# Development of a Zoo Walk Navigation System using the Positional Measurement Technology and the Wireless Communication Technology

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**Abstract**

In this article, we propose and evaluate a Zoo Walk Navigation System consistings of the Animal Contents Registering and Editing Web Management System and the Animal Contents Browsing and Acquiring Smartphone Application. The Animal Contents Registering and Editing Web Management System for zoo staff enables to register/edit various animal contents. Thereby, this web management system provides real-time and flesh zoo information to the Animal Contents Browsing and Acquiring Smartphone Application. On the other hand, the Animal Contents Browsing and Acquiring Smartphone Application for zoo visitors enables to browse various animal contents which zoo staff registered through the Animal Contents Registering and Editing Web Management System. The Animal Contents Browsing and Acquiring Smartphone Application has the animal guide browsing function, the animal quiz function, the beacon notification browsing function, the zoo map navigating function, and the AR camera function. Zoo visitors can enjoy a zoo park using this smartphone application. This system is the new type navigation system which zoo staff can renew contents to avoid contents obsolescence. And, this system always provides new information to zoo visitors in real time by the beacon notification function.

**Keywords**: Zoological Garden, Position Information Measuring System, Wireless Signal Information Notification Technology, Walk Navigation System, Augmented Reality

## 1 Introduction

The number of visitors of the zoo and the aquarium have been declining year by year with diversification in the leisure facilities and the amusement facilities in recent years. Consequently, these facilities must be considered in order to increase visitors with a reduced cost in a difficult business environment [14, 1, 10, 11, 13, 8, 2]. The number of visitors reached about 61 million in 1991, but it fell steadily after that, and was about 42 million in 2000 in 167 zoos that are a members of the Japanese Association of Zoos and Aquariums [15]. Effective trials and public relations activities for collecting visitors are demanded under the circumstances.

Kamine zoo in Hitachi-city, Ibaraki Prefecture also has similar issues. Since a zoo started operation in 1957, Kamine zoo has played an important role as a tourist resource in Hitachi-city. However, the number

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of visitors widely declined from the peak time because of diversification of recreational facilities, low birth rate, aging facilities, and outflow to other recreational facilities. Therefore, Hitachi-city has worked on redevelopment of Kamine park facilities from 2006.

The number of visitors reached about 460,000 in 1970, but it fell steadily after that, and was about 260,000 in 2004 in Kamine zoo. Since then, the number of visitors increased to about 356,000 in 2014 by redevelopment of Kamine park facilities. However, Kamine zoo has several issues such as the increasing number of visitors, the measures for aging facilities, and the promotion activities [3, 4, 5].

On the other hand, in recent years, a cellular phone spread quickly by development of broadband, information and communication technology. In particular, a smartphone and a table terminal with the high processing capability are used widely. At present, the navigation system utilizing an information communication technology is considered to be important. In these circumstances, several systems targeted the leisure facilities and the amusement facilities have been developed.

In these circumstances, several navigation systems targeted a zoo have been develop. However, these systems have several problems.

The rest of the article is organized in the following way. The related work is descried in section 2. And, the purpose of our research is described in section 3. System configuration and architecture of our proposed Zoo Walk Navigation System are explained in section 4 and section 5. The Animal Contents Registering and Editing Web Management System and the Animal Contents Browsing and Acquiring Smartphone Application which constitute the Zoo Walk Navigation System are described in section 6. The sequence of the Zoo Walk Navigation System are described in section 7. Section 8 evaluates the Zoo Walk Navigation System, and finally we conclude our findings in section 9.

## 2 Related Works

Few research works have been done, which develop various navigation system for theme park.

In [7], Kawajiri et al. developed a navigation system for zoological gardens. And, in [9], Ogino et al. developed a contents browsing system utilizing a Global Positioning System (GPS). However, zoo staff can't renew contents in this navigation system and contents browsing system. This problem causes contents obsolescence. Moreover, this navigation system and contents browsing system have not been officially released yet for zoo visitors.

In [6], Ichikawa et al. developed a sightseeing information system for theme park of history. However, this sightseeing information system have no navigation function. Moreover, theme park staff can't renew contents in this sightseeing information system.

Comparative table between our work and related works is shown in Table 1. Our system provides the navigation function by the GPS, the contents renew function through the web system, and the real time latest information providing function to zoo visitors.

## 3 Purpose of This Research

In this article, we describe the Zoo Walk Navigation System using the positional measurement technology and the wireless communication technology. This system consists of the Animal Contents Registering and Editing Web Management System and the Animal Contents Browsing and Acquiring Smartphone Application. Zoo staff uses the Animal Contents Registering and Editing Web Management System mainly. This web management system enables to register/edit various animal contents. Zoo visitors can receive the real-time information from the Animal Contents Registering and Editing Web Management System on the Animal Contents Browsing and Acquiring Smartphone Application. The content obsolescence is avoided by zoo staff registering/editing various information from the Animal Contents

Table 1: Comparison with Related Works

| Function | Our Proposed System | Kawajiri et al. [7] | Ogino et al. [9] | Ichikawa et al. [6] |
|---|---|---|---|---|
| GPS Navigation Function | Available | Available | Available | Not Available |
| Web Contents Renew Function | Available | Not Available | Not Available | Available |
| Real-time Latest Information Providing Function | Available | Not Available | Not Available | Not Available |

Registering and Editing Web Management System. Moreover, this web application is available without being limited by place, time, and terminal because it corresponds to all web browsers. On the other hand, zoo visitors use the Animal Contents Browsing and Acquiring Smartphone Application mainly. This smartphone application enables to browse various animal contents. The Animal Contents Browsing and Acquiring Smartphone Application provides the animal guide browsing function, the animal quiz function, the beacon notification browsing function, the zoo map navigating function, and the AR camera function.

# 4 System Configuration

The system configuration of this system is shown in Figure 1. This system consists of the Animal Contents Browsing Agent, the Animal Contents Management Agent, the Animal Contents Control Application Server, and the Animal Contents Storage Database Server.

- The Animal Contents Browsing Agent
  The Animal Contents Browsing Agent is visitors in a zoo. When zoo visitors install this application in the mobile terminal, this application receives a JSON file of the contents information stored in the Animal Contents Storage Database Server through the Animal Contents Registering and Editing Web Management System. Thereby, zoo visitors can browse various animal information. Moreover, zoo visitors can use the zoo map navigating function and the beacon notification function.

- The Animal Contents Management Agent
  The Animal Contents Management Agent is zoo staff. Zoo staff can manage the animal guide, the animal quiz, and the beacon notification. Renewed animal information is reflected to the Animal Contents Browsing and Acquiring Smartphone Application in real time.

