Abstract
Previous work on eye tracking and eye-based human-computer interfaces mainly concentrated on making use of the eyes in traditional desktop settings. With the recent growth of interest in smart glass devices and low-cost eye trackers, however, gaze-based techniques for mobile computing is becoming increasingly important. PETMEI 2014 focuses on the pervasive eye tracking paradigm as a trailblazer for mobile eye-based interaction and eye-based context-awareness. We want to stimulate and explore the creativity of these communities with respect to the implications, key research challenges, and new applications for pervasive eye tracking in ubiquitous computing. The long-term goal is to create a strong interdisciplinary research community linking these fields together and to establish the workshop as the premier forum for research on pervasive eye tracking.

Author Keywords
gaze-based interaction, eye tracking, human-computer interaction

ACM Classification Keywords
H.5.2 [Information interfaces and presentation (e.g., HCI)]: User Interfaces/Input devices and strategies
Introduction and Motivation

Eye tracking technology has been maturing in recent years, and eye-based interaction is gaining attention in various application areas. While early work on applied eye tracking investigated gaze as an input modality to interact with desktop computers, it is becoming increasingly important to take eye tracking out into pervasive and mobile settings in various areas such as human-human and human-robot interaction and wearable computer systems.

We call this new paradigm pervasive eye tracking - continuous eye monitoring and eye-based interaction 24/7 [3, 2]. The potential applications for the capability to track and analyse eye movements anywhere and any time call for new research to further develop and understand visual behavior and eye-based interaction in mobile daily-life settings. Pervasive eye tracking opens up new research across a number of disciplines including ubiquitous computing, human-robot and human-computer interaction, eye-tracking research, egocentric vision, cognitive psychology, and design. Identifying the implications and addressing the challenges of pervasive eye tracking and mobile eye-based interaction will require an interdisciplinary approach at the crossroads of these fields.

The advent of video-based eye-tracking technologies has paved the way for new research in everyday environments and mobile settings [9]. Eye tracking is beginning to be implemented on mobile devices such as smart phones and tablets, which are increasingly equipped with the user facing cameras [19, 13]. Wearable cameras or smart glass devices such as Google Glass\(^1\) are also gaining more attention in recent years, and eye-tracker components have the potential to play an important role for future development.

\(^{1}\)http://www.google.com/glass/start/

A growing number of researchers study eye-based interaction in mobile daily-life settings, thereby opening up new application areas and promising eye-based interaction to become mainstream. Mobile eye trackers can provide an indicator of user attention in daily environments [10, 1, 18, 7, 16], and eye movements can be used as a new modality for activity and context recognition [4, 14].

Research on pervasive eye tracking is also highly relevant for basic research on human-human interaction and important for more social human-robot interactions. While eye tracking analysis has a long history in psycholinguistics and cognitive psychology, the focus was restricted to single users for a long time. With the development of unobtrusive eye-tracking technology, the potential scope of investigation is broadened to interactive settings, and multi-user eye tracking is a promising tool to study social factors in visual thinking and support collaborative interaction [8, 16].

Another important precondition for context-aware gaze-based interaction is a sound knowledge about the visual environment. Egocentric vision is an emerging research topic in the field of computer vision, which aims at machine understanding of egocentric videos taken by wearable cameras recording from the point of view of the user. Egocentric vision is closely related to visual attention and human perception, and gaze is considered as an important cue in recent research. For example, egocentric videos have been used to reconstruct 3D social gaze to analyze human-human interaction [15], and eye gaze information has been incorporated into first-person activity recognition [6]. The use of gaze information is also becoming more and more important in computer vision tasks such as object and scene recognition [11, 20].
The PETMEI Workshop Series
The first workshop on pervasive eye tracking and mobile eye-based interaction was held in conjunction with UbiComp 2011 in Beijing, China [3]. PETMEI 2011 attracted about 30 participants who enjoyed 11 high-quality oral presentations and demos of the latest mobile eye trackers presented by four of the leading eye tracking companies. Following the success of PETMEI 2011, the second workshop PETMEI 2012 was held in conjunction with UbiComp 2012 with 9 oral presentations and also approximately 30 participants [2].

In contrast to the first two workshops, PETMEI 2013 was organized as a conference track at the 17th European Conference on Eye Movements (ECEM 2013), a conference of basic research in psychology, linguistics and computer science. In this interdisciplinary setting, twelve oral presentations successfully attracted about 60 participants.

The fourth PETMEI in 2014 is again part of UbiComp. This year, we would like to further advance pervasive eye tracking technologies with our special theme egocentric vision, which is also highly-relevant in the area of ubiquitous computing. We thus especially hope to attract participants who are new and open to eye-tracking and gaze-based interaction research from this scientific area. We further want to stimulate and explore the creativity of researchers working in human-computer interaction, ubiquitous computing, computer vision and eye tracking with respect to the implications, challenges, and new applications for pervasive eye tracking.

Objectives
The main objective of the workshop is to bring together researchers and practitioners working in human-computer interaction, context-aware computing, egocentric computer vision and eye tracking. The workshop will create a forum for these researchers to gather, present their ideas, and to discuss techniques and applications that go beyond classical eye tracking and stationary eye-based interaction.

