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Bavarian State Research
Center for Agriculture

Automatic monitoring of sheep pasture behaviour using motion sensor data

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Introduction: Modern technologies & alpine farming

- **Application of modern technologies in agriculture**
  - GPS technology already established especially for crop production (e.g. telematics)
  - GPS and other motion sensors not yet fully established for livestock on pasture

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Aims of the study

- **Application of modern technologies to optimize the farm management in alpine regions and to reduce workload**

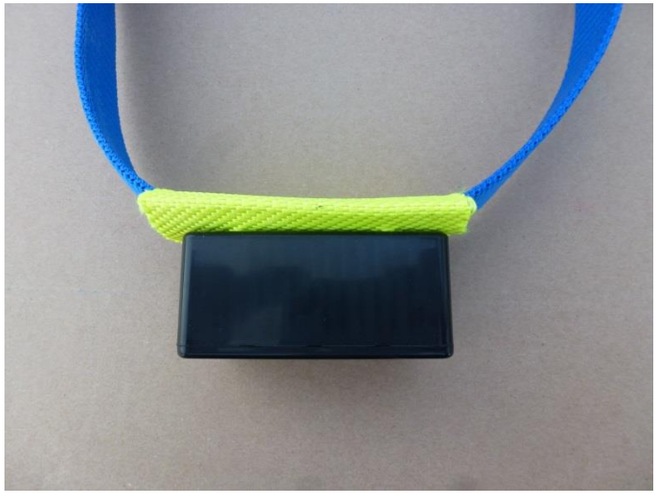
  ⟹ **Test of a tracking system for alpine areas**

  ⟹ **Development of decision-support software tools**

  ⟹ **Identification of sheep behaviour on pastures based on motion sensor data**

Materials and methods

- **Prototype of the tracking system**



4 GPS satellite signals for animal tracking

Data transmission to web database via GSM, GPRS

Online configuration and control of animals

Materials and methods

- **Identification of sheep behaviour**

  Data collection:

  - Tracking collars → 3-axis accelerometer and magnetometer (10 Hz) data from 5 ewes (German Black-headed Mutton Sheep)
  - Paddock in Upper Bavaria, Germany
  - Visual observations → continuous video sampling; up to 8 hours/day; 4 days
  - 7 behavioural activities recorded: walking, running, grazing, ruminating, standing, lying and social behaviour

Materials and methods

Data analysis and algorithm development:

- 4 behavioural activities analysed: walking, grazing, standing and lying
- Log-transformed accelerometer and magnetometer data (x, y, z-axes) used for analysis
- Sensor data merged with behaviours into 10-s intervals
  → calculation of mean and SD (according to González et al., 2015)
- Selection of variables with significant effect on behaviour based on mixed effects regression analysis using Bonferroni correction
- Fitting of probability density function (PDF) to data with mixture distributions to obtain threshold values (R, mixdist package)

Results: Selection of variables

Differences among behaviours based on accelerometer data (10-s means and SD)

	Walking	Grazing	Standing	Lying
X - mean	11.39[a]	11.28[a]	11.52[a]	11.65[a]
Y - mean	9.44[a]	9.66[a]	9.42[a]	9.01[a]
Z - mean	11.93[a]	11.99[a]	12.01[a]	11.82[a]

Results: Selection of variables

Differences among behaviours based on magnetometer data (10-s means and SD)

	Walking	Grazing	Standing	Lying
X - mean	6.73^{a}	7.67^{b}	5.03^{c}	4.77^{c}
Y - mean	6.55^{a}	7.44^{b}	4.70^{c}	4.52^{c}
Z - mean	6.65^{a}	7.36^{b}	4.91^{c}	4.56^{c}

