Detecting Parameter Redundancy in Complex Ecological Models

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To be able to fit a parametric model successfully using maximum likelihood, all the parameters need to be estimable. Parameter redundancy arises if the model can be rewritten in terms of a smaller set of parameters. Parameter redundancy is not always obvious, in which case the definitive method for detecting parameter redundancy involves calculating the symbolic rank of an appropriate derivative matrix. This symbolic procedure, which has been developed for exponential family models, is given in Catchpole and Morgan (1997) and Catchpole et al (1998). However for complex ecological models, such as that proposed by Jiang et al (2007), the computer may run out of memory calculating the rank of the derivative matrix. Numerical methods may be used instead, but this can lead to misleading results if *near* parameter redundancy is picked up rather than actual parameter redundancy (see Catchpole et al, 2001).

The solution to this problem is to reparameterise the model in such a way that it is possible to evaluate the rank of the reparameterised model's derivative matrix. Calculating the rank of the derivative matrix of the reparametrised model can then provide the parameter redundancy of the original model. This approach is described in the talk, with an application to multi-state mark-recapture models discussed in Hunter and Caswell (2007).

Although the examples used to illustrate this method come from ecological statistics, the approach is perfectly general.

References:
Catchpole, E. A. and Morgan, B. J. T. (1997) Detecting parameter redundancy. *Biometrika*, **84**, 187-196
Catchpole, E. A., Morgan, B. J. T. and Freeman, S. N. (1998) Estimation in parameter redundant models. *Biometrika,* 85, 462-468
Catchpole, E. A., Morgan, B. J. T. and Freeman, S. N. (2001) On the Near-Singularity of Models for Animal Recovery Data. *Biometrics*, **57**, 720-726.
Jiang, H., Pollock, K. H., Brownie, C. Hightower, J. E., Hoenig, J. M., Hearn, W. S. (2007) Age-dependent tag return models for estimating fishing mortality, natural mortality and selectivity. *JABES,* **12**, 177-194.
Hunter, C. M. and Caswell, H. (2007) Rank and redundancy of multi-state mark-recapture models for seabird populations.