Applications of machine learning in large amount of NIR calibration results in animal feed

Noud Aldenhoven

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Nutreco and Trouw Nutrition

International producer of animal nutrition, fish feed, and processed meat products.

- Around 100 production facilities.
- Active in more that 30 countries.
- Over 10’000 employees.

Trouw Nutrition, subsidiary of Nutreco

- Feed, premixes, and nutritional services in animal nutrition.
- 5’000 employees
- Research & Development

Modelling & Data Science Centre (MDS)

R&D Centre that consist of the following specialists:

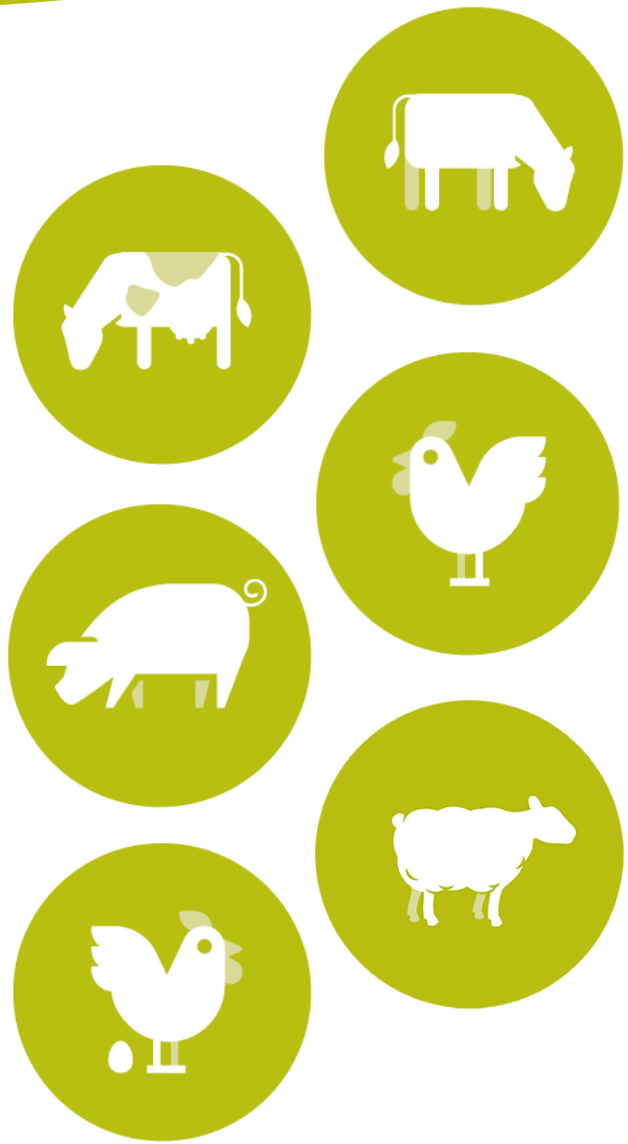
- Poultry Modelling (Nayara Tavares)
- Ruminant Modelling TBD
- Swine Modelling (Neil Fergusson)

- Cloud Computing / Databases / Models / APIs (Balu Estamsetty)
- Deep Learning / Fundamental Mathematics (Noud Aldenhoven)
- Data Science / Statistics / Analytics Translator (Marc Jacobs)

Animal Nutrition (simplified)

