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Minds in Motion

# Using Multimedia, Wireless and Sensor Technology to Develop Novel Healthcare Solutions

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TATA

# Presentation Roadmap

**Introduction**

Use Case Scenarios

Components

Implementation and Demo

# Vision and Mission

- To make Cardiac Health Care more patient centric than hospital centric
- To apply advances in the areas of Multimedia, Mobile Technology and microelectronics to bring expert cardiac health care to rural masses.
- To design and develop a prototype of TCS Cardionet as proof of concept
- To conduct field trials at various hospitals in the country and arrive at comprehensive product specifications

# Motivation

- Lack of specialized cardiologists at primary health centers
- Need of a low cost solution for the rural masses
- Need for constant cardiac monitoring

# The Solution

- A low cost secondary e-consultation service
  - Augmented by a centralized Decision Support System (DSS)
  - Assists medical practitioners to expedite interpretation and diagnosis of cardiac ailments
- Intended to provide life saving gadgets at low cost
- Aims at providing low cost telecardiology services
  - To the rural masses of the country at their door steps
  - To the ambulatory patients

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# Intelligent Cardionet

Patient in Ambulance

Hospital

Patient at Home

There is need for collaboration with doctor

- In real-time
- In a cost-effective manner
- Using low-bandwidth

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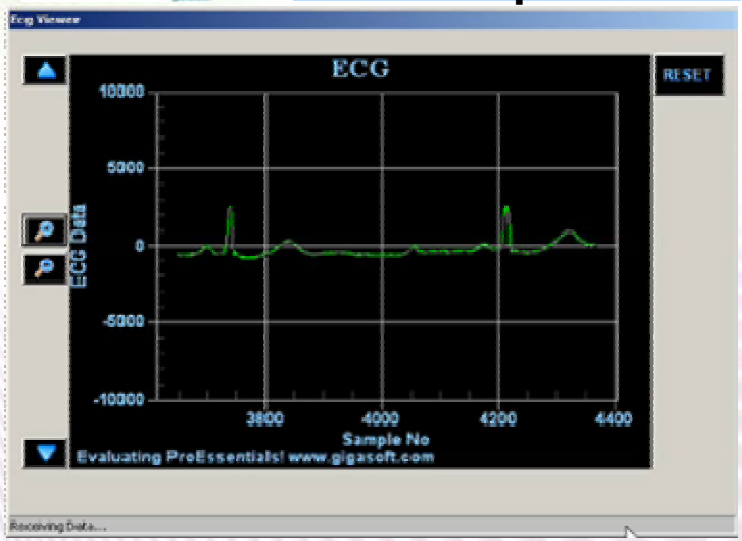
# Patient @ Home

