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Biomimetics Image Retrieval Platform

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SUMMARY Biomimetics is a new research field that creates innovation through the collaboration of different existing research fields. However, the collaboration, i.e., the exchange of deep knowledge between different research fields, is difficult for several reasons such as differences in technical terms used in different fields. In order to overcome this problem, we have developed a new retrieval platform, "Biomimetics image retrieval platform," using a visualization-based image retrieval technique. A biological database contains a large volume of image data, and by taking advantage of these image data, we are able to overcome limitations of text-only information retrieval. By realizing such a retrieval platform that does not depend on technical terms, individual biological databases of various species can be integrated. This will allow not only the use of data for the study of various species by researchers in different biological fields but also access for a wide range of researchers in fields ranging from materials science, mechanical engineering and manufacturing. Therefore, our platform provides a new path bridging different fields and will contribute to the development of biomimetics since it can overcome the limitation of the traditional retrieval platform.

key words: *biomimetics, inter-field collaboration, visualization-based image retrieval, scanning electron microphotograph*

1. Introduction

Biomimetics is a new research field that yields new manufacturing concepts based on the structures, functionality and reproduction processes of natural organisms. For example, it is known that by mimicking physical architectures of biological neuronal systems, various kinds of neuromorphic very large-scale integration (VLSI) sensors can be developed [1]. In addition, by artificially reproducing surfaces of biological organisms including unique functions, a wide variety of nanomaterials can be also developed [2], [3]. Based on collaboration between different research fields such as biology and engineering, biomimetics has attracted much attention due to its potential to realize a sustainable society [4], [5].

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1.1 Background

In the field of biomimetics, mutual exchange of knowledge between different research fields is necessary. More specifically, biomimetics requires biological knowledge, but obtaining that knowledge is difficult due to the biodiversity. Biomimetics has contributed to the development of excellent products and technology, but in order to continuously provide new manufacturing concepts and create the next-generation sustainable manufacturing foundation, we need a platform that allows us to obtain information related to the manufacturing from biological aspects.

Recently, due to the widespread use of the scanning electron microscope (SEM), observations of subcellular structures on the surfaces of various biological organisms have been intensively carried out. Researchers of nanomaterials and nanofabrication have become able to reproduce nanostructures that are similar to the unique nanostructures of biological organisms for realizing their specific functions in materials. Therefore, it is necessary to not only enable access to researchers of different kinds of biological organisms by integrating the separately accumulated SEM images of various organisms including insects, birds and fish but also enable access to a wide range of researchers in material science, engineering and manufacturing fields [2], [3]. However, due to the biodiversity, collecting effective data from bio-organisms requires much knowledge and effort.

For collecting data useful for biomimetics, the cooperation of museums that accumulated samples and information pertaining to this vast diversity would be necessary. In recent years, knowledge of bio-organisms as well as surface structures of bio-organisms revealed by microscopic images has provided useful insights for manufacturing. Thus, there is a need for a retrieval system that supports the extraction of data that are useful for manufacturing from the large volume of bio-organism data.

1.2 Related Works and Remaining Problems

Many services for image and video retrieval are currently being used. Existing retrieval systems are based on metadata attached to each content. There has recently been an acceleration in research of image/video analysis, more specifically, image/video semantic understanding, which can automatically attach metadata to multimedia contents [6]. This technology is currently being used in existing services [7]. Furthermore, with the rapid growth of deep learning technologies [8], there has been a great improvement in image/video understanding performance in the field of generic object recognition [9]. Although existing research fields such as machine learning have contributed greatly to the improvement in performance, overcoming the "Semantic Gap" remains an important problem [10]. The "Semantic Gap" is the gap between the numeric features extracted from image data and their meanings. In order to achieve accurate image/video understanding, methods based on machine learning still need a large volume of diverse training data that correspond to the meaning of each keyword. However, when dealing with image data for biomimetics, it is impossible to prepare a large volume of training data for each category, e.g., each kind of bio-organism. Generally, due to the biodiversity, there are many images of various bio-organisms. However, for each kind of bio-organism, small number of images are only taken. Furthermore, when dealing with SEM images, this problem becomes more significant since only one image is generally taken for each part of each kind of bio-organism at each magnification. Therefore, the above condition causes the problem of decreased retrieval accuracy.

In addition to the above problems, a new problem has become significant in recent years. Sometimes, we cannot clearly provide a query keyword that expresses the desired contents, making it difficult to obtain the desired contents using conventional retrieval methods [11]. This problem is mentioned in the investigation reports of the International Data Corporation (IDC) [12]–[14], and they conclude that we will need new search and discovery tools. The above problem has become more significant in the field of biomimetics. More specifically, when researchers search for images from a research field other than their own, it is difficult for them to express their desired content using appropriate technical terms. This is because technical terms often differ significantly between different research fields.

1.3 Our Contribution

In order to provide a solution to the aforementioned problems, we have studied a new retrieval technique that includes visualization methods for obtaining desired information from a large volume of data [15]–[18]. This image retrieval technique enables users to obtain desired images from a large volume of accumulated images by visualizing the images even if they cannot provide appropriate keywords, i.e., technical terms. Through the visualization results provided by this image retrieval technique, users can find an overview of the entire database and reach their desired images more effectively.

A novel biomimetics image retrieval platform based on the visualization-based image retrieval technique is presented in this paper. From SEM images acquired by researchers in different research fields, we focus on the characteristic that although the terminology used to describe certain properties is completely different between different fields, the visual features of corresponding SEM images are similar to each other if their nanostructures are similar. Thus, we utilize the similarity in visual features between images to visualize the entire database in a low-dimensional space that is viewable by users. Therefore, even if two SEM images come from different fields, as long as their nanostructures are similar, they will be placed close together in the low-dimensional visualization space, enabling researchers from various fields to understand the potential properties of these SEM images. In other words, this retrieval platform can play an important role as a trigger for creating inter-field collaboration.

