Steps towards an Augmented Reality workspace for Air Traffic Controllers

Thomas Hofmann (1), Christina König & Andreas Röbig (2)

1University of Applied Sciences Osnabrueck, 2TU Darmstadt, GERMANY

Scope

Increasing complexity and dynamics as well as capacity constraints in aviation are key-challenges for future air traffic control (ATC) (Manning & Stone, 2005). A technical support to the automation should ensure safety, punctuality and efficiency in air traffic. The design of appropriate human-machine-interfaces (HMI) requires knowledge of the respective jobs, environmental conditions and the characteristics, needs and usage patterns of users. An inappropriate design can increase users' stress and reduce safety of the entire work system (Köper, 2001). Superfluous information must be avoided as well as missing - since both lead to increased cognitive workload and distraction from the task at hand.

This applies even more for the work of the tower controller (Hilburn, 2004). Visual attention to assistive technology means less attention to the external view and the risk that relevant information or changes are missed. Adding information in the air traffic controller's field of view (Augmented Reality), e. g. aircraft data or runway closures, would lower this risk, reduce head-down times and the cognitive workload.

For decades, therefore, several augmented reality approaches have been used to enrich the external view of the air traffic controller with relevant information. However, this approach holds numerous technical, human and organizational challenges. In our project IMAN (part of the joint project 'iPort' BMBF), we performed a systematic analysis of technical solutions and design options and developed an AR solution for tower controllers to direct traffic safely and efficiently while considering ergonomic and design point of views.

Project organization

The aim was to develop workplace concepts that reduce the daily mental workload of tower air traffic controllers. So one main task was to assess current controllers’ loads and tasks and anticipate the future. Building on this, a concept for an innovative workplace was designed and evaluated in several iterations, integrating ergonomic knowledge, product and interface design as well as air traffic control specific know-how.

Project phases

The project was divided into:

1.) Analysis
   Technical systems and implementation into the overall system ATC workplace
   Existing interactions of human-machine system

2.) Conception
   Participatory development of a basic architecture
   Development of an AR HMI concept

3.) Implementation / iteration
   Continuous simulation evaluation in iteration cycles
   Implementation of several real-time simulations

4.) Evaluation
   Review the new (simulated?) system involved controllers, as well as new arrival will users

Design process

The development of HMI done in several iterative steps:

The first step was recognized as the basis for the design of an actual analysis of the current situation of ATC (air traffic controllers), the information and support needs, design and use of existing systems and the associated gaze and interaction areas / operating difficulties.

In addition to the use of technical literature and company sources, several observations in the Tower Frankfurt and interviews with pilots were conducted.
The next step involved careful analysis of existing requirements and the integration of these results with ergonomic findings to define the specific requirements for this project. Workshops with different experts and ATC were used.

In the subsequent iterative design phase, several prototypes have been developed, representing a particular stage of development. In this case, different questions were pursued. Already at an early stage in the design process first demonstrators were built. This allowed the already mentioned early involvement of the future users and an evolutionary prototyping. In support of prototyping, the use of the prototypes in a real-time simulation of a tower simulator of the DFS was carried out (see König et al. 2008).

The high degree of realism of the HMI could therefore examined under realistic conditions and largely derived from findings are at least partly transferred to the reality. From the beginning of the development all design and interaction innovations were evaluated by different methodological investigations. So ATC were asked about the new design from the beginning. In later stages of development, users were always involved in the design process. Any change in design was backed by a corresponding occupational scientific investigation.

Human Factors topics covered

The project was conducted in a strictly iterative and interdisciplinary way, in a team consisting users (air traffic controllers) as well as ergonomic experts, psychologists and designers - a massively participatory design process. The focus was primarily on ergonomic aspects of interface design, especially an suitable integration of Augmented Reality in existing work processes. As part of a research project were not only technical aspects in particular, but:

- The presentation of content (situation-specific information needs)
- The type of information representation (colours, shapes)
- The impact of situational dynamics (movements and status changes of aircraft, timing)
- As well as the environmental conditions (traffic, weather and lighting conditions, ...) considered

Moreover, several head tracking possibilities were tested to ensure the correct projection the AR object depending on the user’s line of vision.

Numerous user tests in all design stages were performed in real-time simulations, accompanied by workshops in which all interactions and scenarios were simulated and assessed.

The paper describes the approach as well as major design steps and deals relevant requirements of AR environments from an ergonomic point of view. Using the example of individual design solutions it discusses also fundamental advantages and disadvantages of AR solutions, such as textured backgrounds and light dependence discussed.

Results

Conclusion

The HMI in the present context requires a close fit between users and the technical system, and must contribute to the controller’s work, e. g. Reduce his mental workload or offer additional information that improves decision making. Additionally, the work of a air traffic controller is highly complex and difficult to assess. Therefore, the approach of a massive participatory analysis and development has been as very useful to ensure this close fit and to enable continuous evaluation in realistic work scenarios. Although this is time-consuming and requires intensive communication, this is essential to develop complex HMI using innovative and sometime poorly conceived technology. Thus, this paper illuminates the interplay between technical potential and constrains on the one hand and human needs and skills on the other hand, and how future work systems can be designed respecting the human.

References

