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Defence Innovation Network Grant Scheme: Pilot Project

SELF AWARE ARTIFICIAL INTELLIGENCE (AI) NAVIGATION AND CONTROL SYSTEM

PROBLEM

Defence has an ongoing need to provide in theatre battlefield logistic and strategic support. Often, there is insufficient surface or airborne vehicular capacity, insufficient time to provide support or the threat to personnel delivering the support is too great.

NEED AND RELEVANCE TO DEFENCE

Reducing the number of aircrew on board military aircraft will ultimately reduce the loss of life that may occur in battle or in training exercises. The more capability that is offloaded to the unmanned system itself will allow for faster and more flexible mission design, incursion into higher threat areas and greater capacity to design stealthier aircraft.

Tactical delivery of fuel and ordinance to advanced troops, strategic resupply over difficult terrain, as well as medical evacuation support for Land and Maritime Forces is ever present. Ancillary tasks such as land mine detection, threat emitter detection and electronic surveillance are alternate applications of such a platform. Delivery of goods from vessels such as an LHD to unprepared locations or perhaps after a natural disaster that is being supported by Defence using unmanned heavy lift rotorcraft will demand the technology proposed by this project.

To operate effectively in this environment Defence will need a high speed VTOL aircraft that can carry several hundred kilograms of payload or more and provide tactical support, strategic support and reconnaissance in ways fixed wing aircraft are incapable of undertaking.

To enhance the effectiveness of high speed low altitude unmanned aircraft operations, a new paradigm for navigation and system awareness is required.

RESEARCH QUESTION

Can a Self Aware Artificial Intelligence (AI) Navigation Planning and Control system be developed that uses Machine Learning and a Blended Sensor Suite to optimise unmanned aircraft flight path control?

To stimulate conceptual manifestation some thoughts have been posed:

The AI will need to cater for any multi-purpose unmanned vehicle capable of high speed which matches or exceeds the speed of any conventional VTOL aircraft.

The platform should be able to fly below 100’ AGL at speeds greater than 250kts but ideally, use Nap of the Earth (NOE) techniques.

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The AI system should provide:

- rules based navigation guidance which includes threat area avoidance, mission prioritisation (fastest route v's longest dwell time) and acceptable mission risk level;
- interpretation of physical structures and topographical terrain;
- inflight obstacle and intruder avoidance; and
- deconfliction from other known airspace users which might include rounds fired from surface assets, operations by close air support aircraft, unmanned strike aircraft, etc.

A blended data system might use content from Laser, Radar, Ultra Sonic, Infra-Red, Visual, EM direction of arrival, Acoustic, Synthetic Aperture Radar (multiple platforms integrating data) as well as external sensor data depending on what sensors and systems are fitted to the aircraft. This might include satellite based terrain maps, terrestrial maps of known objects such as power and rail lines or high altitude real time intelligent systems.

Can AI navigation make predictive decisions to modify the navigation route while maintaining a defined mean line of track to optimise an ingress and egress route? What rules apply:

- additional fuel used;
- restricted areas;
- tolerable threat level;
- lowest visual line of sight exposure to observers;
- weather effects?

Can Machine Learning techniques be employed to:

- respond to standard Air Traffic Control voice/CPDLC instructions;
- respond to Mission Lead verbal instructions enroute (drone mule);
- differentiate between a bird, a drone, a balloon, a friendly aircraft, an enemy aircraft, a civilian aircraft, a glider, a missile;
- determine whether an aircraft may be about to encounter an area of adverse wind by observing flags, trees, smoke or clouds;
- identify a series power stanchions and understand that there may be a power line running between the stanchions without necessarily detecting the power line;
- determine environments where Vortex Ring State might occur;
- determine whether a prepared surface is actually a runway and subsequently avoid the area? This may be enhanced by detecting whether an observed (detected) aircraft is flying a take-off or landing profile.

Can the positioning, navigation, and timing (PNT) solution combine with AI navigation to define a suitable VTOL landing area and provide guidance instructions to land the aircraft?

Can the air vehicle be self aware? The AI should /could:

- stop rotor blades rotating if an intruder (person or other object) approaches whilst on the ground;

- determine if people or other objects are on the landing site;
- identify nominated landing platform, ship, trailer, truck, robotic arm;
- match velocity, pitch and roll of any moving landing platform;
- determine what height is tree height, hold below that height and raise an observation sensor equipped periscope;
- return to base when reaching low fuel level commensurate with egress flight plan fuel variations;
- identify and prioritise alternate landing sites inflight;
- generate contextual audible/visual warnings – “Stand Clear, About To Start”;
- for ‘In Flight Follow Me’ station keeping, ‘Loyal Wingman’ the AI identification of what mission leader looks like and how to maintain all weather station keeping;
- weather awareness – detect and where necessary avoid thunderstorm, wind shear, heavy rain, freezing conditions;
- determine if an intruder is on a collision course and subsequently take avoiding action;
- alert when overloaded – temperature and fuel load are determinants;
- report defects/position/fuel load;
- unlock secure doors and access ports when authorised maintenance personnel approach;
- manage speed when limited by environmental conditions such as low visibility;
- be aware of its kinetic and potential energy so that it can predict whether it can overfly an obstacle such as a mountain when flying into a katabatic wind;
- capture and process gathered intelligence and prioritise relevance for distribution. This may include using that intelligence to alter the navigation route based the intensity of local EM traffic;
- Once a mission is defined, calculate the fuel required plus reserves and cut off refuelling when that volume is reached;
- Manage inflight performance that may be restrictive based on the payload or package on board for that mission i.e. g limit, airspeed limit;
- Update local Ring Laser Gyro (RLG) / Fibre Optic Gyro (FOG) / Micro Electro Mechanical System (MEMS) inertial measurement unit (IMU) position from geographic features/man-made objects/Shuttle Radar Topography Mission (SRTM) correlation/GNSS; and
- Manage pre-flight and inflight vibrational modes.

Can the AI encapsulate a suitable data bus such as MIL-STD-1773 or MIL-STD-1553 be utilised to enable plug and play addition of sensors and navigation components?

Can the above tasks be achieved in all weather and in a GNSS denied environment?

What Control and Communication system is required?

Can an Augmented Reality interface enhance the process?

EXPECTED OUTCOME

The project outcome will result in the next generation of navigational systems for VTOL NOE aircraft.