The biomimetics image retrieval platform explained in this paper accumulates SEM images in a database and is intended to (1) allow biology researchers from different fields to make new discoveries and (2) allow engineering researchers to obtain new knowledge from existing bio-organisms. Furthermore, by rearranging the images in the database, the platform enables the generation of new ideas through several different patterns of cooperation between different research fields. Thus, we can find a new path existing between different fields by using the proposed platform, and the development of biomimetics is realized since our platform can drastically break the limitation of the traditional retrieval platform.

1.4 Organization

This paper is organized as follows. First, in Sect. 2, the necessity of biomimetics image retrieval is described and a solution using visualization-based image retrieval is provided. A detailed explanation of the biomimetics image retrieval platform is given in Sect. 3. In Sect. 4, the effectiveness of the biomimetics image retrieval platform is discussed on the basis of results obtained by applying it to a real biological image database. Finally, concluding remarks are given in Sect. 5.

2. Necessity of Biomimetics Image Retrieval and New Visualization-Based Image Retrieval Technique

In this section, we first explain the motivation of our study, i.e., necessity of biomimetics image retrieval, in 2.1. The idea of the new visualization-based image retrieval technique, which is a fundamental element of the biomimetics image retrieval platform, is introduced in 2.2.

2.1 Necessity of Biomimetics Image Retrieval

As described above, biomimetics is a research field that creates innovation through the collaboration of various research fields. In order for researchers with deep knowledge of their own research fields to cooperate with each other, exchanging and sharing their knowledge is necessary. However, it is difficult to understand different research fields due to the

Fig. 1 Image Vortex, an image retrieval system based on visualization-based image retrieval. In this system, we can find relationships among images in a database according to their visual features in three-dimensional space.

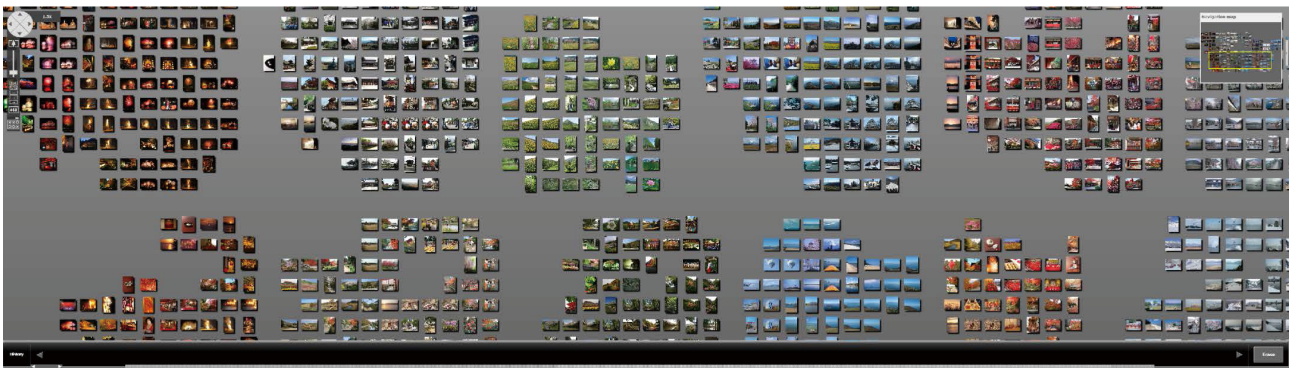


Fig. 2 Image Cruiser, a large-scale database retrieval engine that was developed as a practical implementation of Image Vortex.

difference in terminology. Below, we show an example of the word "adhesion" being used in different fields.

Biology [19]: "After applying the adhesive to the substrate, the samples were allowed to dry for 24 hours under a bio-safety cabinet."

Medicine [20]: "Adhesion formation is the most common complication following peritoneal surgery and the leading cause of small bowel obstruction, acquired infertility and inadvertent organ injury at reoperation."

Robotics [21]: "The result is Stickybot, a robot that climbs glass and other smooth surfaces using directional adhesive pads on its toes."

The use of the word "adhesion" in the three examples above demonstrates that, while the high-level concept remains constant, there are subtle differences in meaning. Such differences become an obstacle to mutual understanding between different fields and hinder the consolidation of knowledge. In order to minimize this obstacle, construction of dictionaries and ontologies over different fields is effective, and several trials for biomimetics have been carried out [22].

On the other hand, establishing relationships between different technical terms has its limitations, and we propose another novel approach, which tries to provide breakthroughs by utilizing unstructured data such as image and video data obtained from different fields. More specifically, this is the "Biomimetics Image Retrieval Platform", which integrates different types of data from different fields and is based on the theory of visualization-based image retrieval. By using this retrieval platform, it becomes feasible to find images that share a common visual structure and to find their relationship without using technical terms of each research field. Then, by using visual features that can be directly compared between different fields, images that were accumulated separately can be consolidated, realizing cooperation between researchers from different research fields.

2.2 New Visualization-Based Image Retrieval

Visualization-based image retrieval analyzes features of unstructured data such as image and video data and enables users to find new data of different fields. Figure 1 shows the interface of the system "Image Vortex," which was developed on the basis of the idea of visualization-based image retrieval. Image Vortex enables image information retrieval in conditions under which conventional retrieval methods struggle – more specifically, where the user is unable to provide a specific query keyword [16]. This system enables users to effectively obtain their desired content from a large volume of accumulated image data. The system calculates a visual feature vector for each image in the database and utilizes these vectors to define the difference between pairs of images as the distance between them [23], [24]. Finally, based on the defined distance, the system visualizes the images in a three-dimensional space as shown in Fig. 1. By utilizing this interface, users can view the entire database as an overview and reach their desired image effectively.

Figure 2 shows "Image Cruiser", a large-scale database retrieval engine that was developed as a practical implementation of Image Vortex. Image Cruiser realizes high-speed image rearrangement by utilizing the image distance measure defined by Image Vortex. By realizing an easy-to-user interface, the system enables users to see an overview of a large volume of image data and reach their desired images quickly and effectively. Furthermore, this interface does not require users to express their desired content as a query, using keywords or otherwise.

