Can Artificial Intelligence pass the CPL(H) Skill Test?

ICAS Workshop 2017-09-11

Dr. Luuk van Dijk -- Anna Chernova
1 Why?
2 What?
3 How?
4 Yes?
FIG. 4.—Governor and Throttle-Valve.
"To fast-forward to the **safest** possible operational state for VTOL vehicles, network operators will be interested in the path that realizes **full autonomy as quickly as possible.**" (source)

"Electr**ically operated aerial vehicles combined with more autonomous operation** and data-driven business models could herald the **biggest change in aviation in decades.**" (source)

"Pilotless planes are technically feasible, and could bring material benefits" (source)
1 Why?
2 What?
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Every other startup idea since 2015

1. Collect BIG DATA
2. Apply magic-AI-black-box
3. Profit!
What is this “AI” you speak of?

(depends on who you ask)

_The science and engineering to create machines (computer programs) that use understanding of the world to achieve goals._
A broad range of CS techniques

- Computer Vision
- Robotics
- Statistics on Big Data
- Machine Learning
- “Deep” neural networks
- Reinforcement Learning
- Adaptive (learn on the job)

New algorithms are made possible by strides in computational capacity.
Build what you require

Require the right things to be there

Require the wrong things to be not there

Build what you require
§ 23.1329 Automatic pilot system.

If an automatic pilot system is installed, it must meet the following:

(a) Each system must be designed so that the automatic pilot can—

(1) Be quickly and positively disengaged by the pilots to prevent it from interfering with their control of the airplane; or

(2) Be sufficiently overpowered by one pilot to let him control the airplane.
Chapter 3
Helicopter Flight Controls

Introduction
There are three major controls in a helicopter that the pilot must use during flight. They are the collective pitch control, the cyclic pitch control, and the antitorque pedals or tail rotor control. In addition to these major controls, the pilot must also use the throttle control, which is usually mounted directly to the collective pitch control in order to fly the helicopter.

In this chapter, the control systems described are not limited to the single main rotor type helicopter but are employed in one form or another in most helicopter configurations. All examples in this chapter refer to a counterclockwise main rotor blade rotation as viewed from above. If flying a helicopter with a clockwise rotation (left and right references must be reversed particularly in the area of rotor blade pitch change, antitorque pedal movement, and tail rotor motion.)

If rpm is
and ragnut pressure is
Solution

- Increasing the throttle increases main shaft pressure and rpm
- Lowering the collective pitch increases main shaft pressure and decreases rpm
- Raising the collective pitch decreases main shaft pressure and decreases rpm
- Reducing the throttle decreases main shaft pressure and rpm
Adaptive AI systems face 3 layers of challenges

- Sufficiently reliable hard- and software
- Regulatory capture
- **Actually Solving The (Hard) Problems of Flying!**
  - Dealing with the unexpected
1 Why?
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Modern AI & the unexpected?

- Pool flight hours
  - Copies of our systems can share their learnings
- Simulations
  - Generate much more data than you could ever train a human on!
  - Take $10^4$ Hours of real data,
  - …. multiply by $10^8$ scenarios...

What if we created an autopilot
with $10^{12}$ hours of PIC time in Day, Night, IFR...
The real art of flying

I. Preflight preparation
II. Preflight procedures
III. Airport operations
IV. Hovering maneuvers
V. Takeoffs, landings and go-arounds
VI. Performance maneuvers
VII. Navigation
VIII. Emergency operations
IX. Special Operations
X. Postflight procedures
industry assessment of autonomy's current ability

Deconstructed Pilot
Areas Where Autonomy Can Be More Capable

- Systems Management
- Navigation
- Communication
- Basic Airmanship
- Terminal Procedures
- Takeoff and Landings
- Detect and Avoid
- Planning and Decision Making
- Emergency Procedures

Source: recent report by NASA Autonomy Incubator
The real art of flying

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VIII. Emergency operations
IX. Special Operations
X. Postflight procedures
Reconnaissance for confined area landings

- High reconnaissance
  - Wind direction and speed
  - Find touchdown point
  - Forced landing options
  - Approach/departure axes

- Low reconnaissance
  - Reconfirm earlier observations
  - Wires, poles
  - Surface conditions: dust, sand, snow, debris and obstacles
    - Anything that is dangerous
  - Slope

Source: Helicopter Flying Handbook ch 10 “Advanced Maneuvers”
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*Source: Helicopter Flying Handbook ch 10 “Advanced Maneuvers”*
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How to outperform the human

● The easy bits
  ○ Permanent attention for everything
  ○ Always a plan ready
  ○ Look in all directions always
  ○ Superior control over the airframe
  ○ Should we pull the parachute?