Patient at Home

Hospital

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# Patient @ Ambulance

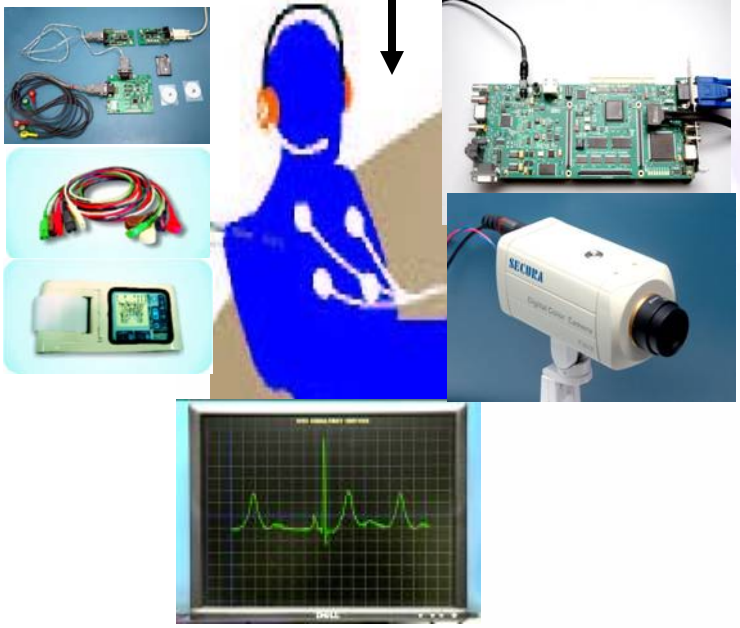
Audio/Video and ECG data from ambulance

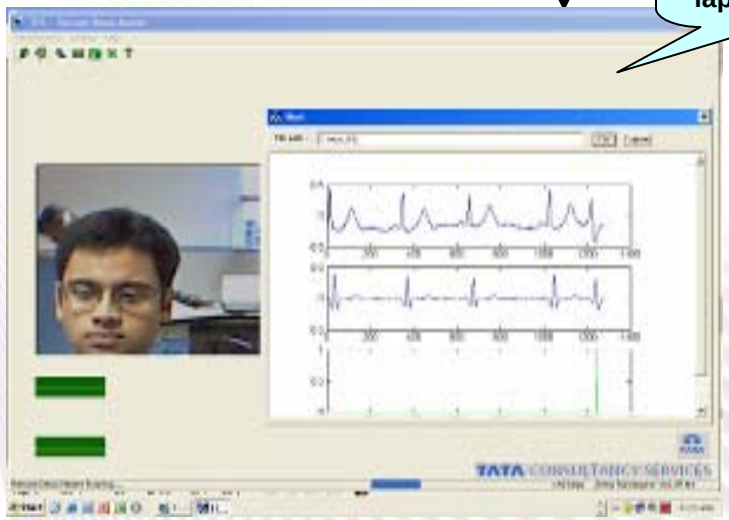
Audio data from doctor

**Patient in Ambulance**

**Hospital**

Doctor's View at his laptop/desktop





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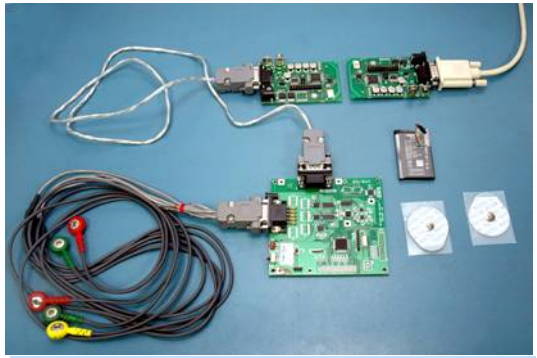
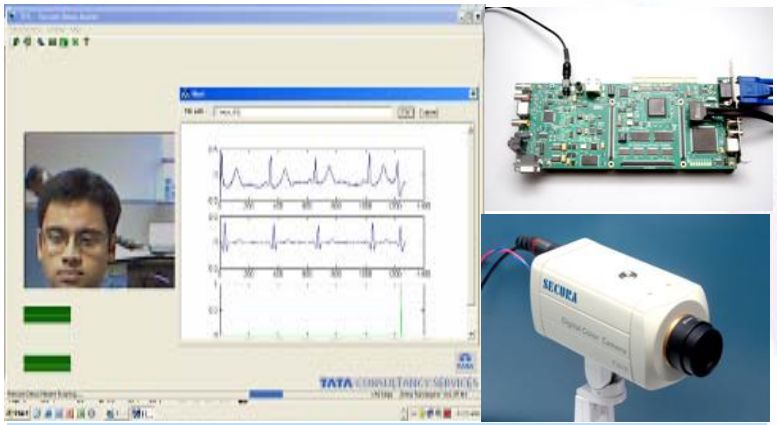
# Components

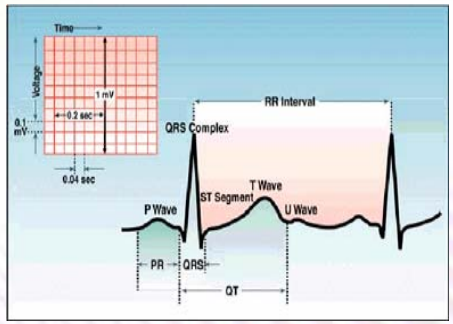
1/3/12 Lead Wearable ECG Recorder



12 Lead, ECG Recorder



Remote Video Consultation System




ECG
Decision Support System

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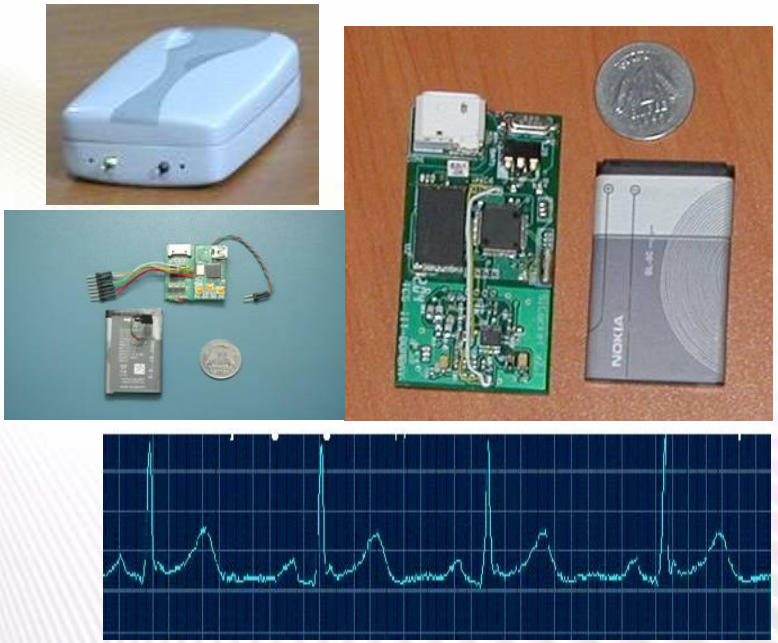
# 1/3/12 Lead Wearable ECG Recorder