3. Biomimetics Image Retrieval Platform

The biomimetics image retrieval platform is described in this section. An overview of the system is given in Sect. 3.1, and the main functions of the platform are explained in detail in Sect. 3.2.

3.1 System Overview

A system overview of the biomimetics image retrieval platform based on the idea of the visualization-based image retrieval introduced in the previous section is given in this subsection. The biomimetics image retrieval platform shows an overview of the entire database consisting of a large volume of SEM image data. More specifically, the platform enables visualization of the images in the database by performing dimensionality reduction – rearranging the images in a 2D space based on the distance between the visual features extracted from images in the database. The algorithm performing the rearrangement is based on our previously reported algorithm [16]. Through the cruising model based on the 2D-interface, users can make a survey of the whole data (all of the images in the database) and easily find their desired images. Our system consists of the following three basic algorithms.

(i) Extraction of visual features from images
Several visual features, such as color histograms, color correlograms and those focusing on target objects, are extracted from images [23]. For these feature vectors calculated from all of the images in the database, principal component analysis is applied to reduce their dimensions to lower dimensions.

(ii) Definition of the distance between two images
The distance between a pair of visual feature vectors is defined by the simplest l_2-norm [24].

(iii) Dimensionality reduction for visualization
Two-dimensional positions are determined for all of the images in the target database based on the dimensionality reduction algorithm [16] using the distances calculated in (ii).

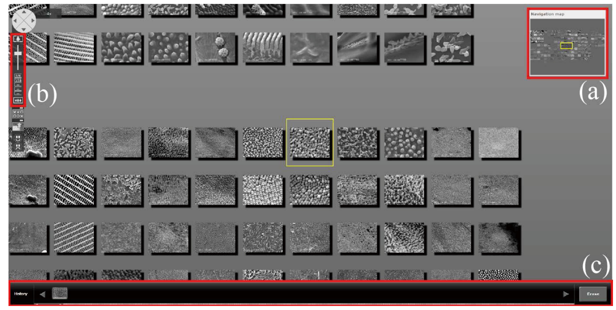


Fig. 3 The interface of the biomimetics image retrieval platform: (a) displayed parts of the entire image database, (b) function that changes the number and size of displayed images, and (c) history of previously viewed images.

In our system, it is possible to select different visual features, distance measures and dimensionality reduction algorithms that are more effective for the target database, enabling better visualization results to be obtained. For example, some results presented in the next section were obtained by using speeded up robust features (SURF) [25] for the feature extraction. In that case, we confirmed that the results strongly reflect the properties of visual patterns.

3.2 Main Functions Implemented in Our Platform

The main functions implemented in the biomimetics image retrieval platform are explained in this subsection. The biomimetics image retrieval platform is implemented as an interface that enables users to effectively find the information they need to achieve their goals by accessing an overview of the database that contains SEM images useful for manufacturing, e.g., materials science. In the rest of this subsection, we explain the main functions of the proposed retrieval platform.

(A) Overview of the Image Database
Figure 3 shows the appearance of the image database overview. Each item in the interface of the biomimetics image retrieval platform is explained within this figure. The parts of Fig. 3 (a) contained within the yellow border show the displayed parts of the entire image database. The displayed parts can be moved by dragging. Furthermore, by using Fig. 3 (b), we can change the number and size of the displayed images. As shown in Fig. 3 (c), the bottom part of the interface shows a history of previously viewed images.

(B) Confirmation of Bio-organism Information
By selecting each image, we can confirm the details of the bio-organism as shown in Fig. 4. Specifically, the entire inventory information for the target bio-organism is shown, with each SEM image containing attached inventory information. Table 1 shows representative inventory information attached to each SEM image as metadata. Furthermore, if users select their

desired inventory information, it is possible to narrow down the displayed images using that information. Figure 5 illustrates the use of this function in practice. The displayed SEM images are narrowed down to only images that show a specific magnification. The inventory information allows biologists to enter important information about the functions of the bio-organism shown in each image, particularly ecosystem keywords ("Eco. keywords") that represent unique characteristics and functions of target bio-organisms. Therefore, when de-

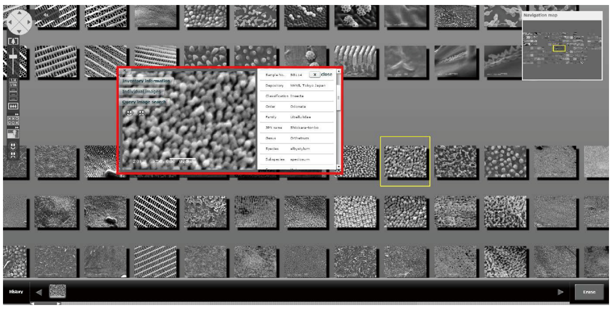


Fig. 4 Selection of an image and confirmation of its bio-organism information.

Table 1 Representative inventory information attached to SEM images in the biomimetics image retrieval platform.

Order	Magnification	Position
Genus	Depository	Classification
Sex	Family	JPN name
Collector	Species	Subspecies
Eco. keywords	Locality	Method
Coating	Habitat	Camera
Photographer	Size (mm)	–

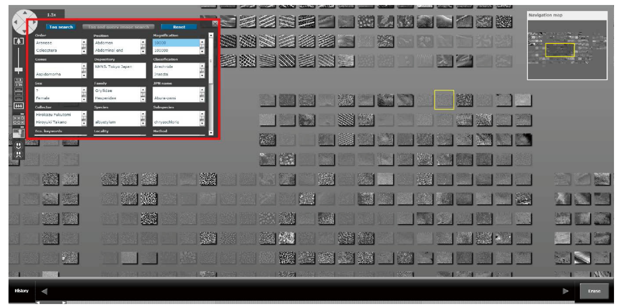


Fig. 5 Appearance of images narrowed down to only images that show a specific magnification. In this figure, the results are limited to images of magnification ×10000.

