FACULTY OF ECONOMICS AND BUSINESS ADMINISTRATION

DEPARTMENT OF MARKETING, INNOVATION AND ORGANIZATION - CLUSTER DATA ANALYTICS

PREDICTING THE MILK YIELD CURVE OF DAIRY COWS IN THE SUBSEQUENT LACTATION PERIOD USING DEEP LEARNING

Arno Liseune, Matthieu Salamone, Dirk Van den Poel, Bonifacius Van Ranst, Miel Hostens

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RESEARCH GAP

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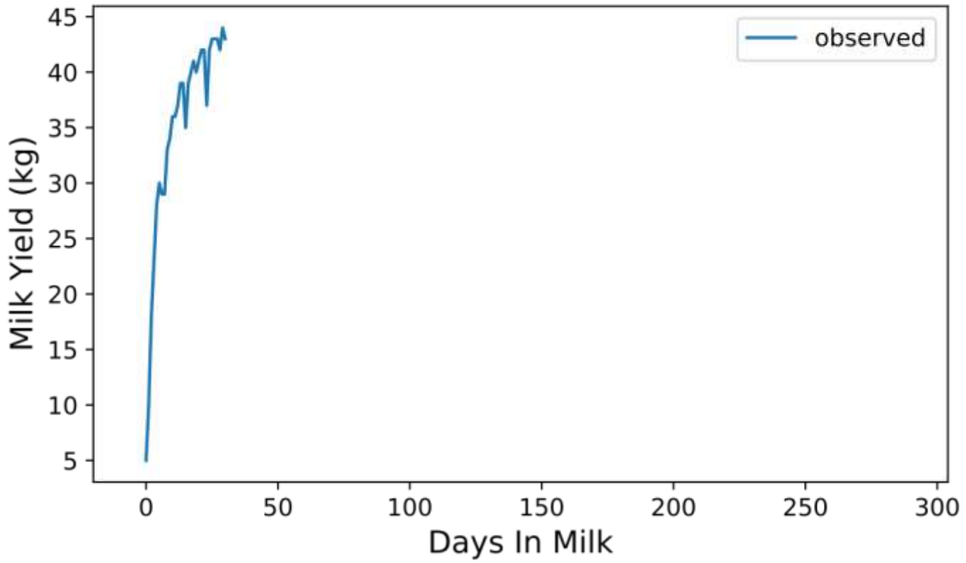
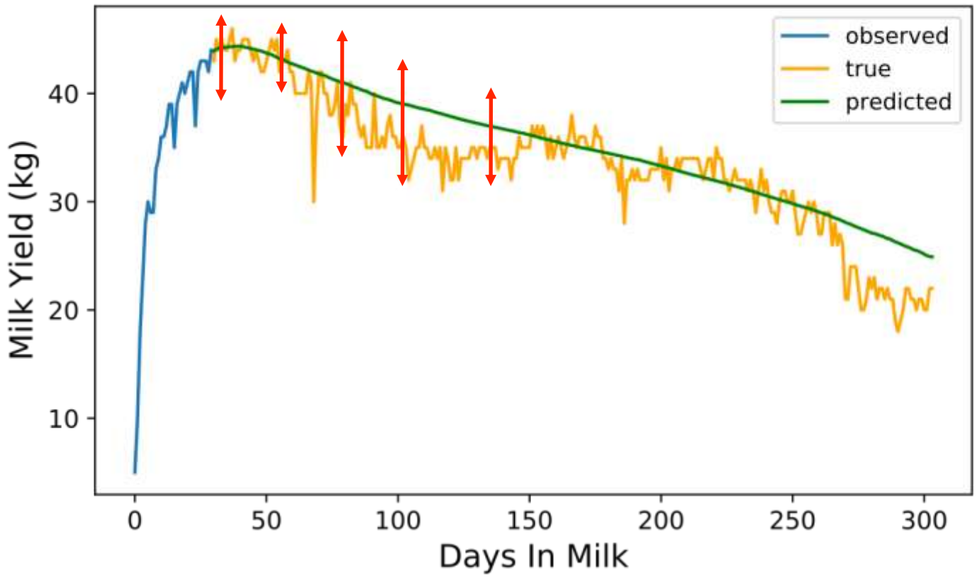
Previous Research

Parity X



Animal statistics
Herd statistics

Parity X



- Observed milk yields in same parity
- Prediction of remaining milk yields
  - Animal monitoring by comparing true vs predicted
  - Animal monitoring from first day of prediction

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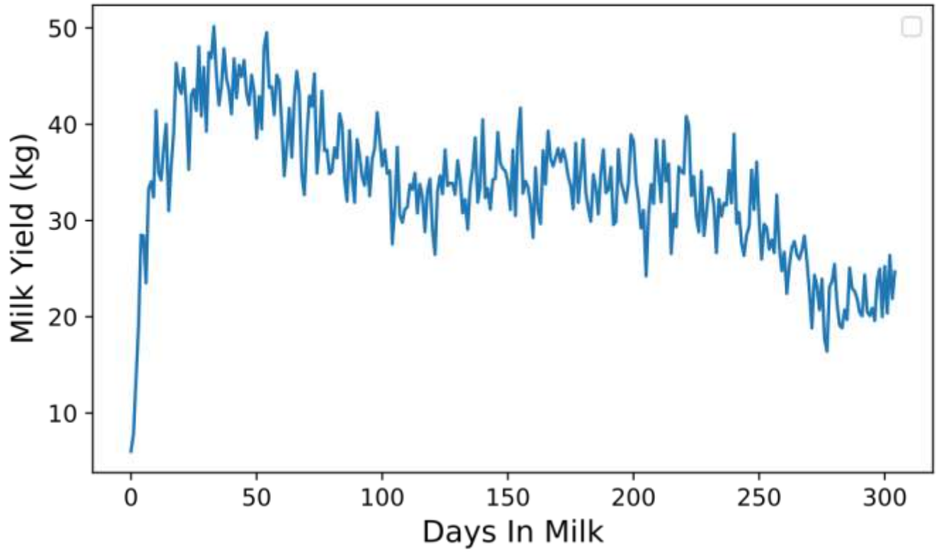
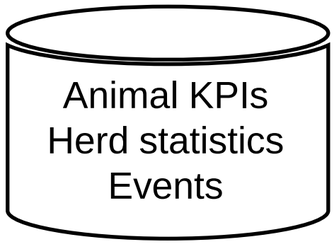
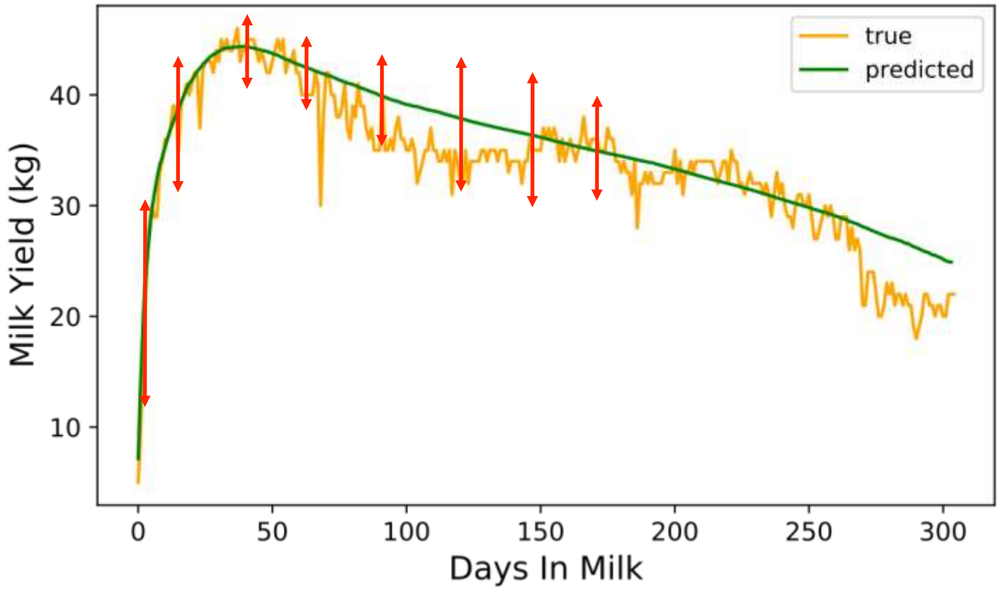
This Research

