Development of an integrated automatic system to monitor cow welfare

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**Abstract.** In the last decades, many sensors and tools have been developed to monitor welfare in dairy cows. However, since there many different types of instruments, there is still a need to integrate data from single sources, such as those monitoring cow behaviour and microenvironmental conditions in the barn, to obtain a complete picture of cow welfare. To test the feasibility of collecting and integrating parameters from the barns, we developed a prototype of an integrated system, based on existing technologies to monitor cow behaviour and barn climate. In this system, a series of sensors were installed on 3 dairy farms in Northern Italy, characterized by a loose housing system. The system was installed in barn sections hosting 90-145 cows. To monitor the barn climate, microenvironmental sensors were installed at different positions in the barn to measure internal air temperature, humidity, light intensity, wind speed, black globe temperature, gas concentrations (NH3, H2S, CO2), sound level, drinking water temperature and intake, litter temperature and humidity. In addition, a weather station was installed close to the barn to measure external air temperature, humidity, wind speed and rainfall. To monitor cow behaviour, 3D accelerometer devices were developed and mounted on neck collars. Each device included a system on board, antenna and a host-board, all fitted in a hard plastic case. With these sensors, 32 cows were observed for a total of 108 hours to train and validate an algorithm that could detect the time cows spend lying, standing, feeding and ruminating. A Decision Tree algorithm was selected as the best method to classify behaviours, with an average accuracy of 85%. All the sensors of this integrated system can be accessed on the farm through Bluetooth, using a custom-made app. At the same time, they are connected via a dedicated 2.4 GHz radio channel to a gateway on farm. This data is then stored on the cloud and can be monitored and processed remotely on an online dashboard. On this dashboard, graphs and tables visualize the data of single sensors as well as computed data, such as mean values from multiple sensors and the Temperature-Humidity-Index. The architecture, implementation and first data collected by this system will be presented. The integration of information on the farm is a key point of current issues that need to be solved by Precision Livestock Farming technology. This prototype provides a good starting point towards integrated automatic welfare monitoring that could assist farmers in detecting reduced cow welfare on their farms.