Analysis of the Use of the Maintenance Documentation Using Eye-Tracking: A Pilot Study

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Keywords: Eye-Tracking, Aircraft Maintenance, Real-World Research, Ergonomics, Expertise.

Abstract: Maintenance tasks have an essential role in the safety of helicopters throughout their life. It is performed by aircraft maintenance technicians (AMT). Two major types of operations in the maintenance activity are information intake/processing and motor actions. This extended abstract will present a new work-analysis methodology, using a mobile eye-tracking system to measure the use of maintenance documentation during the preparation and execution of the maintenance task.

1 INTRODUCTION

Helicopters maintenance, which is performed by aircraft maintenance technicians (AMT) is a critical process that involves the use of visual information obtained from aircraft maintenance manuals. In this context maintenance documentation is important to ensure the security of the whole process. In order to understand the maintenance activity, we need to collect data on the use of these documents by the AMT in the real work environment with minimum interference. Eye-tracking is a behavioral measurement tool adapted to real-world conditions that provides insights about information intake and a view on the action.

The aim of this preliminary, observational study is to validate a new methodology using eye tracking to capture the operator's viewing of documentation (task prescription) during a helicopter maintenance task.

2 LITERATURE REVIEW

Maintenance has an essential role in keeping the airworthiness of the helicopter. Aeronautical maintenance is part of the framework of industrial maintenance and is considered critical for both the operator and the system. Criticality is explained by a high level of uncertainty and variability in maintenance operations. The execution of all the tasks requires a trained workforce (Grusenmeyer, 2014; Souza et al., 2021), aircraft maintenance technicians. In order to have a high level of consistency and reliability in the outcome of maintenance activities, it is prescribed by a set of rules, procedures and standards.

Procedural documents are technical documents guiding the operator's actions toward the task requirements (Leplat, 2008). However, as part of an aeronautical maintenance study Zafiharimalala (2011) mentioned the lack of data on the actual use of the maintenance documentation.

In this context eye-tracking appears to be an interesting tool to better understand the visual behavior of the AMTs. This tool measures eye movement and provides metrics on gaze fixation. In particular, the spatial and temporal pattern of fixations in the environment provides information about attentional processes. Eye tracking is used to analyze how the operator selects the sources of visual information essential to carry out the work activity (Duchowski, 2002; Souza et al., 2021). To measure visual attention, the area of interest (AOI) (Jacob & Karn 2003) classification combines all the fixations

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Paris, F., Casanova, R., Bergeonneau, M. and Mestre, D.
Analysis of the Use of the Maintenance Documentation Using Eye-Tracking: A Pilot Study.
DOI: 10.5220/0011958400003622
In *Proceedings of the 1st International Conference on Cognitive Aircraft Systems (ICCAS 2022)*, pages 57-60
ISBN: 978-989-758-657-6

made in a defined area of interest (an object for example). Visual attention distribution analysis was previously used in several analyses of the activity under ecological conditions (Henderson, 2003; Land, 2006) or highlighting information gathering strategies for in the cockpit by the pilot-co-pilot pair (Hutchins et al., 2013).

A mobile eye tracking tool in the form of glasses has the advantage of being minimally invasive for the operator. The realization of eye-tracking measurements is based in part on a stage camera for allowing to reference eye movements in relation to the environment. This camera has an egocentric view of the action environment, offering a significant gain of information compared to a fixed stage camera: the camera is closest to the operator and moves with him. The operator hands are visible and when handling objects, objects are located at maximum arm distance (Ren & Philipose, 2009). Eye-tracking is a behavioral measurement tool adapted to the real (mobile) condition, providing cues to the information intake (here the maintenance documentation) but also a view on the action (stages of the maintenance procedure).

Our study proposes a new methodology to evaluate information intake in the maintenance documentation, depending on the progress in the operation (stages).

3 METHODOLOGY

3.1 Procedure

During this pilot study, the aircraft maintenance technician (AMT) performed an inspection of the component parts of the right rear landing gear brake unit on a H215/225 helicopter. The operation consists of 3 phases: disassembly, inspection, assembly. The task is divided into stages that are bounded by milestones. Milestones are specific steps of the task. The sequence of milestones cannot be performed in any other order. The whole maintenance operation is presented in Figure 1. It is broken down into 3 phases and 9 stages, delimited by 8 milestones. The first phase is the removal and disassembly phase: to reach the break, the operator lifts the helicopter on jacks and removes a pin, then removes the wheel (Stage I & II). The braking unit is extracted from the helicopter (Stage III) and all its components are removed (Milestone 4). The second phase is an inspection of the brake components (Stage V). The third phase is an assembly and installation phase: the brake unit is reassembled and put back on the helicopter (Stage VI), then the wheel and the pin are installed and finally the helicopter is put back on its wheels (Stage VII & VIII).

