Supporting Acceptable Dialogue Start Based on User Uninterruptibility Estimation for Avatar-Mediated Multi-tasking Online Communication

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Abstract. Current users of real-time online communication tools have difficulty recognizing the status of interaction partners. Therefore, initiation dialogue has a risk of unintended interruption of the partner. To overcome the problem, we focused on application-switching (AS) as a potential intelligent activity discontinuity marker for uninterruptibility estimation. Preliminary experiments revealed an uninterruptibility reduction effect of AS. Therefore, we prototyped an acceptable dialogue start supporting agent system that allows users to recognize the uninterruptibility of interaction partners naturally. The system estimates uninterruptibility using AS, keystrokes, and mouse clicks, and presenting the results by avatar posture and motion using overlapping expressions to control the impression of uninterruptibility.

Keywords: Multi-tasking, online communication, interruptibility.

1 Introduction

In recent years, instant messaging tools such as MSN Messenger or Yahoo Messenger have become popular for daily online communication. Interaction with these tools feature multi-tasking online communication. Most messaging tools have a function that shows user status, for example, Busy / Away from Keyboard (AFK) etc. However, the status is manually set by users who tend to set the status to AFK to avoid being interrupted by dialogues even while they are using the tool for communication. This status operation is inconvenient because the user cannot recognize whether interaction partners are really busy. Therefore, automatic status estimation and ambient display of the status is expected to help users avoid unintended interruption.

One potential method for estimating user online status is to count the keystrokes or mouse clicks [1]. However, these physical activity indexes incompletely reflect the intelligent activity that should be uninterrupted because sometimes intelligent activity has no observable output. Another approach is to specify the purpose of PC usage based on the application being used. However, multi-purpose applications, such as web browsers, prevent this estimation. Several recent studies attempted to estimate

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user context using various sensors set in the living space or on the users. They still require further study to estimate user intelligent activity [2] [5].

Text-based or voice-based real-time chat systems are used widely for online communication. Most chat systems provide no or negligible nonverbal communication functions in spite of its importance in expressing and recognizing emotions, intentions, attentions, etc. Avatar-mediated communication systems are also becoming popular in recent years. Embodied avatars have a potential for assisting a nonverbal communication. Facial expression is an essential component of emotional expression. A number of systems provide facial expression control functions, most requiring manual operation. Gaze has rich communication control functions such as turn-requesting and turn-yielding. Some studies have attempted automatic control of the avatar's gaze by using eye-tracking cameras [8].

The uninterruptibility expression must be intuitive in order to reduce the cognitive load of the user. Some studies have examined ambient awareness using nonverbal information. The movements of head, face, and body were found to be effective in expressing a nonverbal behavior [6]. It was also demonstrated that the user can recognize emotional states of a virtual character through head movement and body posture during gaze shifts [4]. The anthropomorphic motions helped the user understand the robot's status [3]. The expression of uninterruptibility using nonverbal information through an avatar appears promising for intuitive recognition of uninterruptibility.

In this study, we prototyped an acceptable dialogue start supporting (ADSS) agent, for assisting pleasant and acceptable dialogue initiation in avatar-mediated multi-tasking communication systems (AMMCS). The ADSS agent estimates and expresses user uninterruptibility, and presents the dialogue requests from the communication partner. In an attempt to resolve the intelligent activity interruption problem, we focused on application-switching (AS) as a potential intelligent activity discontinuity marker for uninterruptibility estimation. We also used the avatar's postures and motions, including gazing, for ambient and intuitive expression of uninterruptibility and in presenting a partner's dialogue request.

2 Acceptable Dialogue Start Supporting Agent

In recent years, avatar-mediated communication systems have become popular, not only in research but also in commerce [7]. Avatars provide functions to express the presence and nonverbal information of interacting partners over a network. Also, multi-tasking communication is getting prevalent as an online communication approach, especially for instant messaging tools. Communication is one of the tasks for the PC user in this approach. An inconsiderate dialogue start may disrupt a interacting partner's task. Therefore, we focus on nonverbal information expression functions of the avatar avoiding unintended disturbance by dialogue initiation.