- MSP430F149: 16 bit Ultra low-power microcontroller from TI
- Sampling rate of 360 samples per second
- 12 bit A/D Converter
- 32 MB Flash for data storage
- 3.7V mobile battery
- Low Power
- Low-cost
- Lightweight

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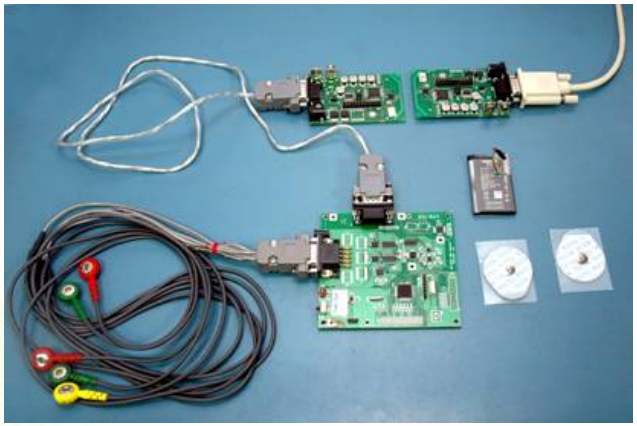
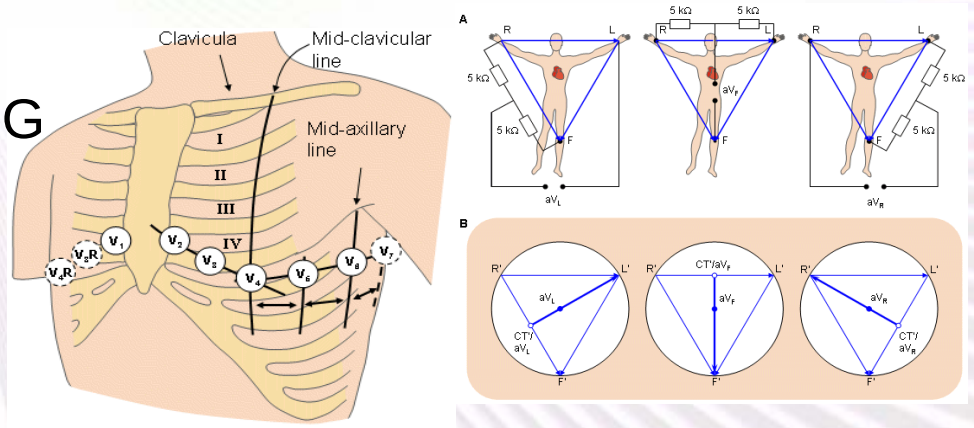
# 12 Lead Recorder

- 12 Lead ECG System
- Leads: I, II, III, aVR, aVL, aVF, V
- Standard Calibration pulse
- Gain adjustment in ½ and 1 gain modes
- Acquisition of ECG @ 256 samples per second
- Thermal Printer for printing ECG on graph (at std rates of 25mm/sec, 50mm/sec)
- Battery powered and Internal battery charging
- Portable



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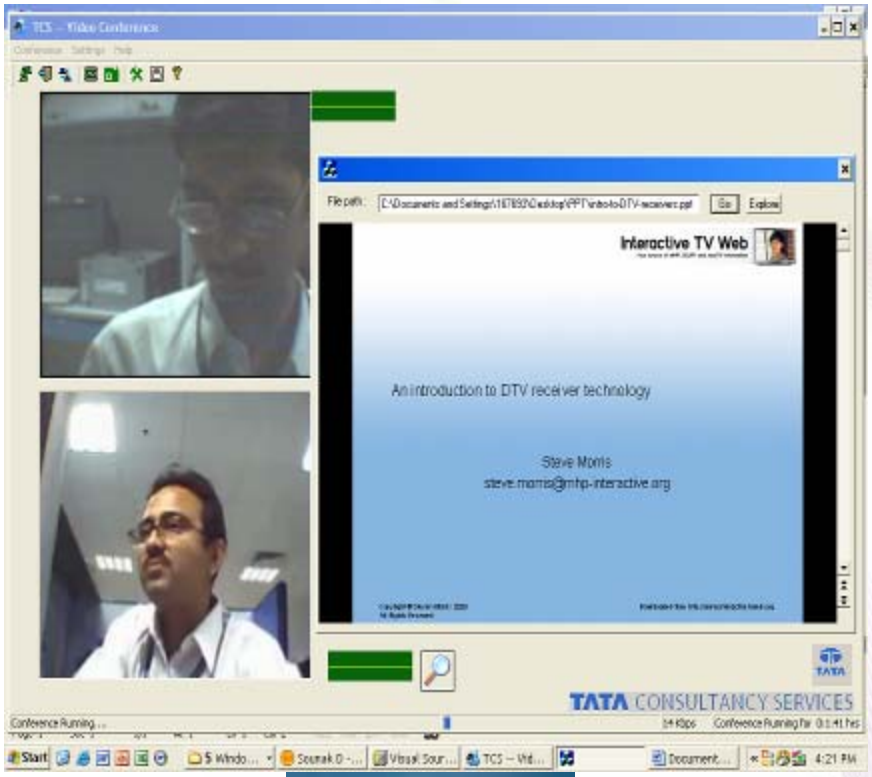
# Remote Video Consultation System



