Conflict Detection Metrics for Aircraft Sense and Avoid

Fredrik Lindsten, Fredrik Gustafsson ({lindsten, fredrik}@isy.liu.se) &
Per-Johan Nordlund (per-johan.nordlund@saabgroup.se)

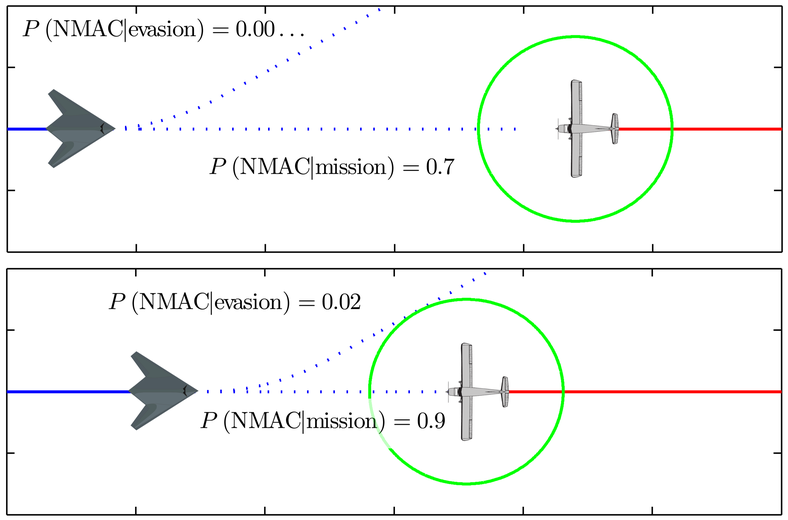
Contributions

- Different approaches to risk assessment are compared in an extensive simulation study.
- Cumulated risk is shown to be more robust to state uncertainty than the traditional instantaneous risk.
- A recently proposed approximate method for cumulated risk computation is evaluated and shown to perform within the statistical confidence bounds of a corresponding Monte Carlo method.
- A real mid-air collision between traffic aircraft is studied. It is shown that a simple self-contained collision avoidance system could have been used as a backup to a primary system like TCAS. This way, severe accidents involving manned traffic aircraft could have been averted.

Collision avoidance

For unmanned aerial vehicles (UAVs) to be able to operate in the same airspace as other aircraft, it is crucial that they can avoid near mid-air collisions (NMACs).

For this purpose the UAV will need to be equipped with a sense and avoid system, in which one critical step is to determine the risk for collision. If the estimated risk for a predicted evasive maneuver is considered to be too high the avoidance needs to be initiated.



Risk assessment

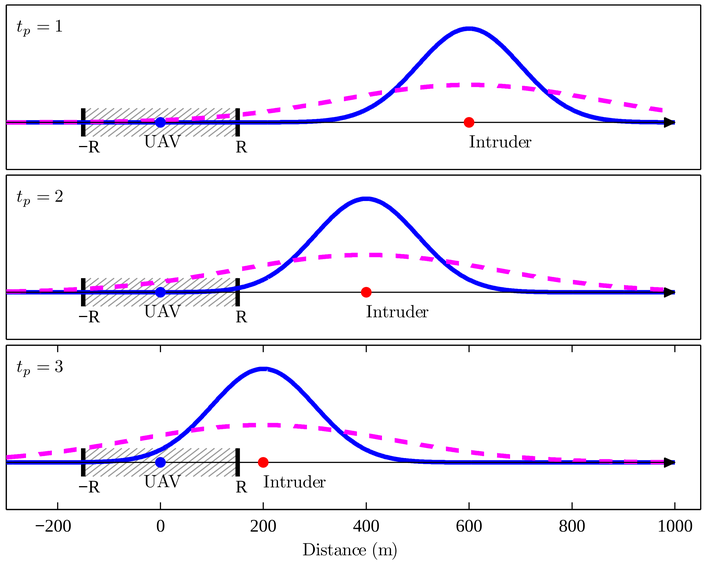
Different approaches to risk assessment can be used. The traditional way is to focus on the maximum instantaneous risk

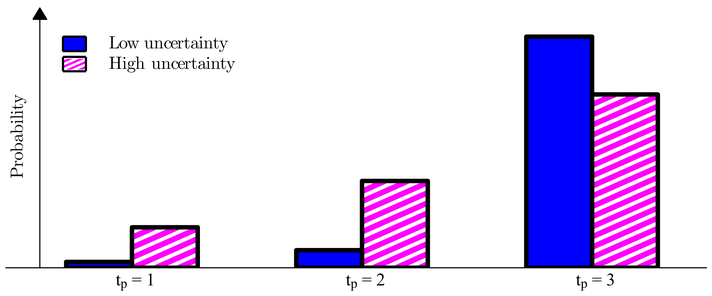
$$\max_{0<t_p<T_p} P(NMAC_1 t_p) = \max_{0<t_p<T_p} P(|s(t_p)| < R)$$

A more recent idea is to calculate the cumulated risk over a critical time horizon [2]

$$P(NMAC_{(0,T_p)}) = P\left(\min_{0<t_p<T_p} |s(t_p)| < R\right)$$

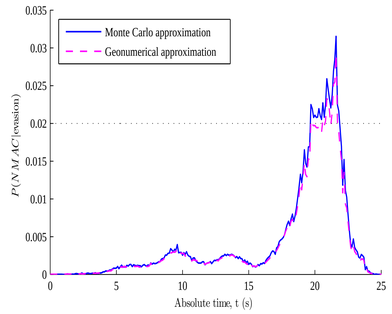
The traditional approach will be sensitive to an increased state uncertainty. If the uncertainty is large, the maximum instantaneous risk will be diminished, although the actual risk remains large. Cumulated risk is, through an extensive simulation study, shown to be more robust against this uncertainty [1].





Risk computation

A recently proposed method for cumulated risk computation (see [2]), suitable for real-time implementations, has been evaluated. The method was shown to perform within the statistical confidence bounds of a corresponding Monte Carlo method [1].



Case study

The approximate method for risk computation is mainly focused on a UAV application, but to see if it is applicable in other areas as well a replication of a real mid-air collision between commercial aircraft has been studied.

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It was shown that a self-contained collision avoidance system could serve as a backup for a primary system like TCAS. This could have averted severe accidents involving manned traffic aircraft.

References

[1] F. Lindsten, P.J. Nordlund, and F. Gustafsson. Conflict detection metrics for aircraft sense and avoid systems. *Accepted for the 7th IFAC Symposium on Fault Detection, Supervision and Safety of Technical Processes*, 2009.

[2] P.J. Nordlund and F. Gustafsson. Probabilistic near mid-air collision avoidance. *Accepted for IEEE Transactions on Aerospace and Electronic Systems*, 2008. www.control.isy.liu.se/~fredrik/reports/08TAES_CA.pdf.