Feed

- Water
- Energy
- Protein
- Vitamins
- Minerals
- …



Protein

- Milk
- Eggs
- Meat

Genetics

Environment

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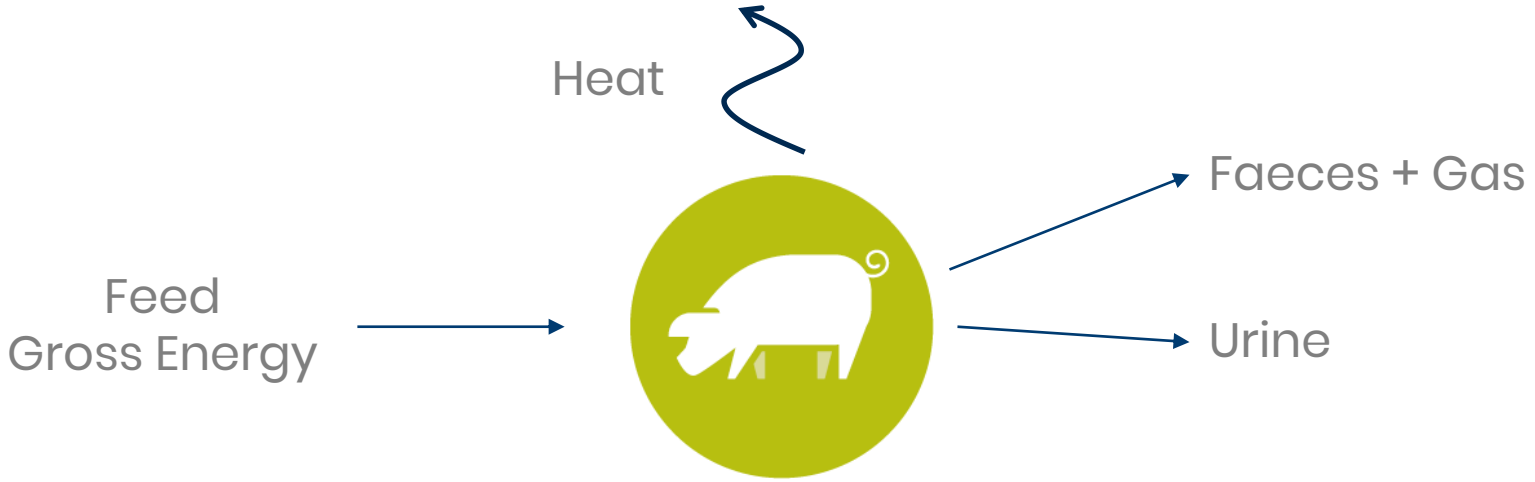
Net Energy



Net Energy = Gross Energy – “Faeces and gas energy loss” – “Urine energy loss” – “Heat loss”

- Net Energy is difficult to measure directly. Often calorimeter needed. Animal dependent.
- Large calorimeter databases are build to create (empirical) Net Energy estimation formulas.
- Given the chemical composition of the feed, we can estimate the Net Energy in the feed.

NIR Calibration lines for Net Energy

Masterlab NIR Calibrations

- Analyze around 2 million animal feed related products every year.
- Among other things, nutrient composition of raw ingredients is determined.
- Specific for Net Energy: crude protein, crude fat, starch, sugar, moisture, crude ash.
- Using NIR calibration results, Net Energy can be estimated.

Feed $\xrightarrow{\text{NIR Calibrations}}$ Nutrient Composition $\xrightarrow{NE_{CVB}}$ Net Energy Estimations

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Net Energy Estimation Formula for Swine

Warning: Mathematical formulas ahead! (2 slides)

The CVB Swine Net Energy Formula 2015 given in kcal/kg DM:

$$NE_{CVB} = 2.80 \cdot DcP + 8.54 \cdot DcFAT + 3.38 \cdot (STA + 0.9 \cdot SUG_e) + 2.33 \cdot \left(DNSP + C_{Di} \cdot SUG_f\right).$$

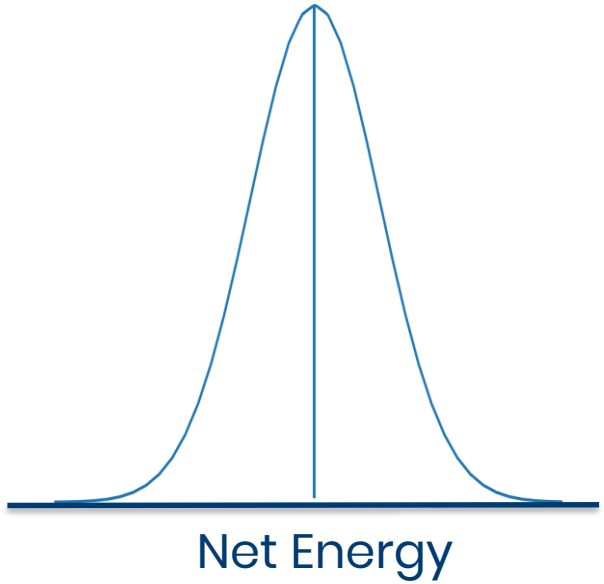
where Non-Starch Polysaccharides (NSP) are defined by difference (rest fraction):