Parity X





Parity Y



- Observed milk yields in previous parity
- Prediction of all milk yields
  - Animal monitoring by comparing true vs predicted
  - Animal monitoring from day 1 of lactation
  - Increase forecast horizon of milk prediction
  - Impact health and reproduction events

METHODOLOGY

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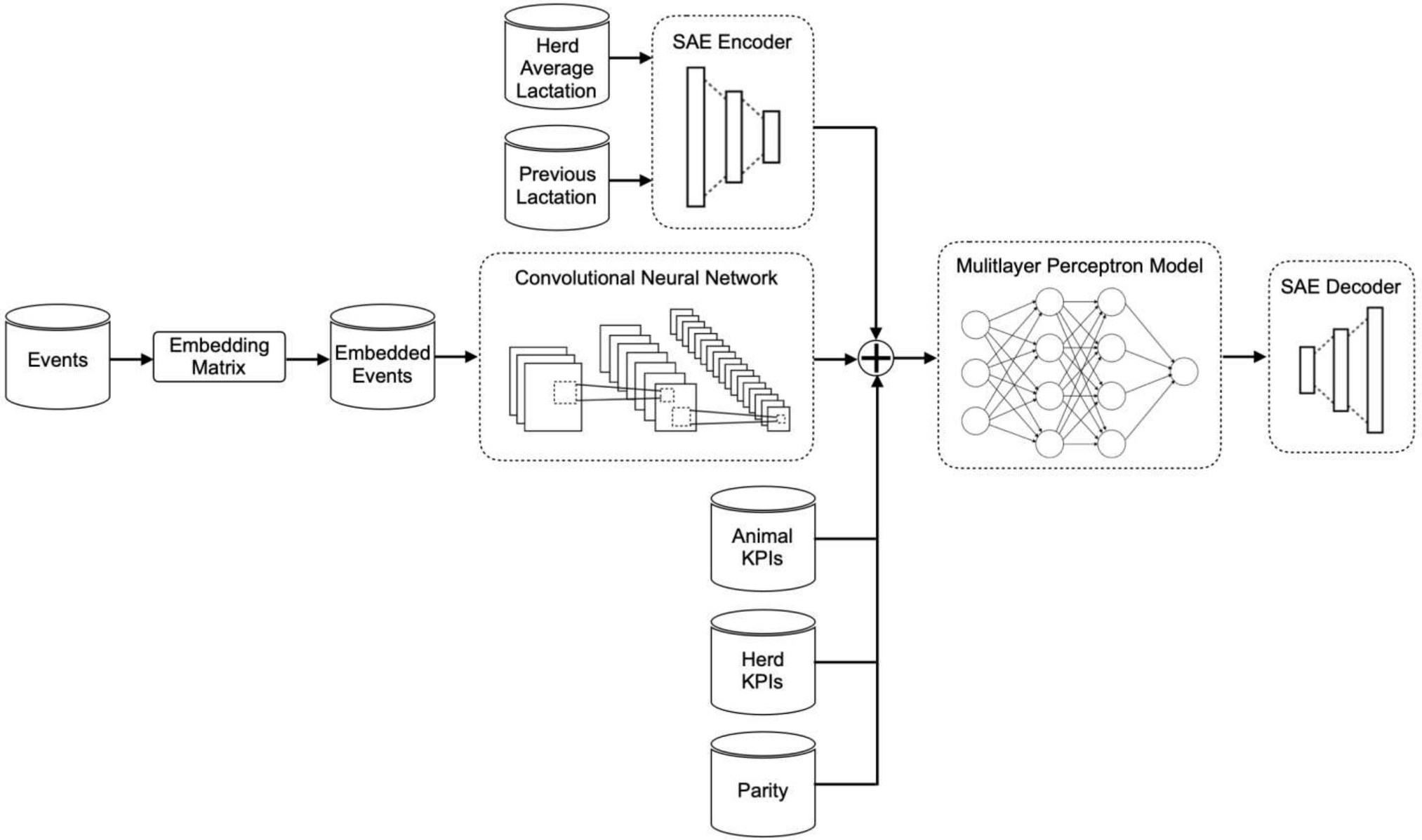
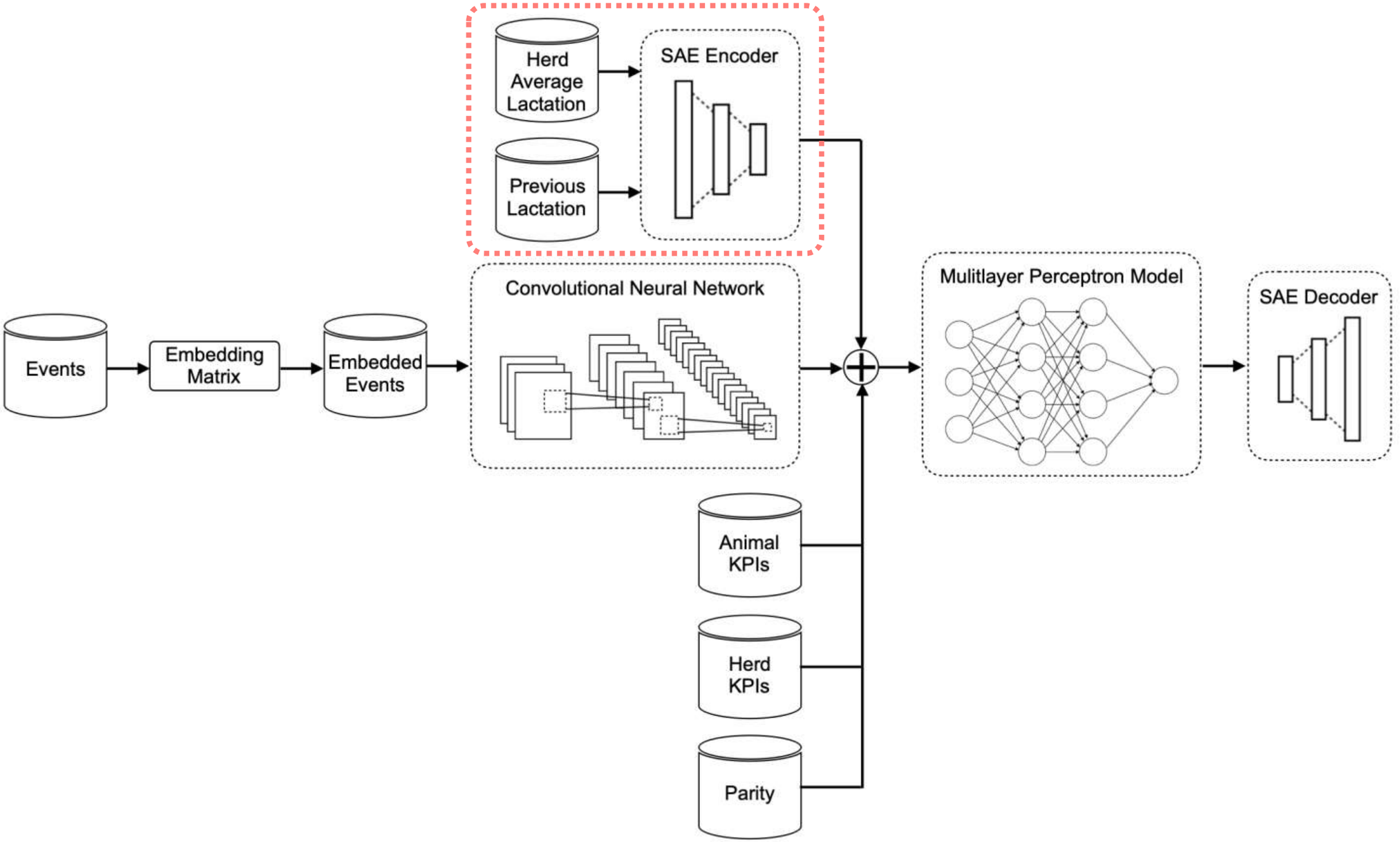
OVERVIEW


