DIP Activator Program

Scalable distributed active sensing and sense making systems: Enable early warning and increased situational awareness for chemical hazards

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28th June 2024

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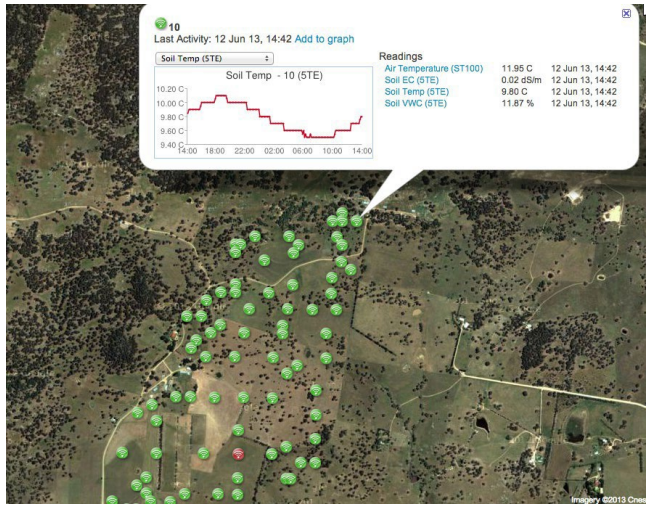
AI in Agriculture

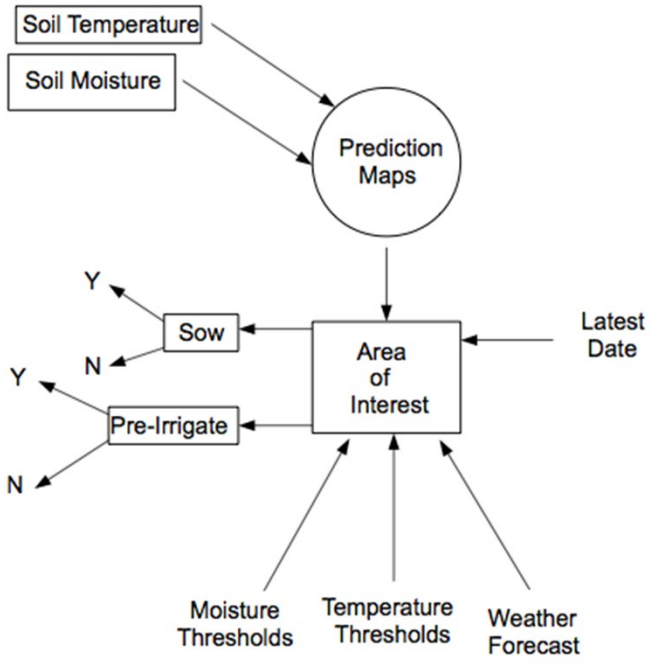
- Autonomous Robotics & Quad-copters
- Satellites – Water Resource Monitoring and Forecasting
- Sensor Networks – Environmental Monitoring
- Sensor Networks – Irrigation
- Smart Sensors – Livestock Welfare Monitoring

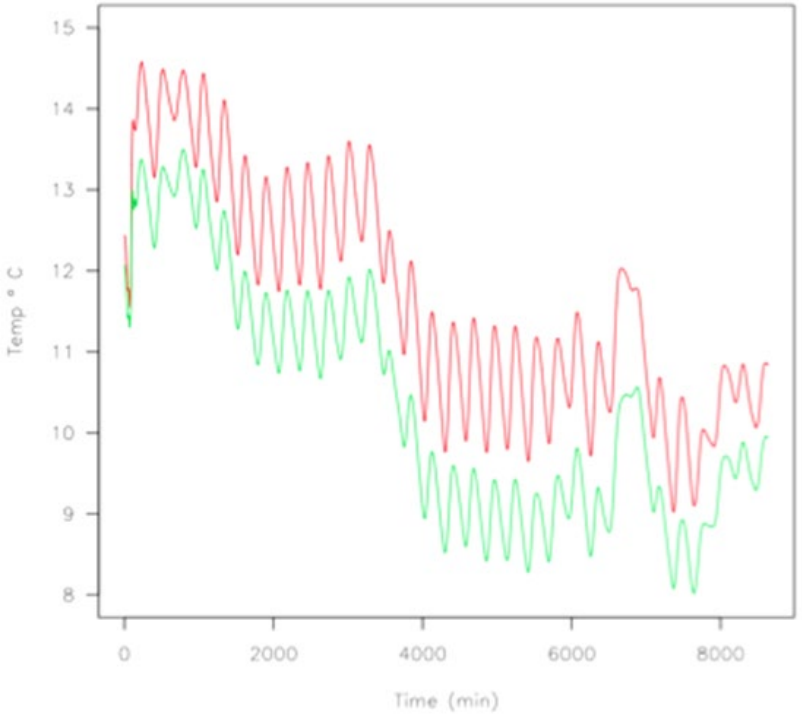


Sensor Networks & Edge Intelligence

Taylor, K., Griffith, C., Lefort, L., Gaire, R., Compton, M., Wark, T., Lamb, D., Falzon, G. and Trotter, M., 2013. **Farming the web of things.** *IEEE Intelligent Systems*, *28*(6), pp.12-19.

Falzon, G., Henry, D., Taylor, K., Lefort, L., Gaire, R., Wark, T., Schneider, D., Trotter, M., Murphy, A. and Lamb, D., 2013. **Surviving the data deluge: geostatistical and signal processing methodologies for smart farm sensor networks.** In *Proceedings of the Digital Rural Futures Conference*. University of New England.



