Toward Museum Guide Robots Proactively Initiating Interaction with Humans

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ABSTRACT

This paper describes current work toward the design of a guide robot system. We present a method to recognize people's interest and intention from their walking trajectories in indoor environments, which enables a service robot to proactively approach people to provide services to them. We conducted observational experiments in a museum as a target test environment where participants were asked to visit that museum. From these experiments, we have found mainly three kinds of walking trajectory patterns of the participants inside the museum that depend on their interest in the exhibits. Based on these findings, we developed a method to identify participants that may need guidance.We confirm the effectiveness of our method by experiments.

Categories and Subject Descriptors

I.2.9 [**Artificial Intelligence**]: Robotics

Keywords

Walking trajectory pattern, guide robot, laser sensor

1. INTRODUCTION

The identification of those in need is an important task for service robots. In typical systems, people explicitly call the robots for help. There has been a great deal of research to extend the modalities that we can use such as voice and gesture in these cases. In addition, Yamazaki et al. proposed that robots should show their availability and recipiency by nonverbal behaviors so that people can easily start asking for help [2]. However, there may be cases where robots are expected to offer their service to people who seem to need or want their service. In our daily life, for example, if we find a person who is looking around with a map in his/her hand at a train station, we may ask him/her if we can help him/her. The purpose of this research is to develop service robots that can serve people in such a proactive manner as opposed to the conventional reactive approach where they wait until people explicitly request them for their service.

HRI'15 Extended Abstracts, March 2–5, 2015, Portland, OR, USA.
ACM 978-1-4503-3318-4/15/03.
http://dx.doi.org/10.1145/2701973.2701974.

The main research topic here is to find such people who may want the service of the robot. We believe that we can find such people by observing their various bodily actions. In this paper, we address this issue by taking museum guide robots as an example. Several robots were proposed that can make a guided tour to a predetermined group of people. However, here we consider a guide robot that can find a person who seems to be interested in a particular exhibit and offer him/her more detailed explanations of the exhibit.

We set up an art museum in our laboratory and observed behaviors of people with various levels of interest in the exhibits. By analyzing the observed results, we have found that we can detect people who may desire the robot's service from their walking trajectory pattern in the room. We then developed a method for robot that can find such people to offer them guidance concerning their exhibit of interest.

2. OBSERVATIONAL EXPERIMENTS

We set up an art museum room sized 8m×10m where we hung 6 paintings. We used 4 laser range sensor poles to track people and to obtain global behavior information such as their walking trajectories. The tracking method can be found in our previous work[1]. The method tracks the locations and orientations of people by using a particle filter framework, which is an important requirement for maintaining the continuity of walking trajectories. Our tracking of people's walking trajectories via laser range sensor poles is illustrated in Fig. 1(a). We also attached a USB camera to each painting to observe people's local behaviors. The overall setup of our art museum is illustrated in Fig. 1(b).

Visitors to a museum may be there for various purposes and have different intentions. Their interests in the exhibits may also vary. We considered the following three cases as the most typical cases.

• *Case1.* They are interested in the collection of the museum and would like to look at all paintings.

• *Case2.* They know that a famous painting by some painter is in this room and would like to appreciate it.

• *Case3.* They are visiting the museum because they happen to be in town and may not be so interested in the exhibits.

In order to observe the above three types of visitors, we divided 48 participants from Saitama University into three groups and instructed each group as follows.

• *Group1* (14 participants). Look at all paintings carefully and choose one that you most like. We will ask about the painting later.

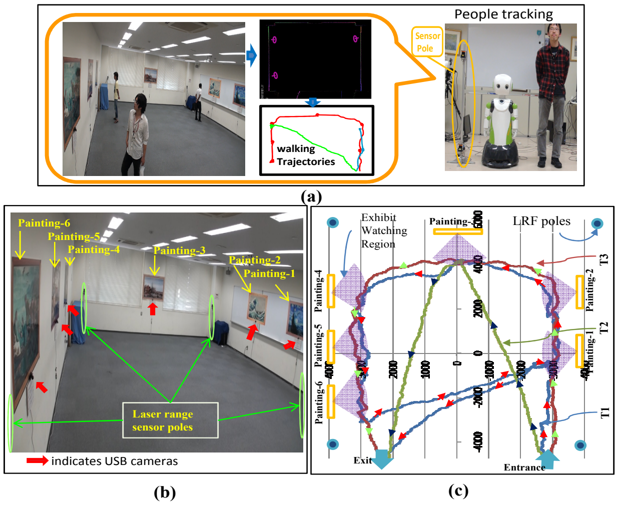

Figure 1: (a) Visitors walking trajectory tracking using laser range sensor poles, (b) Setup of our designed art museum, (c) Visitors' typical walking trajectories for $T1$, $T2$, and $T3$.

