Implementing Eye-Tracking for Persona Analytics

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ABSTRACT

Investigating users' engagement with interactive persona systems can yield crucial insights for the design of such systems. Using eye-tracking, researchers can address the scarcity of behavioral user studies, even during times when physical user studies are difficult or impossible to carry out. In this research, we implement a webcam-based eye-tracking module into an interactive persona system, facilitating remote user studies. Findings from the implementation can show what information users pay attention to in persona profiles.

CCS CONCEPTS

• **Human-centered computing** → Human computer interaction (HCI).

KEYWORDS

Persona Analytics, Eye-tracking, Remote User Studies

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1 INTRODUCTION

Personas, frequently used in Human-Computer Interaction (HCI) and User-Centered Design (UCD), are fictitious representations of users [Cooper, 1999]. Personas communicate needs and requirements [Aoyama, 2007], mitigate designers' self-referential bias [Marsden et al., 2017], and make it possible to think of users even when they are absent [Pruitt and Grudin, 2003]. Additionally, personas give faces to analytics data [Jansen et al., 2020], humanize market segments [Chapman et al., 2008], offer design inspiration [Nielsen, 2019], help carry out comparisons of users [Jung et al., 2019], and prioritize design decisions [Rönkkö, 2005]. Research states that personas facilitate team members' communication over user needs and pain points [Blomquist and Arvola, 2002]. They are traditionally presented as profiles with information about the users (see Figure 1).

Research on persona user behavior is needed for advancing both theory and practice. Some of the currently unaddressed questions are: (1) *What persona information do users pay attention to?* (2) *How do users (visually) engage with personas?* Answers to these questions help design layouts and information content of persona profiles.

Users' engagement with personas can be measured in several ways. In particular, eye-tracking is a useful technique for observing how users interact with personas [Salminen et al., 2018b]. If eye-tracking is integrated directly into an interactive persona system, it can provide rich datasets of how users interact with and use personas. Integrating webcam-based eye-tracking enables remote user studies under exceptional times when physical user studies are not possible. To this end, we implement a fully functional eye-tracking subsystem directly within an interactive persona system. We demonstrate the capabilities of this integrated system and discuss ways of using it for empirical user studies.

2 RELATED LITERATURE

Three trends have led to the rise of interactive persona systems [Salminen et al., 2020a]: (1) **user data from web analytics and social media platforms via APIs**, (2) **data science algorithms and libraries** that facilitate persona generation, and (3) **web technologies (UIs/interactivity)** that remove the limitations of paper as the medium. These trends signify a transition from static "flat file" personas to "full-stack personas" [Jansen et al., 2021] traceable to the user-level data [Jansen et al., 2020]. They have also resulted in the emergence of *interactive persona systems* [An et al., 2018; Mijač et al., 2018; Salminen et al., 2020a]. These systems are typically served via web browsers [Jung et al., 2018], as web technologies make personas accessible practically from any web-enabled device. Multiple interaction techniques (e.g., persona chat/dialogue systems [Chu et al., 2018]) could be implemented to serve different user needs. However, these possibilities call for better understanding of user behavior, which requires *measurement.*

Online eye-tracking systems have evolved a lot over the years, but their use in research is still rare relative to physical eye-tracking systems that provide higher accuracy and a more controlled environment. The challenges of online eye-tracking include, among others, challenging lighting conditions in users' environment, and the inability of webcams to record changes in the iris, as well as designated eye-trackers, do. Perhaps the most advanced research-based tool is **WebGazer.js**[1] [Papoutsaki et al., 2018; Papoutsaki et al., 2017; Papoutsaki et al., 2016], an online gaze tracker developed