Results: Selection of variables

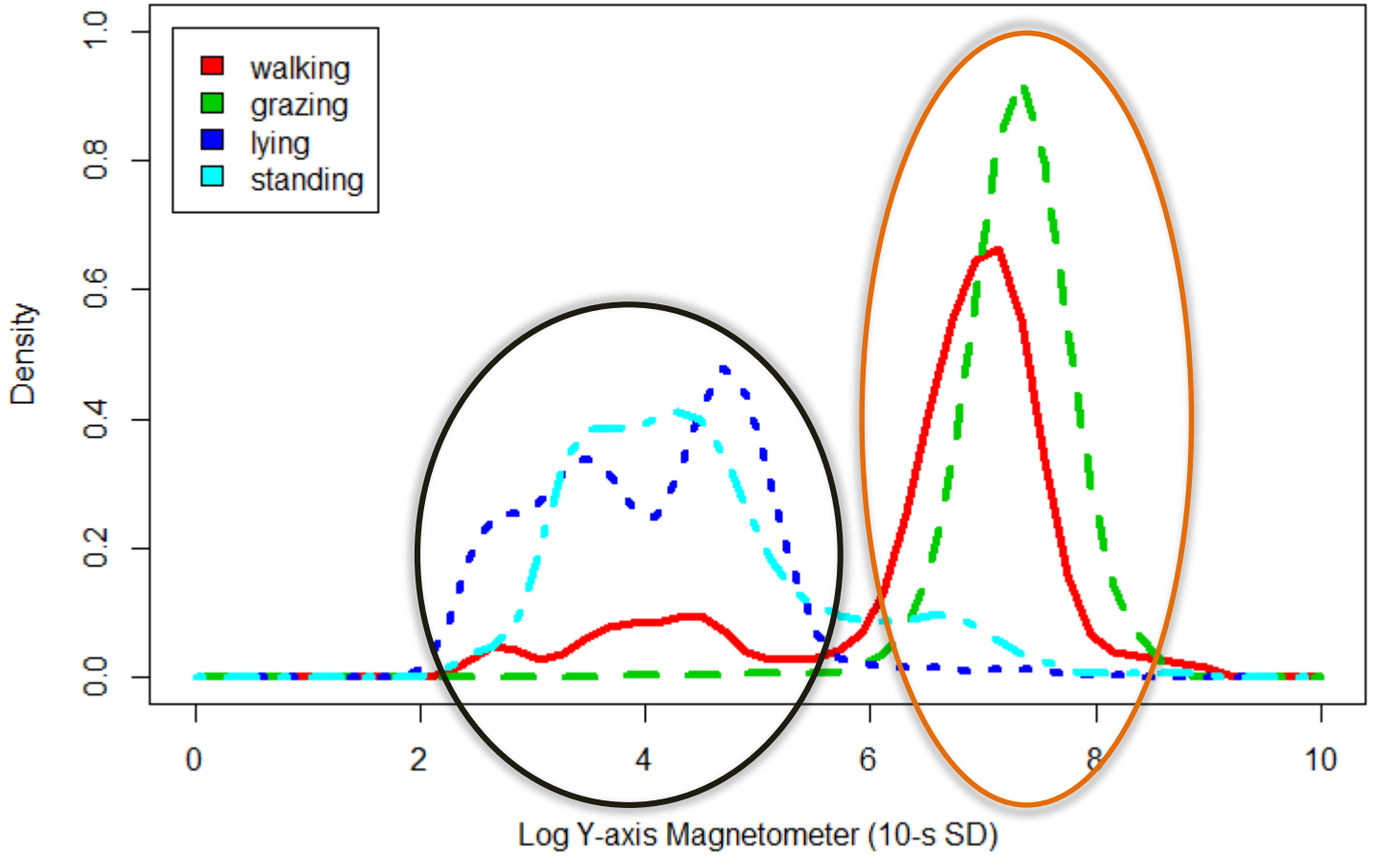
Differences among behaviours based on magnetometer data (10-s means and SD)

	Walking	Grazing	Standing	Lying
X - mean	6.73^{a}	7.67^{b}	5.03^{c}	4.77^{c}
Y - mean	6.55^{a}	7.44^{b}	4.70^{c}	4.52^{c}
Z - mean	6.65^{a}	7.36^{b}	4.91^{c}	4.56^{c}
X - SD	6.57^{a}	7.52^{b}	4.90^{c}	4.53^{c}
Y - SD	6.46^{a}	7.33^{b}	4.55^{c}	4.05^{c}
Z - SD	6.36^{a}	6.[illegible]5^{a}	4.71^{b}	4.24^{b}

Y-axis (SD) and vector-magnitude of X, Y, Z-axes of magnetometer included for further analyses

