Natural Intelligence Outperforms Artificial Intelligence for Autonomy and Vision

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Opteran

Introduction – Opteran

- Opteran's purpose is to re-engineer nature's algorithms to create a software brain that enables machines to perceive, behave and adapt more like natural creatures

- An award-winning business:
  - Vision Tank Audience Choice 2021
  - Robotics Business Review Top 50 Innovation Award 2021

- Featured by Wired, New Scientist, BBC, …

The Problem Opteran Solves

- "Supervised ML doesn't live up to the hype. It isn't actual artificial intelligence akin to C-3PO, it's a sophisticated pattern-matching tool"
  - Stefan Seltz-Axmacher – CEO, Starsky Robotics
- "There are two ways of approaching [UAV] autonomy, photogrammetry and AI – Opteran's approach is a third way"
  - Gur Kimchi Founder – Amazon Prime Air Business Unit

The Promise of Whole-Brain Modelling – 'Natural Intelligence'

- Imitating the brain, or the mind, to develop AI goes back to Turing
- Deep learning is based on a cartoon of a tiny part of the primate brain – ignores its vast complexity
- Modern neuroscience techniques are giving the information to faithfully reverse-engineer real brains
- …but doing so requires great insight and creativity

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MIND

A QUARTERLY REVIEW

OF

PSYCHOLOGY AND PHILOSOPHY

I.—COMPUTING MACHINERY AND INTELLIGENCE

By A. M. Turing

1. *The Imitation Game.*

I propose to consider the question, 'Can machines think ?' This should begin with definitions of the meaning of the terms 'machine' and 'think'. The definitions might be framed so as to reflect so far as possible the normal use of the words, but this attitude is dangerous. If the meaning of the words 'machine' and 'think' are to be found by examining how they are commonly used it is difficult to escape the conclusion that the meaning and the answer to the question, 'Can machines think ?' is to be sought in a statistical survey such as a Gallup poll. But this is absurd. Instead of attempting such a definition I shall replace the question by another, which is closely related to it and is expressed in relatively unambiguous words.

The new form of the problem can be described in terms of a game which we call the 'imitation game'. It is played with three people, a man (A), a woman (B), and an interrogator (C) who may be of either sex. The interrogator stays in a room apart from the other two. The object of the game for the interrogator is to determine which of the other two is the man and which is the woman. He knows them by labels X and Y, and at the end of the game he says either 'X is A and Y is B' or 'X is B and Y is A'. The interrogator is allowed to put questions to A and B thus :

C : Will X please tell me the length of his or her hair ?

