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Real-time control approaches for site-specific irrigation and fertigation optimisation

Dr Alison McCarthy, Dr Tai Nguyen and Professor Steven Raine

National Centre for Engineering in Agriculture
Institute for Agriculture and the Environment
mccarthy@usq.edu.au

A Research Centre of the University of Southern Queensland

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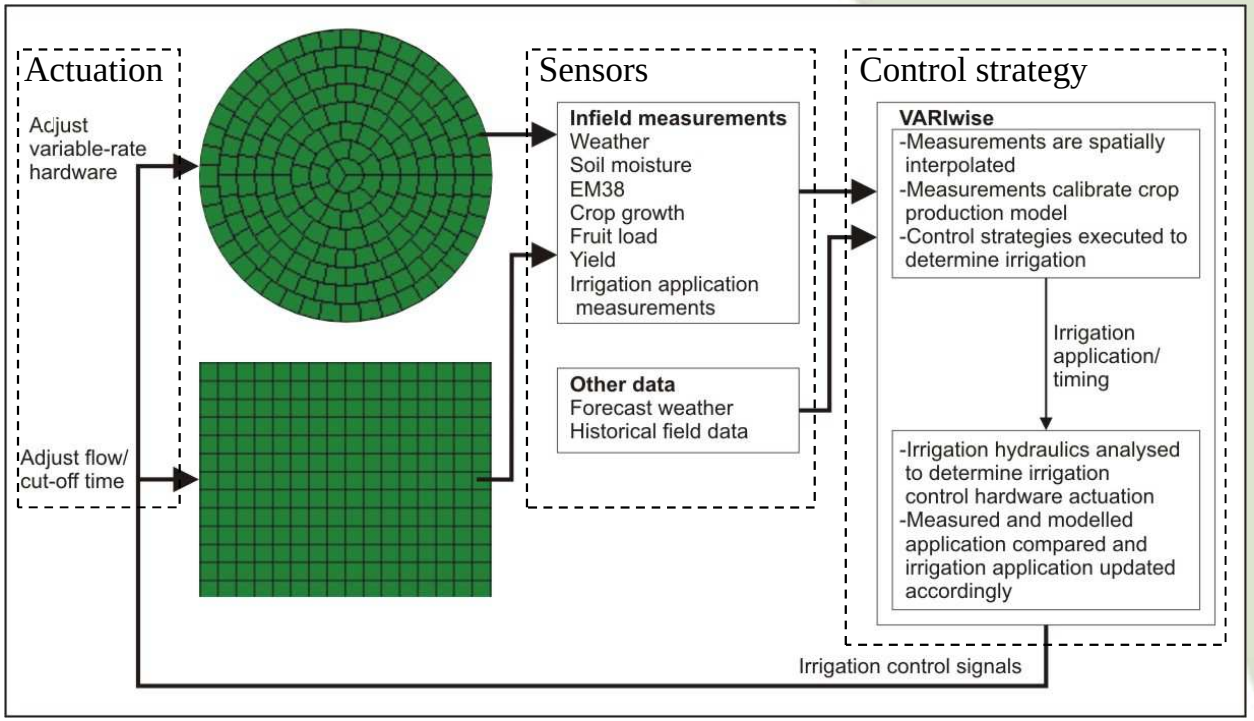
fulfilling lives

Real-time irrigation and fertiliser control

- Adapts to different crops, weather, soil, irrigation systems and water availability
- Considers spatial variability in irrigation and nutrient requirements
- Runs on remote server
- Internet-enabled sensors



Sensor –based control of irrigation timing

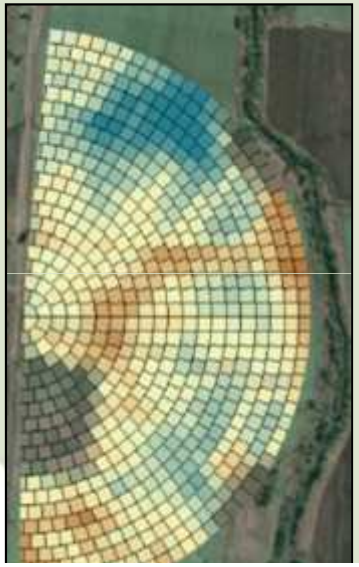
- Soil moisture regulation
- Temperature sensors to detect stress point
- May not be robust to data and water unavailability

