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The UNIVERSITY of OKLAHOMA

Characterization of Air Traffic Controllers' Visual Search Patterns and Control Strategies

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What

The focus of this research was to develop a better understanding of the underlying motives behind the visual scanning & searching strategies, methods of conflict control and overall decision-making made by expert Air Traffic Controllers in a high fidelity simulation through the analysis of scanpaths from eye-tracking data and protocol.

Goals

The project aims to characterize and classify the visual search patterns and aircraft control strategies of expert air traffic control specialists (ATCSs) using various types of scenarios in order to support the effective training of air traffic control candidates.

How

Participants

Eleven expert Air Traffic Controllers, either retired or currently employed. Due to the high skill requirement for the target population, a within-subjects experiment was designed. Experiment was supported by FAA CAMI.

Task

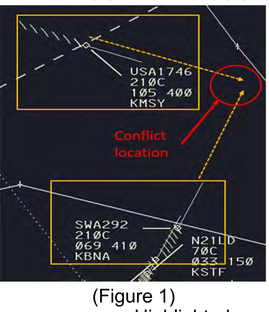
The Air Traffic Controllers were subjected to a high-fidelity air traffic control simulation, in which they had to apply their visual scanning strategies in order to search for conflicting aircraft and to de-conflict them, if such situations were identified. During the task, the expert's eye tracking data was collected and a structured interview was performed after the task was completed.

Scenario

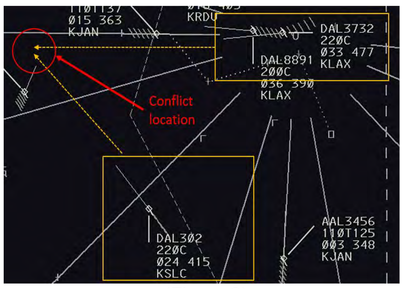
12 scenarios were designed, each testing a particular type of conflict based on the geometry of two or more aircraft (converging, head-on, tailgating, and streams) and were ordered randomly for each expert.

Scenario	Type of conflict(s)	
1	No conflict type I	No pre-determined conflicts, main objective was to observe visual scanning strategy
2	No conflict type II	
3	Converging conflict type I	Require one or more control actions from the ATC's, as there exists a variety of pre-determined conflicts that will occur in the future unless they are identified and de-conflicted. The objective of these scenarios was to investigate the type of de-conflicting strategies the experts apply under diverse situations.
4	Converging conflict type II	
5	Head-on conflict type I	
6	Head-on conflict type II	
7	Converging/Head-on conflicts type I	
8	Converging/Head-on conflicts type II	
9	Tailgating conflict	Special cases to test a number of effects such as tunnel vision (focusing on one complex area too much), reactions to highly contested streams of aircraft and precautionary actions that may be applied by ATC's.
10	Convergence conflict	
11	Streaming type I	
12	Streaming type II	

Table I. Scenarios and their respective conflicts

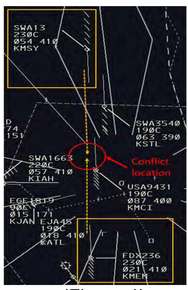


(Figure 1)



(Figure 2)

(Figure 3)



(Figure 4)

Highlighted examples of aircraft converging (Figures 1 and 2) and head-on (Figures 3 and 4)

Data Analysis Examples

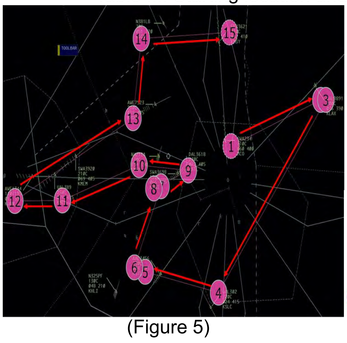
Geometrical pattern	Freq.	Starting location	Freq.	Participant
Spiral	4	High density-based	3	P2,P10,P11
		Center of sector	1	P9
Circular	2	High density-based	1	P1
		Preference based on training and experience	1	P3
Linear (e.g. zigzag)	1	Low density-based	1	P5
Quadrants	1	Areas of conflict	1	P4
Mixed (circular + linear)	1	High density-based	1	P6
Random	2	Incoming sector traffic	1	P8
		High density-based	1	P7

Table II. Visual search strategies: search pattern (i.e geometrical shape)

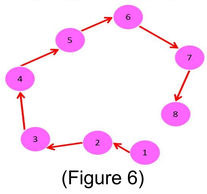
Starting location of visual search	Freq.	Order of information observed			Freq.	Participant
High density-based	6	Altitude	Direction	Speed	3	P1, P6, P7 P10, P11
		Altitude	Speed	Direction	1	P2
Incoming sector traffic	1	Altitude	Direction	Speed	1	P8
Low density-based	1	Altitude	Direction	Speed	1	P5
Center of sector	1	Altitude	Direction	Speed	1	P9
Areas of conflict	1	Altitude	Direction	Speed	1	P4
Preference based on training and experience	1	Altitude	Direction	Speed	1	P3

Table III. Starting location and order of information observed

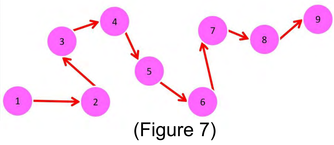
These tables were created through a protocol analysis of transcriptions from the structured interviews that were held with all the experts ATCS after the completion of all 12 scenarios. Here we can see that, for example, Participant 1 starts at high density-based locations and proceeds to scan in a spiral manner (Table II), applying a hierarchy of information that starts with altitude, direction and then speed (Table III). An example of an expert's circular scanpath (and ideal) can be seen below in Figures 5 and 6.



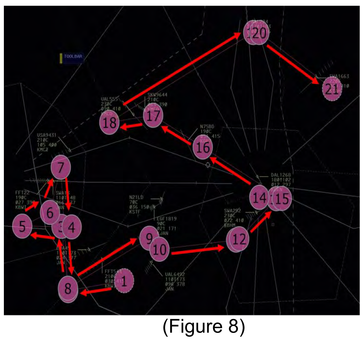
(Figure 5)



(Figure 6)



(Figure 7)



(Figure 8)

Figure 5 represents a highlighted expert's circular scanpath, while Figure 6 shows an ideal circular scanpath. Similarly, Figure 8 represents an expert's linear scanpath while Figure 7 shows an ideal linear scanpath.

Why

In general, this project is valuable to the FAA as it would have effect in numerous areas such as: improving or enhancing ATCSs' skill and performance, training efficiency and other elements.

Impact

This research is important because it would allow us to better understand the underlying causes of the applied visual scanning, searching and conflict mitigation strategies; and the different factors or situation characteristics that create different hierarchies regarding conflict solutions or the order in which the information is read.