



Multi-trait mixed modelling of milk infrared spectral data for better accuracy of prediction

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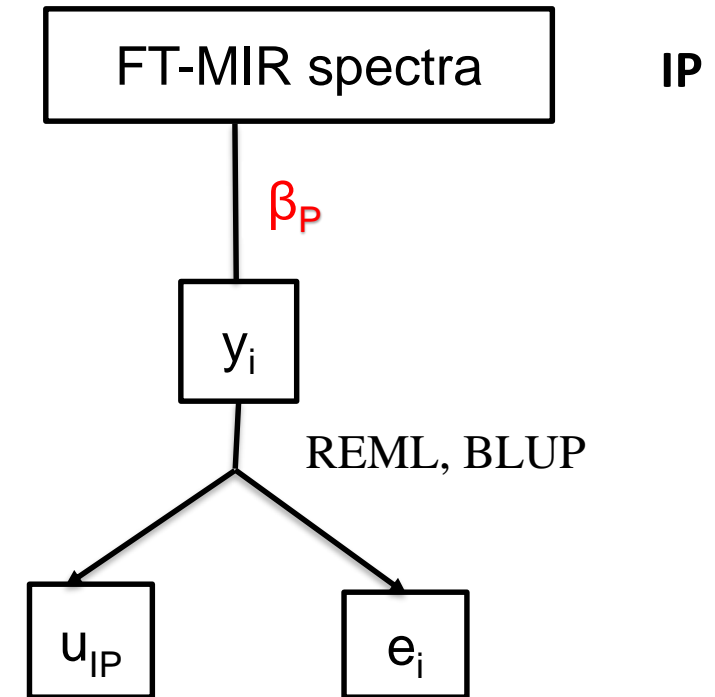
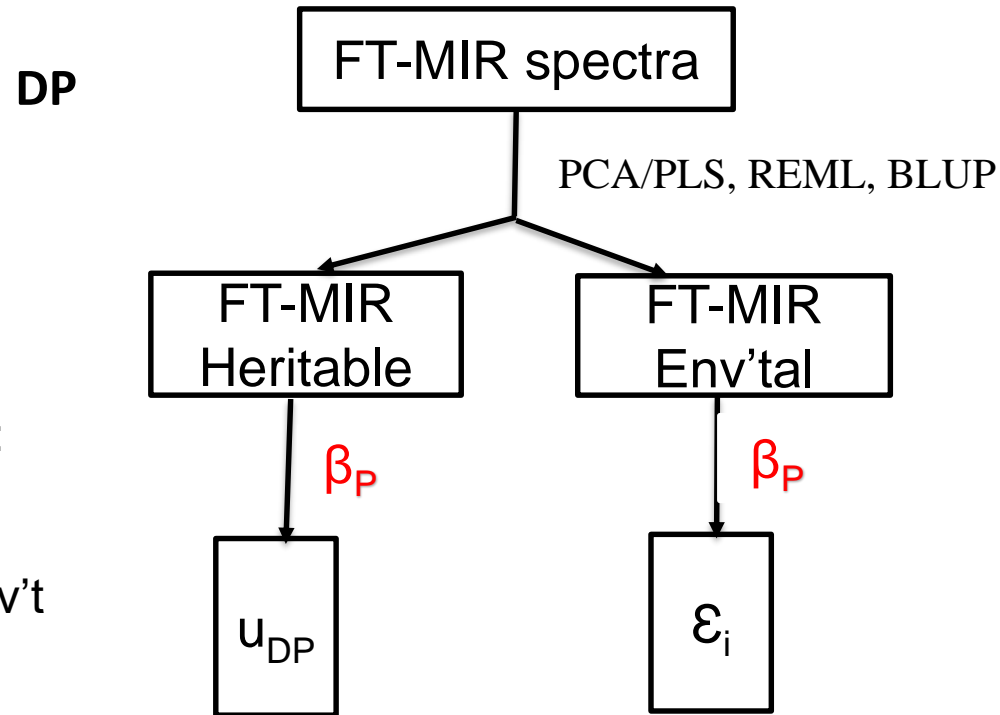
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Introduction

- Fourier transform mid-infrared (FT-MIR) spectra of milk is **routinely recorded**.
 - FT-MIR spectral information could be exploited through two approaches:
 - Mainly utilized for **phenotyping** of traits before EBV prediction – **Indirect prediction (IP)**.
 - Use of breeding values of **spectra directly** is not common - **Direct prediction (DP)**.
-

Introduction...