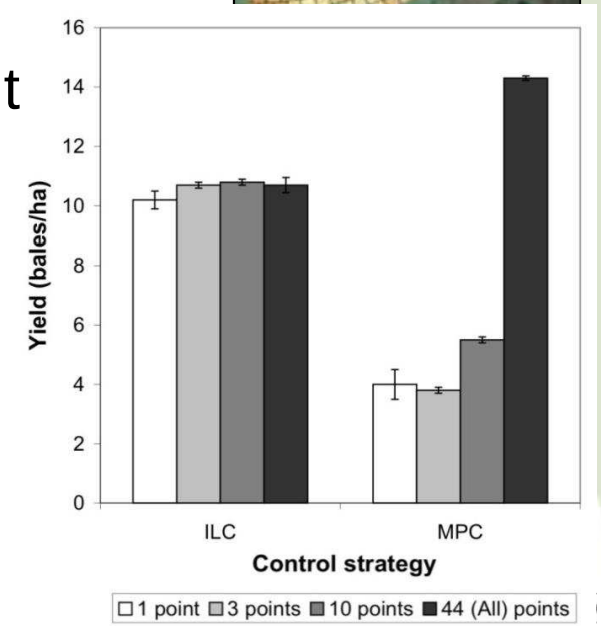
Learning control

- Uses sensor feedback without a model to perform optimisation
- Iterative Learning Control (ILC):
  - Uses error between the ***measured*** and ***desired*** soil moisture deficit after the previous irrigation,
  - . . . to ***adjust*** the irrigation volume of the next irrigation event.
  - ‘Learns’ from history of prior error signals to make better adjustments.
- Iterative Hill Climbing Control (IHCC):
  - Tests different irrigation volumes in ‘test cells’ to determine which volume produced desired response
- Typically low data requirements

Model predictive control

- Iteratively executes model to optimise process inputs rather than numerical operation on the model
- A calibrated crop model simulates and predicts the next required irrigation, i.e. volumes and timings
  - according to evolving crop/soil/weather input
  - separately for all cells/zones
  - can choose alternative end-of-season predicted targets
- High data requirements
- Off-the-shelf, black box industry models may not be updated