Herd Average Lactation
SAE Encoder
Previous Lactation
Convolutional Neural Network
Events
Embedding Matrix
Embedded Events
Mulitlayer Perceptron Model
SAE Decoder
Animal KPIs
Herd KPIs
Parity

SAE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SAE

The **milk yields of the previous lactation period** will be used

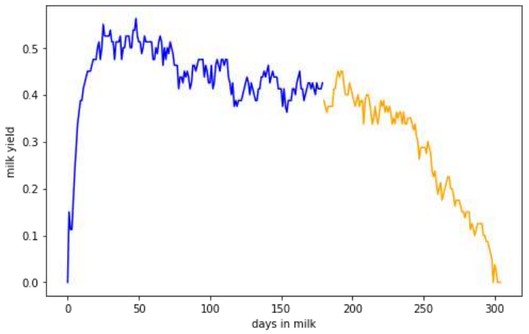
- Contains some information about a cow's general productivity
- Contains some information about how a cow typically transitions through the lactation cycle

Problem: **milk yield curves are often incomplete**:

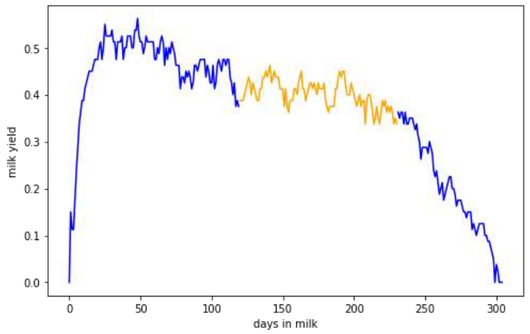
- Some farmers don't record milk yields on a daily basis
- Some farmers have their recording systems installed during their cows' lactation periods
- The recording systems can be defective for some time
- …

In general, this results in **4 types of problems** regarding missing data for milk yield curves:

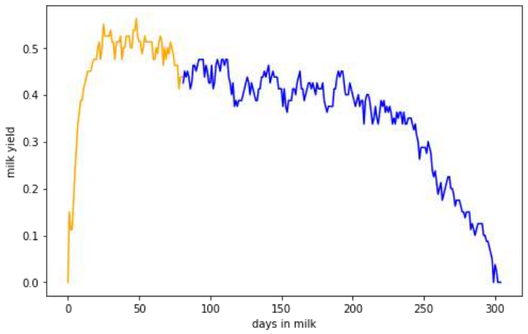
Prediction



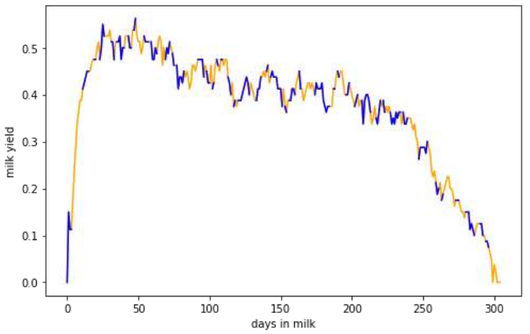
Missing window



Backtracking



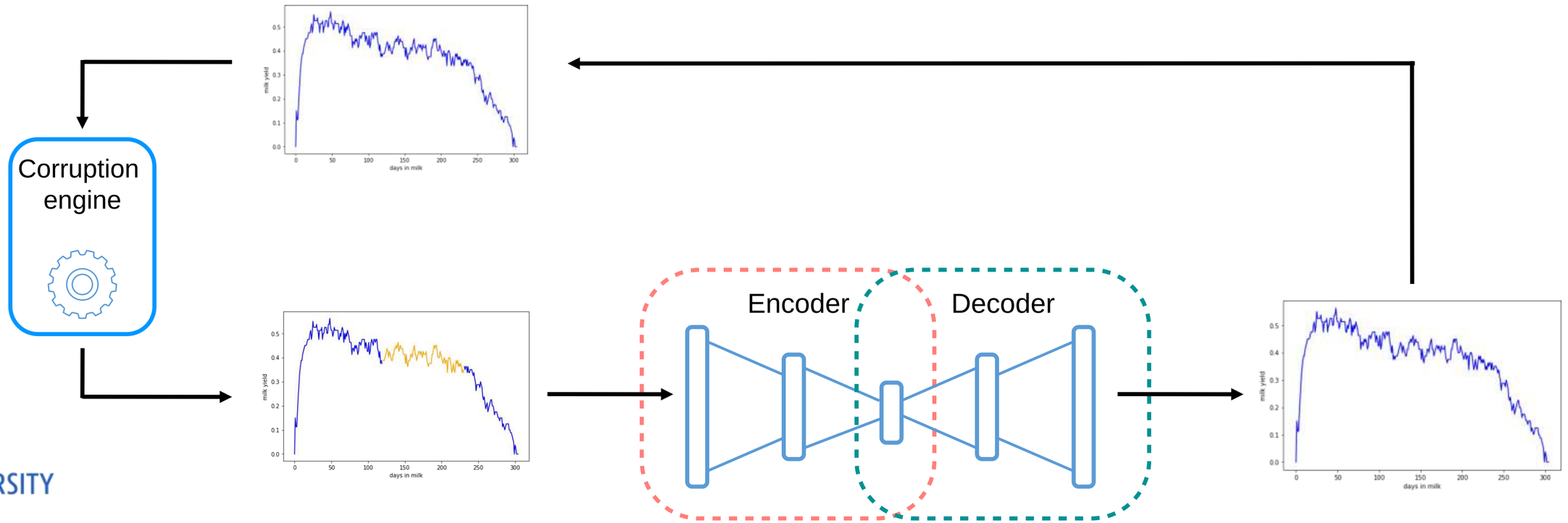
Interpolation



SAE

Solution: Sequential Auto Encoder (SAE)

