Model-Free Bridge-Based Vehicle Classification

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and

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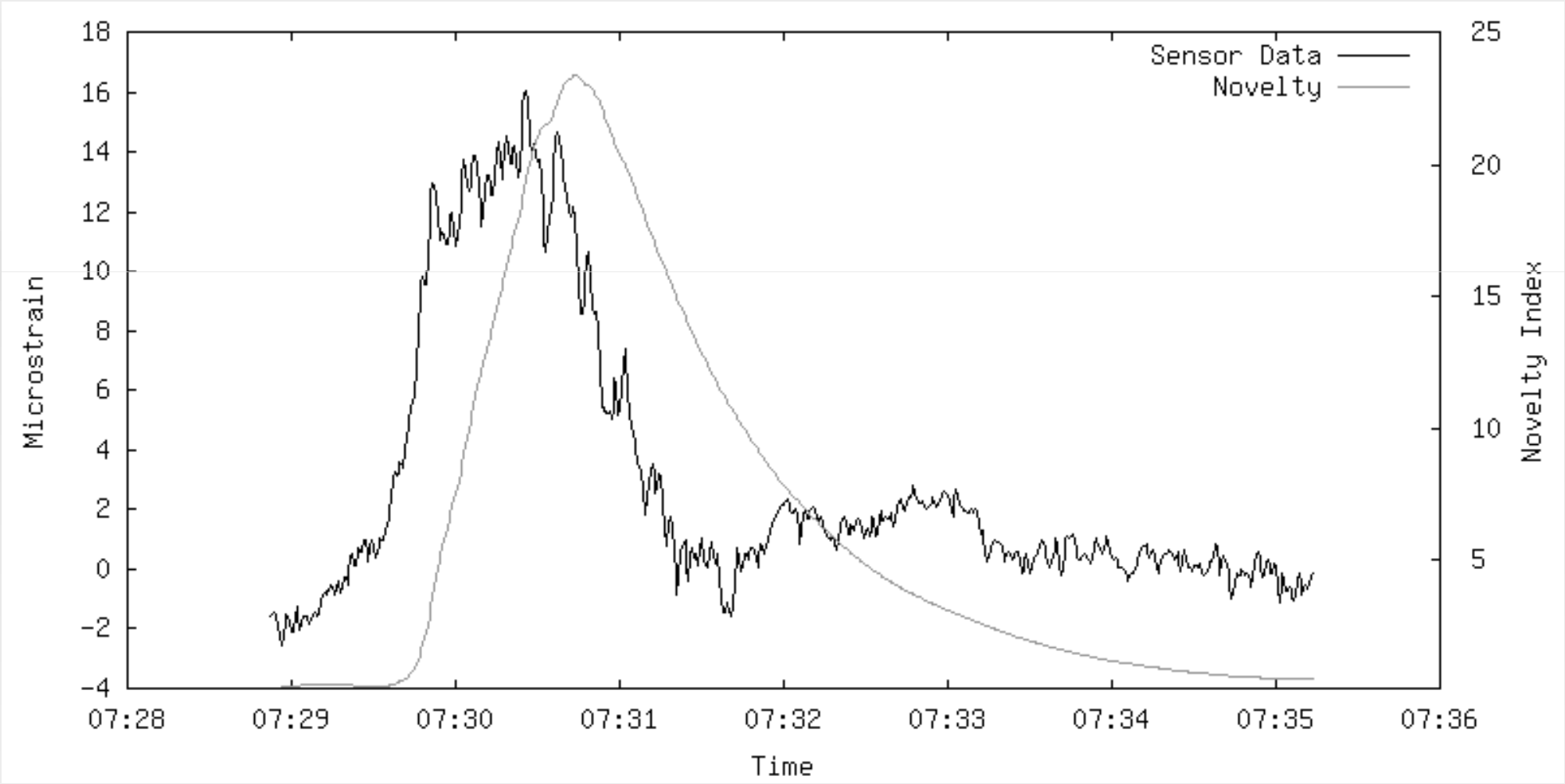
Introduction

- Structural Health Monitoring
  - Sensors embedded in bridges
- Use sensors to gather traffic information
  - Vehicle class
  - Vehicle weight

Sensor System

- North Perimeter Highway Red River Bridge
- GFRP-reinforced steel free design
- Electrical Strain Gauges (ESGs)
  - Deck
  - Girders
  - Straps