[1] https://webgazer.cs.brown.edu/

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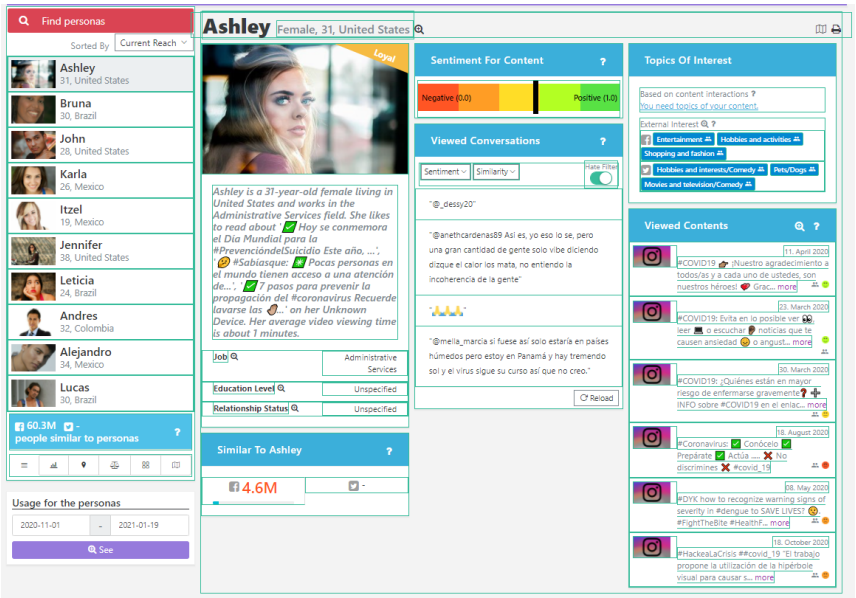


Figure 1: The Automatic Persona Generation system. Users' gaze fixations over the rectangle information elements are logged. The data can be downloaded via the dialogue in the bottom-left corner, only available for system administrators.

Table 1: Use cases for Persona Eye-tracking.

	Research Question (RQ)	Useful for. . .
RQ1	What personas were most/least viewed?	Persona Creation
RQ2	What persona information was most/least viewed?	Persona Information Design
RQ3	What were the most/least common transitions between the information elements?	Persona Information Design
RQ4	What was the average duration of viewing a persona?	Persona User Behavior
RQ5	How long did User A view Persona X?	Persona User Behavior

by the HCI group at Brown University. WebGazer is written entirely in JavaScript, and it is available open source[2]. In this research, we integrate WebGazer to an interactive system called Automatic Persona Generation (APG) [An et al., 2018]. WebGazer returns [x, y] coordinates of a user's gaze fixations on the screen. We then implement the tracking system using the returned coordinates. First, the system maps the coordinates to the corresponding information element the user is gazing upon. Second, the logs are recorded into the database of the system with "in" and "out" timestamps sequentially. The entire logs can be retrieved from the system for further analysis.

3 EYE-TRACKING FOR PERSONA ANALYTICS

We define 'persona analytics' (PA) as *the systematic measurement of behaviors and interactions of users engaged with interactive persona systems*. When a web browser is used to serve personas, PA includes eye-tracking that records the users' gaze movements on the information in the persona profiles.

3.1 Design Requirements

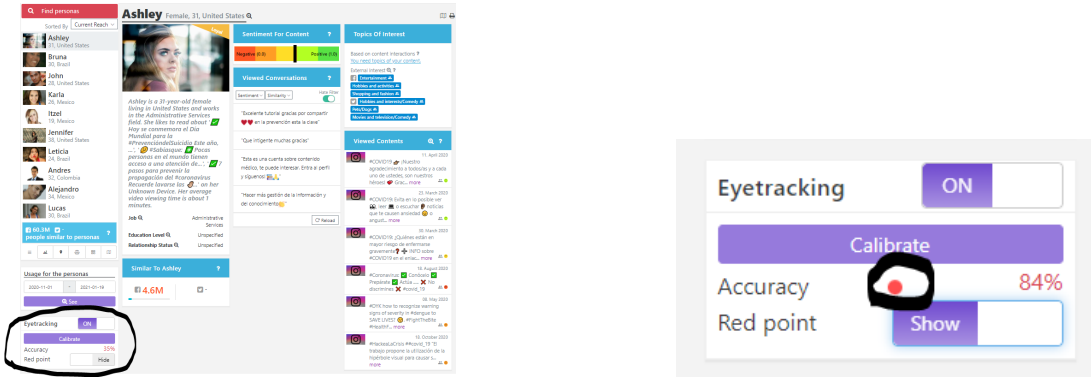
We propose research questions (RQs) for empirical research using the eye-tracking system (see Table 1), as similar questions have been investigated in previous user studies [Salminen et al., 2018a; Salminen et al., 2019; Salminen et al., 2020b; Salminen et al., 2018b]. The answers to these RQs can reveal fundamental patterns in user behavior concerning interaction with personas.

