Stronger Measures of Genomic Connectedness Enhance Prediction Accuracies across Management Units

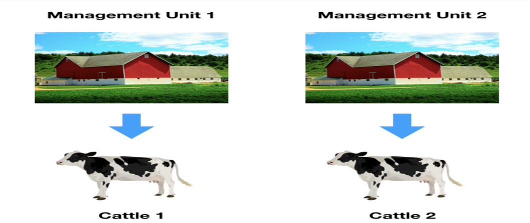
World Congress on Genetics Applied to Livestock Production

Gota Morota

Theory to Application 1

February 12, 2018

Genetic connectedness



- BLUP offers meaningful comparison of the breeding values across management units when they are connected

Can we safely compare estimated breeding values or genetic values across management units?

Connectedness metrics

Prediction error variance of the difference (**PEVD**)

$$\begin{aligned}\mathrm{PEVD}(\hat{u}_i - \hat{u}_j) &= [\mathrm{PEV}(\hat{u}_i) + \mathrm{PEV}(\hat{u}_j) - 2\mathrm{PEC}(\hat{u}_i, \hat{u}_j)] \\ &= (\mathbf{C}^{22}_{ii} - \mathbf{C}^{22}_{ji} - \mathbf{C}^{22}_{ij} + \mathbf{C}^{22}_{jj})\sigma^2_\epsilon \\ &= (\mathbf{C}^{22}_{ii} + \mathbf{C}^{22}_{jj} - 2\mathbf{C}^{22}_{ij})\sigma^2_\epsilon,\end{aligned}$$

Small PEVD == greater connectedness

Coefficient of determination (**CD**)

$$\mathrm{CD}_{ij} = 1 - \lambda \frac{\mathbf{C}^{22}_{ii} + \mathbf{C}^{22}_{jj} - 2\mathbf{C}^{22}_{ij}}{\mathbf{K}_{ii} + \mathbf{K}_{jj} - 2\mathbf{K}_{ij}}.$$

High CD == greater connectedness

Choice of **K**

a) Parametric

- **A**: Pedigree kernel
- **G**: Additive genomic kernel
- **D**: Dominance genomic kernel

GBLUP

b) Non-parametric

- **GK**: Gaussian kernel
- **MK**: Matérn kernel
- **DK**: Diffusion kernel

RKHS

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RKHS

$\Downarrow$

Question 1

Does genomic information increase measures of connectedness relative to pedigree?

Paper - DOI:10.1534/g3.117.300151

Genomic Relatedness Strengthens Genetic Connectedness Across Management Units

Haipeng Yu, Matthew L. Spangler, Ronald M. Lewis and Gota Morota

G3: GENES, GENOMES, GENETICS *Early online August 31, 2017; https://doi.org/10.1534/g3.117.300151*

Intermediate summary

- Genomic relatedness strengthens measures of genetic connectedness relative to pedigree

- 1) Improving the quality of breeding value comparisons vs. 2) Improving the accuracy of genomic prediction

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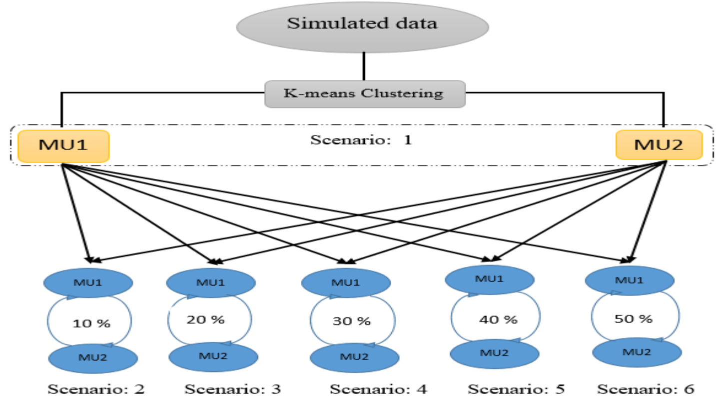
- Genomic relatedness strengthens measures of genetic connectedness relative to pedigree
- 1) Improving the quality of breeding value comparisons vs. 2) Improving the accuracy of genomic prediction

Question 2

Does increased connectedness observed by genomic relatedness also leads to increased prediction accuracy across management units?