Event Detection



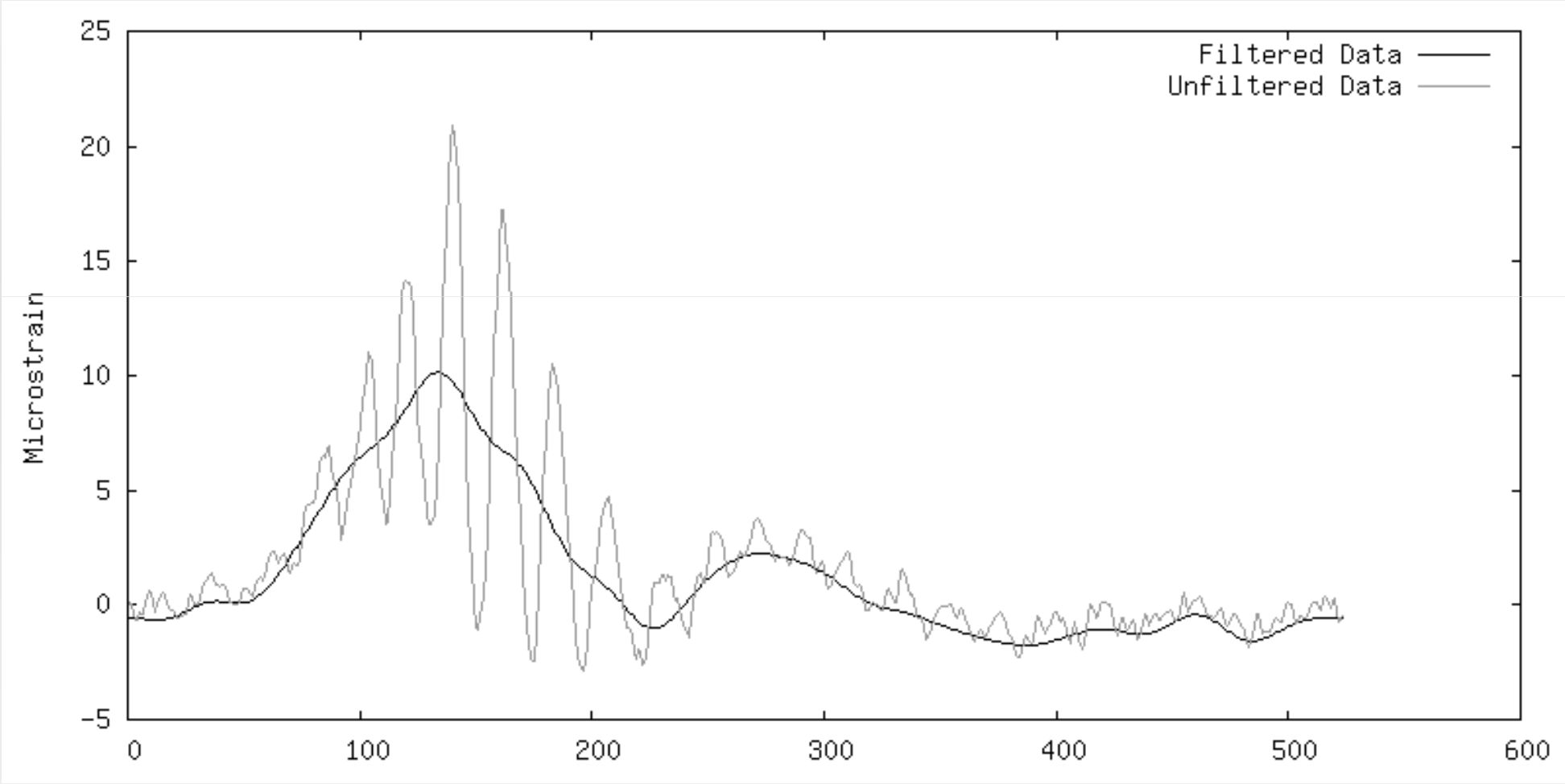
Manual Classification

- July 12, 2007
  - Trucks with known weight
- August 22, 2007, and Feb 5 & 6, 2008
  - Other vehicles
  - Normal trucks (Left and right lanes)
  - Multiple vehicle events

Manual Classification

- Manually identified events were lined up with detected events.
- All events were low-pass filtered, both filtered and unfiltered data were saved.