- H.264 based video, AMR based audio
- Constant bit-rate (CBR) and Variable bit-rate (VBR) support
- Low-bandwidth/High-quality
- Proprietary error resilience algorithms for robust performance
- On-way or two-way video
- Instrumentation Signals / any other application data can be shared remotely

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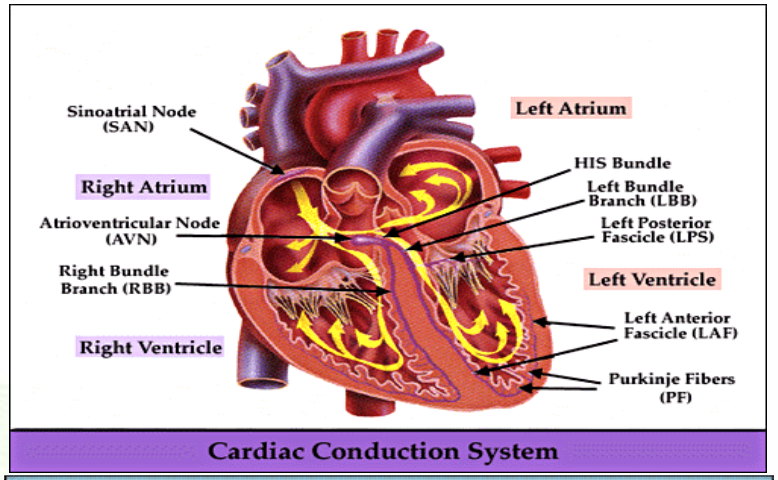
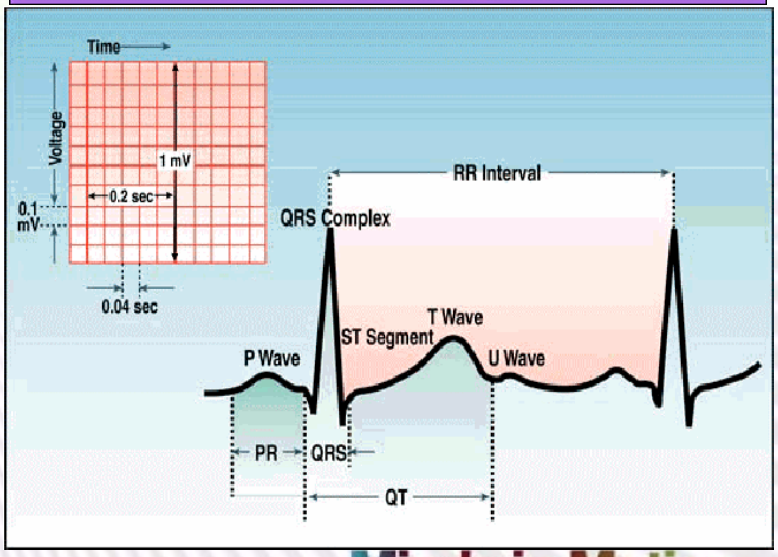
# DSS - Cardiac Ailments

- Tachycardia (Supraventricular and Ventricular)
- Bradycardia
- Premature Ventricular Contraction (PVC)
- R-on-T
- Various types of blocks (SA block, AV block, LBBB, RBBB)
- ST segment changes (Ischemia, MI)
- Fibrillation
- Electrical Axis Deviations



Cardiac Conduction System

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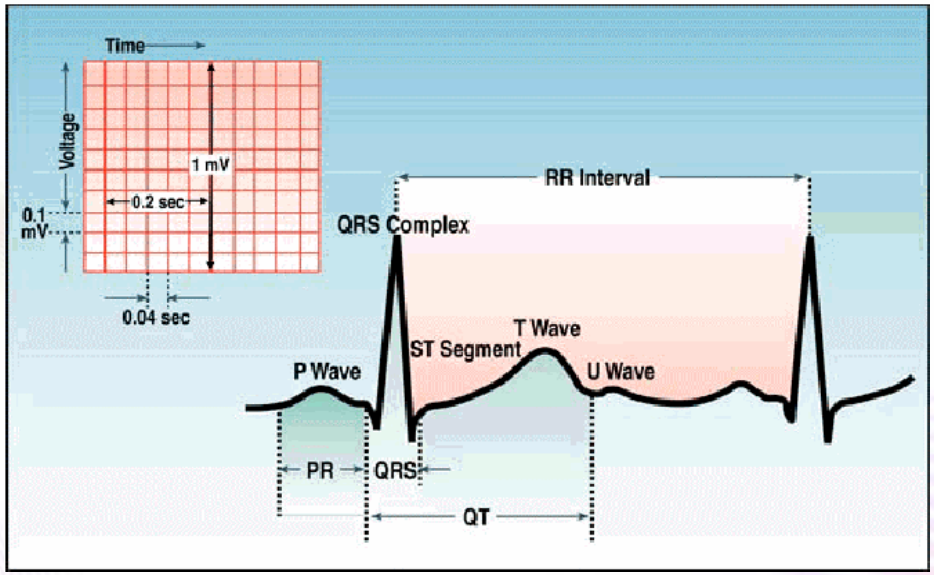
# DSS for PVC