1. The **Corruption engine** randomly inserts missing values into complete milk yield curves
2. The **Encoder** encodes a vector of milk yields into a low-dimensional representation
3. The **Decoder** decodes the low-dimensional representation back into a vector of milk yields



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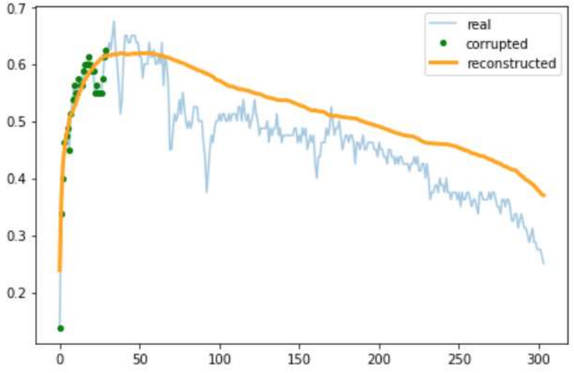
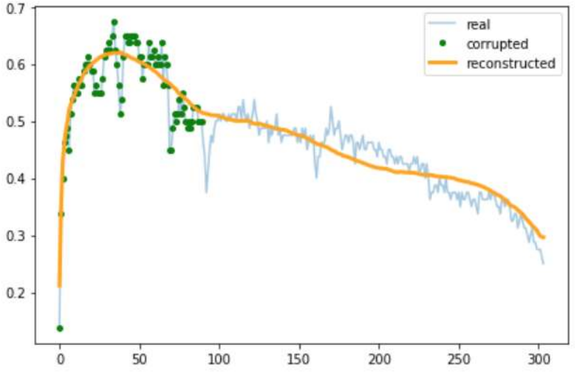
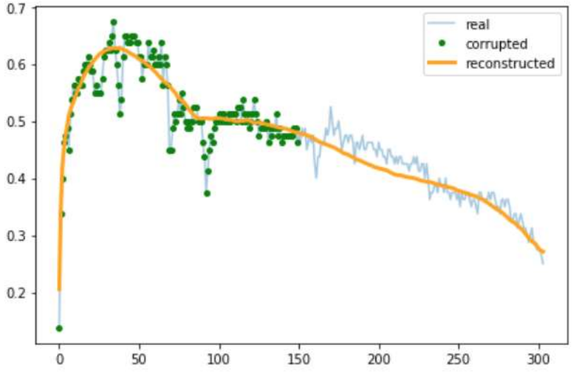
SAE

Results SAE

Prediction







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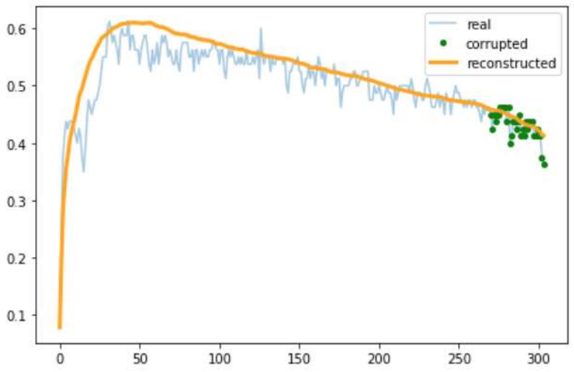

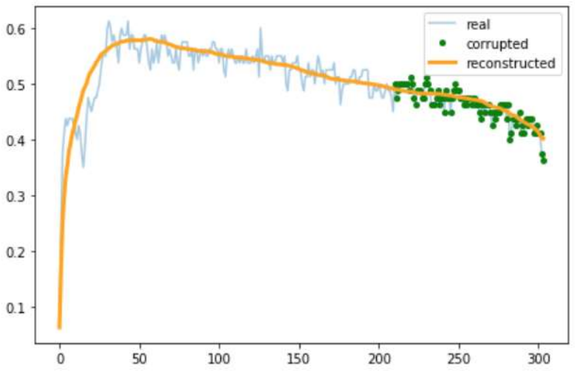

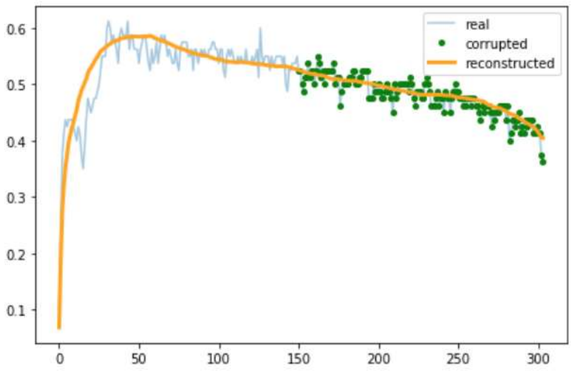

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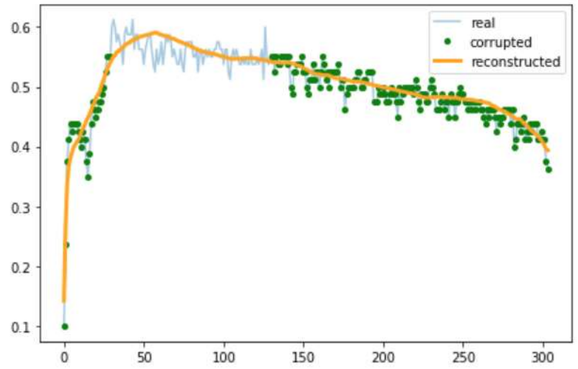
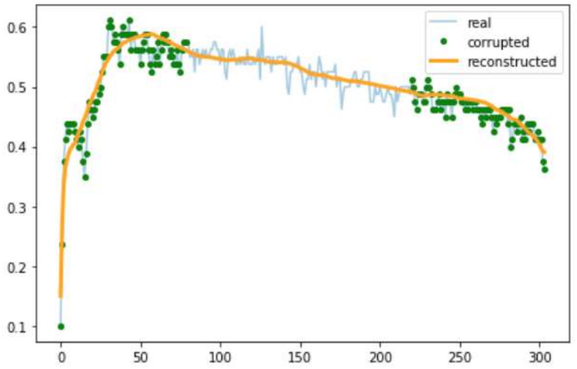
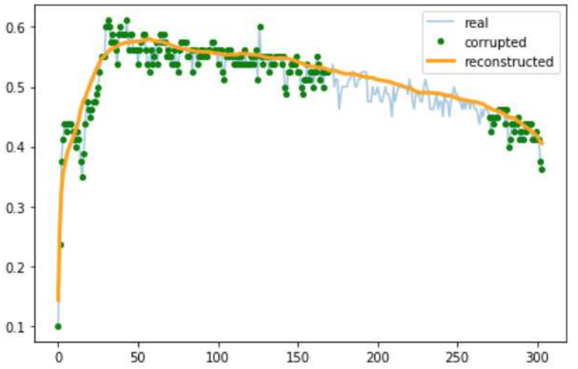
SAE

