Surveillance Data Processing System (SDPS)

Algorithms for localization and tracking of civil aircraft

Project Goal

For air traffic control, air traffic controllers must be informed at all times about the current Air Situation Picture, consisting of the type of each aircraft, the flight number, the position and speed of all aircrafts. The task of a Surveillance Data Processing System (SDPS) is to generate so-called tracks for all aircrafts by combing the data from various radar stations. The aim of this project was to develop an algorithm for such an SDPS, which calculates a highly accurate and reliable Air Situation Picture from all available data and information. This algorithm was implemented and integrated as a software module in an existing SDPS with very high reliability and quality requirements.

In terms of data processing, the greatest challenge in this project for the creation of an SDPS was the use of many different radar technologies. Examples of this are primary radar, secondary radar according to the Mark X and Mark XII standards, Automatic Dependent Surveillance - Broadcast (ADS-B) and Wide Area Multilateration (WAM).

The challenge is that the sensor technologies used in the radars have different measurement models, interference properties, error patterns and measurement rates. The data from the various radar technologies must be processed in real time in the SDPS and merged with one another in order to generate a precise, common Air Situation Picture. The used algorithms and their specific implementation as software modules must calculate the tracks very efficiently, yet precisely and reliably. Another major challenge is the high level of precision and reliability, which should be guaranteed in all situations and under all circumstances, including during major interference.

This is only possible if the algorithms automatically detect incorrect measurements such as reflections, radar interference and incorrect radar settings and compensate for them with plausible values. Such algorithms make it possible to reliably obtain a high-quality image of the air situation of all moving objects.

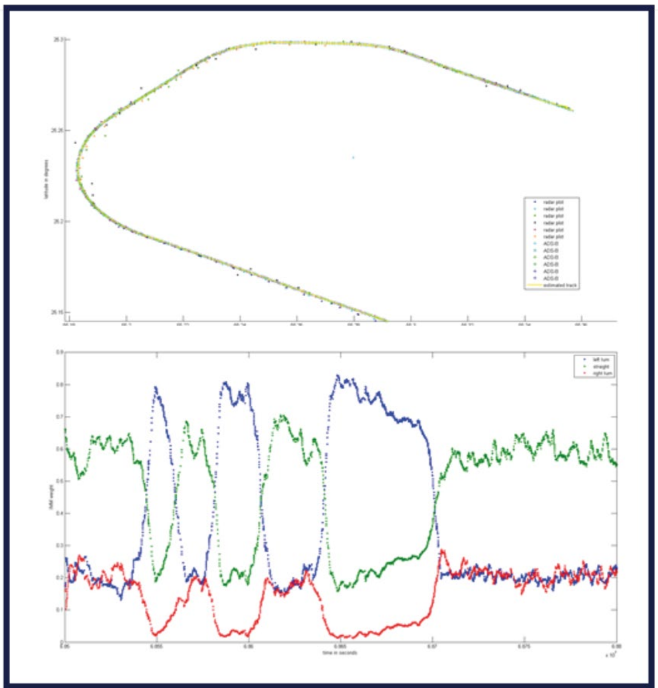
Primary and Secondary Radar
(below and above)

Primary and Secondary Radar. A primary radar implements the radar principle exclusively and directly, i.e. the immediate (passive) echoes of the previously emitted impulses are analyzed and the distance to the object is deduced. In contrast, the secondary radar is a radar that works with active, cooperative objects and derives additional information from a data signal. In practice, a combination of primary and secondary radar often occurs.

Procedure & Solution

- Development of an algorithm for data association: assignment of radar measurements subject to interference to aircraft
- Algorithm development for track updates: optimal calculation of position and speed in 3D, update and processing of other variables transmitted by the aircraft such as mode C and mode S
- Development of the algorithms beyond the current state of research and technology
- Development, evaluation and optimization of the algorithms in a rapid prototyping environment
- Implementation in C++ according to V-Model and quality standards (here EUROCAE ED153) with coding rule
- Tests: Comprehensive unit tests, partially automated tests with real data, development of a simulation tool for testing with simulated data.

Generating an Air Situation Picture. A specific algorithm uses the data from the various sensor technologies to generate the position and speed of all flying objects (tracks). This enables a precise, reliable image of the air situation to be generated.



Flight Trajectory
Detected Maneuvers

Display of the Flight Trajectory and Detected Maneuvers. The figure above shows the position of an object as it is sent by the individual radar technologies and the calculated track. It can be seen that the data is very noisy and has offsets, whereas the calculated track is very smooth and much more precise. Furthermore, the detected maneuvers (e.g. left, right or straight flight) that can be calculated using the tracking algorithm are shown.

Results & Benefits

- Very precise and reliable position determination of the aircraft
- Internal representation in a global coordinate system for worldwide tracking
- Automatic detection and compensation of outliers, disturbances and reflections
- Detection of flight maneuvers, such as climbing and descending flight or turning maneuvers
- Simultaneous monitoring of the calibration parameters of all radar stations for the automatic deactivation of defective systems
- Redundant system for instantaneous takeover of data processing in the event of failures

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