

Biomedical Signal Processing (BSP) Toolbox

BIOMEDICAL SIGNAL PROCESSING LAB
bsp.pdx.edu

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Overview

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- Introduction
- BSP Toolbox Architecture
- Documentation and Interface
- Detection Algorithms
- Spectral Analysis
- Nonlinear Filtering
- Multisignal Analysis
- Visualization Tools

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Introduction

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- Purpose: To develop a toolbox that enables researchers to conduct rapid preliminary analysis of physiologic signals.
- Implementation: All the BSP toolbox components were implemented in Matlab.

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BSP Toolbox Architecture

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```
graph TD; A["Common Biomedical Signal Processing Tools  
Linear filters (lowpass & highpass)  
Signal Resampling (Interpolation)  
Figure Formatting"] --> B["Detection Algorithms  
ECG (QRS)  
ABP/ICP Components  
Manual Annotation"]; A --> C["Spectral Analysis  
Blackman-Tukey  
Welch's Method  
Harmonic PSD"]; A --> D["Nonlinear Filters  
Median Filters  
Weighted Order  
Hybrid Filters"]; A --> E["Correlation Analysis  
Autocorrelation  
Cross-correlation  
Coherence"]; B --> F["Nonstationary Signal Visualization  
Spectrogram  
Pulse Morphology  
Coherence"]; C --> F; D --> F; E --> F;
```

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Documentation and Interface

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- Every function in the BSP Toolbox is fully documented following the same documentation template.
- Documentation includes the function syntax, input/output arguments, description of the algorithm, an example, and references.
- All functions share a common interface (standard function and variable names, standard handling of input and output arguments, etc)

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Test Data

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- The documentation in each function includes an example of the function applied to a sample signal.
- Test data used in the examples is provided with the BSP toolbox.
- Test Data includes ECG, ICP, ABP, etc. recorded at the Pediatric Intensive Care Unit of the Doernbecher Children's Hospital, Oregon Health & Science University (OHSU)

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Detection Algorithms

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- Contents
 - Building blocks used in detection algorithms such as filters, functions for maxima and minima detection, heart rate estimators, etc.