Now suppose X is actually A, then A must answer. It is A's

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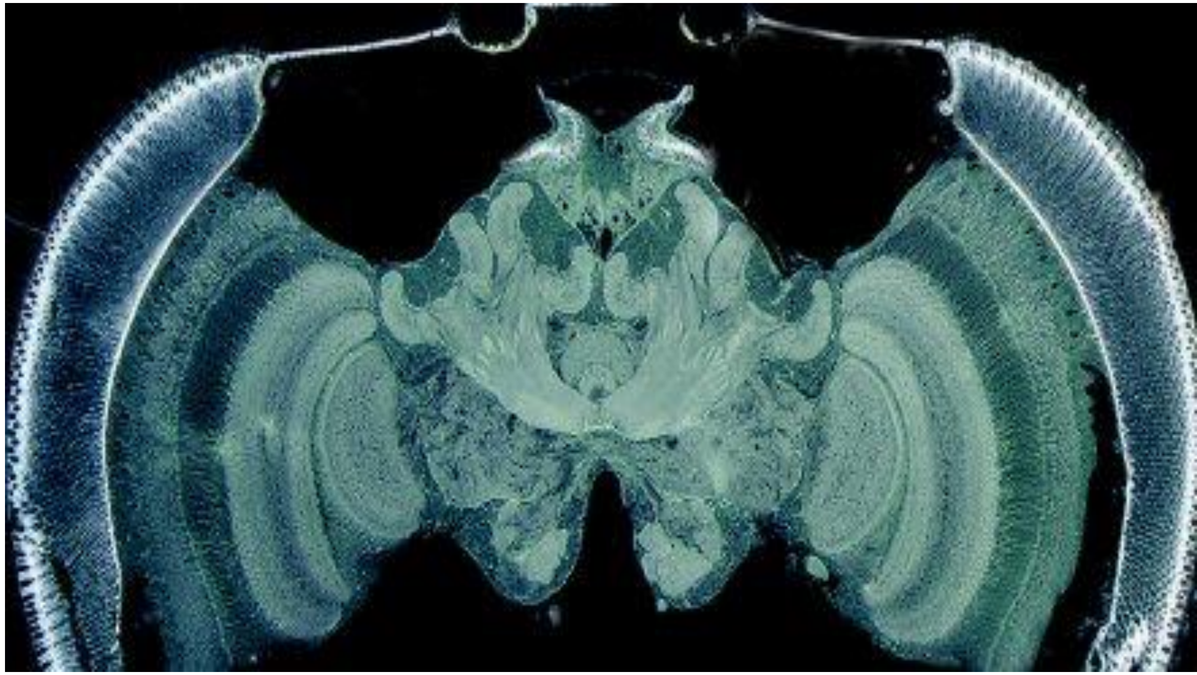
Insects as Models for Vision-Guided Autonomy

- Rather than start with primate brains, start with some of the simplest brains on the planet
- Insects have tractable brains (<1M neurons), but still very useful vision-guided autonomy behaviours
- E.g. honeybee foragers navigate out and back up to 7 miles, communicate location in space to nestmates, primarily visually



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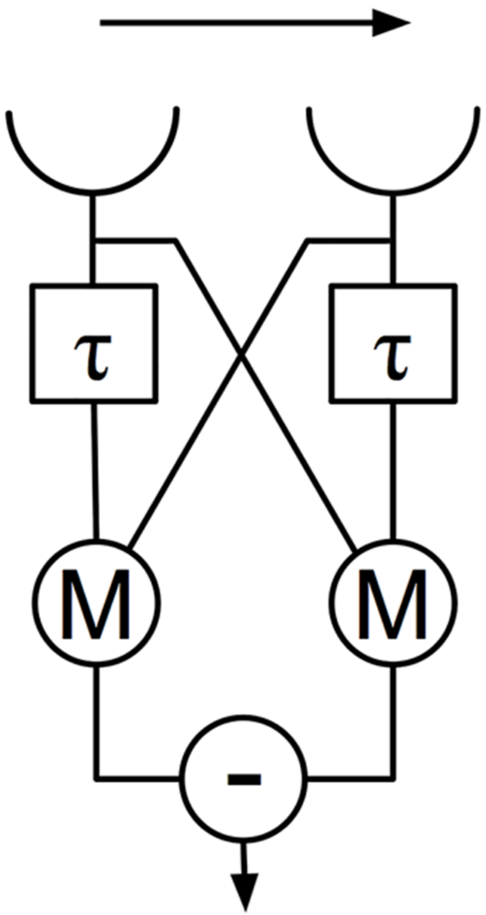
Reverse-Engineering a Best-in-Class Optic Flow Algorithm from the Honeybee Visual System

Overview:

- Fundamental principles of biological motion detection
- A novel arrangement of elementary units
- 10 kHz optic flow processing for <1 W
- Performance exceeds the deep learning state-of-the-art by orders of magnitude
- Robot demonstration

