Detection of neonatal calf diarrhea using suckle pressure

Beibei Xu[1], Claira R. Seely[1,2], Katherine Gottwald[1],Tapomayukh Bhattacharjee[3], Taika E. von Konigslow[1]

[1] Department of Population Medicine and Diagnostic Sciences, College of Veterinary Medicine, Cornell University, Ithaca, NY

[2] Department of Agriculture, Nutrition and Food systems, College of Life Sciences and Agriculture, University of New Hampshire, Durham, NH

[3] Department of Computer Science, Bowers College of Computing and Information Science, Cornell University, Ithaca, NY

Beibei Xu
bx74@cornell.edu

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TvK Calf Lab

Introduction

- Neonatal calf diarrhea (NCD) is the leading cause of morbidity and mortality in preweaned dairy calves (Caffarena et al., 2021).
- Clinical health scoring (CHS) to assess fecal consistency for early NCD detection and testing disease severity require time, training, and resources particularly in group housing (Dillane et al., 2021).
- Weakened or absent suckle reflex, when fingers are placed in a calf's mouth, can be used to gauge NCD severity and guide treatment decisions (Schinwald et al., 2022).
- Sensor technologies are increasingly being adopted by the dairy industry, but there are no studies on the relationship between disease and quantitative changes in suckle pressure data obtained from sensors.

Objective

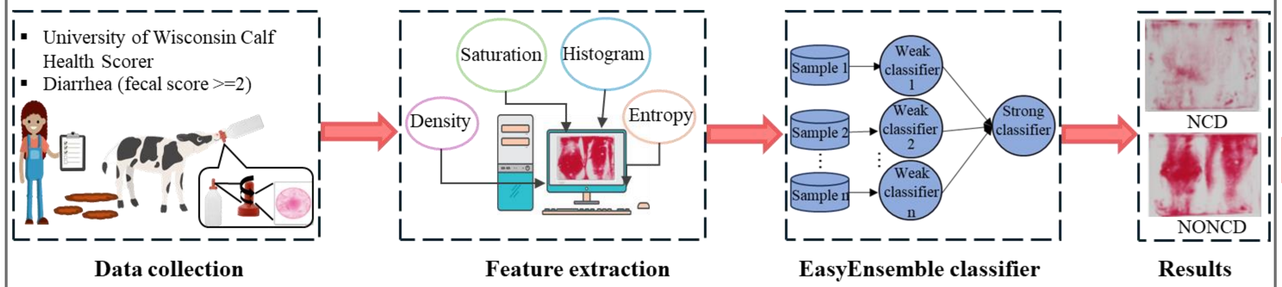
- Evaluate suckle pressure measurement for NCD detection.
- Investigate the earliest prediction window for NCD using suckle pressure changes.
- Inform novel sensor modality.

Materials

- 50 female Holstein calves were enrolled at 1 d of age and followed to 21 d of life.
- Calves received daily CHS and suckle pressures were measured at 1, 3, 5, 7, 10, 14, 21 d, and daily during bouts of NCD.
- Pressure scale sensor film was wrapped around the nipple of an empty calf nursing bottle to collect the data.
- A total of 349 images were collected, of which 54 were from calves with diarrhea.

Suckle pressure and machine learning can detect and predict neonatal calf diarrhea

Methodology



- Capture suckling pressure variations by extracting density, saturation, entropy and histogram features to characterize film properties under different pressure levels.
- Machine learning (**ML**) classifiers explored: K-Nearest Neighbors (**KNN**), Random Forest (**RF**), Support Vector Machine (**SVM**), Gradient Boosting (**GB**), and EasyEnsemble (**EE**).
- Training and testing: random partitioning (8:2), grid search for hyperparameters optimization, and 5-fold cross-validation.

Results

Table 1. Performance of ML models for NCD detection

	Precision	Recall	F1	Accuracy
RF	0.63	0.45	0.53	0.87
GB	0.67	0.36	0.47	0.87
EE	**0.64**	**0.82**	**0.72**	**0.90**
KNN	0.57	0.36	0.44	0.86
SVM	0.57	0.36	0.44	0.86

Table 2. Comparison of NCD prediction using data from various pre-diarrhea intervals using EE

	Precision	Recall	F1	Accuracy
NCD	0.60	0.72	0.65	0.81
NCD -1d	**0.67**	**0.70**	**0.68**	**0.74**
NCD -2d	0.38	0.47	0.42	0.46
NCD -3d	0.42	0.49	0.45	0.49
NCD -4d+	0.36	0.41	0.38	0.44

NCD: The first occurrence of diarrhea; **NCD-nd**: n days before diarrhea (n=1, 2, 3, 4).

Summary

- The EE classifier offered the best trade-off between precision and recall for NCD classification of suckle pressure images.
- Detectable differences in suckle pressure images were found for the day before diarrhea onset.
- Suckle pressure measurement shows potential for automating the detection and prediction of calves with NCD.
- These results will be used to inform design considerations for sensors being embedded in calf feeding nipples.

Conclusion

- Suckle pressure can be used to detect NCD and shows potential for NCD prediction the day before CHS changes.

Reference

Caffarena et al., 2021. Doi: 10.1007/s42770-021-00440-3
Dillane et al., 2020. Doi: 10.1371/journal.pone.0230708
Schinwald et al., 2022. Doi: 10.3168/jds.2021-21667

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Definitions