 - Automatic detection algorithms for pressure signals (ICP & ABP)
 - Automatic QRS detection algorithms.

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Spectral Analysis

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- Contents
 - Functions to estimate the PSD of a given signal using parametric and nonparametric methods (modified periodogram, Welch, Blackman-Tukey, Maximum-Entropy, etc)
 - Functions to estimate the heart rate from the arterial blood pressure, intracranial pressure, or the electrocardiogram signal, using spectral analysis methods.

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Nonlinear Filtering

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- Contents
 - General nonlinear filters such as ranks filters, trimmed-mean filters, hybrid filters, etc.
 - Image processing algorithms based on nonlinear filters to remove noise from the spectrogram and synthesize the signal in the time domain.

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Multisignal Analysis

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- Contents
 - Functions to estimate relationships between two signals, such as correlation, coherence, cross-spectral density, transfer function, etc.

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Nonstationary Visualization

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- Contents
 - Functions for nonstationary visualization, such as the spectrogram, cross-spectrogram, cross-correlation, pulse morphology, coherency, etc.

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Examples of Functionality

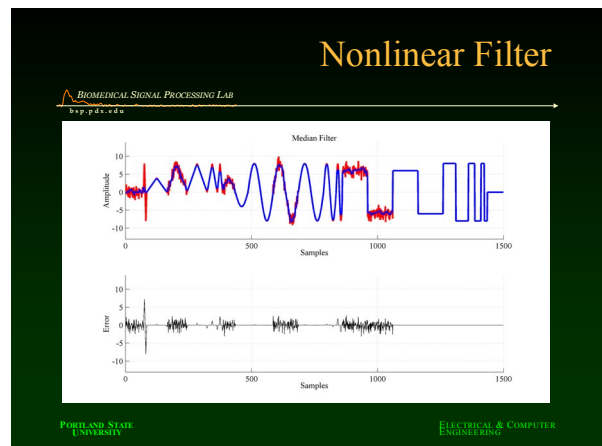
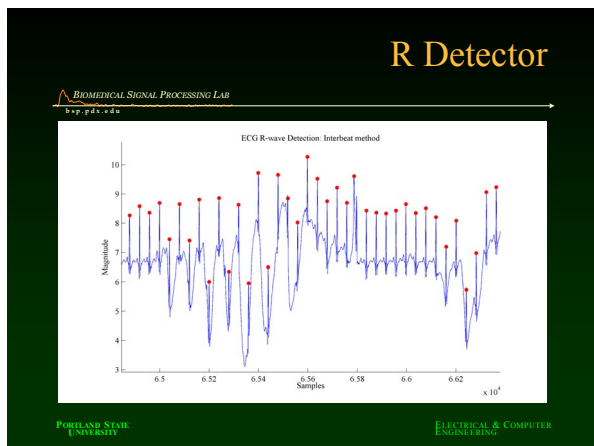
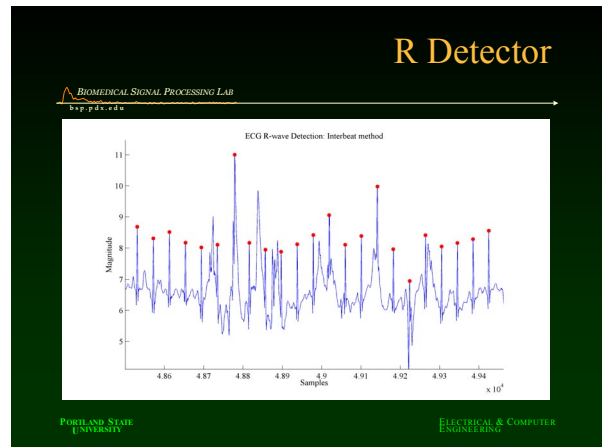
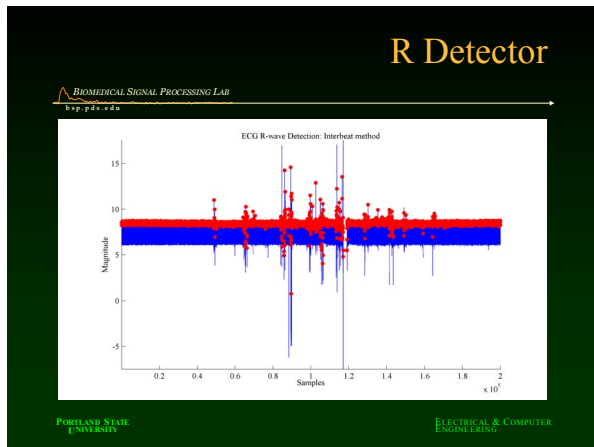
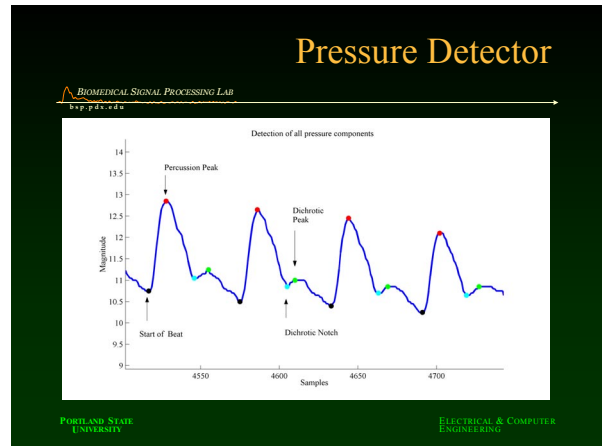
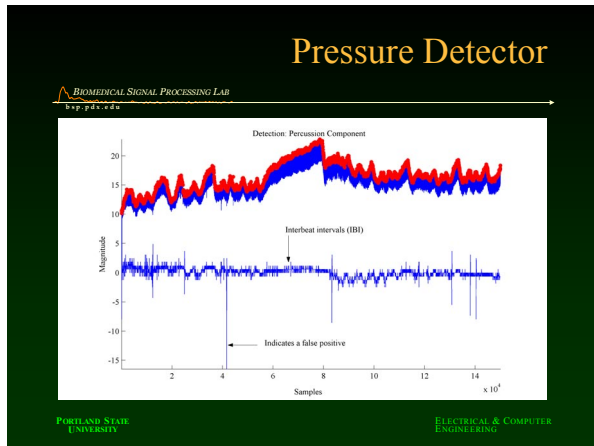
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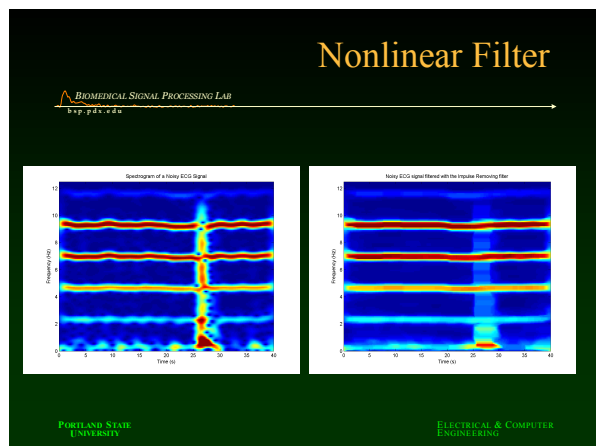
- Examples that follow are intended to give a flavor of the BSP toolbox functionality.
 - Pressure Detector
 - R Detector
 - Nonlinear Filters

Note: the examples include only four functions of the ~70 functions available in the first release.

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Summary

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- BSP toolbox developed by the Biomedical Signal Processing Lab at Portland State University, and the Complex Systems Lab at Oregon Health & Science University
- The BSP toolbox includes ~ 70 functions, intended for rapid preliminary research on physiologic signals.
- First release publicly available at <http://bsp.pdx.edu> . Second release scheduled for August 2002

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