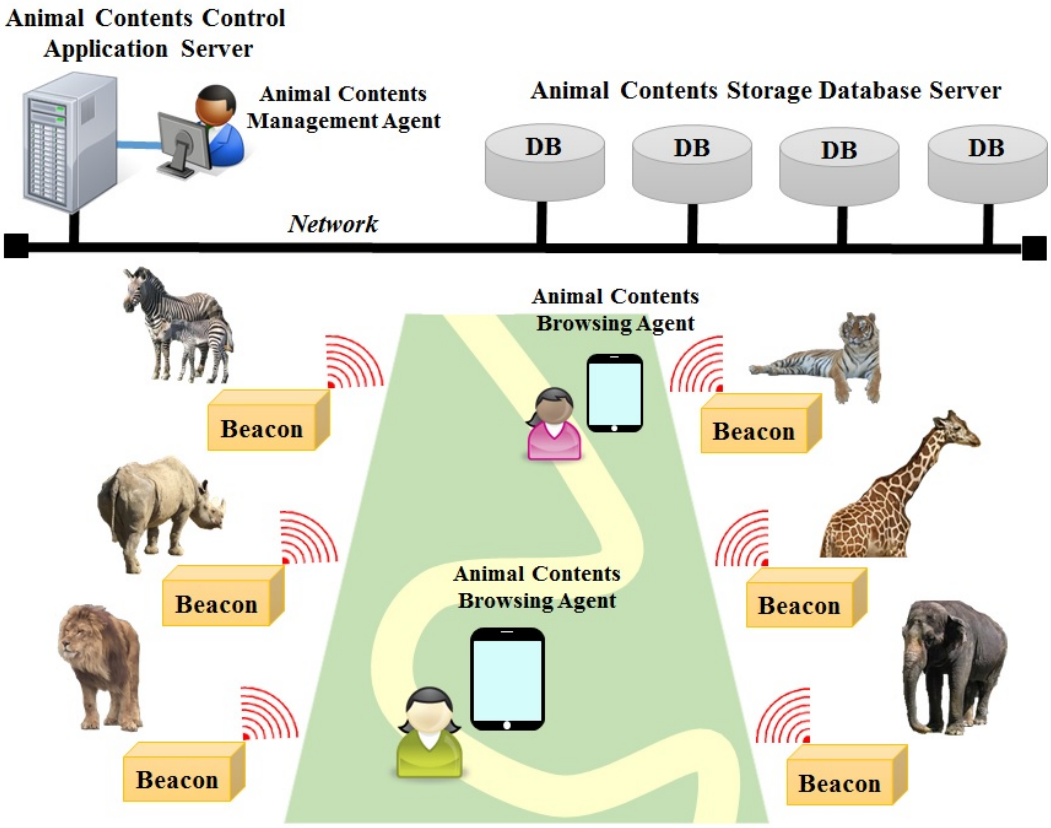


Figure 1: System Configuration

- The Animal Contents Control Application Server
  The Animal Contents Control Application Server receives various animal information from the Animal Contents Registering and Editing Web Management System, and stores in the Animal Contents Storage Database Server. When animal information is stored in the Animal Contents Storage Database Server, the data contents are written in a JSON file. After that, a JSON file is transmitted to the Animal Contents Browsing and Acquiring Smartphone Application according to the request from the user.

- The Animal Contents Storage Database Server
  The animal guide information, the animal quiz information, and the beacon notification information are stored in the Animal Contents Storage Database Server through the Animal Contents Registering and Editing Web Management System.

## 5 System Architecture

The system architecture of this system is shown in Figure 2.

(A) The Animal Contents Browsing Agent

- App Read Manager (ARM)
  App Read Manager has the function to switch activity using intent according to the user's action.
- File Download Manager (FDM)
  File Download Manager has the function to acquire a file from the web server using HTTP communication.
- File Read Manager (FRM)
  File Read Manager has the function to read and analyze a JSON file from acquired by File Download Manager.
- GPS Reception Manager (GPSRM)
  GPS Reception Manager has the function to acquire a coordinate by positioning of the present position using the GPS.
- Beacon Detection Manager (BDM)
  Beacon Detection Manager has the function to detect the beacon terminal by using the Bluetooth Low Energy communication. When the beacon terminal detected, Beacon Detection Manager has the function to analyze received data and identify the solid.
- Camera Control Manager (CCM)
  Camera Control Manager has the function to start a camera application using intent.
- Web View Manager (WVM)
  Web View Manager has the function to read and display a web page of designated URL.
- List View Manager (LVM)
  List View Manager has the function to listing the file information read from File Read Manager.
- Picture Read Manager (PRM)
  Picture Read Manager has the function to read a picture file by referring to the file information read from File Read Manager.
- Picture View Manager (PVM)
  Picture View Manager has the function to display a picture file read from Picture Read Manager.

(B) The Animal Contents Management Agent

- File Read Manager (FRM)
  File Read Manager has the function to read contents information by acquired a JSON file from the web server.
- Contents List View Manager (CLVM)
  Contents List View Manager has the function to listing contents information from File Read Manager.

- Information View Manager (IVM)
  Information View Manager has the function to display contents information for each item from File Read Manager.
- Picture Read Manager (PRM)
  Picture Read Manager has the function to read a picture file by referring to the file information read from File Read Manager.
- Input Acceptance Manager (IAM)
  Input Acceptance Manager has the function to read inputted contents information.
- Information Delete Manager (IDM)
  Information Delete Manager has the function to delete contents information.
- Information Registration Manager (IRM)
  Information Registration Manager has the function to register contents information.
- Information Transmit Manager (ITM)
  Information Transmit Manager has the function to transmit the renewal contents information to the web server read from Input Acceptance Manager, Information Delete Manager, and Information Registration Manager.

(C) The Animal Contents Control Application Server

- Picture Save Manager (ISM)
  Picture Save Manager has the function to save a picture data transmitted from Contents Management Agent.
- Contents Save Manager (CSM)
  Contents Save Manager has the function to store contents information transmitted from Contents Management Agent.
- File Create Manager (FCM)
  File Create Manager has the function to write content information in a JSON file.
- Database Operation Manager (DPM)
  Database Operation Manager has the function to edit the database according to the request from Contents Save Manager and File Create Manager.

(D) The Animal Contents Storage Database Server

- Animal Information Storage Database Server (AISDS)
  The animal guide information is stored in the Animal Information Storage Database Server.
- Beacon Information Storage Database Server (BISDS)
  The beacon notification information is stored in the Beacon Information Storage Database Server.
- Login Information Storage Database Server (LISDS)
  The user account information is stored in the Login Information Storage Database Server.
- Quiz Information Storage Database Server (QISDS)
  The animal quiz information is stored in the Quiz Information Storage Database Server.

