DISCOVER ENGAGE IMPACT

VEER RIGHT; SAFE FLIGHT

Drawing inspiration from nature, studying how bees and birds make decisions to test navigation and safety strategies for unmanned aircraft.

After 100 years of manned aviation, unmanned aircraft are being introduced into the national airspace system.

However, when you remove the pilot, you also remove the ability to see and avoid other aircraft. Looking forward is often about looking back and, just as the Wright Brothers did before him, Professorial Research Fellow Professor Mandyam Srinivasan, Head of the Neuroscience of Vision and Aerial Robotics laboratory at the Queensland Brain Institute (QBI), draws inspiration from nature.

“I should invent a new term to describe what we do,” says Professor Srinivasan.

“It is not quite biomimicry because we are not slavishly copying everything an insect or a bird does, or copying the way they are built in fine detail. We absorb the general principles of these animals’ systems and then realise the musing off-the-shelf equipment. We are ‘bio-inspired’.”

Bio-inspiration does not extract or harvest from nature; rather, it consults nature.

“For example, bees do a beautiful thing – they adjust their speed based on the world around them.”

Bees keep the image of the world moving at a constant rate so that, for example, when they come in to land, they have automatically slowed down, without measuring their speed or the distance to the ground or doing any of the other things engineers would ordinarily do.

“We don’t want to completely copy the animal because, quite often, an animal can be designed for various purposes and that design may not be optimal for our purposes,” Professor Srinivasan says.

“But, what we can do is take inspiration from that beautiful autopilot for a soft landing, develop an algorithm and apply it to an off-the-shelf quadcopter unmanned aircraft, which can mimic some of the behaviours of bees, and use it to make the unmanned aircraft automatically slow down to make a smooth landing.”

Bio-inspiration.

Bio-inspired collision avoidance

Professor Srinivasan and his lab are not the only ones who are bio-inspired. Boeing, the world’s largest aerospace company, is collaborating with Professor Srinivasan in the hope of applying bio-inspiration to aircraft.

“We initially started working with Boeing in a minor way when we were developing algorithms based on how bees use their vision to navigate,” Professor Srinivasan says.

Bees measure how far they have flown using a visually driven odometer; they are a completely self-contained system. Boeing was interested to see if some of this bee visualisation could be combined in a novel navigation solution that assured a navigation solution in challenging environments.

And then the opportunity arose for Professor Srinivasan and Boeing to collaborate on research about mid-air collision avoidance.

Computer vision can enable an unmanned aircraft to detect and avoid other aircraft, as well as enabling an unmanned aircraft to navigate through unmapped or dynamic complex environments. Existing technologies for ‘detect and avoid’ collisions are still in an early iteration, and this research may enhance their capability into the future.

Beyond just wanting not to crash and damage their unmanned aircraft, unmanned aircraft operators must avoid collisions with people, property and other vehicles.

“More and more aircraft are populating our airspace and, with improvements in unmanned and autonomous technology, there will be an increase in the number of unmanned aircraft sharing the airspace,” Professor Srinivasan says.

“These aircraft are going to have to act independently of each other and come to a mutually compatible solution when aircraft confront each other.”

Extrapolating from his work with bees, Professor Srinivasan started working with budgerigars, another small-brained animal, but with the remarkable ability to fly through complex environments at incredible speed, rarely colliding. While it can be assumed that birds have established basic rules and strategies to minimise their risk of collision, surprisingly little is known about how they do it. Past studies, including work by Professor Srinivasan’s team, have focused on how birds avoid obstacles, negotiate narrow spaces, or maintain their position within a flock. But no previous studies had specifically looked at what happens when two birds fly towards each other.

This is where Professor Srinivasan focuses this work, which is funded by the Australian

Research Council and Boeing, with the Queensland University of Technology as a co-investigator. In his most recent series of experiments, his laboratory released pairs of budgerigars from opposite sides of a flight tunnel to look for general strategies they might use so as not to collide.

Their preliminary analysis shows that the birds always veer to the right and maintain a specific altitude to avoid head-on collisions. He also found that collision avoidance does not depend on the direction of flight, ruling out the possibility of an internal compass.

