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Analysis of the traffic conflict situation for speed probability distributions

Zs. Öreg* , H.-S. Shin  and A. Tsourdos 

Centre for Autonomous and Cyber-Physical Systems, School of Aerospace, Transportation and Manufacturing, Cranfield University, Cranfield, UK

*Corresponding author. Email: zsombor.oreg@cranfield.ac.uk

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Abstract

The increasingly widespread application of drones and the emergence of urban air mobility leads to a challenging question in airspace modernisation: how to create a safe and scalable air traffic management system that can handle the expected density of operations. Increasing the number of vehicles in a given airspace volume and enabling routine operations are essential for these services to be economically viable. However, a higher density of operations increases risks, poses a great challenge for coordination and necessitates the development of a novel solution for traffic management. This paper contributes to the research towards such a strategy and the field of airspace management by calculating and analysing the conflict probability in an en-route, free-flight scenario for autonomous vehicles. Analytical methods are used to determine the directional dependence of conflict probabilities for exponential and normal prescribed speed probability distributions. The notions of geometric and speed conflict are introduced and distinguished throughout the calculations of the paper. The effect of truncating the set of available flight speeds is also investigated. The sensitivity of the calculated results to speed and heading perturbations is studied within the analytical framework and verified by numerical simulations. Results enable a fresh approach to conflict detection and resolution through distribution shaping and are intended to be used in an integrated, stochastic coordination framework.

Nomenclature

a	parameter of the exponential distribution for the ownship [—]
ACAS	airborne collision avoidance system
ADS-B	automatic dependent surveillance-broadcast
ATC	air traffic control
b	parameter of the exponential distribution for the intruder [—]
CA	collision avoidance
CNS	communication, navigation and surveillance
d	distance to be traversed between sensing range and conflict range ^(m)
DAA	detect and avoid
erfc	complementary error function
GC	geometric conflict
l	lower speed limit [Kn]
MDP	Markov decision process
NMAC	near mid-air collision
p	magnitude of normal distribution variables [—]
PAV	personal aerial vehicle
PDF	probability density function
$\Pr(x)$	probability of x

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