

A Model to Predict Feeding Time of Dairy Cows Using Indoor Positioning Data

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Feeding time of dairy cows

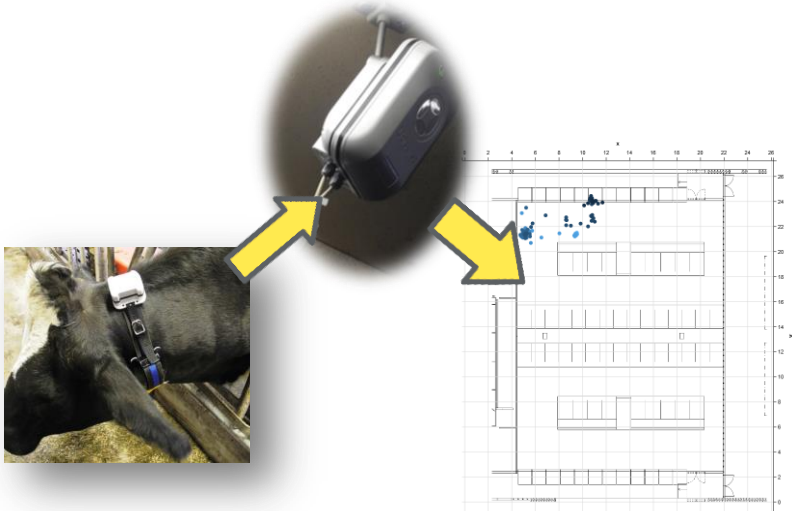
- Indicator of health and welfare status? (e.g. lameness, Norring et al 2015)
- Improves prediction of feed intake (Halachmi et al. 2015)
- Can be measured using RFID, accelerometers or
→ Additional use for indoor positioning systems?



LUKE/Mikaela Mughal

Data collection

- Continuous data from 50 dairy cows for 7 days in freestall barn
- Insentec visits with consumed feed as reference



Ubisense real time location system



Insentec RIC

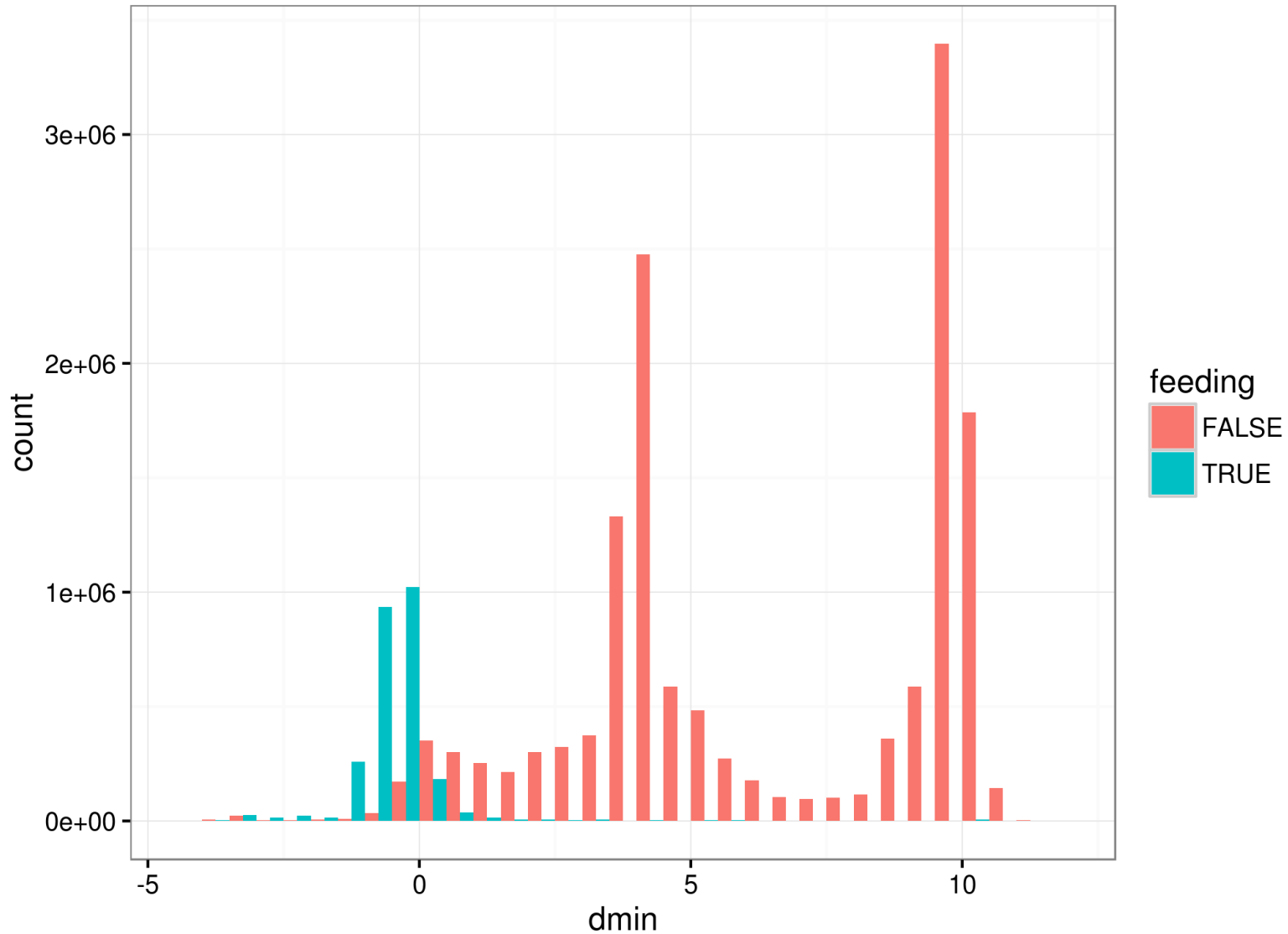
Ubisense positioning system in this study

