ANALYSIS OF GENERALIZED LINEAR MIXED MODELS WITH MATVEC

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INTRODUCTION

Matvec is both a library of C++ classes and a statistical analysis program. Originally developed by Wang and Fernando (1995), Matvec included the ability to analyze multiple trait linear mixed models. The capabilities of Matvec have now been extended to include the analysis of generalized linear mixed models.

USE

Models. In addition to multiple trait linear mixed models, Matvec can analyze generalized linear mixed models using a variety of link functions given in Table 1. The random effects in the linear predictor can include multiple environmental and genetic random effects. The environmental random effects are distributed as $N(0, I \otimes V_i)$ and the genetic random effects are distributed as $N(0, A \otimes V_i)$ where I is an identity matrix, A is the numerator relationship matrix, and V_i is the covariance matrix for random effect i. The random effects can be correlated and include interactions with covariates. The program has been used to estimate variance components in models with up to 160,000 equations.

Table 1. Available link functions

Function	Distribution	Link	Inverse Link[A]	Variance Function[B]
normal	Multivariate Normal	Identity	η	$\mathbf{R} = \{ \sigma_{ij} \}$
logit	Binomial/n	Logit	$e^\eta / (1 + e^\eta)$	$\mu(1 - \mu)/n$
probit		Probit	$\Phi(\eta)$	
thresh	Multinomial	Threshold	$\Pr(\eta + \tau_{i-1} < Z < \eta + \tau_i)$	$\text{Diag}(\mu) - \mu\mu'$
poisson	Poisson	Log	e^η	μ
weibull	Weibull			

[A]The inverse link is $E(y \mid u) = g(\eta)$ where $\eta = X\beta + Zu$ is the linear predictor, β is the vector of fixed effects, u is the vector of random effects, and X and Z are design matrices.
[B]The variance function is the conditional variance of y given u as a function of the conditional mean $\mu = g(\eta)$.

Example. The following Matvec program will carry out the analysis of the threshold example in (Gianola and Foulley, 1984).

```
D=Data();
D.input("../data/calve.dat","HY age sex $ sire n score");
M=Model();
M.equation("score=HY age sex sire,score=intercept");
M.variance("sire",1/19,0,0,1);
M.weight("n");
M.link("thresh",0);
M.param(1);
M.fitdata(D);
M.glim();
M.contrast("HY",[1,0,-1]);
M.save("calve.out");
```

COMPUTING METHODS

Algorithms. Matvec calculates penalized quasi-likelihood estimates of fixed and random effects and approximate REML estimates of variance components (Breslow and Clayton, 1993). The estimating equations for the fixed and random effects are stored as sparse matrices and the ordering of the equations are obtained using the Metis library (Karypis and Kumar, 1998). Variance component are estimated using a modified Average algorithm Information (Gilmour *et al.*, 1995) with matrix exponentials (Chiu *et al.*, 1996) for random effect covariance components.

AVAILABILITY

The Matvec program is copyrighted and free. The source code is available at http://meishan.ansci.iastate.edu/rohan/software.html. Documentation and binaries for Windows and Linux are available at http://biometry.unl.edu/faculty/steve/software/matvec/.

COMPUTING ENVIRONMENT

Matvec is written in the GCC dialect of C++ and has been successfully built under both Windows and Linux.

REFERENCES

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