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Prescription irrigation will be smarter and interactive

By Gary Alcorn

Adaptive control will become the new 'gold standard' in irrigation management by combining the advantages of precision agriculture with automatic real-time adjustments of inputs based on small plot needs.

Professor of Irrigation Engineering at the University of Southern Queensland, Dr Rod Smith is adamant there is nothing new coming in water delivery systems – but researchers and growers can achieve a lot more by refining and integrating existing technologies.

"We have to look beyond the idea of applying uniform amounts of water across a paddock and recognise the many variables that interact to influence irrigated crop production be it cotton, maize, sugar or fruit," Rod said.

"Dryland farmers know how precision agriculture involves recognising and fine tuning inputs such as different soil types, fertility, water-holding capacity, crop agronomy, climate and machinery design and operation timing.

"Irrigation engineers, agronomists and growers now have to combine their skills to design input controllers which recognise all the variables impacting on irrigated crops and how to adjust the next mix of inputs to suit the particular needs of individual small crop cells across the field," he said.

He believes the goal of monitoring inputs and sensing crop response automatically – so the next set of inputs are for example, adjusted to optimise particular crop responses in these small cells – are close to practical implementation.

This is hands-off adaptive control using sensors such as machine vision to monitor crop vigour and feed data to software programs which control irrigators, fertigation and other operations to deliver optimum inputs based on identified shortfalls.

"I envisage a day quite soon when the farmer can stay in bed some mornings or do other farm work confident that infield com-

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WHAT IS PRESCRIPTION IRRIGATION?

According to the authors of this SEAg 07 conference paper, prescription irrigation requires the identification of the appropriate volume and timing of the irrigation event.

This implies that the operator has access to detailed data and response information regarding the crop, soil, weather, environment and other production inputs and that there is adequate knowledge regarding the interaction of these variables and the economic responses to variable inputs.

In this case, prescription irrigation is used to maximise the value of the other crop inputs while minimising wastage and environmental impacts.

So effective prescription irrigation requires the same four management steps: An ability to measure, interpret, control, and evaluate.

But prescription irrigation requires this data, the relevant underlying knowledge and the level of technological control for the whole crop production system and not just the irrigation sub-component. This requires a holistic view of irrigation management that includes all of the factors needed to make irrigation a precise activity as well as those required in prescription agriculture.

Prescription irrigation might soon mean 'more time in bed' for farmers.

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puters are switching components on and off in response to real-time crop needs.

"That's prescription irrigation through adaptive control, programs such as *Irrimate* for furrow irrigation are signposts pointing in the right direction," Rod said.

Of course irrigation equipment must be able to deliver precise amounts of water to different parts of the paddock based on a range of physical and chemical markers.

Spatially varied irrigation

'Spatially varied irrigation' is the term used to describe those systems that are able to deliver differential amounts of water to different areas of the field. The notion of spatially varied irrigation is predicated on the hypothesis that the crop is non-uniform and the water requirements are similarly non-uniform, probably as a result of differences in root zone conditions.

It is also assumed that yield will be maximised if each plant is supplied with water exactly matching its individual requirements.'

Table 1 rates the spatial scales of common irrigation systems.

Soil and crop mapping and plotting will help refine paddock variability which will trigger changes in application rates. The impact of rainfall on crop growth can be recognised and compensated for using machine vision and paddock mapping.

