SPAL: Appraising People's Attention in The Real World

Niwat Thepvilojanapong[1,6], Yasunori Yakiyama[2], Oru Mihirogi[3], Masayuki Iwai[1,6], Keisuke Aizawa[3], Atsuhiro Takagi[3], Kazumasa Oshima[3], Kazunori Umeda[4,6], Yoshito Tobe[1,6], and Ryosuke Shibasaki[5]

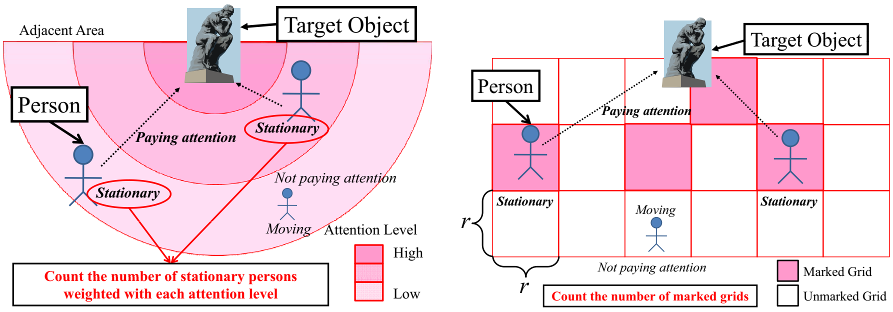
[1] School of Science and Technology for Future Life, Tokyo Denki University, Japan
[2] School of Advanced Science and Technology, Tokyo Denki University, Japan
[3] Department of Info. Systems and Multimedia Design, Tokyo Denki University
[4] School of Science and Engineering, Chuo University, Japan
[5] Center for Spatial Information Science, University of Tokyo, Japan
[6] Core Research for Evolutional Science and Technology, JST, Japan
wat@osoite.jp,{yakly,oru,masa,kekke,atsu,shima}@u-netlab.jp,
umeda@mech.chuo-u.ac.jp,yoshito_tobe@osoite.jp,shiba@csis.u-tokyo.ac.jp

Abstract. Although human activities in the World Wide Web are increasing rapidly, we still need to appraise how things such as pictures in a museum receive attention in the real world. To measure people's attention, we propose a *Sensor of Physical-world Attention using Laser scanning (SPAL)*. A key scheme to identify the attention is determining how long a moving person lingers around the target object. In this paper, we describe the design of SPAL and show the results from the real-world experiments.

1 Introduction

Laser scanners and image sensors have been used for measuring human behavior [1]. Most of previous works focus on the detection or tracking of human. The measurements of such works are applied to traffic management and security systems. However, a measurement of people's attention has not been studied sufficiently. We believe that a measurement of people's attention benefits human society as a metric for the purpose of comfortable urban activity. For example, we can place objects at the right places in an exhibition hall or a museum according to people's attention.

This paper proposes a *SPAL (Sensor of Physical-world Attention using Laser scanning)* system to calculate a degree of people's attention from their behavior in the real world. Our system focuses on attention of target objects in a conventional hall and museum. In the first step, the system detects human objects based on data measured from laser scanners. It then determines staying people of each detected human object, and calculates a degree of people's attention as an output of the system. A *Degree of Real-World Attention (DRWA)* is defined as a metric to show a degree of people's attention. We propose three measurement models to calculate the DRWA.



(a) The DWCPS model. (b) The CGPS model.

Fig. 1. Measurement models.

We performed the experiments to study the performance of SPAL system. The experiments were done indoor by placing three posters as target objects. The DRWAs are calculated and compared with the actual attentions of people which are taken from questionnaires.

2 Models for Real-World Attention

Since the SPAL calculates real-world attention from a state of people staying, we define *Value of People Staying (VPS)* as the number of people who stay nearby a target object. Let U be a set of N target objects. We define *Degree of Real-World Attention (DRWA)* of the target object x ($x \in U$) as a ratio of the attention level of the target object x and that of all target objects in U (Equation 1).

$$DRWA(x) = \frac{VPS(x)}{\sum_{i=1}^{N} VPS(x_i)}. \tag{1}$$

Counting states of People Staying (CPS) Model The CPS model determines the state that people stay at a certain point more than a threshold period as a state of paying attention to a target object. Let $CPS(x,t)$ be the number of staying people at time t for the target object x.

$$CPS(x,t) = \sum_{i=1}^{DP(x,t)} f(x,t,i), \text{ where} \tag{2}$$

$DP(x,t)$ is the number of detected people at time t and $f(x,t,i)$ is the function to decide whether people i is staying at time t. In particular, $f(x,t,i)$ is one if staying period is longer than a threshold, otherwise zero. The VPS of the target object x is a sum of $CPS(x,t)$ for measurement period T, i.e., $\sum_{t=0}^{T} CPS(x,t)$.

