

A 3D PHOTO-LOGGING SYSTEM FOR EASY AND EFFECTIVE RECORDING AND UNDERSTANDING OF ARCHAEOLOGICAL SITES

^aRieko Kadobayashi and ^bAkira Seike

^aNational Institute of Information and Communications Technology
3-5 Hikaridai, Seika-cho, Soraku-gun, Kyoto 619-0289, Japan
rieko@nict.go.jp

^bDepartment of Humanities
Faculty of Humanities and Economics
Kochi University
aseike@cc.kochi-u.ac.jp

KEY WORDS: Camera phone, 3D viewpoint, GPS, motion sensor, photograph, documentation

ABSTRACT:

A “3D photo-logging system,” a new method for recording archaeological sites, was developed. The prototype system consists of several servers running on a single machine and logging units composed of a camera phone equipped with a motion sensor attached to the mobile phone and a GPS sensor, and a notebook PC for logging the position and orientation of the camera phone. Using the 3D photo-logging system, we carried out an experimental survey of a real archaeological site, a cluster of tumuli. Two researchers recorded 14 tumuli by 142 images with 3D viewpoint information and text explanation in one day. These data were uploaded to the blog of the archaeological site in real time. Users can also access these data through distribution map which allows them to check the distribution and the direction of tumuli in arbitrary map scale. Comparing to traditional recording methods, it is easier to record archaeological sites and make more accurate maps with richer information about the site. The collected data are easily organized in various forms such as blog and distribution map so that users can choose the most appropriate way to explore the data. The 3D photo-logging system is, thus, a promising method for recording archaeological sites.

1 INTRODUCTION

We have developed a new method using the “3D Photo Logging system” (Kadobayashi et al., 2007) for recording archaeological sites. The method is based on recording 3D viewpoint information as well as pictures and text explanation when taking pictures of archaeological sites in order to facilitate easy access to pictures of interest. The position and orientation of the camera are regarded as a user’s point of view in a 3D space and referred as 3D viewpoint information, which is a key element for bridging 2D images and 3D spaces (3D computer graphics models, 3D virtual world, or the real world) (Kadobayashi and Furukawa, 2005). That is, it bridges the digital world and the real world.

The most important feature of the 3D viewpoint information is that it enables users to search pictures intuitively without specifying key words (Kadobayashi and Tanaka, 2005). This feature is especially effective for image retrieval from an archaeological database (Kadobayashi, 2005). Firstly, users do not need to formulate appropriate queries, i.e., a combination of several key words. Keyword-based searching of images in archaeological digital archives is often unsatisfactory. Users may have difficulty in combining several keywords to formulate a query that can distinguish between images that are very similar. More importantly, a keyword-based search requires users to have some knowledge about the content so they can make an appropriate query. However, this assumption is too restrictive in real use. Another retrieval method, called content-based image retrieval (CBIR) (Flickner et al., 1995, Smith and Chang, 1996), uses image features such as color, shape, and texture that are automatically extracted from images. However, owing to the special characteristics of the images contained in archaeological digital archives, CBIR is also unsuitable.

Moreover, 3D viewpoint information is useful for organizing and analyzing data associated with spatial data. It is applicable to

many applications, such as archaeological information systems (Drap et al., 2007). The 3D photo-logging system is thus designed to fully utilize the advantages of 3D viewpoint information.

Using the 3D photo-logging system, we conducted an experimental survey of a real archaeological site, a cluster of tumuli. A tumulus cluster is a group of similar tumuli scattering in a certain area. To record the distribution of such tumuli is very important, though it is not an easy task. By using the 3D photo-logging system, we expect that the time needed to record them can be reduced while the accuracy is maintained or improved compared to a manual survey.

2 3D PHOTO LOGGING

2.1 Overview

We use the term “photo logging” to express a way of recording objects and events in the real world by photographs. 3D photo logging means photo logging with 3D viewpoint information.

The goal of the 3D photo logging system is to create a framework for recording, organizing, analyzing, searching, and presenting every object and event in the real world with “portable devices” such as camera phones in an intuitive and casual manner. Objects are, for example, buildings, monuments, landscapes, archaeological sites, and events are, for example, festivals. Anything that exists or happens at a particular location can be a target of the 3D photo-logging system.

2.2 System configuration

The configuration of the 3D photo logging system is shown in Figure 1, and the hardware setup of user terminal is shown in Figure 2.