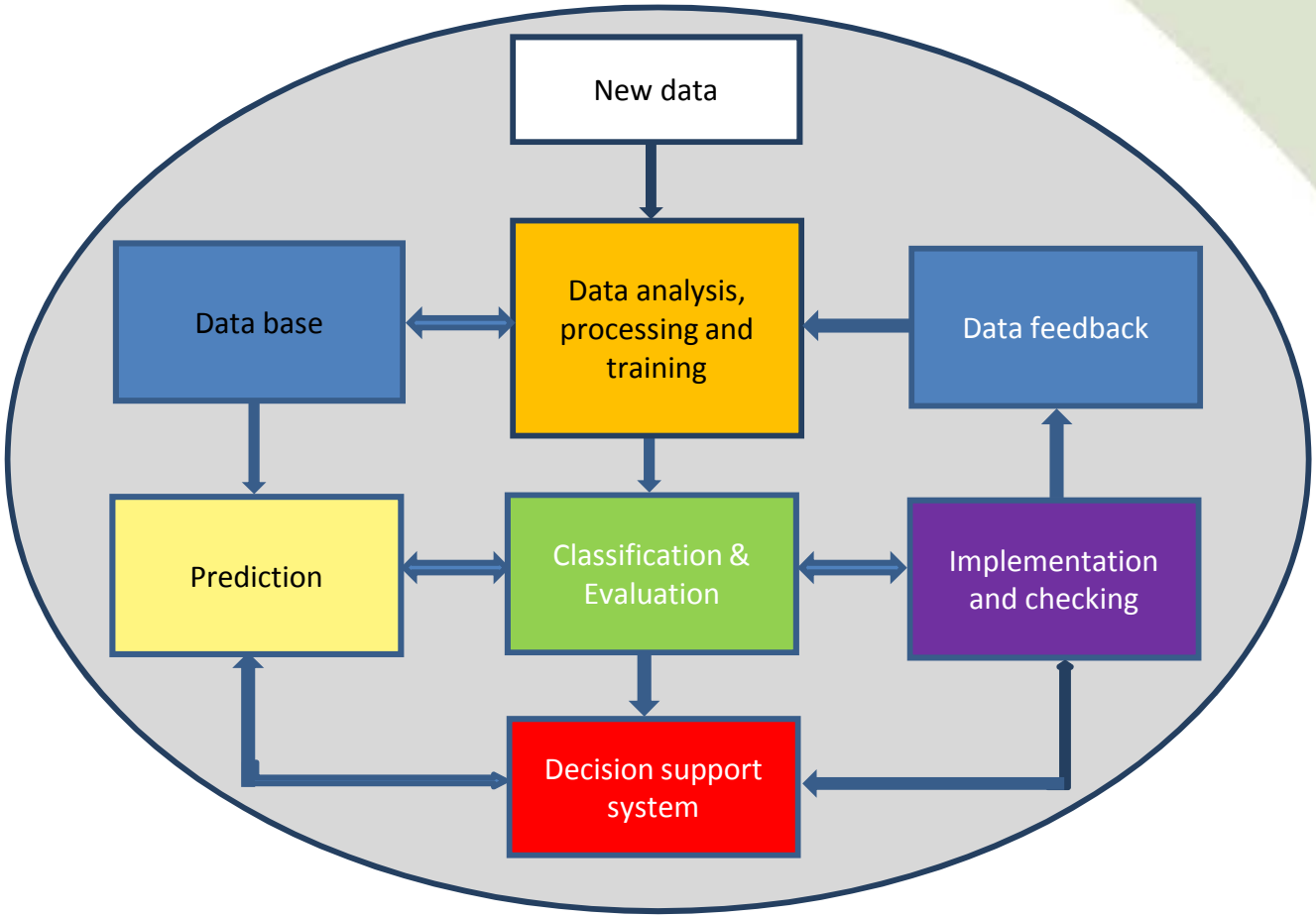


Artificial intelligence (AI)

- Artificial neural networks can be used for developing models from large datasets if
  - explicit knowledge is acquired
  - represented in the knowledge base
- Existing strategies consider soil moisture and economics, not crop production
- Inbuilt self-learning capability
- Evolutionary computation used for optimisation

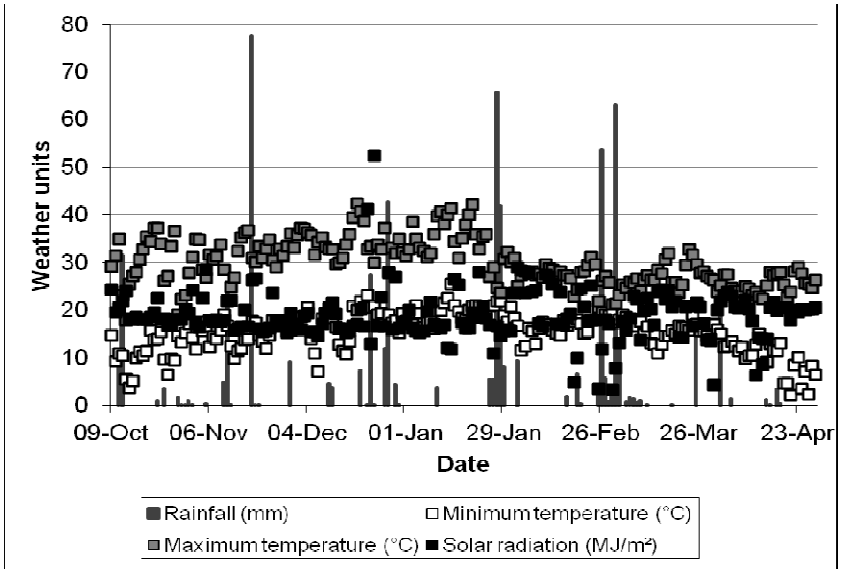
Hybrid artificial intelligence system

- Artificial intelligence system for learning crop dynamics and optimising inputs