For the PA system to be able to address these RQs, there is a need to capture (a) **time spent per persona** (based on the persona profile being actively viewed), (b) **time spent in each persona information element** (based on the gaze over the element), and the (c) **transition from one information element to another** (based on gaze movements). These metrics stem from previous user studies [Salminen et al., 2018a; Salminen et al., 2019; Salminen et al., 2020b], including dwell time and sequence of information viewed. In the PA system, dwell time is defined as the time duration for which a user's gaze is placed over a screen element.

[2]https://github.com/brownhci/WebGazer

(a) (b) (c)

Figure 2: (a) Calibration is instantly launched after the user is logged in. (b) During the calibration, the user is shown his head position in a target rectangle. The nine-point calibration involves simultaneously viewing and repeatedly clicking on the indicator marks on the screen (see the arrow). (c) After the calibration, the user is shown their score, and they can continue or retry calibration.



(a) (b)

Figure 3: (a) eye-tracking controls in the APG UI (admin view) [(b) shows a zoom-in]. Admins can turn eye-tracking on and off. For regular users, this can be done in the user account system only. Admins can recalibrate at any time, and they can choose to see the red point (circled in the figure) that indicates gaze movement. These features are disabled for regular users, as they are intended to focus on task completion using APG and not concern themselves with the settings.

3.2 Calibration

After logging into the APG system, users that have eye-tracking enabled by the admins (i.e., those running the user study) are automatically (a) asked permission to access their webcam and (b) transferred to the calibration sequence. We modified the WebGazer's calibration example for our use case (see Figure 2).

3.3 System Behavior and UI Features

The system logs the gaze movements during the user's interaction with the system into the backend database. To facilitate analysis, the screen coordinates [x, y] are automatically converted to the corresponding information elements in the logs using JavaScript. That is, instead of a coordinate tuple such as [115, 232], the system logs that as a fixation focused on "Persona name," with the duration determined from the difference of "in" and "out" timestamps for a given element). The system has predefined designated elements for the persona profile page. The designated elements in the HTML have a particular attribute to be classified. When the coordinates correspond to an element, the information of this interaction is sent by the client browser to the backend via Ajax (Asynchronous JavaScript and XML) to the backend database.

In total, we track 120 UI elements, i.e., all the information elements of the persona profile (see Figure 1). The main elements are **Headline** (name, gender, age, country), **About** (picture, text description, job, education level, relationship status), **Audience Size**, **Sentiment**, **Viewed Conversations**, **Topics of Interest**, and **Viewed Contents**. Data exports (see **bottom-left** in Figure 1) are available for system administrators to examine and analyze the data logs, in which each gaze recording, its timestamp, its target in the persona profile, and associated information (e.g., User ID, Session ID), are stored into a CSV file. To prepare the data exports, the system uses Pandas (Python Data Analysis Library) after retrieving the logs from the backend database. It computes the durations based on "in" and "out" timestamps and generates a comprehensible data report with the corresponding information for the corresponding persona profile. During the use of the system, users are provided with different functions to access the eye-tracking features (see Figure 3).

4 IMPLICATIONS AND FUTURE WORK

As online eye-tracking may currently impose quality challenges, in that some users' gaze can be tracked better than that of others, researchers are advised to take precautions. Since accuracy values can be obtained based on the online eye-tracking tool's calibration, researchers can define an accuracy threshold either before a study or after by investigating the data – users failing to meet this threshold can be dropped from the final analysis. Because this likely results in losing a non-negligible number of subjects from the final dataset, researchers should consider this by using larger sample sizes so that enough data for statistical analysis can still be collected when losing some participants due to quality issues.

Although we leave a more extensive evaluation for future work, our initial evaluations indicate the accuracy ranging from ∼50-84%. It appears that accuracy can be increased by multiple iterations of calibration, although this requires further study. We plan to conduct a more extensive evaluation. Future work could also develop tables and visualizations directly in the persona system's UI. Currently, researchers must download the reports and analyze them separately.

Calculating time spent per persona enables the analysis of how users viewed different personas. Behavioral topics such as order effects, comparisons, and choice of a persona can be approached using Markov Chain techniques. Information design of persona profiles can be informed by dwell time analyses, and information viewing patterns can be investigated based on a live system. As such, eye-tracking in APG opens up remarkable avenues for future research.

In conclusion, we demonstrated an implementation of online eye-tracking within an interactive persona system, which can be used for studying questions such as: *How are personas actually used? What information do users most interact with? How do users browse and select personas?* Our solution has particular value during exceptional times when physical user studies are difficult or impossible to conduct.

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