# Grid-pattern indicating interface for ambient assisted living

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## ABSTRACT

We propose a grid-pattern indicating interface to provide instructions remotely from remote site to support independent daily life of senior citizens. Our aim is to realize smooth and easy telecommunication between supported senior citizens at local site and supporting caregivers who are in remote site. Although we have used a monitoring method with video streaming where the remote caregivers indicate work steps as a conventional way, occlusion and depth perception problem was occurred. Our method that provides grid-pattern interface to remote caregivers could be a solution for the problems by indicating the spatial instruction easily on 2D input interface. Our prototype has been implemented with a colour camera, a range image sensor, and projector.

## 1. INTRODUCTION

Most countries are facing serious situations nowadays, and one of them is super-aging society. It is estimated by the year of 2050 in Finland and Japan, the amount of people over the age of 65 will cover 27% and 33% of the total population, respectively. The number of senior citizens who suffer from varying memory impairments is also going to get doubled during the next 30 years (Ferri et al, 2006). The increase of senior population requires more caregivers inevitably. However, most of caregivers have already reported physical and mental problems (Schulz et al, 1990; Rabins et al, 1982). We need to consider the balance between the supporting generation and the supported generation, and avoid from making negative feedback loops by increasing heavily supported persons. On the other hand, most of the persons who have mild cognitive impairment persons just need small help to avoid from getting bad in memory. One of our goals is to realize the ambient assisted living environment that allows 5 to 10 caregivers support 10 to 30 senior citizens remotely via the Internet connection. In this paper, we propose a grid-pattern indicating interface because an easy instruction system would be required to make burdens of caregivers as less as possible.

We focus on a kitchen workspace because cooking is an important part of daily life. Our method is to utilize the combination of a camera and a projector, to provide visual information as guidance or as a set of instructions onto the physical surface as Molyneaux et al. has proposed (2007). Ju et al. (2001), Bonanni et al. (2004), and Sato et al. (2014) had applied the projection technology to kitchen workspace for supporting cooking. On the other hand, the research about the remote collaboration has been often done as references (Kuzuoka, 1992; Sakata, 2003) show. We also are challenging to create a remote collaboration situation in kitchen and especially pay attention to how easily the remote caregiver better provides instructions to a senior citizen at the local site. In this paper, we propose grid-pattern interface for the remote caregivers to indicate points in the space at the local site a solution.

## 2. METHOD

We propose a grid-pattern indicating interface for remote caregivers to assist local persons remotely. The whole system consists of two sites: a local site where assisted persons are and a remote site where caregivers are.

Figure 1 (a) shows the overview of our conceptual system. Remote site has remote monitoring view and grid interface on the computer screen. At the local site at a kitchen workspace, a camera, a range image sensor, and a projector are installed. The camera captures a scene from the workspace including the objects and the surfaces. In order to realize our system, we need to calibrate geometrical relations between each device as shown in Figure 1 (b). Using the result of the calibration, we can keep the correspondence between grid-pattern interface view and real workspace.