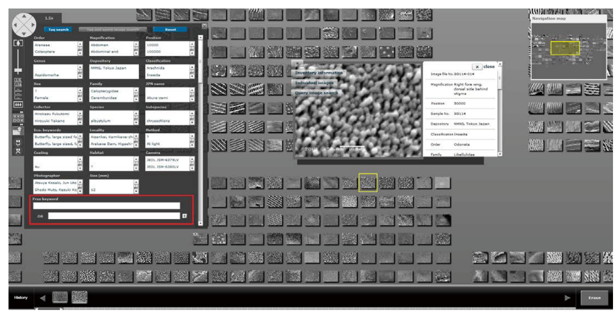
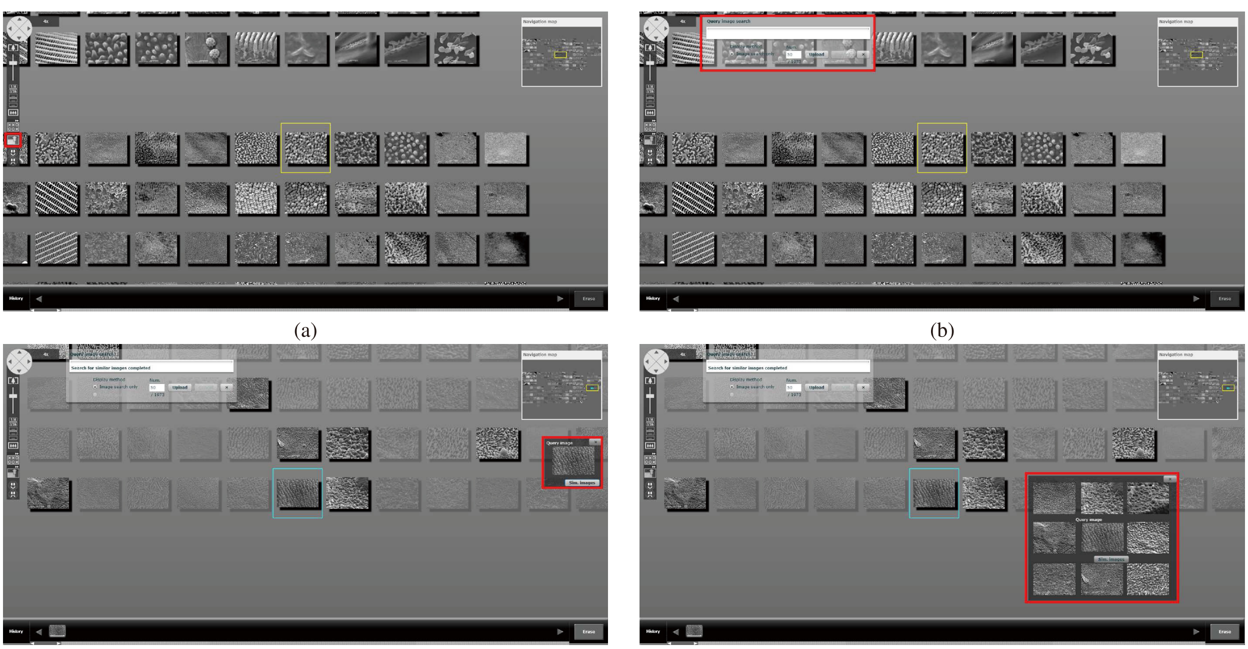


Fig. 6 Function of the keyword-based retrieval. By inputting keywords, images including keywords in the inventory information can be found.



(a) (b) (c) (d)

Fig. 7 Appearance of query image-based retrieval. By selecting the function of "query image-based retrieval" shown in (a), the uploader appears as shown in (b). The uploaded query image is shown in the right side of the interface as can be seen in (c). Furthermore, eight similar images surrounding the query image can be seen as shown in (d).

veloping particular materials, engineering researchers are able to discover a new functionality by searching for SEM images of bio-organisms that have structures similar to those of the developed materials and by examining the ecosystem keywords for those images. For example, Eco. keywords in the current database are moth-eye, anti-reflectivity, hydrophobic, structural adhesion, structural color, photonic crystal, etc.

(C) Query Keyword-based Retrieval
As mentioned earlier, each image in the biomimetics image retrieval platform contains inventory information. Based on this information, it is possible to enter keywords and search for bio-organism images that match the keywords, as shown in Fig. 6. Since, in practice, biologists and engineers often know "what biological properties" or "what kind of material functionality" they are searching for, it is possible to effectively reach the desired data by performing keyword-based retrieval. However, as mentioned previously, keyword-based retrieval is difficult since the terminology differs between different research fields. In order to overcome this problem, construction of dictionaries and ontologies that connect technical terms across different fields is effective, and such dictionaries are being created for the different fields encompassing biomimetics [22]. Then, by registering keywords that can be used across different fields as Eco. keywords, the platform provides a new path to the user for reaching their desired contents.

(D) Query Image-based Retrieval
Figure 7 (a) illustrates image-based retrieval: the button shows the "query image retrieval" panel, allowing the user to upload a new image (see Fig. 7 (b)). Once the retrieval is completed, the uploaded image is shown in the blue frame (see Fig. 7 (c)), and the "query image" window appears. Upon clicking on the "Similar images" button, eight similar images are shown (see Fig. 7 (d)). The displayed eight images are selected on the basis of the distance of the visual features explained in the previous subsection. This function enables biologists and engineers to find SEM images with similar visual structures without relying on the differences in terminology across different fields. Furthermore, as mentioned previously, the inventory information contained in each SEM image in the retrieved results, in particular, the ecosystem keywords, enable a common functionality to be discovered without having special biological knowledge.

4. Discussions of the Effectiveness by Application to an Actual Image Database

In this section, the effectiveness of the biomimetics image retrieval platform is discussed on the basis of results obtained by applying the platform to a real-world biology image database. The platform enables retrieval in a networked environment, where an example site of the platform can be accessed from the following URL:
http://bmireng.ist.hokudai.ac.jp/
Through a Web browser, users can access our retrieval platform.

