Rumination Detection in Dairy Cattle Using Acceleration Based Bolus Sensors

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DairyCare, CERTH, Thessaloniki

Our Background

- CIDCOM is a research group at the University of Strathclyde within the Department for Electronic and Electrical Engineering

- Strong focus on industrially focussed projects related to sensors, edge computing, data analytics and machine learning

- Several current projects in the area of dairy cows (welfare, milk optimisation, and tracking)

Reticulorumen Activity Monitoring

- Movement of bolus based sensors for detecting temperature/pH may provide insight into animal health in a similar manner to collar based sensors

- Combination of movement and temperature in single package is desirable

- First stage was to see what rumen activity looked like and then aim to develop a model related to behaviour
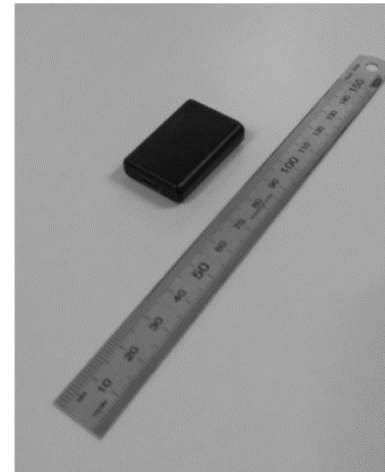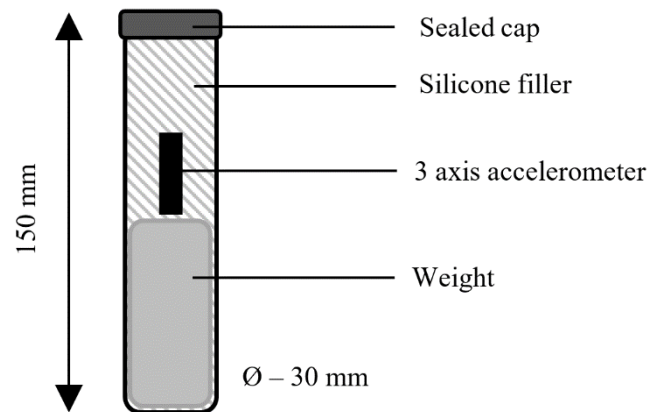
Testing Facility

University of Glasgow's research facility Cochno in North-West of Glasgow used by animal scientists and vets

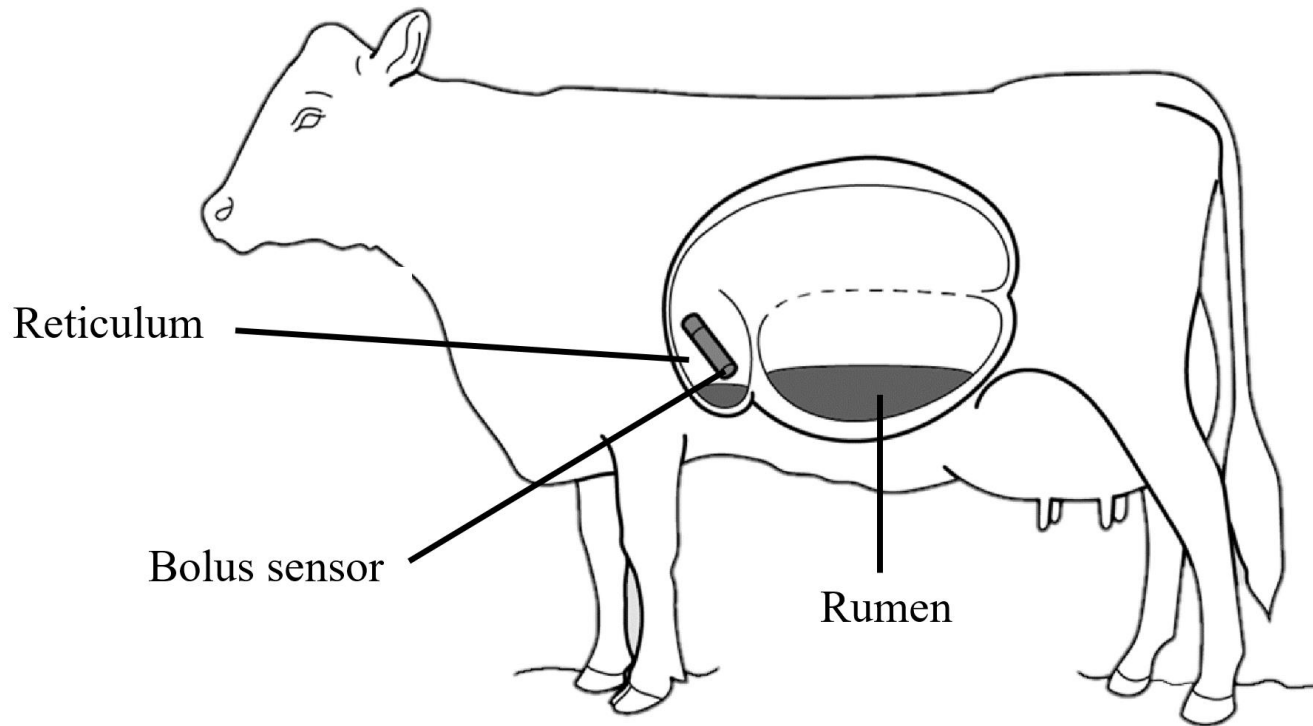Total of 6 cows were used for the test over a 60 day period

