AMSI VACATION RESEARCH SCHOLARSHIPS 2014/15:

STATISTICAL PROTOCOLS FOR LATE MATURITY α-AMYLASE IN WHEAT

The assessment of grain defect traits is assuming greater importance in wheat germplasm selection. Late maturity α-amylase (LMA) is one such characteristic that renders wheat unsuitable for high value end products, even though the grain may appear sound. The frequency of lines in wheat breeding programs which LMA appears reasonably high, and hence LMA has become an important trait that is now routinely assessed in all wheat breeding programs in Australia.

In contrast to grain yield, statistical design and analysis methods specific to the measurement of LMA expression have been far less extensively researched. Like many grain quality traits in wheat, phenotyping for LMA involves a complex process involving experiments which are so-called multi-phase experiments. A multi-phase experiment is an experiment which involves several time periods, and has observational units which are completely different to those from the preceding phases. The simplest multi-phase experiment involves 2 phases, and these were first introduced by McIntyre (1955). A very common 2-phase experiment in agriculture involves a field phase and a laboratory phase. In the field phase, a field trial is carried out on field (experimental) units and then the grain from that experiment is taken in to the laboratory where the experiment involves laboratory units. Phenotyping for LMA has at least 4 phases, most of which are unrandomised.

In response to concerns with the accuracy of LMA expression experiments, Butler et al. (2009) developed a protocol to improve the design and analysis of LMA expression experiments. This protocol accounts for non-genetic sources of variation in all phases by adoption of a model-based approach to design using the R package **od** (Butler, 2013). This protocol has been in use since 2011 but there remain some unresolved issues. One of these issues concerns the relatively high residual variation (i.e. relative to other sources of non-genetic and genetic variation). Preliminary analyses of the past four LMA expression experiments suggest that there may be ways of reducing this variation by a more sensible compositing and laboratory randomisation scheme. The aim of this project is to examine this initial observation in more detail and consider the accuracy of various alternative schemes which achieve higher accuracy, but are inexpensive and easy to implement.

References

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Butler, D. G., M. K. Tan, and B. R. Cullis (2009). Improving the accuracy of selection for late maturity α-amylase in wheat using multi-phase designs. *Crop and Pasture Science 60*, 1202–1208.

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Research proposal: Quasi-primal Cornish algebras

Motivation

The two-element Boolean algebra plays a hidden but fundamental role in our everyday lives, forming the logical basis of electronic circuits and computers. What makes this algebra so special?

Every first-year computer science student learns how this algebra can be used to build all possible circuits (more formally, all possible operations on the set $\{0, 1\}$). Researchers in universal algebra found that one particular operation (called the ternary discriminator) gives the two-element Boolean algebra many of its special properties. This led them to generalise the two-element Boolean algebra to the much wider class of quasi-primal algebras (Werner [6], Pixley [5]).

Quasi-primal algebras are of ongoing interest among researchers working on the applications of algebra to the study of logic. They also arise naturally in classical algebra (every finite field is quasi-primal) and play an important role in universal algebra (for example, in McKenzie and Valeriote's [4] ground-breaking characterisation of varieties with a decidable theory).

Background

The *ternary discriminator* on a set A is a function $t\colon A^3 \to A$ given by

$$t(x, y, z) = \begin{cases} x & \text{if } x = y, \\ z & \text{if } x \neq y. \end{cases}$$

A finite algebra $\mathbf{A}$ is called *quasi-primal* if there is a term t in the signature of $\mathbf{A}$ such that $t^{\mathbf{A}}$ is the ternary discriminator on A. It is very easy to check that $t(x, y, z) := ((x \wedge z) \vee y') \wedge (x \vee z)$ yields the ternary discriminator on the two-element Boolean algebra, and so it is quasi-primal.

Recently, Davey, Nguyen and Pitkethly [3] characterised the quasi-primal Ockham algebras. *Ockham algebras* are the algebraic counterpart of the non-classical logic in which the law of the excluded middle and the double negation law are dropped but the De Morgan laws are retained [1]. Cornish [2] introduced a natural generalisation of Ockham algebras, which are now named after him. *Cornish algebras* are the algebraic counterpart of certain non-classical logics with more than one concept of negation. It is natural to seek an extension to Cornish algebras of the characterisation of quasi-primal Ockham algebras.

Aims

(a) Review Priestley duality as it applies to Cornish algebras.
(b) Review the various characterisations of quasi-primal algebras and techniques for proving that a finite algebra is quasi-primal.
(c) Use the knowledge gained from (a) and (b) to find examples of quasi-primal Cornish algebras with the aim of characterising them.

References

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[4] R. McKenzie and M. Valeriote, *The Structure of Decidable Locally Finite Varieties*, Progress in Mathematics, **79**, Birkhäuser, Boston, 1989.
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