Gaze and Foot Input: Toward a Rich and Assistive Interaction Modality

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Abstract
Transforming gaze input into a rich and assistive interaction modality is one of the primary interests in eye tracking research. Gaze input in conjunction with traditional solutions to the "Midas Touch" problem, dwell time or a blink, is not matured enough to be widely adopted. In this regard, we present our preliminary work, a framework that achieves precise "point and click" interactions in a desktop environment through combining the gaze and foot interaction modalities. The framework comprises of an eye tracker and a foot-operated quasi-mouse that is wearable. The system evaluation shows that our gaze and foot interaction framework performs as good as a mouse (time and precision) in the majority of tasks. Furthermore, this dissertation work focuses on the goal of realizing gaze-assisted interaction as a primary interaction modality to substitute conventional mouse and keyboard-based interaction methods. In addition, we consider some of the challenges that need to be addressed, and also present the possible solutions toward achieving our goal.

Author Keywords
Gaze and foot interaction; Eye tracking; Foot input; Tabletop interaction; Authentication

ACM Classification Keywords
H.5.2 [Information Interfaces and Presentation]: User Interfaces—*Input devices and strategies*.

Introduction
Realizing gaze-assisted interaction as a primary input modality has gained momentum since the work of [2] and [3]. A seamless integration of the gaze modality in desktop environments enriches user interactions, and can also serves as an assistive technology [6]. For systems leveraging the gaze modality, executing a user's commands at the point of regard has always remained an issue that needs to be addressed. Apart from dwell time and blink based solutions for executing a user's commands, other solutions use voice and gesture input along with the gaze modality. Recent work has demonstrated that the foot input to register user actions is the most feasible solution [1]. However, a thorough comparative study of all solutions to the "Midas Touch" problem [2] has yet to be done.

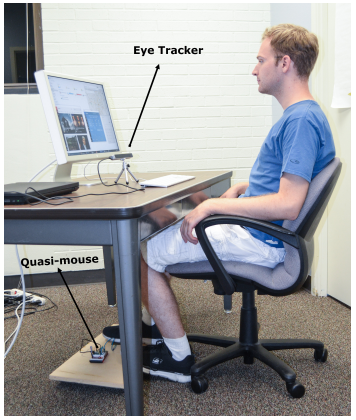

Figure 1: A User Working on a Computer Using GAWSCHI

A task that involves both mouse and keyboard based sub-tasks, in an alternate order, becomes cumbersome, as the user needs to constantly switch the hand between the keyboard and mouse. We envision a system that eliminates these issues, in addition, empowers the user to perform tasks quicker than the mouse interaction, while also serving as an assistive technology for the physically challenged. An ability to interact using the combined gaze and foot modality has a stronger applicability for tasks that mainly rely on the mouse input, with a limited dependency on the keyboard input. Our work, GAWSCHI: a Gaze-Augmented, Wearable-Supplemented Human-Computer Interaction framework enables gaze-assisted interaction, supplemented by the foot-input [5]. The user executes a command, like a click, by looking at the point of regard on the screen and gently pressing the "pressure pad" attached to the quasi-mouse with the foot. A pictorial depiction of GAWSCHI is shown in Figure 1.

Related Work
Design and implementation of foot-operated input devices have always been the areas of interest in Computer-Human Interaction research. Velloso et al. [7], provide a comprehensive survey of the foot-operated interaction modality. Seminal work in foot-operated input devices is conducted by Pearson and Weiser [4], who proposed the design of foot-operated devices, mainly to eliminate the restriction of switching one's hand between the keyboard and mouse. However, only Göbel et al. [1], have combined both the gaze and foot input modalities with a specific focus on pan and zoom interactions. Additionally, [1] states that foot interaction systems are suitable for course pointing interaction (secondary tasks). The gaze and foot interaction framework that we have developed explores these limitations to support precise "point and click" interactions, with an improved design of the foot-operated quasi-mouse [5]. The quasi-mouse can either be placed on the floor (non wearable) or attached to the user's footwear as shown in Figure 2 and 3.

