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VAST: A High-Fidelity Prototype for Future Air Traffic Control Scenarios

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Abstract. Significant changes in air traffic control (ATC) are planned within the Single European Sky ATM Research (SESAR) initiative. Some of the goals are an increase in air traffic, reduction in delays and an improvement of safety. Further, 4D trajectories should ensure flights on the most direct route to the destination airport. The team in the research project "Virtual Airspace & Tower" (VAST) wants to explore the design space and give ideas for future ATC interfaces to meet the ambitious SESAR goals. This paper and demo present the high-fidelity prototype developed. The air space can be displayed three-dimensionally. Separation minima - the minimum space needed between airplanes - and planned routes can be shown as well.

Introduction

Within the research project "Virtual Airspace and Tower" (VAST), the team explored new concepts for visualising and sonifying complex air traffic scenes in two and three dimensions. The team followed a user-centred design process (Bowles, 2013) and developed three low-fidelity prototypes (Rottermanner et al., 2018) as well as one high-fidelity prototype. Background of this work is planned innovations in the next years in air traffic management. Next to an increase in air traffic, reduction in delays and improvement of safety, 4D trajectories will ensure flights on the most direct route to the destination airport (SESAR, 2015). Instead of using flight levels, the implementation of 4D trajectories will ensure flights on a “practically unrestricted, optimum trajectory for as long as possible [...] to meet very accurately an arrival time over a designated point” (SKYbrary, 2017). To be able to handle these innovations, Air Traffic Control Officers (ATCOs) need appropriate tools, especially for the visualisation of 4D trajectories.

Related Work

From the very beginning, air traffic control (ATC) has been an important field of CSCW research. Ethnographic studies have shown the importance of seamless communication between operators and of awareness in coordinating air traffic (e.g. Bentley et al., 1992; Schmidt, 2002). The air traffic has increased dramatically since then (SESAR, 2015) and the computer is an integral part in communication and controlling. The challenge is, as in many CSCW projects, to improve situation awareness and problem detection.

Regarding related work in 3D visualization, Bourgois et al. (2005) describe a stereoscopic representation which includes concepts for navigation, weather information, positional audio and presentation of conflicts. They compared it with a 2D representation. Objective measurements in a study with former ATCOs indicated that “controllers were quicker in identifying the target in the 3D stereoscopic than in the 2D condition”. Also, subjective data showed that the controllers estimated that their performance was better with the 3D stereoscopic interface. Baier and Zimmer (2016) reveal that “an adequate 3D airspace representation for air traffic control allows an immediate perception of danger and urgency in a given situation”.

Related work also reveals a bunch of challenges regarding prototyping and evaluating for the ATC domain. Compared to other disciplines, ATCOs must have a clear picture not only of the static interface elements itself, but also how it is changing and reacting in case of events over time (Rottermanner et al., 2017). Also, to make testing as real as possible, one way is to integrate existing tools and visualisations, already used by ATCOs into a simulation. But often they are proprietary, inaccessible or costly, and cannot be adapted to the required research functionality (Prevot et al., 2018). Prototyping is essential to test the most important usage scenarios as early as possible. Therefore, it is necessary to simulate air traffic realistically to make profound decisions about the quality of the concepts. As a result, the project team decided to develop a fully-interactive high-fidelity prototype using a simulator, which provides the prototype with real air traffic movements.

High-Fidelity Prototype Development

The developed high-fidelity prototype is a result of preliminary work (e.g. interviews and focus group discussion with ATCOs, on-site visits of approach and terminal control centres, development and evaluation of three low-fidelity prototypes) within the project (Rottermanner et al., 2018, 2017). The high-fidelity prototype will be described in this section in more detail.

Flight Data Interface (NAVSIM)

NAVSIM is an air traffic simulator, developed and continuously enhanced by University of Salzburg in close cooperation with Rokitansky et al. (2018) and the Mobile Communications R&D ForschungsGmbH. It can simulate realistic actual and future worldwide gate-to-gate air traffic. Various datalink and voice interfaces like the ATCO or pilot interface allow for full interaction in system performance testing and human in-the-loop exercises. The prototype uses the speech recognition feature of NAVSIM to let ATCOs give realistic commandos to the “pilots”. Also, Non-ATCOs can give instructions by clicking on the airplane label and entering new values. NAVSIM runs in parallel to the prototype on separated PCs. NAVSIM has a persistent network connection to the prototype. It is possible to route an aircraft to a specific waypoint or to use radar vectoring and instruct a new heading. Also speed and height changes as well as clearances for instrumented landing system approaches & landing can be instructed this way.

High-Fidelity Prototype: User Interface and Interaction

The prototype was developed with Unity. It can display 4D trajectories of air planes without the need of flight levels. The orthographic top down view can be rotated to a perspective 3D view (see Figure 1).

Figure 1: Conventional orthographic 2D view (left) and 3D perspective view (right)

A normal PC mouse is used for all interactions: By pressing the left mouse button it is possible to rotate the view. Further tilting triggers a transition from an orthographic top down to a perspective 3D view. The user can pan the view by pressing the right mouse button and moving the mouse. Zooming is done by using the mouse wheel. Flight labels show only the call sign and altitude by default. The user can double click the label to reveal more information, in this prototype the speed and heading of the air plane. Labels are movable by left mouse click and drag. For conflict warning, both flight labels will be highlighted in red. To increase situation awareness and to decrease the response time in case of critical events, the team implemented an auditory display as an additional perceptual channel, based on continuous sonification intermittent auditory alerts (Watson, 2006). A video of the prototype can be found here: https://youtu.be/u7SU3rjNkUI

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