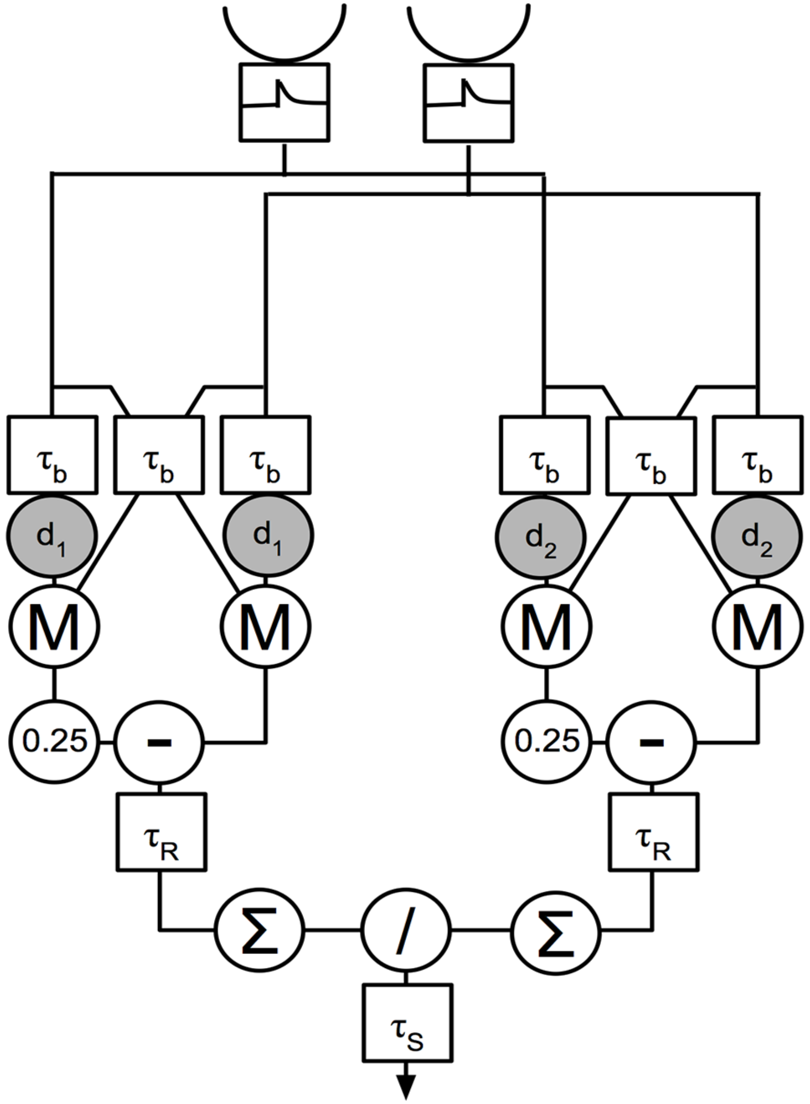
Fundamental Principles of Biological Motion Detection

- Elementary Motion Detectors (EMDs), or Hassenstein-Reichardt detector, first derived with insect experiments
- Neural recordings in fruit fly correspond with model predictions
- But, sensitive to spatial frequency, and contrast, so poor for visual navigation



A Novel Arrangement of Elementary Units

- Honeybee flight behaviour shows great robustness to spatial frequency, and contrast, so something more must be going on
- We discovered a novel arrangement of EMDs that reproduced the bees' behaviour
- This provides a robust Visual Inertial Odometry and collision avoidance algorithm *(US patent no. 11,170,646)*



