Intelligent Medical Platform for clinical decision making

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I. Introduction
II. Intelligent Medical Platform
III. Case Study: Cardiovascular Silo
IV. Summary
Introduction
Introduction: Big Data in Healthcare

Implication:
- Big data usage in healthcare is rapidly growing
- Each personal will provide various kinds of health data which average hospital will store about 665TB of data by 2015 → **Big data processing technique will be essential**

Source:
Introduction: AI in Healthcare System

- **IBM Research Project (2000 - )**
- **Jeopardy! Grand Challenge (Feb 2011)**
- **Watson for Financial Services (Mar 2012 - )**
- **Watson Industry Solutions (2012 - )**

- **R&D**
- **Demonstration**
- **Commercialization**
- **Expansion**
- **Cross-industry Applications**
Introduction: Healthcare Technologies

Existing Wellness and Healthcare Systems

Medical Education

Diagnostics & Treatment

Physician and Patient Assistance

Notification & Reminders

Laboratory Test Assistance

Data Analysis

Fitness Measurement

Salient Features

Food Recommendation

Activity Tracking

Voice Notifications

Healthcare Technologies

- Speech Processing
- Image Processing
- Data Analytics
- IoT devices Interaction
- Rule-base Reasoning
- Knowledge Integration
- Body Recognition
- Telemedicine
Introduction: Mobile Healthcare Markets

Mobile Healthcare Competitors

*Source: Allied market research, Statista 2016*
Introduction: Requirements of Healthcare

- Stability
- Secure
- Personalization
- Credibility
- Precision
- Transparency
- Context Awareness
- Easy to Use

Introduction: Our Research Goal

❖ Intelligent Medical Platform (Smart CDSS)

❖ Novel Knowledge Acquisition (Data Driven + Expert Driven)

❖ Knowledge Engineering Tools (V&V, Maintenance)

❖ Medical Knowledgebase Silo Construction
Introduction: Definition of CDSS

Social Needs
- Quality of Medical Services
- Reduce Medical Cost
- Efficiency & Safety

Solutions
- CDSS

Expected Impacts
- Improve quality of healthcare delivery
- Save Medicare cost
- Reduce medical malpractices

Evidence-Based Medicine
- Decision Making
- Clinical Practice Guidelines
- Efficiency of healthcare delivery
- Patient Safety
Introduction: CDSS Market Trends

- The global clinical decision support systems (CDSS) market size was valued at USD 471.96 million in 2016. Rising demand for quality care and integrated reliable technical solutions is one of the key trends escalating market growth.

- Healthcare Artificial Intelligence Software, Hardware, and Services Market to Reach $19.3 Billion Worldwide by 2025

https://www.grandviewresearch.com/industry-analysis/clinical-decision-support-system-market

Introduction: CDSS in General
Introduction: Decision Support in Medical Platform

Seoul National University Bundang Hospital, Korea

✓ Knowledge at the point of care  
✓ Apply the best evidence  
✓ Serve as a peripheral brain - assist  
✓ Decision making – enhance communication  
✓ Improve Healthcare processes and outcomes

https://www.researchgate.net/figure/Scheme-of-the-clinical-decision-support-system-CDSS-based-u-healthcare-service-The_fig1_275836182
Medical Knowledge is used in the wood-grain, being sure to keep the freshness, adaptability, and always will be, to be able to be present in most commercial reliability medical expert system knowledge base does not have these characteristics.