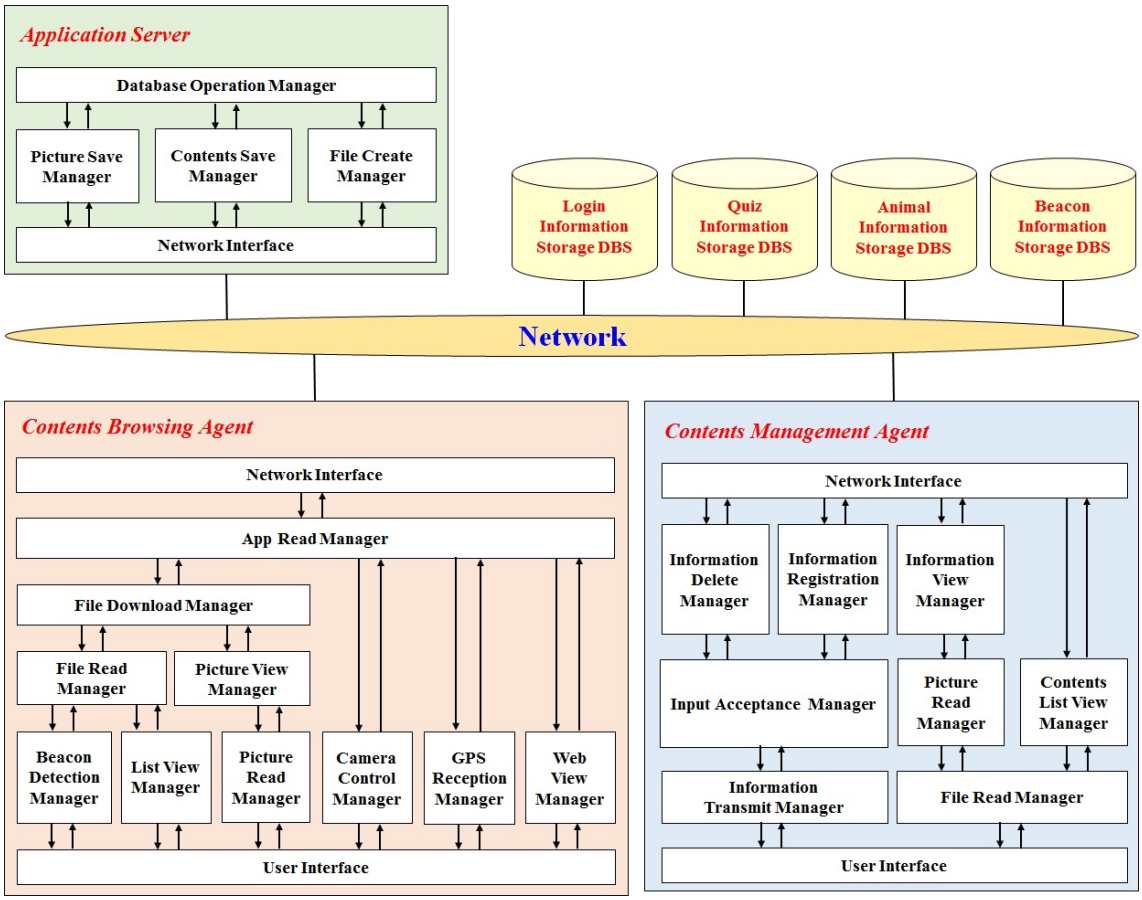


Figure 2: System Architecture

# 6 The Zoo Walk Navigation System

This system consists of the Animal Contents Registering and Editing Web Management System for zoo staff and the Animal Contents Browsing and Acquiring Smartphone Application for zoo visitors. The relation of each system and user is shown in Figure 3.

## 6.1 The Animal Guide

The animal guide provides the various animal contents registered from the Animal Contents Registering and Editing Web Management System to zoo visitors. The zoo visitors can browse these contents on the Animal Contents Browsing and Acquiring Smartphone Application.

### 6.1.1 The Animal Guide Registering and Editing Function

The animal guide registering and editing screen is shown in Figure 4. When zoo staff renew registered animal information, a ”REGISTER” button is clicked. Moreover, when zoo staff selects a ”Non-display” item, this information is not reflected to the Animal Contents Browsing and Acquiring Smartphone Application. Furthermore, when zoo staff deletes registered animal information, a ”DELETE” button clicked. Thereby, animal information is deleted from the Animal Contents Storage Database Server.