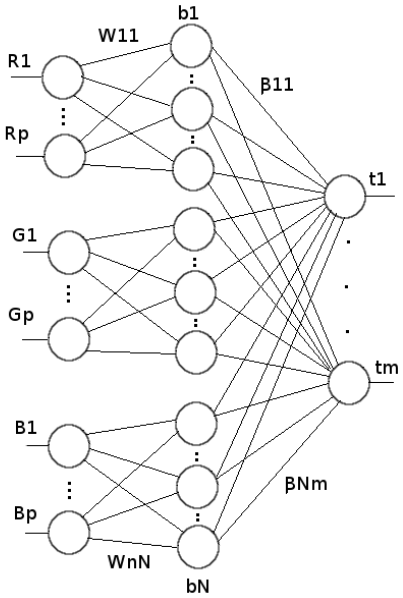


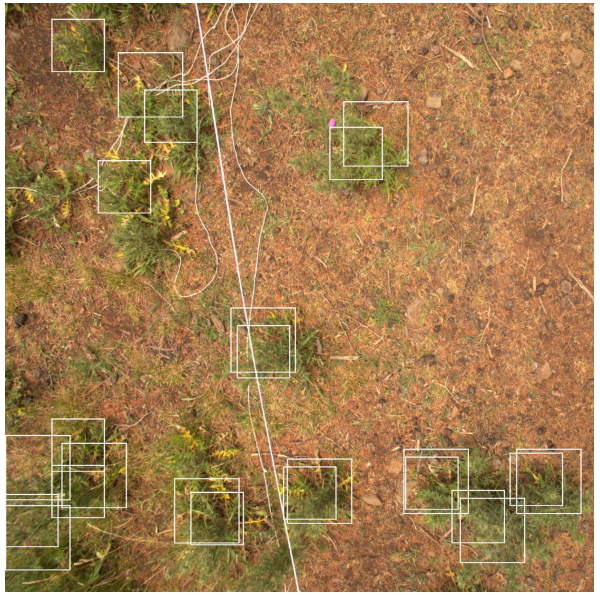
Airborne Autonomous Systems

Sadgrove, E. J., Falzon, G., Miron, D., & Lamb, D. W. (2021). **The segmented colour feature extreme learning machine: applications in agricultural robotics.** *Agronomy*, *11*(11), 2290.

Sadgrove, E.J., Falzon, G., Miron, D., & Lamb, D. W. (2018). **Real-time object detection in agricultural/remote environments using the multiple-expert colour feature extreme learning machine (MEC-ELM).** *Computers in Industry*, *98*, 183-191.

Sadgrove, E. J., Falzon, G., Miron, D., & Lamb, D. (2017). **Fast object detection in pastoral landscapes using a colour feature extreme learning machine.** *Computers and Electronics in Agriculture*, *139*, 204-212.



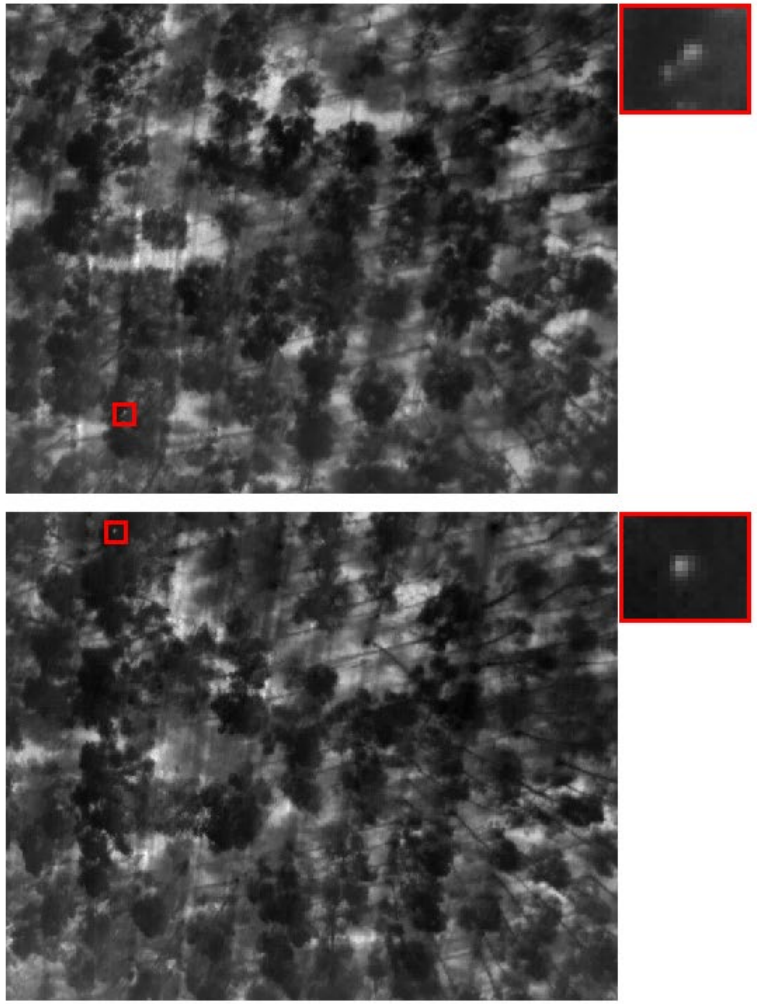


Smart Sensors

- Putting biologically inspired processing between the sensor and decision maker
- Enhances signal-to-noise facilitating better decisions
- Reduces training data requirements and size of artificial networks
- Helps human operators make faster and more accurate decisions
- Early warning for small signals in noise