2.1 Overview of Acceptable Dialogue Start Supporting Agent

We are developing an AMMCS for an unconsciously harmonized multi-tasking online communication. The system's design is based on an interaction model with three stages: before dialogue, during dialogue, and closing dialogue. The ADSS agent, which is the core of the developing AMMCS, is designed for assisting pleasant and

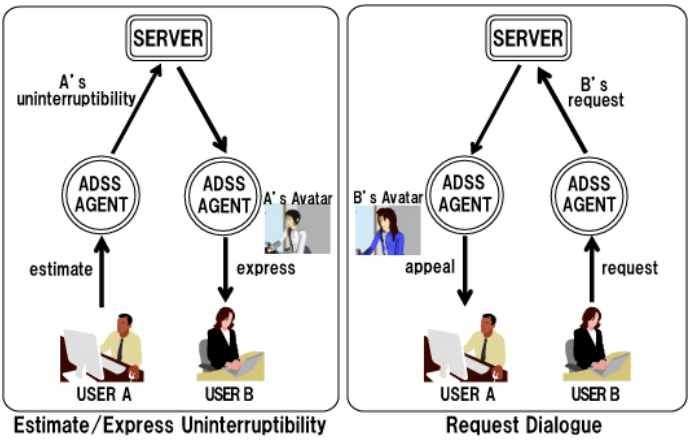

Fig. 1. Overview of ADSS agent

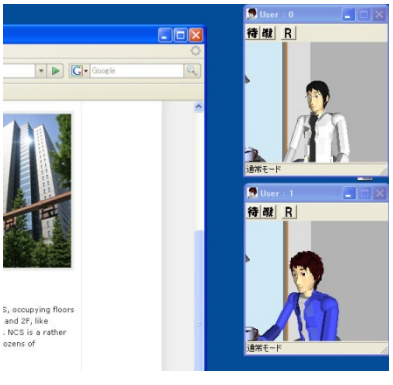

Fig. 2. Screenshot of user desktop using the ADSS agent system

acceptable dialogue initiation. This paper focuses on an ADSS agent that estimates and expresses user uninterruptibility, and presents dialogue requests from a partner during the before-dialogue stage.

Fig.1 shows an overview of the ADSS agent. The agent monitors its user's activity and estimates the user's uninterruptibility. Each agent connects to the server and exchange uninterruptibility information over the Internet. The agent expresses the partner's uninterruptibility using a CG avatar. When the agent receives a dialogue request such as "I want to talk with you" from a partner, the agent presents the dialogue request using unobtrusive motions. Fig. 2 shows a screenshot of the user desktop while using the agent. Each communication partner is displayed as an avatar in a small individual window. The avatars make each user aware of the partner's uninterruptibility and requests by posture and motion.

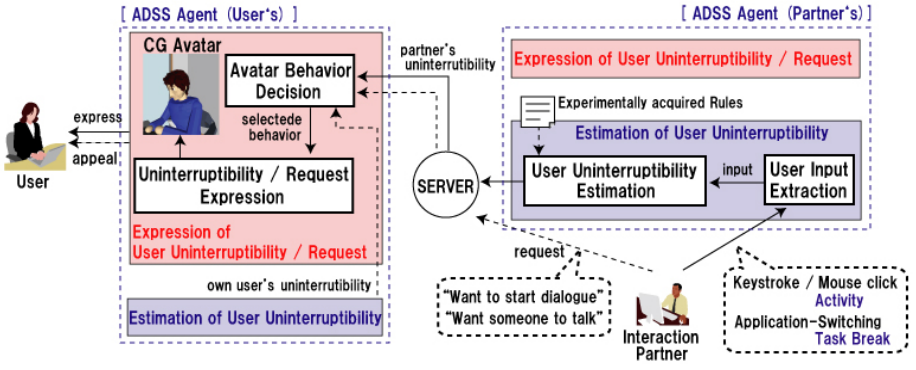

Fig. 3. Architecture of the ADSS agent

2.2 Architecture of Acceptable Dialogue Start Supporting Agent

Fig.3 shows the architecture of prototyped ADSS agent. The developed agent consists of two main functional components, the user uninterruptibility estimation component and the expression component for user uninterruptibility and dialogue request expression.

The user uninterruptibility estimation component monitors the user's PC operation activity, and estimates user uninterruptibility based on experimentally obtained rules. The estimated uninterruptibility is exchanged, and the expression component expresses the uninterruptibility of the interaction partner using a CG avatar. The expression component also expresses intentional dialogue requests of the interaction partner such as, "want to start dialogue" or "want someone to talk to." The expression strength of the request is modified based on the user and the partner's uninterruptibility, to attain pleasant and acceptable dialogue initiation.