Results SAE

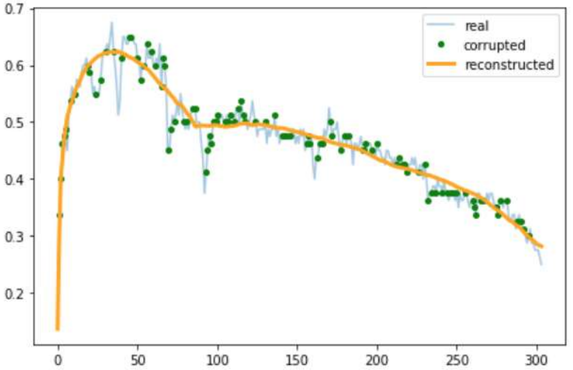
Missing window

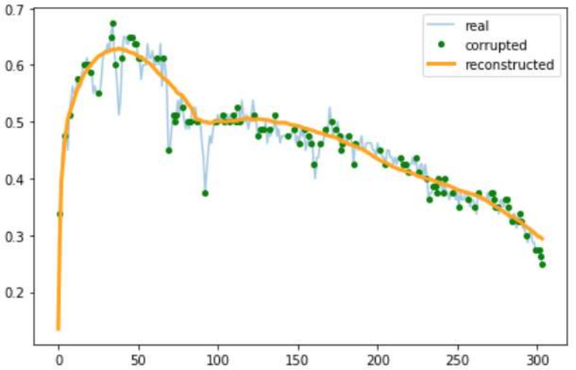


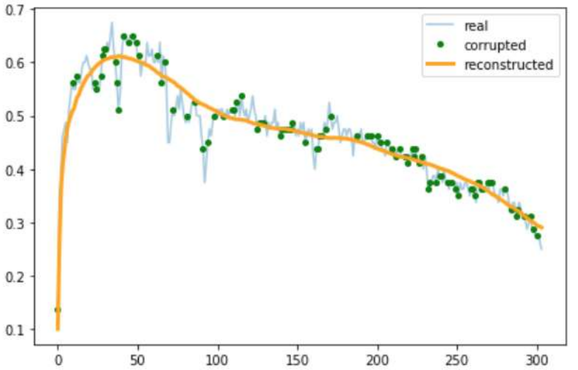




Interpolation







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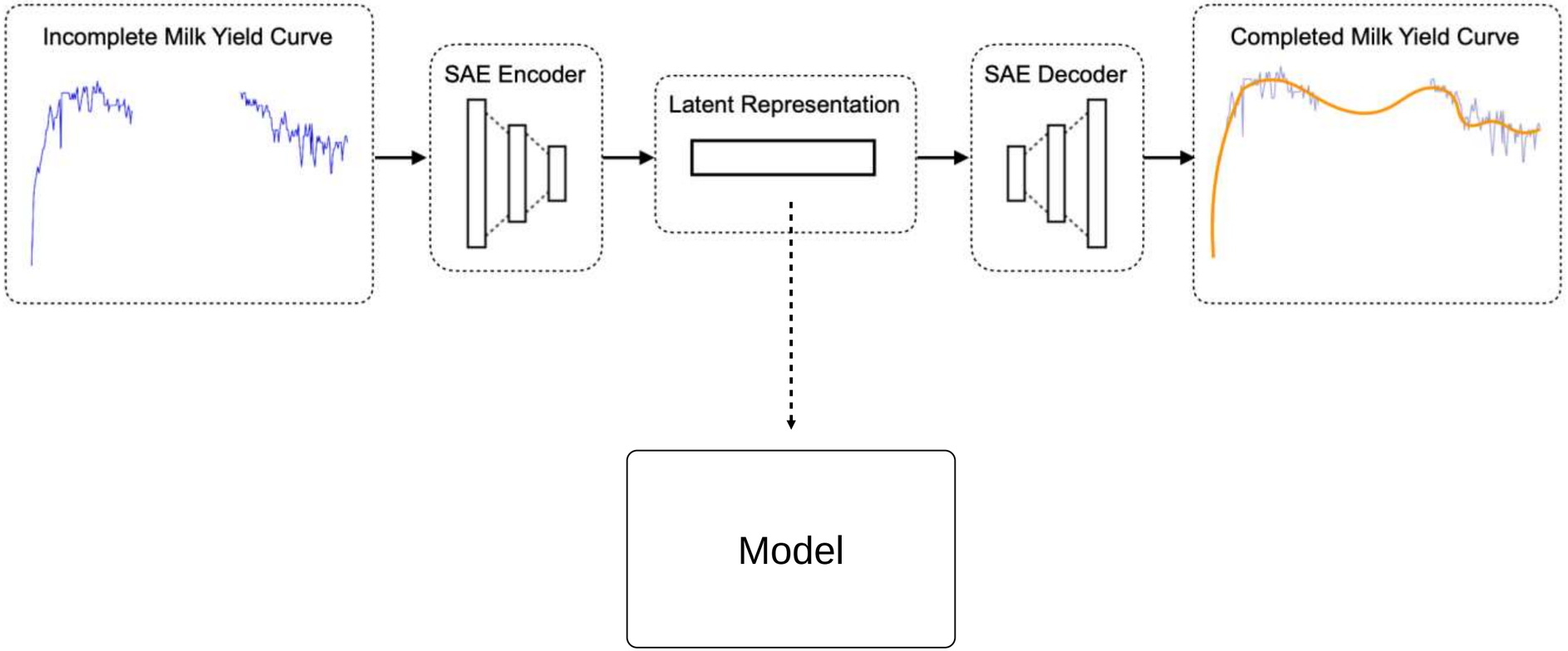
SAE

SAE implementation



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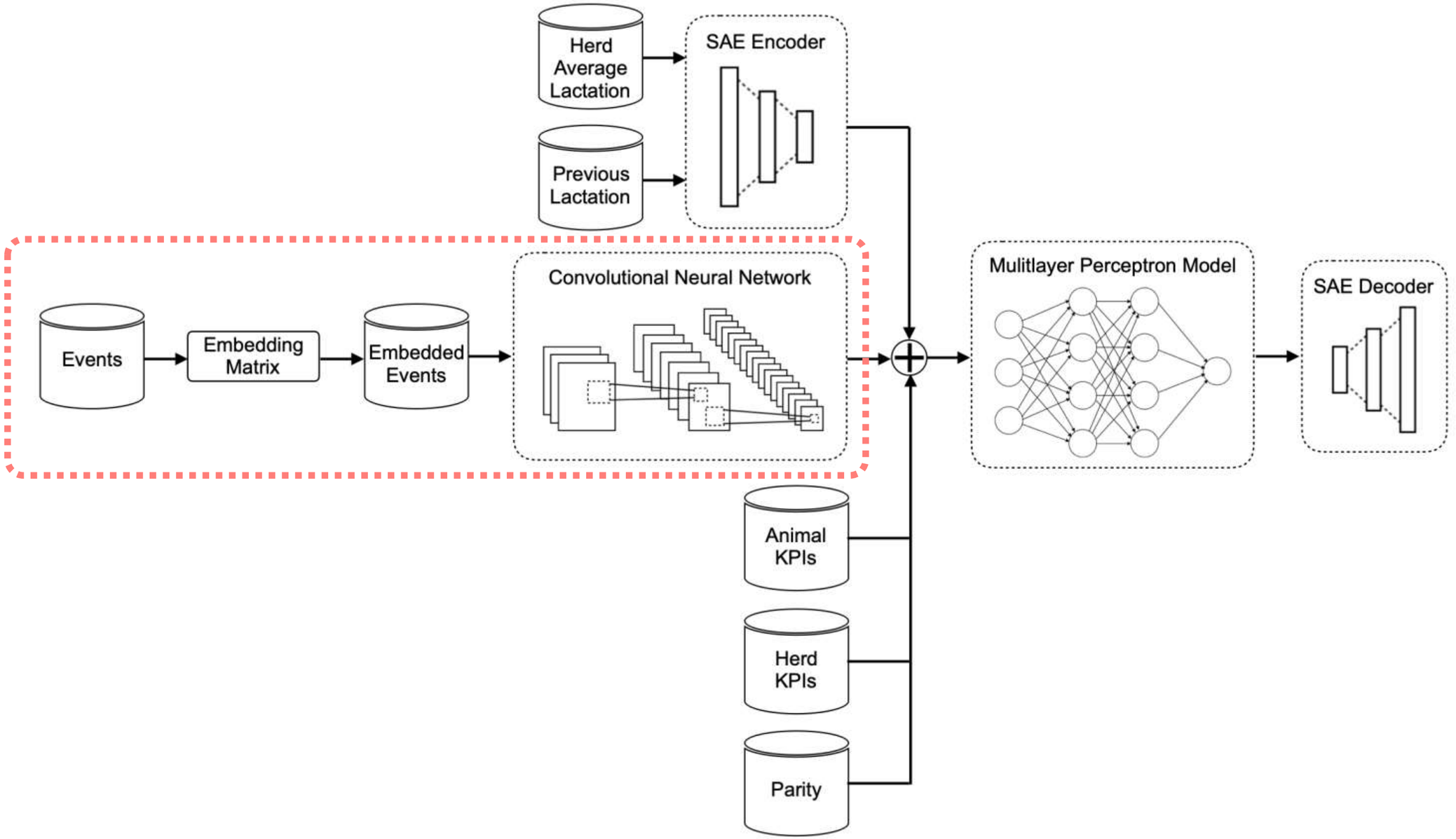
CNN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Parity