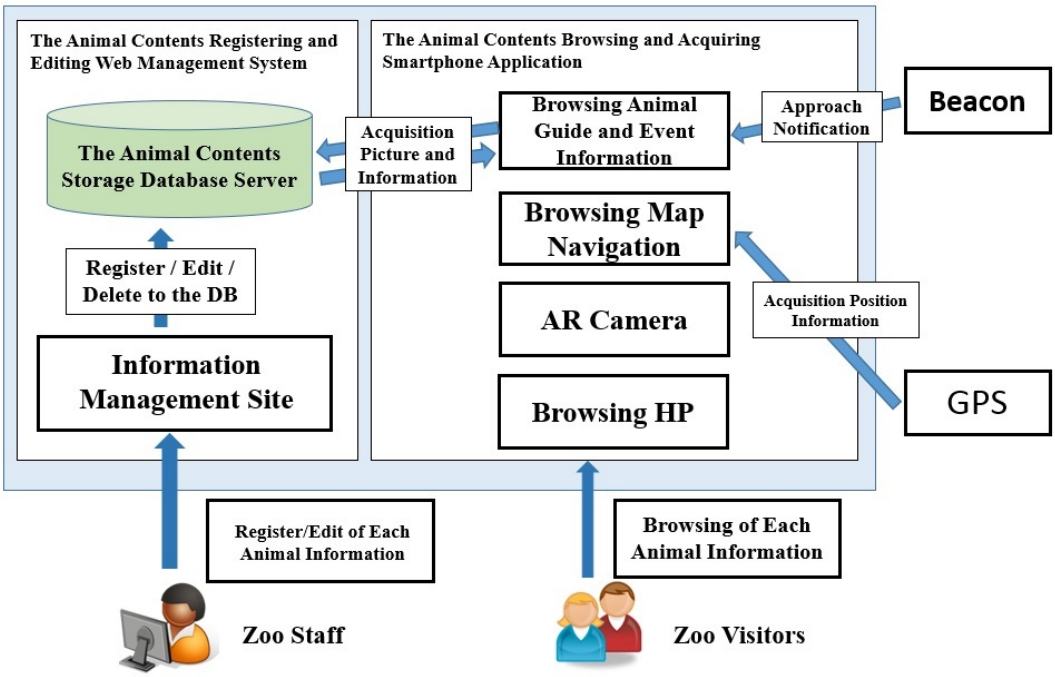


Figure 3: The Relation of the Each System and User

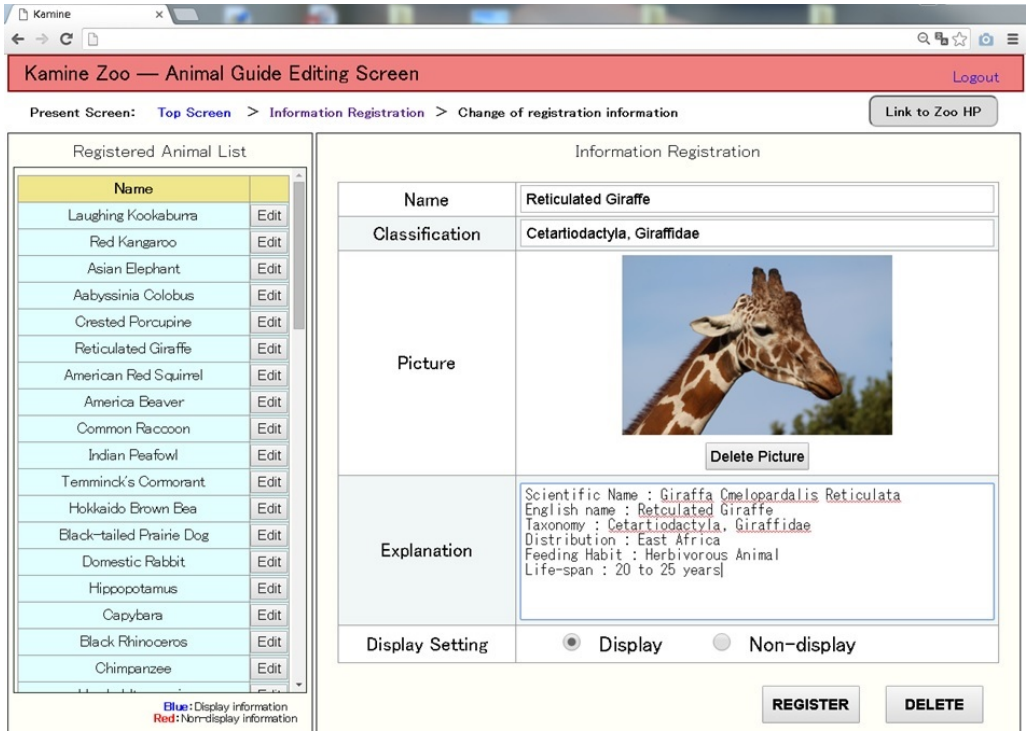


Figure 4: The Animal Guide Registering and Editing Screen

### 6.1.2 The Animal Guide Browsing Function

The animal guide browsing screen is shown in Figure 5. The animal list stored in the database is displayed on the animal guide browsing screen. The animal guide browsing screen transfers the animal contents detail screen as shown in Figure 6 by selecting an optional animal on a list. Zoo visitors can browse detailed information (name, classification, taxonomy, and explanation of an animal) on the animal contents detail screen. In this research, we registered 65 kinds of animal information in the Animal Contents Storage Database Server.


Figure 5: The Animal Guide Browsing Screen

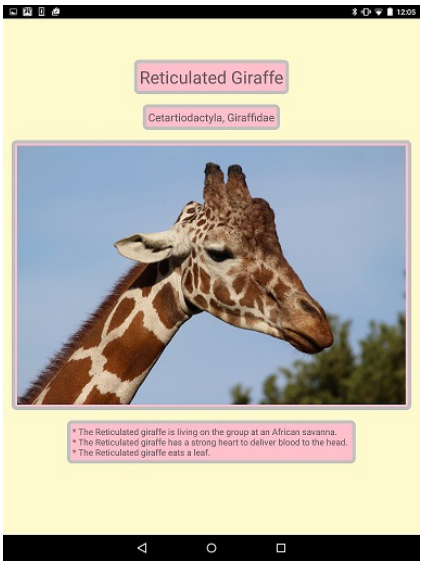


Figure 6: The Animal Contents Detail Screen

## 6.2 The Animal Quiz

The animal quiz provides various animal quiz information registered from the Animal Contents Registering and Editing Web Management System to zoo visitors. Zoo visitors can enjoy these quiz on the Animal Contents Browsing and Acquiring Smartphone Application.

### 6.2.1 The Animal Quiz Registering and Editing Function

The animal quiz registering and editing screen is shown in Figure 7. When zoo staff renew registered quiz information, a ”REGISTER” button is clicked. Moreover, when zoo staff deletes registered quiz information, a ”DELETE” button clicked. Thereby, quiz information is deleted from the Animal Contents Storage Database Server.

### 6.2.2 The Animal Quiz Browsing Function

The animal quiz browsing screen is shown in Figure 8. The animal quiz list stored in the database is displayed on the animal quiz browsing screen. The animal quiz browsing screen transfers the animal quiz detail screen as shown in Figure 9 by selecting an optional quiz on a list. Each animal quiz information (title, question, correct answer, incorrect answers, picture, and explanation of an animal quiz) is displayed on the animal quiz detail screen.

