Faculty of Agricultural and Nutritional Science

Christian-Albrechts-University Kiel

Institute of Animal Breeding and Husbandry

Selecting variables from sensor data using principal components and partial least squares

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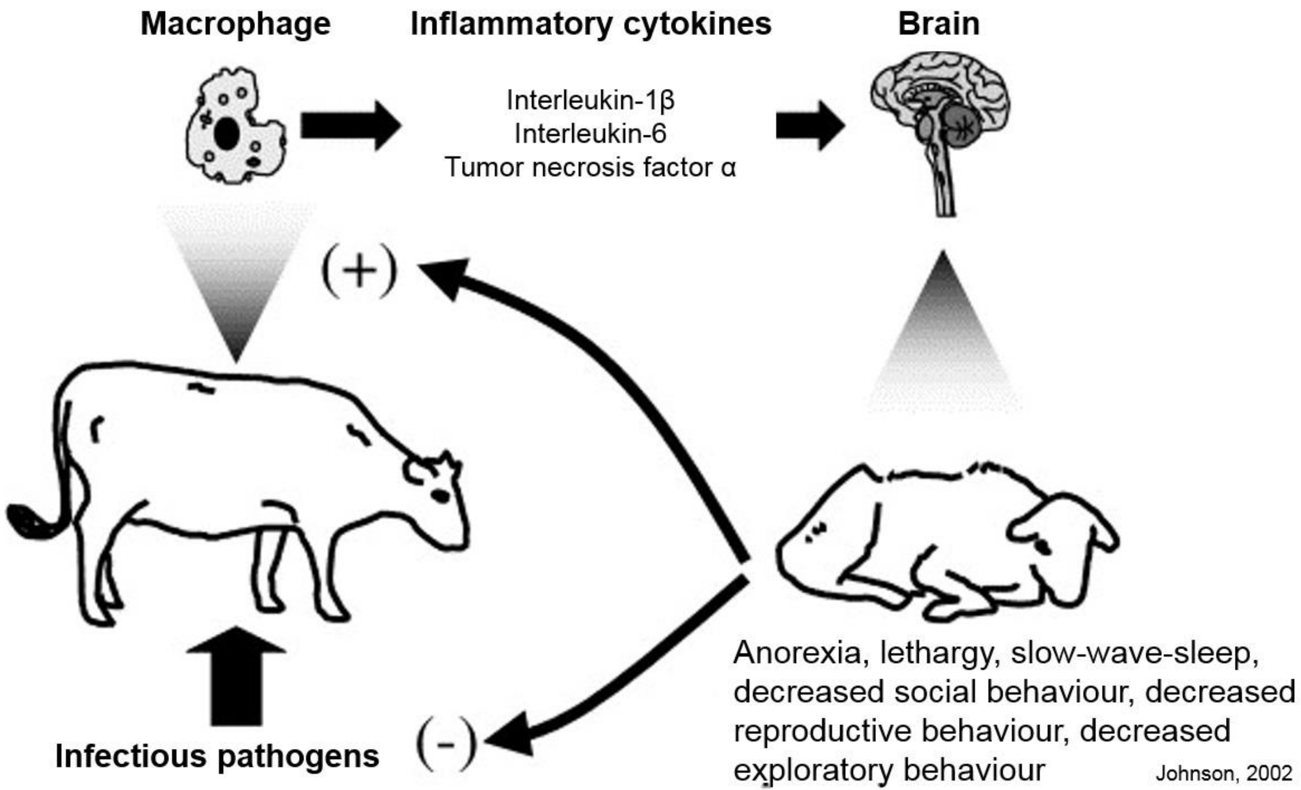
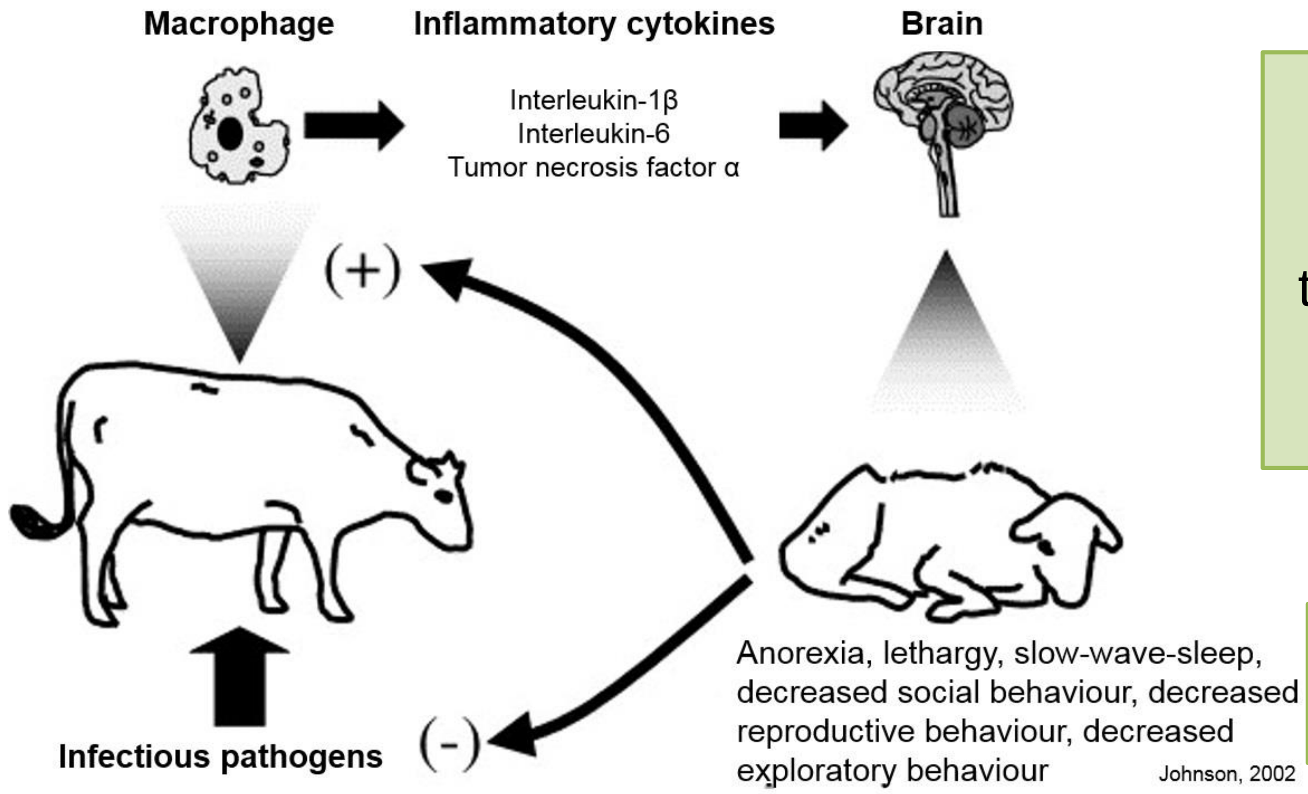
Sickness behaviour