Bolus Sensor

Sensors used local storage for data and was retrieved from the bolus after experimental period
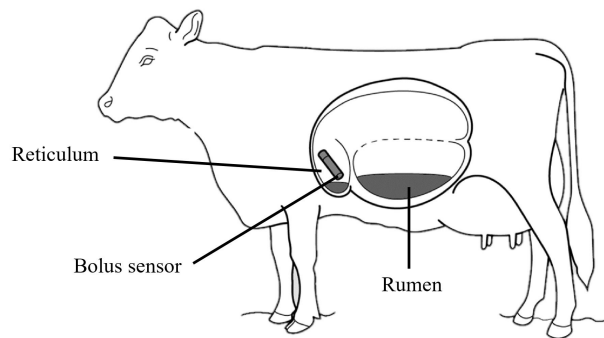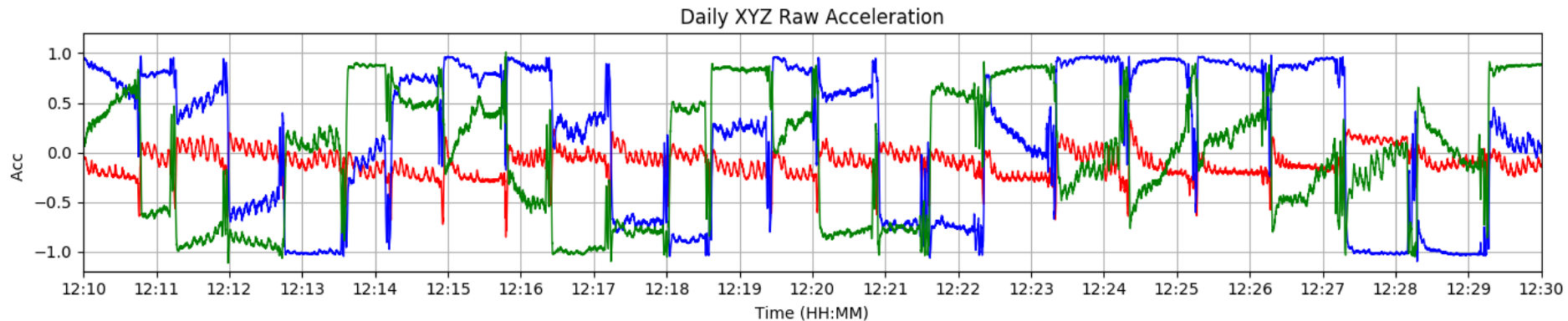

Sealed cap

Silicone filler

3 axis accelerometer

Weight

150 mm

Ø – 30 mm

Sensors were inserted into and retrieved from the cows via a cannula to the rumen

Bolus Sensor

Reticulum

Bolus sensor

Rumen

Raw Acceleration Data

3 axes acceleration with range of +/- 1 g
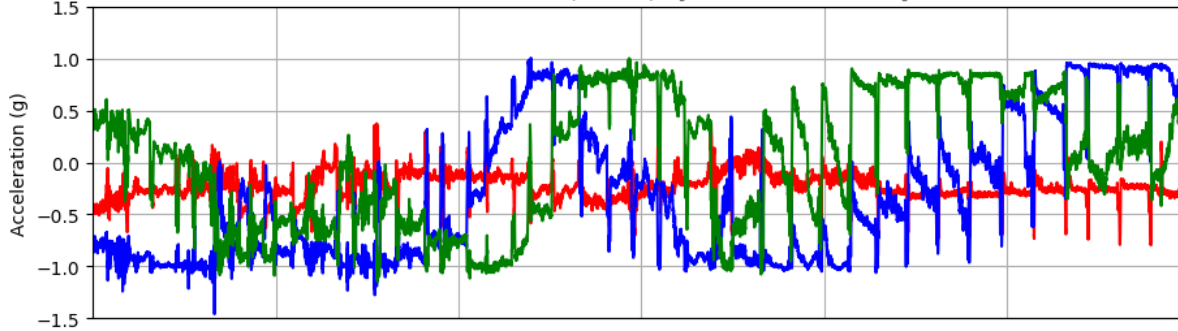X,Y, Z – red, blue, green, respectively