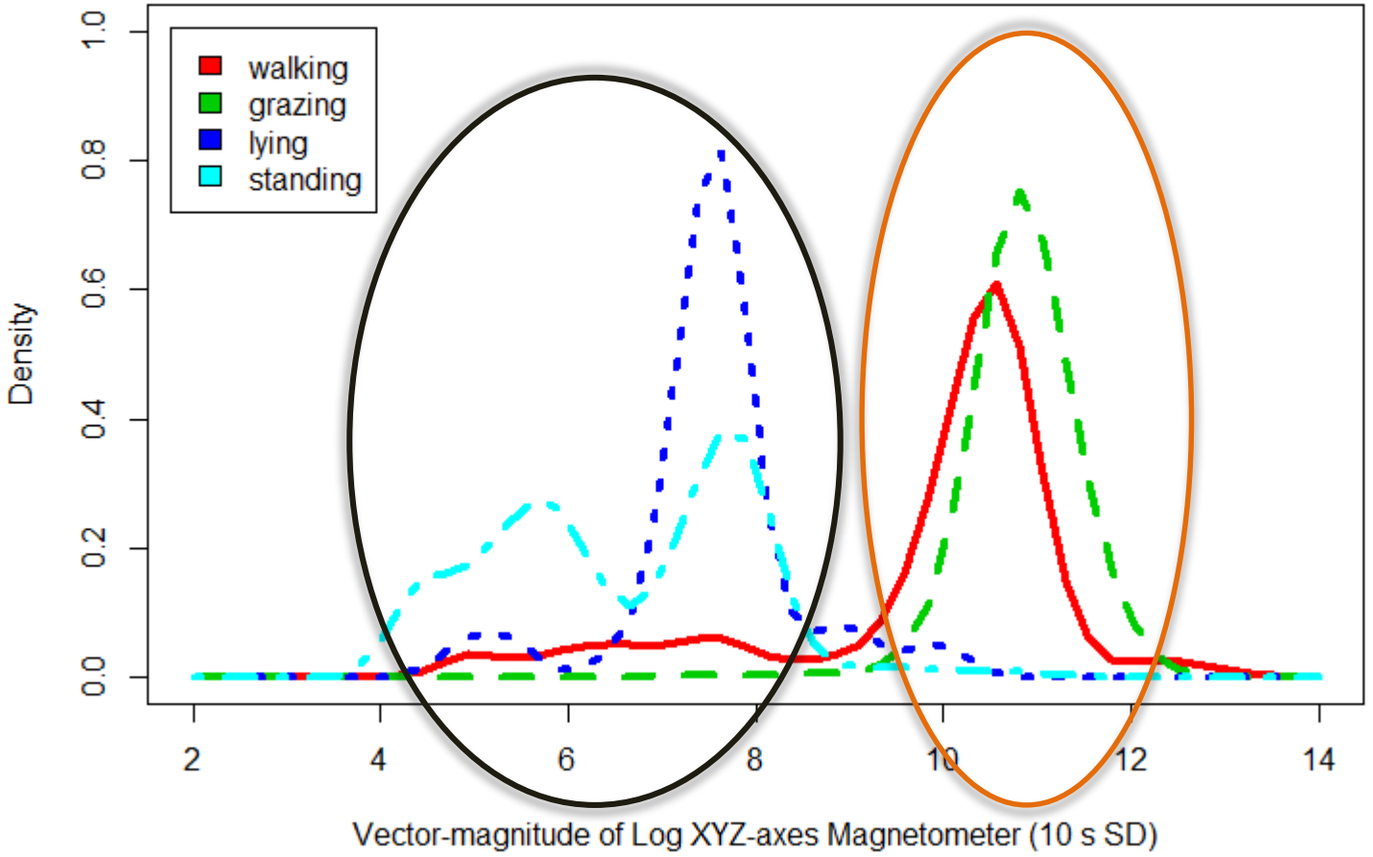
Results: Algorithm development

Distribution of Y-axis magnetometer data (10-s SD) per observed behaviour



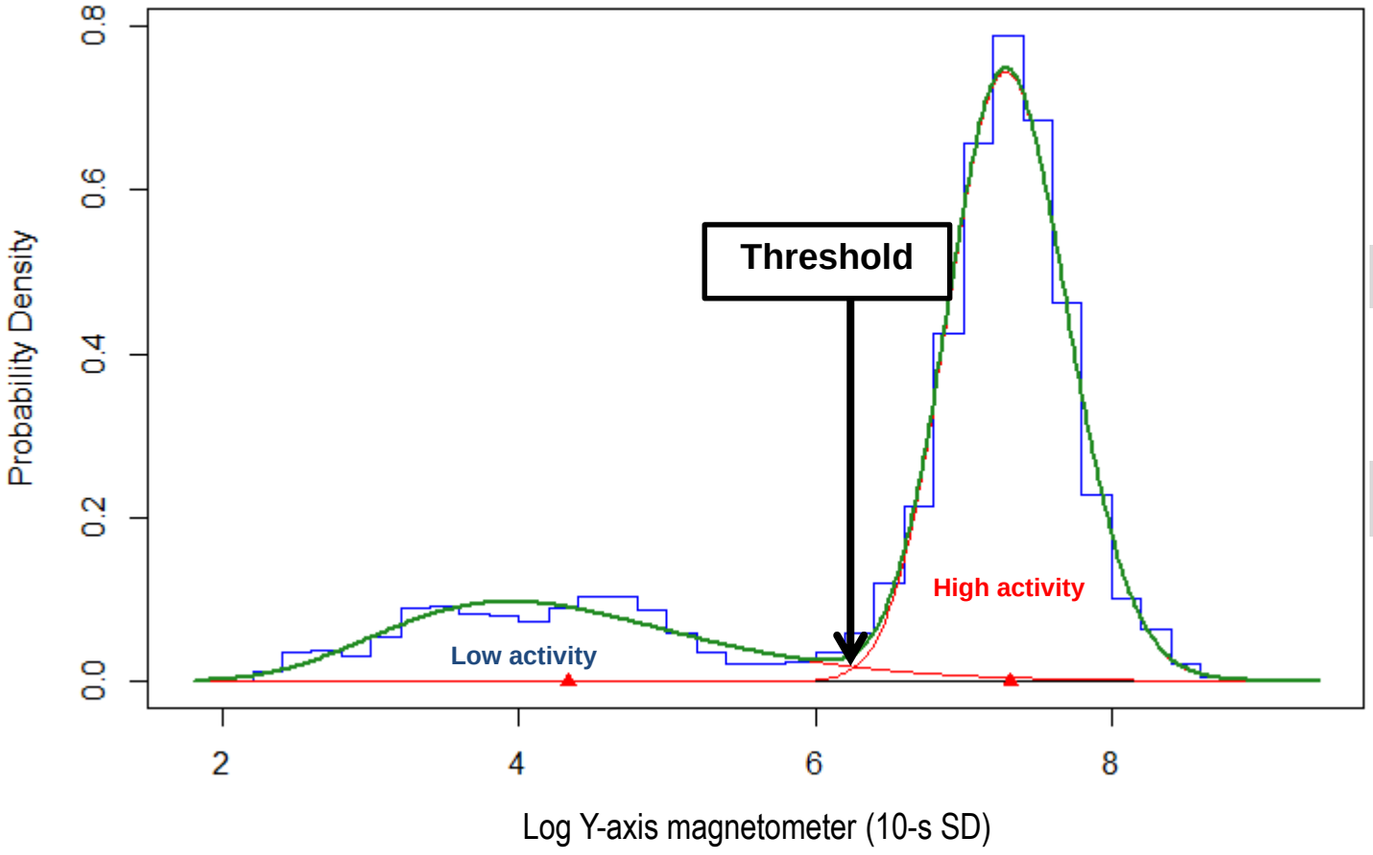
Results: Algorithm development

Distribution of vector-magnitude of XYZ-axis magnetometer data (10-s SD) per observed behaviour



Results: Algorithm development

Distribution of Y-axis magnetometer data (10-s SD) across all behaviours



High activity → Grazing, Walking

Low activity → Lying, Standing

Results: Evaluation

Performance measures of classification algorithm

	Low activity Lying / Standing	High activity Grazing / Walking
Sensitivity (%)	94.3	96.1
Specificity (%)	96.1	94.3
Accuracy (%)	95.7	

Conclusions and perspectives

- **Conclusions**
  - Tracking systems for sheep can be very useful in extensive conditions such as on alpine pastures.
  - Sheep behaviours with low and high activity could be distinguished based on Y-axis magnetometer or by applying the vector-magnitude of X, Y, Z-axes of magnetometer.
  - In total, 96 % of data could be correctly classified into both activity levels in test dataset.

Thank you for your attention!