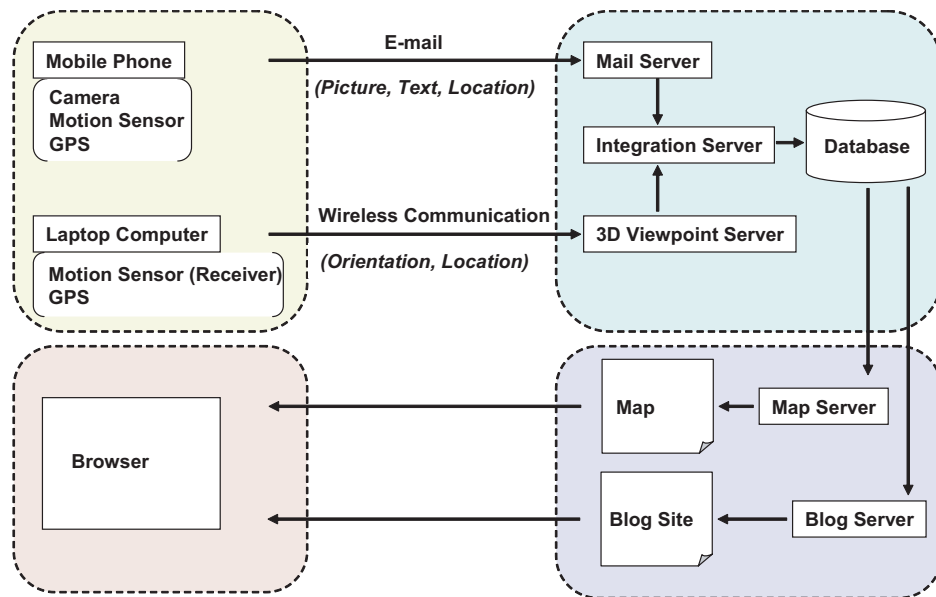


Figure 1: System configuration

Our prototype system consists of a server machine and a logging unit composed of a camera phone equipped with a motion sensor attached to the mobile phone and a GPS sensor, and a notebook PC for logging the position and orientation of the mobile phone. On the server machine, a database server, a mail server, and an integration server are run.

The user terminal is composed of a camera phone with a built-in GPS sensor and a laptop PC. A motion sensor is attached to the back of the camera phone to obtain the orientation of the camera phone when a user takes a photograph. The motion sensor data is transmitted by wireless to its receiver, which is connected to the laptop PC via USB.

To obtain the posture of the user's mobile phone, we use AMI601-CG (Aichi Micro Intelligent Corporation, 2007) from Aichi Micro Intelligent Corporation. AMI601-CG is an evaluation kit of AMI 601, a six-axis G2 motion sensor, which has a three-axis magnetic sensor and a three-axis accelerometer (Aichi Steel Corporation, 2006). As the kit provides dynamic link library (DLL), the pose of the camera phone is obtained as yaw (azimuth), x-tilt (roll) and y-tilt (pitch) value by calling the DLL from our software. From the pose of the camera phone, we calculate the direction of the user's gaze.

2.3 Processing flow

The process flow of 3D photo logging of archaeological sites is as follows. When a user takes a photo of an archaeological site with a camera phone, the user sends the photo to the mail server via e-mail with a text explanation. It is preferable to write the name or identifier in the subject field of the e-mail and comments in the e-mail body so that these text explanations can be transformed to the title and description of a blog entry. This increases the readability of the blog on the archaeological site.

The user iterates this procedure as many times as desired to record the site. The motion sensor attached to the camera phone detects the orientation of the camera phone every second and sends the information with a timestamp to the laptop PC by wireless link. The location is detected by the GPS sensor connected to the PC via USB. Note that the position of the camera phone can be obtained by the GPS sensor installed in the camera

phone itself, though accuracy will decrease. The data of the position and orientation of the camera phone is uploaded to the 3D-viewpoint server automatically. Comparing the timestamp in an e-mail that contains a picture and text with that in the position and orientation data, the integration server finds the correct position and orientation data for the picture and stores them in the database.

Every time the mail server receives an e-mail, the picture included in the e-mail is processed and stored in the database with associated information. The blog server then updates the blog site so that the recent picture is shown as a latest entry on top of all the entries.

