Predicting Sleep and Lying Time of Calves with a Support Vector Machine Classifier Using Accelerometer Data

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Sleep is essential for calf survival, but so far only possibilities for measuring sleep in production systems are either using ambulatory EEG or validated sleeping behavior (Hänninen et al. 2008). Changes in sleeping and lying time can give an indication of changes in animals' health and welfare status.

We aimed at developing a small wireless accelerometer system for measuring the sleep and lying time of calves from their neck. We collected data from 6 dairy calves developed a model based on wavelet analysis with Support Vector Machine Classifier for measuring sleep and lying time in calves.

Materials and Methods

The Measurement System

We developed a new wireless 3-dimensional acceleration measurement device, which registered movement and inclination of the device in three axes. The dimensions of the device with a half AA battery attached, measured 15 x 36 x 34 mm and it weighed 19 g. The device used an MMA7260Q (Freescale, Austin, USA) acceleration sensor combined with an nRF9E5 (Nordic Semiconductor, Oslo, Norway) micro controller and transceiver. We used a wireless 869 MHz radio, which ensured reliable signal transmission in barn conditions. The radio channel permitted the transmission of 330 messages per second (four 8-bit bytes: x, y and z acceleration, and sensor ID) from a single transmitter. We programmed the devices to measure and transmit with the range of ±2 g at 25Hz and a simple listen-before-transmit protocol. The sensor is described in more detail in Pastell et al. (2009).

Collecting Behavioral Data

The accelerometers were attached to collars of 6 under 6 week-old calves, kept in a straw-bedded group pen. We filmed calves behaviour simultaneously for 24 hours coded the behavior of the calves using CowLog – software (Hänninen & Pastell 2009). We estimated the daily duration for sleep (S), rapid-eye-movement sleep (REMS) and non-REM sleep (NREMS) based on resting posture from the videos.

Developing the Model

A model for predicting lying time based on the accelerometer data was developed with the data from 3 calves, and the accuracy of the model was tested with the other 3 calves. Mean, variance and the wavelet variance of the horizontal axis of the accelerometer were extracted from the data in 20 s epochs and used to predict lying time with Support Vector Machine (SVM) classifier with

a radial basis kernel. Support Vector Machines are robust nonlinear classifiers that need only a few parameters and produce stable and reproducible results. A grid search was performed on the teaching data to find best parameters for the SVM.

The mean of the data describes the orientation of the head and variance and wavelet variance describe the movement. The wavelet variance was calculated using maximum overlap discrete wavelet transform (MODWT) using least asymmetric wavelet filter with length 8 and a circular boundary condition. MODWT provides a multi resolution analysis of data that can be directly associated with time-scale changes in the data. Wavelet variance is specifically appealing for studying data, which fluctuates both within and across a wide range of scale. R 2.81 (R Development Core Team, 2008) together with wmtsa and e1071 packages was used in the modeling.

Results

The model was able to distinguish (mean ± S.E) 93 ± 3% of total S time, 89 ± 9% of total NREMS and 83 ± 2% of total REMS. There were no statistically significant differences ($p>0.05$) in daily S, REMS or NREMS between the observed and predicted behavior for the 3 calves used in validation (621 vs. 602 min, 351 vs. 339 min, 316 vs. 351 min, respectively).

The daily time spent lying was calculated from the observed and predicted behaviors, and compared with a t-test. The model was able to distinguish (mean ± S.E) 97 ± 1% of total lying time. There were no statistically significant differences ($p>0.05$) in lying time between the observed and predicted behavior for the 3 calves used in validation (990 vs. 984 min).

Discussion and Conclusions

We were able to record calves´ sleep and lying time using a wireless accelerometer together with a model for classifying the behavior with a good accuracy. The operation of the model will be validated with more animals.

The device provides a method to continuously measure sleep and lying time in calves in production environment without disturbing the animals. This is potentially useful data for automatically detecting health problems and studying different production systems.

References

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