$$NSP = 1000 - cP - cFAT - STA - C_{Di} \cdot SUG - ASH.$$

Net Energy Estimation Formula for Swine

Precision is defined as the variance of the NE formula given the variance of its chemical components. The variance of the NE formulas can be algebraically derived:

$$
\begin{aligned}
Var(NE_{CVB}) = {} & (2.80\ D_{CP} - 2.33\ D_{NSP})^2\ Var(cP) \\
& + (8.54\ D_{Fath} - 2.33\ D_{NSP})^2\ Var(cFAT) \\
& + (3.38 - 2.33\ D_{NSP})^2\ Var(STA) \\
& + (3.04\ R_e - 2.33\ (R_e + D_{NSP} - 1)\ CF_{DI})^2\ Var(SUG) \\
& + 2.33^2\ D_{NSP}^2\ Var(MOI) + 2.33^2\ D_{NSP}^2\ Var(ASH)
\end{aligned}
$$



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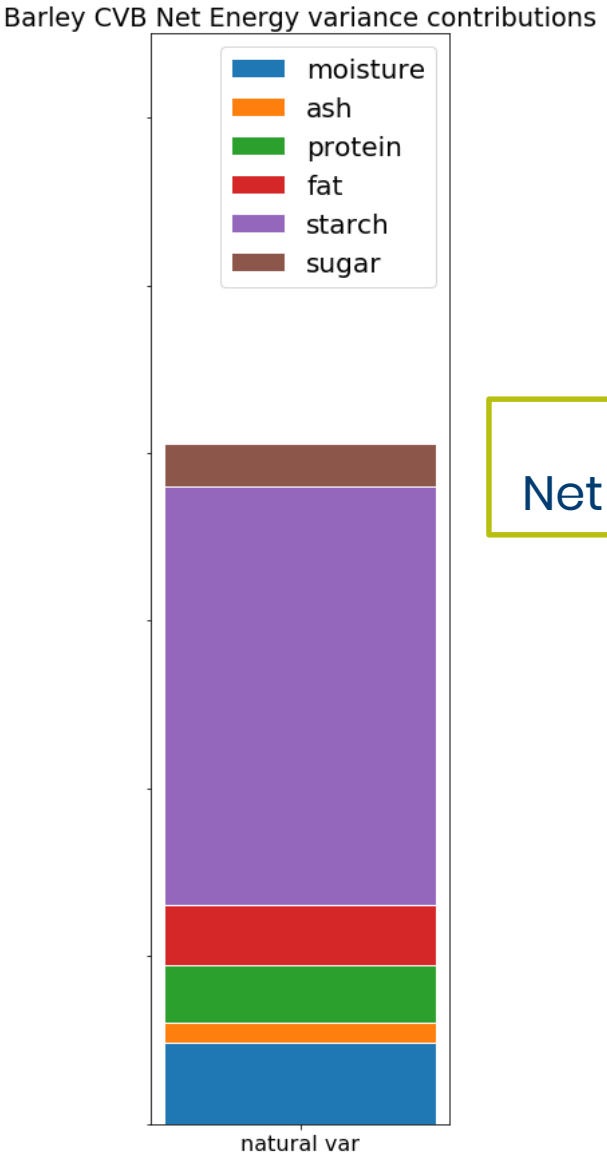
Natural std of Swine Net Energy in Barley

Based on our historical NIR results.

Nutrient	Natural std
Moisture	8 g/kg
Ash	2 g/kg
Protein	8 g/kg
Fat	2 g/kg
Starch	23 g/kg
Sugar	3 g/kg



Natural std in
Net Energy (52 kcal/kg)

