# Different Specialties, Different Gaze Strategies: Eye Tracking Opportunities in Seismic Interpretation Context

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## ABSTRACT

Identifying how geoscientists interact with seismic images allows a deeper understanding of their rationale and the seismic interpretation process itself. Moreover, identifying nuances involving seismic interpreters performing slightly different roles opens new possibilities relative to how


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decision support systems could become part of the seismic interpretation. In this work, we detail an eye tracking study involving 11 seismic interpreters interacting with two seismic images. The results show that seismic interpreters, with different specialties, interact with seismic images differently. From the results, it is possible to better characterize gaze strategies from different seismic interpreters, which could also be used as input information for decision support systems.

**KEYWORDS**

Eye tracking; Seismic interpretation; User study.

**ACM CLASSIFICATION KEYWORDS**

• **Human-centered computing~User studies**

• Human-centered computing~Heat maps

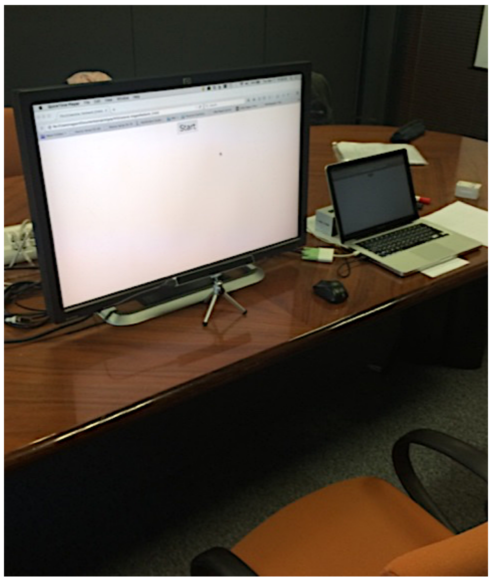


**Figure 1: Room setup for the user study. The proposed activities were performed on a MacBook Pro provided by the study facilitator and participants used a wireless mouse to interact with the seismic images. An external monitor equal to the ones used by interpreters in their workstations was utilized. The eye tracker used was from The Eye Tribe manufacturer.**

## INTRODUCTION

Seismic interpretation is a quintessential knowledge intensive visual inspection process. It is performed by seismic interpreters (geologists or geophysicists) with the goal of identifying and characterizing subsurface structures from seismic data (including seismic images) and other geological data (location, formation, history, and the like). This process involves the painstaking analyses of seismic horizons, identification of geological structures, identification of seismic textures, and others, usually taking weeks to months of analysis. Seismic interpreters thus play a key role in the Oil and Gas (O&G) industry. They are key players in the knowledge intensive workflow of interpreting seismic data and converting the whole body of knowledge about basins, blocks, or reservoirs into information for decision making with respect to, for instance, exploring or not a reservoir, placement of drilling wells, building O&G platforms, etc. For the sake or brevity, we will not detail the seismic interpretation activity nor all the nuances of the O&G upstream processes. For more information, please refer to Ylmaz [15].

The literature presents studies investigating the ways in which specialists carry out tasks in the contexts of health care [4] [8], sports [7] [11] and aviation [1] [2]. In these studies, eye tracking is used to shed new light on how specialists performed tasks. The use of eye tracking builds on the eye-mind hypothesis, which asserts that people are usually thinking about what they are looking at [6]. This means that if people are looking at something, concentrating on a particular task, cognitive processes are tied to the elements at which people are looking [12].

Eye tracking plays an important role to start of revealing things that users cannot always articulate (in a user study or otherwise). Literature reveals that users are unable to describe gazes or areas where they look at in 47% of the time [5]. This motivates the use of eye tracker as an additional data source in user studies. Such gaze data can be used as input for new insights about user studies and as reflection material for users to re-think and articulate about their own interaction flow. In the context of geoscience, Santana et al. [13] propose an eye gaze model for identifying when seismic interpreters are interacting with seismic images coming from well-known regions. In addition, Sivarajah et al. [14] present a comparison involving more experienced and less experienced geoscientists. The authors report a significant variation in observation patterns given that experienced interpreters employ more systematic search strategies for spotting areas of interest. In this work, we explore how different roles and different experience levels impact the gaze strategies while geoscientists interact with two seismic images from offshore Santos basin, in Brazil, and Penobscot basin, in Canada.