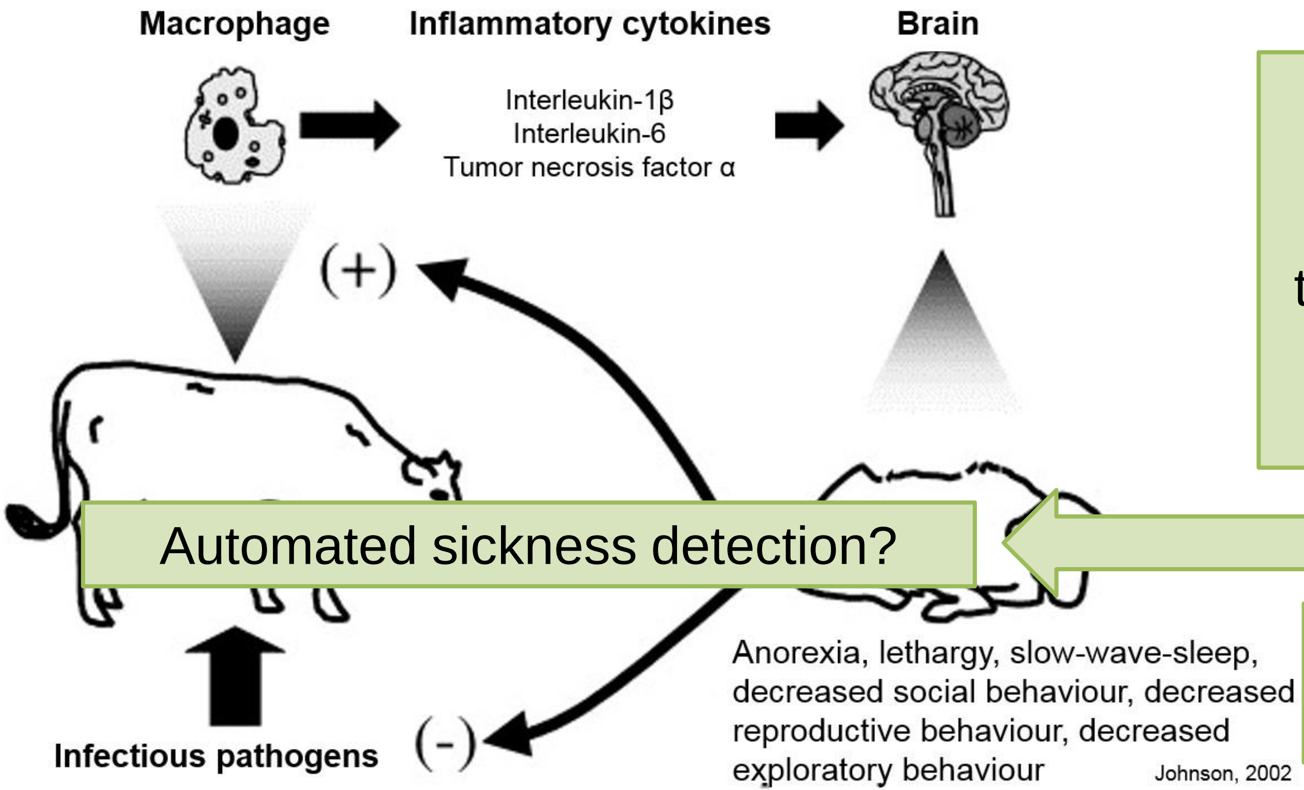
Sickness behaviour



Resting, activity and feeding behaviour changes proceed in the same direction for the most common production diseases

Extent of changes is individual

Sickness behaviour



Automated sickness detection?

Resting, activity and feeding behaviour changes proceed in the same direction for the most common production diseases

Extent of changes is individual

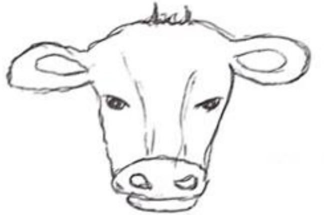
Automated sickness detection?

Data collection

Computation/Analysis

Decision

Healthy

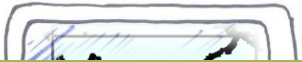


Sick

Aim of the study

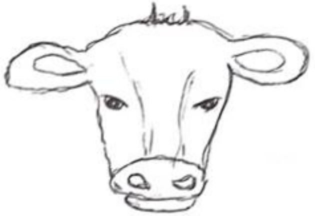
Data collection

Computation/Analysis



Decision

Healthy



Selecting variables from sensor data by using principal component analysis and partial least squares model to identify sick dairy cows using multivariate CUSUM charts