Gaze and Foot Interaction Framework
We have successfully implemented and evaluated a gaze and foot interaction framework: GAWSCHI. Through a user study involving 30 participants, we have shown that GAWSCHI performs as good as a mouse in the majority of tasks, where each task can either be a simple or a complex task involving sub-tasks [5]. During the system evaluation, the participants performed eleven predefined interaction tasks on a computer using GAWSCHI. Some of the tasks included are opening applications from the Start

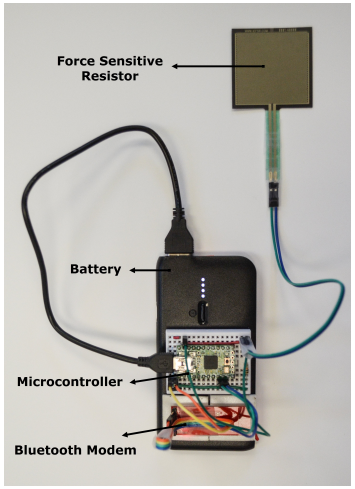

Figure 2: Foot-operated Quasi-mouse on the Floor (non wearable)

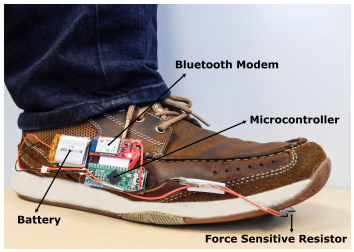

Figure 3: Foot-operated Quasi-mouse, a Wearable Version

menu, desktop, and toolbar; reading emails, navigating on Google maps, and watching videos on a browser; operating on a calculator and task switching, etc. Further details regarding the GAWSCHI framework, system implementation, evaluation, and limitations can be found in [5].

Challenges to be Addressed

In the following sections, we present the challenges in realizing our main goal of leveraging gaze-assisted interaction as a primary interaction modality.

The Interactions should be Natural

Mouse and keyboard based interactions feel quite natural to the user since the user experiences complete control over the interactions. However, with the gaze, it is hard to establish the same "sense of authority" over the interactions due to the lack of appropriate feedback to the user. A gaze-assisted system should reinforce the user with the "sense of authority" over the interactions through an intuitive feedback mechanism. Realizing this goal will translate to more users being open to adopting gaze-assisted interaction.

The System should Support User Learning

Though it is an accepted notion that the skill levels of a user improve with practice, this does not hold true for some interaction modalities such as gesture interaction. However, mouse and keyboard based interactions are intuitive to the users as the system supports user learning. In general, interaction systems that exhibit learning effect become intuitive to the users over time. From the evaluation of GAWSCHI, the learning effect is evident as the users get quicker and more accurate over time. Specifically, once the user starts interacting with GAWSCHI, s/he is able to subconsciously adapt to the combined gaze and foot interaction modality by adjusting head movements and posture. However, the learning effect seen with GAWSCHI needs to be thoroughly explored, and necessary modifications need to be incorporated to make the learning effect apparent.

Enable Interactions Quicker than Mouse

One of the main advantages of gaze-assisted interaction is, a user will already be looking at the Region Of Interest (ROI). If the system could support the user in executing an appropriate command at the ROI, this avoids an additional task of moving the mouse to the ROI, leading to quicker interactions. We hypothesize that through an increased familiarity with a gaze-assisted system, a user can outperform the mouse. Our experiments with GAWSCHI are suggestive of this observation, However, an elaborate study needs to be conducted to validate our hypothesis.

The System should Support Text Input

Gaze-assisted typing is one of the challenges that is yet to be well addressed. The existing solutions use a virtual keyboard along with gaze for text input, but with limited speed and accuracy. We are currently working on incorporating a swipe keyboard with GASWCHI, and hypothesize that this solution would improve the speed and accuracy of text input.