FT-MIR Env'tal:

- Herd*test-day
- Permanent env't
- Residual

Dagnachew *et al.* 2013



Research questions:

- Does the DP approach improve accuracy of prediction?
 - Is it reasonable to use PLS regression outputs ($\hat{\beta}_p$) for converting:
 - covariance components into variance components (e.g. $\hat{\mathbf{G}}_{5 \times 5} \xrightarrow{\hat{\beta}_p} \hat{\sigma}_a^2$) ?
 - genetic part of latent traits into EBV (e.g. $\hat{\mathbf{a}}_{5 \times 5} \xrightarrow{\hat{\beta}_p} \text{EBV}$) ?
 - Is there a relationship between performance of the IP or DP and predictive ability of calibration models (R^2)?
-



Materials and Methods

- **Data:** both real and simulated data used.
 - **Traits:** milk protein%, fat%, lactose% (for EBV prediction) and blood BHB (for phenotypic prediction) .
 - Calibration model-using partial least square (PLS) regression.
-



Materials and Methods...

- Spectral dimension reduced by PCA/PLS regression.
- An animal model fitted to estimate CVC and predict EBV and phenotypes.

$$y = Xb + Za + Wp + Qh + e$$

- Accuracy(r) of prediction:
 - $\text{cor}(\text{measured/simulated, predicted values})$, or
 - based on coefficient matrix to find PEV.
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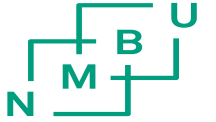
Results: real data

- Better accuracy of EBV in DP than IP approach (for milk contents):
 - Reduction in mean PEV for using DP: **3.73 - 7.06%**
 - Relative genetic gain for using DP : **2.99 - 4.85%**
 - The reverse is true for phenotypic prediction (for blood BHB):
 - Accuracy is **0.543** in IP, but **0.527** in DP (improved by 3.04% in IP)
 - Accuracies both in IP & DP are less than in PLS (**0.586**).
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Simulation

- Program written in R (https://github.com/soloboan/Multi-trait_simulations) used.
 - Different genetic (low to high: 0.10 to 0.90) and residual (zero to high) correlations considered in simulation.
 - PLS regression on (1st trait (y) vs 2nd & 3rd latent traits (x)):
 - true phenotypic values (TPV): β -phenotypic ($\hat{\beta}_p$), R_p^2
 - true breeding values (TBV): β -genetic ($\hat{\beta}_g$), R_g^2
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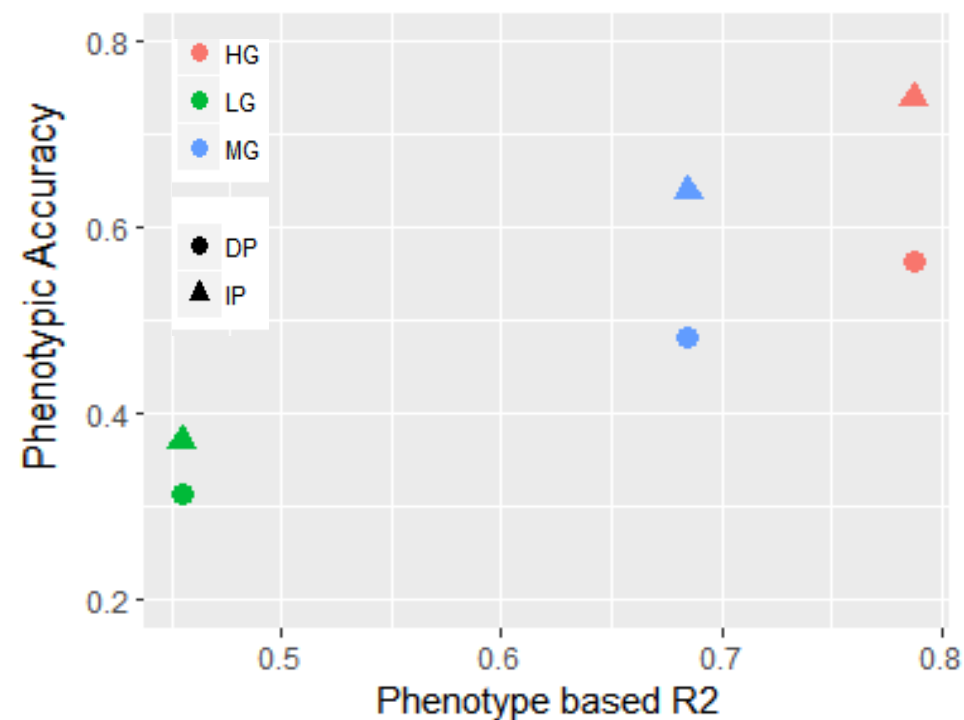
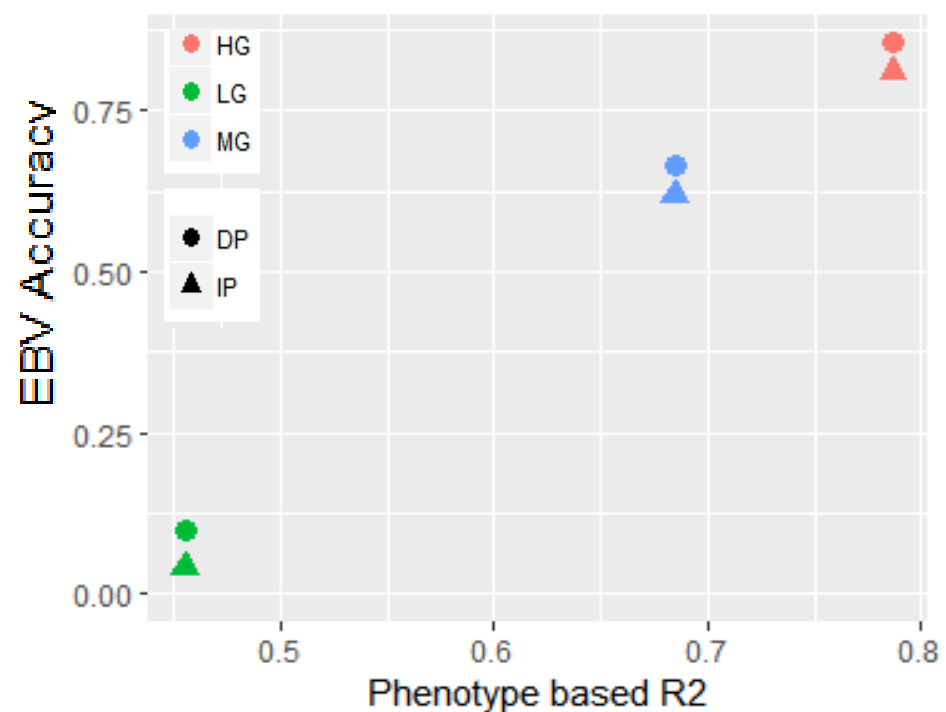