- UWB based – set up by Noldus
- Raw data collected using custom software and saved to daily HDF5 data files
- Accuracy varies from $\pm 30\text{cm}$ up $\pm 1\text{m}$ depending on location
- Raw data filtered using a custom jump filter correcting reflection errors and 5point median filter
- Missing data interpolated using linear interpolation

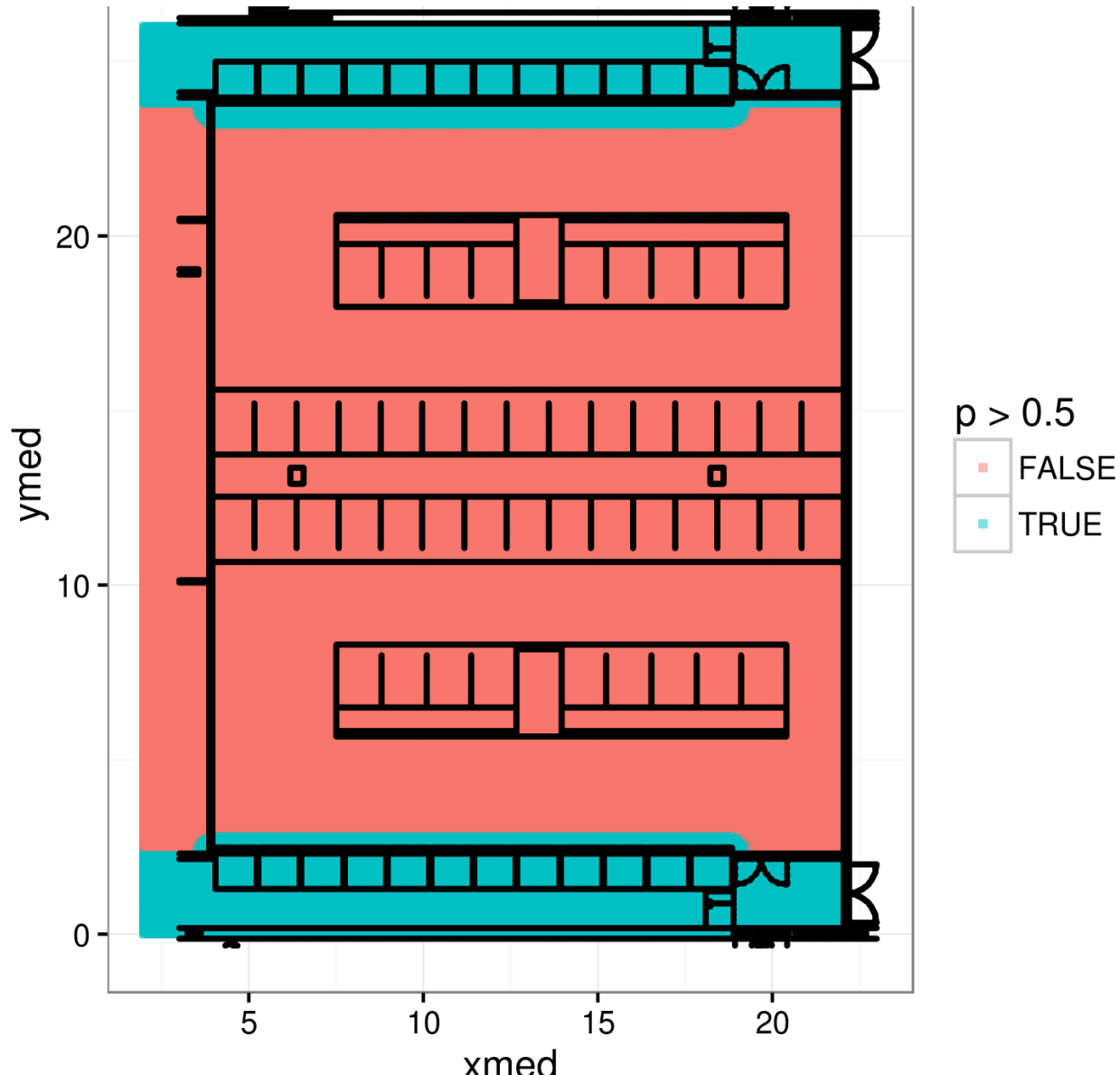
Model development

- Divided the data:
 - Teaching dataset 25 cows 7 days
 - Validation dataset 25 cows 7 days
- 2 different models:
 - Linear discriminant (LDA) with distance to feeding barrier as input
 - Probability of feeding calculated for different grid sizes from the teaching data
- Applied the Viterbi algorithm to **feeding probability** from both models to calculate most likely state (Hidden Markov Model)

