InteractionScope: Non-fixed Wearable Positioning for Location-aware System

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ABSTRACT

Information concerning the relative position between humans and artifacts is important for context-aware computing [1]. Previous systems require the installation of fixed devices in every room that must be connected to a central server to calculate the relative position. Based on InteractionScope, we present a wearable device and a method for detecting the relative position defined by observation results of human-human and human-artifact interactive activities.

Keywords

Ubiquitous computing, local positioning system, wearable devices, context awareness, interaction

INTRODUCTION

Relative position information between humans or between humans and artifacts is important for many applications used in an interactive context. Applications can infer activities or appropriate services that provide a user with such different types of relative position information as a person turning toward a display up to a certain distance or persons facing each other at a distance within which they can read each other's facial expression [2] (figure 1). Many systems for indoor localization that use a vision-based, supersonic-based, or infrared photodetector-based method [4] have been proposed. Such technologies often require the installation of large-scale fixed devices in every room that generally need to be connected to a central server to calculate relative position. Such systems thus involve installation costs and a tradeoff between computational costs and accuracy of position. Moreover, they are unable to provide real-time context information for everyday living.

On the other hand, we propose a decentralized accurate wearable relative positioning device consisting of transmitters that use infrared light emitting diodes, and a localization device that uses a vision chip and an 8-bit microcontroller (figure 2). These wearable devices an IrID Tag and IrID Tracker can detect relative positions in real-time as an "interaction scope" that is defined by distance and angle to the object in a physical space. The scope can handle differences based on the kind of object, such as a person, a display or a poster. These differences are defined by observation results of human-human and human-artifact interactive activities obtained by using a high-accuracy multi-camera Vicon (R) motion tracker.

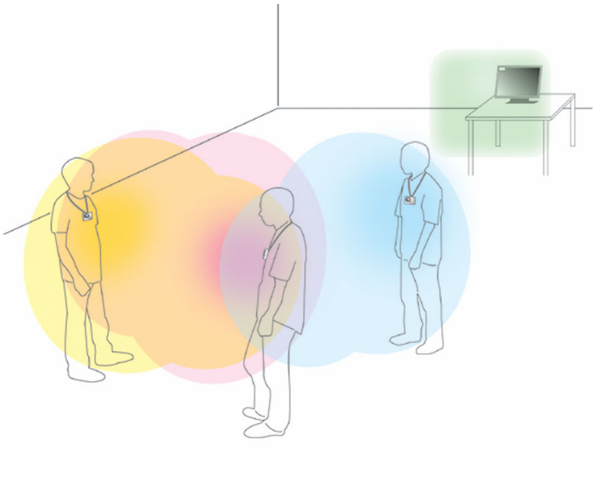

Figure 1. Scope of Interaction

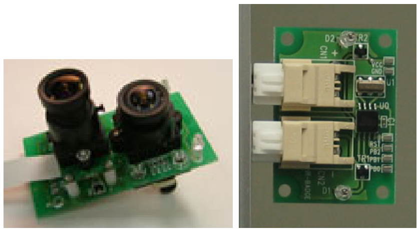

Figure 2. IrID Tracker / Tag

Scope of Interaction

Vision supports various daily activities as sensoriums of visual information. Visual acuity is the ability of the eye to read characters or facial expressions, which is a significant factor in defining the possible spatial range of interactive activities involving objective humans or artifacts [3]. General scope can be defined by resolution when an object is an artifact that has visual information resources, such as a poster or a display.

Scope for an objective person is determined not only by resolution but also social relation. To define scope for a person, we observed small group interaction activities in a workspace (figure 3) and defined the shape of the scope that surrounded almost every observed interaction distance and angle (figure 4). These scopes were generalized and assembled as a radiation pattern of the IrID Tag.

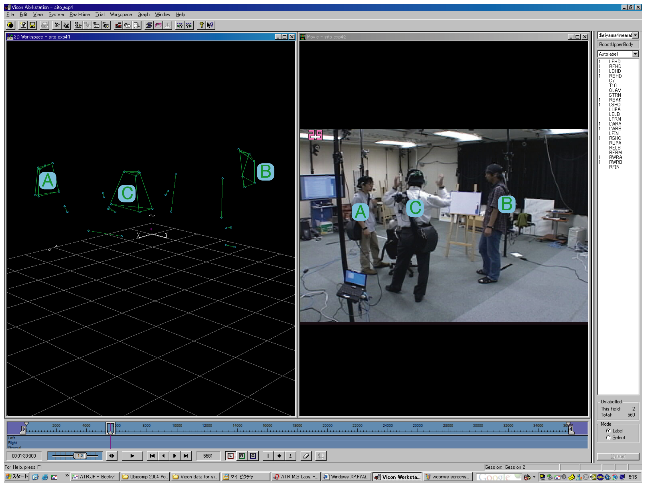

Figure 3. Observing interaction activities.

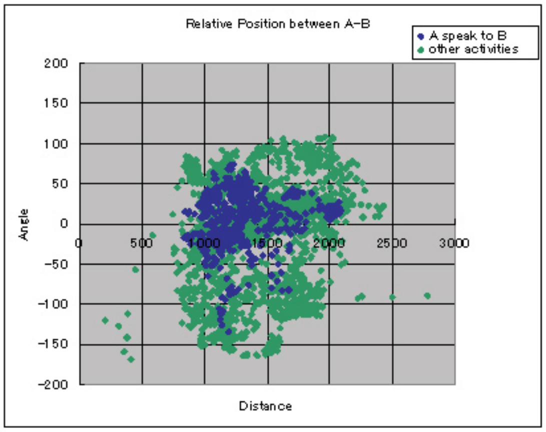

Figure 4. Relative position between A and B.

The observer's view field information is important for determining which tag is observed. We chose the head direction as the view field direction because tracking the actual view field in everyday life would require unacceptable costs. The angle and shape of the view field is defined by the observed interaction activities in the workspace (figure 4).

Implementation

This system consists of an IrID Tracker for the observer's view field and an IrID Tag, attached to the object for visibility scope (figure 2). An IrID Tag has a directional infrared single-reflection LED and a light-shaping diffuser with a holographically recorded diffusion layer that provides controlled light divergence and a radiation pattern as interaction scope. Each IrID Tag has a unique name that is transmitted by the blinking of a Manchester-coded 200 Hz LED controlled by an 8-bit AVR microcontroller.

The IrID Tracker has a 90 degree view angle optical lens, a vision chip that can perform high frame rate windowing in a low pixel clock, and an Intel 8051 compatible 8-bit microcontroller. It can output the detected IrID Tag name, coordinates, and frame image. Full frame image grabbing and tag detecting that use the windowing function are processed in turn. The first detection time is $Ft + ((Tl * 10 \text{ msec}) * Tn)$. Ft is the time needed for full frame grabbing. At default exposure time, Ft is 150 msec. Tl is the bit length of the IrID Tag name, and the default name length is 10 bits. Tn is the number of IrID Tags in the view angle, where the maximum number is 64. Spatial resolution in 2 m distance is 1.78 mm x 1.78 mm.

FUTURE WORK

These instruments were developed as head-worn type and necklace type wearable devices. The first IrID Tag and IrID Tracker prototypes were used for detecting interaction among visitors at our labs open house last year. A new large number of IrID Tags and IrID Trackers are ready to be evaluated in other situations.

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