● The harder bits
  ○ Recognizing water, debris, snow
  ○ Visual clues for the wind
  ○ “anything dangerous”
1 Why?
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Engineering is the art of solving problems within constraints

In the Aerospace sector we like to see those formulated as requirements
Commercial Pilot
Practical Test Standards
for
Rotorcraft
(Helicopter and Gyroplane)

February 2013

Flight Standards Service
Washington, DC 20591

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SUMMARY OF SAE INTERNATIONAL'S LEVELS OF DRIVING AUTOMATION FOR ON-ROAD VEHICLES

Issued January 2014, SAE International's J3016 provides a common taxonomy and definitions for automated driving in order to simplify communications and facilitate collaboration within technical and policy domains. It defines more than a dozen key terms, including those italicized below, and provides full descriptions and examples for each level.

The report's six levels of driving automation span from no automation to full automation. A key distinction is between level 2, where the human driver performs part of the dynamic driving task, and level 3, where the automated driving system performs the entire dynamic driving task.

These levels are descriptive rather than normative and technical rather than legal. They imply no particular order of market introduction. Elements indicate minimum rather than maximum system capabilities for each level. A particular vehicle may have multiple driving automation features such that it could operate at different levels (depending upon the features) that are engaged.

System refers to the driver assistance system, combination of driver assistance systems, or automated driving system. Excluded are warning and monitoring intervention systems, which do not automate any part of the dynamic driving task on a sustained basis and therefore do not change the human driver's role in performing the dynamic driving task.

<table>
<thead>
<tr>
<th>SAE level</th>
<th>Name</th>
<th>Narrative Definition</th>
<th>Execution of Steering and Acceleration/Deceleration</th>
<th>Monitoring of Driving Environment</th>
<th>Feedback Performance of Dynamic Driving Task</th>
<th>System Capability (Driving Modes)</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>No Automation</td>
<td>The full-time performance of the human driver or all aspects of the dynamic driving task, even when enhanced by warning or intervention systems.</td>
<td>Human driver</td>
<td>Human driver</td>
<td>Human driver</td>
<td>n/a</td>
</tr>
<tr>
<td>1</td>
<td>Driver Assistance</td>
<td>The driving mode-specific execution by a driver assistance system of all steering or acceleration/deceleration using information about the driving environment and with the expectation that the human driver perform all remaining aspects of the dynamic driving task.</td>
<td>Human driver and system</td>
<td>Human driver</td>
<td>Some driving modes</td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>Partial Automation</td>
<td>The driving mode-specific execution by one or more driver assistance systems of both steering and acceleration/deceleration using information about the driving environment and with the expectation that the human driver perform all remaining aspects of the dynamic driving task.</td>
<td>System</td>
<td>Human driver</td>
<td>Some driving modes</td>
<td></td>
</tr>
<tr>
<td>3</td>
<td>Conditional Automation</td>
<td>The driving mode-specific performance by an automated driving system of all aspects of the dynamic driving task with the expectation that the human driver will respond appropriately to a request to intervene.</td>
<td>System</td>
<td>System</td>
<td>Some driving modes</td>
<td></td>
</tr>
<tr>
<td>4</td>
<td>High Automation</td>
<td>The driving mode-specific performance by an automated driving system of all aspects of the dynamic driving task, with or without a human driver's input at any time.</td>
<td>System</td>
<td>System</td>
<td>System</td>
<td>Some driving modes</td>
</tr>
<tr>
<td>5</td>
<td>Full Automation</td>
<td>The full-time performance by an automated driving system of all aspects of the dynamic driving task under all roadway and environmental conditions that can be managed by a human driver.</td>
<td>System</td>
<td>System</td>
<td>All driving modes</td>
<td></td>
</tr>
</tbody>
</table>

Key definitions in J3016 include (among others):
- Dynamic driving task: includes the operational (steering, braking, accelerating, monitoring the vehicle and roadway) and tactical (responding to events, determining when to change lanes, turn, use signals, etc.) aspects of the driving task, but not the strategic (determining destinations and wayfinding) aspect of the driving task.
- Driving mode: is a type of driving scenario with characteristic dynamic driving task requirements (e.g., expressway merging, high speed cruising, low speed traffic jam, closed-campus operations, etc.).
- Request to intervene: notification by the automated driving system to a human driver that she should promptly begin or resume performance of the dynamic driving task.

Contact: SAE INTERNATIONAL • +1 724-776-4841 • Global Ground Vehicle Standards • +1 248.276.2495 • Asia +86 21 61857758
Dynamic driving task includes the operational (steering, braking, accelerating, monitoring the vehicle and roadway) and tactical (responding to events, determining when to change lanes, turn, use signals, etc.) aspects of the driving task, but not the strategic (determining destinations and waypoints) aspect of the driving task.
A modest proposal

● Define **descriptive** levels 0...5 cf. the SAE for a comprehensive set of tasks
  ○ Not necessarily the CPL(H) ones

● For each task, level define **normative** metrics that would constitute sufficient and convincing bars of compliance

● ..... 

● Profit!
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