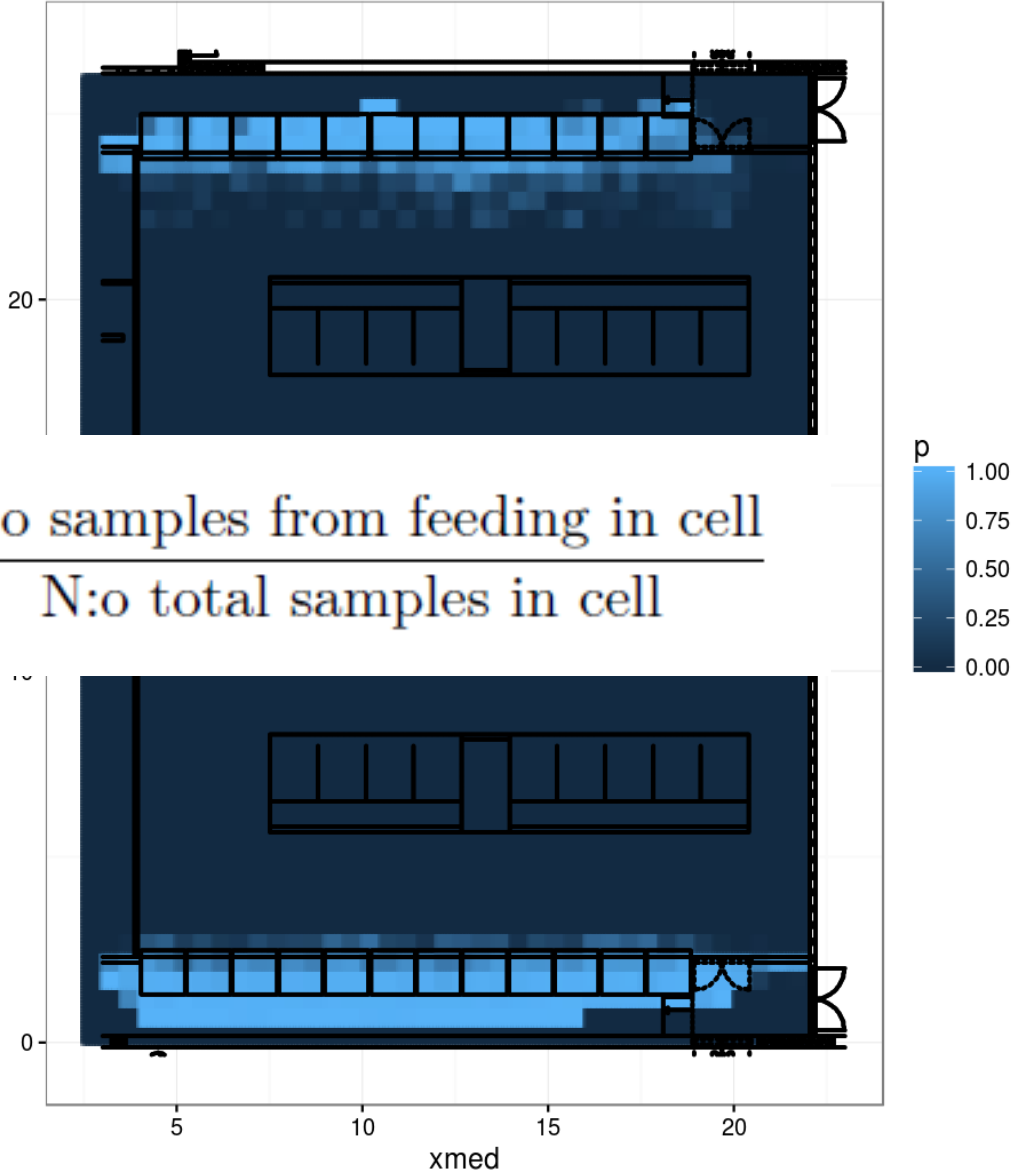
LDA distance to feed barrier as input



LDA distance to feed barrier as input



Probability of feeding for 50x50cm grid



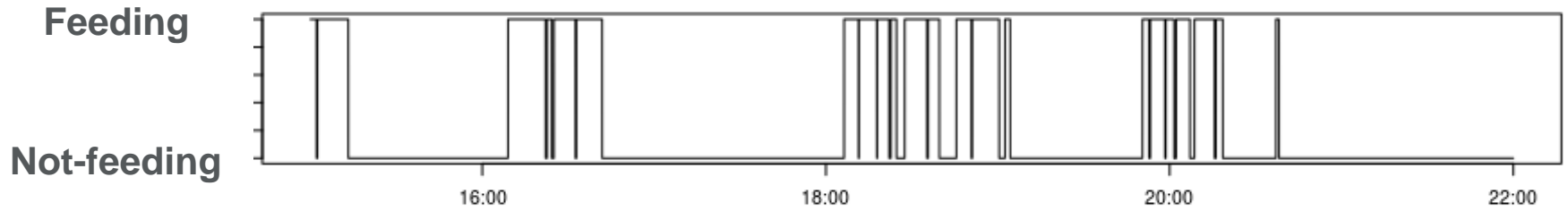
$$P_{feeding} = \frac{\text{N:o samples from feeding in cell}}{\text{N:o total samples in cell}}$$

