Introduction to the Special Issue on Eye Gaze in Intelligent Human-Machine Interaction

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Given the recent advances in eye tracking technology and the availability of nonintrusive and high-performance eye tracking devices, there has never been a better time to explore new opportunities to incorporate eye gaze in intelligent and natural human-machine communication. In this special issue, we present six articles that cover various aspects of eye gaze in human-machine interaction, including applications of gaze tracking in human-machine interaction, techniques that recognize gaze gestures and render gaze behaviors, and the analysis of gaze behaviors in social interactions.

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1. THE TOPIC OF THE SPECIAL ISSUE

Given the availability of nonintrusive and high-performance eye-tracking devices, there has been an increasing interest in incorporating human eye gaze into intelligent user interfaces. Eye gaze has been used as a pointing mechanism in direct manipulation interfaces, for example, to assist users with "locked-in syndrome". It has also been used to reflect information needs in Web search and to tailor information presentation. On the basis of the way in which joint attention is indicated by eye gaze, it has been used as a facilitator in computer-supported human-human communication. In conversational interfaces, eye gaze has been used to improve language understanding and intention recognition. It has also been incorporated in multimodal behavior of embodied conversational agents. Recent work on human-robot interaction has further explored eye gaze in incremental language processing, visual scene processing, and conversation engagement and grounding.

2. ARTICLES IN THE SPECIAL ISSUE

This special issue presents six articles that address different topics on the role of eye gaze in human-machine interaction. The first three articles investigate the tracking of real-time human gaze behaviors as input to applications concerning safe driving, information retrieval, and the control of electronic devices. The last three articles

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examine the role of artificial or human eye gaze in situated social interactions between humans and artificial agents.

2.1. Gaze Guidance Reduces the Number of Collisions with Pedestrians in a Driving Simulator

The article by Pomarjanschi and colleagues explores new approaches that incorporate gaze tracking with real-time vision systems to unobtrusively direct the drivers' eye movements toward critical events (e.g., a pedestrian crossing the street). The empirical studies using a driving simulator have demonstrated that their approaches can help drivers efficiently distribute their attention resources and significantly reduce collisions. This work has important implications for enabling technology to provide safer driving in the future.

2.2. Attentive Documents: Eye Tracking as Implicit Feedback for Information Retrieval and Beyond

In this article, Buscher and colleagues present new empirical findings addressing the relations between eye-movement, attention, and text relevance while reading. The authors have developed a reading detection algorithm that takes raw gaze data from an eye tracker and detects users' reading behaviors. They have further applied the detection algorithm to Web search. Their empirical results have demonstrated that incorporation of the implicit feedback in eye movements can significantly improve search performance.

2.3. Gliding and Saccadic Gaze Gesture Recognition in Real Time

The article by Rozado and colleagues introduces an approach to controlling electronic devices in real-time, using gaze gestures. The authors are able to show that a specific combination of gaze gesture types and recognition algorithms allows for a very reliable use of intentional gaze gestures. Since the approach does not interfere with other kinds of gaze interaction, it offers great promise for future human-machine interfaces, for example, in the area of accessibility.

2.4. Taming Mona Lisa: Communicating Gaze Faithfully in 2D and 3D Facial Projections

The article by Al Moubayed and colleagues starts from the observation that traditional displays of talking heads introduce severe limitations in communication because of the Mona Lisa effect. Regardless of the viewing angle of the users, a talking head always seems to follow them. As a solution, the authors present a setup that projects the talking head onto a physical model of a head. The work is of high relevance to video conferencing systems and embodied conversational agents, because the ability to distinguish between eye contact and averted gaze is the most important prerequisite for successful communication.

2.5. Conversational Gaze Mechanisms for Humanlike Robots

In this article, Mutlu and colleagues present mechanisms for enabling conversational gaze in humanlike robots. It starts with a systematic investigation of the role of eye gaze in information, conversation, and participation structures in human-human conversation. It then captures the observed human behaviors in computational models for topic signaling, turn-taking, and role-signaling. Through empirical studies, the article demonstrates that the use of conversational gaze mechanisms in robots allows humans to conform better to their conversation roles, to develop rapport with the robot, and achieve a sense of "groupness" with the robot. This is an important contribution in facilitating robots' humanlike behaviors as well as human-robot dialogue.

2.6. Adaptive Eye Gaze Patterns in Interactions with Human and Artificial Agents

The paper by Yu and colleagues makes an important contribution to the understanding of gaze-based human-agent communication by presenting a novel experimental design to directly compare eye gaze in human-human interaction with eye gaze in human-robot interaction. Unlike earlier work, this article addresses the challenge of understanding the exact causes of micro-level multimodal behaviors in a naturalistic task. In their experiments, they identify a number of interesting differences in the dynamics of gaze that may provide very useful insights to the designers of future human-agent interfaces.