Hybrid artificial intelligence system for irrigation and fertigation

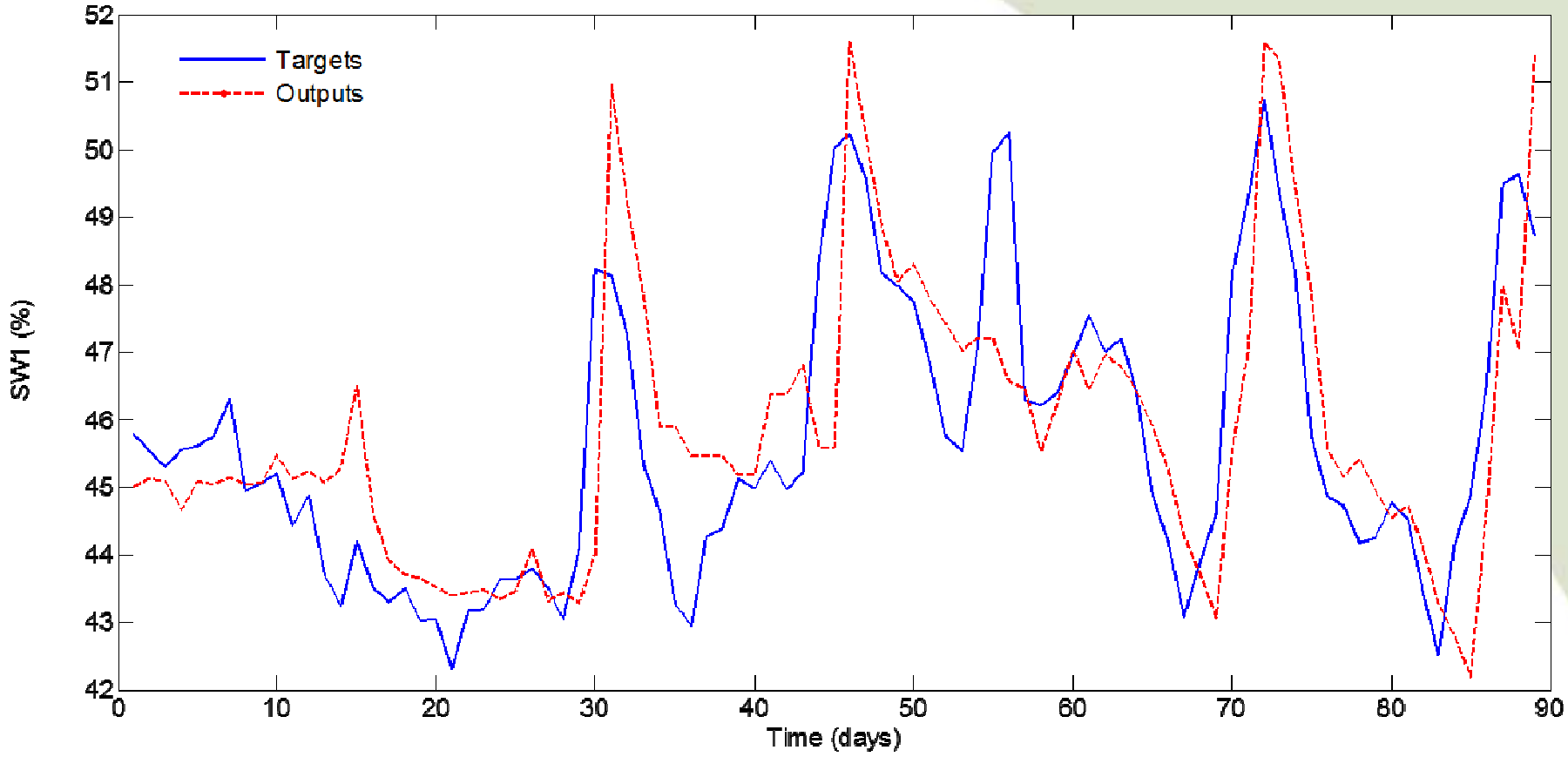
- Artificial Neural Network (ANN) used for training and predicting crop dynamics based on historical and real-time infield data
- Weather and soil data input used for preliminary development



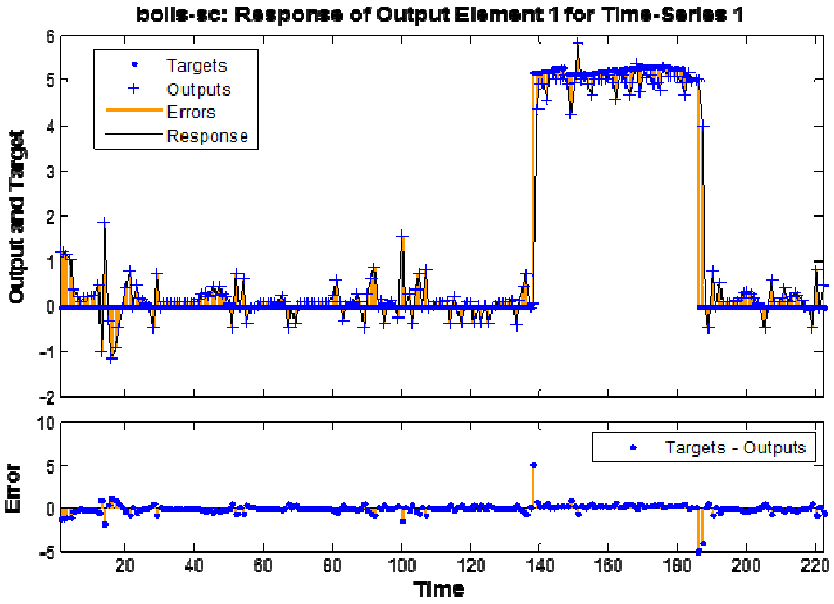
ANN trained using field and simulation data