Data

Raw data

480 milking cows

Diagnoses (veterinarian, claw trimmer)

→ Mastitis, claw issues/lameness, metabolic disorders

Selection criteria

>50 days with observations (9/2018 to 4/2019)

No missing values (except for days of disease)

Final data set

298 cows with 44,852 observation days

$n_{healthy}$ =154

n_{sick}=144

Sensor information

Neck sensor

Leg sensor

Milking parlour

Sensor information

Neck sensor

Neck activity, feeding, rumination, inactivity
→ 4 variables

Leg sensor

Milking parlour

Milkyield, milk flow, conductivity
→ total, quarterwise
→ 15 variables

Sensor information

Neck sensor

Leg sensor

Leg activity, walking, lying, standing, lying→ standing,
→ 5 variables

Milking parlour

Milkyield, milk flow, conductivity
→ total, quarterwise
→ 15 variables

Method

Principal component analysis → Principal components → Explaining total variance

Partial least squares regression models → Partial least squares factors → Explaining variance of dependent variable

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MCUSUM

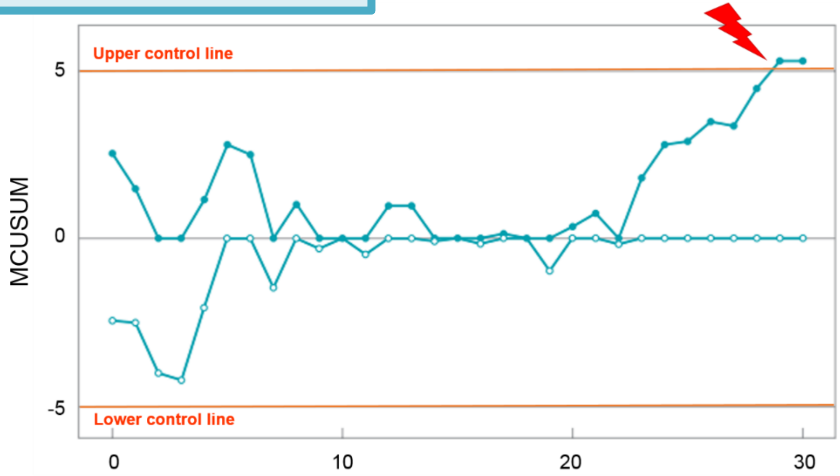
Method

Multivariate cumulative sum control chart (MCUSUM)

Calculated according to Miekley et al. 2013

Individual level

Threshold values tested: 1 to 15



Montgomery, 2009

Method

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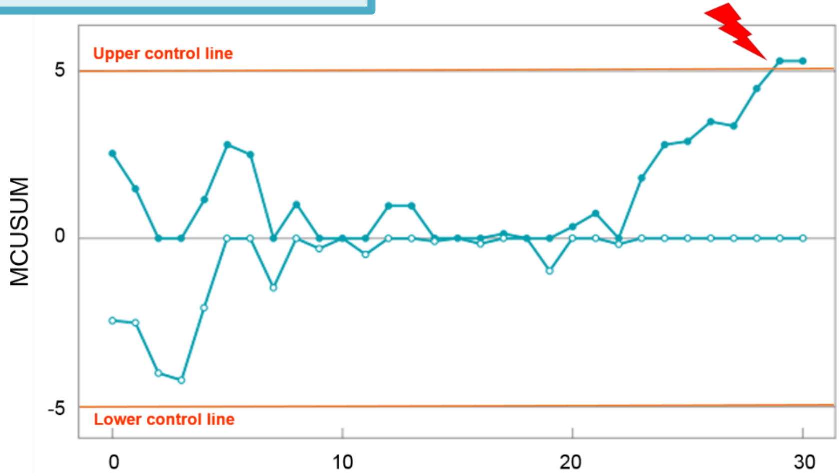