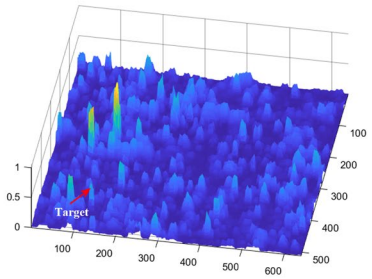
Target Detection

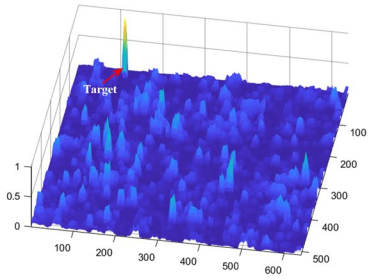
Drone Footage



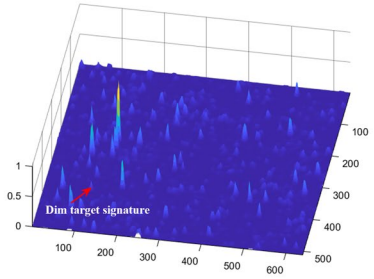
State-of-the-Art Enhancement Methods

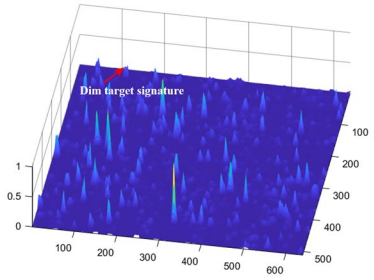
Multiscale Local Contrast Measure



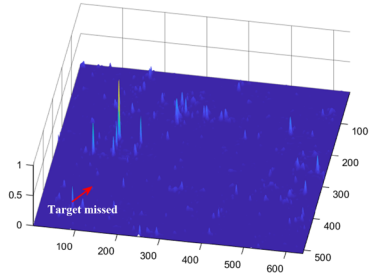


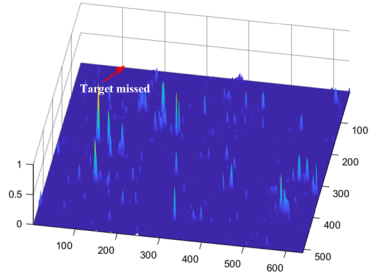
Improved Local Contrast Measure



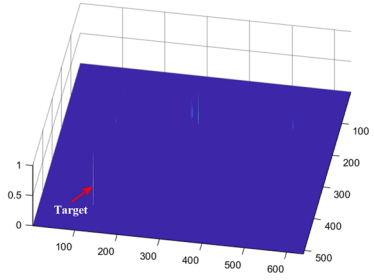


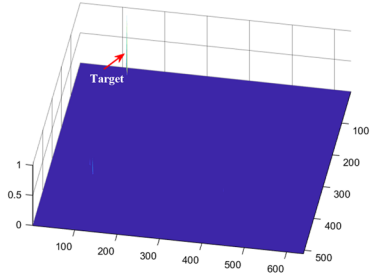
Average Absolute Grey Difference





Bio-Inspired





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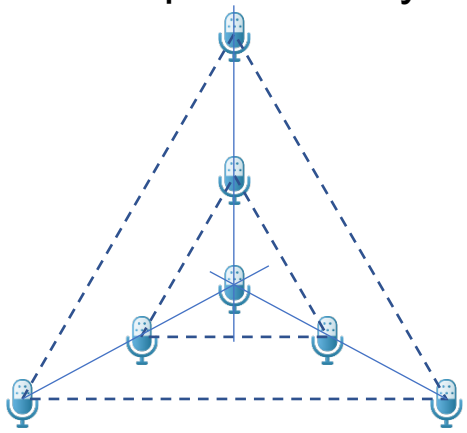
Investigator: Russell Brinkworth