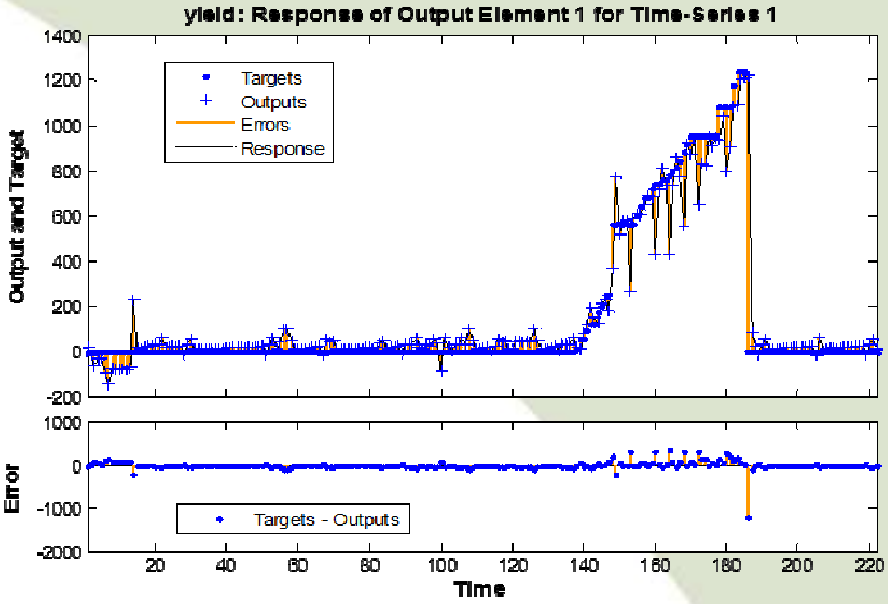
- Field data
  - Input: soil-water data 30cm layer
  - Output: soil-water(%) prediction
- Simulation data
  - Input: irrigation, fertiliser, yield, crop vegetation and fruiting
  - Output: bolls, yield, fertiliser

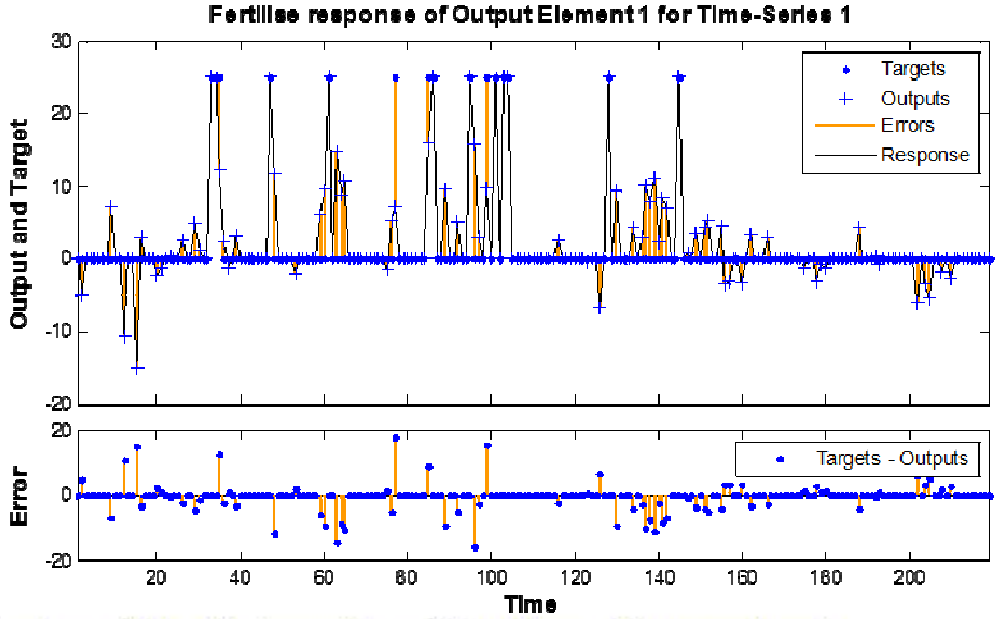
ANN prediction using field data



ANN prediction using simulation data







Conclusion

- Evaluating irrigation control strategies using learning and model predictive control
- Artificial intelligence has potential for use as self-learning crop model for irrigation and fertigation
- Training datasets from Internet-enabled sensors

Acknowledgements

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