Results: simulated data

- DP resulted in better accuracy of EBV than IP (using either $\hat{\beta}_p$ or $\hat{\beta}_g$).
 - E.g. improved by 5.2 - 214.8% when $\hat{\beta}_g$ used, by 4.1 - 54.4% when $\hat{\beta}_p$ used.
 - In DP, $\hat{\beta}_g$ improved accuracy of EBV, but not in IP.
 - E.g. 11 - 138% at low genetic correlation scenario.
 - Better phenotypic accuracy found in IP than DP approach.
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Results: simulated data

- EBV/phenotypic accuracy increased with calibration R^2 and correlation structures.

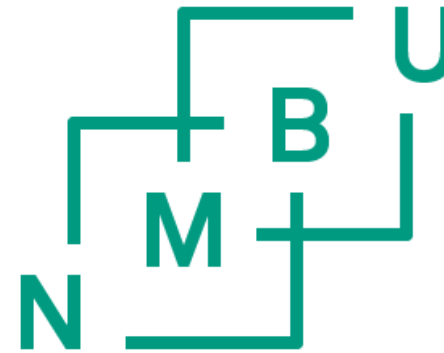




Conclusions

- The DP approach would be useful method for EBV prediction directly from heritable part of spectra.
 - Even resulted in better EBV accuracy when $\hat{\beta}_g$ used
 - The IP approach/PLS regression based equation is preferable for phenotypic prediction.
 - Calibration R^2 , correlation structures, type of PLS coefficients or dimension reduction techniques used had influenced the 2 approaches.
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Acknowledgments



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Polish Federation of Cattle Breeders and Dairy Farmers

Thank you for your attention!



Reading materials on IP and DP approaches

J Dairy Sci. 2013 Sep;96(9):5933-42. doi: 10.3168/jds.2012-6068. Epub 2013 Jul 5.

Genetic components of milk Fourier-transform infrared spectra used to predict breeding values for milk composition and quality traits in dairy goats.

Dagnachew BS¹, Meuwissen TH, Adnøy T.



J. Dairy Sci. 100:6312–6326
<https://doi.org/10.3168/jds.2016-12252>

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An attempt at predicting blood β -hydroxybutyrate from Fourier-transform mid-infrared spectra of milk using multivariate mixed models in Polish dairy cattle

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Prediction accuracy of direct and indirect approaches, and their relationships with prediction ability of calibration models

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Comparison between direct and indirect methods for exploiting Fourier transform spectral information in estimation of breeding values for fine composition and technological properties of milk

[V. Bonfatti](#)  , **[D. Vicario](#)**, **[L. Degano](#)**, **[A. Lugo](#)**, **[P. Carnier](#)**