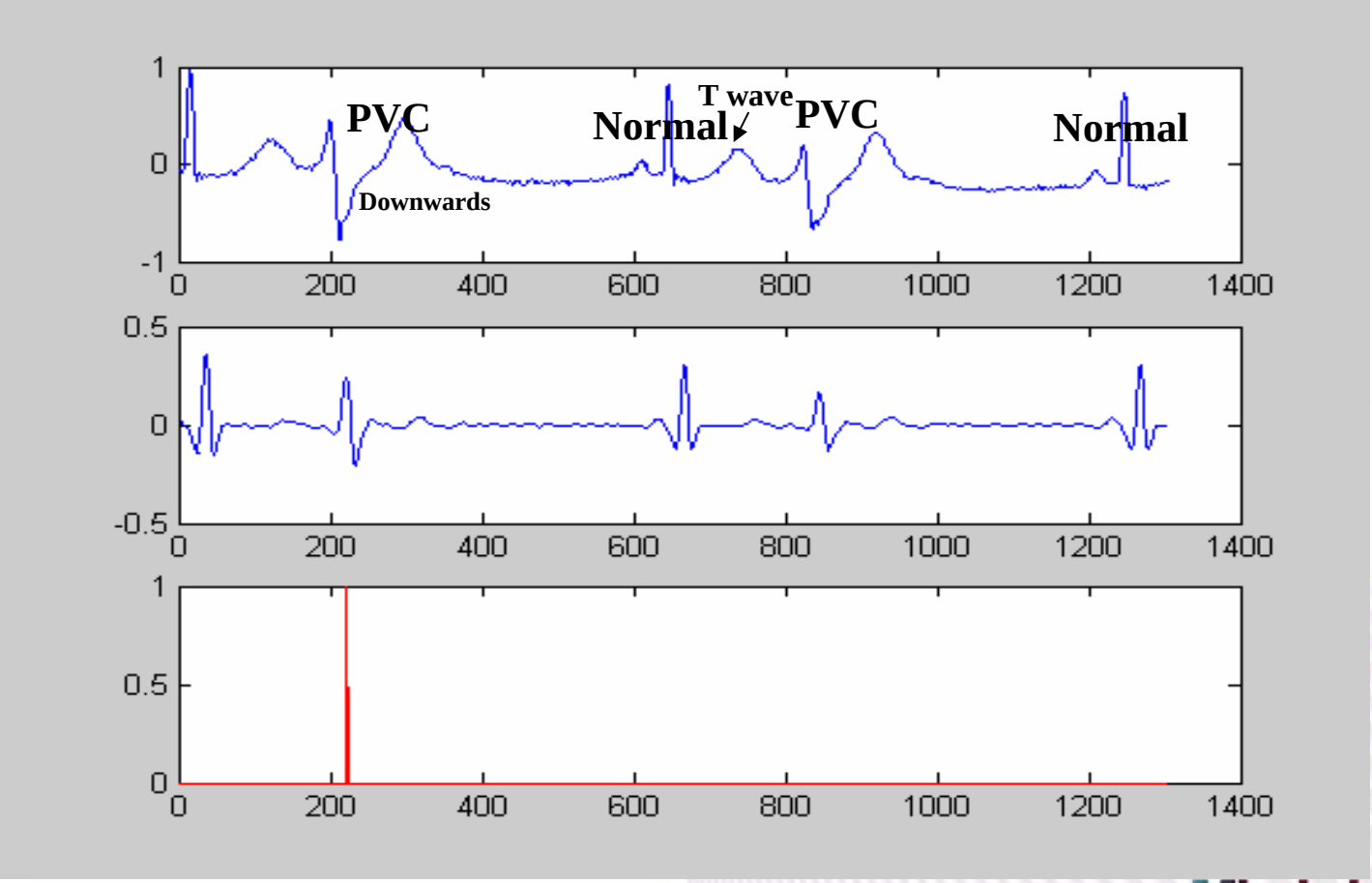
- Premature Ventricular Contraction (PVC)
- This implies Ventricular Contraction takes place before Atrial finishes its function (Premature)
- The algorithm is based on single lead of information (Modified lead II information from MIT Arrhythmia data base)
  - Record Length 30 minutes
  - Samplingrate:360/samples/sec