As mentioned above, the biomimetics image retrieval platform supports retrieval of SEM images of biological organisms. Specifically, it includes SEM images of several species such as insects, fish and birds†, with over 50000 SEM images having been registered in the platform. The effectiveness of its core algorithm, i.e., the visualization algorithm based on dimensionality reduction, has already been verified from the perspective of information science [26]. Furthermore, in order to show the effectiveness of the platform from a biomimetics perspective, it is necessary to demonstrate that it supports real researchers in the discovery of new ideas. Therefore, the effectiveness of the platform is verified in this section by presenting examples of new discoveries obtained through actual use of the proposed platform by real biologists and engineers. We show examples of discoveries of bio-organisms that share common structures and discoveries of similar characteristics in bio-organisms and materials in the following subsection.

(I) Discovered Similarities Between Different Biological Organisms
Figure 8 shows the application of the biomimetics image retrieval platform to examine the database. Figure 8 (b) shows retrieval results of the lower-right cluster of Fig. 8 (a), limited to Dytiscidae. As shown in Fig. 8 (c), among the results limited to Dytiscidae, there are some results related to *Cybister japonicus*, but, as shown in Figs. 8 (d)–(f), there are many images belonging to different families in the neighborhood of that particular image, e.g., *Haliplus ovalis* (Haliplidae), *Orectochilus villosus* (Gyrinidae) and *Hydrophilus acuminatus* Motschulsky (Hydrophilidae). Although these images belong to insects from different families, they are placed close together since they possess similar visual structures.
Figures 9 and 10 show other retrieval results of the biomimetics image retrieval platform. These figures show visualization results of insect images and fish images. Figure 9 (b) shows a fish image and Fig. 9 (c) shows an insect image. However, these images are shown at close positions as can be seen in Fig. 9 (a) since their visual characteristics are similar. Similarly, the images in Figs. 10 (b) and (c) are shown at close positions as can be seen in Fig. 10 (a). These images are a fish image and an insect image, respectively.

†The SEM images of insects, fish and birds included in the biomimetics image retrieval platform were provided by Dr. Shuhei Nomura, Dr. Gento Shinohara, Dr. Keiichi Matsuura in National Museum of Nature and Science and Dr. Takeshi Yamasaki in Yamashina Institute for Ornithology.

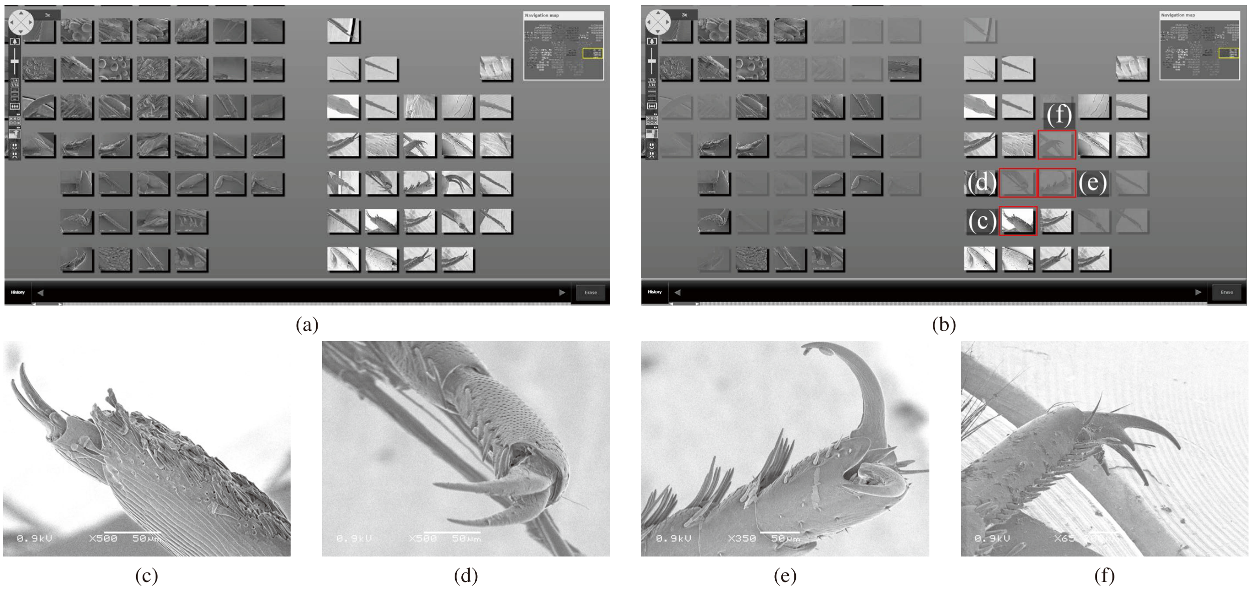


Fig. 8 Examples of retrieved images of biological organisms using the biomimetics image retrieval platform: (a) images shown in our retrieval platform and results limited to (b) Dytiscidae, (c) *Cybister japonicus* (Dytiscidae), (d) *Haliplus ovalis* (Haliplidae), (e) *Orectochilus villosus* (Gyrinidae), and (f) *Hydrophilus acuminatus* Motschulsky (Hydrophilidae).

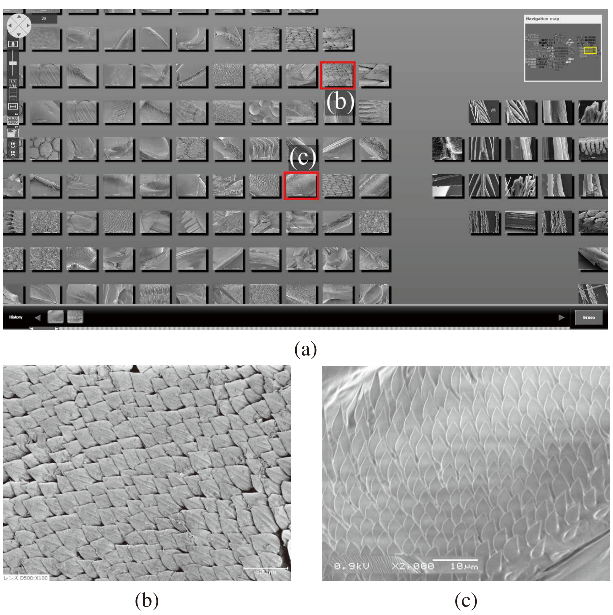


Fig. 9 Examples of retrieved images of biological organisms using the biomimetics image retrieval platform: (a) images shown in our retrieval platform and images for (b) *Mustelus manazo* (Triakidae) and (c) *Copelatus tenebrosus* (Dytiscidae).