The collected photographs can be shown on Google Map¹ or on Google Earth². When browsing the photographs on Google Map, markers with line segments are displayed on the map to show the position of the camera, i.e., the location from which the pictures were taken and the direction to which the camera faced. As Google Map is two-dimensional, the orientation of the camera is decomposed into azimuth and elevation angle, and the azimuth angle is shown as the line segment attached to the markers. Clicking a marker, a user can see a photograph with elevation data represented graphically.

The 3D photo-logging system provides multiple criteria for searching photographs, namely, distance between two cameras, similarity of azimuth angle, similarity of elevation angle, and time duration. Once a user chooses a picture from those shown on Google Map, sets the value for the criteria, and clicks a search button, the system shows the results on the map graphically, i.e., markers and line segments. Interactively changing the value for criteria, users can search photographs intuitively.

Since the photographs and their 3D viewpoint information are stored in a general-purpose database, it is easy to visualize them in several different ways. The system enables users to browse photographs in "blog style", treating each photograph and its explanation as an entry and laying them out in anti-chronological order. Each entry has links to Google Map or Google Earth so users to see the photograph with 2D and 3D maps.

¹Google Map is a registered Trademark of Google Inc.

²Google Earth is a registered Trademark of Google Inc.

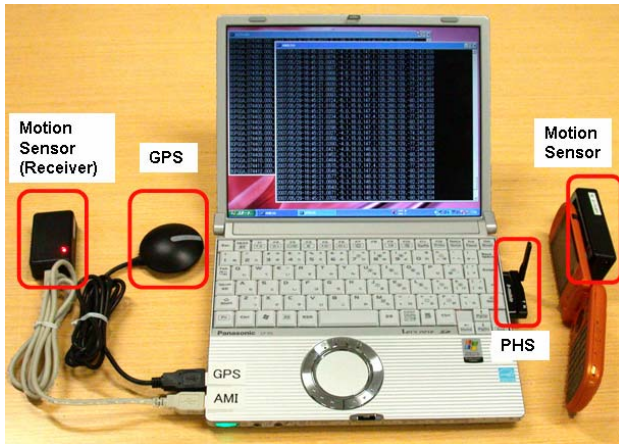


Figure 2: Hardware setup of a user terminal



Figure 3: Experimental use of the 3D photo logging system

3 EXPERIMENT

3.1 Test site

We chose the Ichisuka tumulus cluster as a test site, since it has about 250 tumuli scattered in an area of 1.5 kilometers by 1.5 kilometers around the Chikatsu Asuka Museum, which is located in the southern part of Osaka Prefecture, Japan (Chikatsu Asuka Museum, 2007), and since research reports are already available as a result of several archaeological surveys and excavations.

Most of the tumuli are either circle-shaped mounds 10 to 20 meters in diameter or square-shaped mounds 10 to 20 meters square. Although they were originally covered with mound, many of them lost the mound and their stone chambers are exposed. These tumuli are separated into 23 branches. Among them are 40 tumuli maintained and opened to the public as the Chikatsu Asuka Fudoki-no-Oka Historical Park.

3.2 Data collection

We spent one day collecting data at the Ichisuka tumulus cluster. Using the 3D photo-logging system, two users recorded 14 tumuli of five branches. They respectively took 79 images and 63 images of the tumuli. This means about four to five images per tumulus were taken by each user. Figure 3 shows the recording scene where a user is taking a picture of a ruined stone chamber and a stone coffin located in it.