# Features of PVCs

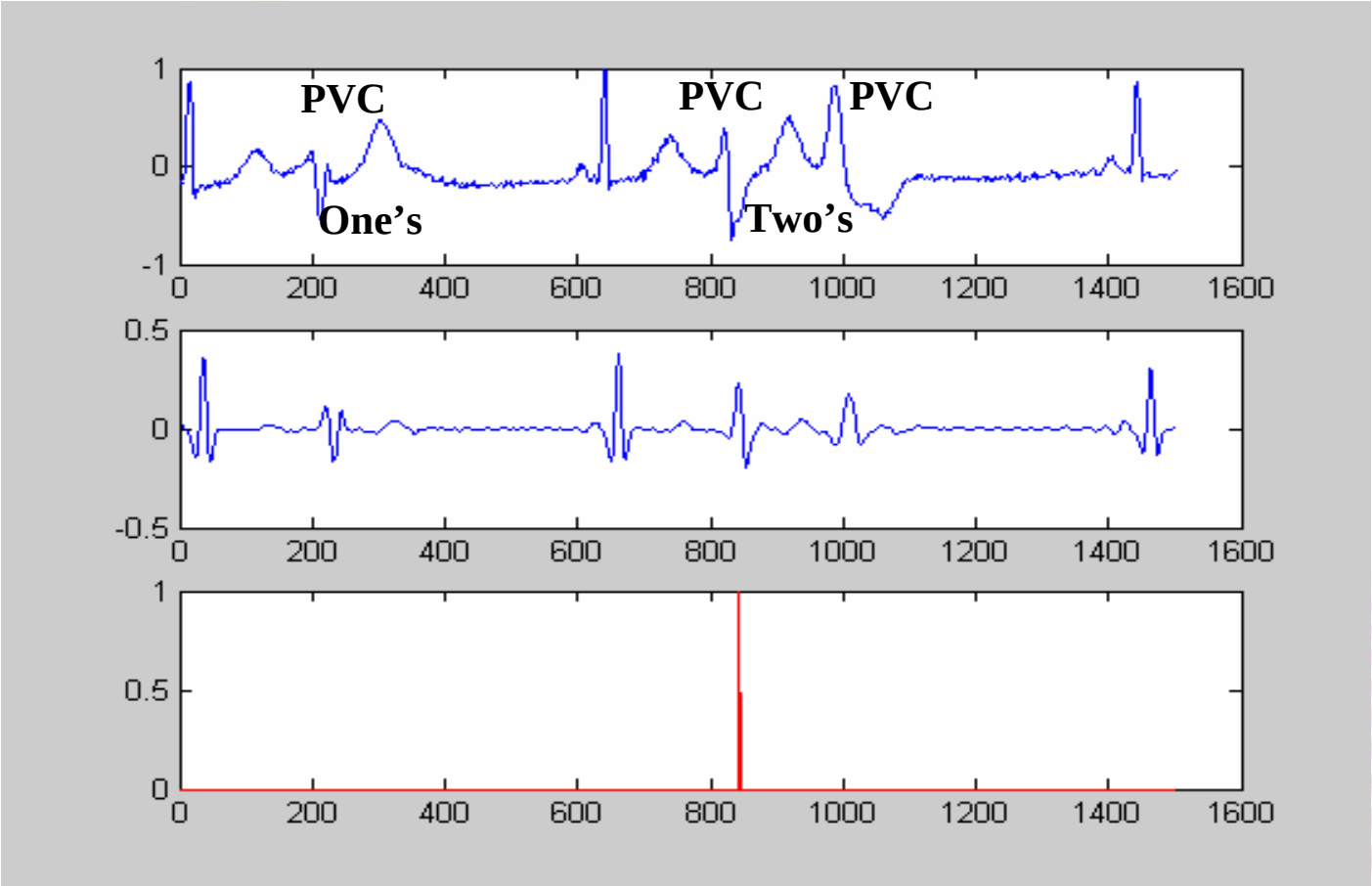
- Change in RR interval
- Absence of P wave
- Bizarre Wave shape
- Unifocal or Multifocal
- Can occur in groups of one's or two's