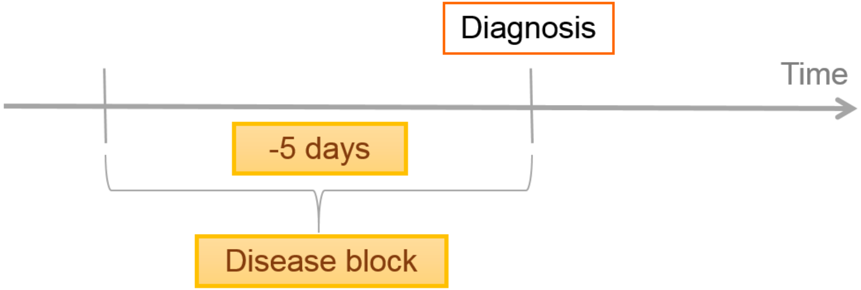
Montgomery, 2009

Quality of classification

Sensitivity, specificity, false-positive-rate (FPR)

Block sensitivity

→ Percentage of correctly detected diseases of all diseases



Variable selection


Neck sensor


Milking parlour

Principal component analysis

5 principal components

72% of total variance explained

PC	Cumulative explained total variance (%)
1	29.7
2	45.3
3	60.6
4	67.2
5	72.3

Variables selected

Milkyield, conductivity, feeding, rumination

Partial least squares

3 PLS-factors

2% of healthstatus’ variance explained

PLS-factor	Cumulative explained variance (%)
1	1.2
2	1.9
3	2.0

Variables selected

