Bavarian State Research
Center for Agriculture

Analysis of behaviour of grazing cattle based on GPS and accelerometer 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
- **Current situation in alpine farming**
  - App. 29,000 registered farms; 1.8 M cattle, 1.6 M sheep + goats
  - Decrease of livestock units → pasture succession
- **Workload on alpine farms**
  - Work with animals accounts for app. 70 % of the total labour input
  - Average daily walked distances up to 9 km + 1,600 height meter
  - Compared to lowlands higher workload and lower income

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Aims of the study

- **Application of modern techniques (GPS + GSM) to optimize the farm management in alpine regions and to reduce workload**

➡ **Test of cattle tracking systems for alpine areas**

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

➡ **Identification of behaviour of grazing cattle based on GPS and accelerometer data**

Materials and methods

- **Prototype of the tracking system**

At least 4 GPS satellite signals

Data transmission via GSM, GPRS terminal to web database

Configuration and control of animals

Materials and methods

- **Identification of behaviour of grazing cattle**

  Data collection:

  - Tracking collars → GPS (1 Hz) and 3-axis accelerometer (3 Hz) data from 6 heifers (Limousine and Simmental)
  - Pasture paddock (app. 1 ha) in Bavaria, Germany
  - Direct visual observations → continuous sampling on random animals; max. 8 hours/day; 4 days
  - 6 behavioural activities were recorded: grazing, walking, ruminating, standing, lying, drinking and social behaviour

Materials and methods

Data analysis and algorithm development:

- 3 behavioural activities analysed: grazing, ruminating and lying
- Speed (m/s) calculated from GPS positions and accelerometer data (x, y, z-axes) log-transformed and used for analysis
- Speed and accelerometer data merged with behaviour data into 10-sec 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, Bonferroni correction
- Fitting of probability density function (PDF) to data with mixture distributions and obtaining of threshold values (R, mixdist package)

Results: Selection of variables

Differences among behaviours based on GPS data (10-sec means and SD)

	Grazing	Ruminating	Lying
Speed - mean	0.30[a]	0.18[a]	0.20[a]
Speed - SD	0.18[a]	0.11[a,b]	0.10[b]

[a,b] Pd0.05; SE = 0.021 – 0.048; all data log-transformed

Results: Selection of variables

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

	Grazing	Ruminating	Lying
X - mean	10.45[a]	10.42[a]	10.48[a]
Y - mean	10.41[a]	10.44[a]	10.35[a]
Z - mean	10.40[a]	10.40[a]	10.27[a]
X - SD	9.79[a]	8.73[b]	7.93[c]
Y - SD	9.69[a]	9.14[a]	8.29[b]
Z - SD	9.59[a]	9.19[a]	8.22[b]

[a,b,c] Pd0.05; SE = 0.062 – 0.197; all data log-transformed

Results: Selection of variables

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

	Grazing	Ruminating	Lying
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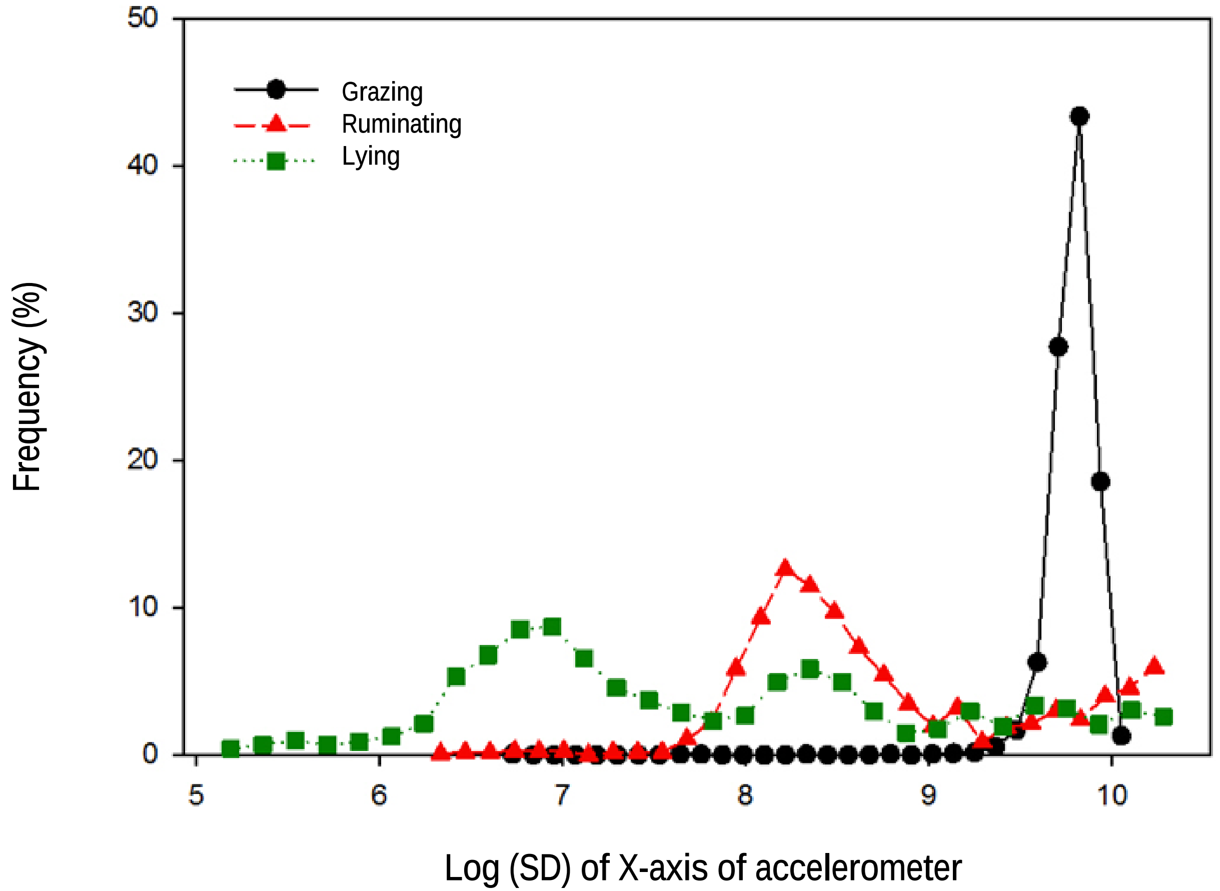
SD of X-axis accelerometer data included for further analyses