Distance based Weighted Counting states of People Staying (DWCPS) Model In the CPS model, all staying people are counted as the same value, namely, one. However, in an actual situation, it is considered that the nearer the distance between people and a target object, the higher the attention level of people is (Figure 1(a)). Therefore, we define DWCPS model that includes a weighted parameter corresponding to the distance between people and the target object when calculating the VPS.

$$DWCPS(x,t) = \sum_{i=1}^{DP(x,t)} w(x,t,i) f(x,t,i). \tag{3}$$

$$w(x,t,i) = \begin{cases} 1, & d(x,t,i) \leq d_1 \\ \dfrac{d_0 - d(x,t,i)}{d_0 - d_1}, & d_1 < d(x,t,i) < d_0 \\ 0, & d_0 \leq d(x,t,i). \end{cases} \tag{4}$$

$w(x,t,i)$ is the weighted parameter at time t of people i for the target object x, and $d(x,t,i)$ is the distance between people i and the target object x at time t. The VPS of DWCPS model is a sum of $DWCPS(x,t)$ for measurement period T, i.e., $\sum_{t=0}^{T} DWCPS(x,t)$.

Counting Grids existed states of People Staying (CGPS) Model We propose CGPS model which divides a scanning area into multiple grids (Figure 1(b)). Let $G(X_i, Y_i)$ be a state of a 2D grid, where X_i and Y_i indicate indices of the grid. In an initialization step, all grids are unmarked and the values are zeros, i.e., $\forall G(X_i, Y_i) \leftarrow 0$, when $t = 0$. If people move into an unmarked grid and stay longer than a threshold, the grid is marked and the state is changed to one. Once a grid is marked, the state is permanent until the end of the measurement. The VPS is the number of marked grids at $t = T$, i.e., $\sum_{i=0}^{\forall X} \sum_{j=0}^{\forall Y} G(X_i, Y_j)$.

3 System Architecture and Implementation

System Architecture This section briefly describes the processing flow of SPAL system. First, the system performs a step of detecting human objects by using a Human-Detection algorithm. The algorithm is as follows: (1) generate background data by scanning an area of interest while no one exists, (2) compute a margin between current data and background data in counterclockwise direction, (3) if the margin is longer than a threshold (5 cm), the current point of current data is set as a begin edge, (4) continue until the margin is shorter than the threshold where an end edge is found, (5) if the distance between the begin and end edge satisfies the condition (between 30 cm and 70 cm), the recognized object is determined as a person.

The system then uses a Staying-Detection algorithm to determine whether a human object is a staying person. The algorithm is as follows: (1) store location of detected person for five cycles (total 1.065 seconds), (2) compute the vibration of the people which is the difference between the maximum and minimum values in five cycles, (3) if the vibration is less than a threshold (30 cm), the person is recognized to be a staying one. The system logs positions of staying and moving people. Then the VPSs are counted for each target object individually, and the DRWAs are calculated by using Equation 1.

Prototype Implementation The SPAL system consists of a laser scanner which connects to a processing node through RS-232C interface. The laser scanner is LMS-200 developed by SICK[7] in Germany. The laser is 905-nm near infrared rays and the safety class is 1A. The laser scanner scans counter-clockwise direction with maximum scanning angle of 180 degree. The angular resolution is 0.5 degree which means the laser scanner has 361 scanning steps. The maximum scanning distance is 80 m and the distance resolution is 1 cm. In the SPAL system, we place the laser scanner 140 cm above the ground level. Thereby the scanning plane is approximately the chest of an adult. The scanning rate is 4.7 Hz.

The processing node is a laptop computer running Windows Vista, and we use .NET Framework 2.0 as runtime environment. We developed an application software and installed in the processing node. The application software obtains scanned data from the laser scanner, and then analyzes the data by detecting a person and calculating the degree of real-world attention. GUI is also developed for easy usage.

4 Conclusion

This paper has studied the tendency of people's attention in the real world by using the proposed SPAL system. The system calculates people's attention based on three proposed measurement models, i.e., CPS, DWCPS, and CPGS models. We have implemented the system and conducted the experiments. Raw data obtained from laser scanners are input of the system, and people's attention based on three models has been calculated to study the performance of the system. The results show that the proposed models are good candidates for determining people's attention which correlates to a distance between people and a target object. We note here that a problem of personal privacy does not concern the SPAL system because our system does not recognize an individual.

References

1. Zhao, H. et al.: A laser scanner system for acquiring walking trajectory data and its possible applications to behavioral science. In: Studies in Human and Social Sciences with GIS (Chapter 3). Taylor & Francis/CRC Press (November 2005)

[7] http://www.sick.com/