3 Estimation and Expression of User Uninterruptibility

3.1 Experimental Evaluation of the Effect of AS on Uninterruptibility

The system estimates the uninterruptibility of PC users based on three kinds of information: keystrokes, mouse clicks, and AS. The transition of the focused application window is considered as an intentional switching of working space or working target by the user. Therefore, user concentration at AS has a high probability of being lowered instantaneously compared to that during continuous work. It means AS may be a suitable timing to start a dialogue. To examine the assumption, we experimentally collected user operation and subjective interrupt evaluation logs.

We implemented a logging tool that records keystrokes, mouse clicks, and the active window name every 500 ms. In our research, we detect AS as a change in the active window. Fig.4 shows the architecture of the logging tool. The tool interrupts the user at AS or every 5 minutes during continuous work (NAS), requesting the user to subjectively evaluate the extent to which the user does not want to be interrupted. The evaluation is scaled from 1: "No problem" to 5: "Absolutely uninterruptible."

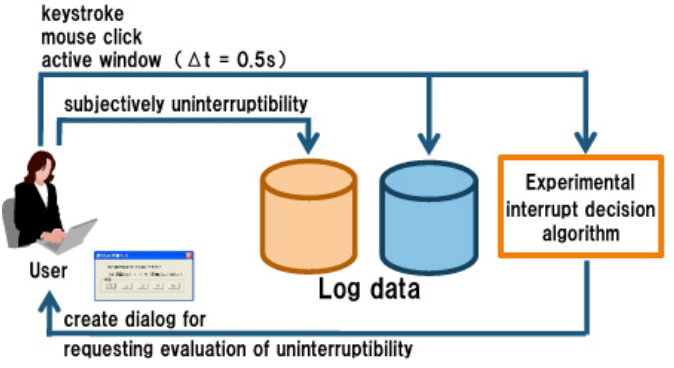

Fig. 4. Experimental logging tool

Evaluation logs exceeding 20 hours of evaluation during daily PC activity were collected from 10 university students without intentional PC usage. The main purposes of PC use were programming, web browsing, report writing, and data arranging.

3.1.1 Log Data Analysis: AS vs. NAS

Table 1 shows the uninterruptibility comparison between AS and NAS. The experimental results suggest that interrupts at AS are significantly more acceptable for users than interrupts during continuous work ($p < 0.01$).

However, some highly uninterruptible evaluations occurred at AS, indicating that some kinds of AS have less of an uninterruptibility reduction effect. Therefore, we analyzed the relationship between uninterruptibility and the AS frequency. From this analysis, interruptions at less frequent AS were more acceptable than those at more frequent AS ($p < 0.05$).

As interrupts at AS are acceptable significantly for users than those during continuous work, expressing AS interaction partners with avatar motion is useful for assisting pleasant and acceptable dialogue initiation.

3.1.2 Log Data Analysis: Activity and Uninterruptibility during NAS

From the above analysis, AS periods are more suitable for starting dialogue than the periods of continuous work. However, in some situations, the user cannot wait for AS for some reasons (emergency, important information, etc.). Therefore, uninterruptibility estimation during NAS is also needed for encouraging/discouraging dialogue initiation. We analyzed uninterruptibility and activity, keystrokes, and mouse clicks for estimation during NAS.

Table 1. Subjective evaluation of system interrupt at AS and NAS

	Subjective score of uninterruptibility					
	1	**2**	**3**	**4**	**5**	**Ave.**
Application Switch	51	80	67	45	36	**2.8**
Not Application Switch	7	14	22	20	12	**3.2**

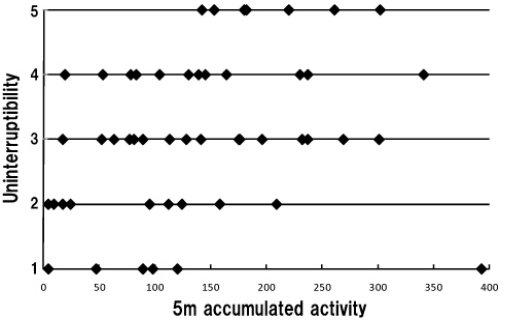

Fig. 5. 5-minutes' accumulated activity and uninterruptibility

In this study, the activity A(t) is calculated using equation (1). Kt is the keystroke count, Ct the mouse click count, and Ht the amount of mouse wheel use. The keystroke count is considered as an important factor because it reflects the user status efficiently [1].

$$A(t) = 2\,Kt + Ct + Ht\,. \tag{1}$$

Fig.5 shows the 5–minute's accumulated activity and the uninterruptibility score. No data in the study has a zero activity, which suggests that at least 5 minutes of activity accumulation is needed to distinguish the working and resting status. A correlation between uninterruptibility and the 5-minutes' accumulated activity was also observed suggesting that the 5-minutes' accumulated activity reflects uninterruptibility during NAS.