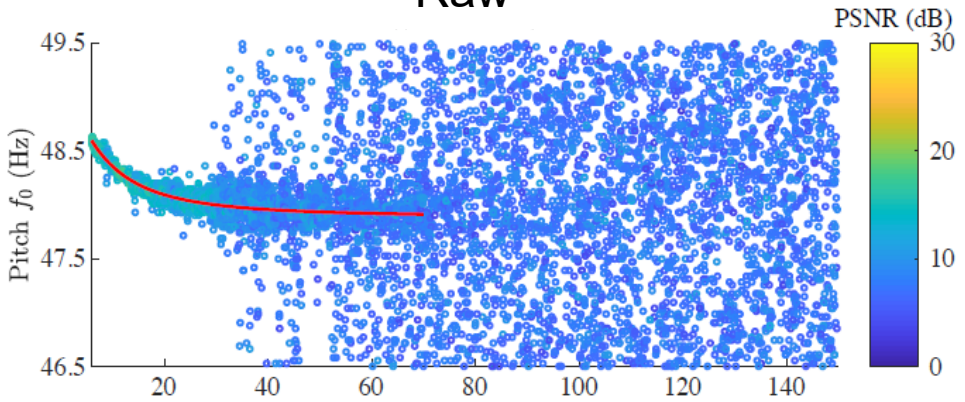
Acoustic Tracking

DJI Matrice 600

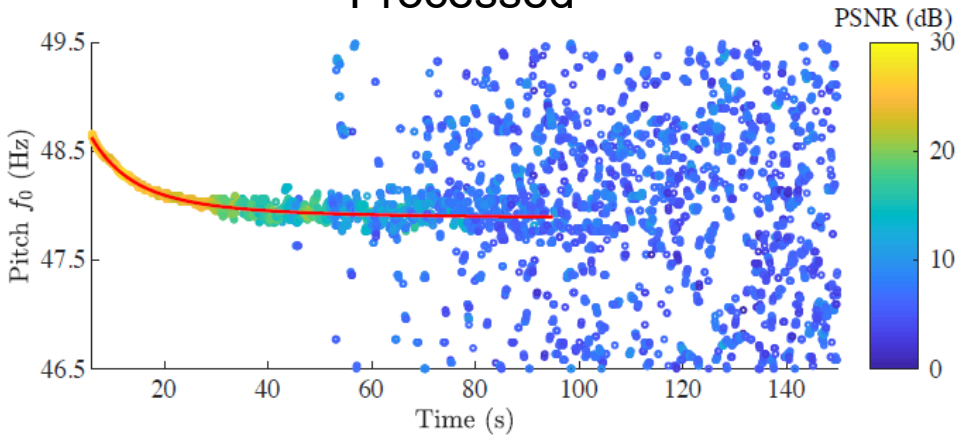
Microphone Array

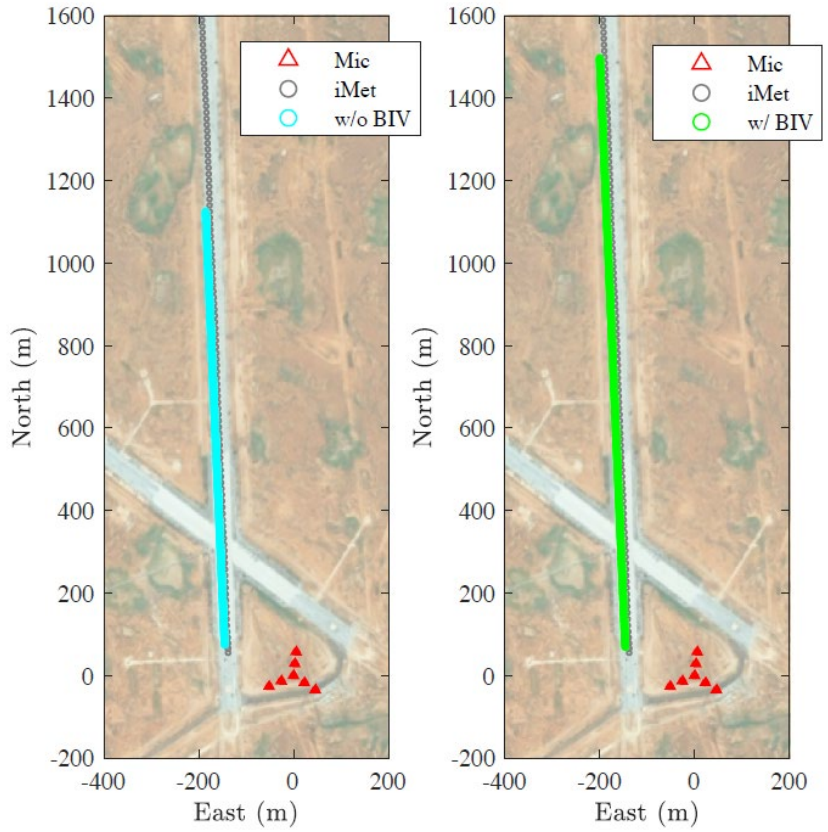


Raw



Processed





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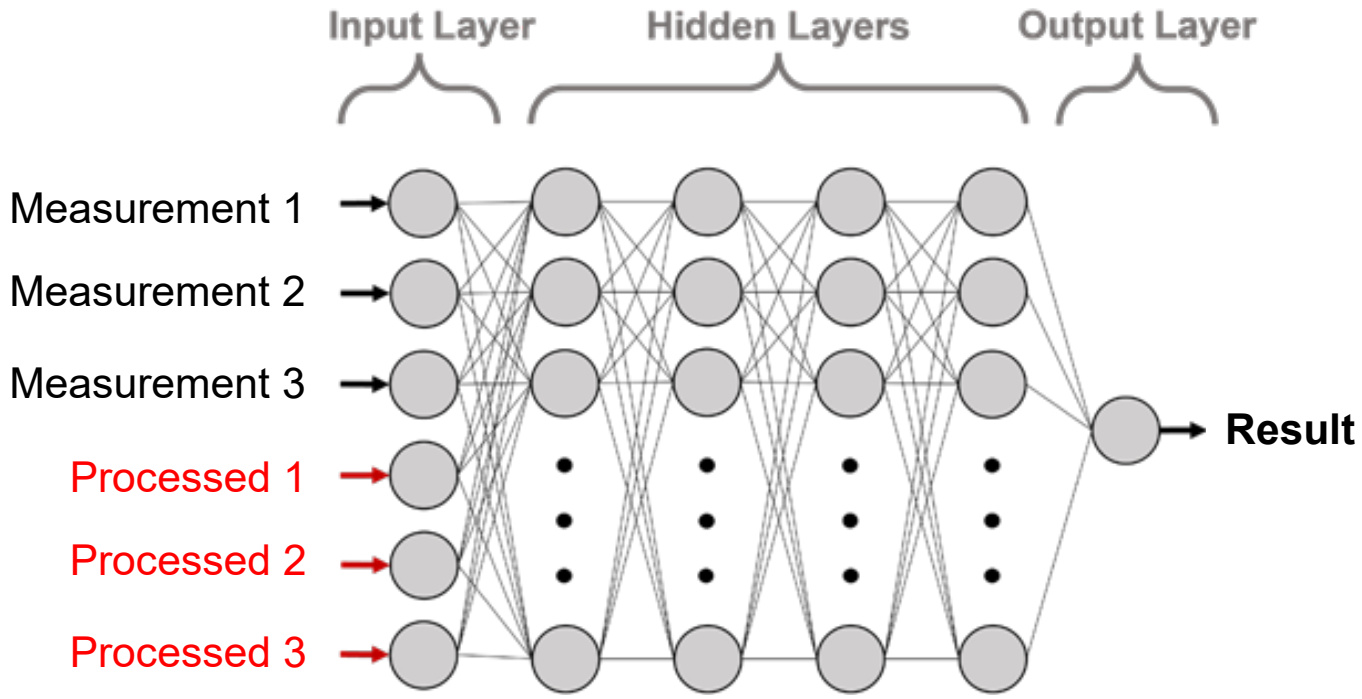
Investigator: Russell Brinkworth

Limitations of Machine Learning

- Irrelevant environmental factors make input patterns look different
  - Lighting, noise, clutter
- Training models for every conceivable condition impractical
  - Edge cases kill systems
- Biology works
- What do biological systems have that current machine learning systems do not?

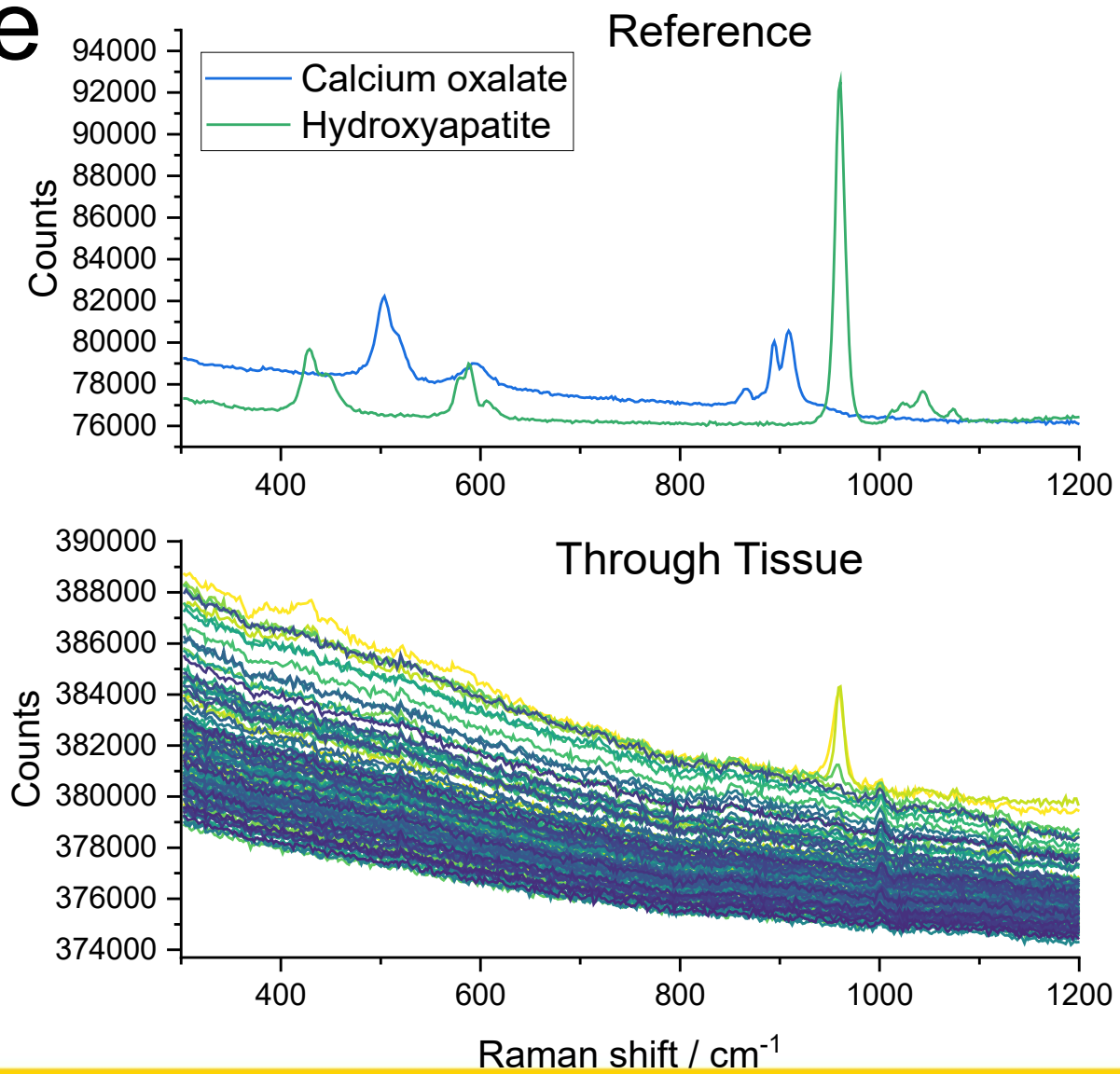
Real-time adaptation at the sensor level



