Optimize the individual insemination strategy in extended lactations of dairy cattle **using a neural net** to **predict phenotypic lactation curves**

75th EAAP Annual Meeting, Florence, Italy - 1/5 September 2024

L. Polman, J. Wabbersen, J. Braunleder, S. Schierenbeck, R. Reents
IT Solutions for Animal Production (vit)

Background

Niedersächsisches Ministerium für Ernährung, Landwirtschaft und Verbraucherschutz

vit

longer than …?

standard: 305 Days?

	Ø lactation lenghts *
La.	**DIM**
1	360
2	355
3	356

* min. 270 DIM & following calving

challenges

- Plan dryoff yield?
- Overconditioning in end of lactation?
- What is the potential of the individual animal? (start of lactation)

Extended lactations?

management

Potential benefits

- Use individual possibilities
- Risk of a calving ↓
- calves per year ↓
- Dry periods per year↓
- …

Implementation in paxis?

- EBV for persitency (since April in 2023)
- **Individual insemination strategy**

Individual insemination strategy ⇨

A) Estimate phenotypic lactation curve at start of lactation

B) Calculate back when to start with insemination

→ dryoff yield, planed time for dry period

Estimate phenotypic lactation curve at start of lactation

- Use neural net with 3x per year training to predict daily lactation curves with all new information
  - Training with 3.1 Mio. full lactation curves from 2017 onwards (use milk-kg)
    - Include approx 290.000 lactations > 400 DIM

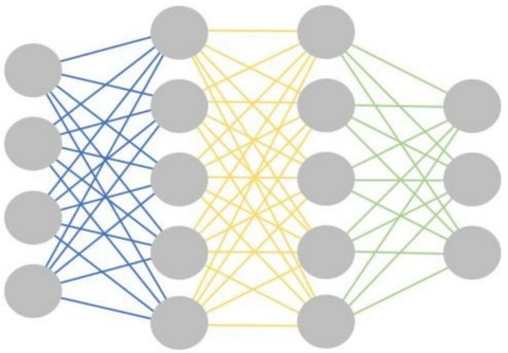
Input parameters

- lactation number
- breed
- age at calving
- season at calving
- previous calving interval
- mean herd-test-day (from RRTDM for milk traits)
- mean milk yield on farm in differnet periods during lactation in last year
  - arround DIM 150 (120 bis 180)
  - arround DIM 305 (275 bis 335)
- timestamp of last (=succsessfull) insemination in lactation
  - test different possible future timestamps while prediction
- test-day-records of previous lactations
- first test-day-records of actual lactation

Training

on completed lactations

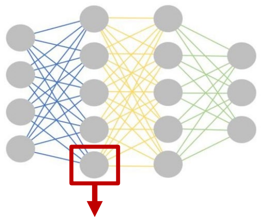
official test-day-records
from milk recording system



Output: prediction

- all informations available at time of prediction
- allow missing values
- daily

How an artificial neural network works

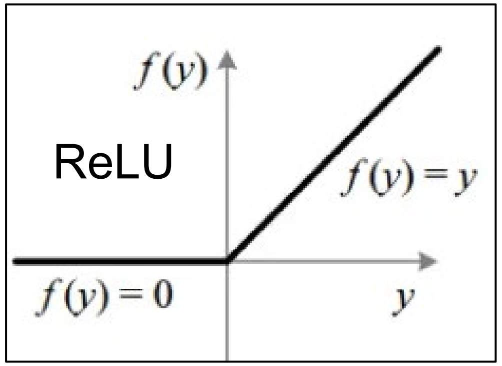
input →  → **output**

$$\text{out} = \varphi\left(-\theta + \sum_{i=1}^{n} w_i x_i\right)$$

$\theta \in R$ → bias to learn

$x_1, \dots, x_n \in R$ → input values

Activation function
- ReLU - Rectified Linear Unit (hidden layers)
- Linear (output layer)



https://databasecamp.de/ki/relu

How an artificial neuron works

n = number of weeks
m = N training cases

input → → output

$$\text{out} = \varphi\left(-\theta + \sum_{i=1}^{n} w_i x_i\right)$$

$\theta \in R$ → bias to learn

$x_1, \ldots, x_n \in R$ → input values

Activation function

- ReLU - Rectified Linear Unit (hidden layers)
- Linear (output layer)

