A KNOWLEDGE-DRIVEN FRAMEWORK FOR ECG REPRESENTATION AND INTERPRETATION

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SAiL

INTRODUCTION AND MOTIVATION

A unified model for ECG representation and interpretation

Motivation

ECG applications
- need for reliable representation
- need for interpretability

Wearable devices
- varying environmental conditions
- large amounts of data

Previous work
- basis function fit(Laguna et al '96)
- convex optimization(Polania et al '15)

Our approach

Signal representation
- sparse decomposition
- low dimensionality

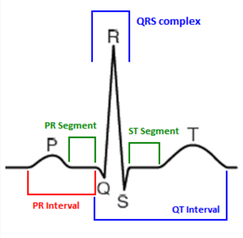
Dictionary design
- parametric atoms
- capturing different signal parts

Interpretation
- detection of meaningful components
- identification of abnormalities

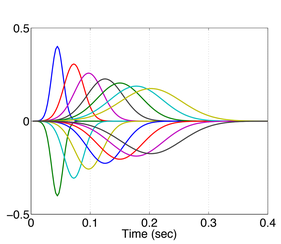
DATA DESCRIPTION

- MIT-BIH Arrhythmia (Moody & Mark '01)
- 48 subjects (30 mins each)
- human-derived annotations

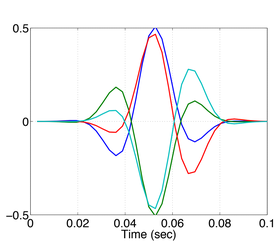
SPARSE REPRESENTATION OF ECGs



Typical ECG components



0th order Hermite



AM Sinusoid

Dictionary atoms
- 0th order Hermite (P/T)
- AM Sinusoid (QRS)
- Straight lines (level)
- 57817 atoms

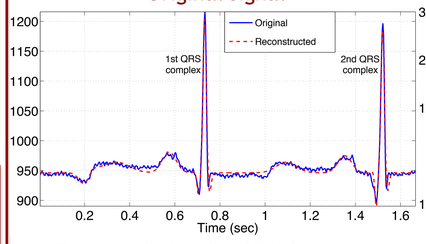
Sparse decomposition
- Orthogonal Matching Pursuit (OMP)

QRS DETECTION

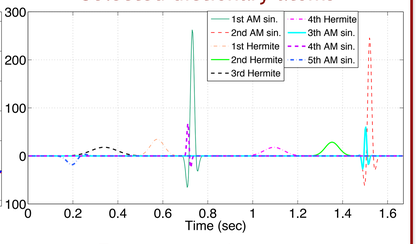
Heuristic approach
- Location/coefficients of selected AM sinusoids
- Histogram-based grouping wrt location of atoms
  - addresses false positives

Machine-learning-based approach
- Feature design
  - type/parameters/coefficients of selected atoms
- random forests (8-fold cross-validation)

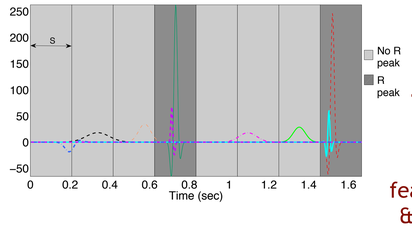
Original signal



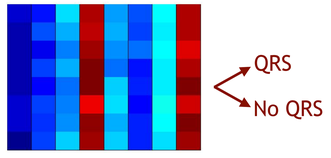
Selected dictionary atoms



Feature design for QRS detection



Feature matrix



feature matrix = type, parameters & coefficients of selected atoms

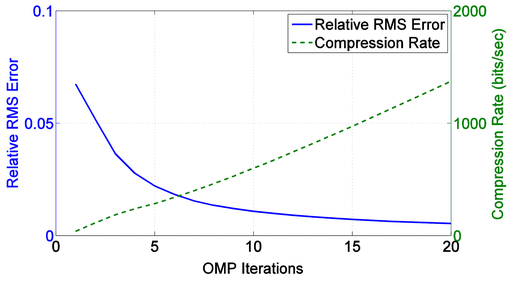
BEAT CLASSIFICATION

Features (20 total)
- closest selected AM sinusoid & 0th order Hermite
  - parameters, coefficients
  - distance from frame center
- R-R distance

Classification
- decision tree, leave-one-subject-out cross-validation
- binary: normal / abnormal
- 3-way: premature / paced / ventricular

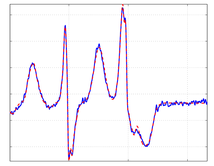
RESULTS

Signal representation

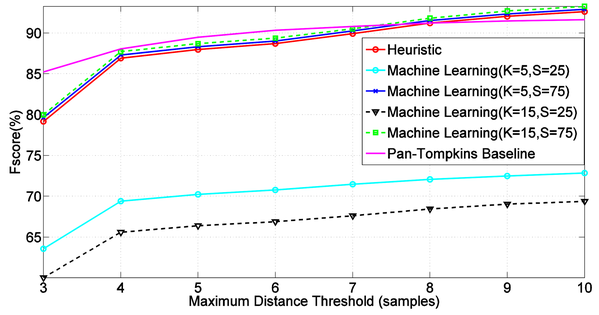


paced beat

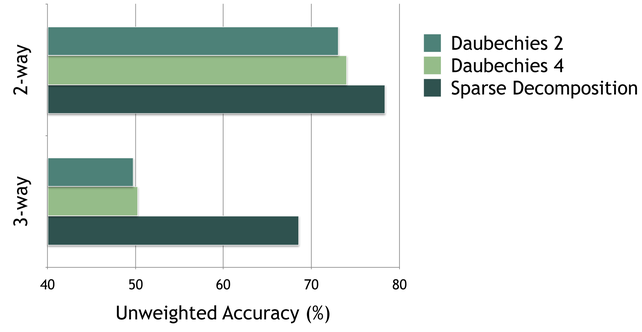
premature ventricular contraction



QRS detection



Beat classification



CONCLUSION AND FUTURE WORK

- Unified model: ECG representation & interpretation
- Sparse decomposition & parametric dictionaries
- Future work: data driven methods (e.g. NMF, EMD)

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