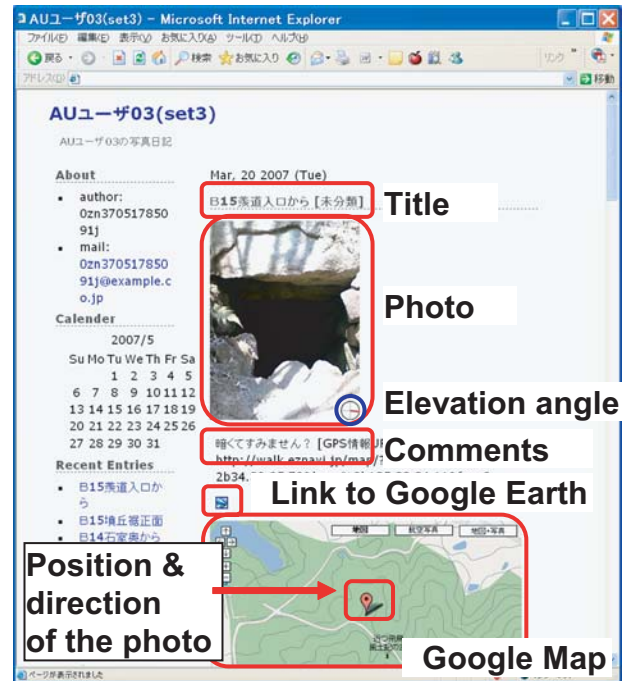


Figure 4: Blog-style browsing of pictures with comments and map

4 RESULTS

4.1 Blog

When creating a blog entry, the subject of an e-mail text is used as a title of the entry, and the message in the e-mail body is used as a comment. The location and the azimuth of the picture are displayed on Google Map while the elevation angle is displayed as an icon in the bottom right of the picture, as shown in Figure 4. There is also a link to Google Earth in the entry; users can follow this link to view the picture overlaid on top of Google Earth.

Pictures were sent to the server via a mobile-phone e-mail service, and the 3D viewpoint information was sent to the server via PHS wireless so that these pictures can be processed in real time and uploaded to the blog site. However, the e-mail service and the PHS wireless link were occasionally not available (since the Ichisuka tumulus cluster is located on a hillside). This caused a lack of entries on the blog since the server uploads the pictures only if the position and orientation data is available. In such case, we manually extracted the 3D viewpoint information from the log stored in the laptop PC and stored it in the database so that the blog server could create entries.

4.2 Distribution Map

To determine the distribution of tumuli, a map-based interface is useful. Figure 5 shows an overview of the distribution of the tumuli that were recorded with the 3D photo-logging system. Users of this site can narrow down the data to be displayed on the map by selecting a user's name, tumulus's name, and/or blog entries. In this case, one of the two users that carried out the survey is chosen. All of the tumuli that the user visited and all of the entries about those tumuli are selected.

In another example, shown in Figure 6, all entries of a particular tumulus are selected, and the area of the map is narrowed. This makes it easier to observe data closely.

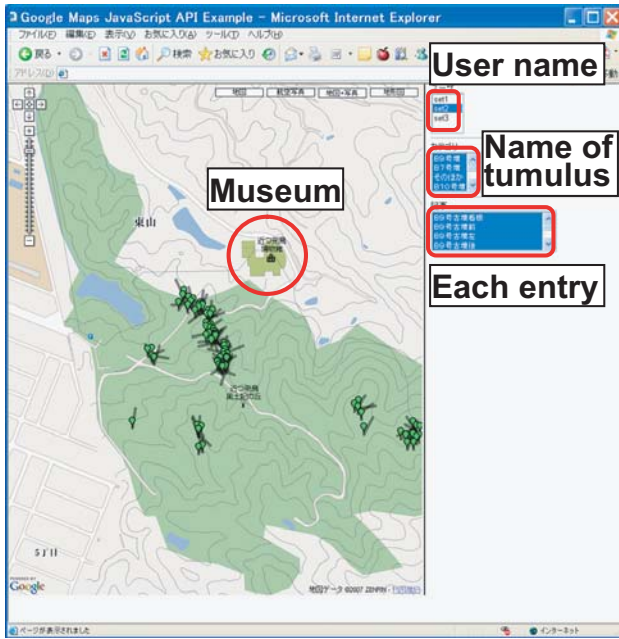


Figure 5: Distribution map of the tumuli in Ichisuka tumulus cluster. Each marker denotes the position of the user when taking a picture and each line denotes the direction at which the user was facing

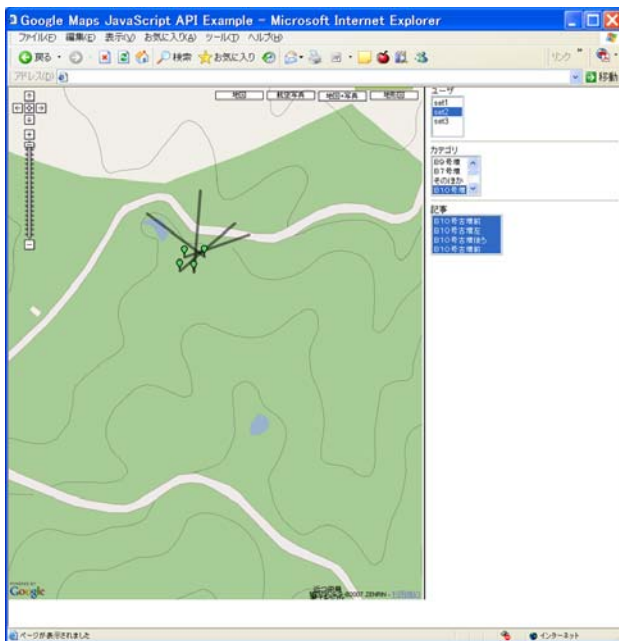


Figure 6: Close observation of selected photographs of a particular tumulus

Figure 7 illustrates a case where only one entry on a tumulus is selected, and the picture of the tumulus with a title and comments is displayed.

