

# 3RD U.S. PRECISION LIVESTOCK FARMING CONFERENCE (USPLF2025)

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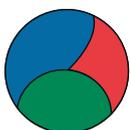


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*The USPLF conference aims to bring together scientists, engineers, veterinarians, companies, farmers, policymakers, and associations who are interested in applying technology to improve animal care and well-being.*

*At this conference, we are building a platform for professionals to engage and exchange ideas within the entire PLF community. Our goal is to highlight state-of-the-art research and groundbreaking innovations while critically evaluating the overall sustainability of our animal systems. As a truly transdisciplinary event, the conference provides an ideal place to share research results and gain inspiration for the future.*



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### 31. Social interactions of dairy cows: A distance-based approach

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**Keywords:** Dairy cows; Distance-based; Social behaviour

#### Implications

Animal positioning can be of crucial importance for precision livestock farming (PLF) applications and, more in general, for studying animals' behavior. While outdoor positioning has become relatively convenient and easy to implement thanks to the GPS technology, indoor precise positioning implies more technical efforts due to the operative environment itself (Johansson and Wassénus, 2019), like obstructions and the presence of metal structures. The comparison of different methods based on relative position between animals and "absolute" position in a given reference system can help in the choice of the right technologies to adopt in PLF applications and studies.

#### Introduction

The knowledge of animal behavior and, more specifically, of the animal social interactions, can be of great importance in many aspects that concern PLF, such as animal management, production assessment, animal health and welfare. Starting from the assumption that interactions occur at close distances between animals, this study aims to compare methodologies such as proximity logging, indoor location tracking, and AI-based image analysis, either independently or in combination. Distinguishing between 'short' and 'long' distances among barn-confined dairy cows will facilitate and accelerate the analysis of their social behaviors.

#### Materials and methods

The scope of the present work is to set up a rapid and efficient method for measuring and analyzing the inter-individual distance among barn-confined dairy cows to investigate their social interactions. To achieve this scope three different technologies were taken into consideration to compare the results of each of them separately or in a combination. For relative positioning between cows, a "proximity logging approach" was used recurring to the RSSI (Received Signal Strength Indicator) of the BLE (Bluetooth Low Energy) chip (Debnath and O'Keefe, 2023; Kirkpatrick et al., 2021) of the microcontroller units (MCU). For absolute positioning in a user defined coordinate system, Ultra Wide Band (UWB) modules working as tags and anchor points were used (Benaissa et al., 2023; D'Urso et al., 2023). Finally time-lapse images were used for a mixed approach using an object detection algorithm (YOLOv8) (Bai et al., 2024). Starting from the coordinates of the detected objects' bounding boxes it is possible to calculate: 1. the distance between two or more objects (i.e. cows) and the eventual overlapping of the boxes themselves; 2. the coordinates of the center of the bounding boxes inside the user defined coordinate system "geo-referencing" the images thanks to visible control points located in the study area. To analyze the data, batch processing were performed using multiple software tools. The UWB data of the tags were analyzed in a GIS environment (QGIS 3.16.16) using also the Python programming language scripts. The data of the bounding boxes of the detected animals were processed via Python in Visual Studio Code (Microsoft), while the final elaboration with the BLE proximity logs was conducted in Microsoft Excel. The validation of the cross-analysis was done through visual inspection of pictures or videos captured by the time lapse camera (Leso et al., 2022). Measurements were conducted in a controlled laboratory setting using two nadirally oriented time-lapse cameras mounted on the ceiling and seven UWB-BLE modules. Four modules were positioned as anchors at the corners of the room, while the remaining three were used as tags, worn by operators simulating animal movements in pens. A trained operator visually inspected the time-lapse recordings to identify all "proximity" events, serving as the gold standard. YOLOv8 was trained to detect operators in each frame, generating bounding boxes (BBs), and overlaps between BBs were classified as proximity events. UWB-derived positions were used to compute inter-tag distances, with simultaneous distances below 30 cm defining a proximity event. BLE-derived distances were processed similarly. A matrix-database was constructed, recording a binary outcome for each visually detected proximity event: 1 for correct detection, 0 for incorrect or missed detection. Statistical comparisons among methods were conducted using Cochran's Q Test, with significance set at  $P < 0.05$ . Additionally, the accuracy of Euclidean distances derived from UWB and BLE methods was assessed using a linear model in R (version 4.0.3).