Daily XYZ Raw Acceleration

Bolus would occasionally have very low data likely due to movement between reticulum and rumen

Resolution to Activity

2 stage filter was used to create measure of mean variance of the combined X,Y and Z accelerations

Filter was based on the sampling frequency and was optimised to remove low level peaks through zero-crossing thresholds

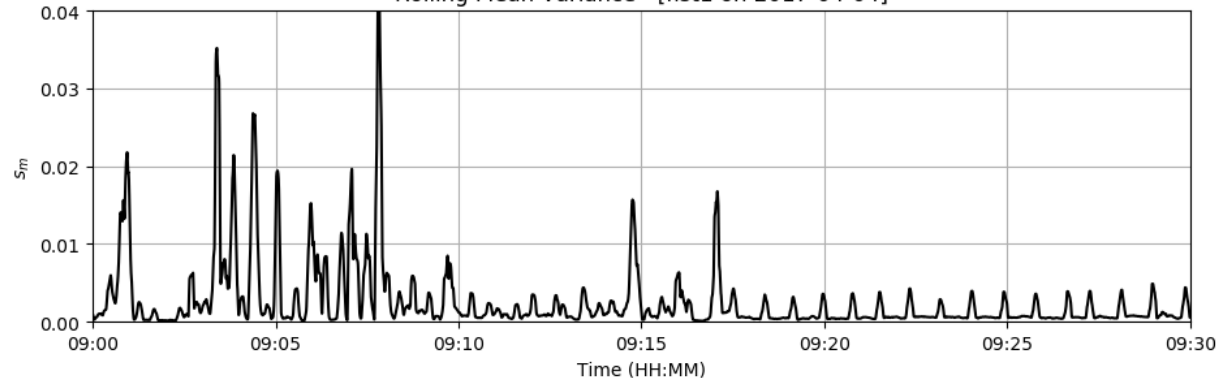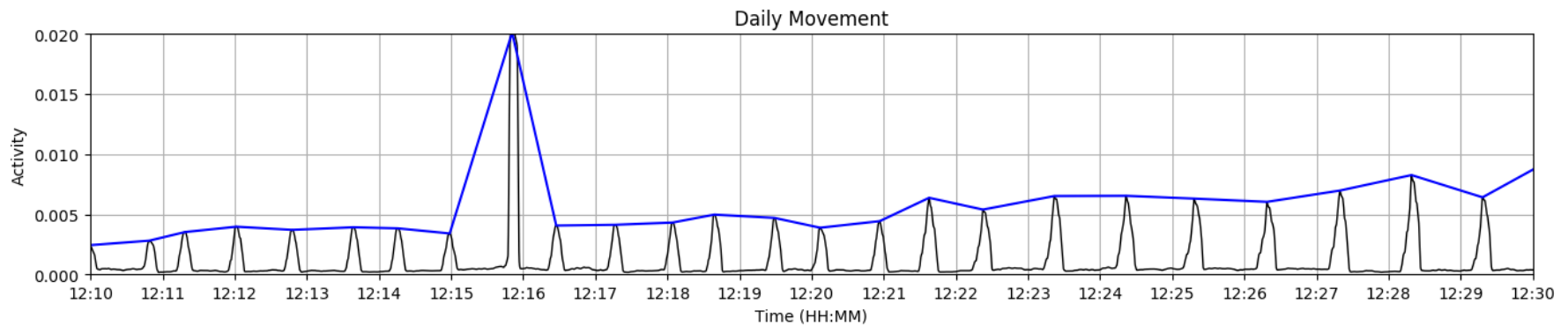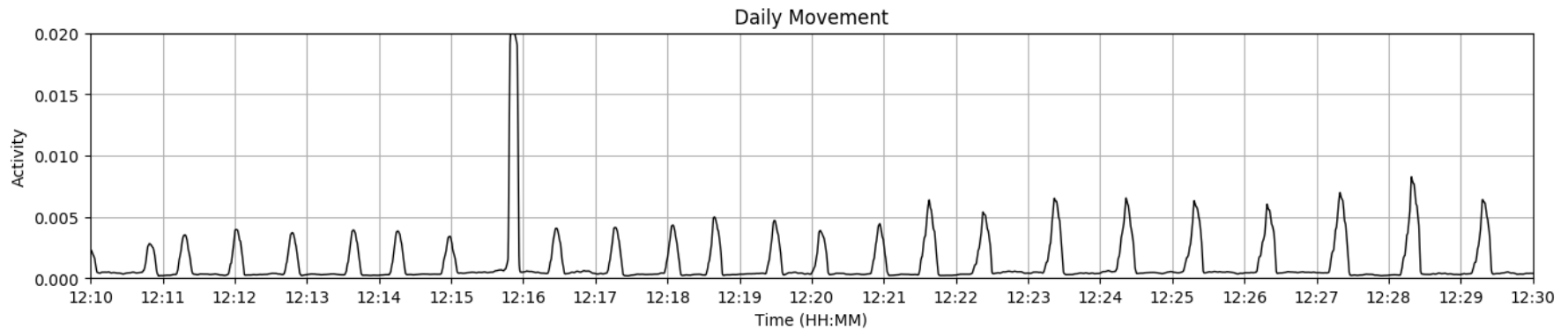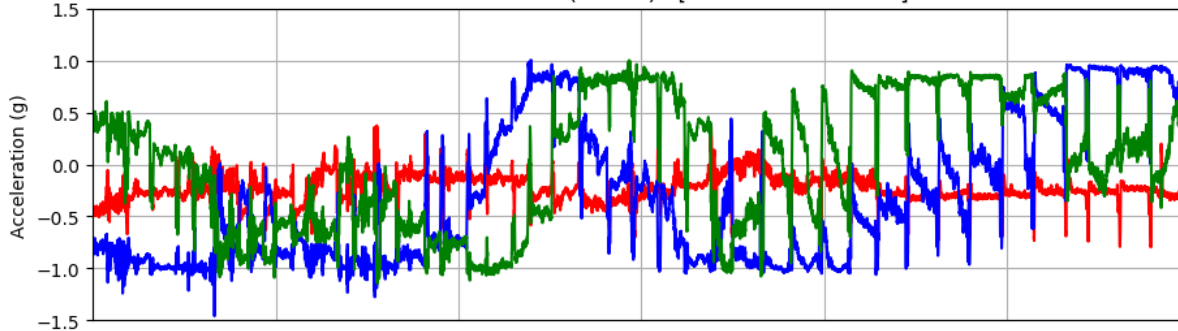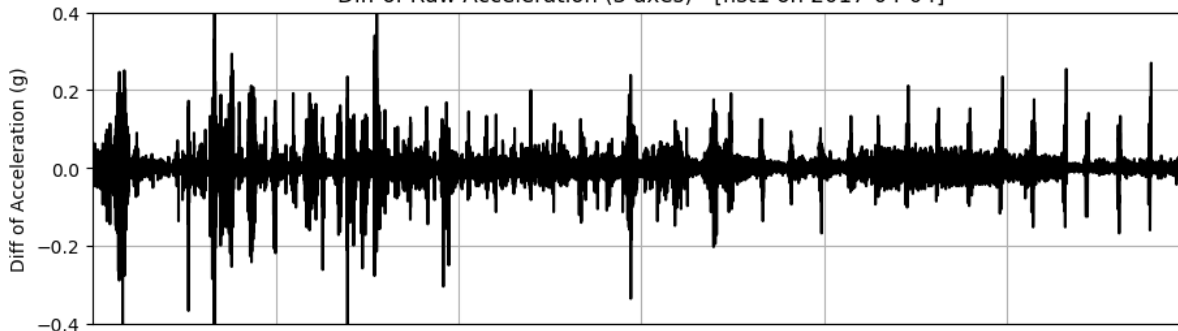# Detection of Peak Strength and Time Between Peaks
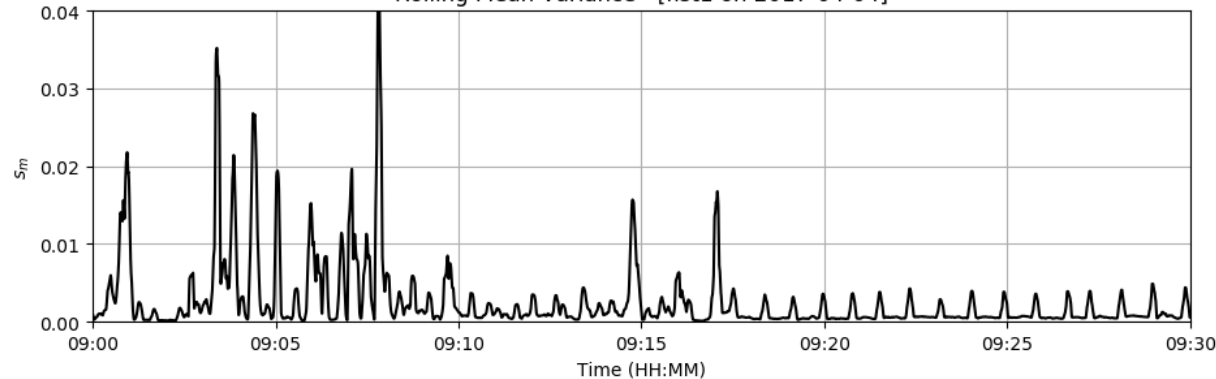
Relationship to Behaviour