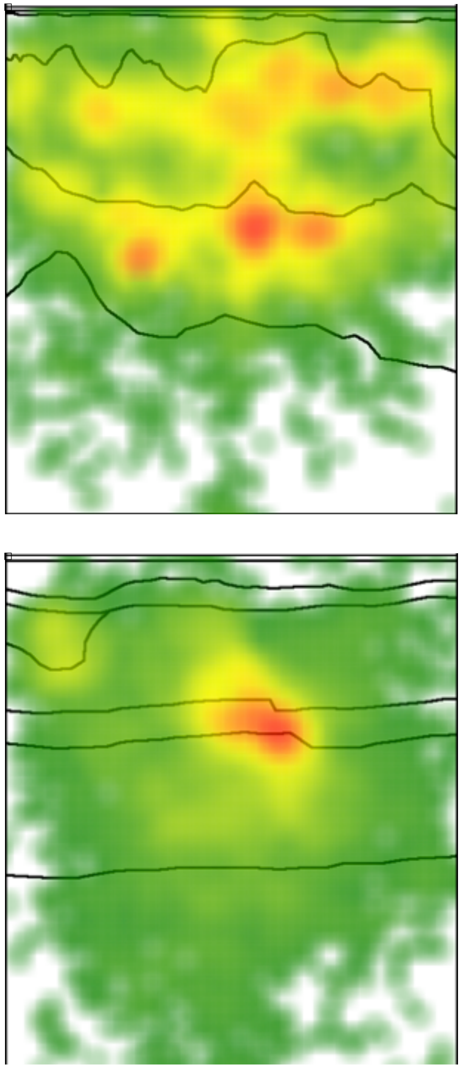


**Figure 2: Figure 2: Eye tracker heat maps showing the summary of all participants interacting with seismic image from Santos basin (top) and Penobscot basin (bottom).**

## METHOD

The study was carried out with 11 seismic interpreters. These participants had a mean of 6.27 years of experience in geosciences (σ = 5.17 years). They were grouped according to Milkov's [10] three levels of experience in geosciences:

(I) Less than 6 years of experience;
(II) Between 6 and 12 years of experience, and;
(III) More than 12 years of experience.

In addition, participants were grouped according to the phases of the O&G exploration workflow they work in:

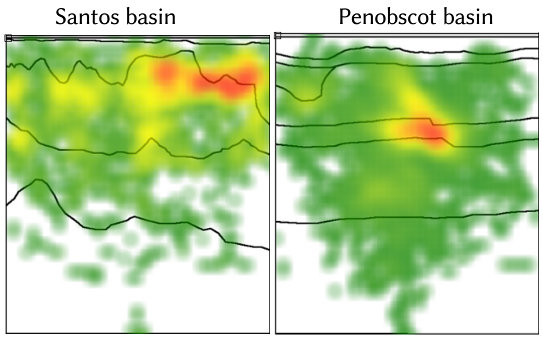
(1) New ventures, responsible for picking areas to explore;
(2) Exploration, responsible for exploring basins to discover new reservoirs;
(3) Reservoir geology, responsible for working on confirmed discoveries.

These phases reflect their specialties and departments they operate. Thus, we will refer to them as specialties.

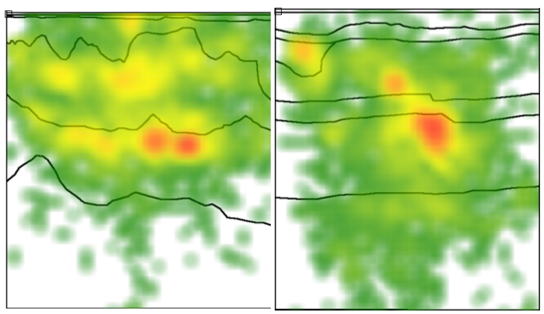
The seismic images selected for the user study are from Santos basin, Brazil, and Penobscot, Canada. The selected images were of the same size, and resolution. The rationale for selecting these two regions involved previous experience of the participants (Santos basin) and the how they could relate Penobscot with its conjugate margin in the Portugal's coast, a region also familiar to the participants. The selection of seismic images and the rationale behind this step were supported by an experienced geologist from our lab. The seismic images were placed on static no-scrollable HTML pages, supporting the analysis of gaze behavior with the seismic images. The study took place in a separate office from their everyday work environment; room setup is presented in (Figure 1). The environment was prepared to reduce luminance changes, as suggested in [3], [12].

