Embedded real challenges As the number of people and the amount of data being produced grows, the challenges become:
- How to extract useful information for identifying health states
- How to integrate complex large data processing algorithms into a live power wearable device
- Embedded real-time processing is a must
  - Perform signal processing and classification right at the sensor instead of transmitting the raw data and therefore significantly saving communication power and storage requirements
- Increasing energy-efficiency (i.e. $\text{OPS} \times \mu \text{J}$), accuracy, and reliability requires innovations in algorithms, programming models, processor architectures, and circuit design
- Study methods to represent large volumes of medical time series so that the information they carry about health states is exposed
- Study the algorithms are best to extract that information and can be implemented efficiently
- Explore classification accuracy, computational complexity and memory requirements
- Study the implementation of the algorithms on different hardware approaches (e.g. FPGA, GPUs, and ASIC).

## Objectives

- Personalized health care depends crucially on continuous monitoring and processing of large volumes of data about individuals and populations.
- As the number of people and the amount of data being produced grows, the challenges become:
  - How to extract useful information for identifying health states
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## Wearable EEG Seizure Detection

- Electrical signals can be detected by EEG signals before or just at the start of clinical symptoms
- The ability to detect can be used to warn the patient or caregiver
- Implementation must be able to detect seizures and warn the patient or caregiver within one to two seconds after the electrical onset
- Each signal represents one channel from an electrode
- CH1 and CH2 detect seizures
- Complex algorithms and multichannel detection is necessary to remove false positives

## Detection accuracy comparison

- Comparison of different classifiers detection accuracy (F1 score) when single patient data is used for training and test

## Computation and Memory Complexity Comparison

- Complexity comparison between KNN, CNN, SVM, and LR relative to LR for Simple Features

## Feature Extraction and Classifiers Used

- Feature extraction
  - Total of 9 features of the dataset are derived from the raw time series signal
- Deep belief network (DBN)
  - Learn deep structures in the time-series data
- Classifiers
  - Classify the incoming DBN abstraction of the time-series with a certain class label
  - Support vector machine (SVM)
  - K-nearest neighbor (KNN)
  - Logistic regression (LR)

## Embedded Processors in the Big Data Infrastructure

- Wearable medical monitoring systems
  - Wearable medical monitoring systems that are small and seamless multi-physiological signal processing and monitoring integrated into patients daily life routine
- Data analysis
  - Real-time data analysis and diagnosis for efficient healthcare delivery
- Data delivery
  - Real-time data transmission to healthcare providers (e.g. nurses, primary care physicians, and first responders) through networks

## Smart Health Monitoring: Analysis & Delivery

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## Case study: Seizure Detection

- Epilepsy is the 4th most common neurological disorder and affects about 2.2 million in the US, and 1 in 25 people may develop epilepsy in their lifetime.
- Current ambulatory seizure monitoring devices are ineffective for long-term, continuous use due to large false positive/negative signals, noise due to patient activity, bulky equipment, high power consumption, and the inability of patients to carry on with their daily lives.

## Embedded real-time processing is a must

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