Table 1: Relationship between different groups of participants and the walking trajectory patterns

	$T1$	$T2$	$T3$	$Others$
$Group1$	09	00	04	01
$Group2$	00	11	06	01
$Group3$	01	0	15	00

•*Group2* (18 participants). We show them one of the paintings and tell them to look at that painting. We will ask about that painting later.

•*Group3* (16 participants). No specific instruction is given.

In this paper, we concentrate on walking trajectory. We have found that there are three major trajectories $T1$, $T2$, and $T3$ where $T1$:*"trajectory where all exhibits were viewed sequentially followed by a return back to any one of the previously viewed exhibits"*, $T2$:*"trajectory where the person went straight to view only one exhibit before leaving the museum"*, and $T3$: *"trajectory where all exhibits were viewed sequentially"*. Examples of found walking trajectory patterns of type $T1$, $T2$, and $T3$ are illustrated in Fig. 1(c). Table 1 shows the relationships of the three groups and the walking trajectory patterns.

Visitors with trajectory pattern $T2$ are interested in a specific painting. Such people are the first candidates for the robot to offer its guidance. It is also natural for visitors to see paintings that they like multiple times. Thus people with trajectory pattern $T1$ are assumed to be interested in the painting they returned to and are also candidates for receiving extra commentary from the robot about the painting.

3. NEW METHOD FOR GUIDE ROBOT

Based on the accumulated trajectory patterns, in this section, we introduce a method of extracting walking trajectory patterns of type $T1$ and $T2$. We defined painting viewing regions with region-ID (rID) for n-paintings inside the museum. The rIDs will be used to construct a trajectory vector (TV) to define the visitor's walking trajectory pattern where each rID inside the TV will represent the visitor's visited regions inside the museum. If any visitor view paintings then the TV will be updated by concatenating the $rIDs$ of all the visited regions of those paintings. An example of the TV for the $T1$ walking trajectory pattern can be expressed as TV_{T1}=[$rID_1, rID_2, ..., rID_n$, rID_2] where it is seen the visitor visited the region rID_2 a second time to check the painting again. Thus the visitor with this TV would be a candidate to offer an explanation from the robot about the painting residing inside the region rID_2. To check whether the visitor's position is stable inside any viewing region, the variances of their position coordinate values ($Var(x)$ and $Var(y)$) for every past 10 consecutive frames are calculated and combined using $D = \sqrt{(Var(x))^2 + (Var(y))^2}$. For any visitor, if his/her position is inside any viewing region with the body orientation toward the painting, and D<80 for the next 100 consecutive frames then, the robot will assume that the visitor is stable at that region. Again if any visitor goes directly to any region rID to view a painting without viewing other paintings at other regions in the museum, we treat the visitor as having a $T2$ walking trajectory. However, our conditions of stability in this case require that his/her position should be inside any painting viewing region with body orientation toward the painting, and D<80 for next 200 consecutive frames. This is because it was observed from the experiment that the visitors with $T2$ trajectory spend more time viewing only one particular painting than the average time a visitor take to view a painting.

We examined the performance of our method to recognize the $T1$ and $T2$ walking trajectory patterns by applying it to the stored data recorded in the observation experiments. Our method correctly recognized 80% (8 out 10), 81% (9 out 11) of the $T1$, and $T2$ walking trajectory patterns, respectively, thereby recognizing participants that were especially interested in to any particular paintings.

4. CONCLUSIONS

In this study, we conducted observational experiments on the behaviors of people with varied interests in the exhibit inside a museum. Furthermore, we analyzed the people's walking trajectories as global behavior information and proposed a method for guide robots that can find people who are potentially interested in a particular exhibit. We found our proposed method effectively identifies people's interests but we did not include a robot in the current setup. We are now planning to incorporate this method into an actual guide robot in a museum. We may also be able to find people who are interested in a particular exhibit from some local information obtained from the camera. This is left for our future work.

5. ACKNOWLEDGMENTS

This work was supported by JST, CREST.

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