Location and Orientation Estimation Methods using Networked Sensing

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Abstract. This paper presents an outline of activity capture method of attendees and facilitators for indoor interactive workshops, which are events designed for participatory learning and creative endeavors in group. Without any special location sensors or direction sensors, a simple acoustic recorder and player for every user and artifact in the workshop enables the method to estimate the user location history as well as recording the audio scenery.

1 Introduction

Since the 1960s, participatory learning activities called workshops has been spread widely. The aim of workshops is not only problem-solving training like group working but also discussion such as town development by community resident. Against this background, there has been a blossoming of citizen's creative workshop in recent years. For example, CAMP(Children's Art Museum & Park)[1], YCAM(Yamaguchi Center for Arts and Media)[2]and CANVAS[3]have been regularly organizing workshops that enhance children's creativity and expressiveness. In UK, Capture Wales[4]provides storytelling style workshop that uses visual contents. Some workshop has an idea that activates interactions between attendees[1]

In terms of enhancing creativity and expressiveness, reviewing autochtonous activities by cognitive approach is important. Such reviewing is called *reflection*. The reflection by verbalization is shown to be helpful in accelerating attendee"s learing[2]. Focusing on expressive activity, the reflection of workshop has been categorized into the following:

- self reflection by attendee who performed the expressive activity on the workshop;
- reflection by facilitator who developed, organized and conducted the workshop.

The facilitator takes on an important role for the workshop In particular, upskilling of the facilitators helps the efficient operation of the workshop through the examining their and attendee's activities.

[1] http://www.camp-k.com/otona/camp/
[2] http://www.ycam.jp/greetings/
[3] http://www.canvas.ws/
[4] http://www.bbc.co.uk/wales/audiovideo/sites/galleries/pages/capturewales.shtml

One of the workshop analysises is a conversational analysis that measures how the creation or the expression has been performed. In the conversational analysis, interaction patterns of the attendee's speech are significant factors[3]. Therefore, videos and/or IC recorders are used in many workshops to record activities. The interesting scenes are extracted and the speech patterns are analyzed. At this time, it is considered that the efficiency of analysis are improved if the extraction of speech and situation are automated.

Therefore, we have been trying to tackle the extraction of workshop situation from the record of IC recorder sound using acoustical analysis technique. As the first step toward extraction, we especially focus on attendee's location and orientation of the situation. This paper summarizes our essential approach for estimating location and orientation using networked sensing, called topological estimation, and describes an outline of acoustical analysis of the topological estimation.

2 Location and Orientation Estimation Method and User Devices

While there proposed various types of location estimation method[4], many of the previous methods focus on absolute position estimation. The key of workshop, however, is attendees. At the reflection time, the important events can be observed around attendees. Therefore, we focus on the relationship between attendees, that is local relationship, rather than absolute position.

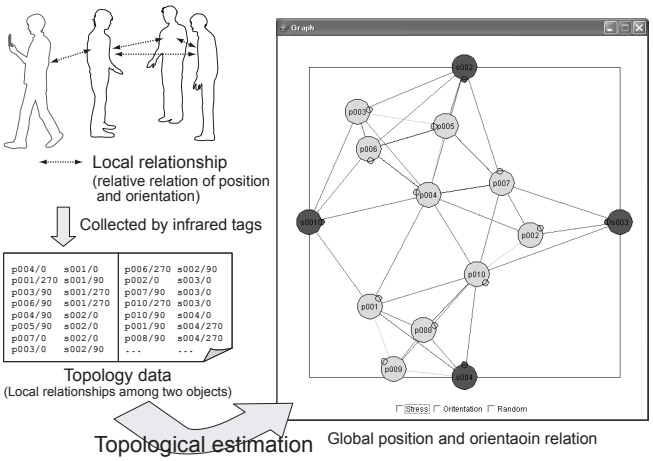

Fig. 1. Overview of the topological estimation

Our principal estimation method for location and orientation uses topology that is defined as collection of *local relationships*. The local relationship is the

positional and angular relationship between two objects: humans or things. The *global relationship* is a set of objects' relationships represented by the entire local relationship.

The topological estimation engine extracts a global relationship from the local positioning relationships. Fig. 1 shows an overview of input (left part) and global relationship output (right part). Then the engine produces context information of the objects, such as a classified group or an interesting object for a user, based on the global relationship. In this paper, however, we emphasize an examination of users' devices described in the next section. The detailed algorithms-how the global relationship can be estimated-can be found in [5].

