it is due to the sequence of biological classification.

To overcome such difficulties, we propose a new model, the *ISOIS* (Insect Search based on Observation of the Insect's Structure) method. It is based on natural observation in the sequence of insect's structure. In addition to that, it is equipped with inference through similarity measure according to the observation attributes by the sequence of biological classification to improve user satisfaction. Finally, we compare it with the *ISBC* and *ISOBC* methods. In order to compare the priorities among these three insect search systems, using the AHP method, we derive three evaluation criteria for user satisfaction and three sub-evaluation criteria for each evaluation criterion. In the empirical survey results, we found the order of priorities was *ISOIS*, *ISOBC*, and *ISBC*. This shows that the *ISOIS* system proposed in this study is comparatively superior to the *ISBC* and *ISOBC* systems in usage and quality.



## 1. Introduction

By the recent rapid spread of the personal hand-held devices with the cutting-edge IT, the existing paradigm of the circumstances surrounding education has changed into a u-Learning system. Free learning behavior is being implemented in ubiquitous space which is unlimited in learning scopes. Generally, u-Learning systems related with insect observation can provide almost all learners with the related learning contents according to the level of the knowledge and the information about insect species without illustrated insect books and guides. In a natural ecology area, non-experts anywhere and anytime can discern the observed insect and acquire the specific learning contents from the u-Learning system.

In insect identification, it is very important to use the search system for discrimination of the insect species in order to make the best use of the related contents and improve learning effectiveness. The naïve web search system based on insects' scientific names cannot help the non-experts to search insects because they are laypersons of insects.

Currently, non-experts usually obtain information and knowledge on insect species using insect search system based on biological taxonomy and classification according to insects' Order-Family-Species (Animal diversity web, 2014; Bric, 2014; Digital insect collection of Seoul National University, 2014; Doopedia, 2014; Ecosystem of Seoul, 2014; Green gyeonggi-do with beautiful forests, 2014; Insect collection, 2014; Insect life forms, 2014; Insect search center, 2014; Ko, Jun, Park, & Chung, 2009; Korean bioinformation center, 2014; National biological species knowledge information systems, 2014; National institute of biological resources, 2014; The mystery of butterflies, 2014; The wonderful world of insects, 2014; Wen, Guyer, & Li, 2009). We call it Insect Search based on Biological Classification (*ISBC*), which is based on an insect specialist-oriented taxonomy.

* Corresponding author. Tel.: +82 2 950 7621; fax: +82 2 950 7639.
*E-mail addresses:* yschang@hs.ac.kr (Y.S. Chang), esjun@induk.ac.kr (E.S. Jun).
[1] Tel.: +82 31 379 0594; fax: +82 31 372 3343.

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Under the environment of such websites, various problems on the search effectiveness and the learning effects are issued for non-experts to search through a large number of insect species. Especially, it is very difficult for them to distinguish the relevant insect species in insect data bases from the view point of search efficiency and learning effectiveness when using search methods designed for insect experts.

In order to handle the problems mentioned above, an approach on Insect Search through Observation based on Biological Classification (*ISOBC*) as a more efficient search algorithm was proposed (Jun, Chang, Kwon, & Kim, 2011; Jun, Chang, Kwon, Ko, & Kim, 2010; Ko et al., 2009). This approach provides non-experts in entomological taxonomy or biological classification with an appropriate search method that focuses on the observation of the major characteristics of insect's structure according to hierarchical observation based on vertical entomological taxonomy. That is to say, similar insect species are distinguished by computing their similarities from the characteristics of their appearance observed by learners.

However, the observation of non-experts centers on insect's appearance structure such as the head, the thorax, the abdomen, wings and legs, which are irrelevant to the entomological taxonomy. So, observation efficacy is an issue in terms of the rudimentary insect knowledge of learners. In order to ensure effective observation learning, we propose a new method, Insect Search based on Observation of the Insect's Structure (*ISOIS*), to identify insect species effectively with observation in the sequence of insect's structure and similarity measure according to the observation attributes by the sequence of biological classification to improve search effectiveness and user satisfaction. It will be more useful than *ISOBC* in the ecological nature environment. This means that effective learning based on observation could be implemented by looking at the structure of the insect species freely according to the generic and horizontal observations of major insects.