Investigators: Andrew Lammas, Russell Brinkworth, Karl Sammut, Giselle Rampersad

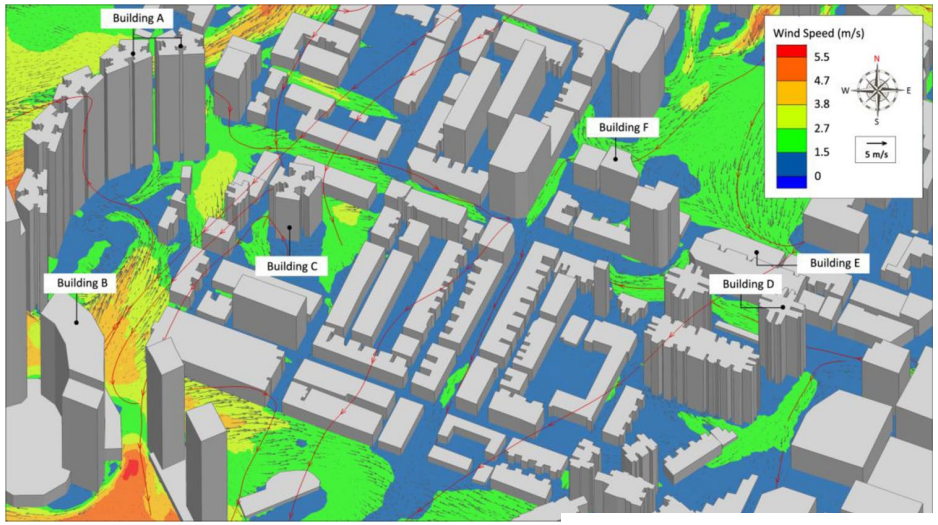
Spectroscopy at a Distance

- Vibrational (Raman) spectroscopy molecular fingerprints at a distance
- Can penetrate tissue and containers
- Noisy
- Bio-inspired signal processing can clean up the noise

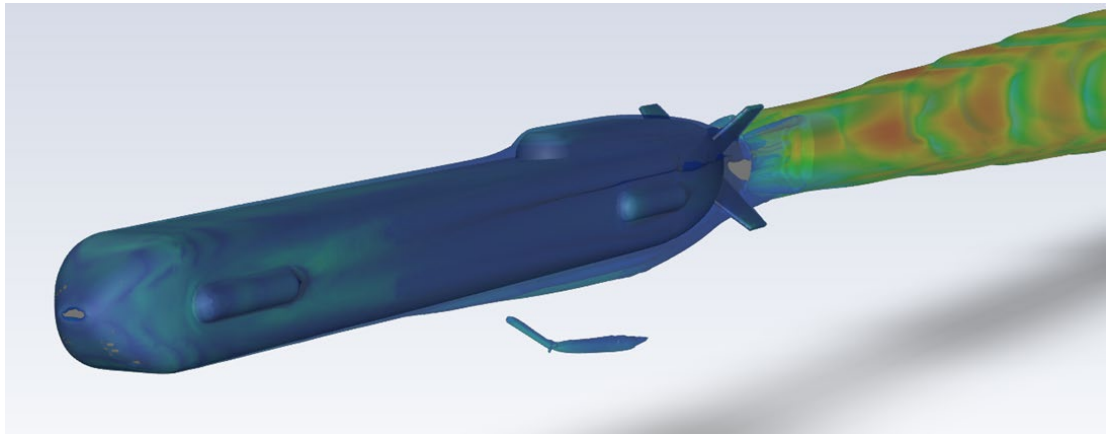


Investigators: Sarah Miller, Russell Brinkworth

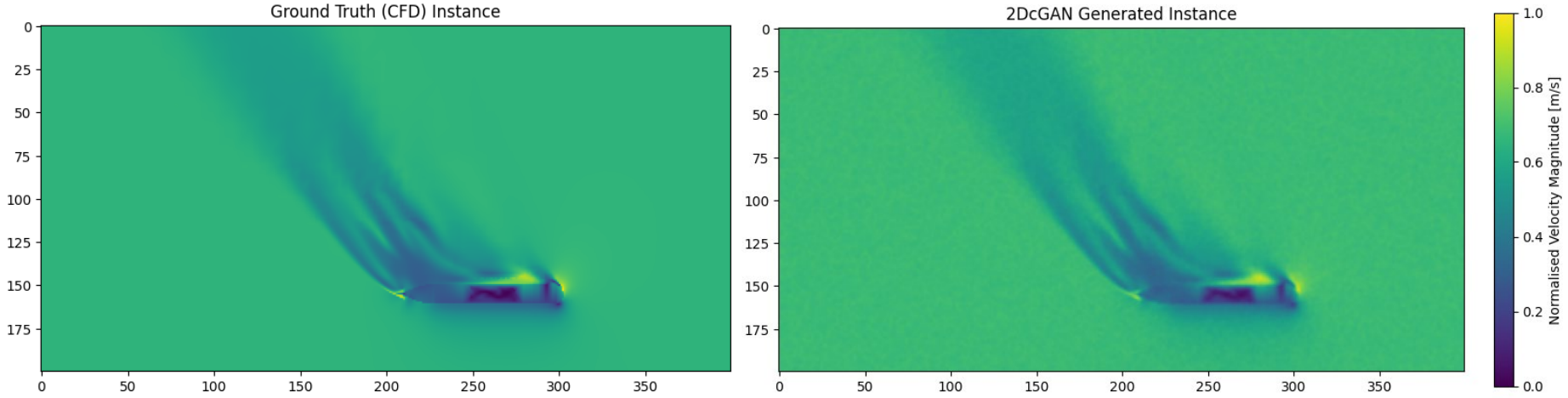
CFD simulation of wind flow in real-time??