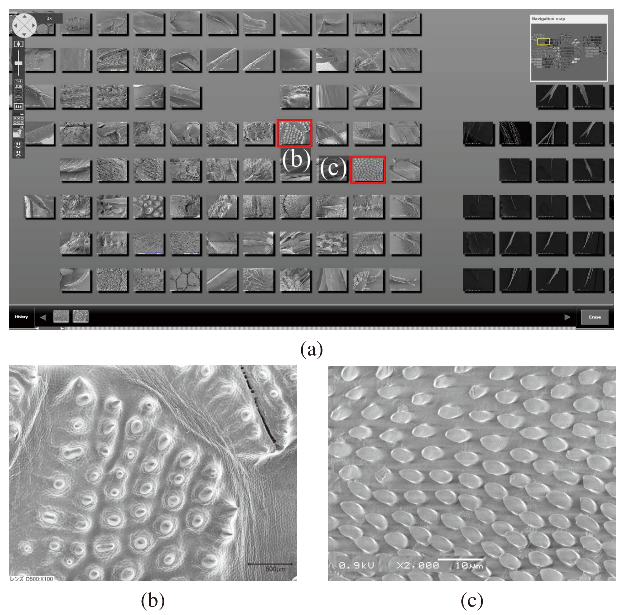


Fig. 10 Examples of retrieved images of biological organisms using the biomimetics image retrieval platform: (a) images shown in our retrieval platform and images for (b) *Sufflamen fraenatum* (Balistidae) and (c) *Copelatus tenebrosus* (Dytiscidae).

(II) Discovered Similarities Between Biological Organisms and Materials: Example 1

Figure 11 shows the results of retrieval from insect images using the biomimetics image retrieval platform. Figure 11 assumes a scenario where a material scientist registers his/her own four material images and searches for images of biological organisms. Figure 11 (a) shows that images of the micro lens array generated on the basis of [27] are placed closely to images of the moth-eye structure of *Helicoverpa armigera*, the wings of the cicada *Terpnosia nigricosta*†, and the surface of the front wings of *Graptopsaltria bimaculata*.

†The SEM images of *Helicoverpa armigera* and *Terpnosia nigricosta* were provided by Dr. Takahiko Hariyama in Hamamatsu University School of Medicine.

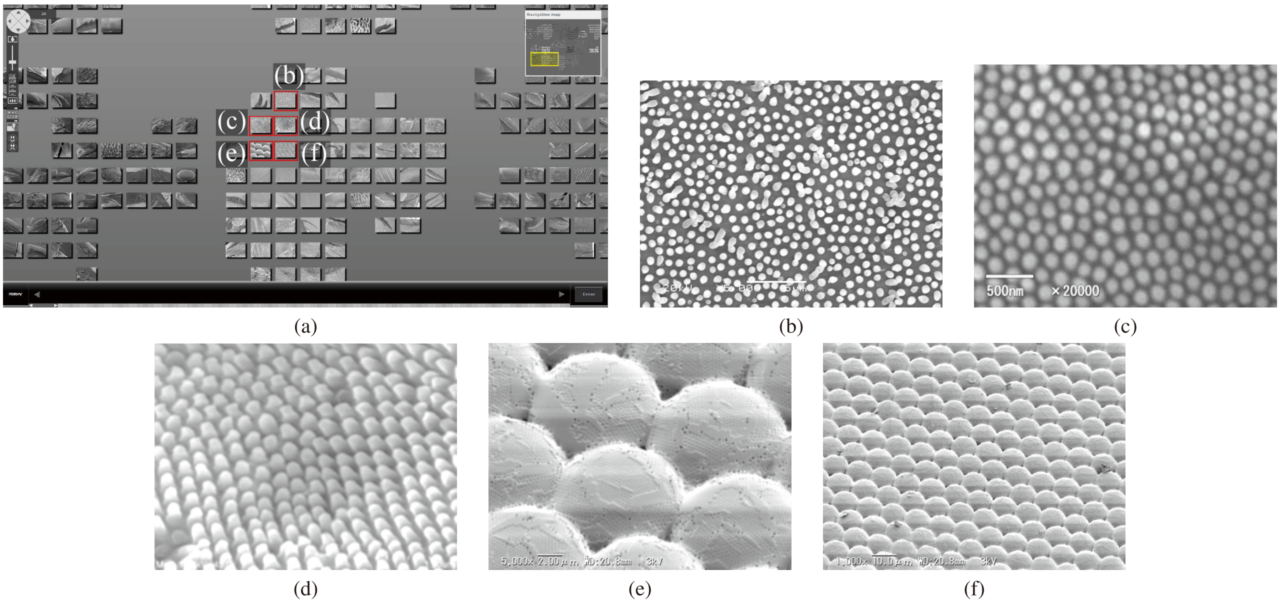


Fig. 11 Retrieval results including similar structures of insects and materials (Example 1): (a) visualization results of SEM images including similar structures, (b) *Helicoverpa armigera* (Noctuidae), (c) *Terpnosia nigricosta* (Cicadidae), (d) *Graptopsaltria bimaculata* (Cicadidae), and (e) and (f) micro lens array (material images).