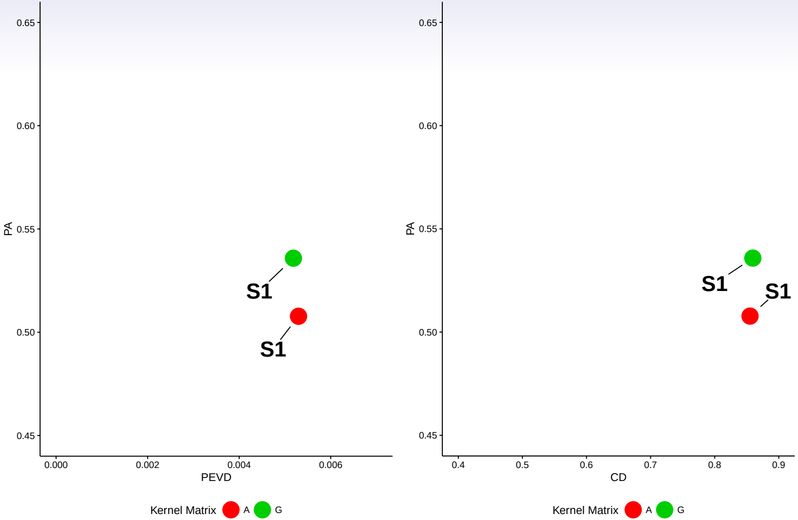
Haipeng Yu

Management units simulation



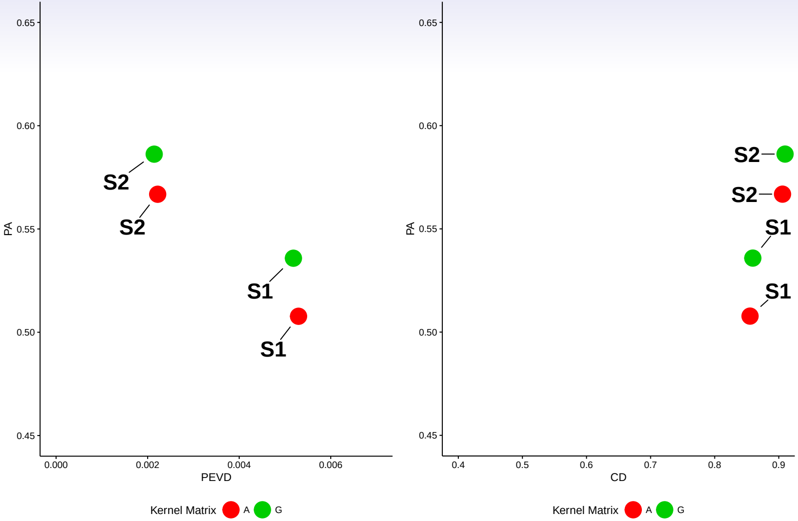
The degree of connectedness was increased by exchanging 10%, (S2) 20%, (S3) 30%, (S4) 40% (S5) and 50% (S6) of randomly sampled individuals between MU1 and MU2.

Scenario 1



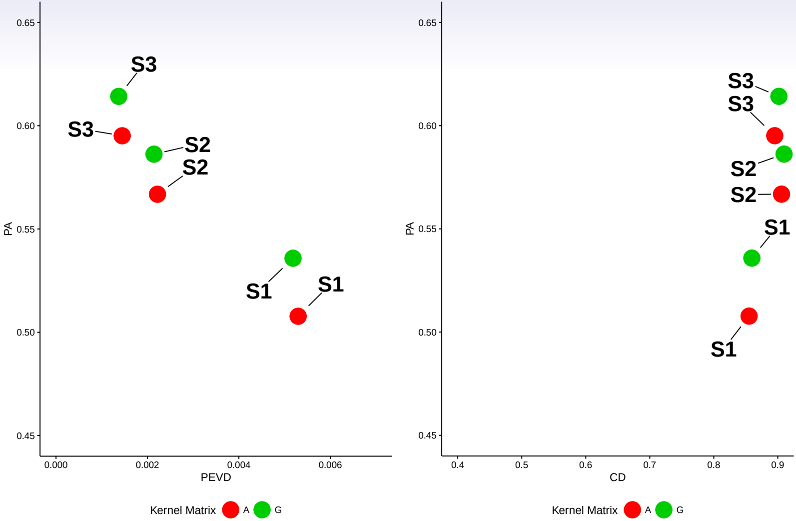
D: 1,015 QTLs and 50,000 markers ($h^2 = 0.8$)