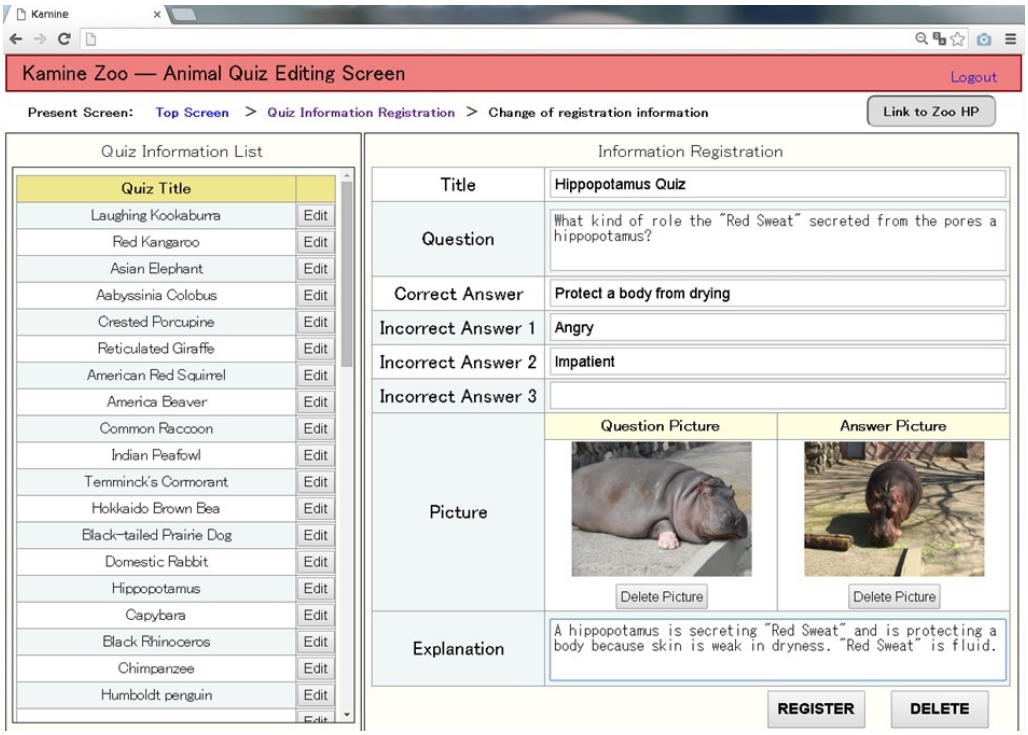


Figure 7: The Animal Quiz Registering and Editing Screen

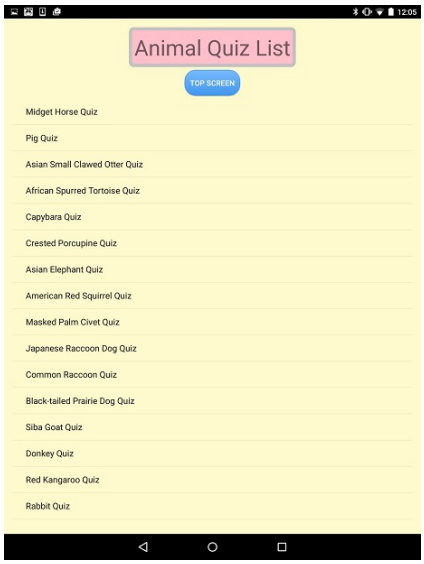


Figure 8: The Animal Quiz Browsing Screen

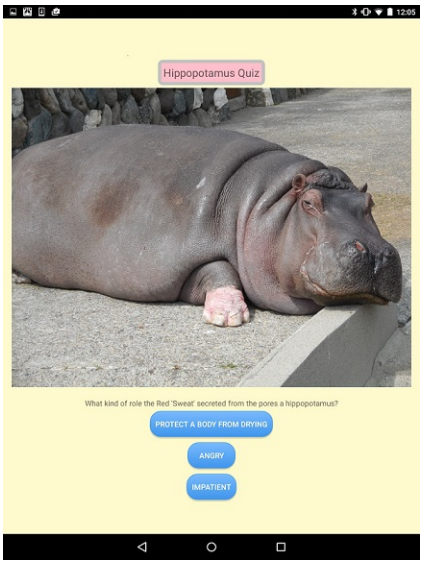


Figure 9: The Animal Quiz Detail Screen

## 6.3 The Beacon Notification

The Animal Contents Browsing and Acquiring Smartphone Application can receive various real-time event information by the beacon notification function. When a unique ID in the Animal Contents Browsing and Acquiring Smartphone Application and the detected beacon ID are matched, beacon information is pop-up displayed on the visitor's mobile terminal (Figure 10).


Figure 10: The Pop-up Display of Beacon Information

### 6.3.1 The Beacon Notification Function

The beacon notification registering and editing screen is shown in Figure 11. When zoo staff renew registered beacon notification information, a "REGISTER" button is clicked. Moreover, when zoo staff deletes registered beacon notification information, a "DELETE" button clicked. Thereby, beacon notification information is deleted from the Animal Contents Storage Database Server.

### 6.3.2 The Beacon Notification Browsing Function

The beacon notification pop-up screen is shown in Figure 12. The beacon notification pop-up screen transfers the beacon notification detail screen as shown in Figure 13 by clicking a "CONFIRMATION" button. Zoo visitors can browse detailed information (title, picture, and explanation of an event) on the beacon notification detail screen. By the way, even if zoo visitors do not start the Animal Contents Browsing and Acquiring Smartphone Application, the receive function of beacon information starts in the background of the mobile terminal.

## 6.4 The Zoo Map Navigating Function

The zoo map navigating screen is shown in Figure 14. The zoo map navigating function displays the visitor's present position as a marker on the zoo map navigating screen by acquiring position information from a GPS. Position information from a GPS is renewed every several seconds. When a visitor has moved, the Animal Contents Browsing and Acquiring Smartphone Application acquires a coordinate newly. When acquiring a coordinate newly, the Animal Contents Browsing and Acquiring Smartphone Application calculates relative distance with a reference mark, and a marker is displayed on the zoo map navigating screen.