Filtering


Filtered Data
Unfiltered Data
Microstrain
25
20
15
10
5
0
-5
0
100
200
300
400
500
600

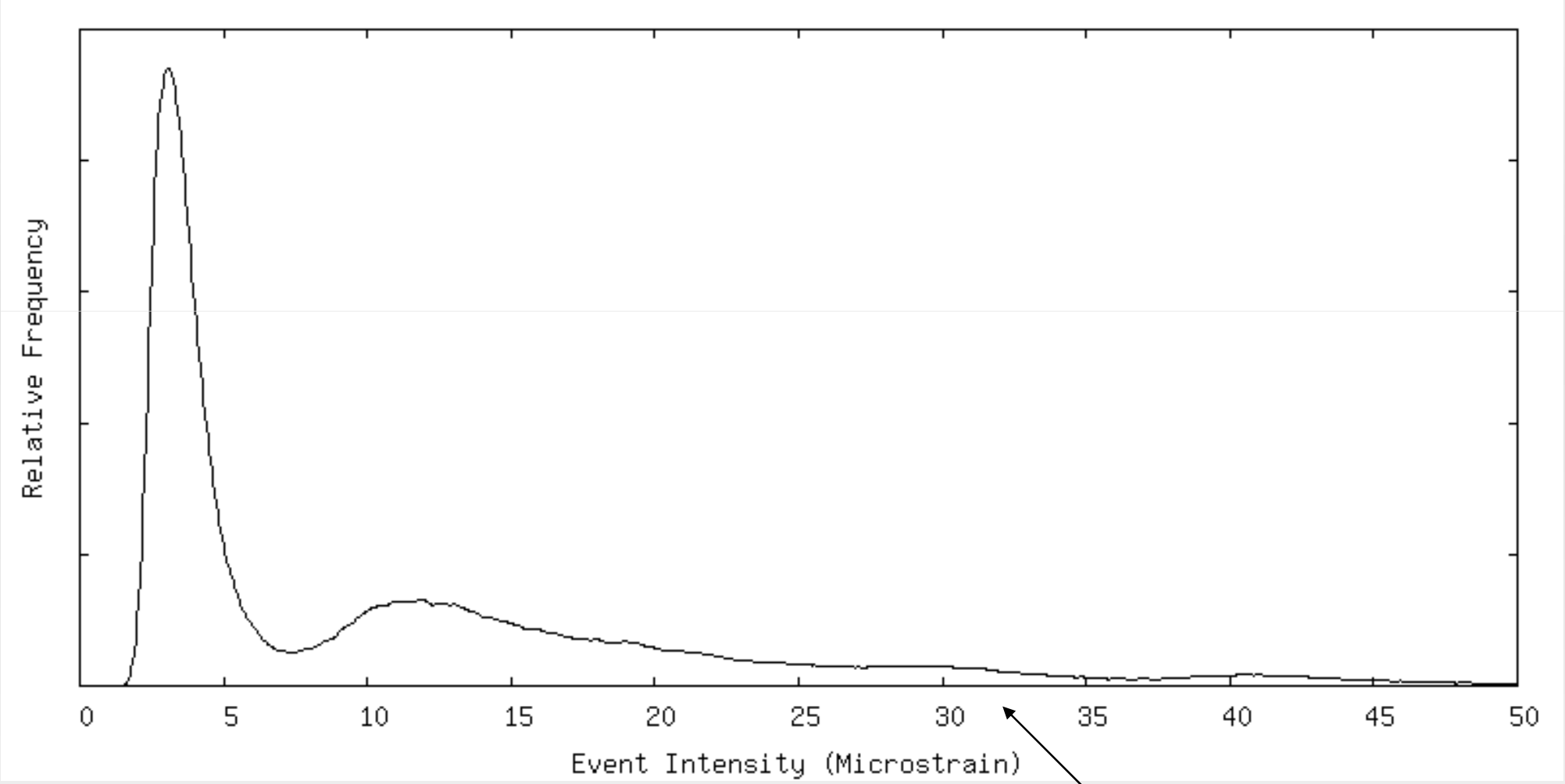
Feature Extraction

- Peak values (unfiltered)
- Variance sums (unfiltered)
- Peak of cross-correlation (both)
- Event length (filtered)
- Temperature
- Bump measurements (filtered)

Data Analysis

- Event detector ran for Aug 23 2007-Feb 4 2008
- 379600 unlabelled events
- High level analysis:
  - Kernel density estimate of event intensity (average peak of girder sensors) was performed

KDE Analysis



Use 32 microstrain as fully loaded vehicle (estimate)

KDE Analysis

- Approximating 32 microstrain from the KDE for 62500 kg fully loaded vehicle.
- Gives ratio of 1953 kg/microstrain
- July 12 data – gives different results:
  - Smaller vehicle: 1127 kg/microstrain
  - Larger vehicle: 1486 kg/microstrain
- Large disparities