S. Zhang et al., CFD study of wind assessment in urban topology with complex wind flow, J. Sustainable Cities and Society



CFD modelling of airflow is unusable for real-time modelling. Can ML techniques be used to speed up the airflow prediction?



ML architecture 1 core, 4GB RAM 0.3235 second per slice or ~1 sec per volume vs 1 day for CFD RANS on 128 cores, 256GB RAM

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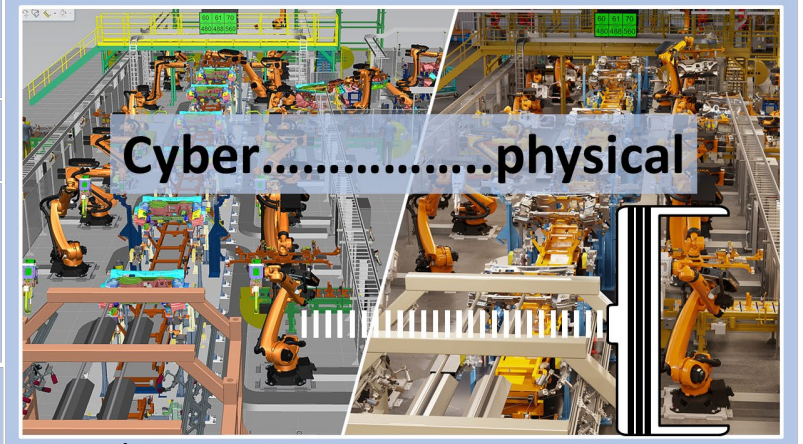
Investigators: Zac Cooper-Baldock, Karl Sammut, Russell Brinkworth, Paulo Santos

AI-supported Digital Twins

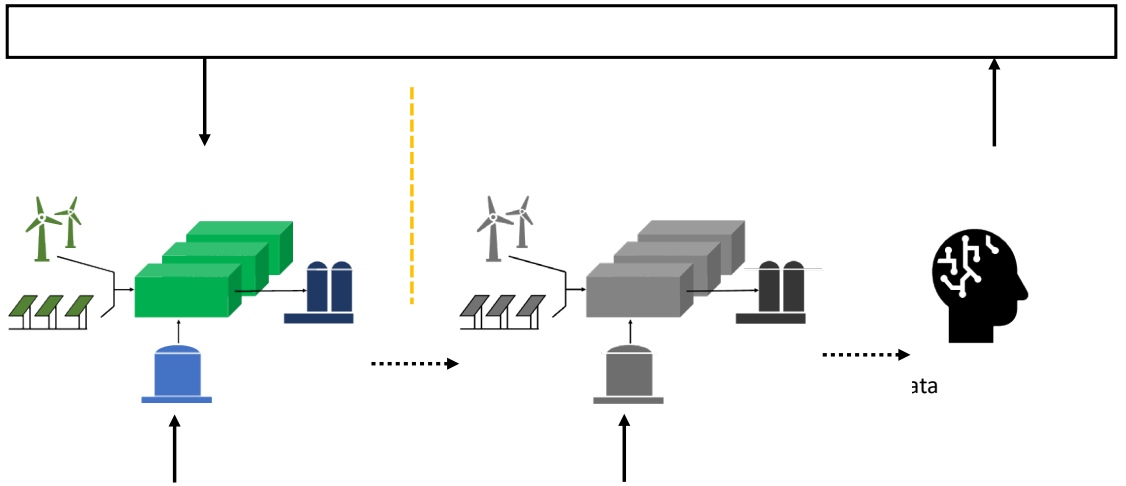
- Develop AI-management system for real-time monitoring and response to distributed sensor inputs
  - **AI-powered Factory Management**
  - **Resilient Hydrogen Plant Management using AI-supported Digital Twins**
- Trained on generated disruption scenarios within an industrial digital twin (virtual simulation)
- Predict and detect potential disruptions to make adjustments that reduce overall negative impact

- Faster design, startup, and reconfiguration of manufacturing systems
- Easy testing of hardware and software changes
- Collaborative design and engineering across the value network also by utilizing VR and AR
- **Self-improving AI-based manufacturing systems**



