Project proposal template

Graduate School studentships

March 2015

Project title	Stabilisation of hex-rotor unmanned aerial vehicle.	
First Supervisor	Dr	Yahya Zweiri
Second Supervisor	Robert Rayner	
School	Mechanical and Automotive Engineering	
Other member of supervisory team (no more than three KU supervisors in total)	Prof Necip Sahinkaya	
Specific requirements beyond 2:1 degree		

Project summary **(max 4,000 characters)**

i) Problem statement

Unmanned aerial systems applications that require high manoeuvrability vehicles frequently consider quad-rotor. However, quad-rotor has some potential defects such as smaller payload capacity, minimum anti-crosswind capability and lack of hardware redundancy. Lack of hardware redundancy means that failure of a single rotor results in instability and loss of the vehicle. The main characteristics of the hex-rotor Unmanned Aerial Vehicle (UAV) are increased payload capacity, stability in the windy weather and hardware redundancy.

The proposed research project covers a key area of unmanned systems research, which will serve basis for external grant applications and publications in high impact journals, essential for future REF submission by the Faculty.

ii) PhD deliverables

The hex-rotor UAV will be developed for safety of critical missions.

Key PhD stages:

1. Flight dynamic modelling and mission profile analyses.
2. Developing feedback flight control algorithm using digital sliding mode and feed forward based on neural networks dynamic inversion technique.
3. Establishing failure recovery strategies.
4. Initial test of the solutions using computer simulation and in a controlled environment.
5. Field test and validation.

iii) Solution technical overview

In this proposal, a hex-rotor UAV will be developed as an alternative to the quad-rotor. A flight dynamic model will be derived based on Euler-Lagrange method, a hex-rotor is a six-degree-of-freedom, highly non-linear, multivariable, strongly coupled, and under-actuated system. A robust feedback controller based on digital sliding mode and feed-forward neural network dynamic inversion will be developed and implemented. A three-term back-propagation neural networks algorithm will be employed to generate the system dynamic inversion (Zweiri et al., 2003; Zweiri et al., 2005).

A control recovery strategy will be developed for the case of a single rotor failure, the strategy is essential for safety of critical missions. Novel recovery strategies will be developed based on (Alzu'bi, Zweiri et al., 2013; Alzu'bi, Zweiri et al., 2015). The approach will be tested by numerical simulations and implemented on a real system.

iv) Proposed study novelty

- A novel intelligent, robust feedback control algorithm.
- Data fusion of system sensors.
- A self-recovery in case of a motor failure.

v) Collaboration

Internal: This work would involve collaboration between staff of Mechanical Engineering, Aerospace & Aircraft Engineering and Computing within SEC. It will also allow training of new staff using expertise in the area.

External: The work will develop new collaborative links with industry and governmental research institutions, particularly with Morgan company and Defence Science and Technology Laboratory (Dstl).

vi) References

- **Y.H. Zweiri**, J.F. Whidborne, and L.D. Seneviratne: A three-term backpropagation algorithm. Neurocomputing, 50:305-318. 2003.
- **Y.H. Zweiri**, L.D. Seneviratne and K. Althoefer: Stability Analysis of a Three-Term Backpropagation Algorithm. Neural Networks Journal. 18 (10): pp. 1341-1347, 2005.
- Hamzeh Alzu'bi, **Yahya H Zweiri**, Basim Alkhateeb, Ibrahem Mubarak Al-Masarwah: Quad tilt rotor vertical take-off and landing unmanned aerial vehicle with 45 degree rotors. **USA patent 20130105635**, May 2013.
- Hamzeh Alzu'bi, **Yahya H Zweiri**, Basim Alkhateeb, Yahya Al-Majali: Sided performance coaxial vertical take-off and landing unmanned aerial vehicle and pitch stability technique using oblique active tilting (OAT). **USA patent 8931729**, Jan 2015.