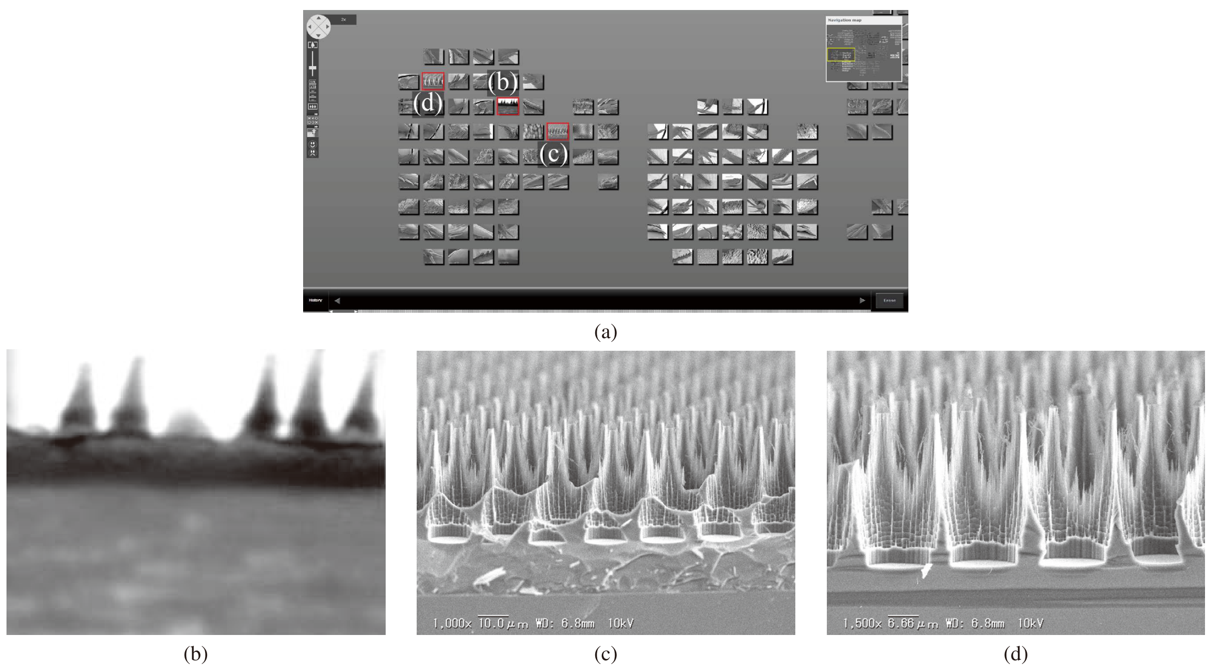


Fig. 12 Retrieval results including similar structures of insects and materials (Example 1): (a) visualization results of SEM images including similar structures, (b) *Terpnosia nigricosta* (Cicadidae), and (c) and (d) silicon nanospike array.

Furthermore, Fig. 12 shows that images of the silicon nanospike array generated on the basis of [27] in the material field are placed closely to images of the wing cross-section of *Terpnosia nigricosta*. These retrieval results show that focusing on similar surface structures enables retrieval of different kinds of information (e.g., biological organisms and materials).

(III) Discovered Similarities Between Biological Organisms and Materials: Example 2

Figure 13 shows an example of retrieval results after uploading an SEM image of artificial photonic crystals† as a query. In this case, the image retrieval system

†The SEM image of the artificial photonic crystals was provided by Dr. Hiroshi Fudouzi in National Institute for Materials Science.

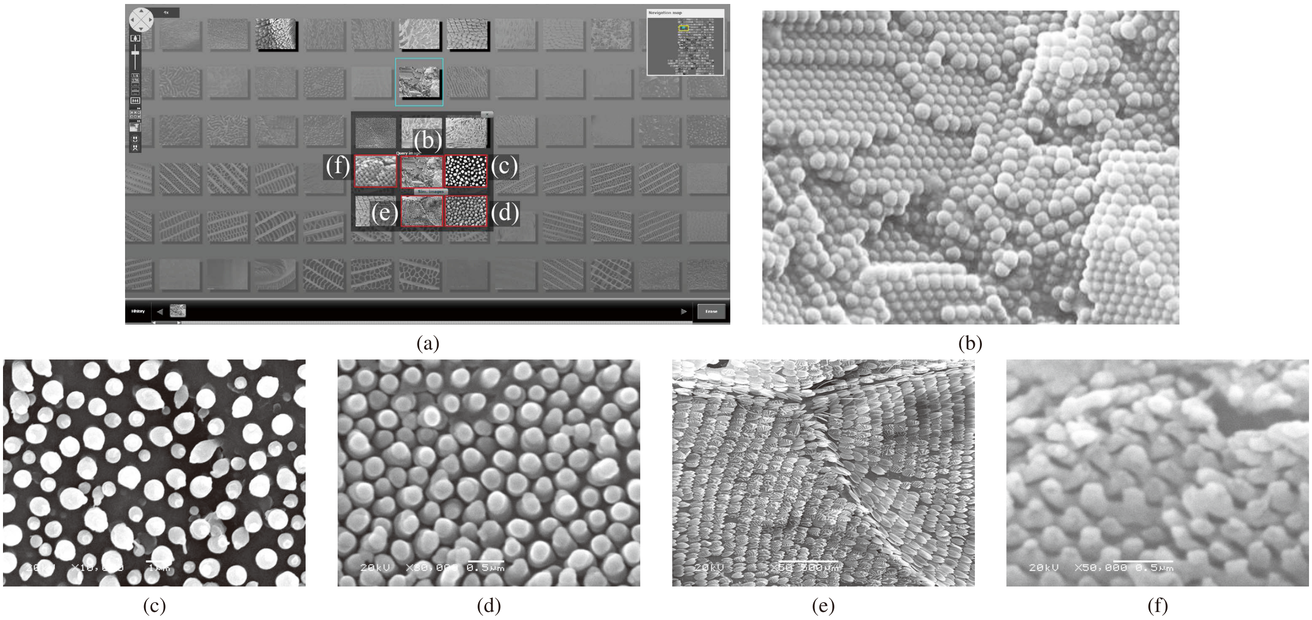


Fig. 13 Results of query image-based retrieval after uploading an SEM image of artificial photonic crystals to the biomimetics image retrieval platform (Example 2): (a) results obtained by uploading the SEM image of artificial photonic crystals, (b) artificial photonic crystals (query image), (c) *Platypleura miyakona* (Cicadidae), (d) *Meimuna opalifera* (Cicadidae), (e) *Parantica sita* (Nymphalidae), and (f) *Eupholus schoenherri* (Curculionidae).