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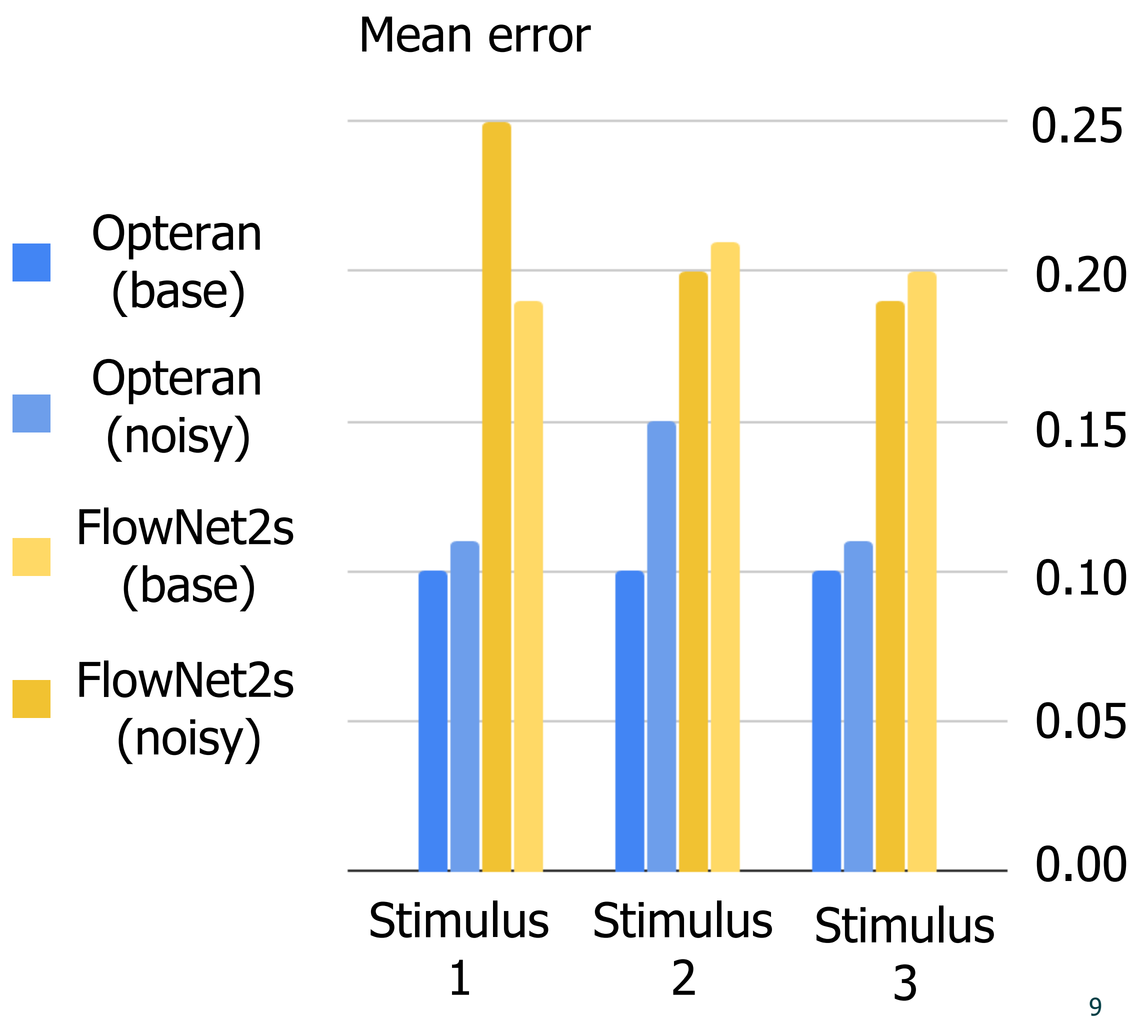
10 kHz Optic Flow on FPGA for a Fraction of a Watt

Outperforms State of the Art computer vision and deep learning approaches to optic flow:

- E.g. 2x accuracy improvement relative to FlowNet2s, and robust to noise
- …and orders of magnitude higher fps
- …for a fraction of the power draw
- But we mainly care about real-world performance