Our study's objective is that we provide an intelligent insect search system based on the *ISOIS* method. To achieve it, this paper is organized as follows. We review the related research in Section 2, and classify the appearance characteristics of the insect body from an observational perspective and propose the search procedure on the observation of insect's structure and the similarity measure between the observed information and the related insect species in Section 3. We also perform a comparative evaluation based on the AHP method (Saaty, 1980) to compare user satisfaction for *ISBC*, *ISOBC*, and *ISOIS* in Section 4. Finally, we conclude our study and suggest areas for further research in Section 5.

## 2. Literature review

### 2.1. Insect search system

Insect learning activity based on the u-Learning paradigm is very important for us to preserve a global green environment and to establish green policies while spreading education on ecology and the insect learning for the protection of insect species.

In past research, there were several insect identification studies using AI and expert systems with a knowledge base. These studies focused on insect identification for forest protection by using expert system in the bioinformatics field within a few insect species which were grouped into the forest damage species (Arrignon, Deconchat, Sarthou, Balent, & Monteil, 2007; Batchelor, McClendon, Adams, & Jones, 1989; Beck, Jones, & Jones, 1989; Kaloudis, Anastopoulos, Yialouris, Lorentzos, & Sideridis, 2005; Pasqual & Mansfield, 1988; Wen et al., 2009). They especially implemented the identification of pests and the analysis of forest damage using AI approaches for forest protection through the characteristics of insects and forests. Several studies on AI methods for pest management were implemented and they were used to evaluate the forest damage to identify the precise insects and to predict the amount of damage (Kaloudis et al., 2005; Wen et al., 2009). These studies are no longer suggesting the general insect search methods for non-experts who want to get the name and the knowledge of the generally identified insect in the wild life.

The concern with furnishing effective contents has been growing in e-Learning and u-Learning systems. Worldwide, websites on the biology species provide us with a variety of contents on insect diversity (Animal diversity web, 2014; Bric, 2014; Digital insect collection of Seoul National University, 2014; Doopedia, 2014; Ecosystem of Seoul, 2014; Green Gyeonggi-do with beautiful forests, 2014; Insect collection, 2014; Insect life forms, 2014; Insect search center, 2014; Korean bioinformation center, 2014; National biological species knowledge information systems, 2014; National institute of biological resources, 2014; The mystery of butterflies, 2014; The wonderful world of insects, 2014). For example, in the web sites of National biological species knowledge information systems (2014) and Insect life forms (2014), taxonomic drill down browser of the insects and their life forms are designed to aid in exploring, identification, and learning. For shortcuts to an insect to be identified, learners have to select the related insect characteristics from the insect life forms or the field guide by Order-Family-Species using the insect taxonomy tree. They can search insects by links provided above and below through taxonomic drill down. They can also enter the search keywords of a scientific name in the text box. As mentioned above, almost all the current websites on insect search provide us with search methods by the insect scientific name or the taxonomy tree. While on the other hand, in order to obtain information on specific insect species, non-experts should recognize the biological classification of the corresponding insect species or the scientific name of a certain insect exactly.

Hence, non-experts are confronted with the difficult problem of identifying relevant information on observed insects by search method because of insufficient information on insect taxonomy. So, there is a growing need to develop an effective search system that is capable of finding the necessary information from massive databases. In general, learners who are non-experts on insect species acquire the relevant information through search based on identification by appearance, color and the living habit characteristics of the observed insects. Therefore, from the view of a general observer, an insect search system that appropriately identifies an insect species from observed information provides a more user-friendly method than a search system based on biological classification designed for experts.

A system, U-EREMS, provides u-Learning on insects and the other environment information on nature and the wilderness (Insect search center, 2014). The system significantly improves the efficiency for using the u-Learning contents on the ecology of insects and information on the environment anywhere and anytime, and also supports various ubiquitous devices as well as hand-held devices. Most of these previous studies provide insect search systems based on the *ISBC* method.

To overcome the limits of *ISBC*-based search systems based on entomological taxonomy, a study has been made on inference search methods in S-EREMS (Jun et al., 2011). The system is based on smart phones and provides u-Learning content on insect observation learning and the *ISOBC*-based search system. However, it has the limits in terms of user input and the search scope by overall observation.

There are two ways for sequential and hierarchical insect classification – *ISBC* and *ISOBC* – according to Order-Family-Species. The *ISBC* way is an insect specialist-oriented taxonomy based on