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<th>Knowledge base requirements</th>
<th>Detail</th>
<th>CASE</th>
<th>Final requirements</th>
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| **Integrity**               | There should be no Rule (knowledge generation) is flawed  
  — Rule should reflect the complete medical knowledge  
  — the Rule is an actual medical environment there should be no shortage of ships to... | Rule DB built without sufficient medical knowledge Nonsense | **Medical staff directly Knowledge be able to create and maintain** |
| **Adaptability**            | Rule must be customized according to hospital environment - It should be customizable according to the situation of available resources (medical equipment, inspection equipment, etc.) by medical environment | Depending on the equipment the hospital has, the test method / treatment method / operation method varies. | |
| **Freshness**               | Easy to update new knowledge  
  - Each time a new treatment, prescription, or surgical procedure are derived, the rule should be updated on these matters. | An update to a new rule Easy to handle | |
| **Reliability**             | Must have sufficient credibility  
  - Knowledge to be used should be sufficiently reliable by certified papers, clinical trial data, or EMR inference data. | It should be based on papers, clinical trial data from pharmaceutical companies, and EMR inference data | **Evidence Based** |
Intelligent Medical Platform (IMP)
Motivation of Intelligent Medical Platform (IMP)

Limitations (Data Driven)
- Poor Knowledge Accuracy Issue
- Difficult to know how to decision making

Limitations (Expert Driven)
- Hard to Knowledge Maintenance
- Difficult to Validate & Verification

How to Create / Maintain

Knockledge Engineering

Knowledge Acquisition
- Reduce Errors
- Reduce Cost
- Improve Efficiency

Knowledge Validation

Knowledge Sharability

CDSS
- Inference Engine
- Knowledge Base
- Hospitals
- Caregivers
- Physicians
- Laboratories
- Insurances
- Pharmaceuticals
- Industries
- Business
- Games

Create/Update

Knowledge Engineer
- Dialogue
- Domain Expert

Gets Knowledge from guidelines

Motivation of Intelligent Medical Platform (IMP)
Clinical Decision Support Systems

Patient education

Clinical diagnosis

Intelligent Communication

Existing Medical Systems

Limitations

- Restricted Knowledge Acquisition Methods
- Difficult to Knowledge Construction by Domain Experts
- Minimum level of Evidence Support
- Lack of User Interaction
- Lack of Interoperability for Heterogeneous HIS

(Data Driven + Human Driven) Knowledge Acquisition

Support Knowledge Authoring Tools

Evidence Support from PubMed

Support UI/UX Tools

Standard based Interoperability

Intelligent Medical Platform

Approaches of IMP
Intelligent Medical Platform Environments

- **Intelligent Medical Platform**
  - Knowledge Engineering Tool
  - Analytics Tool
- **Heterogeneous Input Data**
  - Lifelog
  - Knowledge base
- **Big data Storage**
  - Lifelog
- **Evidence Support Tool**
  - UI/UX Authoring Tool
- **8 Medical Services Silo**
  - Thyroid Cancer Silo
  - Head & Neck Cancer Silo
  - Cardiovascular Silo
  - Diabetes Silo
  - Epilepsy Silo
  - Lung Cancer Silo
  - ENT (Ear, Nose, Throat) Silo
  - Public Health Silos

- **Smart Watch**
- **Blood pressure device**
- **Sleep Monitoring Device**
- **Glucose Meter**
- **Unstructured Text**
- **Medical PACS**
- **Patient Profile**
- **Patient Healthlog**
- **EMR/EHR**
  - Patient
  - Physician
  - UX Expert

**Intelligent Medical Services**
Core-1 : Component Architecture

Knowledge Acquisition and Inferencing Layer

Image-based Knowledge Acquisition
- Defect detection
- ROI Allocation
- Deep Learning based Model Collation
- Segmentation
- Image Preprocessing

Structured Knowledge Acquisition
- Data Preprocessing
- Algorithm Selection
- Rules Generator

Descriptive Knowledge Acquisition
- Text Preprocessor
- Terms Extractor
- Ontology Manager
- Semantic Analyzer
- Knowledge Integrator

Dialogue-based Knowledge Acquisition
- Input Handler
- Sub-Discourse Builder
- Intent Manager
- Knowledge Coordinator
- Output Handler

Actionable Knowledge Evolution and Inferencing
- Knowledge Controller
- Knowledge Inference Engine
- Knowledge Evolution Engine
  - RDR Rule Base