Neural Network Analysis

- Many things to optimize:
  - Type of network: Perceptron or RBF
  - Parameters:
    - Training cycles, number of nodes, learning rate
    - Guassian width for RBF
  - Inputs:
    - 37 possible inputs
    - Too many inputs... needs to be reduced
- All optimization done on classifying February data with August training

Neural Network Results

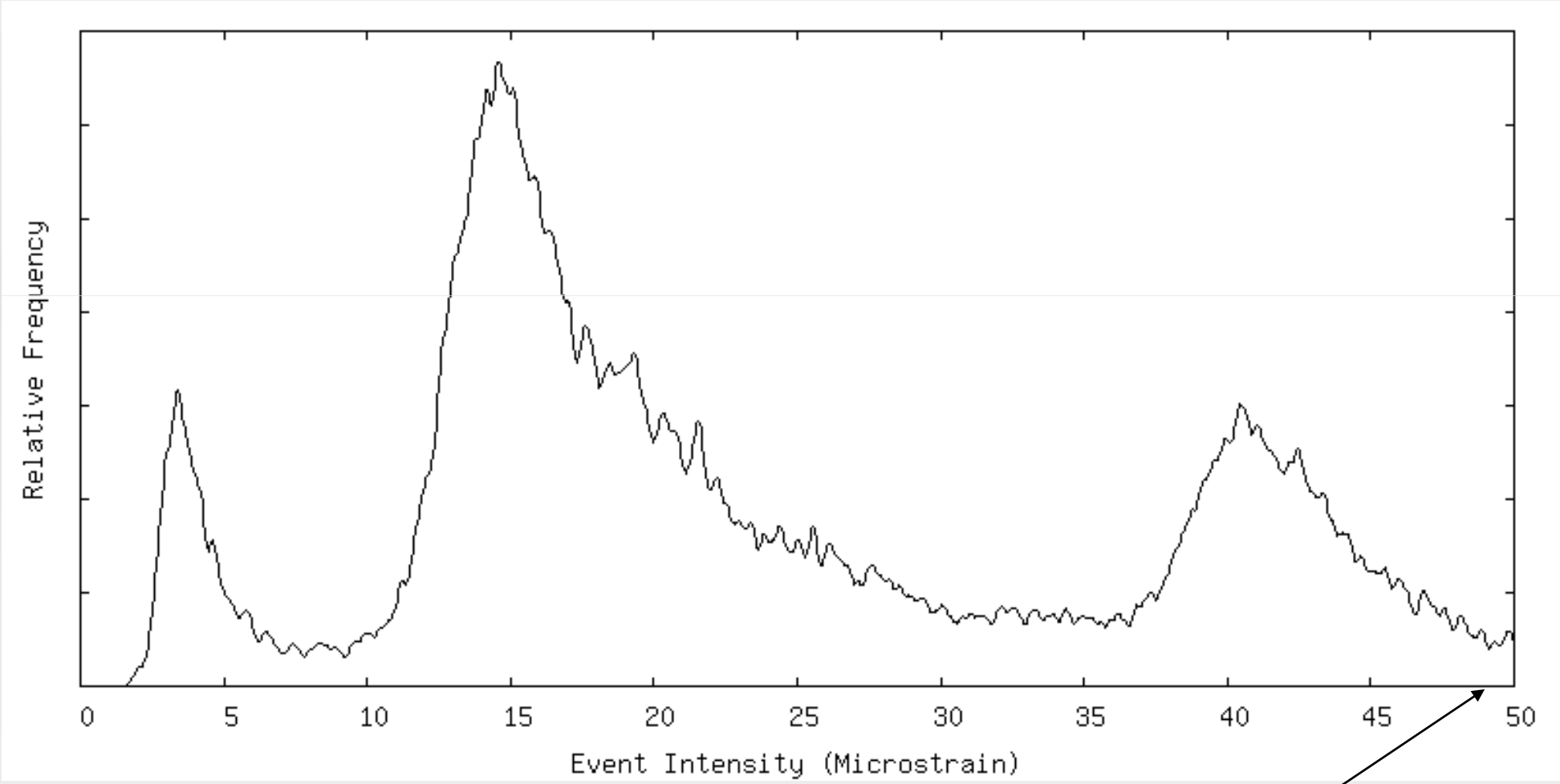
- Best perceptron: 80.15% classification rate
- Best RBF: 67.65% classification rate

- Perceptron used: event length, peak measurements, variance measurements, vehicle length estimates (9 features in total)