# Occurrence of PVCs in groups of one's



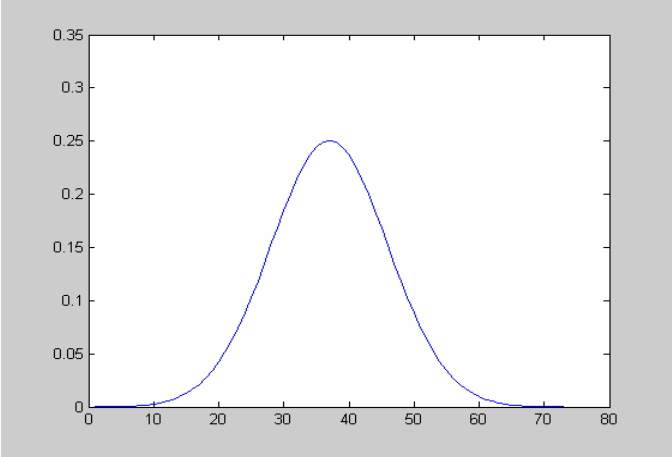
# Occurrence of PVCs in groups of two's

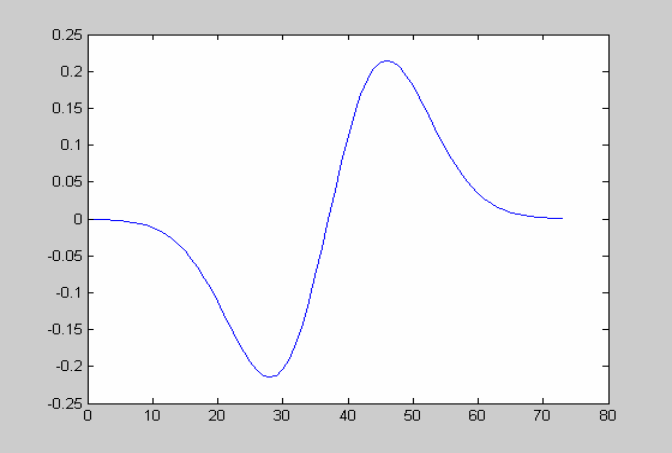


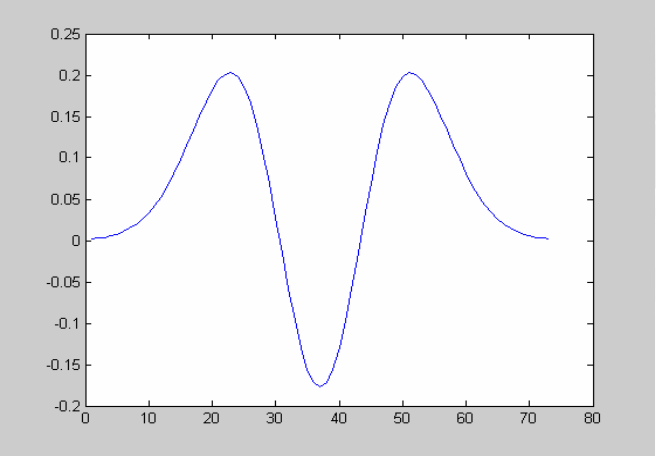
# Detection Strategy

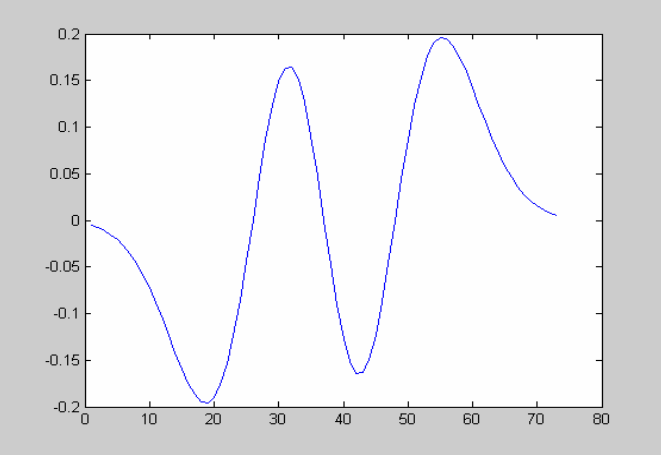
- Arrhythmia Detection (Tompkin's Algorithm)
- Detection of Absence of P waves
- Detection of Bizarre Wave shape using Hermite transforms
- Similarity measurements using coherence function

# Hermite Basis Functions



# DSS Agents

The functions of various DSS agents

- Detection of QRS complex
- Measurement of RR interval and detection of Arrhythmia
- Detection of bizarre QRS complexes
- M-shape detection
- Negative peak detection
- Detection of bi-phase QRS complexes
- Detection of fibrillation related oscillations
- Computation of Hermite transform of QRS complexes
- ST segment measurements
- Computation of KL Transform