The tumuli-distribution map interface, therefore, allows users to move from an overview of the distribution of tumuli to close observation of selected tumuli and vice versa.

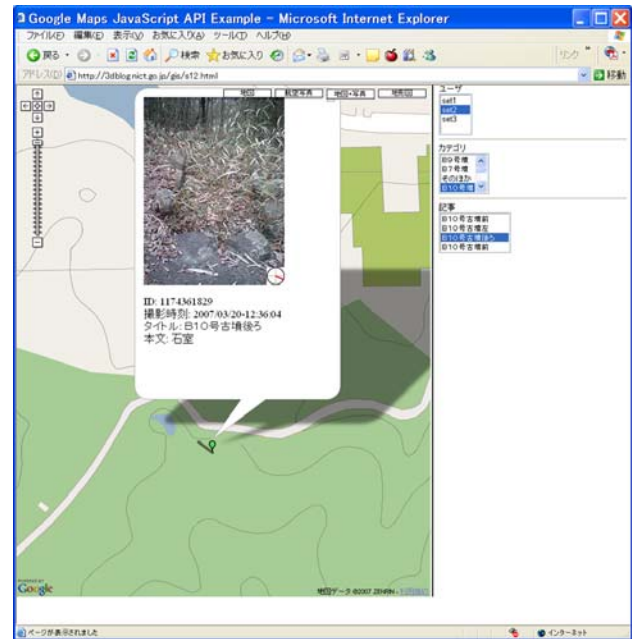


Figure 7: Picture is shown when the marker is clicked

5 DISCUSSION

From the experiment at the Ichisuka tumulus cluster, we confirmed that the 3D photo-logging system has several key advantages in recording and studying archaeological sites.

5.1 Blog and distribution map

The blog and the tumuli-distribution map based on Google Map are very useful for creating handwritten distribution maps of archaeological sites, especially unknown tumulus clusters. Traditionally, archaeologists needed to locate the position of unknown sites judging from surrounding terrain. This created uncertainty, which became worse when matching a map and local landscape was difficult. The occurrence of mis-recording causes the trouble that researchers cannot find the site when they revisit it.

On the other hand, by using the 3D photo-logging system, it is easier to record archaeological sites and make more accurate maps with richer information about the site. The use of pictures is effective especially where a lot of sites exist closely, since each site can be identified easily by the picture. The system will be more useful, however, when we can use a more accurate map than currently provided by Google Map.

5.2 Creating route map for site tour

When giving a guided tour of archaeological sites, guides (like archaeologists and teachers) need to prepare a route map to give to the visitors. Once a guide visits the sites before the tour and records them with the 3D photo-logging system, maps of the sites can be automatically generated.

5.3 Resource for Research

The information on the shooting direction is very useful for archaeological research. For example, if we take photographs along the main axis of a stone burial chamber, which direction the entrance of a chamber opens is obvious, since the 3D photo-logging system can plot such information. Note that the

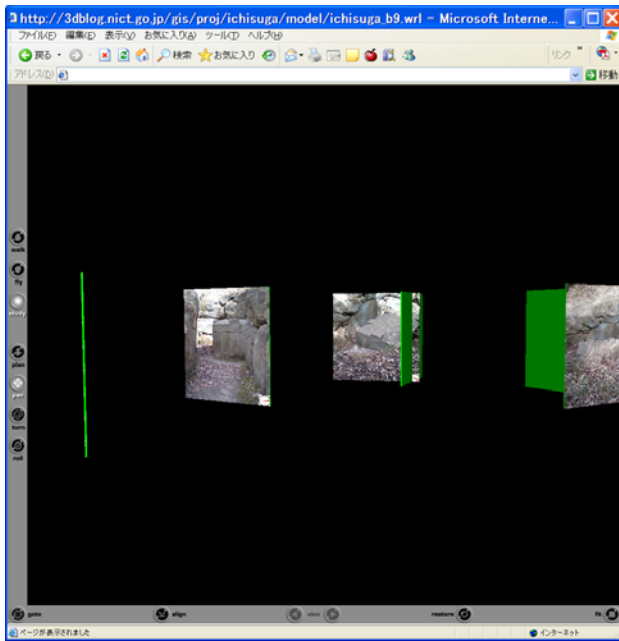


Figure 8: Pictures placed in a virtual 3D space according to each position and direction

main axis means an imaginary line parallel to the longer side of coffins or stone chambers. If the direction of the head of the deceased person is clear, the direction is recorded in a usual archaeological survey.