The entire procedure is detailed in a 21-page aircraft maintenance manual in paper format. During the experiment, there was no time constraint and all the required tools were available.

We studied the use of the maintenance documentation during the course of the operation. We captured the time and duration of each phase and stage and in the same way the time and duration of consulting of the documentation (hereafter called viewing).

3.2 Material

The AMT's eye gaze data was collected using an eye-tracking system Tobii® Pro Glasses V2 (100Hz, 1080p, 60fps). Among the data flow provided by this device, we used the egocentric video from the scene camera and the eye-tracking data.

3.3 Data Analysis & Processing

All fixations were manually mapped on 21 AOIs corresponding to 21 pages of aircraft maintenance manual documentation using Tobii Pro Lab 1.152 analysis software. The milestones timestamps (described above in the procedure), were manually extracted from the scene video. Since Tobii Pro Lab provides a set of predicates for each AOI for each acquisition timestamp, we only combined the 21

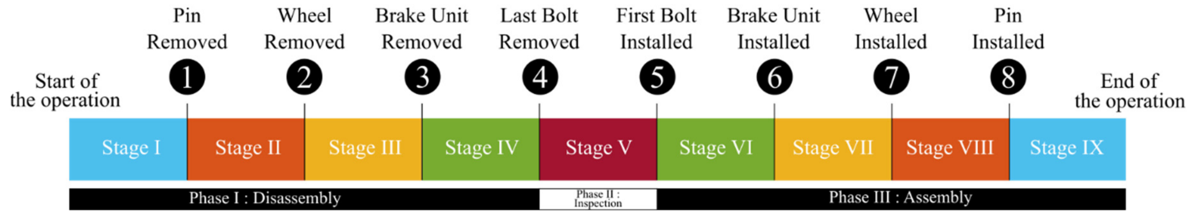

Figure 1: Decomposition of the maintenance operation: The numbers on the upper part are the milestones of the operation, color zones represent the stages between two milestones. Bottom: the three main phases of the operation are represented. The colors used on the figure emphasize the association of pairs of disassembly/assembly stages. The middle phase is the inspection.

Table 1: Relative and absolute duration of execution times and viewing by stage.

	Stage Metrics		Viewing the document		
Stage	Duration (mm:ss)	% / total	Duration (mm:ss)	% / total	% /stage duration
I	09:18	9.6%	01:48	19.1%	19.4%
II	10:22	10.7%	03:37	38.2%	34.9%
III	09:14	9.6%	00:00	0.0%	0.0%
IV	11:25	11.8%	00:55	9.7%	8.1%
V	02:44	2.8%	00:03	0.5%	1.6%
VI	20:16	21.0%	00:54	9.6%	4.5%
VII	16:09	16.7%	00:51	8.9%	5.2%
VIII	10:33	10.9%	01:10	12.3%	11.0%
IX	06:33	6.8%	00:10	1.7%	2.5%

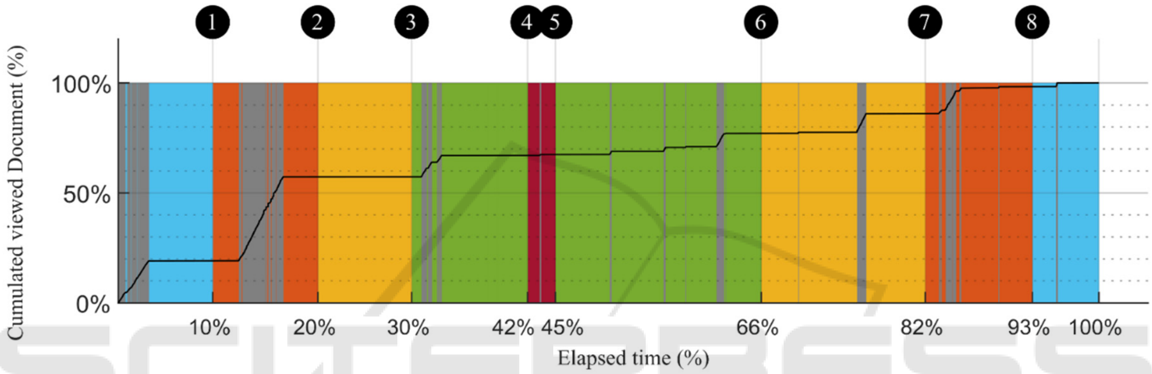

Figure 2: Evolution of document consultation (cumulated) as a function of time. The colored stripes represent stages delimited by milestones (described in Figure 1). The gray areas represent the periods gazing at the document. The black curve represents the cumulated percentage of time past gazing at the document.

predicates corresponding to the pages into a single predicate identifying the action of viewing the document over time. Milestone timestamps are used to describe the evolution of the of the task progress in the time dimension. All data processing outside Tobii Pro Lab was performed on Matlab®.

