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Poster text

High Redundancy in Actuation

Set for Britain, House of Commons, 9th Mar 2009 Department of Electronic and Electrical Engineering

Q: What keeps aircraft flying when something goes wrong?

A: It is not a "bolt on" parachute, but integrated design for safety using redundancy!

The design of safe systems (or high integrity systems) is a well established discipline. Risk cannot be completely eliminated, but engineers try to keep it to an acceptable level. This project tries to improve upon traditional methods by introducing higher degrees of redundancy. The goal is to provide a superior level of safety at higher efficiency and no additional cost.

High Redundancy Actuation

Like a muscle generates a strong force by combining many fibres, the HRA works by engaging a lot of actuation elements. Faults in individual elements have only a minor influence.

1. Basic (Simplex)

- + cheap
- + easy
- not reliable

2. Normal Redundancy (Triplex)

- + redundancy
- + reliability
- cost, weight

3. High Redundancy

- + reliability
- + efficiency
- may lock-up

4. Grid Configuration (Series/Parallel)

- + redundancy
- + reliability
- + lock-up free

The idea is applicable to a range of actuation technologies:

Actuation Technology

Electro-Magnetic

Electro-Mechanical

Piezo-Electric

Hydraulic

Reliability Analysis

In words:

even if one out of 100 elements is faulty,
a 50x50 HRA will only fail on one in 8 billion aircraft.

Passive fault tolerant control
(without reconfiguration)

Robust Control

Simple Controller

- single measurement
- plus load adjustment

Control Structure

- robust PID
- 2 degree of freedom
- state feedback Results with an optimised controller:

Controller Design

- sensitivity based
- H_∞ design
- optimisation
- adaptive control

Active fault tolerance
(with reconfiguration)

Multi-Agent Systems (MAS) deal with complexity by using several cooperating agents for individual functions.

Agent Structure

each agent

is independent

communicates with neighbours

Agent Tasks

fault detection

fault response

multi-model control

Prof. Roger Goodall, Principal Investigator

Fellow of Royal Academy of Engineering, the IET and the IMechE

Research Interests:

- advanced control in electro-mechanical systems
- railway vehicle suspension systems and diagnosis
- state estimation for aircraft flight control systems

Dr. Roger Dixon, Senior Lecturer

Chartered Engineer and Member of the IMechE

Research Interests:

- fault detection and health monitoring

- smart electro-mechanical actuation
- active dampers for vibration suppression

Dr. Argyrios Zolotas, Senior Lecturer

Member of IEEE and SIAM

Research Interests:

- advanced control and optimization techniques
- H ∞ and robust control
- fault tolerant control, especially sensor placement

Dr. Thomas Steffen , Research Associate

Dipl.-Ing., Member of VDI

Research Interests:

- fault tolerant control
- state space methods and the geometric approach
- structure methods and systems engineering

Jessica Davies, PhD Student

Research Interests:

- modelling and identification
- Multi-Agent Systems (MAS)
- software simulation

Dr. Xinli Du, former PhD Student

(now at Aston University Birmingham)

Research Interests:

- fault tolerant control
- optimal control
- mechanical actuation

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