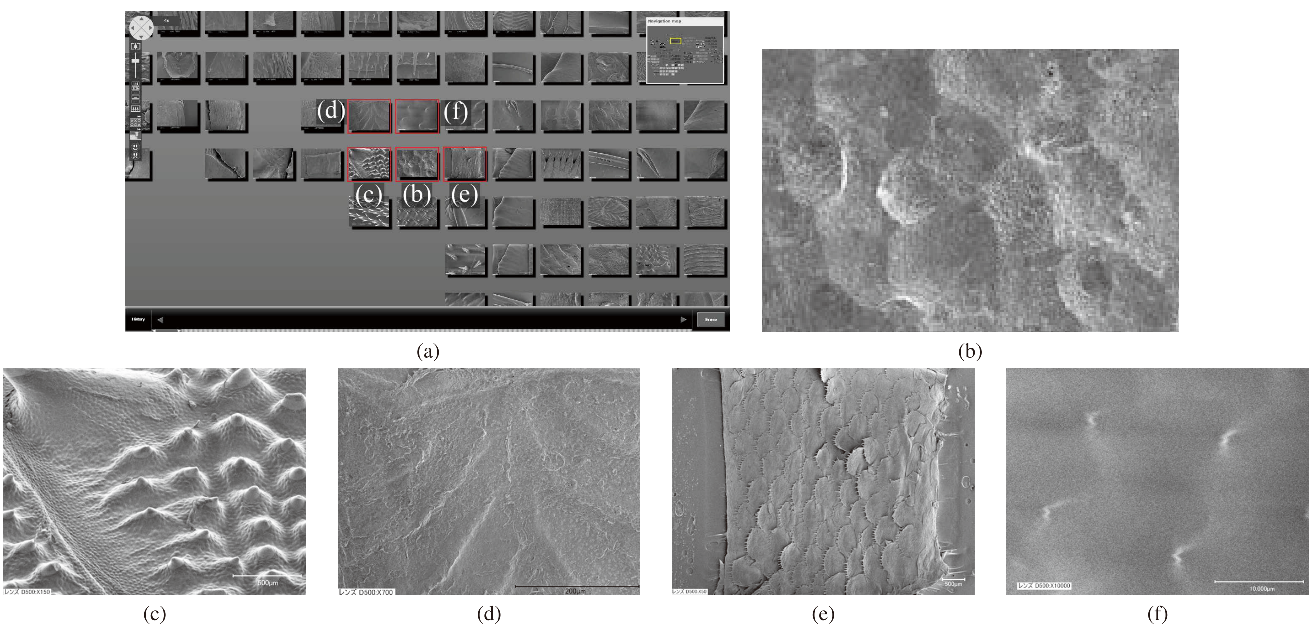


Fig. 14 Results of performing a search of images of fish, insects and materials using the biomimetics image retrieval platform: (a) visualization results of SEM images including similar structures, (b) surface treatment metal, (c) *Sufflamen fraenatum* (Balistidae), (d) *Hippichthys spicifer* (Syngnathidae), (e) *Oplegnathus fasciatus* (Oplegnathidae), and (f) *Cosmiomorpha similis* (Scarabaeidae).

used SURF features [25] as visual features. Figure 13 shows the actual retrieval result focusing on artificial photonic crystals. Photonic crystals are nanostructures with a periodically changing refractive index that can control the way in which light (electromagnetic waves with wavelengths from several hundred to several thousand nm) is transmitted through them. SEM images of *Eupholus schoenherri* are shown as the result of a similar image retrieval. The potion developing color of Curculionoidae are quite similar. It is known that Curculionoidae produces photonic crystals. Furthermore, from the point of view of biologists and material scientists, the similarity between photonic crystals of Curculionoidae and nanopiles of "Cicad body surface" suggests that a functionality is created by subcellular structures. Interestingly, the retrieval results also contain a recurring structure of a completely different scale, as demonstrated by the example for *Parantica sita*.

(IV) Discovered Similarities Between Biological Organisms and Materials: Example 3
Figure 14 (a) shows the visual result of insect images and fish images using the biomimetics image retrieval platform. Figure 14 (b) shows an SEM image of a metallic surface. Images similar to that shown in Fig. 14 (b) are shown in its neighborhood. Figures 14 (c), (d) and (e) show SEM images of fishes including the rear side of *Sufflamen fraenatum*, the right center side of *Hippichthys spicifer*, and the surfaces of the center side of *Oplegnathus fasciatus*. Furthermore, Fig. 14 (f) shows an SEM image of an insect, the left rear wing surface of *Cosmiomorpha similis*. Images in Figs. 14 (c)–(f) are in the neighborhood of the image in Fig. 14 (b) since they are visually similar; more specifically, they possess smooth surfaces and protruding patterns. These results show that even across different biological organisms and materials, it is possible to search for SEM images with similar surface structures and that the similarity enables new discoveries about their relationships.

5. Conclusions

A novel biomimetics image retrieval platform based on visualization-based image retrieval is presented in this paper. Large volumes of image data separately accumulate in different research fields, with each field containing invaluable knowledge. This invaluable knowledge is often difficult to express in words, hindering its ability to be shared with experts outside that particular field. In this situation, the problems in each research field become more complex, and it is often difficult to determine where the problem actually is. Limiting experts' knowledge to a particular field limits our ability to solve such problems. Biomimetics attempts allow us to tackle such problems. The biomimetics image retrieval platform presented in this paper is an implementation of an industrial collaboration platform that supports manufacturing through integrating accumulated knowledge in a cross-field database.

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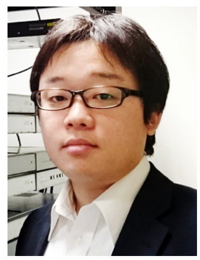

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