The study was divided into two tasks where a participant was asked to describe the seismic image from Santos basin and then the one from Penobscot basin. Both steps followed the same procedures and protocols. The proposed activities were performed on a MacBook Pro provided by the study facilitator and participants were allowed to use a wireless mouse while interacting with and describing the seismic images. An external monitor equal to the ones used by interpreters in their workstations was utilized. During the tasks, participants were instructed to use the Thinking Aloud Protocol [9]. It is noteworthy that participants were asked to describe, rather than to interpret the images. Hence, given the goal of the study, the word describe was used to encourage participants to highlight the main characteristics (or geological features) they could identify in the seismic images, avoiding also fatigue related effects for eye tracking studies, since movements and postures restrictions may apply to cope with the area covered by the eye tracker device. In addition to the participant, a study facilitator and an assistant were in the room throughout the study. Study procedure included the following steps:

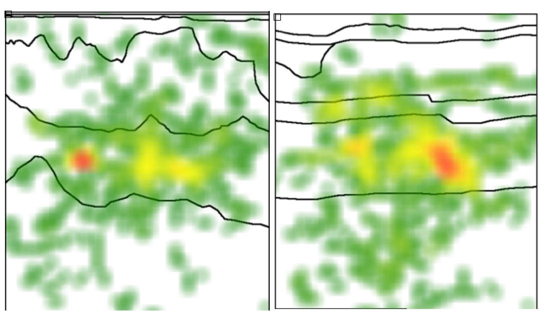
- Facilitator presents the consent form and explains the data capturing process, how to use the Thinking Aloud Protocol, and the basics of eye tracker functioning;
- The user study starts when the participant clicks on the button "Start", showing the first seismic image;




(a) New ventures (3 participants).



(b) Exploration (5 participants).



(c) Reservoir geology (3 participants).

**Figure 3: Eye tracker heat maps showing how participants from different specialties interacted with seismic images.**

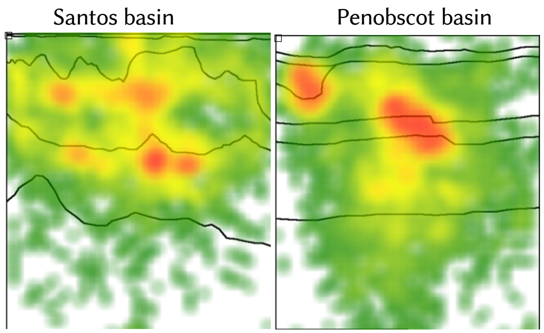
- Facilitator asks the participant to describe the seismic image, highlighting its most important characteristics;
- As soon as the participant finishes describing the first seismic image, she/he clicks on the "Next" button, showing the second seismic image;
- Facilitator asks participant to describe the second seismic image the same way she/he did before;
- Finally, once the participant finishes describing the second seismic, she/he clicks on the button "Finish".

## RESULTS

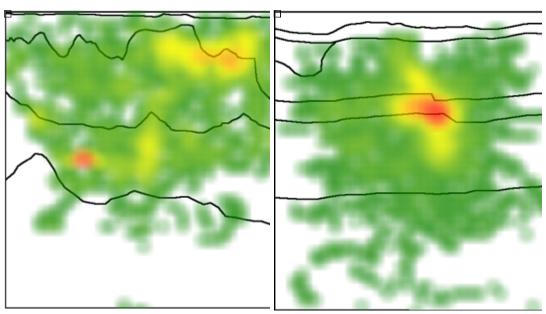
Next, we present the heat maps created using fixations triggered by the participants. The heat maps are presented here as additional layers on top of outlines depicting the main packages of reflectors (areas of interest). The rationale is to highlight gaze data without competing with red-white-blue color scale used in the seismic images. Figure 2 shows the heat maps created using eye fixations from all the 11 participants. It is possible to see that, for Santos basin, the fixations were mostly around top of the salt and pre-salt regions; for the Penobscot basin, fixations were concentrated around a channel in the top-left of the image and in the central part of the seismic image, were a seismic fault crosses a package of parallel horizons. In sum, the gaze strategy followed by interpreters was focused on reservoir candidates and more complex geological structures.