"It's ridiculously simple; in hindsight it seems so obvious," Professor Srinivasan says.

Technology Readiness Level

So how will this information be applied to unmanned aircraft?

Low-level vision and navigation research will continue to play a role in building intelligent, unmanned aircraft that can be used for reconnaissance, surveillance and planetary exploration. In places without access to GPS satellites, unmanned aircraft will have to rely on their own senses and behave like a bird or an insect.

While it is still early days in terms of applying this research to unmanned aircraft, Professor Srinivasan's team are now looking at how birds navigate space in detail – including the wing kinematics of collision avoidance, and testing their data on a mechanical bird.

"Boeing are very broadminded in their support of our research. Studying wing kinematics may not have obvious direct application, but the more we observe and learn from nature's solutions the bio-inspiration provides new and exciting insights and opportunities. Boeing is not only interested in basic strategies of how nature performs collision avoidance and navigation but understanding how birds do what they do as birds have been mastering flight a lot longer than us."

"We are currently developing ways to automatically track flying birds in videos, which can potentially also be applied to detect, identify and track aircraft using machine vision."

While Boeing and Professor Srinivasan's team already work closely, their collaboration has been enhanced with the relocation of 30 Boeing researchers and technical staff to a new Boeing Research & Technology Australia (BR&T-A) site in the engineering hub at UQ's St Lucia campus.

The benefits that Boeing can bring to UQ research can be illustrated using the Technology Readiness Level scale (TRL). NASA developed the TRL scale – a scale from 1 to 9 that lets researchers, developers and investors judge how ready a technology is to be used. So, for example, at Level 1 a technology is just an idea; after Level 9 it is ready to use commercially. To give a representative example, Leonardo da Vinci was at Level 1 when he studied flight, the Wright Brothers were at Level 6 when they first achieved powered flight and a commercial airliner has moved beyond Level 9 into production and operations.

Universities tend to work in the Level 1–3 space; they are after new knowledge. This area is where all new ideas start, where basic research takes place. In collaborating with UQ, Boeing works on the TRL scale at Levels 3–6. This is where we can help scale-up the ideas and start to move them towards prototypes and more commercial uses.

In addition to working with Professor Srinivasan's team, the new BR&T-A facility will collaborate with UQ researchers on issues such as cabin disease transmission, aircraft simulator technologies and manufacturing technologies. Another advantage of industry being involved with the University is the opportunity to suggest projects, work with students and perhaps, in time, to involve more Boeing staff in teaching at UQ.

Shaping a nation

Professor Srinivasan exudes joy for his work. This infectious enthusiasm and his unassuming nature has been expertly captured by Archibald Award-winning artist Sam Leach. The National Portrait Gallery has a collection development policy of commissioning portraits of individuals who have influenced or contributed to shaping of Australia as a nation and a society.

Professor Srinivasan's humble approach and simple explanations of his work make it easy to forget that this man is a giant of Australian science.

His contributions to Australian science have been recognised with his recent appointment as a council member of the Australian Academy of Science Council.

"I have had a fairly good run in my career as a scientist and I think it is about time that I try to give back.

"The role of the Council is very important, primarily to ensure that the future of science in Australia remains robust."

With scientists such as Professor Srinivasan collaborating with forward-thinking companies such as Boeing, the future of science in Australia is both robust and (bio) inspired.

uq.edu.au/research/impact

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Highlights to date:

1988: Discovery of how bees navigate safely through narrow passages

1995: Discovery of how bees control their flight speed

2000: Discovery of how bees use their vision to orchestrate smooth landings

2000: Discovery of how bees use their vision to estimate how far they have travelled

2003: Discovery of how stealthy dragonflies camouflage their motion while tracking intruders or prey

2010: Implementation of insect-inspired methods for stabilising the flight of a fixed-wing aircraft

2014: Implementation of insect-inspired visual guidance algorithms to achieve a fully autonomous flight mission – including takeoff, cruise, aerobatic manoeuvres and landing

2014: Discovery of wingspan awareness in birds

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