An Iterative Dimensionality-Scaling System for Real-Time Health Monitoring Applications

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Introduction

- Many passive sensing wearable health monitoring devices have been proposed in recent years, with applications including: physical activity monitoring, diet tracking, smoking, heart rate monitoring.
- We focus this study on an audio-based nutrition monitoring application using a throat microphone device.

Problem

- To improve classification accuracy during fluctuating hardware resources.

Objective

- How can we efficiently process real-time sensor data using machine learning techniques, when the hardware resource or performance requirements change in real time?

Example: Detecting meal events (weak classifier) vs. identifying specific foods (strong classifier).

- Optimize system cost

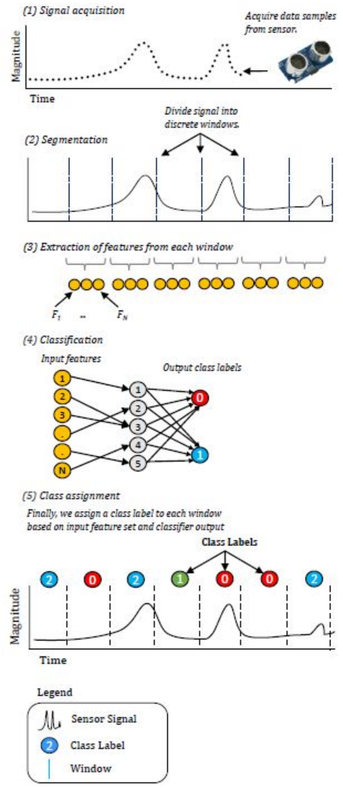
$$C_{total} = C_{acquire} + C_{extract} + C_{classify} + C_{transmit} \quad (1)$$

$$C_{extract} = W \cdot \sum_{i=1}^{N} f_i \quad (2)$$

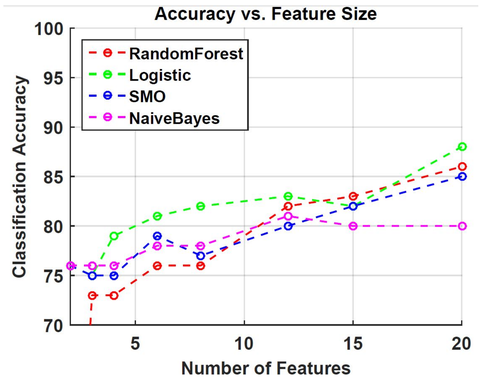
(2): the classifier requires N input features from f_1 to f_N. W refers to the number of signal segmented window frames since each must be processed individually.

Background

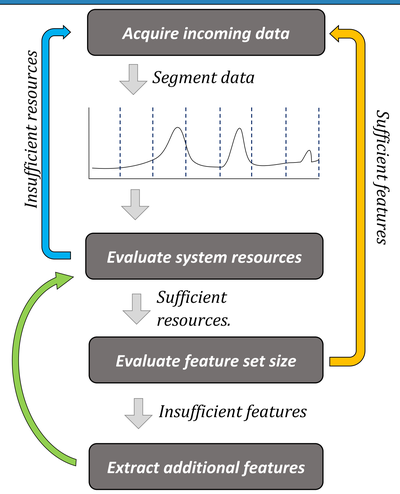
- Wearable *device* ***acquires*** data from sensor and buffers it.
- Signal is ***segmented*** *into shorter windows*, each processed independently.
- A set of *representative features are* ***extracted*** from each window.
- Features are inputted into a *pre-trained* ***classifier***, which outputs class label.
- Each *class* ***label*** *is assigned* to respective window, and labels are identified.
- Final classification **results** are reported to the user.



Methods

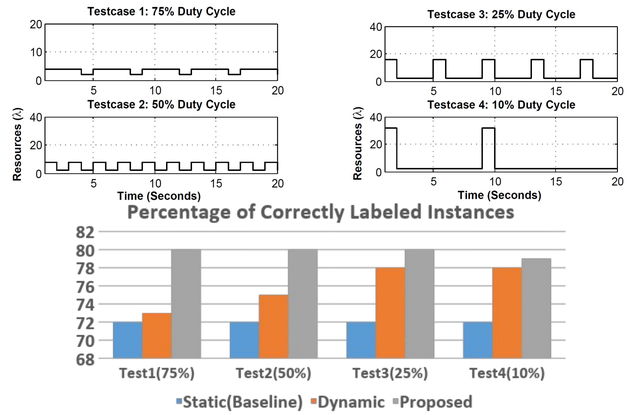


- Maximum achievable classification accuracy varies as a function of classifier **type,** classifier **dimensionality**.
- Maximum accuracy is the maximum value of the best performing classifier at a given feature size.



- We select the optimal classifier and feature count based on a particular performance constraint.

Results



- **Assumption**: Hardware resource availability fluctuates over time
- **Static**: uses a fixed maximum number of features satisfying least hardware resources
- **Dynamic**: as many features as possible are extracted for the most recent data segment
- **Proposed**: as resources become available optimize feature set of past data segments

Conclusions

We demonstrate a novel framework for real-time classification applications where accuracy of recognition is scaled as a function of available system resources.