Viterbi algorithm for calculating the most likely state

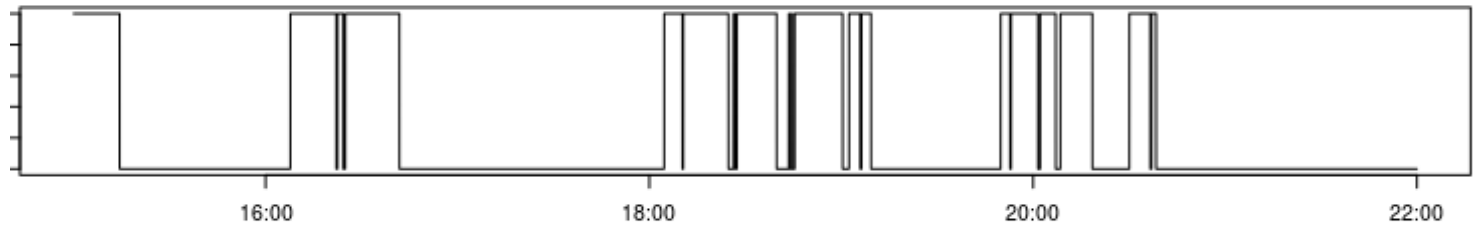
- Viterbi algorithm was used to estimate the most likely state **feeding** / **not feeding** for both models:
 - Emission probabilities from LDA and grid classifier
 - Initial state probabilities set to 50%
 - State transition matrix obtained from training data:

$$\begin{bmatrix} \text{feeding} \\ \text{not feeding} \end{bmatrix} \quad \Gamma = \begin{bmatrix} 0.997 & 0.003 \\ 0.001 & 0.999 \end{bmatrix}$$

Insentec



LDA + Viterbi

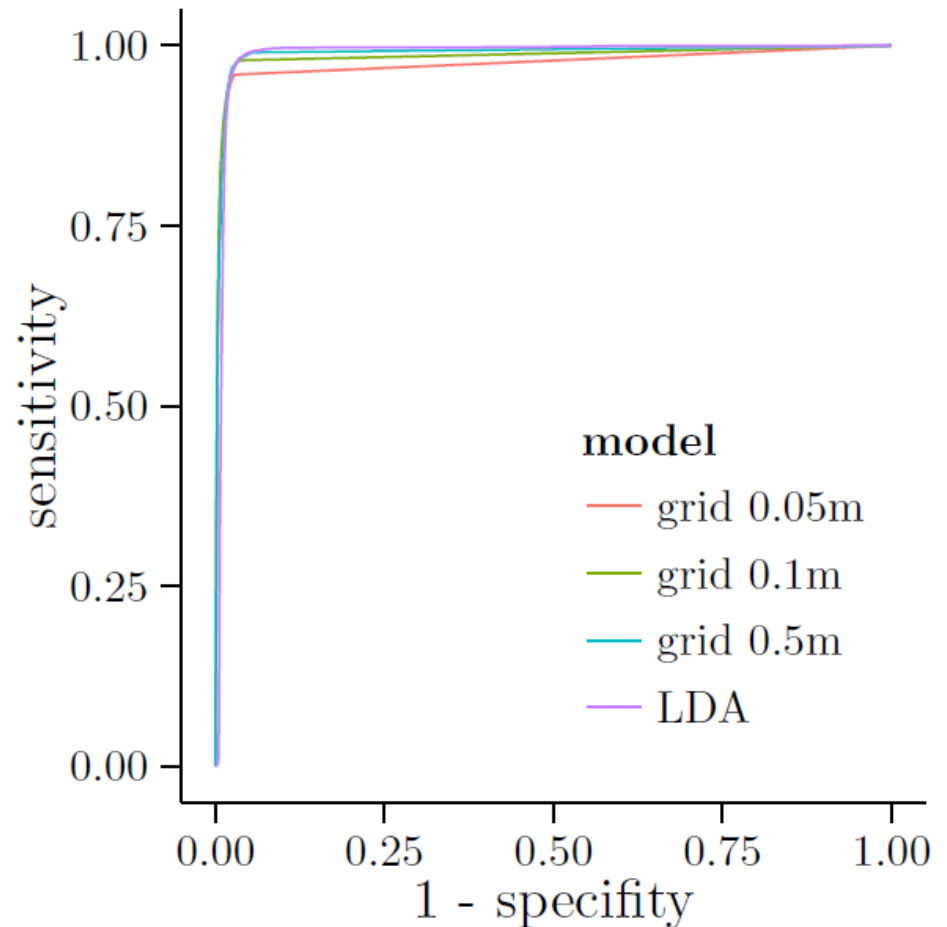


Just LDA



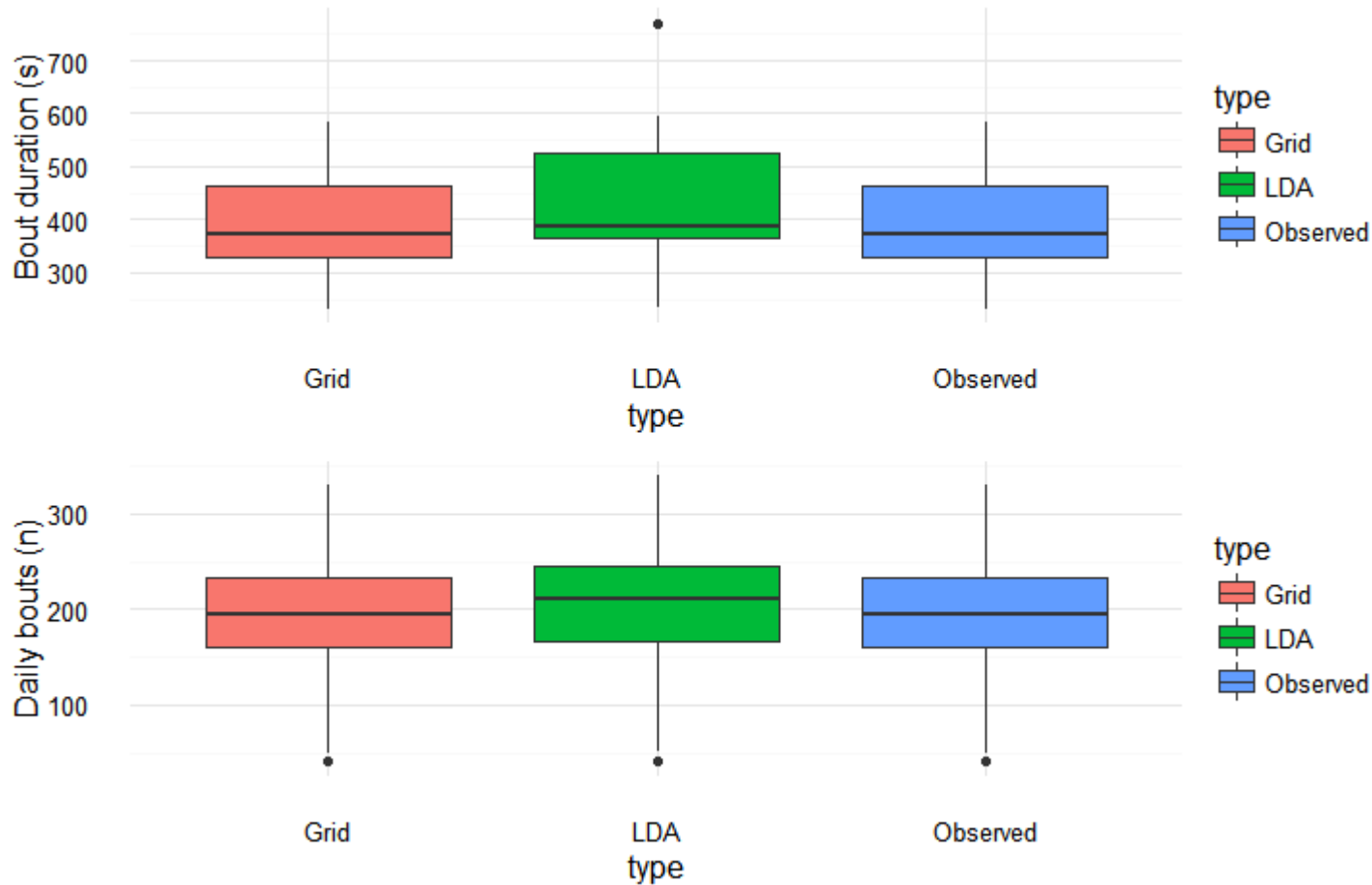
Results calculated for each positioning sample

	LDA	Grid 50x50cm
Accuracy	96.6%	97.7%
Sensitivity	98.8%	94.5%
Specificity	96.3%	98.2%
AUC	0.99	0.99



Results for feeding bouts

Error type:	LDA	Grid
Duration(s)	31 ± 8.1	-10.4 ± 9.9
Count (n)	11 ± 4	2.3 ± 3.4



Conclusions and discussion

- We achieved very high accuracy for measuring feeding in our barn
 - The feed in the test barn is delivered 4 times / day -> cows don't need to wait for feed at the fence
- The grid model was slightly more accurate than LDA
 - Includes positioning noise at different locations in the barn
 - LDA using only distance still provided very accurate estimates
- Oberschätzl,(2015) also obtained good accuracy for feeding time with the same Ubisense system

