Collaborative Remote Medical Imaging Exploration for Brain Science

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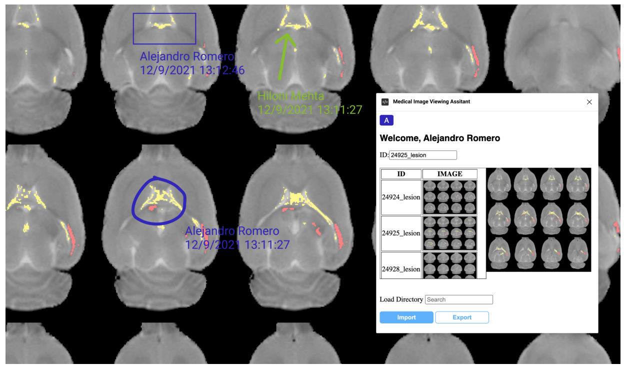

Figure 1: Demo of Figma plugin for collaborative medical imaging exploration

Abstract

We have developed a novel browser-based tool that allows researchers to remotely and collaboratively explore medical images and annotate them in real time. This paper presents a plugin that extends Figma, a popular collaborative design tool. By evaluating the various features of our plugin in comparison to our collaborators' current workflow, we assess the values of a collaborative annotation workflow in a browser-based environment versus annotation via more rudimentary means such as drawing over a screen-share during a video conferencing meeting.

Keywords: Annotation, collaboration, human-computer interaction, evaluation, medical imaging.

1 Introduction

A variety of collaborators across different domains and institutions helps reduce the bias associated with performing research in a single setting. However, current tools for viewing and annotating medical images focus on single user experiences and generally do not provide an efficient workflow for collaboratively evaluating data, making observations, and saving findings for future reference.

Our tool benefits scientific research by allowing collaborators from different institutions to quickly and effectively explore data together, regardless of physical location. The software provides researchers the ability to annotate medical imagery, save a comprehensive history of these annotations, and share their explorations with collaborators. By addressing pain points in present workflows, we found greater efficiency when using our software in comparison to current processes; this has been evaluated through user testing, which combined both formative and summative evaluation techniques in the form of observational studies and a qualitative survey.

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2 Related Work

Presently, analysis of medical images is typically conducted locally in a single-user environment. Popular examples of software used in such workflows include 3DSlicer [9] and ImageJ [12]. These and similar tools do not allow for real-time remote image exploration and annotation, and contain graphical user interfaces (GUIs) that assume a certain level of domain expertise, which may dissuade non-expert collaborators from participating in image exploration. We address these issues in our implementation (see Approach). Various software tools have been created to address the gaps in single-user experiences, namely to allow for real-time collaboration and annotation logging. Such software include MindControl [5], ePad [10], and Med3D [7]. However, many of these software suites have since become deprecated or simply do not provide smooth user experiences, an issue we address in our tool's implementation. Our approach is further supported through user testing (See Hands-On User Study and Questionnaire).

3 Domain Goals

Currently, our scientific collaborators utilize screen-sharing annotation features in the Zoom videoconferencing software to perform real-time medical image exploration. They have reported that this workflow is clunky and time-consuming. Our tool improves efficiency during collaborative exploration of medical images via features that result in faster user performance, as we found in our user studies. Our tool has also been designed to assume no set degree of domain-specific knowledge; that is, our tool can be used by both experts and non-experts in the same collaborative environment.

4 Approach

Our collaborators' current Zoom workflow relies on a single "driver" to share their screen and complete requests from other meeting attendees. This "driver" then has to export a screen capture of the annotations on-screen, name the file manually, and store it locally for future reference. Due to the pain points highlighted by our collaborators in their current workflow, our tool's main purpose is to allow for robust collaborative image annotation in an environment with a relatively small barrier to entry. Because many similar independent projects have become deprecated, we decided to build upon Figma, a widespread and routinely maintained collaborative design tool. Via a Figma plugin, users can access our tool online without any local dependencies and view a persistent annotation and version history in a single private environment shared with their collaborators. Each collaborator can view their own instance of the shared environment on their screen, accompanied by their own GUI, such that they need not rely on a single "driver" to manage the scene view (though an option to "view the driver's screen" remains present).

5 Architecture and Implementation

Our tool is built upon Figma's existing annotation framework, adding functionality for quickly and efficiently importing and exporting medical images, assigning users colors in the shared environment that persist across uses, generating labels with timestamps and usernames under corresponding annotations, and directly saving image annotations for future reference. We worked closely with our collaborators to implement these features to be practical and efficient by minimizing overhead and time spent during exploratory tasks.

