

A Drone-based Building Inspection System

Jun Jo, Zahra Jadidi and Bela Stantic

Institute for Integrated and Intelligent Systems Griffith University, Australia





Projects @ Griffith Robotics Lab

- Autonomous Bridge Inspection using Drones
 - » Autonomous Drone inspecting Cracks
 - » Technologies: 3D mapping and localisation, Feature-based crack detection
- Gas pipeline Monitoring System in Nigeria (ODA proposal)
 - » Monitoring vegetation, gas leakage, coal dust
 - » Technologies: Sensor Networks, Drones, Satellite, hyper-spectral images







Hyperspectral Imaging for Crack Detection





The Spectrum



Problems

- Many heterogeneous devices integrated complicatedly
 » Drones, cameras, GPS, IMU, US, Lidar, Gimbal, etc.
- Often upgraded, replaced, added and changed affecting the whole system.
 - » HW (Computers, Drones, Cameras), SW (languages, codes, algorithms)
- All the components are interrelated and complicated
 - » Eg. PWM_i = f(task, localisation, object detection, GPS, IMU)



Objectives

- To design a modularised agent-based control system model
- To propose a formal language for the communication among the multi-agents.



The Intelligent Monitoring System





A Drone-based Crack Detection System











- **Equilibrium of forces**: $\sum_{i=1}^{4} T_i = -mg$
- **2** Equilibrium of directions: $T_{1,2,3,4}||g|$
- **3** Equilibrium of moments: $\sum_{i=1}^{4} M_i = 0$
- **Equilibrium of rotation speeds**: $(\omega_1 + \omega_3) (\omega_2 + \omega_4) = 0$

An Agent (based on Zielinski, 2017) **Event Manager DB** server inter-agent transmission $_{y}^{T}\boldsymbol{c}_{j,j^{j}}$ **' C**j,j^j transmission internal Cj Cj buffers memory receptor buffers effector buffers $\widehat{E}_{\boldsymbol{\mathcal{C}}_{j,n}}$ Ē**c**j,n $_{y}^{R}\boldsymbol{c}_{j,k}$ $_{x}^{R} C_{j,k}$ 11 **∱**aggregated effector **▲**effector receptor control commands state readings

- C control system
- E effector
- R receptors
- T transmission buffer
- x input
- y output

- *j* agent id (drone)
- k sensor id (GPS or IMU)
- n actuator id (motors)



- C control system
- E effector
- R receptors
- T transmission buffer
- x input
- y output

- *j* agent id (drone)
- k sensor id (GPS)
- n actuator id (motors)



 $(pwm_1, pwm_2, pwm_3, pwm_4)^T := K^{-1}(C_{\phi T}, C_{\theta T}, C_{\psi T}, F)^T$

Crack Detection from an Image







Conclusion

- This paper proposed an agent-based control system model.
 - » For many heterogeneous and complicated devices integrated to be well modularised.
- A formal language proposed for the communication among the multi-agents.
 - » For easily incorporate dynamic changes in both HW and SW.
 - » For complicated but interrelated information to communicated between modules.
- How to measure the usability?