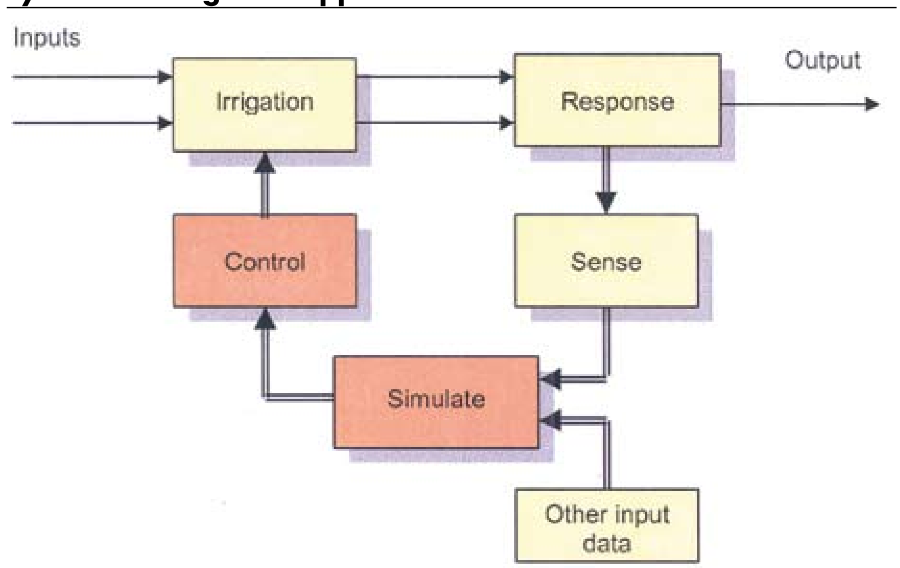
As Rod explains: "There is no doubt that centre pivot, lateral move and low energy precision application (LEPA) machines can be modified to apply spatially variable irrigation. The common strategy employed by most irrigation researchers has been to vary the application rate and hence, depth applied, in response to identified crop needs.

"This applies irrespective of whether it is in response to real time sensed crop needs or to some predetermined plan. But the factor most likely to delay significant commercial application of these systems is the need to develop the technology required to sense the water (and nutrient) requirements of the crop at an appropriate spatial scale.

TABLE 1: Spatial scales of common irrigation systems

System	Spatial unit	Order of magnitude of spatial scale (m^2)
Surface – furrow	Single furrow	1000
Surface – furrow	Set of furrows	50,000
Surface – bay	Bay	10,000 to 50,000
Sprinkler – solid set	Wetted area of single sprinkler	100
Centre pivot, lateral move	Wetted area of single sprinkler	100
LEPA – bubbler	Furrow dyke	1
Travelling irrigator	Wetted area of sprinkler	5000
Drip	Wetted area of an emitter	1 to 10
Micro-spray	Wetted area of single spray	20

FIGURE 1: Conceptual model of a real-time adaptive control system for irrigation applications



"Quantification of the economic benefits of prescription irrigation taking into account water savings, yield improvements and the capital cost of the modified machines will also be necessary," he said.

The role of the controller in prescription irrigation

Two major configurations of control systems are open-loop and closed-loop control systems. An open-loop control system uses known relationships between the process input and output to adjust the controller parameters.

It does not monitor the output of the process. A closed-loop control system measures the output of the system and adjusts the controller parameters based on the difference between the input and the measured output.

This difference is called the error signal. A closed-loop control system monitors the plant output and aims to reduce the magnitude of the error by feeding the error signal to the controller.

Existing control strategies usually initiate an irrigation, rather than decide an irrigation amount. The systems rarely account for spatial and temporal variability, and are usually open-loop (that is, they do not monitor the response of the crop to the irrigation amount).

What would be the elements of a real-time adaptive control system for irrigation applications?

Figure 1 shows a conceptual model of a real-time adaptive control system for irrigation applications.

Among the inputs would be real-time crop response data such as the change in internodal length of cotton plants detected using machine vision as reported by NCEA researcher Cheryl McCarthy in 2006.

Last year she commenced a project to investigate control options for centre pivot and lateral move irrigators carrying cameras to monitor crop growth in real-time.

"Big advances are getting closer every day. With more resources such as eager research students, time and more funding we will soon see giant leaps in prescription irrigation and adaptive control," Rod said.

For further information contact Prof Rod Smith (smithrod@usq.edu.au)

This story is based on the invited SEAg07 conference paper – "Managing spatial and temporal variability in irrigated agriculture through adaptive control".
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