High Level Context Recognizer
- Context Builder
- Context Reasoner
- Context Ontology Manager
- Context Notifier

Low Level Context Recognizer
- Data Router
- Activity Unifier
- Emotion Unifier
- Context Notifier

Core-1

Visual documents
- Image Data
- Medical Image Repository

Structured data
- Structured Data
- Data Preprocessing
- Algorithm Selection
- Rules Generator

Unstructured data
- Unstructured Data
- Unstructured documents

Dialogue data
- Dialogue Data
- Multi-modal data sources

Rules / Patient Case

Knowledge Engineering Tool
Core-2: Implementation Workflow

**Actionable Knowledge Acquisition**
- **Knowledge Authoring Studio**
  - Rule Editor
  - RDR Editor
  - MLM Editor
  - MLM Generator

**Data Analytics**
- **Visualization Enabler**
  - Visualize/Transform
- **Data Transformation**
  - Identify trending parameters
  - Analyze parameter values
- **Statistical Analyzer**
  - Classify parameter

**Uniqueness**
- Visualization for physician and patients
- Statistical and trend analysis of lifelog

**Knowledge Button**
- Quality Recognition Model
  - Related MLMs
  - High Quality Articles

**Executable Environment**
- MLM Invoker
  - Inference Controller
  - MLM Broker

**MLM Augmented Maintenance**
- MLM Validation Handler
  - MLM Augmented CBR
- MLM Loading Interface
  - MLM Case Base

**Knowledge Repository**
- Structured MLM
  - Validated MLM
  - MLM Case

**Data Acquisition and Persistence Layer**
- Log Repository
  - Retrieve Parameters

**Service Integration Manager**
- Recommendation Request / EMR

**Knowledge Authoring Studio**
- Suggested Technology
- Posses Technology
- Existing Technology

**Differentiation**
- Semantic Reconciliation model
- Automatic MLM Generation

**Uniqueness**
- Visualization for physician and patients
- Statistical and trend analysis of lifelog

**Recommendation**
- Recommendation
- Standardized EMR Input

**Evidence Request**
- Evidence Request
Core-3: Component Architecture

Data Acquisition & Persistence
- Multimodal Data Processing
  - Data Acquisition
  - Lifelog Analysis
  - Healthlog Monitoring
  - FHIREnable Data Compliance

Big Data Storage Processing
- Semantically enriched
- Synchronous Interventional Data (EMR, EHR, Documents)
- Multimodal data sources

Documents Library
- Query Writer
- Log Sync
- Query Library
- Data Persistence
- Passive Data Reader

Security & Privacy

External Wellness Services
- Lifelog Fetch
- Lifelog Accumulator
- Lifelog Repository

Observatory Data source(s)
- ECG
- Glucose Level
- Blood Pressure
- Smart Watch
- Raw sensory & Environmental Variables

Interventional Data source(s)
- Image Data
- Structured Data
- Unstructured Data

Health Situation monitoring
- Healthlog
- Persistence
Core-3: Implementation Workflow

Knowledge Extraction

Uniqueness
- Real time active health-log monitoring

Big Data Storage Processing

Data Persistence
- Acquire Content
- Build Content
- Index Content

Query Writer
- Request to Read & write data

Query Library
- Retrieve streaming Data

Log sync
- Request to write data
- Run Query over HDFS

Hive Metastore

External Wellness Services
- Lifelog Fetch
- Lifelog Accumulator

Executable Environment
- Analysis report

Security & Privacy
- soft real-time data read from Big data storage

Uniqueness
- Uniqueness

Data Acquisition
- Observatory Data
  - Raw Data Buffer & Synchronizer
  - Medical Device Manager