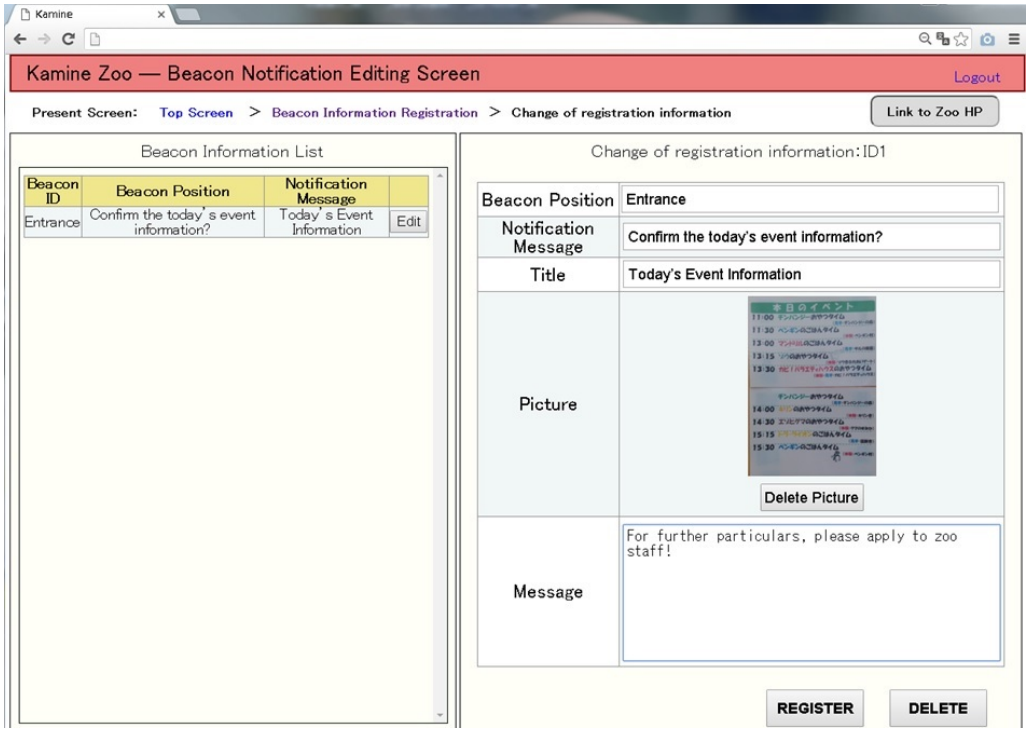


Figure 11: The Beacon Notification Registering and Editing Screen

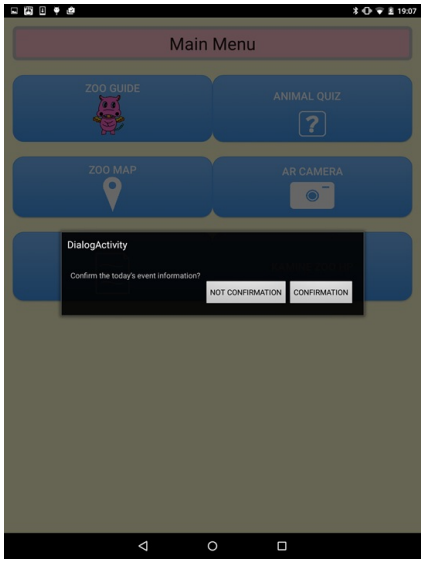


Figure 12: The Beacon Notification Pop-up Screen

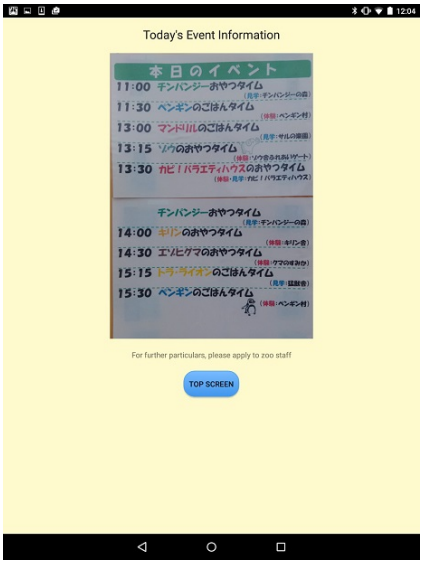


Figure 13: The Beacon Notification Detail Screen


Figure 14: The Zoo Map Navigating Screen

## 6.5 The AR Camera Function

The AR camera menu screen is shown in Figure 15. The 8 menus of ”Zebra”, ”Rhinoceros”, ”Lion”, ”Giraffe”, ”Chimpanzee”, ”Hippopotamus”, ”Elephant” and ”Tiger” is displayed on the AR camera menu screen. Zoo visitors can take a picture with a selected animal AR content. The photographing screen with an animal AR content is shown in Figure 16. An AR content overlap displayed on a camera picture by selecting optional AR content. The user can movement operation and expansion/contraction operation of an overlap displayed AR content optionally.

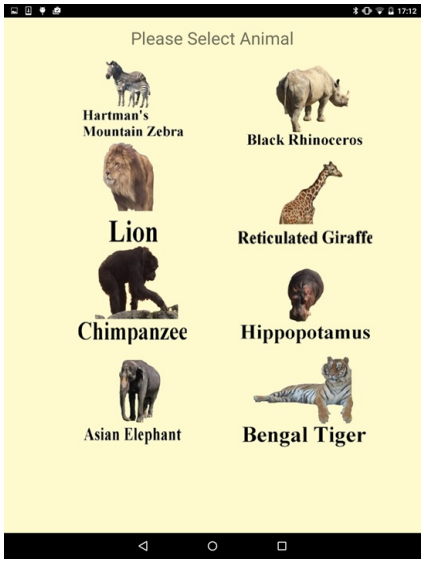


Figure 15: The AR Camera Menu Screen

Figure 16: The Photo Screen with an AR Content

# 7 The Sequence of the Web Management System and the Smartphone Application

In this section, we describe sequence of the Animal Contents Browsing and Acquiring Smartphone Application and the Web Management System and the Smartphone Application.

## 7.1 The Sequence of the Animal Contents Registering and Editing Web Management System

The sequence of the Animal Contents Registering and Editing Web Management System is shown in Figure 17. First, the user of the Animal Contents Registering and Editing Web Management System performs ID authentication and password authentication on the login screen. After authentication, the user registers/edits/deletes various animal information. The data stored in the Animal Contents Storage Database Server is acquired by a JSON file on the registering and editing screen, and an animal contents list is displayed. When the user renewed animal information, registered information in the Animal Contents Storage Database Server is renewed through the Animal Contents Control Application Server.

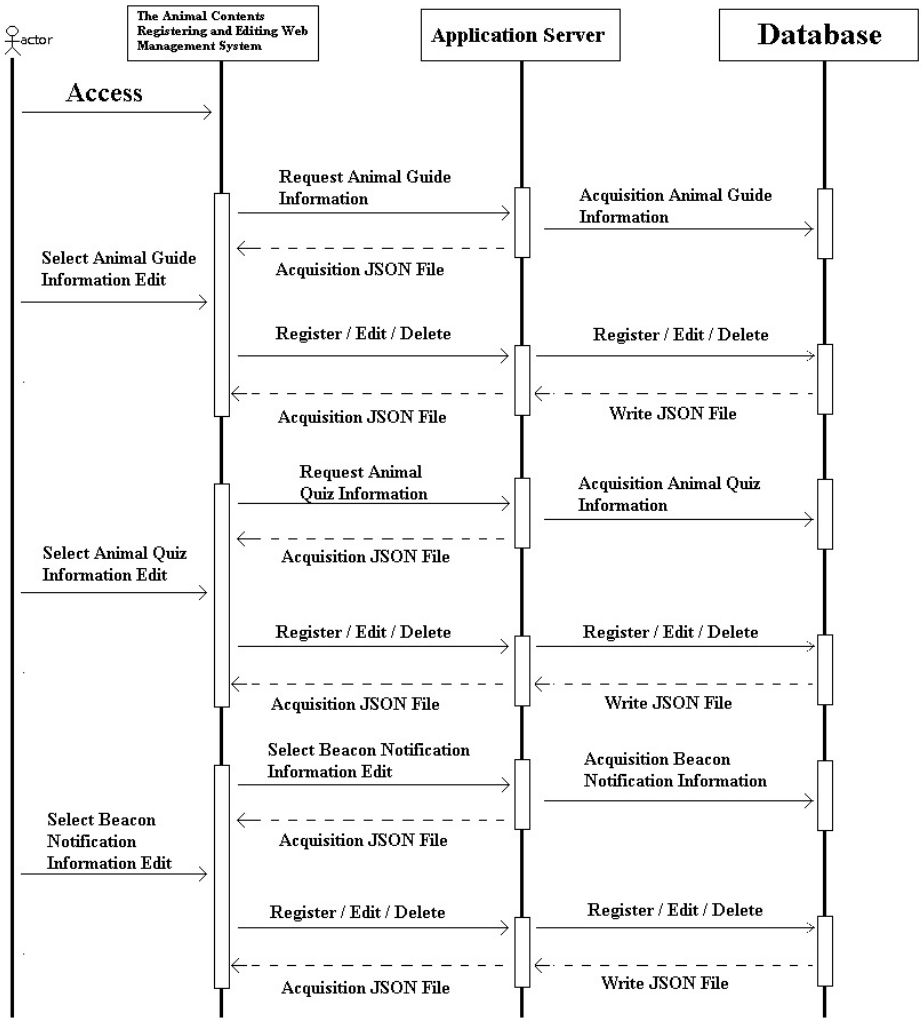


Figure 17: The Sequence of the Animal Contents Registering and Editing Web Management System

### 7.2 The Sequence of the Animal Contents Browsing and Acquiring Smartphone Application

The sequence of the Animal Contents Browsing and Acquiring Smartphone Application is shown in Figure 18. First, when the user starts the Animal Contents Browsing and Acquiring Smartphone Application, and taps a start button, the initial screen transfers the menu screen. The Animal Contents Browsing and Acquiring Smartphone Application detects beacon terminals with the transfer to the menu screen. When the Animal Contents Browsing and Acquiring Smartphone Application detected beacon terminals, this application acquires the data transmitted from beacon terminals. Acquired data is pop-up displayed on the Animal Contents Browsing and Acquiring Smartphone Application.

