Augmented Cyberspace Exploiting Real-time Biological Sensor Fusion

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Abstract

In Web-based CSCW (Computer-Supported Cooperative Work) often including cooperative learning, different from face-to-face communication, partners' situations including their interest, concentration, boredom, and tiredness cannot be easily transmitted. To overcome these problems, "Augmented Cyberspace" for dependable Web-based CSCW Systems, is proposed, which is also applicable to system such as e-learning, e-commerce, etc. This assesses situations of remote users through timely fusing information of multiple biological sensors and the related contexts.

Introduction

In distributed cooperation, different from face-to-face communication, information or intention is not correctly transmitted to distant members, resulting in misunderstandings and contradictions that can cause interface errors and/or problems in cooperative development. We are aiming at solving such problems in Web-based Computer-Supported Cooperative Work (CSCW). CSCW is a technology to support human cooperation by computer (Greif 1988). We propose a concept of "Augmented Cyberspace", which emphasizes the situational features of remote users, using many kinds of biological information and more general situational information called "context"(Gonzalez 2004).

Fig.1 shows the system of the augmented cyberspace. Firstly, physiological information is obtained through natural, unobtrusive and even spontaneous measuring of the physiological conditions of remote users by various kinds of multiple biological sensors. Then, through integrating and analyzing, namely fusing such information, a physiological situation (tiredness level, concentration level, etc.) is assessed. This situation is a physical and mental situation, which contains any strong interest, indifference, or tedious atmosphere. This is a real time process considering also temporal timing. Namely, based on situational information identified through the biological fusion, the system generates information for representing or rather emphasizing user's situations especially physiological situations. Finally, this information is distributed to remote users and displayed in cyberspace using multimedia such as messages, images, sounds, etc.

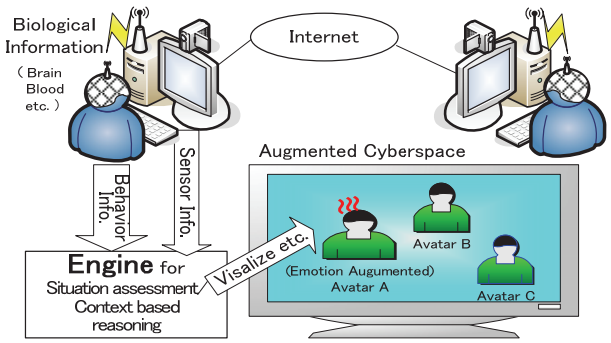

Fig.1. Augmented Cyberspace for Dependable CSCW

Biological Sensor Fusion

In this biological sensor fusion method, the knowledge of information synthesis and analysis is used for fusing various kinds of sensor information to improve the accuracy of the measurement or situation assessment.

- The information synthesis knowledge: It decides which combination or order measurement should be done about the measurement equipment and condition.
- Information analysis knowledge (Information request knowledge): Using this knowledge, systems predict and request information necessary for the contradiction solving, the lost information interpolation, or just confirmation.

Person's physical or mental situation is inferred and estimated using this knowledge. To do this, various sensor data such as the brain wave, the heart beat, and the ocular mobility, etc. is taken as input.

Concretely, the inference proceeds as shown in Fig.3. When a certain set of conditions is satisfied from inputs of multiple sensors, the symptom node becomes active. However, a huge amount of sensor information cannot be processed simultaneously when real time response is considered. Only the basic sensor information that becomes a key for the symptom identification is processed quickly. Next, the obtained symptom and situation are examined in more detail, so that input data obtained in a different measurement condition such as another angle and timing of another sensor can be integrated. Thus, accuracy is improved without losing real time response.

