PhD School on Agriculture, Environment and Bioenergy

(http://sites.unimi.it/dottorato_aab/)

(XXXVII cycle, 2021-24)

Project draft

1.Field of interest

AGR/19 Animal husbandry - AGR/09 Farm Machinery

2.Project title

Precision Livestock Farming technologies for improving animal health and welfare in dairy cattle farms

3.Tutor Maddalena Zucali

Co-tutor Aldo Calcante

4.Relevance of the topic and state of the art:

Dairy production systems have rapidly intensified and concentrated over the past decades in many regions of the world (Clay et al., 2020). Larger farms tend to have fewer workers per animal and fewer opportunities for individual animal care; this creates the need of implementing automated systems for performing some routine operations (milking, feeding, etc.) and sensor systems for continuous monitoring of animal health and welfare conditions. Health and welfare affect mortality, morbidity and growth rates of young replacement animals, as well as fertility, productivity and longevity of adult cows, with a crucial influence on the production efficiency of the farm. These factors have an impact on the farm profitability but also on its environmental sustainability. The environmental impact of milk production, in terms of consumption of non-renewable resources and emissions per kg of product, tends to increase as a consequence of low production, lengthening of the unproductive periods, mortality and diseases (Tullo et al., 2019).

Precision livestock farming (PLF) relies on the application of sensors and information and computer technology (ICT) for the real-time monitoring of individual animals and the implementation of timely and optimized management actions (Norton & Berckmans, 2017). In dairy production, PLF systems can be important tools to support the farmer in managing herds and assessing animal health and welfare; they make individual care possible even in large herds and help to address the challenges associated with optimising operational efficiency (Andonovic et al., 2018).

Currently, the spreading of new technologies in livestock farming encounters some limitations: i) the large amount of data generated by existing sensor systems is only partially exploited by farmers as a decision support; ii) the integration between the information from the different sensors is still very limited; iii) there is a strong need to develop novel non-invasive animal-based sensors.

Thus the main objectives of the project are to:

1) develop novel non-invasive sensors for the evaluation of the animal health and welfare conditions and the early detection of diseases by continuous monitoring of key animal-based indicators;
2) study the possibility of using in a more effective and informative way the big datasets generated by the sensor systems currently available in the dairy farms (e.g., accelerometers, sensors integrated in the milking systems, etc.);
3) integrate data flows from multiple sensors into a single comprehensive control system able to: i) predict and detect critical situations (diseases, distress); ii) alert the farmer; iii) provide decision support.

A further aim of the project is to study the effects of the implementation of the innovative solutions on the environmental sustainability of milk production, using the Life Cycle Assessment (LCA) methodology.

5.Layout of the project (draft)

5.1. Materials & Methods:

1. Study and characterization of key animal-based indicators for the evaluation of the physiological conditions and the early detection of stress status and diseases in calves, heifers and dairy cows (e.g., animal activity and behaviour, body measurements, body condition, body temperature, feed intake, etc.)

2. Study and integration of novel non-invasive sensor systems;

3. Application in a dairy farm scenario and data acquisition with both existing sensors (e.g., accelerometers, sensors integrated in the milking systems) and novel sensor systems.

4. Development of mathematical models to predict and detect critical situations on the basis of appropriate thresholds, provide alerts and support the decision-making process

5. Analysis of the environmental impact of milk production through a Life Cycle Assessment (LCA) approach in different scenarios, aimed at estimate the potential improvement of environmental sustainability of dairy chain achievable through the implementation of PLF technologies in the dairy farms.

The developed systems will be tested in selected dairy farms in operative conditions.

5.2. Schedule and major steps (3 years):

First year
Literature review; definition of the most promising animal-based indicators; selection of sensors; selection of dairy farms to be involved in the study

Second year
Application of sensors in the dairy farms, collection of data, definition and calibration of the predictive models.

Third year
Optimization and validation of predictive models. Environmental impact evaluation

Activities	1st year				2nd year				3rd year			
	1	2	3	4	1	2	3	4	1	2	3	4
Literature review												
Identification of farms, indicators and sensors												
Monitoring period												
Data analysis												

6. Available funds

22375 RL_DG-AGR17ASAND_01 META – Mungitura: efficienza, sostenibilità e qualità 14.288,00 euro

34876 RL_DG-AGR20MZUCA_01 CLEVERMILK - Uso intelligente della tecnologia per un latte a basso impatto ambientale 201,930 euro

7. Literature:

- Andonovic, I., Michie, C., Cousin, P., Janati, A., Pham, C., & Diop, M. (2018, June). Precision livestock farming technologies. In 2018 Global Internet of Things Summit (GIoTS) (pp. 1-6). IEEE.
- Clay N., Garnett T. & Lorimer J. (2020). Dairy intensification: Drivers, impacts and alternatives. Ambio 49, 35–48 . https://doi.org/10.1007/s13280-019-01177-y
- Norton, T., & Berckmans, D. (2017). Developing precision livestock farming tools for precision dairy farming. Animal Frontiers, 7(1), 18-23.
- Tullo E., Finzi A., & Guarino M. (2019). Environmental impact of livestock farming and Precision Livestock Farming as a mitigation strategy. Science of the total environment, 650, 2751-2760