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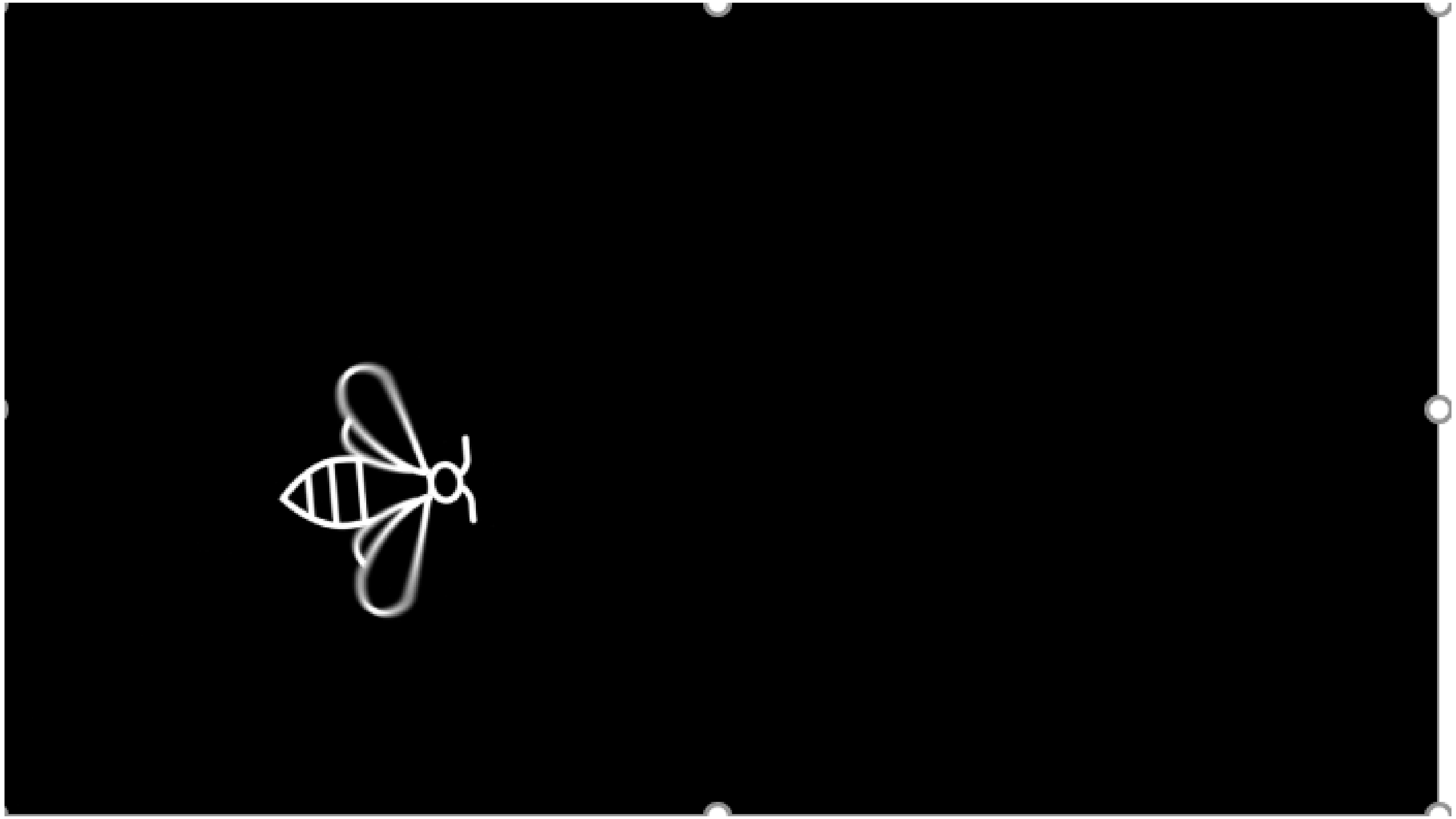
Robot Demonstration



