What the cow is doing?

Computational challenges in deriving dairy cows’ action patterns from accelerometer data

Problem

Given a sequence of accelerometer measurements, what the cow is doing?

1. Body: standing, lying, walking, lying down, standing up
2. Head: still, horizontal or vertical movements, shaking, butting, turning the head towards a side
Accelerometer
Example (standing up)
Sources of accelerations

1. gravitation
   • measurements depend on the orientation of the accelerometer

2. cow’s own motions
   • head movements dominate!
   • hard to separate head and body movements
   • mouth movements subtle

3. movements of the accelerometer
Separating features

• raw acceleration data cannot be used as such!
• we have to compute features which separate different classes
• the features should not depend on the orientation of the accelerometer
Traditional features

- basic statistical measures (mean, standard deviation, skewness, kurtosis, ...) for $x$, $y$ and $z$ separately or the total acceleration
- correlations ($x$–$y$, $x$–$z$, $y$–$z$)
- Fourier and wavelet components (for periodic actions)
- other: “energy”, entropy, peaks, ...
Problem!

- nearly all depend on the orientation!
- many activities are unregular or non-periodic
- different activities have the same elements (e.g. steps without walking)
Solutions

- median correction → eliminates most of the gravitation
  - Assumption: the cow is never in a continuously accelerating movement
- mean value filter → removes noise peaks
- differences between the consecutive acceleration measurements
- total acceleration and accelerations in $xy$, $xz$ and $yz$-planes
  - the orientation matters less
**Principles**

- Given consecutive acceleration vectors $\vec{a}_1$ and $\vec{a}_2$
- Calculate difference vector $\vec{\Delta}$
- $|\vec{\Delta}|$ is always correct!
- Calculate angle $\alpha$ between $\vec{a}_1$ and $\vec{a}_2$
- $\alpha$ is nearly correct (depending on the median correction)
- Together they tell the intensity and direction of the acceleration change
- Can be calculated for the total acceleration or in any plane ($xy$, $xz$, $yz$)
Emphasizing radical motions

- Assumption: in a radical motion both the intensity and direction of the accelerations change
- Instead of $\bar{a}_1$ and $\bar{a}_2$ we study

$$d = (1 + \frac{\alpha}{180})|\Delta|$$

- sequence $a_1, \ldots, a_n$ is replaced by $d_1, \ldots, d_{n-1}$
- the new sequence looks like waves
  - we can calculate amplitude, wavelength, their standard deviations, energy, etc.
Example: original and emphasized walking
Results: basic classification

1=calmly standing/lying, 2=standing/lying + strong head movements, 3=walking, 4=lying down, 5=standing up
accuracy with 10-fold cross-validation

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Results: coarser level classes

1=standing/lying, 3=walking, 4=standing up/lying down

Accuracy:
- 1: 95%
- 3: 82%
- 4: 83%
Results: sub-classes (ruminating, drinking)
Future

- another accelerometer on the leg?
- natural length of observations
- more data, more activities

Thank you!

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