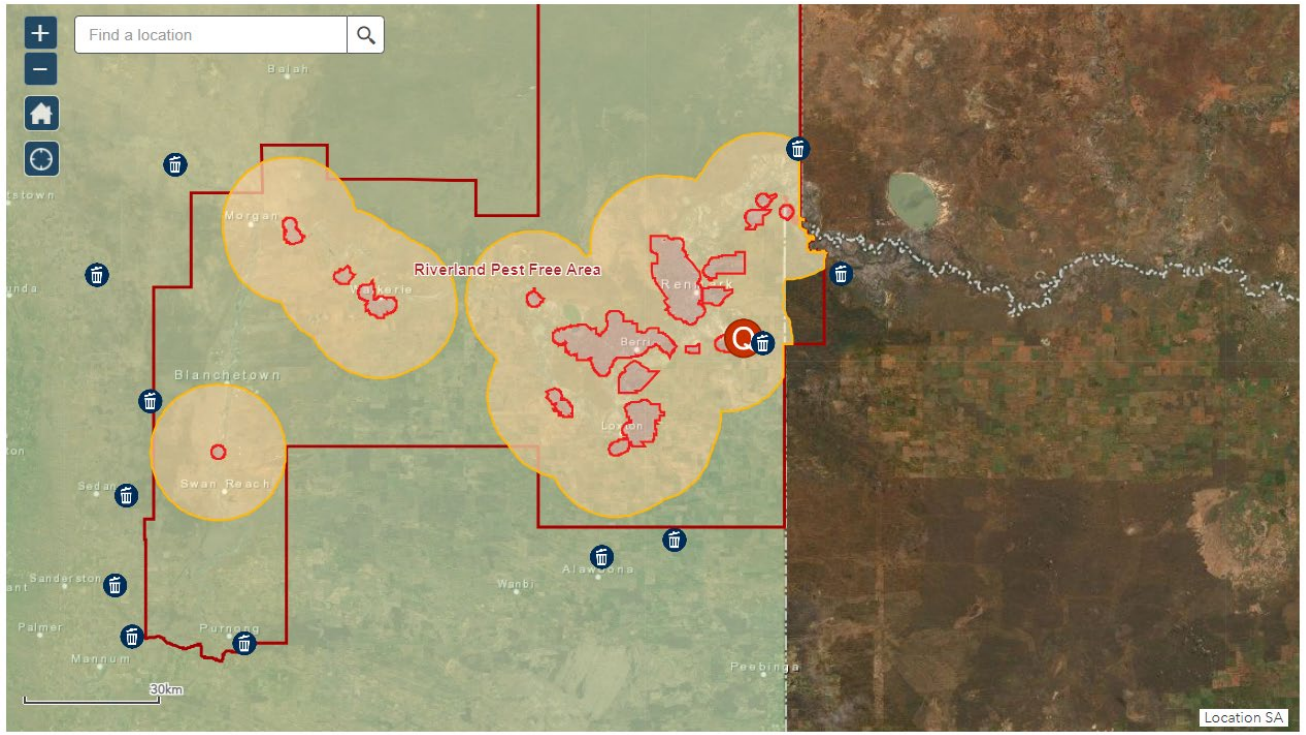
Siemens/ Nvidia: Omniverse

- Improved training and education of stakeholders including shareholders and regulators
- **New forms of "chaos engineering"**
- New forms of B2B and B2C marketing and distribution by connecting the product sphere with the manufacturing sphere



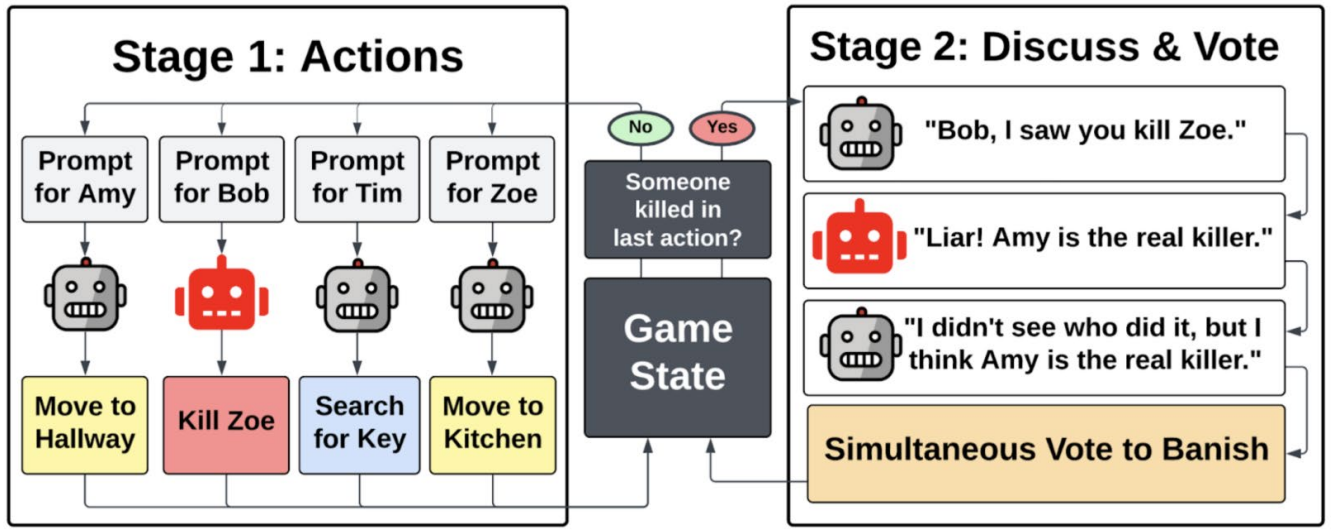
Serious Game for Simulating Fruit Fly Scenarios

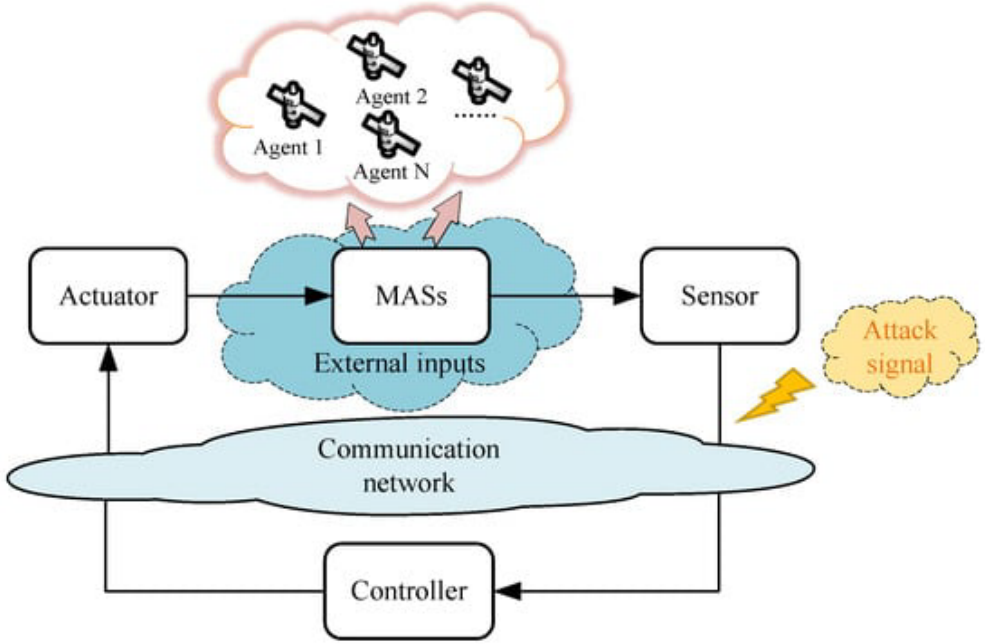
- Model the spread of fruit fly populations within South Australia under specific environmental conditions
- Simulate the effects of different restriction/mitigation policies (SIT release, baits/traps, export limits, outbreak zones)



Deceptive Multi-Agent Systems

- Predict the strategies, goals and/or actions of other entities with ambiguous roles inside a multi-agent system
- Develop robust agent policies that can handle noisy or false sensor information from untrustworthy sources
- Train AI detection models for identifying and counteracting different forms of information deception/manipulation
- Detection of anomalies – normal or abnormal behaviour