Scenario 2



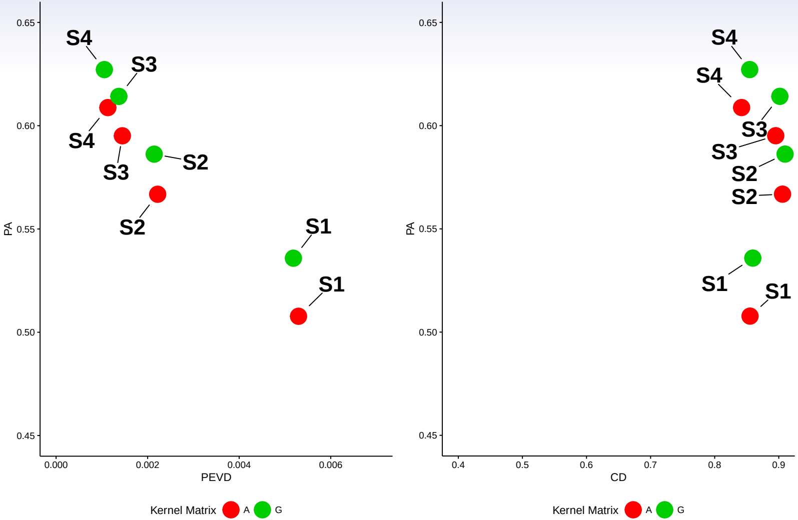
D: 1,015 QTLs and 50,000 markers ($h^2 = 0.8$)

Scenario 3



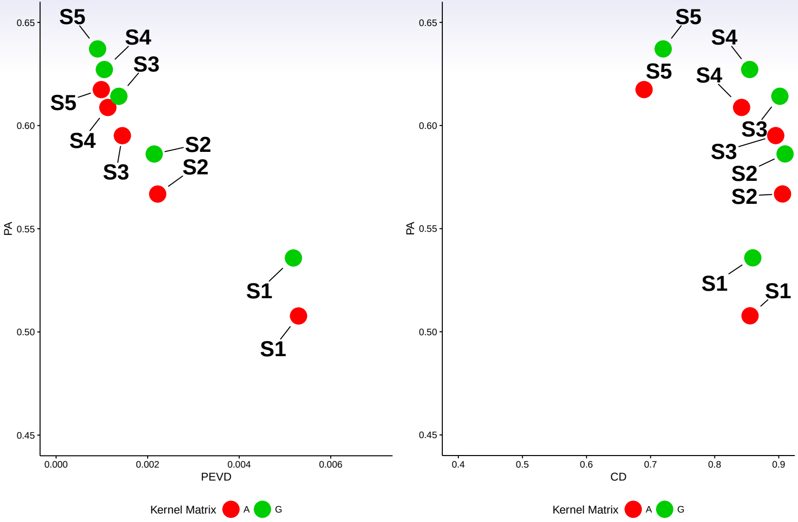
D: 1,015 QTLs and 50,000 markers ($h^2 = 0.8$)

Scenario 4



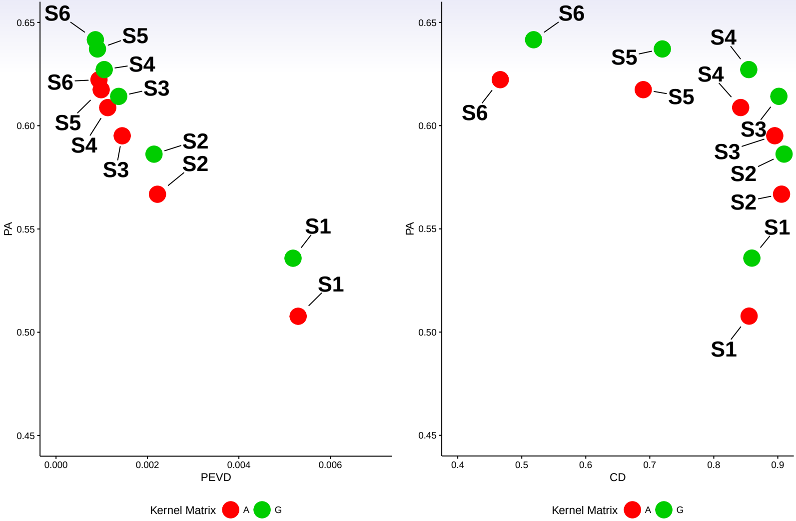
D: 1,015 QTLs and 50,000 markers ($h^2 = 0.8$)

Scenario 5



D: 1,015 QTLs and 50,000 markers ($h^2 = 0.8$)

Scenario 6



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Summary

- Connectedness across units increased with the proportion of connecting individuals and this increase was associated with improved accuracy of prediction
- Sufficient level of connectedness in terms of prediction accuracy

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Related project

- Quantifying genomic connectedness from non-additive and non-parametric relationships

Mehdi Momen