#### Results and discussion

The analysis of video recordings is one of the most effective ways to study the social interactions of animals. However, the challenge lies in filtering, from hundreds of hours of footage, what can be considered social interaction. Again, assuming that interactions occur at close distances between animals, thanks to the batch processing of the data produced by the three devices/technologies, it was possible to focus the analysis on the video time windows where there was a higher probability of social interactions. Thanks to a validation analysis of the three data sources it was possible to step down the false positives and partially also the false negatives (Fig. 1).

#### Conclusions and implications

Knowing where the individual animal exactly is in big farming contexts can be of crucial importance to speed up, as an example, vet medications, locating animals in heat, etc. In the present work the data were analyzed in a post processing phase (more common in research applications), but in production contexts the data have to be streamed and analyzed in real or quasi-real-time.

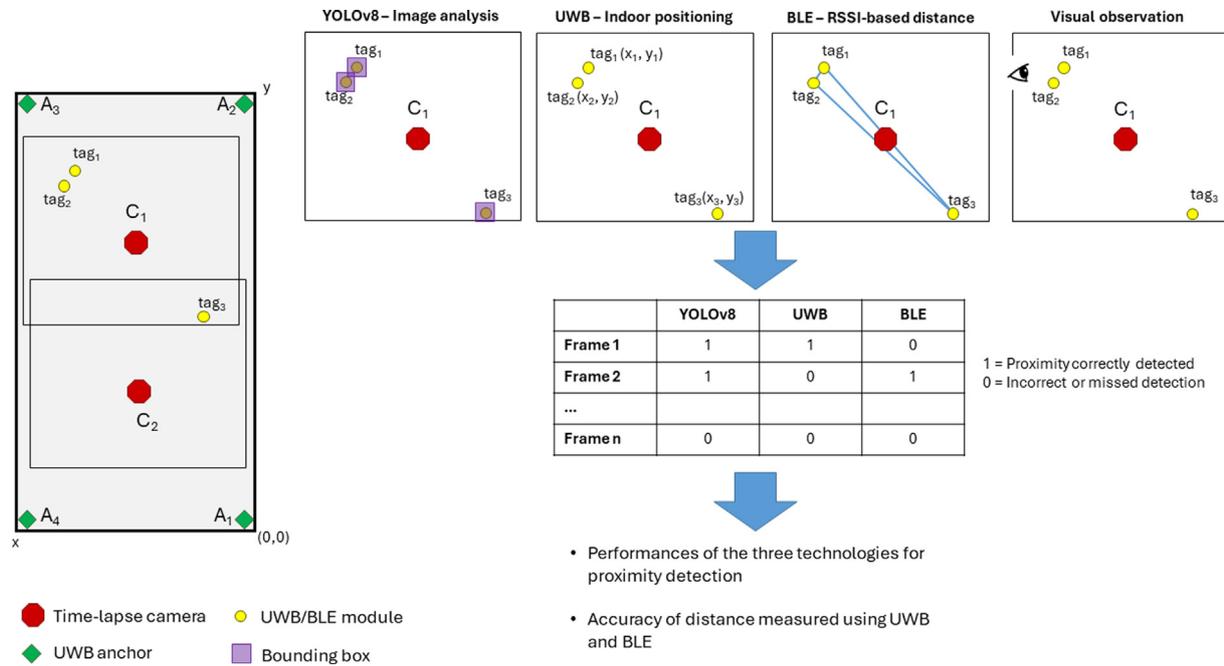


Fig. 1. Setup of the indoor controlled experiment.

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### 32. Sensor-based monitoring of behavioral changes of dairy cows around drying-off

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**Keywords:** Cow behavior; Dry period; Fecal cortisol metabolites; Grazing; Precision livestock farming; Sensor technologies

### Implications

Continuous monitoring of behavior using sensor technologies can help to gain insight into the health and welfare status of animals. The objective of this study was to investigate the time budget of dairy cows around drying-off under confined versus grazing conditions. Linking behavioral pattern with stress parameters should show benefits and differences between the two management strategies. The findings of this project could contribute to a better understanding of cow behavior in different husbandry systems, such as grazing or indoor housing, and under changing conditions.

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