4 RESULTS

The operation lasted 1 hour 36 minutes and 33 seconds with a total viewing time of 09 minutes and 27 seconds. Table 1 provides detailed information on the cumulative percentage of time and viewing at each stage.

The data are presented in Figure 2, with the evolution of cumulative viewing time on the timeline with the viewing occurrence represented by gray bars. Fixations in the documentation separated by less than 1 second were grouped in the same bar.

The end of the disassembly phase (Milestones 4) occur at 41.7% of the total time while 67.0% of the total time is spent viewing the document. The inspection time took 2.8% (Stage V) with 1.6% of the time spent viewing the document. Assembly time (from Milestones 5 to the end) took 55.4% of the total time and 32.5% of the time spent viewing the. More than 55% of the time spent viewing the documentation occurs during stages I and II and after 15 minutes and 24 seconds: 1/6 of the total operation time. 19.4% of the stage I duration is devoted to document consultation; this ratio subsequently increases to 34.9% in stage II. From stage III onwards, it is less than 11.0 %.

5 DISCUSSION

In this study, eye-tracking was used to capture gaze behavior as a function of time and stages in a maintenance task.

The analysis revealed an asymmetrical distribution of phases and stages: the inspection phase (Stage V) is not centered (41.7% to 44.6%). The disassembly phase is shorter than the assembly phase. In more detail, the assembly/disassembly stages are not totally symmetrical: for example, unscrewing does not require any torque wrench, while it is mandatory in the assembly phase.

Nonetheless, the ratio of time spent viewing the documentation is higher in the disassembly phase. In addition, the cumulative time spent viewing the document is mostly at the beginning of the disassembly phase. The two longest phases occur at the beginning of the operation (Stage I & II) corresponding to more than 55% of the total viewing time, while short reading sequences occur in the following stages.

This consultation pattern reveals an important information acquisition phase at the beginning of the operation. This suggests that the operator carries out an initial preparatory organization and viewing on the whole documentation and reads specific information on critical points during each stage (ex. finding a force momentum torque). We suggest that the quality of this preparatory phase has a direct impact on the good and successful progress of the whole operation.

From this first instantiation of our methodology, we conclude that it allows us to demonstrate 1) the unbalanced repartition of the different phases of the operation 2) and a specific pattern of consultation of the procedural documentation. Our methodology will allow us to test the generalization of these patterns to a larger population and to test specific profiles (novice & expert).

ACKNOWLEDGEMENTS

Florence Paris's work is supported by a doctoral grant from ANRT (l'Association Nationale de la Recherche et de la Technologie) under N° IPAH13430, in agreement between Airbus Helicopters and Aix-Marseille University.

REFERENCES

Duchowski, A. T., 2002. A breadth-first survey of eye-tracking applications. (Springer, Ed.) *Behavior Research Methods, Instruments, & Computers*, 34(4), 455-470.

Grusenmeyer, C. 2014. Maintenance: organizational modes, activities and health and safety. Use of a French national survey and in-situ analyses. (Elsevier, Ed.) *Accident Analysis & Prevention*, 187-199.

Henderson, J. M. 2003. Human gaze control during real-world scene perception. (Elsevier, Ed.) *Trends in cognitive sciences*, 7(11), 498-504.

Hutchins, E., Weibel, N., Emmenegger, C., Fouse, A., & Holder, B. (2013). An integrative approach to understanding flight crew activity. (C. SAGE Publications Sage CA: Los Angeles, Ed.) *Journal of Cognitive Engineering and Decision Making*, 7(4), 353-376.

Jacob, R. J., & Karn, K. S. (2003). Eye tracking in human-computer interaction and usability research: Ready to deliver the promises. *In The mind's eye* (pp. 573-605). North-Holland.

Land, M. F. (2006). Eye movements and the control of actions in everyday life. (Elsevier, Ed.) *Progress in retinal and eye research*, 25(3), 296-324.

Leplat, J. (2008). Eléments pour l'étude des documents prescripteurs. In J. Leplat, Le Travail humain (pp. 93-130). *Presses Universitaires de France*.

Ren, X., & Philipose, M. (2009). Egocentric recognition of handled objects: Benchmark and analysis. *IEEE Computer Society Conference on Computer Vision and Pattern Recognition Workshops*, (pp. 1-8).

Souza, M. L., Pereira-Guizzo, C. S., Santos, A. A. B., & León-Rubio, J. M. (2021). Visual attention of experts and novices to a critical industrial maintenance task. (S. Brasil, Ed.) *Gestão & Produção*, 28.

Zafiharimalala, H. (2011). Étude ergonomique pour la consultation sur écran de petite taille de la documentation de maintenance aéronautique (Doctoral dissertation, Université Toulouse le Mirail-Toulouse II).