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$\boldsymbol{w_1, \ldots, w_n} \in \boldsymbol{R}$ **→ parameter/weights to learn**

$$J(\boldsymbol{w}) = \frac{1}{m}\sum_{i=1}^{m} L\left(\hat{\boldsymbol{y}}^{(i)}, \boldsymbol{y}^{(i)}\right)$$

input		prediction		orginal output
$x_1, \ldots, x_n$	→	$\hat{y}_1, \ldots, \hat{y}_n$	⟺	$y_1, \ldots, y_n$

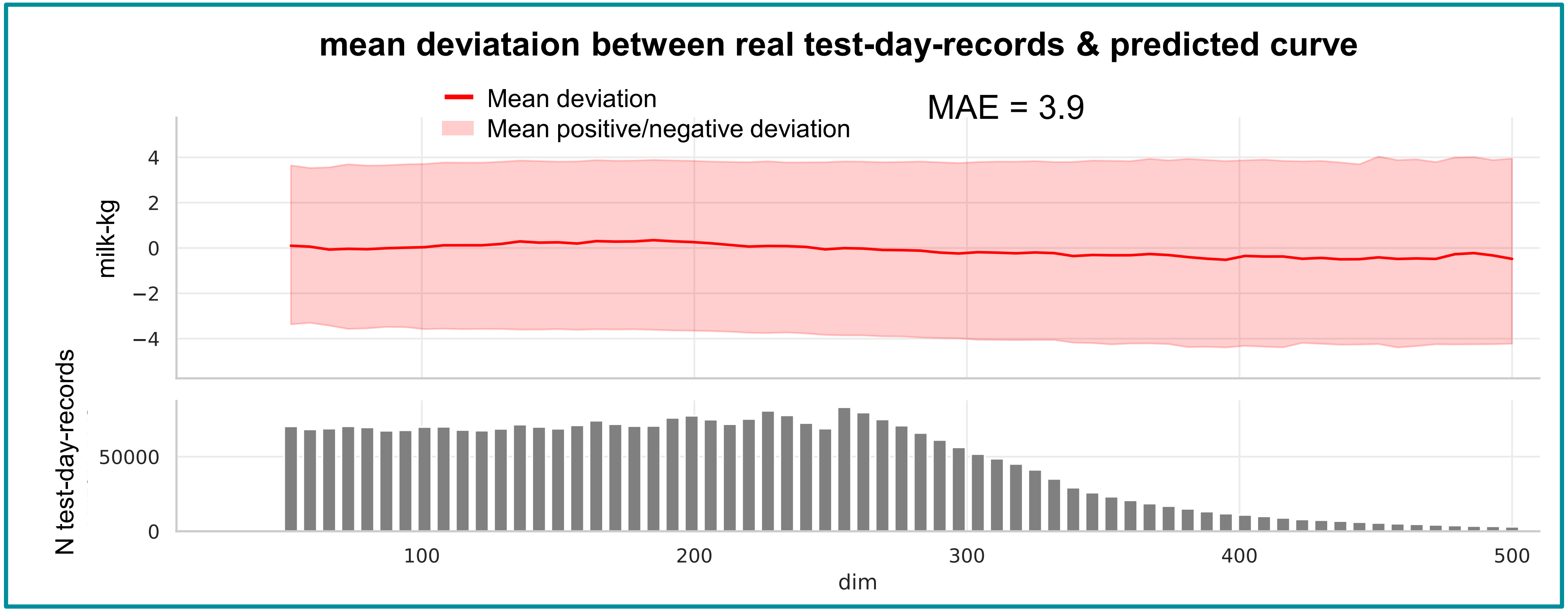
minimize squared Euclidean distance

iteratively

gradient descent method to find local minimum of cost fuction J

Results

- „validation“ - scenario:
  - training & prediction simulated for April 2021
  - compare prediction with real shown lactation curves
    - Consider that the predicted curve is smoothed and the test-day-records curve fluctuates!



Discussion & Conclusion

- the use of a neural network to predict extended lactation curves works in general
  - Our results need to be contextualized within the work of other groups (Innes et al., 2023)

- Areas of application
  - optimized insemination
  - plausibilization of test-day-records
  - management (feeding, general farm strategy, …)
  - …

- missing input values are permitted (best use of available inputs) → useful in practice

- future improvements are probably still possible
  - integration of additional parameters
  - many possible adjustment options in training/structure of the neural network
  - alternatives to neural networks? (random forests, k-nearest neighbors algorithm (KNN), gradient boosting, …)
  - increasing number of data sets with long lactations that can be trained on

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