Usually the entrance of a corridor-style stone chamber faces south. In the Ichisuka tumulus cluster, most stone chambers have a main axis along the north-south direction, although some of them have a main axis along the east-west direction (due to constraints of terrain). It is worth studying the ratio of those stone chambers that do not uphold this general rule.

The location at which a tumulus was created is one of the key topics in a study on tumuli. Accordingly, site location can be easily understood from the tumuli-distribution map of the 3D photo-logging system.

6 CONCLUSIONS AND FUTURE WORK

We proposed a 3D photo-logging system that records 3D viewpoint information of a picture as well as the picture and its explanation. We carried out an experiment at the Ichisuka tumulus cluster and confirmed the effectiveness of the system. The main advantage of the system is that due to the 3D viewpoint information, the data can be used in multiple ways, e.g., surveys, public presentations, and research.

As one of our future works, we are developing a 3D viewer for the pictures, as shown in Figure 8, so that users can browse pictures and grasp the spatial relationship among them in a more intuitive manner. We are developing several methods for searching photographs using the 3D viewpoint information too. Archaeological studies and public presentations using the 3D photo-logging system are also needed to evaluate the system.

REFERENCES

Aichi Micro Intelligent Corporation, 2007. Computer Graphics Controller (AMI601-CG) Instruction Manual AMI-MI-0132E.

http://www.aichi-mi.com/3_products/601-cgmanual_e.pdf (accessed 31 May 2007).

Aichi Steel Corporation, 2006. AMI601 Delivery Specifications. http://www.aichi-mi.com/3_products/ami601ev1.3_061011.pdf (accessed 31 May 2007).

Chikatsu Asuka Museum, 2007. http://www.mediajoy.com/chikatsu/index_e.html (accessed 31 May 2007).

Drap, P., Durand, A., Nedir, M., Seinturier, J., Papini, O., Gabrielli, R., Peloso, D., Kadobayashi, R., Gaillard, G., Chapman, P., Viant, W., Vannini, G. and Nucciotti, M., 2007. Photogrammetry and Archaeological Knowledge: Toward a 3D Information System Dedicated to Medieval Archaeology: A Case Study of Shawbak Castle in Jordan. In: Proceedings of the ISPRS International Workshop 3D-ARCH 2007.

Flickner, M., Sawhney, H. S., Ashley, J., Huang, Q., Dom, B., Gorkani, M., Hafner, J., Lee, D., Petkovic, D., Steele, D. and Yanker, P., 1995. Query by Image and Video Content: The QBIC System. In: IEEE Computer, 28(9), pp. 23–32.

Kadobayashi, R., 2005. Viewpoint-based search and browse of digital archive content. In: Proceedings of XX International Symposium CIPA 2005, ISPRS, Vol. XXXXVI-5/C34, pp. 876–881.

Kadobayashi, R. and Furukawa, R., 2005. Combined use of 2D images and 3D models for retrieving and browsing digital archive contents. In: Videometrics VIII, Proceedings of SPIE-IS&T Electronic Imaging, SPIE Vol. 5665, pp. 134–143.

Kadobayashi, R. and Tanaka, K., 2005. 3D Viewpoint-based Photo Search and Information Browsing. In: Proceedings of the 28th Annual International ACM SIGIR Conference (SIGIR 2005), pp. 621–622.

Kadobayashi, R., Kayama, K., Umezawa, T. and Yairi, I. E., 2007. Sensing Human Activities and Environment for Creating Knowledge Cycle. In: Proceedings of the First International Symposium on Universal Communication, National Institute of Information and Communications Technology.

Smith, J. R. and Chang, S.-F., 1996. VisualSEEK: a Fully Automated Content-Based Image Query System. In: Proceedings of ACM International Conference on Multimedia, pp. 87–93.