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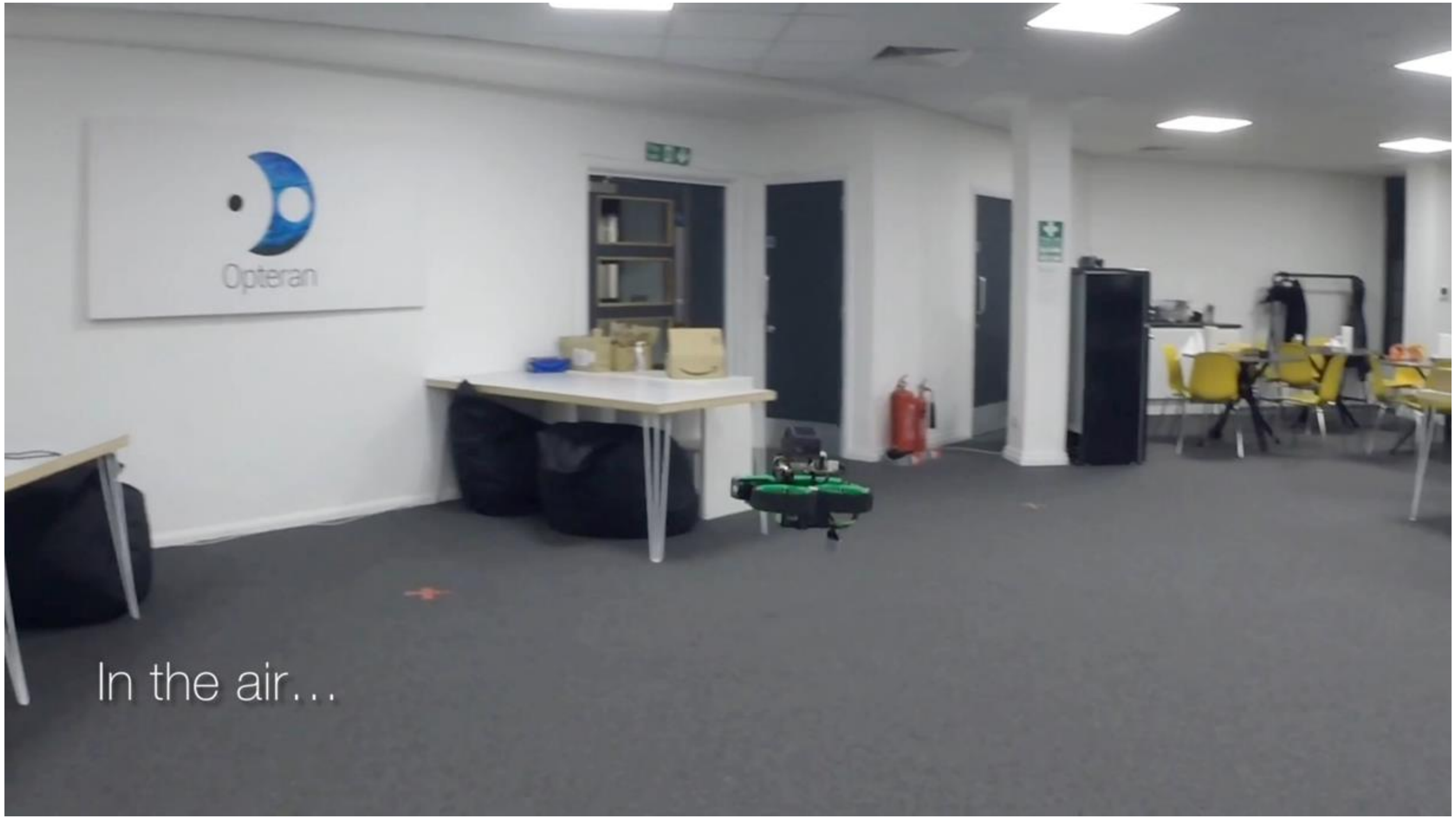
Reverse-Engineering a Best-in-Class 3D Navigation Algorithm from the Honeybee Brain

Overview:

- A different approach to photogrammetry and deep learning
- Navigational autonomy (SLAM + path planning + routing + semantics) for a fraction of a watt, with maps consuming kilobytes of memory
- UAV demonstrator