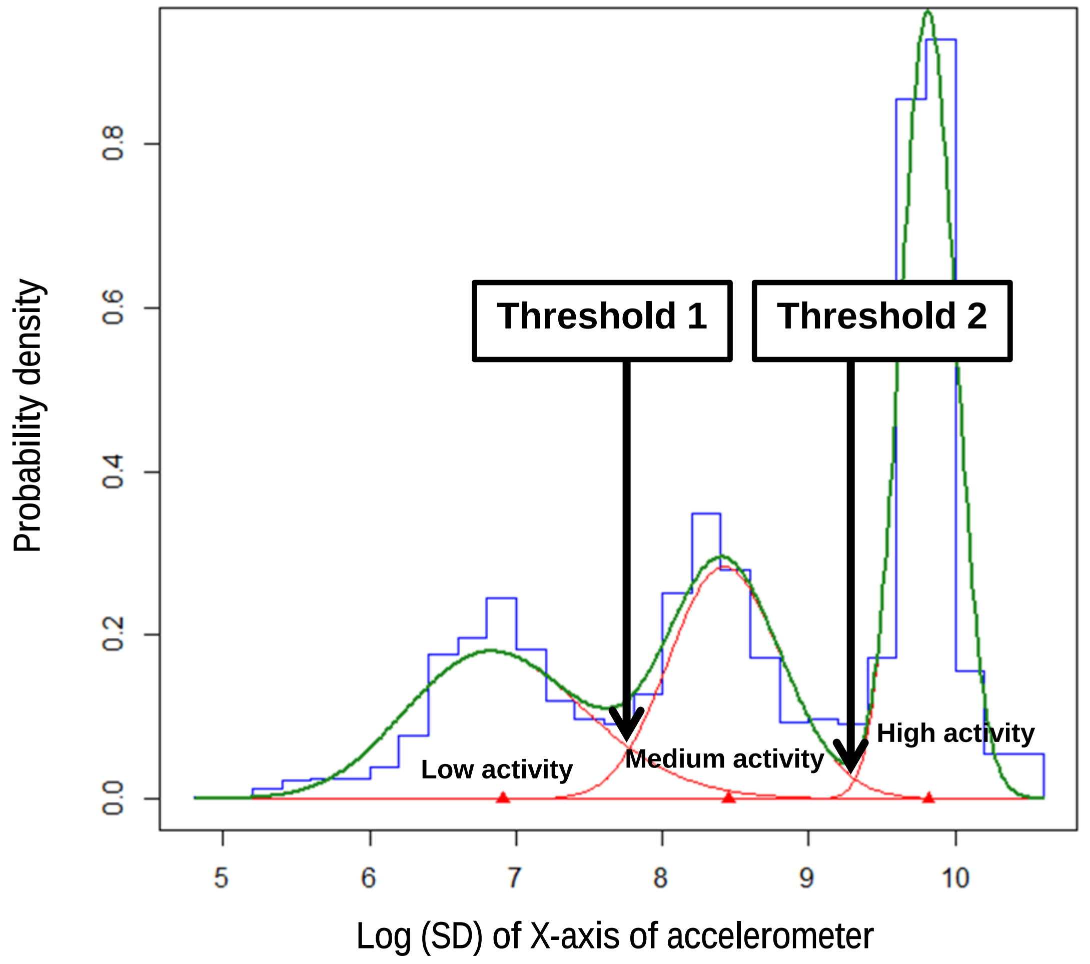
Results: Selection of variables

Frequency distribution of X-axis accelerometer data (SD)

