Worker's State Estimation and Gaze Direction Replication Methods for Remote Collaboration

Abstract

This research investigates two methods for smooth communication in a remote collaboration environment: a method for estimating the worker's state in asynchronous work, and a method for replicating the gaze direction in synchronous work. Many companies and organizations use collaborative work to solve problems and create innovative services and technologies. Such collaborative work has developed into remote collaborative work involving multiple companies and organizations, which will continue to collaborate remotely.

Remote collaborative work consists of two types of work: asynchronous and synchronous work. To facilitate smooth communication during remote collaboration, shared worker awareness is a necessity. Awareness includes state information describing the remote workers and non-verbal information about their activity during conversation. In particular, gaze is an important form of non-verbal information. This research proposes new technologies that support elements of awareness related to the two types of remote collaboration. The remote collaboration environment has two functions using these technologies. First, to ensure that a remote worker can seamlessly switch from asynchronous work to synchronous work by recognizing remote coworker states; second, to make it in such a way so that remote coworkers can smoothly communicate in real time within the same space by replicating the gaze direction.

To seamlessly switch asynchronous work to synchronous work, this research proposes a novel worker state estimation method using collaboration between humans and systems to reduce manual tasks. Many studies on human state estimation have reported a high estimation accuracy using machine learning. To create an estimator using the conventional method requires enormous amounts of learning data, and creating this data is a laborious task. The proposed method is to create an estimator that reduces the manual task through cooperation between people and computer systems. This method uses three automated processes: sensing, clustering, and selection. The clustering process uses an unsupervised clustering method. A prototype system was developed and tested in two workspaces. The proposed system reduced the amount of manual task by approximately 60% and 80% in workspace I and II, respectively. The estimation accuracy was up to 90% in each workspace. The proposed method was effective in simplifying and reducing manual tasks.

For synchronous work, this research proposes a new method for replicating workers' gaze direction using a fused image display. This method replicates the eye contact back-channel information available to attendees in a meeting room. The display consists of two screens that present remote workers' faces to show their gaze direction, that is, the direction they are looking in. A prototype video conference terminal was developed and tested. The results of the evaluation test indicate an average directivity of 17.9–21.1°. At a distance of 1.2 m, this corresponds to a width of approximately 39–46 cm. This range is narrow enough to specify a single person.

These research results will facilitate smooth communication using presence sharing and video conference systems in remote collaborative work.

Keywords: Remote Collaboration, Awareness Support, Presence Sharing System, Worker State Estimation, Gaze-Direction.