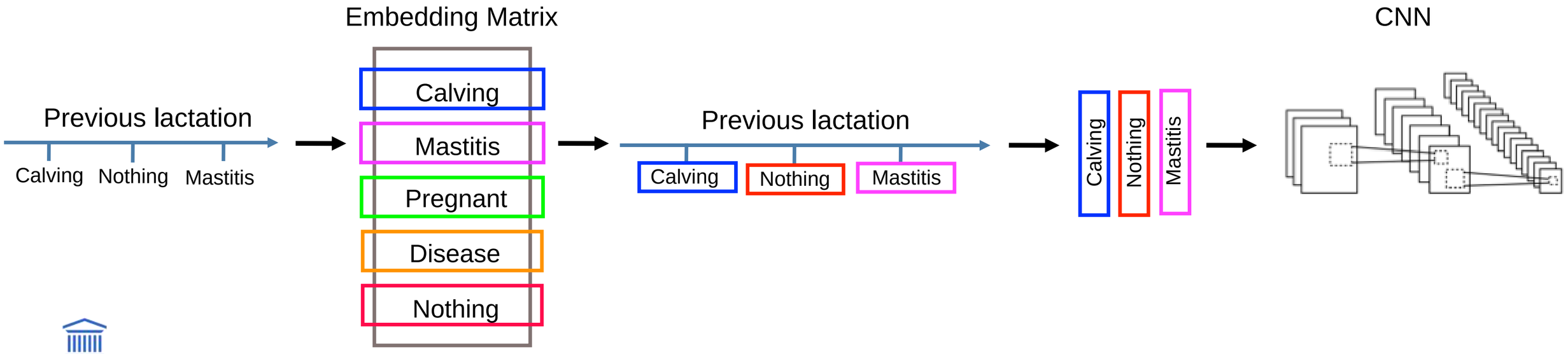
CNN

Cows can encounter many **events** during a lactation period: Calving, Mastitis, Pregnancy, …

- These events can influence the milk yield in the next lactation period

Problem: Machine learning models don't understand these sequences of symbols

Solution: 1) Train embedding matrix that embeds each event in a multi-dimensional vector
2) Extract feature vector representing the sequence of events by CNN



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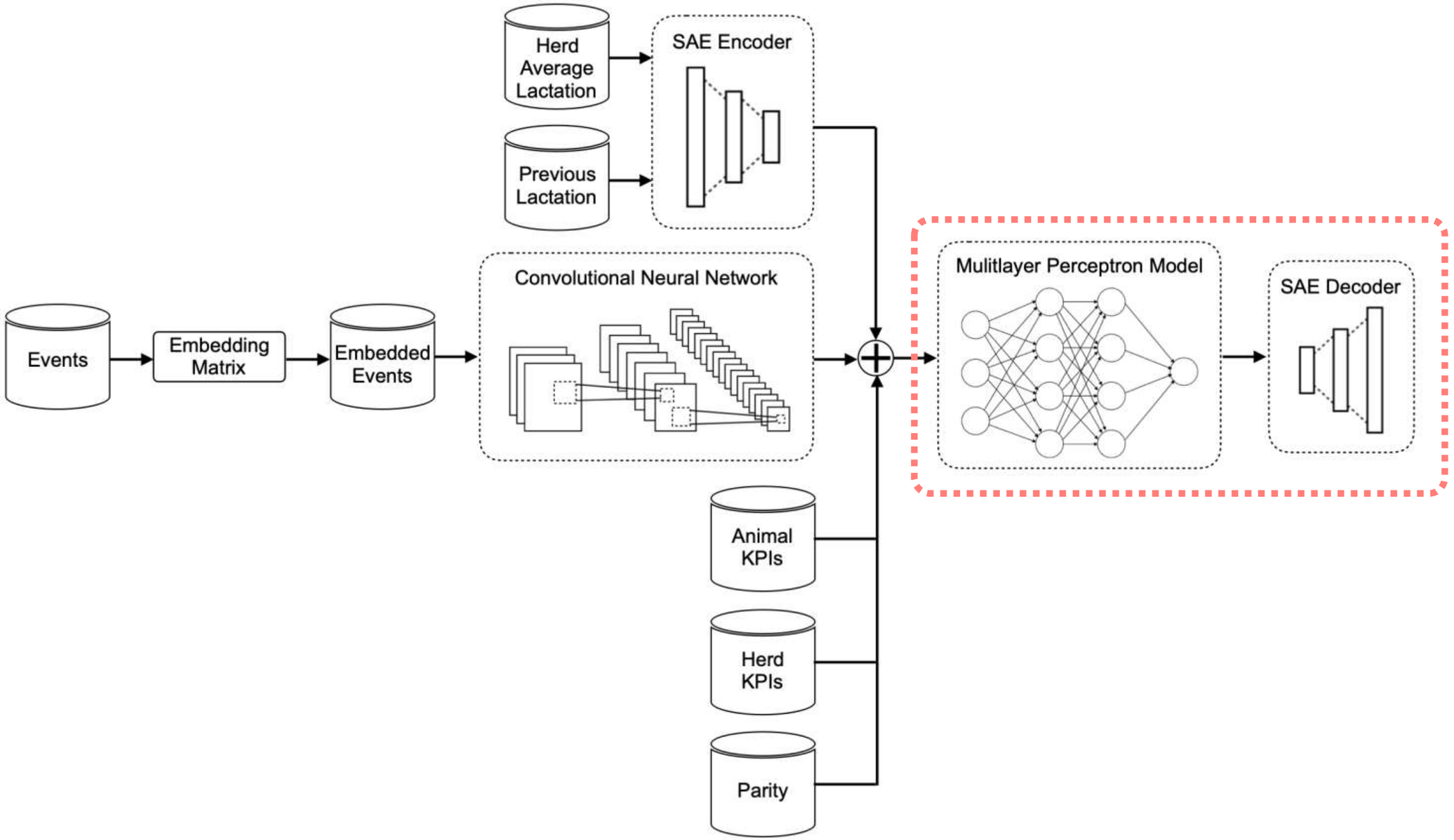
MLP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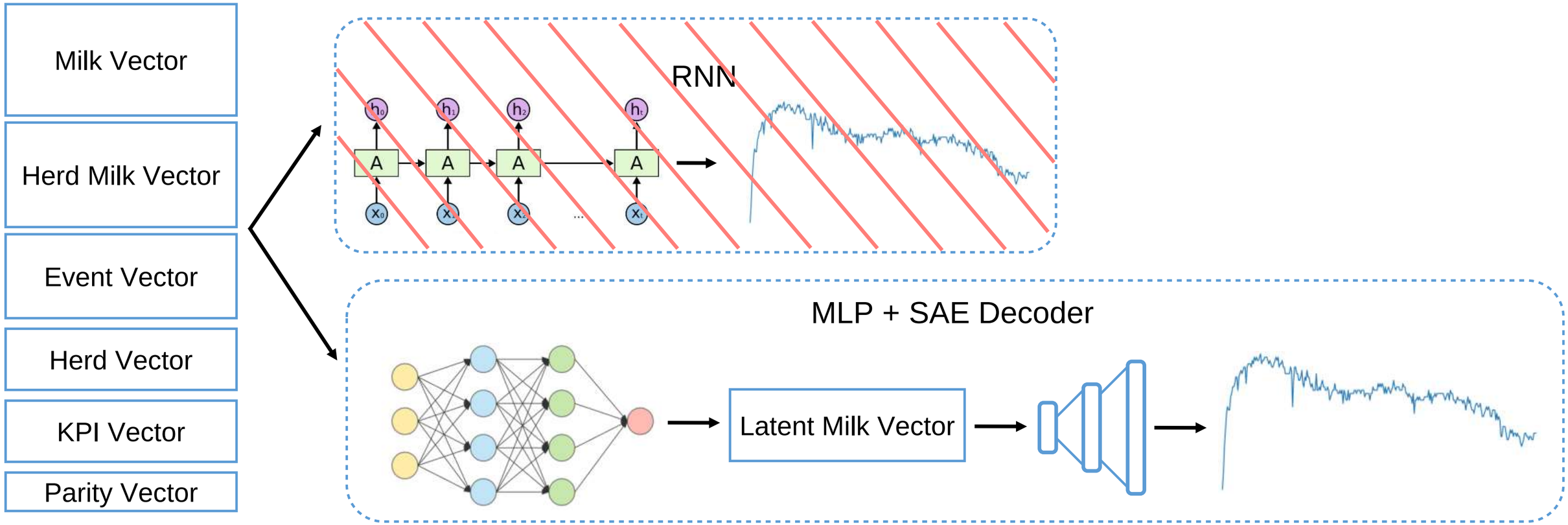
MLP