Specifically, we want to encourage these communities to think about the implications of pervasive eye tracking for context-aware computing, i.e. the ability to track eye movements not only for a couple of hours inside the laboratory but continuously for days, weeks, or even months in people's everyday life. The workshop aims to identify the key research challenges in pervasive eye tracking and mobile eye-based interaction and to discuss the technological and algorithmic methods required to address them. The workshop shall provide intellectual stimuli and build bridges for future collaborations between these communities. The long-term goal is to create a strong interdisciplinary research community linking the different research fields and to establish the workshop as the premier forum for research on pervasive eye tracking in context-aware computing.

Topics of Interest
Topics of interest cover computational methods, new applications and use cases, as well as eye tracking technology for pervasive eye tracking and mobile eye-based interaction.

Methods
Previous research in HCI and eye tracking has resulted in a large variety of methods, e.g. for eye detection and tracking [9], automated eye movement analysis [17], or evaluation of eye movement classification algorithms [12]. We invited participants to reflect on the specific
characteristics of pervasive eye tracking systems and to contrast them with classical methods for eye tracking, eye movement analysis, eye-based interaction, and evaluation. Identifying the key differences will then allow to formulate key requirements for the implementation of mobile eye-based interfaces.

We welcomed contributions reporting on methodological advances on all components of mobile eye tracking systems. This may, for example, include computer vision techniques to face and eye detection and tracking, pupil localization, calibration, and gaze estimation, pattern recognition and machine learning techniques for automated eye movement analysis, as well as methods and user studies to evaluate specific interaction techniques.

The workshop also covers latest technological advances in mobile eye tracking equipment. This includes creative use of existing measurement techniques and systems as well as potentially new types of eye tracking hardware.

- Eye tracking technologies for mobile devices
- Tools for face, eye detection and tracking
- Gaze and eye movement analysis methods
- Integration of pervasive eye tracking and context-aware computing
- Multi-modal sensor fusion
- User studies on pervasive eye tracking
- Devices for portable, wearable and ambient eye tracking

Applications
Classical eye tracking has found a large number of applications in both research and industry [5]. In addition to contributions reporting on methodological advances we also attracted submissions that explore innovative applications of pervasive eye tracking and mobile eye-based interaction. We aim to identify and discuss which applications are possible and which are only imaginable. By inviting researchers from different disciplines, we aim to identify particularly promising applications (the “killer applications”) for pervasive eye tracking and mobile eye-based interaction.

This year we wanted to particularly invite presentations on research on egocentric vision systems that can potentially extend the possibility of current mobile gaze interaction. We also welcomed gaze-related computer vision applications to investigate further possibilities for incorporating real-time gaze information into egocentric vision systems. In this manner, we also aimed to encourage interdisciplinary researches between computer vision, machine learning, human-computer interaction and ubiquitous computing.

- Pervasive eye-based interaction
- Mobile attentive user interfaces
- Eye-based activity and context recognition
- Security and privacy for pervasive eye-tracking systems
- Eye tracking for specialized application areas
- Eye-based human-robot and human-agent interaction
PETMEI will be held on September 13th, 2014, as a one-day workshop as part of the UbiComp 2014 workshop program. Participants will have a background in context-aware computing, human-computer interaction, egocentric vision, or eye tracking. As the workshop covers a new area of research at the crossroads of these fields, we not only aim to attract domain experts but also newcomers with an interest in potential applications of pervasive eye tracking in their respective fields. We also want to leave space for more speculative work and work-in-progress to give researchers the opportunity to present their work to colleagues at an early (but not ill-conceived) stage. In addition, we plan to invite an expert in egocentric vision research to give a keynote at the beginning of the workshop to stimulate the discussion.

In addition to technical presentations we plan to reserve significant time for an afternoon plenary discussion. Based on a structuring summary of the presentations (prepared and given by the organizers) we want to discuss about the implications, key challenges, as well as future directions in pervasive eye tracking and mobile eye-based interaction.

Organizers
The workshop will be organized by three researchers who are actively involved in the research fields of context-aware computing, eye tracking, computer vision and eye-based interaction. All of them have a strong technical background and a long-standing expertise in applications of eye tracking in these fields.

Thies Pfeiffer
Thies Pfeiffer is Akademischer Rat (Assistant Professor) at the Center of Excellence Cognitive Interaction Technology at the Faculty of Technology of Bielefeld University, Germany. His research is focusing on human-computer interaction in virtual and real 3D worlds and human-agent interaction with artificial intelligences. He received his PhD in information science and technology from Bielefeld University in 2010.

Sophie Stellmach
Sophie Stellmach has recently become Scientist at Microsoft investigating novel user experiences. Her eye-tracking research has focused on the visualization of gaze data in virtual 3D environments and on convenient gaze-supported interaction using multimodal combinations of gaze with different input modalities including physical buttons, touch input, and foot input. In May 2013, she has received her PhD on Multimodal Gaze-Supported Interaction from the Technical University of Dresden, Germany.

Yusuke Sugano
Yusuke Sugano is a postdoctoral researcher at Max Planck Institute for Informatics, Germany. His research is focusing on calibration-free gaze estimation and computational models of visual saliency. His further research interests include gaze-assisted computer vision, egocentric vision systems and vision-based human-computer interaction. He was previously a project research associate at Institute of Industrial Science, the University of Tokyo, and received his PhD in information science and technology from the University of Tokyo in 2010.

Program Committee
PETMEI 2014 is supported by the following program committee members:
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References