Conductivity, feeding, rumination

Variable selection


Leg sensor


Milking parlour

Principal component analysis

5 principal components

74% of total variance explained

PC	Cumulative explained total variance (%)
1	28.2
2	43.5
3	58.5
4	68.3
5	74.1

Variables selected

Milkyield, conductivity, leg activity, walking, lying

Partial least squares

4 PLS-factors

1.5% of healthstatus’ variance explained

PLS-factor	Cumulative explained variance (%)
1	0.9
2	1.3
3	1.4
4	1.5

Variables selected

Milk flow, conductivity, standing

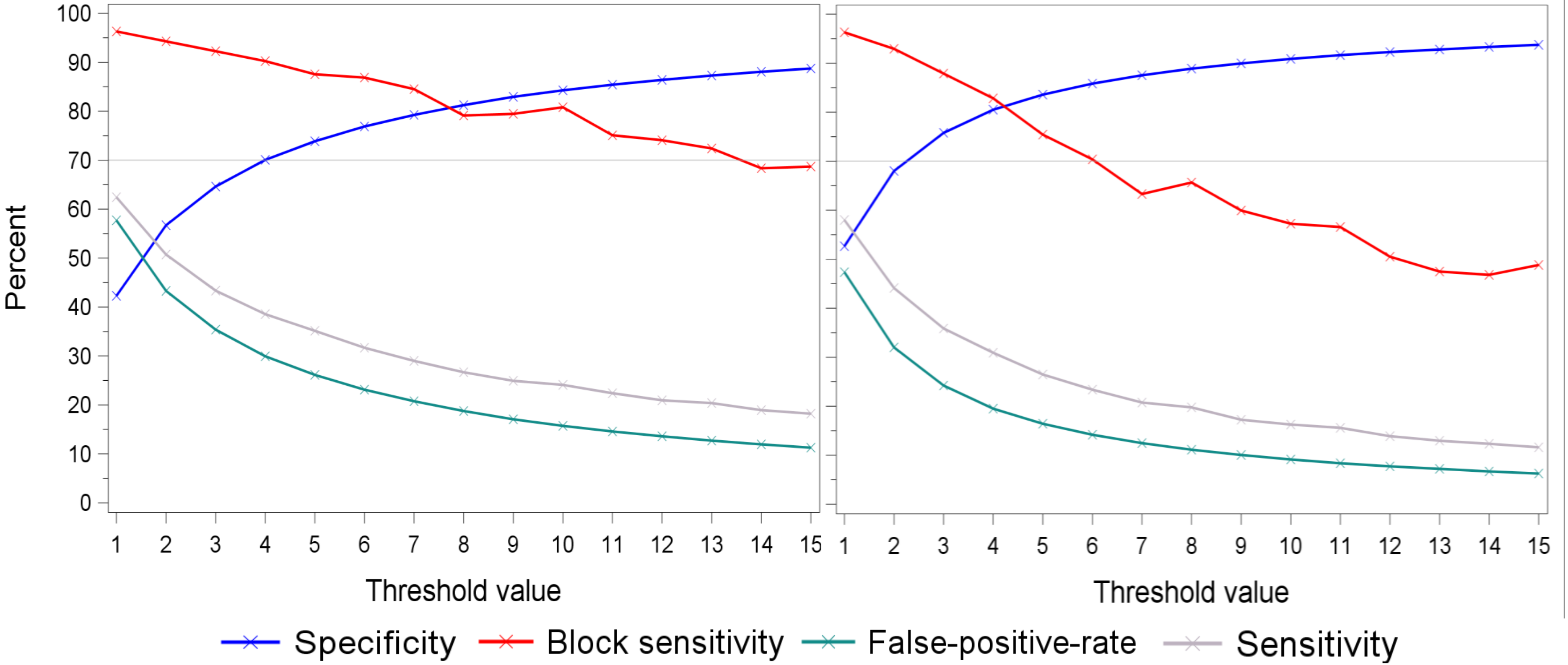
Classification parameters


Neck sensor


Milking parlour

Principal components