**One or more agents facilitate detection of cardiac ailments**

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**Implementation and Demo**

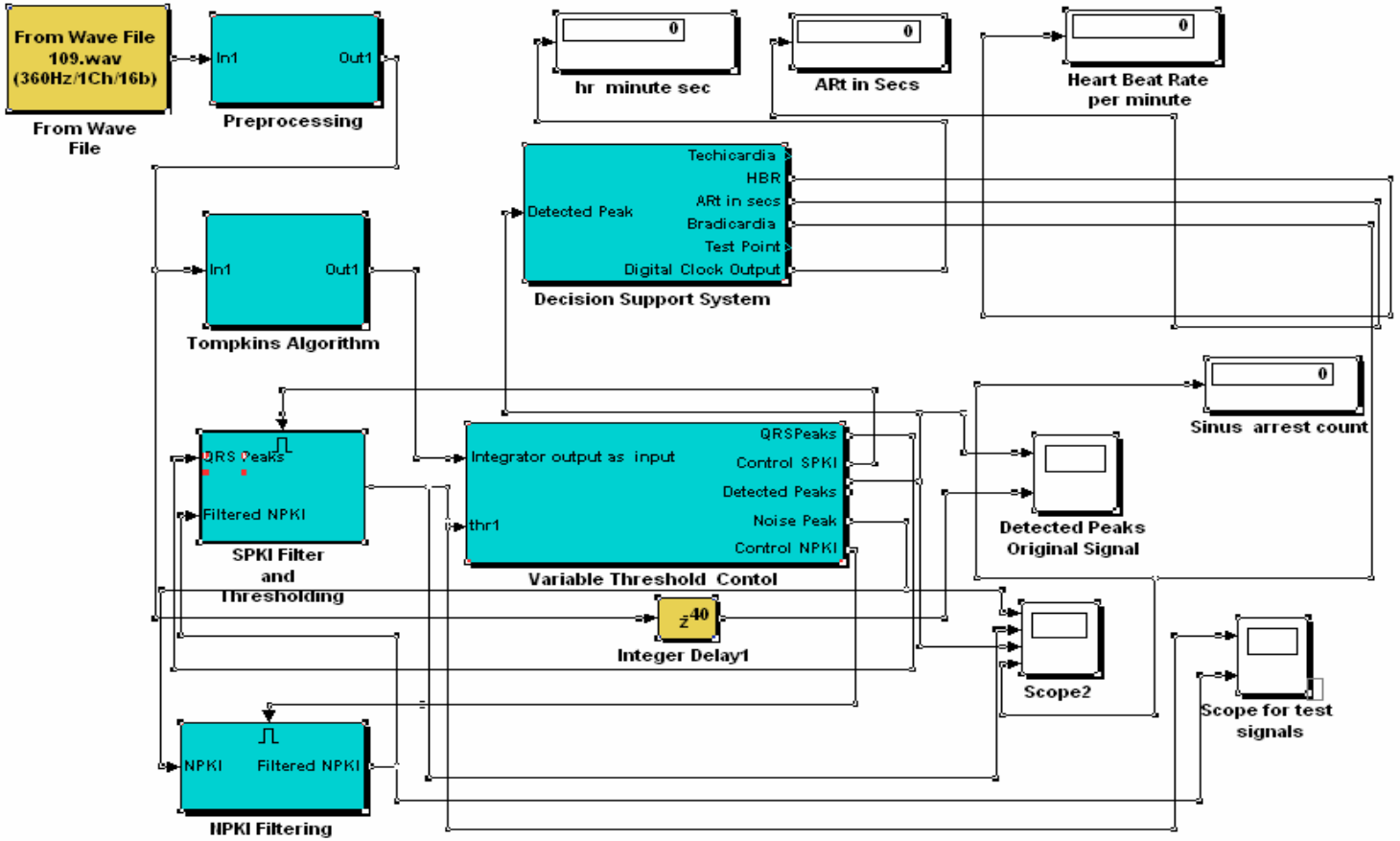
# Implementation

- Stand-alone DSS (PVC) on MATLAB, PC and 64x
- Remote Video Consultation System on PC and DM642

Patient @ Ambulance

- Ambulance side system on
  1. DSS on Laptop with Video Camera
  2. DSS on DM642 with Video Camera
- Doctor's Viewer on PC

# DSS on MATLAB/Simulink



# Value-Add

- 90% to 95% sensitivity and specificity on MIT-BIH database
- Embedded DSS optimized to work with low resource requirements
- Analysis by Embedded DSS in real-time and meant to pre-warn catastrophic and premonitory arrhythmias

# Future Work

## Implementation

- Porting of other cardiac disease detection functionalities of DSS on DSP
- Porting of DSS on DA224 Ultra-low-power DSP

## Research

- Application of wavelet transforms and Hermite functions in the detection of more cardiac ailments
- Application of Self Organizing Maps in the classification of cardiac ailments
- Agent based DSS

# Future Work - Agent Based DSS

- A set of sensor nodes
  - Each element of the set executing the function of a specific agent
  - Will aid in the detection of cardiac ailment through collaborative processing
- Coordination through high level Petri Nets Supporting dynamic changes

# Reference Database

- MIT Data base – www.physionet.com
- European ST Data base - www.physionet.com

# Thank you!

## Any questions, please?

Contact: arpan.pal@tcs.com

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