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Zoom in on the Precision Livestock Farming

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Abstract
Global attention to the welfare of zoo animals and livestock results in stronger legislation and higher pressure for achieving higher standards of animal welfare. Monitoring and understanding animal behaviour can assist in optimising the welfare of zoo and livestock animals. Precision livestock farming solutions open the door to increase automation of behaviour monitoring and welfare management. The overall purpose of the thesis was to investigate the possibilities of using computer vision and sensor technology for studying animal behaviour in zoo and production environments. To fulfil this overall purpose, two main research questions were addressed: How can we identify and track individual animals using computer vision and sensor technology? Combining the identity and position information, how well animal behaviour can be monitored and analysed?
First, we developed and justified methods for identifying and tracking individual animals in different livestock environments: zoo outdoor environment, sheep barn and free-stall dairy cattle barn's indoor production environment. Three methods were developed to identify and track individual animals: a combination of radio frequency identification and camera sensor, a deep learning method based on visual biometrics and behaviour features and an ultra-wideband based real-time location system method. The data quality, in terms of missing data, in one commercially available ultra-wideband system was examined. The choice of method was justified according to different species' natural appearance, breeding strategy and housing conditions. We found that the computer vision system can perform as good as an expert in identifying individual bears based on images. The real-time location system can provide the position of individual animals inside barns with a mean error under 0.4 m. No major obstacles were found to interfere with the ultra-wideband based real-time location system. The between-cow variation was statistically significant.
Second, two animal behaviour monitoring systems that assist activity registration and analysing social interactions were proposed. To detect sheep's standing and lying behaviour in sheep barn environments, infrared radiation cameras, and three-dimensional computer vision technology were used. Dairy cows' negative and positive social interactions were analysed using a Long-term Recurrent Convolution Networks model. Both systems integrated the real-time location system and computer vision system to perform identification, tracking and analysing animal behaviour tasks. Working with real systems in a real-world application setting made the study more credible and valuable for the related research. The result showed that the system was able to understand animal standing lying activity and social behaviour.
The developed technologies and the results of the experiments added value for the animal behaviour monitoring by focusing on individual or sub-group in a herd and analysing individual activity and social behaviour continuously. By understanding animal behaviour, it can push the continuous surveillance system towards a welfare decision support system.

Keywords
Precision livestock farming, Computer vision, Sensor fusion, Object tracking, Real-time location system, Animal behaviour, Machine learning

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