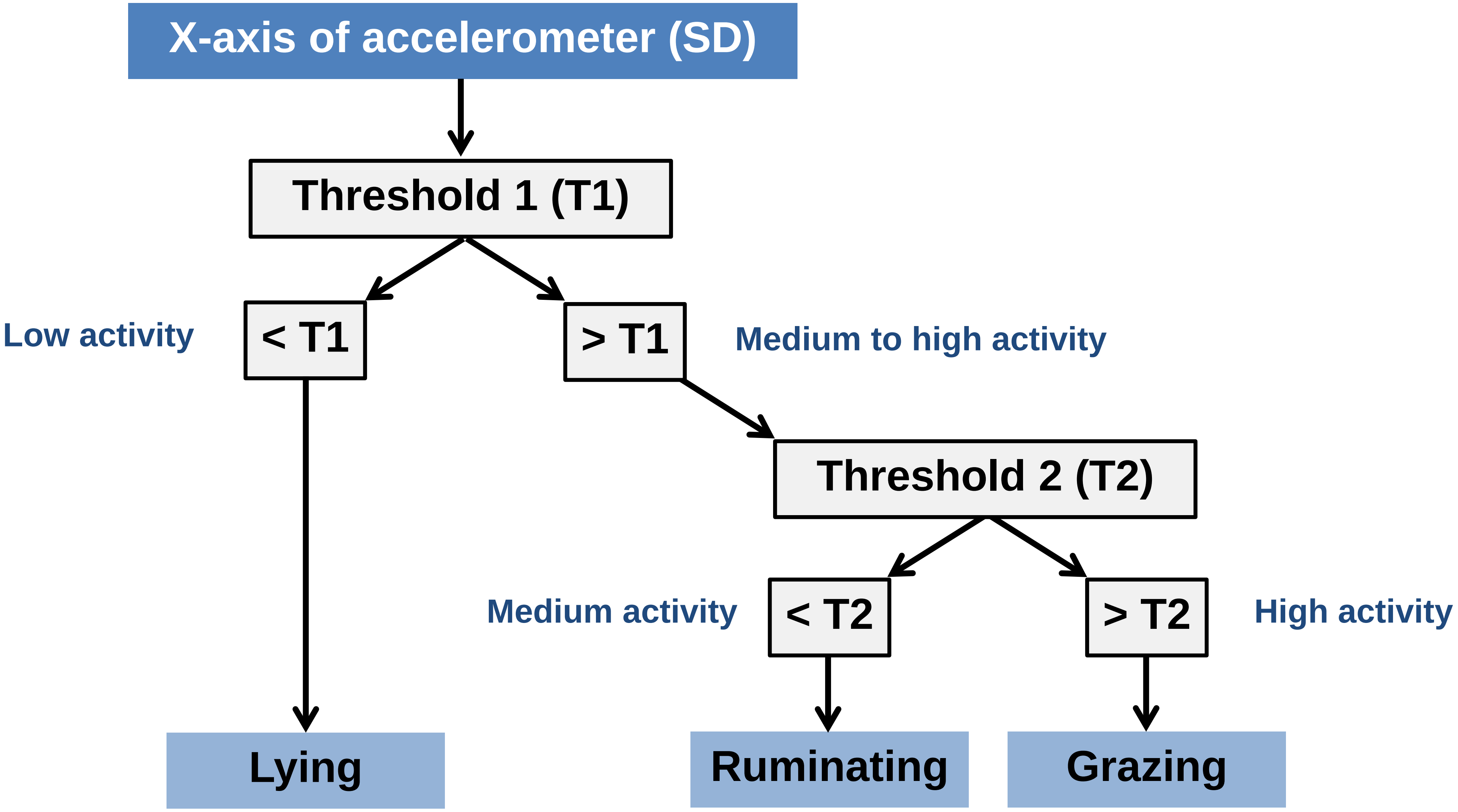


Results: PDF and thresholds

Frequency distribution and PDF of all variables from X-axis accelerometer data



Results: Decision tree



Results: Evaluation

Performance measures for classification algorithm

	Grazing	Ruminating	Lying
Sensitivity (%)	99.4	71.3	55.5
Specificity (%)	80.8	83.6	98.2
Accuracy (%)	86.9	81.1	78.4

Conclusions and perspectives

- **Conclusions**
  - GPS data (speed - SD) were able to distinguish between grazing and lying
  - Animal behaviours grazing, ruminating and lying could be distinguished based on X-axis accelerometer data (SD)
  - In total 82 % of analysed behaviour data could be correctly classified
  - Greatest accuracy for grazing, followed by ruminating and lying

- **Perspectives**
  - Higher prediction accuracy and ability to recognize a wider spectrum of behavioural data by sensor-fusion (e.g. accelerometer, GPS, magnetometer)?
  - Future development of classification algorithms for health monitoring of livestock on pasture

Thank you for your attention!