3.2 Two Ways of Expressing the Two Estimated Uninterruptibility Components

Based on the analysis, we defined two user uninterruptibility components, the activity component and the task break component. The activity component is calculated as the weighted summation of the keystroke and mouse click counts for 5 minutes. The task break component is calculated as the frequency of AS for 5 minutes, representing the uninterruptibility reduction effect of AS. The estimated uninterruptibility is exchanged via the network. The agent sends the activity component to the server every second. When the user switches his/her application, the agent sends the task break component immediately.

The uninterruptibility expression is required to be intuitive for easy and natural recognition. The impression of the expression also needs to be consistent among users and compatible with AMMCS. The uninterruptibility expression of the ADSS agent was designed to control the posture and motion of the CG avatar based on the activity and task break components. Fig.6 shows the relationship between each of the two components and expressions. The posture reflects the gradual change in the activity component that is sent every second. Dynamic motions such as "drinking coffee" are used to express the task break component.

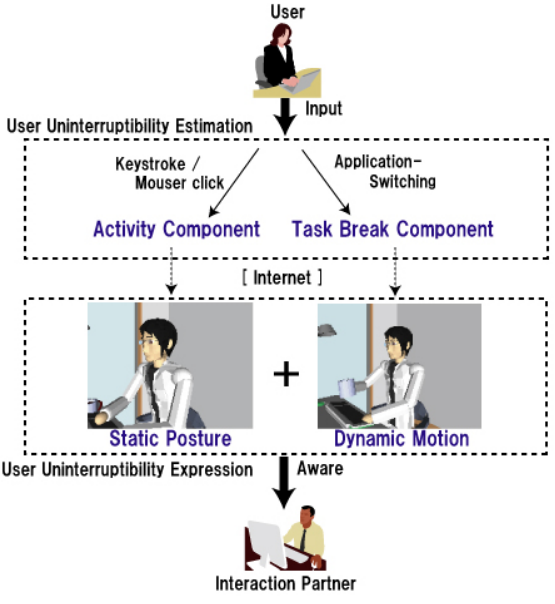

Fig. 6. Relationship between two components and two expressions

4 Ambient Presentation for Acceptable Dialogue Initiation

The expression component shows the uninterruptibility of interacting partners using postures and motions of CG avatars, and dialogue requests using the gaze of the avatar.

4.1 Overlapping Motions for Controlling Uninterruptible Impression

In order to adequately control the intensities of uninterruptibility impressions, interpretations of the uninterruptibility reflected in various postures and motions of humans in daily life were subjectively evaluated prior to the expression design. According to the trends of the evaluation, the following factors were utilized for the uninterruptibility intensity expression.

(1) Distance between body and workspace (PC, desk, etc.): bend forward / neutral / lean against the chair
(2) Body direction relative to workspace: face to workspace / face to other place
(3) Head direction relative to workspace: face to workspace / face to other place
(4) Hand position: on the keyboard / on the desk / under the desk

These factors are useful for expressing uninterruptibility. However, individual difference in the uninterruptibility impression for a posture makes it difficult to control the strength of the impression. For example, the distinction in uninterruptibility between “bend forward” and “keystroke” differs among individuals.

In this research, rather than changing the avatar’s motions to express higher uninterruptibility, we overlapped the motions. This allows us to avoid identification of the

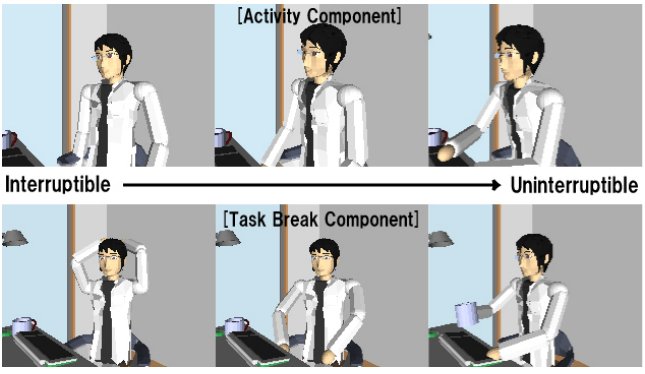

Fig. 7. Examples of postures and motions for uninterruptibility expression

motion that gives a stronger impression of uninterruptibility. Fig.7 shows examples of the postures and motions expressing the activity and task break components using an overlap.