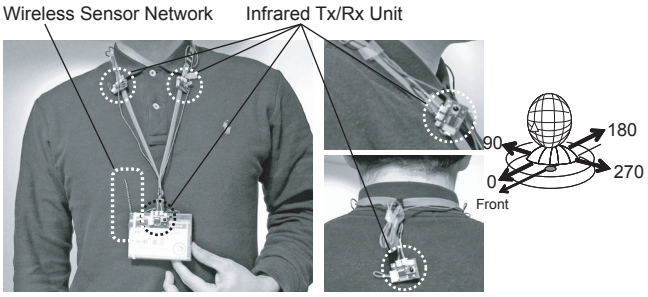

Fig. 2. Nametag type implementation example for 4 directional resolutions

Fig. 2 shows a nametag-type device that collect the local relationships. The nametag has four infrared tags that face in different directions. The infrared tag ID offers its associated direction. In advance, tags are assigned IDs of 0, 90, 180, and 270 in a clockwise direction. The infrared tag can also receive IDs coming from other objects. Thereby, IDs 0 are exchanged when two people stand face-to-face; IDs 90 and 270 are exchanged when two people stand next to one another. These exchanged IDs represent the local relationship. Those four directions of front, back, left and right are simply created meaning that the front is a direction in which interesting things are usually present, the left and right directions correspond to equal positions of a thing, and the back is not applicable to any of the previous. The number of the infrared tags in this method prescribes the direction resolution.

The shortcoming of the infrared tags type user device is low resolution angle measurement. Therefore, we have developed a user device using ultrasonic and radio to overcome them. Fig. 3 shows a block diagram and a prototype device using ultrasonic and radio signals to collect local relationships. It mainly consists of four ultrasonic transponders, an active RFID tag, and a PIC18F2220 microcontroller. We used a small, low-power-consumption-type active RFID tag as the radio module. This module communicates with the sink node, which is the center of the radio network; it is used for sending and receiving the remote commands and the calculation results. The PIC18F2220 microcontroller plays

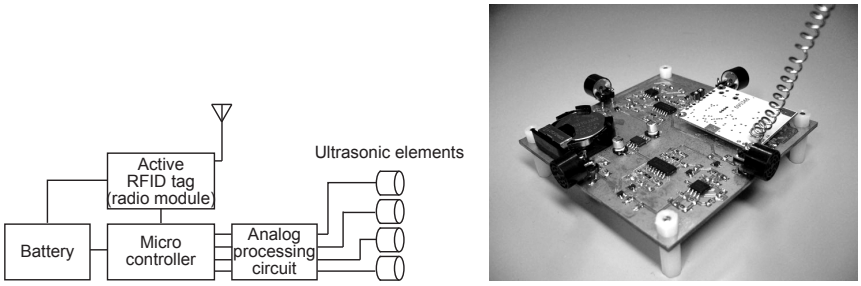

Fig. 3. Prototype users' device using ultrasonic and radio

the role of controlling the ultrasonic and calculating the distance and the angle of incidence. The analog processing circuit processes the ultrasonic waveform and amplifies the signal.

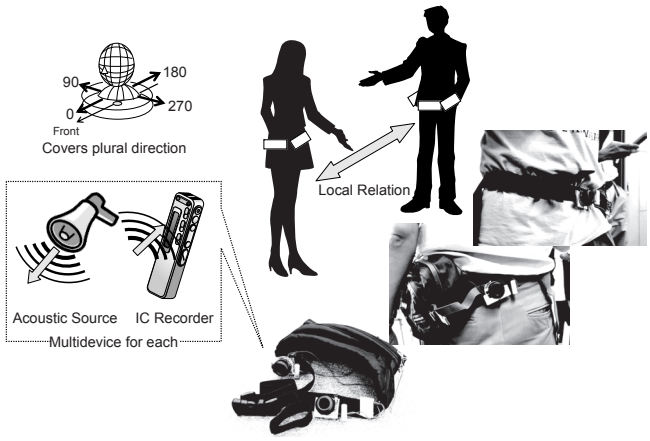

Fig. 4. System structure and users' device using acoustic sound

Fig. 4 shows an acoustic sound based topological estimation structure. In this figure, we use an IC recorder to collect sound signal that indicates users' ID and direction as well as ambient sound such as users' conversation at the workshop. The recorded information is analyzed after the workshop. If the specific sound of user A is found from user B's audio file and the sound user B is found from user A's audio file at a similar time, Then the precise temporal difference of the two audio file and traveling time from user A to user B are calculated. Thereby, the distance and vague orientation among the two users are estimated. By collecting all proximal information of each object, that is local relationships, location and orientation of all the objects are estimated.

3 Summary

One of the purposes of networked sensing is to capture the situations, especially human activity. We are now focusing on the workshop and trying to collect those activities in terms of location and orientation of attendees. This paper has presented a topological estimation method that can estimate the global location and orientation from local relationships between two objects. In the method using acoustic sound, each audio signal captured by a recorder is analyzed and identified as a specific sound emitted from a corresponding audio player. The locations and orientations of all users are estimated by collecting all the information in the vicinity of each attendee.

Acknowledgment

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