KDE Revisited

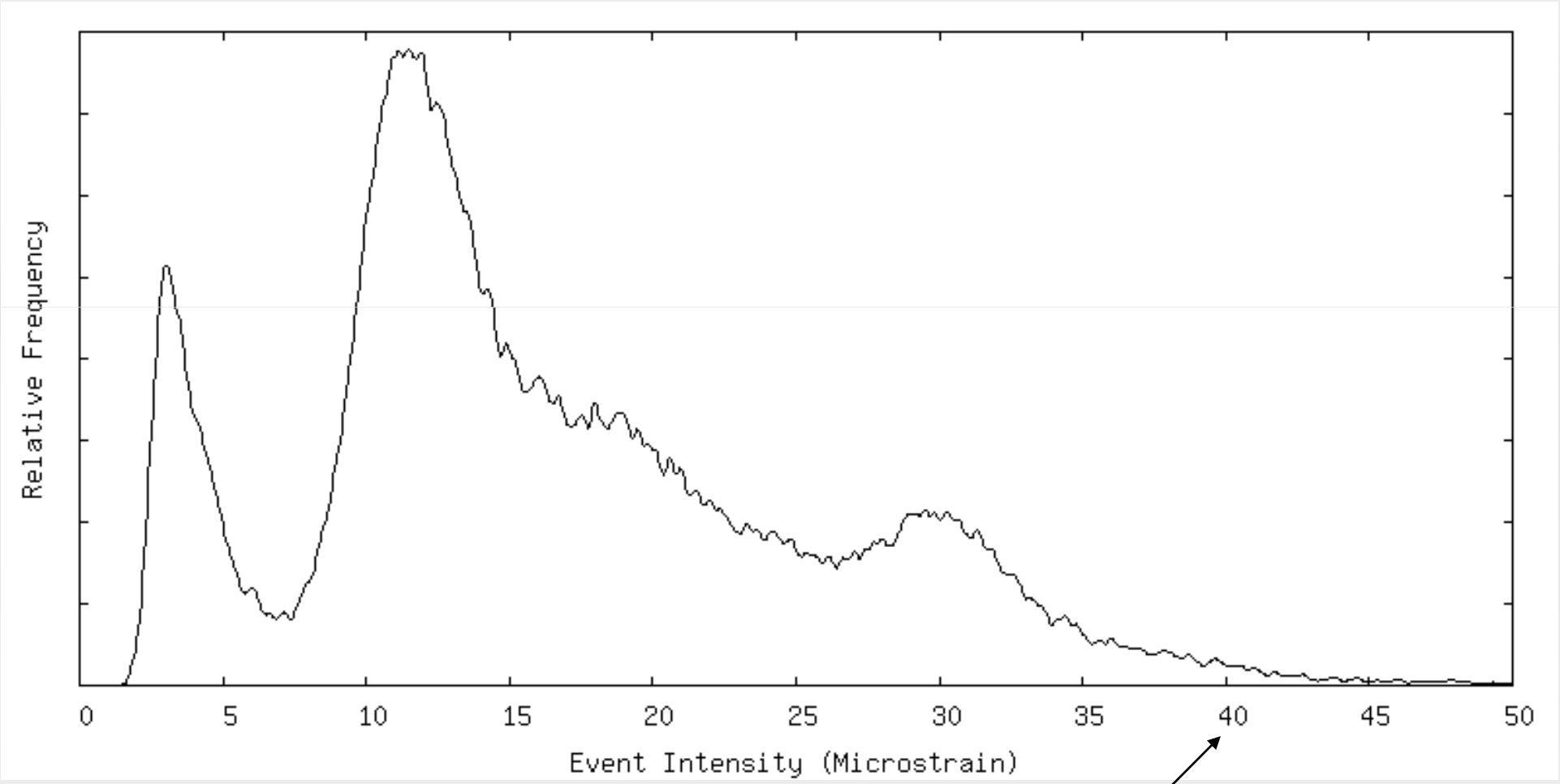
- Using perceptron network, divide unlabelled events into estimated classes.
- Redo KDE analysis with events first sorted by estimated class.
- Better results obtained.

Final KDE Results – Left Lane



Use 48 microstrain as fully loaded vehicle (estimate)

Final KDE Results – Right Lane



Use 40 microstrain as fully loaded vehicle (estimate)

Final KDE Results

Table 4.11: Event intensity to microstrain conversions

	KDE Est.	Small Truck	Large Truck
Left Lane (kg/microstrain)	1302	903	1159
Right Lane (kg/microstrain)	1563	1201	1730

Conclusions

- Optimal features and parameters for vehicle classification investigated.
- Perceptron better than RBF for this problem.
- 4 class sorting can be used to improve basic weight estimates.

Questions?

Thank you for your time!