Automated Detect and Avoid: Autonomy and Ethics

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Overview

• Detect and Avoid
• Automated vs. Autonomous
• Autonomy in need for an Ethical Perspective
• Discussion
• Conclusion
Detect and Avoid

• To assess whether a maneuver is needed based on a display of traffic, the pilot needs to:
  a) Extrapolate position of ownship and traffic into the future (in 3D)
  b) Assess whether within a certain time window both horizontal and vertical separation will decrease below certain thresholds

• To determine the appropriate maneuver based on a traffic display, the pilot needs to:
  c) Estimate change in distance at closest point of approach for considered maneuver options
  d) Weigh ‘cost’ associated with options

• Conflict prediction is rather difficult with a standard Cockpit Display of Traffic Information
• Conflict resolution is even more difficult
• Automation can be used to aid the pilot
Detect and Avoid

• Code of Federal Regulations (CFR) 14 §91.113 “. . . vigilance shall be maintained by each person operating an aircraft so as to **see and avoid** other aircraft. When a rule of this section gives another aircraft the right-of-way, the pilot shall give way to that aircraft and may not pass over, under, or ahead of it unless **well clear**”

• RTCA DO-365 Phase 1 Minimum Operational Performance Standards (MOPS) for UAS Detect and Avoid (DAA) Systems
  • DAA systems used in aircraft transitioning to and from Class A or special use airspace, traversing Class D, E, and G airspace in the NAS.
  • The DAA equipment does not replace the UAS PIC and it does not combine or prioritize all the information the UAS PIC uses to safely aviate, navigate, and communicate.
  • The UAS PIC will use information from the DAA equipment in conjunction with other instruments, airspace knowledge, and ATC instructions to make decisions about maneuvering the UA
In 2014 the Science and Research Panel (SARP) established a quantitative definition of Well Clear
• Thresholds are determined by $P(\text{NMAC} \mid \text{WCV})$ unmitigated = 2.2%
• RTCA’s Special Committee SC-228 has developed a technical standard for airborne equipment that will aid the flight crew of UAS in maintaining Well Clear according to the SARP’s definition
Well Clear and Conflict Space

• Conflict space is that part of the airspace in which the separation with another aircraft (intruder) is predicted to be no longer ‘well clear’

• It should be avoided since penetration may lead to an NMAC

• The contours of the conflict space show the ‘what if’ for an ownship maneuver

• The intruder ‘sees’ a different conflict space

• The point of closest approach (CPA) lies within the conflict space and is static in case neither ownship nor intruder maneuver

• The contours of the conflict space are semi-static, i.e. they change only slight in location until ownship is very close.

• If the intruder maneuvers, the conflict space will move
DAA & Automation

• Automation at work
  • Fusion of multi-sensor data into single traffic entities
  • Computation of conflict space according to pre-defined spatial-temporal thresholds
  • Computation of headings in which DWC will be lost within pre-defined time
DAA Alerting and Guidance Example

- Pilot has level 3 SA* on maneuver options
  - Display presents answer to the ‘what if’ maneuver question
  - No mental extrapolation needed
  - Pilot can weigh options
- The pilot’s decision regarding whether, and if so when and how to maneuver is based on the information provided by the DAA system and experience, training and judgment
- Pilot judgment question
  - Would the maneuver choice be influenced in case the pilot knows one of the intruders is unmanned?

*Level 3 Situation Awareness is indicative of the ability to anticipate the future situation and required for effective decision making.
Automated vs. Autonomous

• In the ICAO Working paper ‘Autonomy and Automation’ a distinction is made between automated and autonomous based on whether a system is deterministic or not.

• It is also stated that: “it is not anticipated that in the short term, any element of an RPAS operating in civil airspace can be considered to be autonomous given current technologies, and social, ethical and legal concerns”

  • Do these concerns only arise from the notion that autonomous systems are “unpredictable” and automated systems are not?
  
  • Or should the transfer of execution authority (from operator to system) with potentially hazardous outcome also be a reason to consider such concerns?
  
  • In the latter case, this will determine the upper limit to the level of automation for certain functions
Drivers for higher Levels of DAA automation

• To compensate for inability of the pilot to decide and initiate action, e.g. due to failure of the Command & Control (C2) Link.

• To compensate for failure of the pilot to decide and initiate action.

• As workload reduction for the pilot (assuming monitoring of the execution is still performed).