The **milk yield production of the next lactation** period is predicted based on all the features

Problem: To predict the entire milk yield curve, 305 predictions should be made sequentially

Solution: 1) MLP predicts latent representation of milk yields
2) SAE decoder converts latent representation back to corresponding milk yield sequence



RESULTS

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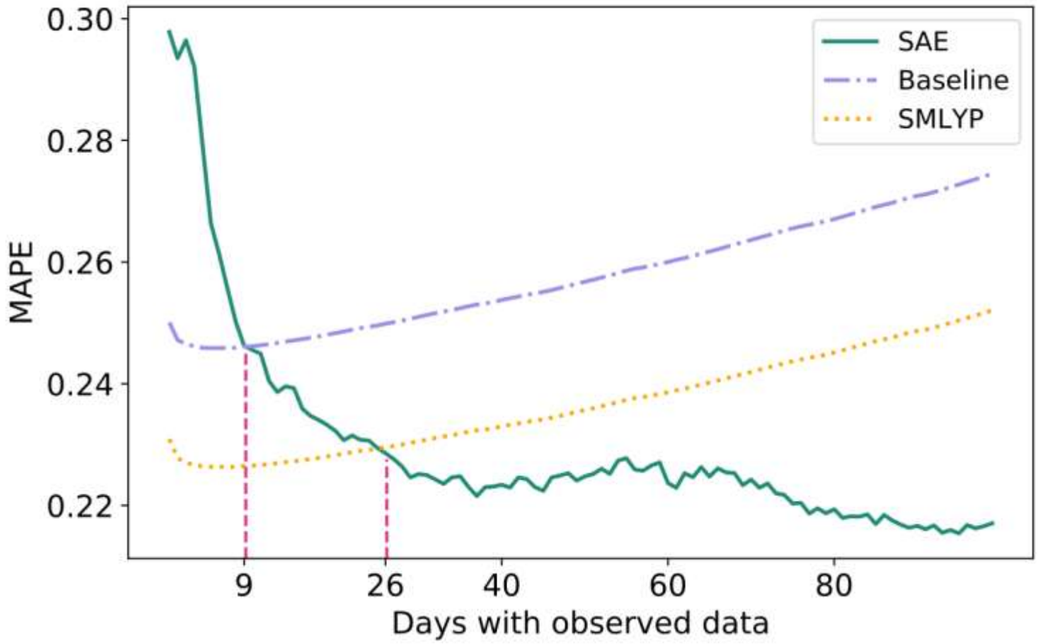
RESULTS

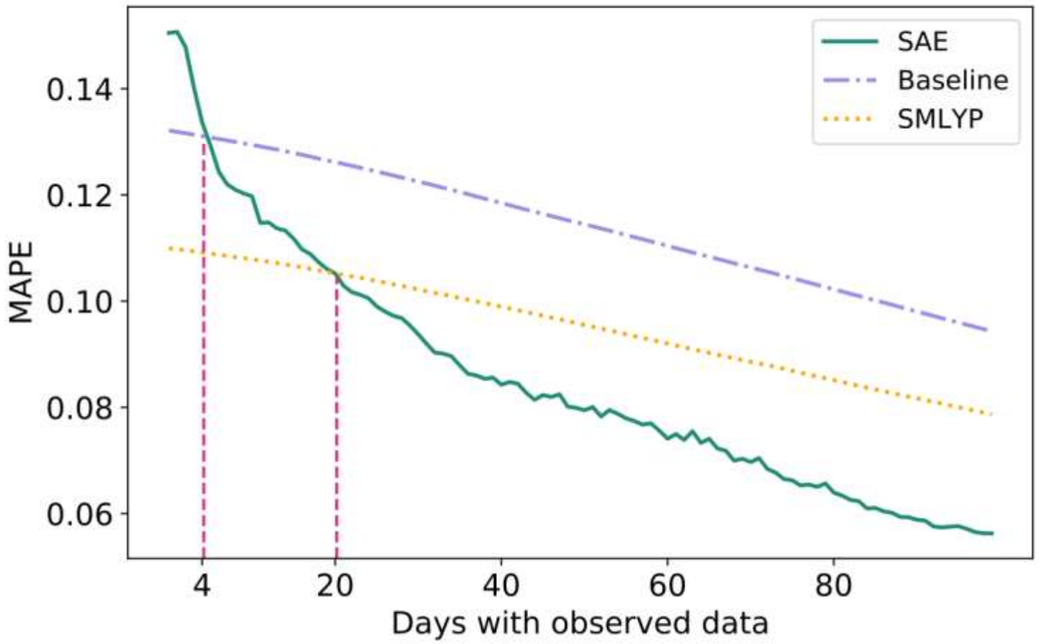
Performance on daily as well as 305d yield of the SLMYP and baseline models. Baseline 1 = lactation curve of preceding cycle, Baseline 2 = average lactation per herd per parity, Baseline 3 = Wood's curve.