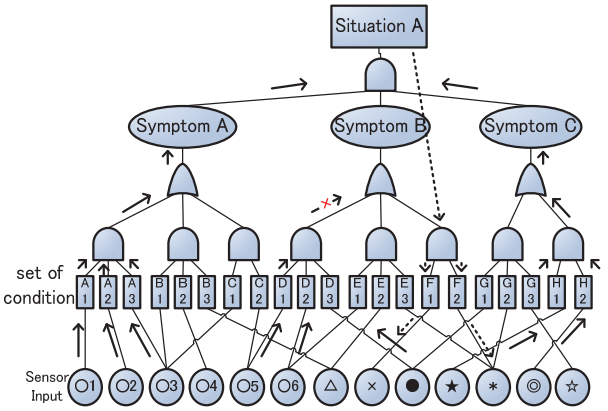

Fig.3. Situation assessment using situation synthesis and analysis knowledge

Biological sensor fusion feasibility

The necessities and feasibility of biological sensor fusion were concretely estimated by the following experiment.

Contents of the experiment: The experiment is conducted to examine the effects on biological information by the drowsy state. We measured the biological information of 11 subjects who were working out easy addition problems (Uchida Kraepelin test), once when the subjects were drowsy and once when the subjects were normal. The measurement for drowsiness was conducted after the subjects had stayed up all night in order to feel drowsy.

Schedule: The test process included, the repetitions of 30 minutes for Kraepelin-test and 5 minutes for a rest: It was checked whether the influence of the calculation load can be detected by the biological sensor information.

Measuring instruments (Biological sensors):

-Finger pulse wave (PTG): Sampling period 50Hz, pulse rate is calculated based on the PTG.

-Fingertip skin temperature: Sampling frequency 1Hz,

-Fingertip perspiration: Sampling frequency 1Hz

The answer count is the number of problems answered correctly in one minute. The results show that the number of answers was decreased when the subject was drowsy. When the number of answers and the concentration level are assumed to be proportional, the number of answers becomes indication of the concentration level. Therefore, Fig.4 shows correlations between pulse rate and concentration. It shows that pulse rate change was growing when the subject was drowsy and the number of answers was low. It also shows that the pulse rate has lowered in drowsiness state compared with the normal state.

The results of correlations between perspiration and concentration showed that perspiration increased when subjects were drowsy and the number of answers was low. The results of correlation between skin temperature and concentration showed that the skin temperature has lowered in drowsiness states compared with normal states.

It was clarified that the influence of the drowsiness or fatigue due to task load or inversely the influence of motivation due to competition such as the symptom of tiredness or concentration can be detected by the fusion of simple but multiple biological sensors.

And, the symptom detected by some of such sensors followed after the curve of the correct answer ratio of the Kraepelin-test, sometimes with delay or individual difference. Thus, various kinds of multiple simple sensors are necessary to detect symptoms, such as concentration and tiredness, needed for improving the collaboration reliability. Therefore, if information on many kinds of many handy biological sensors is fused, appropriate symptoms can be detected with sufficient reliability.

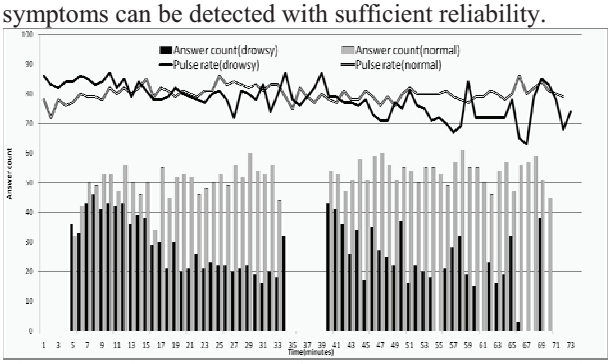

Fig.4. Correlation among pulse (PTG) rate & concentration

Conclusion

Focusing on enhancing the dependability of web-based CSCW, a concept of "Augmented Cyberspace" was proposed. Especially to realize this concept, the situations of remote users are assessed through information fusion of multiple biological sensors and more global contexts though the global contexts were not handled here but will be realized in the near future. For implementing this concept, a mechanism to synthesize sensor information and to analyze the result through information request was proposed to support a dependable communication in Web-based collaboration systems.

The feasibility was investigated as to the information fusion of multiple sensors such as heart beat sensors, skin temperature sensors, and perspiration sensors. The necessity and feasibility for fusing information of various sensors were concretely confirmed by the experiments.

Acknowledgment

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