4.2 Ambient Presentation of Dialog Request Using Gaze Control

The dialogue request expression has a risk of unintentional disturbance on the working partner even if the user monitors the partner's uninterruptibility because of an estimation error. Dialogue requests using popup windows or sound may disturb the partner's work seriously, depending on estimation errors. Therefore, an ambient and natural presentation of the request is needed to allow the busy partner not to respond until a break.

In this research, the designed ADSS agent softly presents a dialogue request to the interaction partner using gazing actions, and leads the user to start the dialogue themselves. Therefore, the soft dialogue request assists pleasant and acceptable dialogue initiation even with estimation errors or uninterruptibility expression misunderstanding. Fig.8 shows the relationship between the uninterruptibility expression and the request presentation.

The ADSS agent on user A's side estimates the uninterruptibility of user A and sends it to the agent for user B. User B recognizes the uninterruptibility of user A and

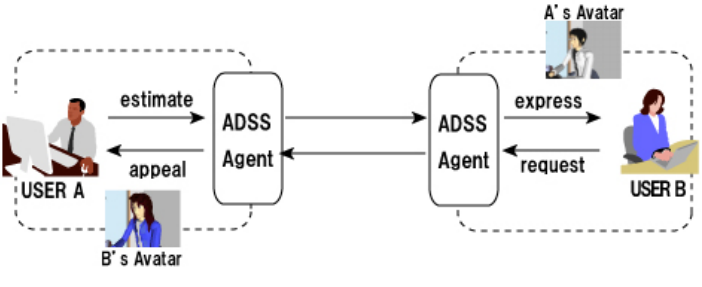

Fig. 8. Relationship among expression and request

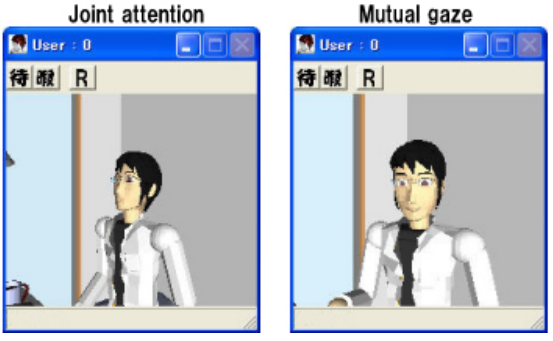

Fig. 9. Expression of dialogue request using joint attention and mutual gaze

judges the dialogue start timing through user A's avatar. The dialogue request by user B is sent to the ADSS agent for user A, and the agent extends the request unobtrusively. The prototype system is designed to express two types of dialogue requests individually; one for a specific partner that means "I want to talk to you," and the other is the wish for chat, which means "I want someone to talk with during an idle time."

The ADSS agent presents a specific dialogue request by using both joint attention and mutual gaze, as shown in Fig.9. If the partner is in the NAS state, the agent avatar sometimes watches the partner's active window. The frequency and duration of the joint attention are controlled based on the partner's uninterruptibility, so as not to disturb the partner's work. At the partner's AS, the avatar gazes at the partner to steer the user to talk. The gaze angle and duration are controlled based on the partner's task break intensity.

The wish for chat is expressed by lowering the user uninterruptibility from the estimated value. A lower uninterruptibility expression is expected to increase the chance to be chosen as a talk partner if there is someone who wants to talk. This appeal is a passive dialogue request to a few interaction partners.

5 Conclusions

We proposed an acceptable dialogue start supporting agent for avatar-mediated multitasking communication systems. The agent estimates user uninterruptibility based on PC operation activity and application-switching. The agent expresses the intensity of partner uninterruptibility using avatar animation that overlaps postures and motions. Moreover, the agent presents dialogue requests from partners and assists pleasant and acceptable dialogue initiation. Experimental evaluation of the effect of the uninterruptibility expression is yet to be conducted.

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