Steps towards the Virtual Tower – Remote Airport Tower Operation Research (RapTOr)

Remote Tower Operation (RTO) describes the goal of remote control of small airports and of large airport’s movement areas which are not directly visible from the control tower.

Within RapTOr an RTO experimental system was realized as extension of the Advanced Surface Movement Guidance and Control System (A-SMGS) at the Braunschweig research airport.

Analysis, cognitive modelling and simulation of the tower work procedures supported the design and development of the demonstrator.

The experimental system demonstrated for the first time the realization of a high resolution videopanorama with real time object recognition and augmentation of flight data. Furthermore the visual performance of the workplace was proved via flight tests.

RapTOr is a first step on the way to the RTO Center for the control of multiple small airports and to the Virtual Tower (ViTo) control center for large airports as long term goal.

In 2005 the DLR project RapTOr (Remote airport Tower Operation research) was started as follow-up of the „Virtual Tower“ concept study (ViTo, 2002 - 2004).

The results of RapTOr are used in the follow-up project RaiCe (Remote Airport Traffic Control Center) which extends the single operator RTO work environment into an experimental RTO center for investigating the remote control of two or more (small) airports from a single location.

Importance of direct far view for controllers’ work

Results of tower work and task analyses exhibit the importance of the direct far view out of the tower windows for establishing the controllers’ situation awareness under present day work conditions.

This finding provides the motivation for designing the RTO Human Machine Interface (HMI) with a high resolution augmented vision video panorama as main component that replaces the controller’s direct far view out of the tower windows.

As a constraint the reconstructed vision of the videopanorama should provide the controller with at least the same quality of information as compared to the real view.

Technical Realization

A PC cluster with the image compression and processing software at the camera position allows for generating a live stream of a 180° panorama and for automatic object tracking via pan-tilt zoom camera (PTZ) and real time movement detection. The data are stored (roughly 40 GByte of data per hour) which provides the possibility of complete panorama replay. The upper picture on the next page depicts the live video panorama of the monitor system, with the remotely controlled PTZ-camera displayed on a separate monitor.

Interaction of the operator with the panorama system (cameras, weather station and microphone) is performed via pen touch-input display. It also displays electronic flight strips and provides virtual buttons for panorama and PTZ-camera control.
180° Videopanorama display system with additional PTZ display above and pen touch input display below.

Augmentation of information: aircraft are detected via image processing and tracked (purple square). If available transponder data with multilateration position are superimposed (yellow), the blue line marks the glide path and red lines GPS data.

**Video See Through Augmented Vision**
Within the video panorama real-time aircraft position information is integrated, obtained from the multilateration system at the Braunschweig airport via transponder. Position information is derived simultaneously from real time image processing movement detection.

Under reduced visibility this Augmented Tower Vision feature allows for localizing the a/c near the correct position because the transponder code, a/c label and numerical information are integrated near the nominal a/c image location in real time. Contours of the movement areas are superimposed on the reconstructed panorama for guiding the operator's attention during darkness or low visibility conditions.

One important advantage of this video see-through augmented vision technique is the easy integration of augmented vision features into the digital video panorama without any computational delay between video and augmentation.

**Validation of the video panorama**
With moderate costs as compared to established surveillance sensors by using latest camera technology a reconstruction of the real view through videopanorama can be achieved that fulfills necessary requirements regarding system ergonomics and the quality of visual information.

The validation of the system by means of flight tests showed, that the detection of the main visual cues necessary for tower control operation was comparable under video panorama as under real view conditions.

The optical resolution has been assumed to play the dominant role for event detection. Quantitative evaluation of field trials for comparing real view and video panorama observation verifies the theoretically predicted video resolution of circa 2 arcmin for the “peripherally” component.

A “foveal” component is provided by the remotely controlled pan-tilt zoom camera with a high resolution exceeding that of the human eye (1 arcmin) within an observation angle less than 15°.