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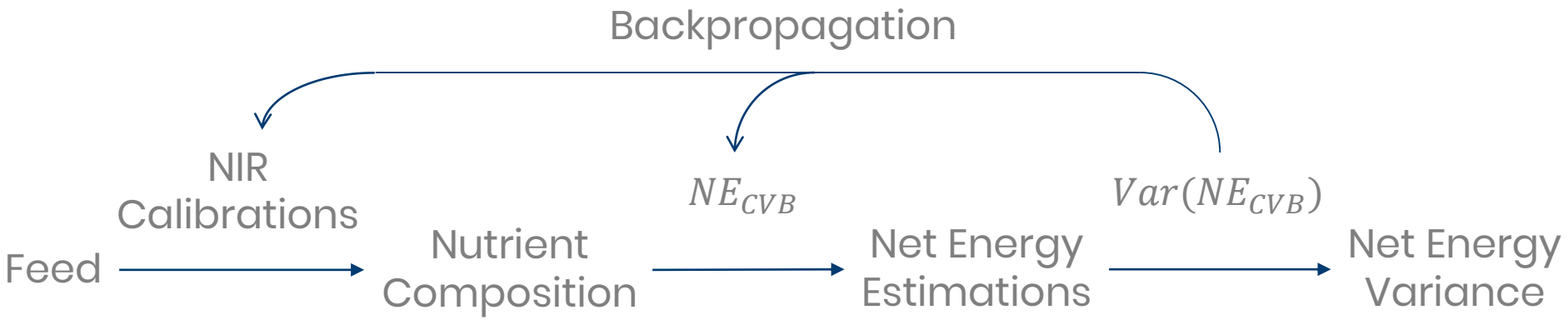
Backpropagation

In Machine Learning Jargon:

- We created a backpropagation on the calibration line results with the precision on energy as loss function.
- Using our historical data on nutrient values, we can pinpoint where the most gains in Net Energy Variance can be achieved.



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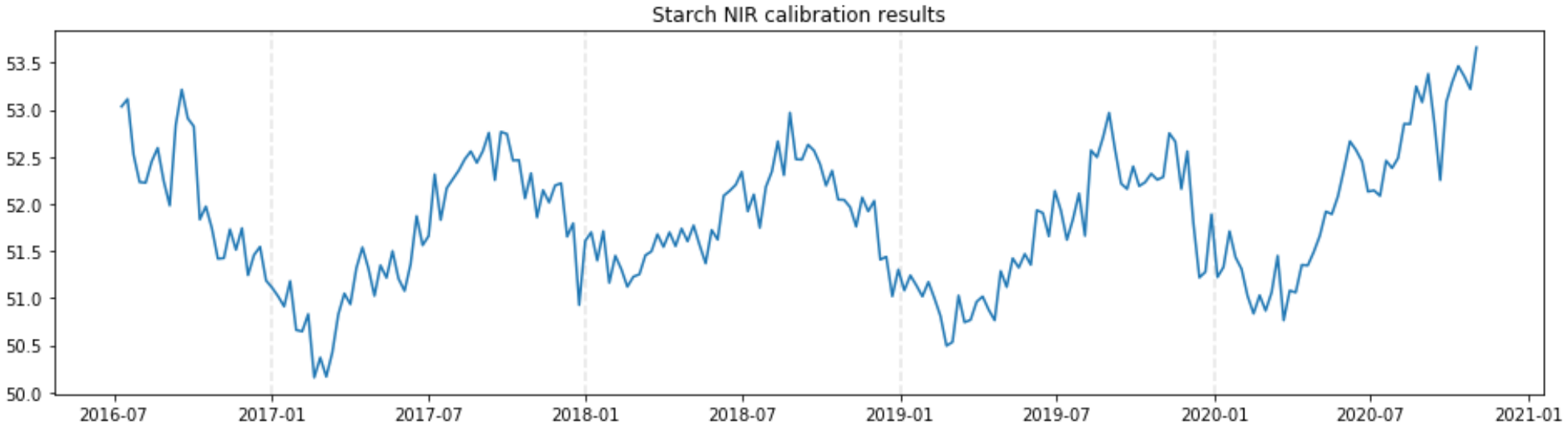
History of Starch in Barley

- Can we get more information out of the historical NIR calibration results?
- Nutrient values are measured with NIR weekly on raw incoming materials at our mills.