Raw Acceleration (3 axes) - [fist1 on 2017-04-04]

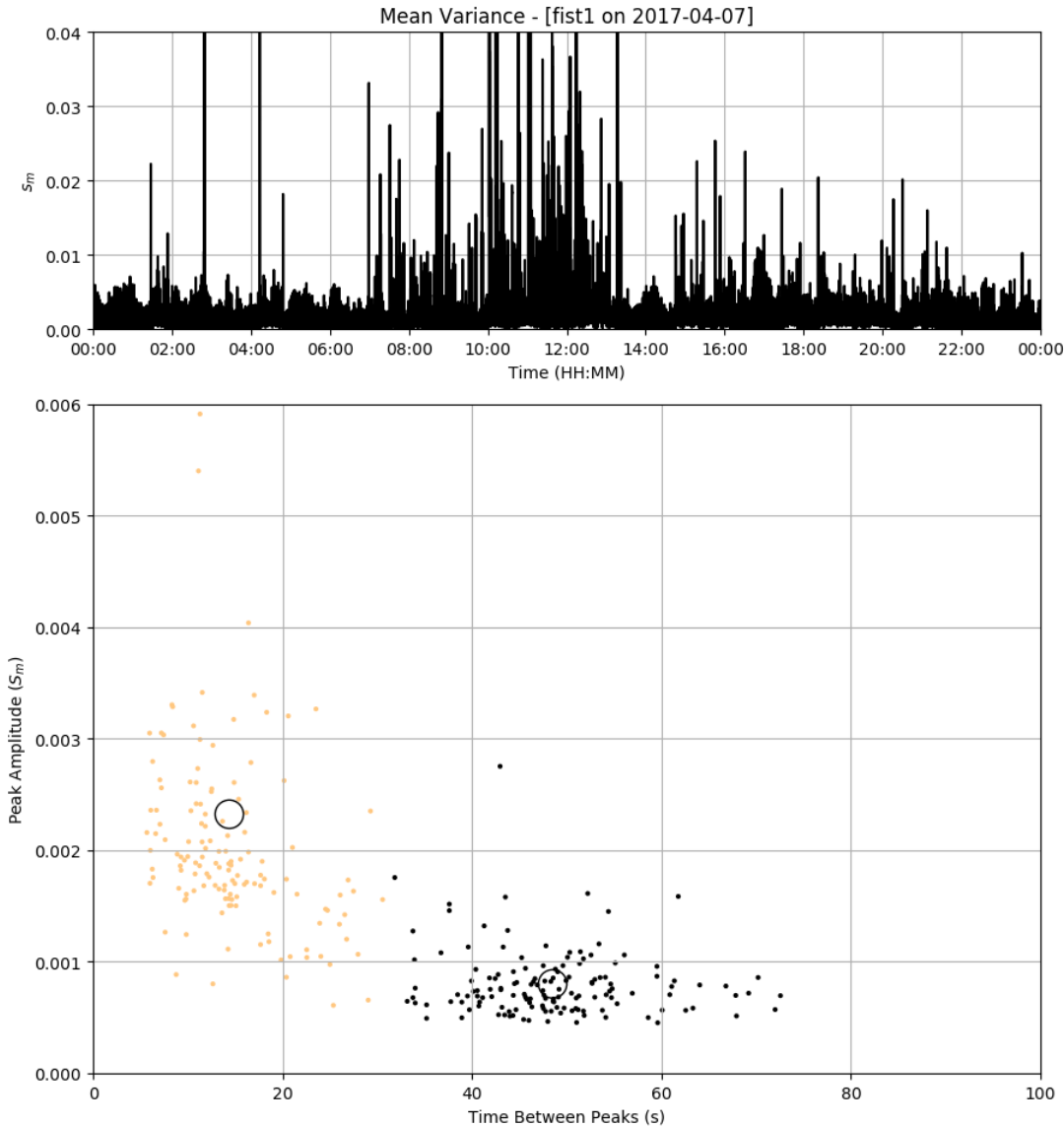Diff of Raw Acceleration (3 axes) - [fist1 on 2017-04-04]