Multimodal Data Processing

Lifelog Analysis
- Healthlog Monitoring

Mapping & Representation
- FHIR Enable Data Compliance

Environmental Variables
- Smart Watch
- Raw sensory & Environmental Variables

Data Persistence

Structured / Unstructured/ Non-textual data

Multi-modal Data Sources
- Observatory Data
- Interventional Data

Structured Data
- Image Data
- ECG
- Glucose Level
- Blood Pressure

Unstructured Data

Security & Privacy
Core-4: Component Architecture

Client Side Components
- Toolkit
- Client Side API
  - Client Side Caching Engine
  - Feedback Monitor
  - Behavior Monitor
  - Context Monitor
  - UI Presenter

Server Side
- Decision Components
  - Server Side Caching Engine
  - Feedback Evaluator
  - Behavior Evaluator
  - Context Evaluator

- Adaptation Components
  - Adaptation Engine
  - Trade Off Manager
  - UIDL

- Data base
  - Feedback data
  - Behavior data
  - Adaptation Rules

User Interface Models
- Task Model
- Abstract Model
- Concrete Model

Client Side Caching Engine
Feedback Evaluator
Behavior Evaluator
Context Evaluator
Adaptation Engine
Trade Off Manager
UIDL
Feedback data
Behavior data
Adaptation Rules
User Interface Models
Task Model
Abstract Model
Concrete Model

Knowledge Engineering Toolkits
Client Side
User Interface
Core-4: Implementation Workflow

Knowledge Engineering Tool

Client Side
- User Interface
- Context Monitor
- Dynamic Parameter values
- UI exist in cache
- Load cache
- Behavior Monitor
- Feedback Monitor
- Cache Engine
- Feedback Data
- Adaptation Rules
- User Interface Models
- UI Authoring Tools

Server Side
- Cache Engine
- Report change
- Adaptive UI
- Predefine parameter values
- Server-side Cache
- Final UI
- UI exist in cache
- Behavior Monitor
- UI Presenter
- Client-side Cache Engine
- Final UI
- Task Model, Abstract UI, Concrete UI, Feedback data, Behavior Data
- User Interface Models
- Database
- Load

End User

Request UI

Suggested Technology
Posses Technology
Existing Technology
Core-5: Component Architecture
Core-5: Implementation Workflow

**Mapping Algorithms:**
- String Matching
- Label Matching
- Child Matching
- Property Matching
- Synonym Matching
- Sibling Matching

**Uniqueness:**
- Scalable mapping repository to store alignments
- Change management mechanism for handling the evolution of standard models

- Dynamic interfaces for converting legacy formats to standardized format
- Big data persistence services in a standardized format for interoperable communication

**Components:**
- Input Adapters
  - Query Generator
  - Device Adapter
  - EMR Adapter
- Output Converters
  - Structural & Semantic Transformation
  - EMR Output Format
- Interoperability Adapter
- Automatic Mapping Authoring
  - Mapping Repository
  - Generalized Mappings
  - Customized Mappings
- Models
  - Evolved Concepts
  - Ontology
- Change Detector
- Change Collector
- Change Formulator

**HMIS:**
- LIS
- Pharmacy
- Pat. Charting
- Data Exchange
  - Data Exchange WS
  - HL7 Exchange Service
- Clinical Models
- EMR/PHR

**Core 2:**
- (Schema) Ontologies

**Core 3:**
- Uniqueness
- Change formulator
- Device adapter
- Query generator
- EMR adapter
- EMR output format

**Off line Process:**
- Change detector
- Change collector
- Change formulator
- Evolved mapping
- Evolved concepts
- Ontology

**On line Process:**
- Legacy EMR recommendation
- FHIR format recommendation
- EMR input
- Mappings
- Mapping repository
**Uniqueness: Knowledge acquisition in IMP**

**Dialog Manager**

- Patient MRI Image Analysis

**Knowledge Acquisition**

- Cloud Endpoint

**Machine Learning**

- Image Data
- Structured Data
- Unstructured Data

**Cloud Endpoint**

**Knowledge Base**

**Knowledge Authoring Tool**

**Domain Expert**

**Expert Driven**

**Data Driven**

**Existing Systems Limitation**

1. It provides way of communication only
2. Deep learning algorithm cannot provide reason of decision making (Black box)
3. Lack of verification and validation for huge number of rules.