	Daily yield				305d yield			
Model	RMSE	MAE	MAPE	ρ	RMSE	MAE	MAPE	ρ
Baseline 1	9.22	7.13	0.26	0.62	2071.33	1081.01	0.16	0.61
Baseline 2	7.97	6.21	0.25	0.70	1705.09	1346.82	0.13	0.61
Baseline 3	9.58	7.67	0.30	0.53	2338.56	1887.68	0.18	0.18
SLMYP	7.38	5.58	0.23	0.75	1448.95	1093.30	0.11	0.73

Daily milk yield prediction

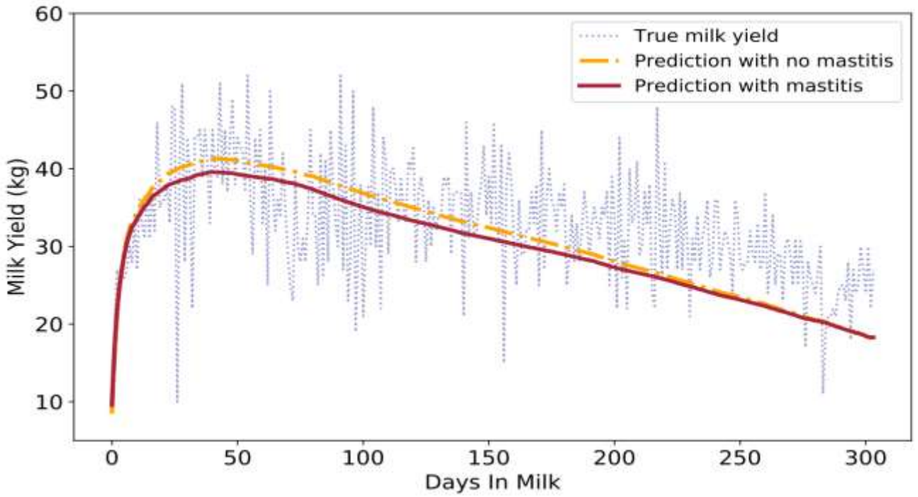


305d milk yield prediction

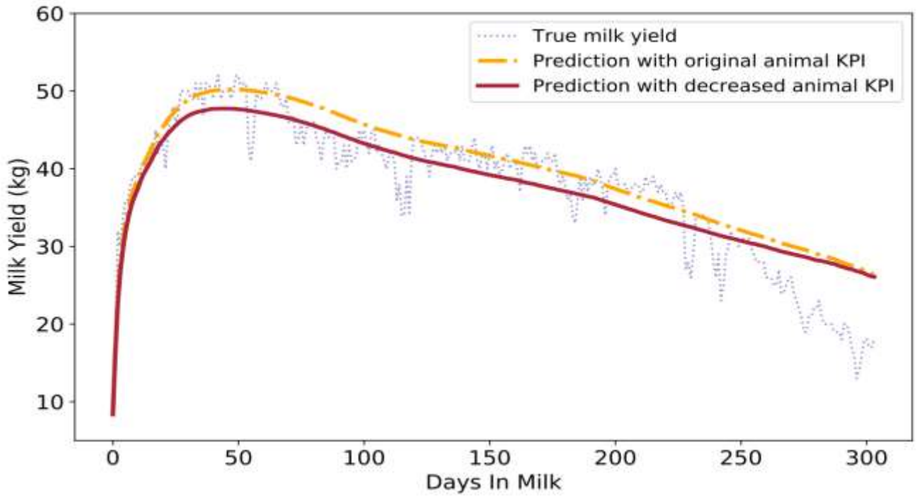


VARIABLE IMPACT

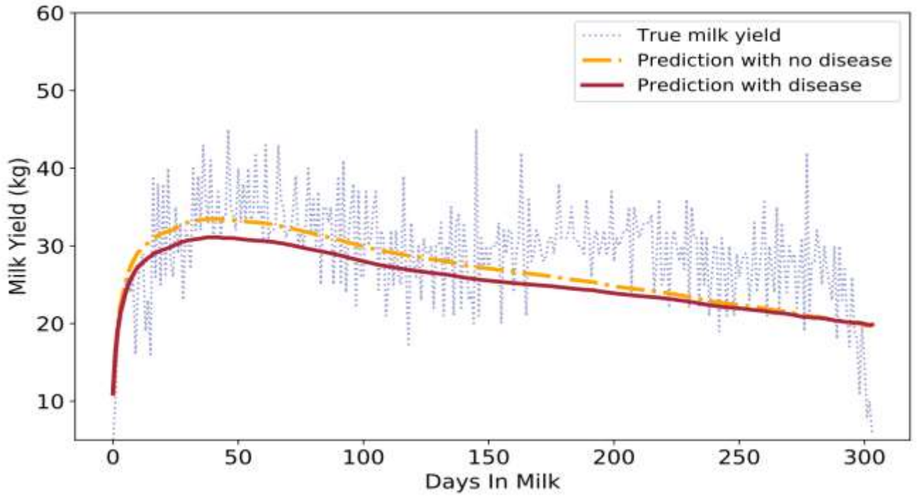
Impact mastitis



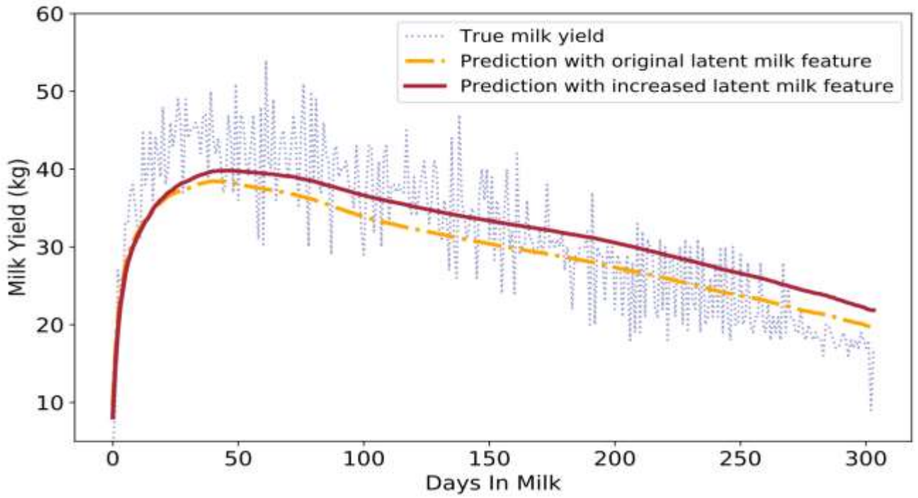
Impact KPI 305d milk yield



Impact disease



Impact milk yield



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