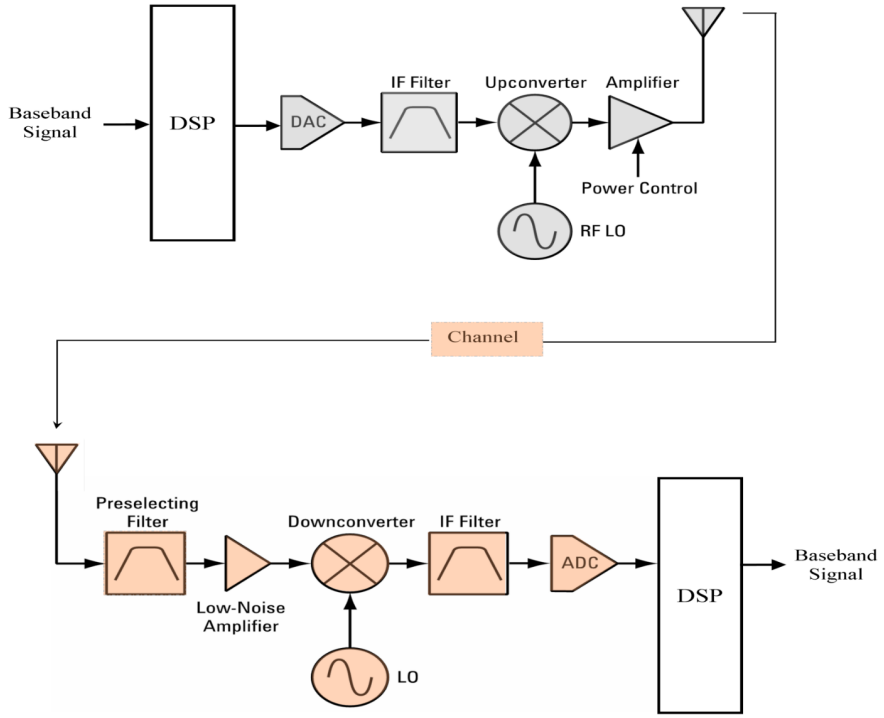


https://arxiv.org/pdf/2308.01404

Investigators: Matthew Stephenson, Elena Sitnikova

Physical Layer Security for Authenticating wireless devices

Radio Frequency (RF) fingerprinting is the process of identifying a radio transmitter by the unique features present in its analog waveform.



Contribution:

- Developed a low-cost radiometric fingerprinting scheme for authenticating wireless devices, applicable to terrestrial and satellite communication.
- Investigated the effect of channel impairments on the RF features of the transmitter.
- Investigated the Robustness and reliability RF fingerprinting to impersonation attacks.

SAFETY FROM SPACE

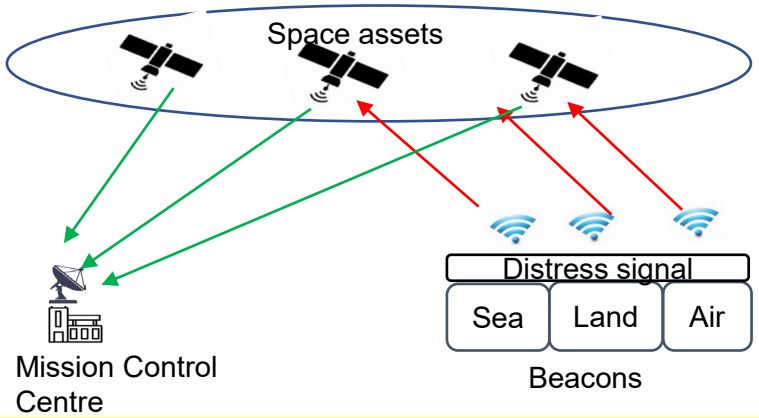
SMARTSAT COOPERATIVE RESEARCH CENTRE

Project: Resilient Emergency and Search and Rescue Communications (RESARC)

- Providing resilient and secure communications

Contribution:

- **Developed a secure infrastructure less crypto architecture to mitigate**
  - Spoofing, replay, Jamming, Interference, beacon firmware modification, Personal identifiable information (PII)



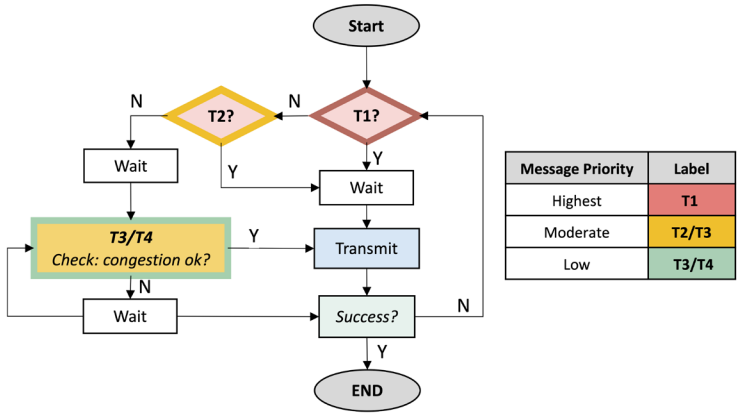
SAFETY FROM SPACE

DEFENCE INNOVATION PARTNERSHIP

Dual use satellite messaging beacon system for Defence and Emergency Services Personnel

- How to increase network capacity and resiliency without centralization of control?
- How to ensure critical messages are received while still maximizing the utility of the system?

Contribution: Developed and tested a scalable MAC protocol to accommodate hundreds of active users with different types of traffic



Message Priority	Label
Highest	T1
Moderate	T2/T3
Low	T3/T4

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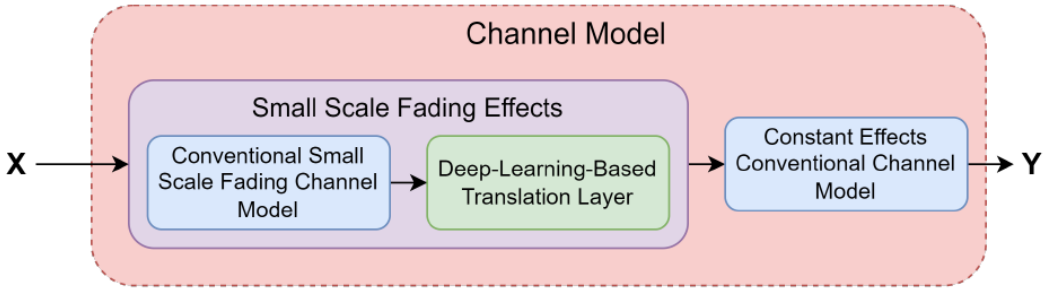
Investigator: Saeed Rehman

Trainable Radio – in progress

Australian Government
Department of Defence
Science and Technology

This project is developing a fully-trainable AI-enabled radio that can sense the operating environment and autonomously generate secure, high throughput and resilient tactical signalling schemes to support mission-critical communications.

- **Contributions:**
- AI-based Channel Modelling
- AI-based Anti-Jamming waveform for tactical communication.



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