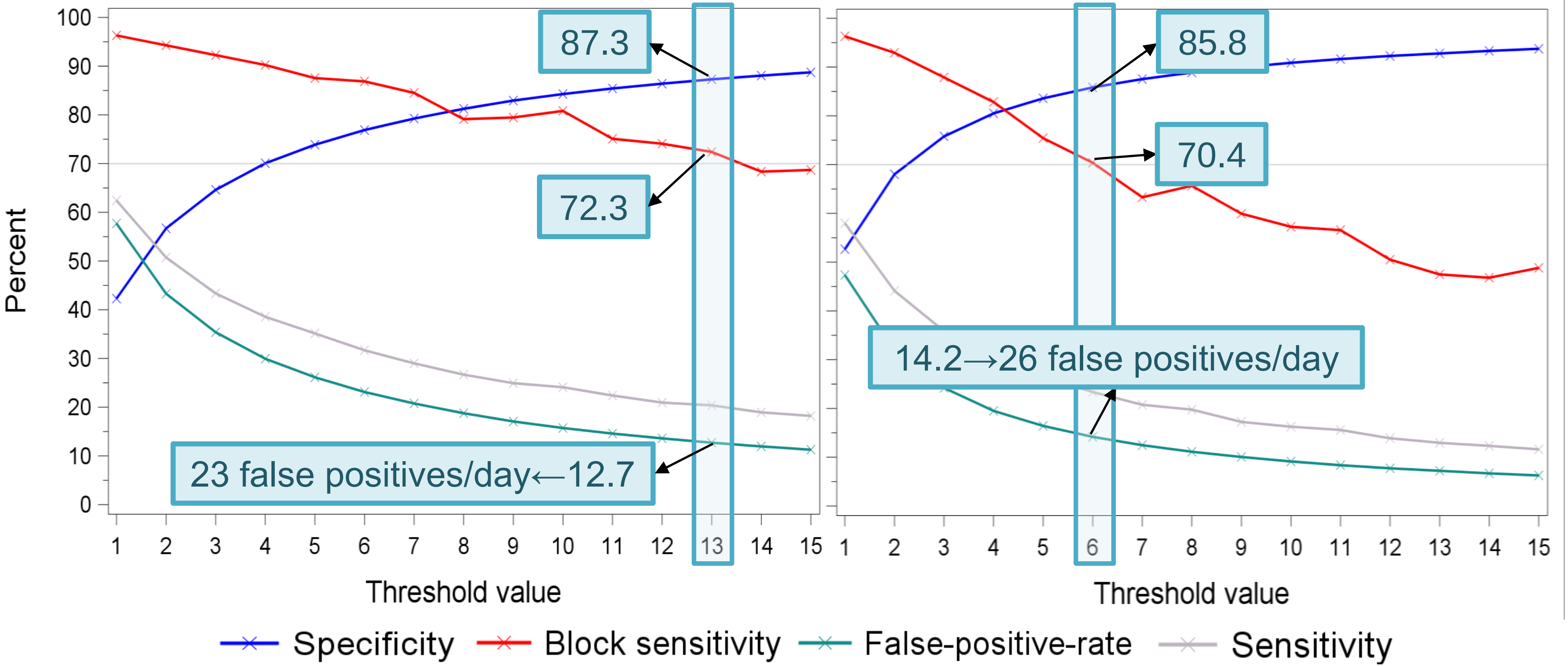
PLS-factors



Classification parameters

Principal components

PLS-factors

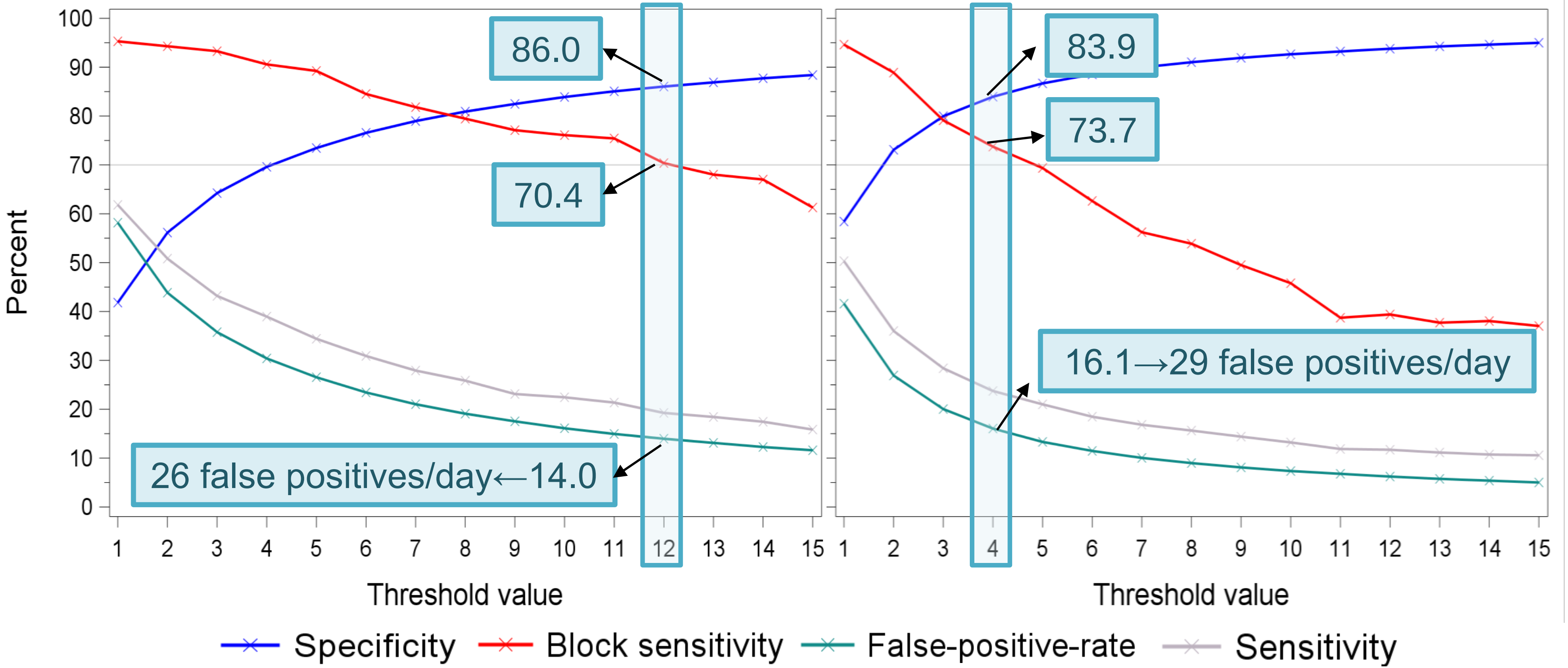


Classification parameters


Leg sensor


Milking parlour

Principal components | **PLS-factors**



Discussion

Variable selection successful → Sickness behaviour

Behavioural variables stress principal components and PLS-factors

→ Both attached sensors

Discussion

Variable selection successful → Sickness behaviour

Behavioural variables stress principal components and PLS-factors

→ Both attached sensors

MCUSUM **- Potential for sickness detection at individual level**

Acceptable qualities of classification

