Drawing-type Search Method Focusing on Penguin's Abdominal Patterns for Enriching Observation Experiences in an Aquarium

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ABSTRACT

Some aquariums give names to the individual animals in their care in order to encourage visitors to observe them. However, it is not easy for visitors to remember names without their having a detailed memory of the individual animals. We previously proposed a method to enable visitors to aquariums to identify individual penguins by drawing the animals' distinctive abdominal patterns and analyzed the similarity of the drawings. In this study, we developed a prototype system that enables users to retrieve penguins' names by drawing abdominal patterns on a smartphone and investigated its effectiveness. The experiment's results suggested that observations using this system improved the ability of some of the experiment's participants to remember the penguins.

CCS CONCEPTS

• **Human-centered computing**; • **Interaction design**; • **Systems and tools for interaction design**;

KEYWORDS

Penguin, Drawing, Search, Observation support, Identification

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1 INTRODUCTION

Zoos and aquariums are not only venues for leisure but also play a critical role in science, observational learning, and environmental education [1, 2]. Studies [3-7] have shown the educational benefits of visits to zoos and aquariums. To enhance the visitor experience, several studies have clarified that exhibit innovations in animal welfare-oriented tourism, keeper interactions [8], and educational interventions [9] are useful. In addition, Luebke et al. [10] highlighted the link between visitor enjoyment and detailed observations of animals, stressing the need for exhibits that showcase animal behavior and visibility.

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Penguins, popular animals with visitors to aquariums [11], are often exhibited by the dozen. To draw attention to individual penguins, some aquariums have named their animals, distinguished them by using flipper bands, or displayed exhibits that explain the particular characteristics of each penguin. However, it still takes work for visitors to match the names of the penguins they are observing with flipper bands or images; i.e., it isn't easy to recognize the color of the flipper band.

Given these problems, we previously proposed a method of drawing the characteristic spotted pattern on the abdomen of penguins and using the drawing to identify individual penguins [11]. We clarified that individual penguins could be identified from drawings of their abdominal patterns. However, the cost of the similarity calculation was very high, so we still needed to clarify the effectiveness of our system in retrieving penguins and observations.

The current study sought to refine this approach by developing a real-time algorithm for identifying penguins by drawings. We built a prototype system and clarified its impact on an observer's memory through field experiments.

2 DRAWING & RETRIEVAL SYSTEM

2.1 Improved algorithm

We represented the drawing on the abdomen of a penguin as a matrix of abdomen patterns by counting the number of points in each of the nine areas shown in Figure 1. Then, we transformed two-dimensional values into vector data and calculated the similarity scores of the drawings by using the cosine similarity and Euclidean distance as follows.

$$\text{similarity score} = \frac{cosine\ similarity}{euclidean\ distance + 1}$$

In addition, we generated a penguins' drawing pattern database by using pictures of 19 penguins at the Sumida Aquarium in Tokyo, Japan (this aquarium has 52 penguins). We asked experimental participants to draw patterns using the drawing system developed in the previous work while looking at the pictures on the screen. The participants in the drawing task used to generate the database consisted of 26 undergraduate and graduate students (19 males and seven females) aged 20-24.

We divided the 26 participants' drawings into two groups of 13 each, used the average of the penguin drawings of one group as the training data, and calculated the similarity of the drawing to the individual drawings of the other group. The penguins were ranked in order of their similarity, and the accuracy of the ranking was determined.

Figure 2 shows the accuracy of our algorithm. The rate of correct answers within the first place rank (Top-1) was 77.1% and exceeded 93.0% within first to third place (Top-3).

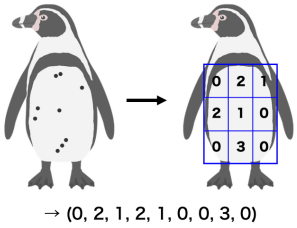

Figure 1: Vector representation of drawing coordinates.

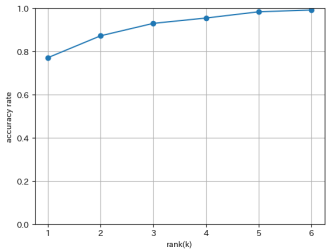

Figure 2: Top-k accuracy for k=1 to 6.

2.2 Prototype system

We implemented a system (https://pensaku.com) that draws penguin patterns and searches for their names using the JavaScript framework Vue.js for the front end, PHP for the back end, and MySQL for the database. In the database, we inserted information on penguins and their abdominal patterns drawn by the 26 participants.

Specifically, when a user accesses the system from a smartphone, the system presents a drawing interface (see. Figure 3), and the user draws the abdomen pattern. After drawing the pattern, our system ranks penguins in order of similarity as search results. The search results present the penguins' image, name, and flipper band color. In addition, tapping on a penguin in the search results reveals an enlarged image and characteristics.

The user can easily search for information about a target penguin simply by drawing an abdominal pattern while observing.

2.3 Experiment at the aquarium

We experimented in the Sumida Aquarium to investigate the effectiveness of name retrieval from penguins' abdominal patterns on memory. We asked participants to observe penguins, draw patterns, and retrieve penguins' names. We instructed them to access the system using their smartphones to draw and search for penguins.

We conducted this experiment on October 13, 2023, with nine undergraduate and graduate students (six males and three females) between the ages of 21 and 23. They drew abdominal patterns of 99 penguins by using our system. Each participant drew an average of 11.0 penguins in this experiment and could search for the names of an average of 6.0 penguins from their drawings. As a response to the question about the user evaluation of the system, "Was the drawing system easy to use?" we asked the participants to rate the system on a 5-point Likert scale from 1 (difficult to use) to 5 (easy to use). The average of all participants' answers was 3.56.

We conducted a memory test six days after the field experiment to investigate the effect of our system on the memories of the penguins. The memory test was conducted as a line-connecting task for 13 penguins that were retrieved by two or more participants in the field experiment. We asked the participants to mark the penguins for which they remembered either the photograph or the name and to link the name to the photograph if they could. As a result, each participant marked an average of 3.4 penguins' photographs and an average of 2.2 penguin names. We also found that four participants correctly linked the photograph and the name and correctly identified more than one penguin.

Figure 3: Interfaces of our prototype system.

3 DISCUSSION & CONCLUSION

The percentage of correct answers within first to third place in the ranking exceeded 93.0%, indicating that the individual judgments had high accuracy. In addition, the cost of our improved algorithm was very low. However, our algorithm had low accuracy if the user drew patterns near the border of each area. To solve this problem, we will improve our algorithm by considering areas near the border in the future.

The results of the field experiment showed that participants could remember an average of 2.2 names of the penguins drawn in the field experiment. Using the system, participants could search for an average of 6.0 penguin names, meaning they remembered about one-third of them. This suggests that our system has some effect on people's memories of penguins. On the other hand, although we did not specify the number of penguins to be drawn in this experiment, we suspect that some participants, who focused too much on drawing the abdominal patterns of many penguins, might have failed to remember the names of the penguins as a result. In addition, the dataset used for the search did not cover all the penguins exhibited at the aquarium, and in some cases, the position of the drawn patterns was shifted to the left or right depending on the direction from which the penguins were observed. This may have reduced the accuracy of the retrieval in the field experiment. To solve this problem, we will improve the algorithm to consider the penguin abdominals' left-right alignment.

In the future, we plan to expand the drawing database to include all 52 penguins in the Sumida Aquarium, and we will re-conduct the experimental test. In addition, we will apply our database to other aquariums, improve our system, and conduct long-term experiments using it in several aquariums.

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