Rolling Mean Variance - [fist1 on 2017-04-04]

Time between peaks and the amplitude of each peak indicated distinct regions

Clustering Analysis

Mean Variance - [fist1 on 2017-04-07]

Each cow data set was broken into 24 hour periods

The mean peak amplitude and time between peak over 5 min segments was used to generate cluster plots
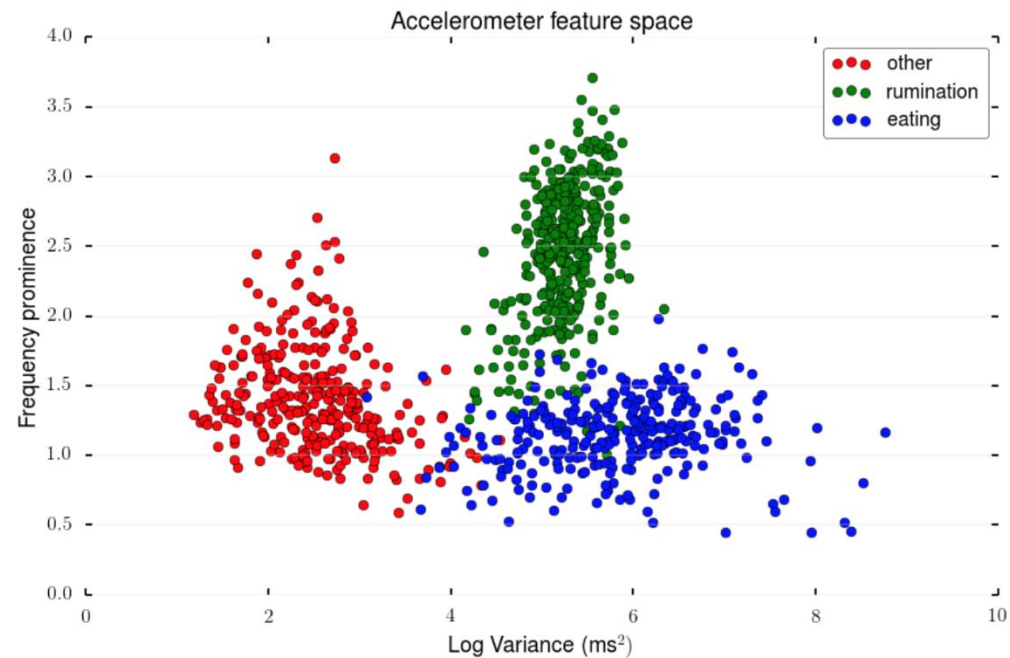
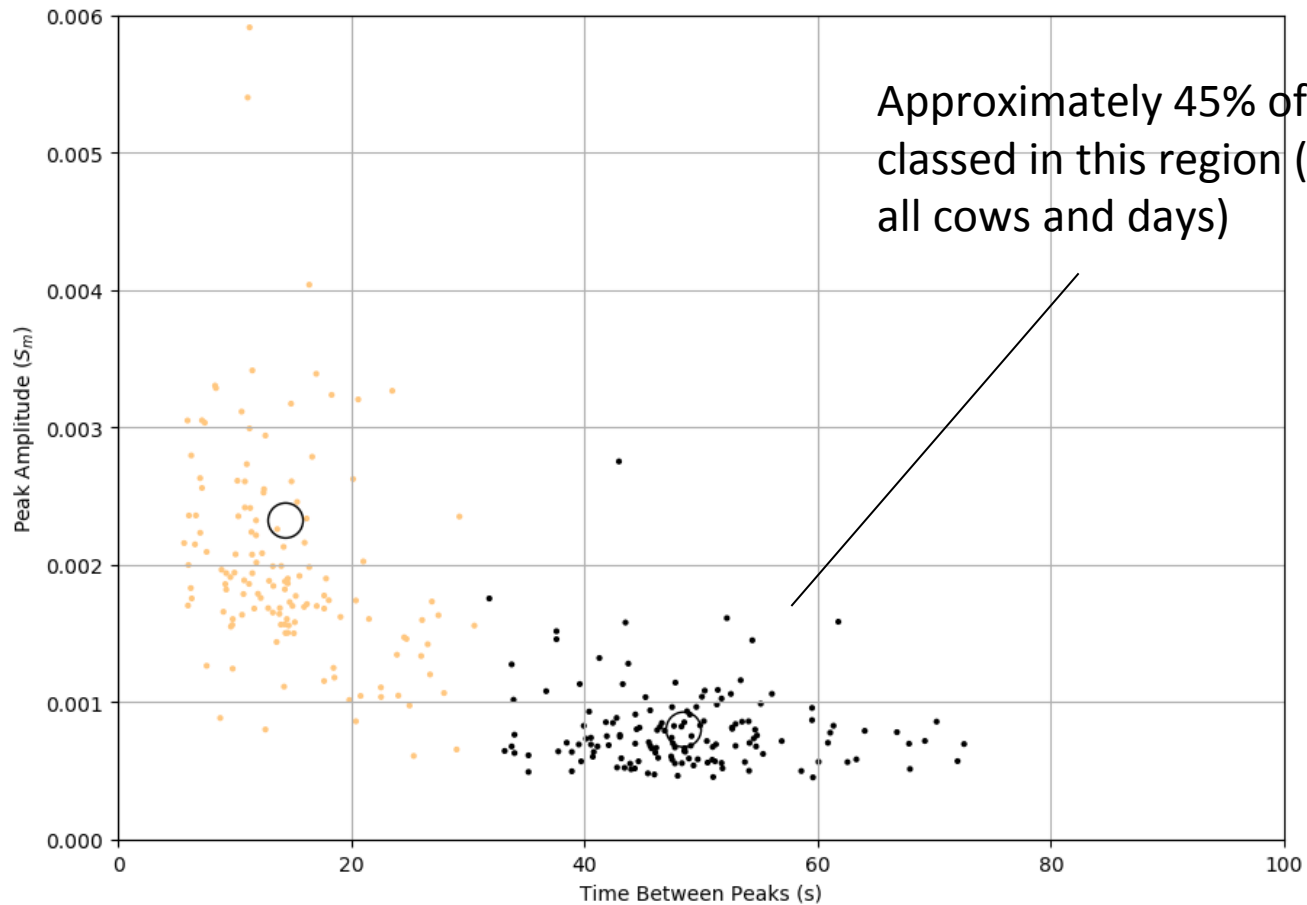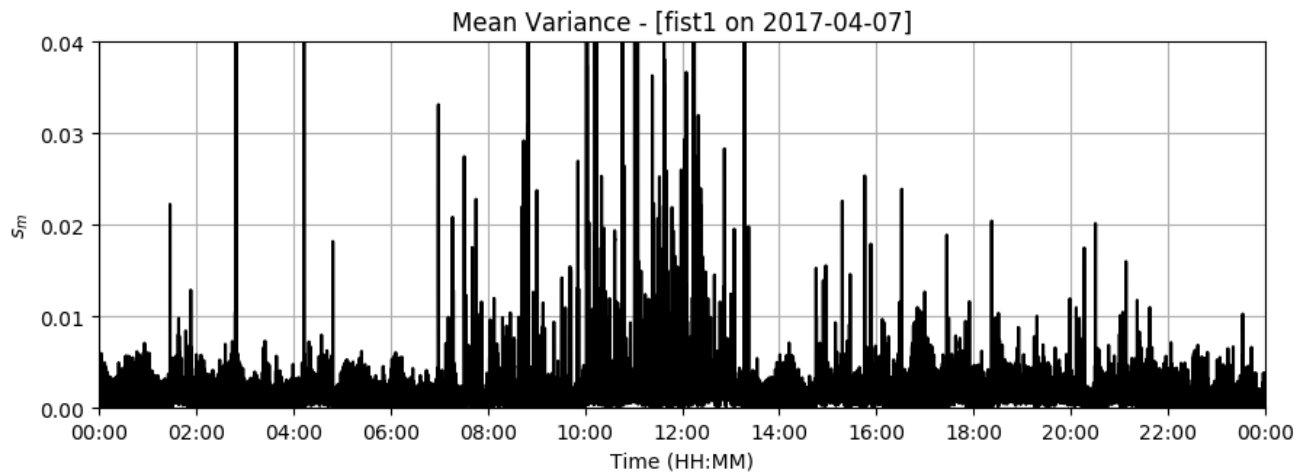K-Means analysis with silhouette to verify optimal cluster #