Comparable to other studies (Miekley et al. 2013, Kramer et al. 2009)

Implementation of this algorithm

Practical conditions

→ Average daily herd size 185 animals

→ 24 to 44 false positive alarms a day

Workload ↑

Conclusion

Principal components and **PLS-factors** → MCUSUM charts

Acceptable sickness detection

Sensor type has only a slight effect

Impact of behavioural information > milk parameters

Implementation of algorithm

False-positive-Rates need still improvement

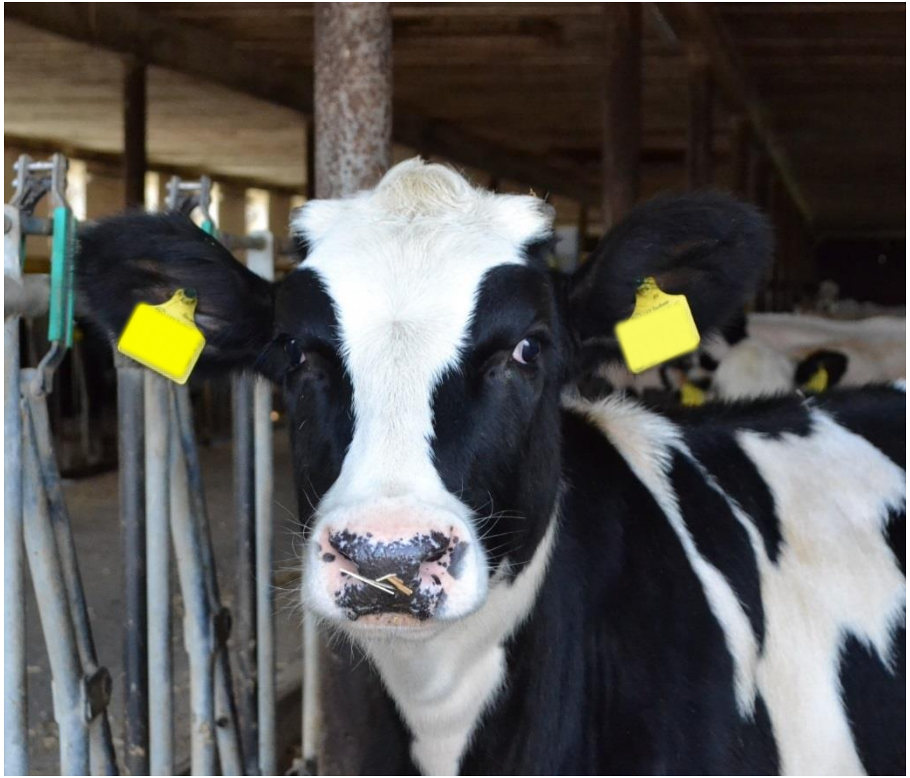
Aimed at ≤ 10%

Feasibility ↑

Neck sensor

Leg sensor

Thank you for your attention



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