6 Hands-on User Study and Questionnaire

The software was tested using a combination of observational studies and a qualitative survey. Four participants were recruited: two expert collaborators and two non-experts. Participants were asked to complete a variety of tasks in both the Zoom screen-share workflow and the Figma plugin workflow. They were asked to complete tasks independently, then to complete tasks collaboratively with another participant. After the collaborative tasks, participants completed a questionnaire prompting them to provide feedback and rate statements regarding the software on a likert scale.

6.1 Evaluation Criteria

Single user observational studies were evaluated on time taken in seconds to complete each task in the Zoom and Figma workflows, respectively. The collaborative sessions consisted of two participants exploring images together in both the Zoom and Figma workflows. They were given two minutes to collaboratively generate insights together. After the allotted time was over, the number of insights (measured by intentional annotations) generated during that time was recorded. Finally, users were all given a questionnaire to provide feedback as well as their ratings of statements regarding each of the workflows (e.g. "Annotating images was intuitive in Figma"). These statements were each rated on a likert scale (1-5, from "strongly disagree" to "strongly agree").

6.2 Results

Times for all participants in the independent user observational studies were averaged and normalized, demonstrating faster task completion time using the Figma plugin for almost all assigned tasks (Table 1).

	Zoom Workflow (in seconds)	Figma Workflow (in seconds)
Previewing Image	13.5 ± 4.04 26.33 ± 8.02	5.25 ± 1.71 28.25 ± 18.02
Importing Image	39.67 ± 11.37	49.25 ± 33.65
Crop	17 ± 7.70	9 ± 2.64
Zoom	7.5 ± 2.081	4.5 ± 2.081
Annotation	12.25 ± 3.5753	8.1 ± 1.11
Exporting image	51 ± 15.132	12.75 ± 1.5

Table 1: Normally distributed values for time taken (in seconds) to complete tasks in the Zoom and Figma workflows.

The number of insights generated from the 2 minute collaborative sessions were compiled and averaged to 7±1 for both the Zoom and Figma workflows. The questionnaire demonstrated an overall preference for the Figma workflow over Zoom, with users noting that the Figma plugin was more intuitive and enjoyable to use. However, a few unrefined features in our early-stage tool resulted in preference for some of the more familiar tools in Zoom.

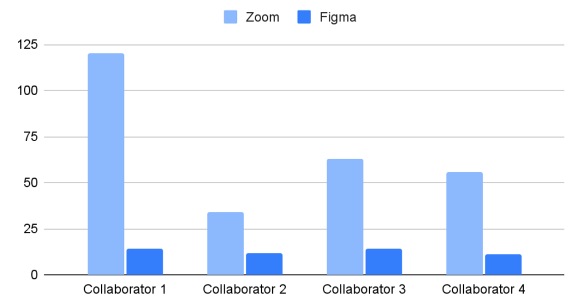

Figure 2: Time taken (in seconds) for users to export an image and its associated annotations in each workflow.

6.3 Discussion

Overall, the results of our user studies demonstrate strong potential for our Figma plugin as a viable tool for collaborative medical imaging exploration and annotation. Across nearly all tasks, users were more efficient when using the Figma plugin than when using the Zoom workflow. To minimize familiarity bias, we acclimated users to the Figma software environment by asking them to complete two blocks of tasks prior to the tasks done in the Zoom workflow. The learning curve in Figma was relatively steep, leveling off after just two blocks of tasks. The third block of tasks consisted of the same tasks completed in Zoom, and were thus the tasks utilized for our data comparison. Our tool's efficiency was most notable in our observations of image exporting (Figure 2).

The number of insights generated in both the Zoom and Figma workflows were the same, suggesting that the significance of our tool lies in the speed with which tasks are completed in the software, not the generation of ideas themselves [11]. Users noted their preference for full control over their own instances of their screen in Figma in comparison to having a single "driver" in Zoom. Users also appreciated the persistent color-coding of user annotations and the timestamps associated with them, allowing for easily keeping track of the annotations made by each user for record-keeping purposes.

7 Conclusion

In this extended abstract, we have presented our work toward more efficient paradigms for a software tool that allows users to collaboratively explore and annotate medical images in a browser-based environment. Moreover, we have generated evidence through user testing that supports many of the feature enhancements employed in our tool. Our results suggest that this tool increases user efficiency when completing common tasks in a collaborative exploration environment, a positive indication that our implementation is a step toward a more holistic methodology for efficient and comprehensive collaborative medical imaging annotation.

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