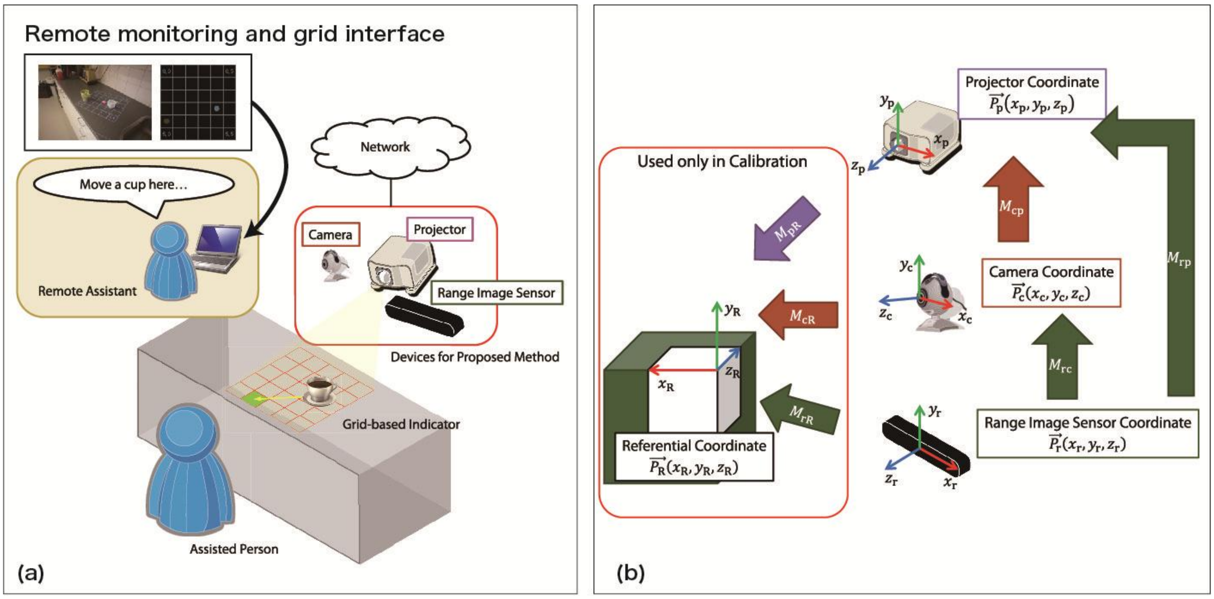


**Figure 1.** *Our conceptual system and coordinate systems of the devices. (a) Remote caregiver can monitor local site remotely with grid-pattern indicating interface via the Internet. (b) Geometrical relations between each device need to be calibrated in advance.*

### *2.1 System Calibration*

There are three coordinate systems: a camera coordinate system, a range image sensor coordinate system, and a projector coordinate system as shown in Figure 1 (b). We can know the geometric relationship with the colour in the target scene by calculating each transformation matrix between each coordinate system in advance. The transformation matrices can be obtained by using a referential coordinate system.

First, transformation matrix between the range image coordinate system and the referential coordinate system is estimated. The range image sensor captures the scene with the referential object as range data, then three plane surfaces on the referential object are detected. The three normal vectors corresponding to the three plane surfaces are used as basis vectors, and in the referential object coordinate system the intersection of three plane surfaces is used as the origin.

Second, we can estimate transformation matrices corresponding to the color camera and the projector by applying Gray code pattern projection (Sato, 1985). The basis vectors and the origin of the referential object that is represented in the camera or projector coordinate system are estimated according to measured geometry of the scene which includes the referential object.

As the last step in main calibration process, we need to compute transformation matrices between each device. For example, the transformation matrix $M_{rc}$ is computed by simple multiplication of $M_{rc} = M_{Rc} M_{rR}$, where $M_{Rc} = M_{cR}^{-1}$.

Only the relative positions between the devices should be maintained in use. In other words, a simultaneous movement of the devices is allowed. It indicates that the system can be moved freely if the devices are fixed in a their locations.

### *2.2 Target Surface Estimation and Object Locating*

There are mainly two steps, which are estimation of a parameter of the target planar for fixing the grid-pattern area in the workspace and visualizing a position and a color of the target objects on the grid-pattern view for the remote caregivers.

First, we estimate the dominant plane from the range image that has a certain color. The color of each pixel in the range image is given from the converted camera image via $M_{cr}$, where $M_{cr} = M_{rc}^{-1}$. Second, the pixels extracted as the target planar surface are clustered according to the distance between each point. Finally, each cluster is projected onto the two dimensional coordinate system of the target planar surface after the center of gravity has been calculated. Then the average color and the position of each cluster are shown on the grid-pattern view.

### *2.3 Grid Pattern Indication*

We assume a situation where a remote caregiver gives some instructions to a senior citizen at his/her home. When the caregiver gives instructions, communication with spatial information where the remote caregiver indicates for the senior citizen is important. In conventional way, the remote caregiver monitors the senior with video streaming and indicates a location by speaking or clicking on the monitoring view. The monitoring makes it easier to understand in terms of spatial information. Nevertheless there is still the remaining problem of occlusion and depth perception, which causes mistakes in a remote caregiver's judgments.

A grid-pattern indicating view for a remote caregiver is one possible solution that can avoid from occlusion and depth perception problems.