Extending the Functionality of GAWSCHI

We believe that a gaze interaction system should be extensible to support devices of various form factors. In addition, the gaze modality should be leveraged for appropriate utility functions such as user authentication. In the following sections, we briefly touch on some of the extended functionality of the GAWSCHI framework that is under development.

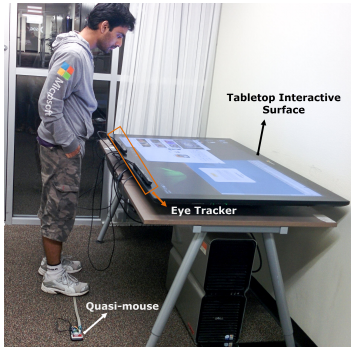

Figure 4: Tabletop Surface Interaction with GAWSCHI

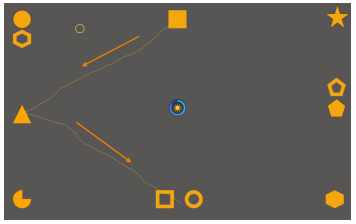

Figure 5: User Authentication Interface with 12 Shapes

Extending GAWSCHI for Tabletop Interactions

Working with tabletop interaction surfaces, like the Microsoft Perspective Pixel, comes with a set of challenges because of the large dimensions of the screen. It is physically strenuous to constantly reach the interface elements that are at, or beyond shoulder length distances. We are extending GAWSCHI to support interactions on tabletop surfaces, where a user will be able to stand next to the device with face directed at the surface, and interact with the UI elements just through gaze, irrespective of their positions of the screen. A pictorial depiction of the system is shown in Figure 4.

GAWSCHI for User Authentication

The gaze modality can be extended to support utility functions. For example, we are extending GAWSCHI to support user authentication; this mode of gaze-driven authentication is non vulnerable to shoulder-surfing attacks. In this method, the user follows three shapes in transition (e.g., triangle, square, circle) on a screen, one at each time, for self authentication. A pictorial depiction of the system is shown in Figure 5. The combination of the three shapes, in sequence, forms a unique password. The system uses sketch recognition algorithms to match the path of the object with the user's scan-path. A hacker with no details of the three shapes, that serve as a password, can not break into the system.

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References

[1] Göbel, F., Klamka, K., Siegel, A., Vogt, S., Stellmach, S., and Dachselt, R. Gaze-supported foot interaction in zoomable information spaces (interactivity). In *Proceedings of the Conference on Human Factors in Computing Systems - Extended Abstracts*, ACM (4 2013).

[2] Jacob, R. J. K. The use of eye movements in human-computer interaction techniques: What you look at is what you get. *ACM Trans. Inf. Syst. 9*, 2 (Apr. 1991), 152–169.

[3] Lankford, C. Effective eye-gaze input into windows. In *Proceedings of the 2000 Symposium on Eye Tracking Research & Applications*, ETRA '00, ACM (New York, NY, USA, 2000), 23–27.

[4] Pearson, G., and Weiser, M. Of moles and men: The design of foot controls for workstations. In *Proceedings of the SIGCHI Conference on Human Factors in Computing Systems*, CHI '86, ACM (New York, NY, USA, 1986), 333–339.

[5] Rajanna, V., and Hammond, T. Gawschi: Gaze-augmented, wearable-supplemented computer-human interaction. In *Proceedings of the Symposium on Eye Tracking Research and Applications*, ETRA '16, ACM (New York, NY, USA, 2016).

[6] Taele, P., and Hammond, T. Developing sketch recognition and interaction techniques for intelligent surfaceless sketching user interfaces. In *Proceedings of the companion publication of the 19th international conference on Intelligent User Interfaces*, ACM (2014), 53–56.

[7] Velloso, E., Schmidt, D., Alexander, J., Gellersen, H., and Bulling, A. The feet in human–computer interaction: A survey of foot-based interaction. *ACM Computing Surveys (CSUR) 48*, 2 (2015), 21.