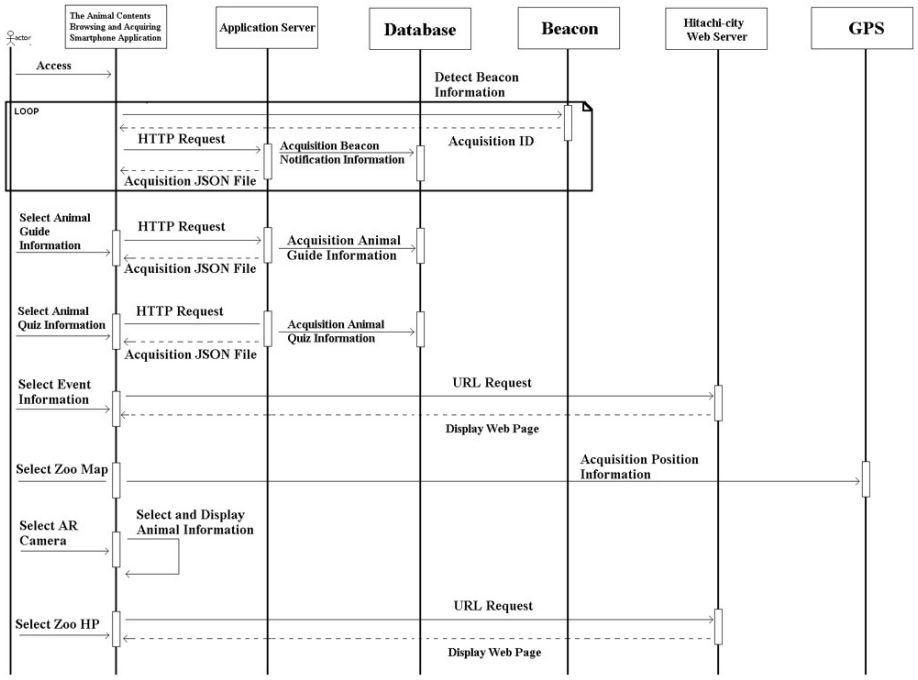


Figure 18: The Sequence of the Animal Contents Browsing and Acquiring Smartphone Application

## 8 Evaluation

In order to evaluate the effectiveness, the operability, the functionality, and the readability of the Zoo Walk Navigation System, we carried out a questionnaire of the dozens of users. The Animal Contents Registering and Editing Web Management System was evaluated for 13 zoo staff. Moreover, the Animal Contents Browsing and Acquiring Smartphone Application was evaluated for 48 zoo visitors.

### 8.1 The Effectiveness of the Zoo Walk Navigation System

The effectiveness evaluation result of the Zoo Walk Navigation System is shown in Figure 19. About the effectiveness of the Animal Contents Registering and Editing Web Management System, about 70 percent of the subject answered ”Effective” or ”Somewhat effective”. There was no one of the subject answered ”Somewhat ineffective” or ”Ineffective”. On the other hand, about the effectiveness of the Animal Contents Browsing and Acquiring Smartphone Application, about 90 percent of the subject

answered ”Effective” or ”Somewhat effective”. There was no one of the subject answered ”Somewhat ineffective” or ”Ineffective”. Therefore, we were able to confirm the effectiveness of the Zoo Walk Navigation System by this questionnaire survey.

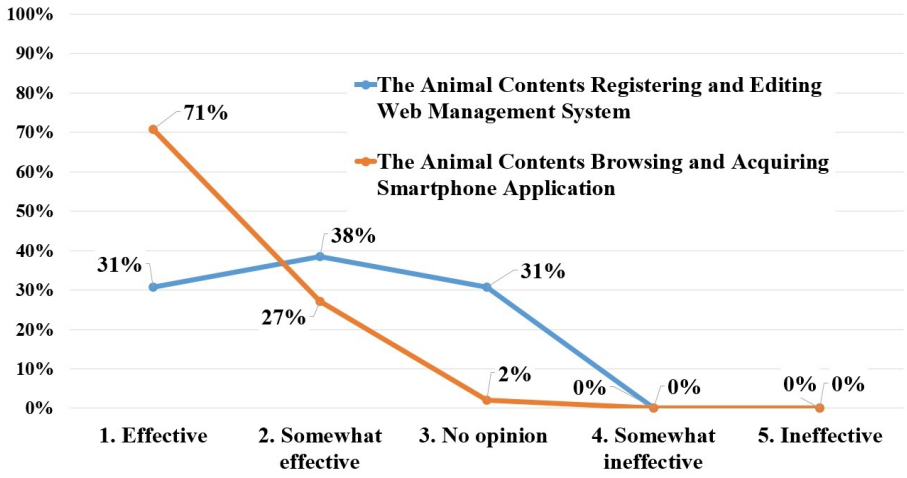


Figure 19: Questionnaire on the Effectiveness of the Zoo Walk Navigation System

## 8.2 The Operability of the Zoo Walk Navigation System

The operability evaluation result of the Zoo Walk Navigation System is shown in Figure 20. About the operability of the Animal Contents Registering and Editing Web Management System, about 60 percent of the subject answered ”Easy” or ”Somewhat easy”, and about 10 percent of the subject answered ”Somewhat difficult”. On the other hand, about the operability of the Animal Contents Browsing and Acquiring Smartphone Application, about 90 percent of the subject answered ”Easy” or ”Somewhat easy”. There was no one of the subject answered ”Somewhat difficult” or ”Difficult”. Therefore, we have to improve the operability of the Animal Contents Registering and Editing Web Management System from this questionnaire survey result.