• As full replacement of the pilot for the DAA role, e.g. in a concept of operation in which a single pilot manages the flight of multiple unmanned aircraft and requires the system to automatically resolve conflicts.

Relationship between DAA Automation and CNPC Link System RLP
From: RTCA DO-365, Appendix K
Potential steps for further automation

• LOA 5: Rather than presenting the pilot with options, the system presents the pilot with the maneuver it has scheduled. It requires active pilot consent for the execution.
  - The pilot’s decision is reduced to accepting or rejecting the proposed maneuver.
  - The pilot’s decision is based on the information provided by the DAA system and experience, training, and judgement.

• Conditional execution authority has been delegated to the DAA system.
  - LOA 6: After a TBD veto time, the DAA system can initiate action without requiring active pilot consent.
  - This provides DAA function availability and continuity in case of a failure of the CNPC link.

For nominal operations, the assumption is that the pilot is still involved and is able to make an informed decision concerning whether to veto an action scheduled by the DAA system.

• Pilot judgment, relying on experience and the human ability to take ethically justified non-normative criteria into account, plays a decisive role.
• Are guidelines for a maximum LOA required?
• Under what conditions is it acceptable to automate judgment?
Autonomy in need for an Ethical Perspective

Designing systems with increased autonomy raises ethical questions.

Example for ‘self-driving cars’: moral dilemma for the autonomous collision avoidance function when having to choose between two evils if harm cannot be avoided.

“it matters to the issue of responsibility and ethics whether an act was premeditated (as in the case of programming a robot car) or reflexively without any deliberation (as may be the case with human drivers in sudden crashes)”*

Questions and implications

• Dilemma situations clearly are an issue with self-driving cars
• This issue is a research topic in the field of experimental ethics
  • Utilitarian approach
  • What do people find acceptable?
  • Dilemma scenarios have no uncertainty in outcome: either A or B, both bad
• To what extent is this relevant for UAS / DAA ?
  • Seems different because of timeframe of DAA (more uncertainty)
  • Seems different because of the details of the information
  • Self-sacrifice dilemma not applicable
  • But there may be (pilot) decisions that involve allocation of risk to manned aircraft
  • To what extent is it acceptable to replace human judgment by an automated process when the decision can impact the safety of other people?
Differences in Ethical perspectives

German Ethics Committee on self driving cars (Kantian view)

- More fundamental questions than the utilitarian approach
  - “Dürfen existentielle dilemmatische Entscheidungen überhaupt abstrakt-generell vorweggenommen und technisch vorentschieden werden?”
  - The committee did not answer this question with no, but advises a strong degree of scrutiny
  - The committee did not reach a satisfactory conclusion and encourages further investigation concerning this fundamental question

Utilitarian approach

- For moral judgment, the focus is on the consequences and outcome of an action
- An often-used theory, as it deals with individual situations in a straightforward, almost mathematical way
- Goal: “to identify moral algorithms that people are willing to accept as citizens and to be subjected to as car owners”
• Utilitarianism leaves no room for the Kantian ‘meta’ questions, as it purely concentrates on the best outcome per situation. Because of this, it is broadly criticized by other moral theories.

• Deontologist theories oppose and criticize utilitarianism: A positive outcome may seem logical, it does not justify the moral value of an action.

• Fairness as a result of equalizing people’s utility does not imply fairness from equalizing expected utility.

• Both deontologist and consequentialist theories could provide guidance and are often used when analyzing dilemma-situations. However, they cannot be further apart in their moral standards.

• In some research into robot ethics it is argued that legal theory may be a better basis for the development of such algorithms that moral theory.
Conclusions

• DAA system autonomy can be increased stepwise, but the gradual increase in LOA can occlude a fundamental transition. What may seem a small step from a technical point of view can be a leap into uncertainty from an ethical perspective.

• Given the current level of DAA automation, there is room for further automation, enabling several of the use-cases discussed in this paper.

• At the level of DAA automation where pilot judgment concerning maneuver decisions is to be replaced by an automated function, the more fundamental question introduced in this paper applies.

• For concepts that aim to fully automate the orient-decide-act phase, the credit given to the contribution of pilot judgment must be made explicit.

• To allow for certain increases of automation, while preventing increments in automation that may be burdened with fundamental ethical question, a more refined use of automation definitions is necessary from a regulatory perspective.

• Similar to considering human-factors in the design of automation that interacts with humans, ethics should be considered in the design of automation that is intended to replace human judgment that affects the safety of other humans.
Thank you

Questions?