## 3. IMPLEMENTATION

We implemented a prototype system as shown in Figure 2. The camera was being used a Logitech C910 which captures images in 640x480 pixels. The range image sensor was a Microsoft Kinect for Windows which obtains range images in 320x240 pixels. The projector was an Optoma EP1691i Digital Light Processing Projector which shows an image in 1280x768 pixels onto a physical surface. Additionally, we applied Point Cloud Library 1.5.1, OpenCV 2.4.0, and Microsoft Kinect for Windows 1.5 to our prototype system.

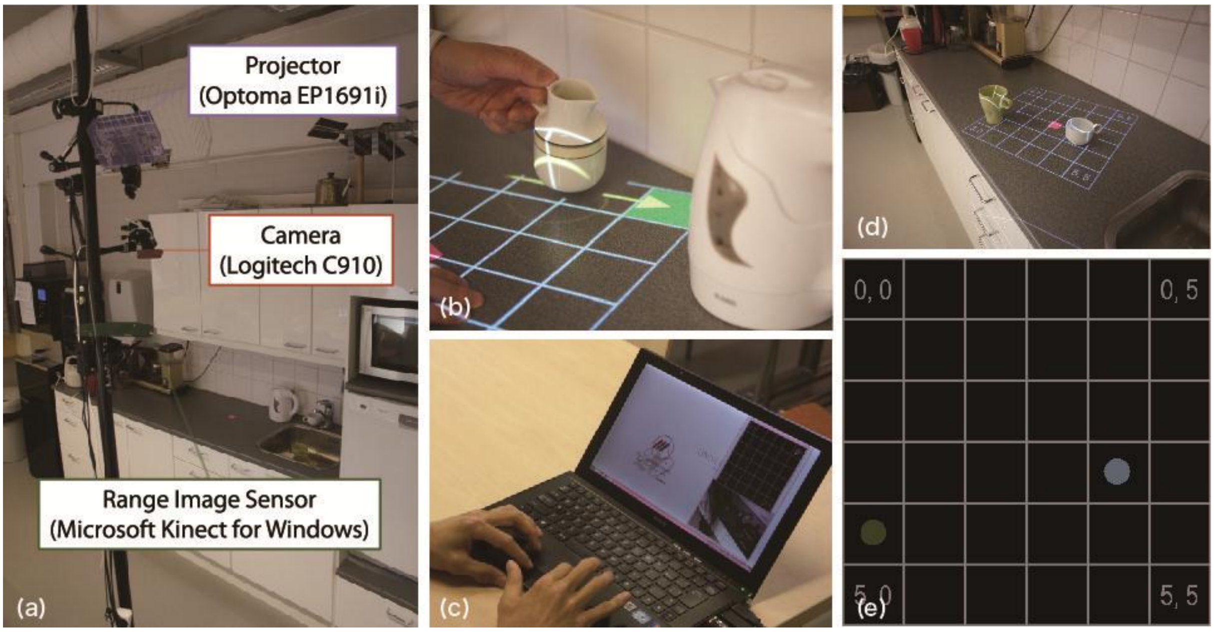


**Figure 2.** *Our prototype system: (a) overview of the prototype system that mainly consists of a colour camera, a range image sensor, and a projector on the pole to project visual instructing information onto the kitchen workspace, (b) the scene of local site with projected lights, (c) the scene of remote site with grid-pattern indicating interface on a computer screen, (d)(e) the view of local site and the grid-pattern interface, respectively, that are shown on the computer to the caregivers at the remote site.*

We demonstrated the implemented system with several test users briefly. As a result of our observation, most of the users whom were remote caregivers could indicate where he/she wanted to indicate in the space of the local site. However, we did not confirm how precise they could indicate with the grid-pattern interface. On the other hand, visualizing the projected grid-pattern onto the local site would not be really needed for the senior citizen to understand where the remote caregiver indicates. Projection with infrared lights could be a method to make invisible and visible grid-patterns on the target surface simultaneously for the local and the remote person, respectively.

## 4. CONCLUSION

We have proposed a grid-pattern indicating interface for remote caregivers in ambient assisted living. Our method was implemented by installing a colour camera, a range image sensor, and a projector on the local site. The grid interface could have correspondence to the real workspace of the local site with calibration between each device. Finally, we briefly confirmed how the implemented prototype operated while the test users indicating remotely.

Future work includes a user test to confirm the accuracy or easiness of our method, making the available workspace bigger, and improving object recognition for representing the real situation into the grid-pattern interface.

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