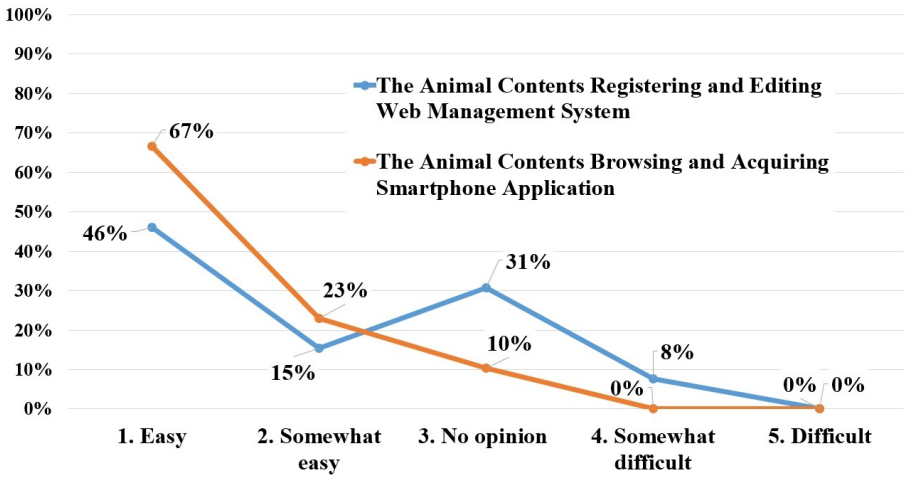


Figure 20: Questionnaire on the Operability of the Zoo Walk Navigation System

### 8.3 The Functionality of the Zoo Walk Navigation System

The functionality evaluation result of the Zoo Walk Navigation System is shown in Figure 21. About the functionality of the Animal Contents Registering and Editing Web Management System, about 60 percent of the subject answered ”Satisfaction” or ”Somewhat satisfaction”, and 15 percent of the subject answered ”Somewhat dissatisfaction” or ”Dissatisfaction”. On the other hand, about the functionality of the Animal Contents Browsing and Acquiring Smartphone Application, about 80 percent of the subject answered ”Satisfaction” or ”Somewhat satisfaction”. A small number of the subject answered ”Somewhat dissatisfaction” or ”Dissatisfaction”. Therefore, we have to improve the functionality of the Animal Contents Registering and Editing Web Management System from this questionnaire survey result.

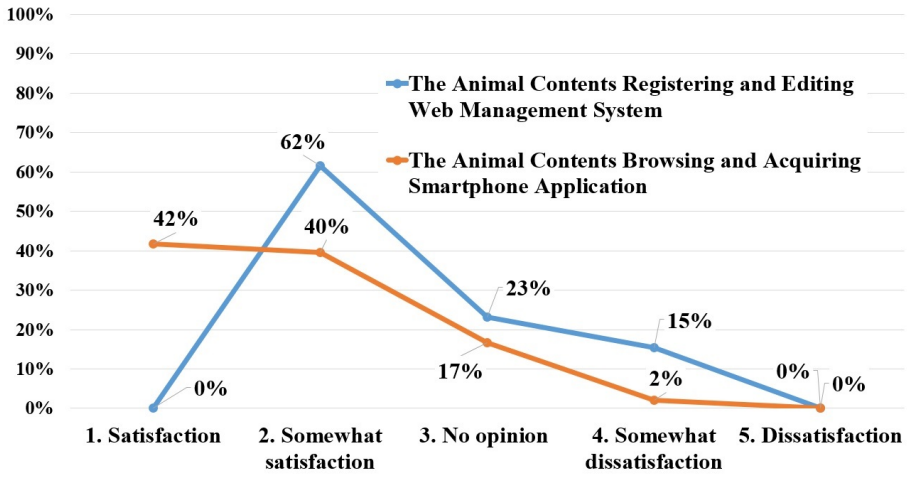


Figure 21: Questionnaire on the Functionality of the Zoo Walk Navigation System

### 8.4 The Readability of the Zoo Walk Navigation System

The readability evaluation result of the Zoo Walk Navigation System is shown in Figure 22. About the readability of the Animal Contents Registering and Editing Web Management System, about 70 percent of the subject answered ”Easy to understand” or ”Somewhat easy to understand”, and about 10 percent of the subject answered ”Somewhat hard to understand”. On the other hand, about the readability of the Animal Contents Browsing and Acquiring Smartphone Application, about 90 percent of the subject answered ”Easy to understand” or ”Somewhat easy to understand”. There was no one of the subject answered ”Somewhat hard to understand” or ”Hard to understand”. Therefore, we have to improve the readability of the Animal Contents Registering and Editing Web Management System from this questionnaire survey result.

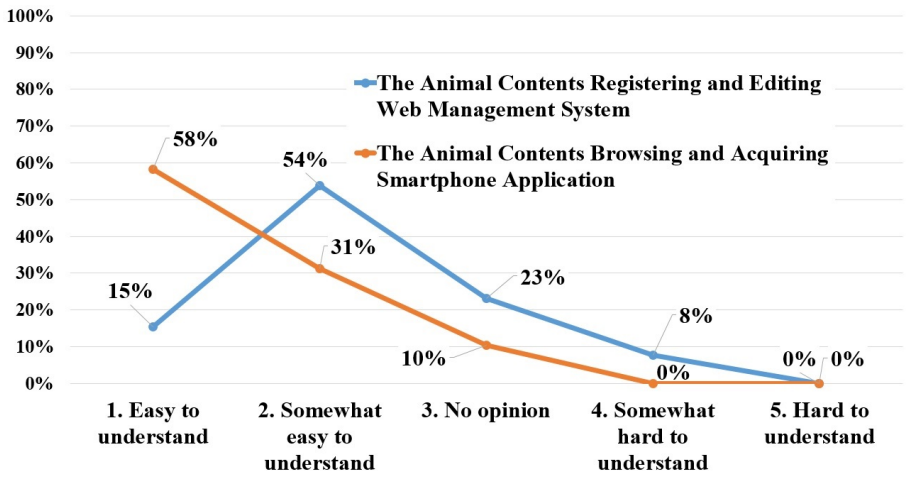


Figure 22: Questionnaire on the Readability of the Zoo Walk Navigation System

# 9 Conclusion

In this research, we constructed the Zoo Walk Navigation System using the positional measurement technology and the wireless communication technology. This Zoo Walk Navigation System consists of the Animal Contents Registering and Editing Web Management System and the Animal Contents Browsing and Acquiring Smartphone Application.

The Animal Contents Registering and Editing Web Management System realized the animal guide register/edit function, the animal quiz register/edit function, and the beacon notification register/edit function. The animal guide register/edit function enabled to register/edit various animal information, and the animal quiz register/edit function enabled to register/edit animal quiz information. Moreover, the beacon notification register/edit function enabled to provide event information to zoo visitors in real time.

The Animal Contents Browsing and Acquiring Smartphone Application realized the animal guide browsing function, the animal quiz browsing function, the beacon notification browsing function, the zoo map navigating function, and the AR camera function. The animal guide browsing function and the animal quiz browsing function enabled to provide various animal information to zoo visitors. The beacon notification browsing function enabled to receive event information in real time, and the zoo map navigating function enabled to navigation in a zoo park. Moreover, the AR camera function enabled to take a picture with an optional animal AR content.

We carried out the questionnaire survey to zoo staff and zoo visitors. We evaluated the effectiveness, the operability, the functionality, and the readability of the Zoo Walk Navigation System. As a result, we were able to confirm the evaluation in all the items.

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