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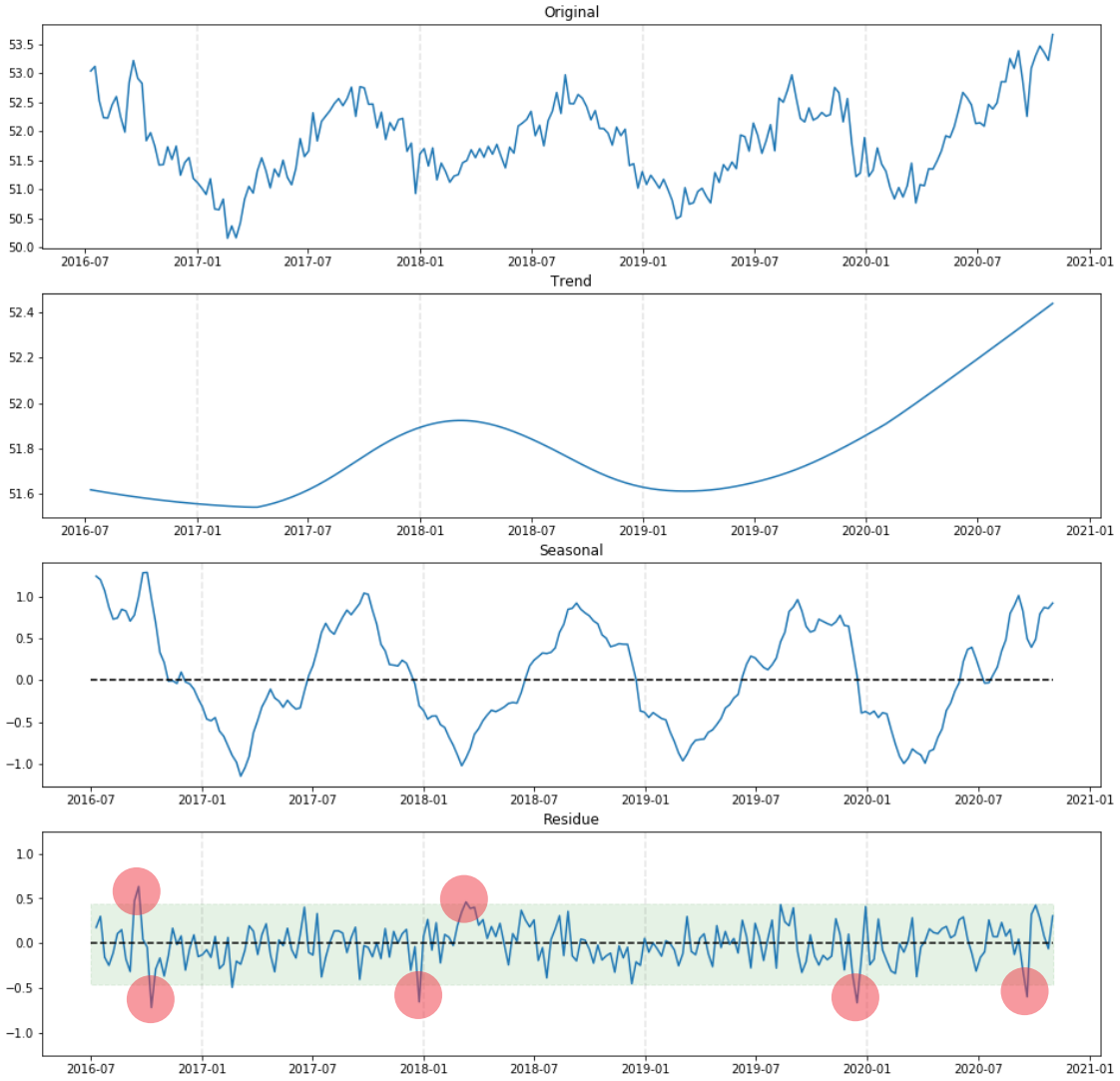
STL Decomposition

- Seasonal and Trend decomposition using Loess. (STL Decomposition)
- Decomposition of time series $N(t)$ in a trend $T(t)$, seasonality $S(t)$, and residual $\varepsilon(t)$.

$$N(t) = T(t) + S(t) + \varepsilon(t)$$

- Cons: the STL decomposition will always find a trend and seasonality. Even if there is none.

STL Decomposition



The million(s) dollar question:

How will the trend and seasonality continue?

Detected outliers

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Thank you for listening

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