Figure 3 shows the heat maps created using eye tracker data, grouping participants by specialties. It is possible to see that the participants from new ventures (Figure 3 (a)) concentrated gazes at the top of the salt and, in the Penobscot basin, the gazes were directed most of the time at the central part package of reflectors around the main seismic fault present in the image, indicating that participants were looking for a trap (structure that traps hydrocarbons allowing for storage to happen) around the seismic fault. Participants from the exploration specialty (Figure 3 (b)) looked more at the pre-salt region in the Santos basin and, for the Penobscot basin, gazes were more distributed along the seismic fault and a possible channel in the top-left corner was investigated. Participants from reservoir geology specialty, in contrast, focused more on the package of reflectors related to the pre-salt region, skimming areas that are not the main interest in their daily activities. Thus, these results indicate that seismic interpreters usually look at areas they are used to work daily-basis. Figure 3 presents that seismic interpreters working on pre-salt region were effective on identifying relevant areas.

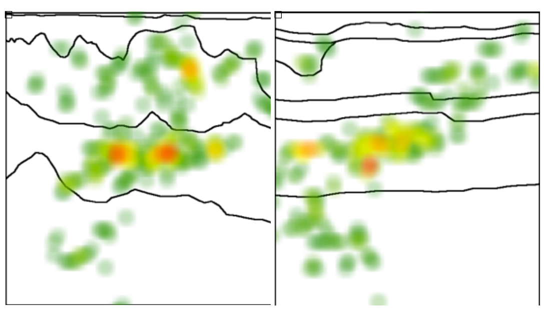
Figure 4 shows the heat maps grouping participants by levels of experience. It is possible to see that the participants with less than 6 years of experience (Figure 4 (a)) distributed the gazes all over the image from Santos basin; in the image from Penobscot basin, the region in the top-left corner was spotted by most of participants in this group. Moreover, the diagonal in the center of the image follows the main seismic fault. Participants having between 6 and 12 years of experience focused on the specific aspects of the seismic image (Figure 4 (b)).




(a) Less than 6 of experience (7 participants).



(b) Between 6 and 12 years of experience (3 participants).



(c) More than 12 years of experience (1 participant).

**Figure 4: Eye tracker heat maps showing how participants with different experience levels interacted with seismic images.**

These participants looked more at the top of the salt and pre-salt region in the Santos basin and, for the Penobscot basin, gazes were around the main seismic fault present in the image, but at the deeper package of reflectors. Finally, the participant with more than 12 years of experience looked at very specific points in the seismic images, mainly related to the pre-salt (Santos) and to an older section of the seismic image from Penobscot, showing how the participant directed the gazes to certain areas of interest, ignoring more recent sections and parts closer to the basement (lower part of the image), consonant to results presented by Sivarajah et al. [13].

## CONCLUSIONS

Eye tracking is a promising technique for revealing how seismic interpreters interact with seismic images. Our findings show that interpreters from different specialties focus on different aspects of the seismic image. The presented results allow us to hypothesize that the specific training required by each specialty leads to different patterns of analysis, for instance, seismic interpreters from new ventures perform a conceptual, integrated analysis while reservoir geologists focus on areas with reservoir candidates. Regarding different levels of experience, besides having unbalanced number of participants, it is possible to identify areas of interest that participants trigger more fixations and, more importantly, areas that interpreters do not look at all. Such result opens new possibilities for understanding how the seismic interpretation process takes place for different geoscientist profiles. Thus, decision support systems could employ features for identifying different specialties before presenting any recommendation to seismic interpreters. For instance, for new ventures seismic interpreters, additional conceptual information could be offered. In the case of reservoir geologists, additional information about reservoirs' characteristics and properties already discovered in the region or in an analogous area.

Future work involves employing eye tracking in an in-depth study covering the whole seismic interpretation process, usually taking weeks to moths. We believe that to deepen the discussion in this subject, a holistic approach should be followed involving, for instance, experience in seismic interpretation, experience on a certain area, recent analysis performed, specialty of the seismic interpreter, fatigue effects (considering the seismic interpretation), effective hours interpreting, among others. Finally, decision support systems can use such results to identify, via classification algorithms, where in the workflow seismic interpreters are and, hence, offer the proper support information at the right time.

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