Deploying a Best-in-Class 3D Navigation Algorithm from the Honeybee Brain



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Opteran Software Stack for Autonomy

Perception: 360° electronically-stabilized vision

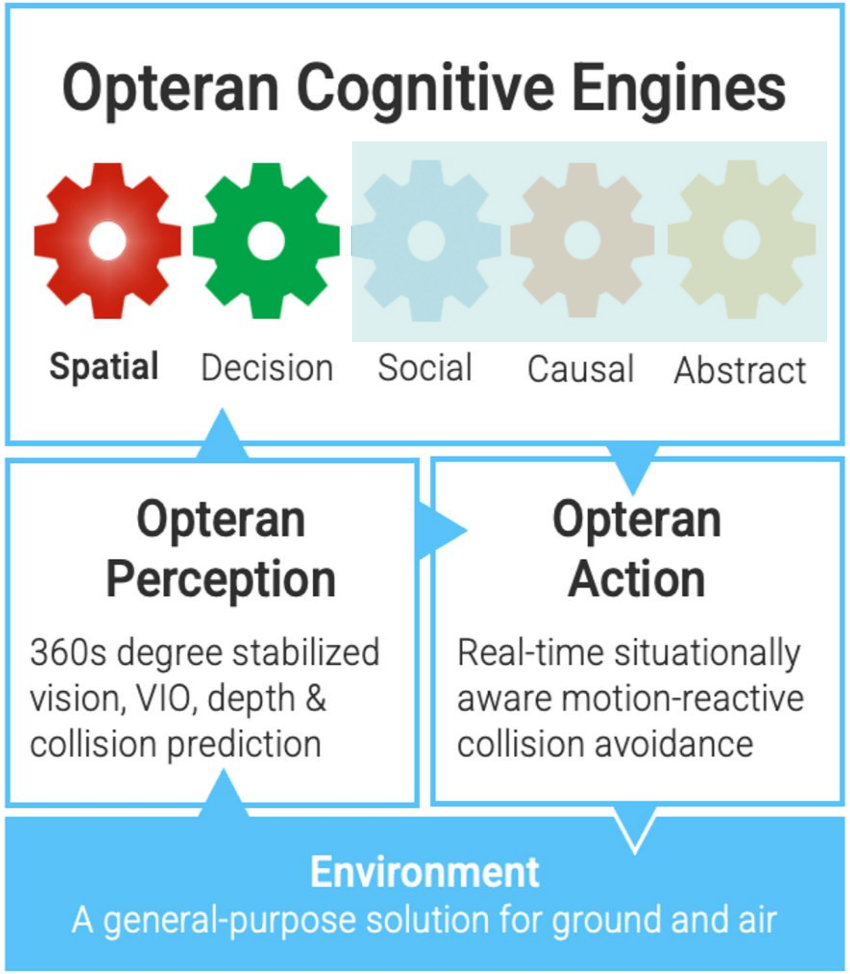
Action: Real-time dynamic collision avoidance

Spatial Engine: Fully autonomous navigation

Decision Engine: Machine decision making

Future! Social, Causal & Abstract Engines

No Data | No Data Centre | No Training



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Available on the Opteran Development Kit

- Two or four MIPI-CSI2 cameras providing 360° integrated electronically-stabilized vision at 150 fps (patent pending)
- Omnidirectional dense optical flow field measurement
- Omnidirectional pixel-wise collision prediction
- <30 g and <3 W
- Interfaced via ROS/Mavlink/C driver over Gigabit Ethernet
- Other compute platforms targetable

Company Resource Slide

Resources

Website

https://www.opteran.com

YouTube

https://tinyurl.com/opteran

LinkedIn

https://www.linkedin.com/company/opteran/

Partnership Programme

https://opteran.com/partnership-programme

2022 Embedded Vision Summit

Visit us at Exhibitor Booth 705