2 clusters proved most stable with successive analysis

Area if interest is the bottom cluster that seemed to correlate with rumination period of 40-50s

Verification with Collar Data

- Cows that were instrumented with bolus sensors and collars were used to verify model

- These collars used a 3 state classification of eating, rumination and other

- Dairy cows will spend approximately 1/3 in each state

Accelerometer feature space

Mean Variance - [fist1 on 2017-04-07]

Approximately 45% of all activity is classed in this region (stable across all cows and days)

Conclusions

- Derivation of a 2 state model of the reticulorumen with 1 cluster strongly correlated with rumination

- Cluster contains other movement that is not rumination, requires further analysis to discriminate further (principle component analysis, etc)

- Sensor design requires refinement to reduce incidence of movement between reticulum and rumen
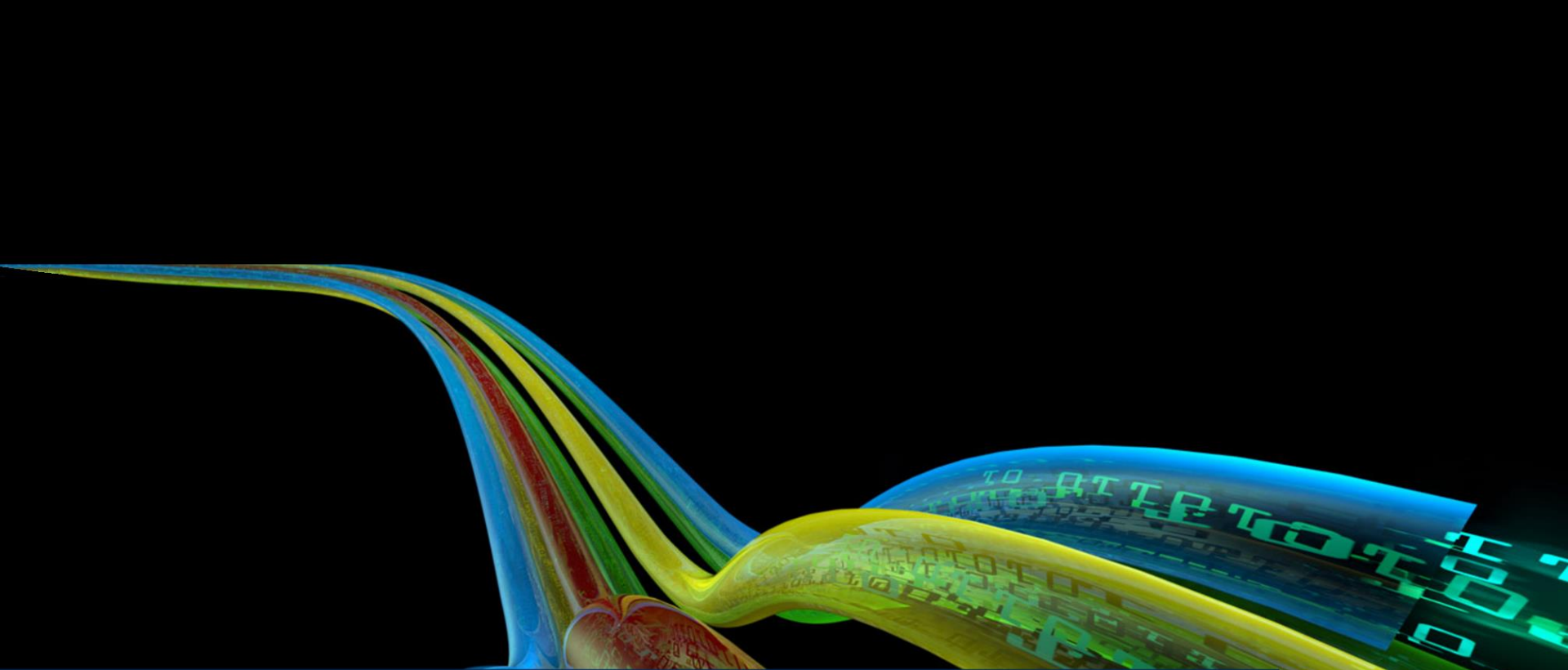
Electronic & electrical engineering

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