**Solutions**

1. Extract knowledge from users dialogue
2. Using white box AI techniques to create knowledge base
3. Incremental knowledge acquisition using MCRDR
Uniqueness: Engineering Tool’s Support

- Incremental Learning-based validation and verification
- Intelli-sense support

- Overall UX quantification over time
- Adaptive UI based on UX

- Evidence support form PubMed
- Quality assessment retrieved documents

- Real time monitoring
- Health-log visualization

Easy to commercialize by providing development environment
SaaS implementation concept

Security Layer
- Authentication
- Authorization
- Credential DB

Runtime Customization Engine
- Application Files
- Application Server
- Monitoring & Logging
- Database Instances
- Cloud Backend Layer

Configuration & Customization Layer
- SLA

Service Layer
- Service Contract

Integration Layer
- Service Integration

Knowledge Engineering Tool
- Knowledge Extraction
- Data Acquisition & Persistence

UI/UX

Control Layer
- Access Token

Service Layer
- Platforms
- Services
- Users
Platform over Cloud

Public Cloud

Knowledge Extraction
- Visual Recognition
- Actionable Knowledge
- Descriptive Knowledge Acquisition

Knowledge Engineering Tool
- Arden Syntax Studio
- Dialogue Manager
  - Knowledge Coordinator
  - Intent Manager
- Executable Environment
- Dialogue Builder
- Language Processing

Knowledge Base
- vMR Ontology

Private Cloud

Data Acquisition & Persistence
- Security and Privacy
- Health-Log Repository
- Documents Library
- Physical Big Data Storage
- Big Data Storage Processing
- Sensory Data Processing

HMIS
- LIS
- Pharmacy
- EMR/PHR
- Data Exchange
- Clinical Models

Interoperability Adapter
- Standard Ontologies

Automatic Mapping Authoring
- Mapping Repository

Service Integration Manager

UI/UX Manager
- Adaptive Engine
- Data Collection
- UX Measurement
- Perceptions
- Consequences

UX Model
Case Study: Cardiovascular Silo
Silo: One of the CDSS Services

Expert Heuristics

Clinical Guideline

Published Research

EMR/EHR

Mind Map

Silo Construction Process
- Mind map creation
- Decision Tree Transformation
- Plain Rule Creation
- Implementation
- Knowledge Execution and Evaluation

Silo is a structure for storing bulk materials

Diagnosis

Treatment

Follow-up

Knowledge Acquisition
Motivation of Silo

Solutions: Medical Services Silo

Social Needs
- Quality of Medical Services
- Reduce Medical Cost
- Efficiency & Safety

Expected Impacts
- Improve quality of healthcare delivery
- Save Medicare cost
- Reduce medical malpractices
Silo Development Process

Stage 1: Knowledge Acquisition
- Expert heuristics, guidelines, published research and existing systems are sources of domain knowledge.

Stage 2: Knowledge Modeling
- The acquired knowledge is transformed into a formal representation such as Decision Tree.

Stage 3: Rule Generation
- Knowledge is transformed from formal representation to computer executable format i.e. Plain Rules.

Stage 4: Implementation
- A standalone executable environment is developed to execute the created knowledge for providing recommendations.

Stage 5: Evaluation
- The accuracy of the system is evaluated on the real patient data of the corresponding sub medical domain.
Knowledge Acquisition Process

1. Clinical Knowledge Model
   - Medical Experts
   - Creates Mind Map

2. Decision Tree
   - Knowledge Engineer

3. Rule Creation
   - Production Rule

4. MLM Creation
   - MLM creation using SRM
   - MCRDR

5. Production Rule Creation
   - Production Rule Generation

6. Knowledge Execution
   - Executable Knowledge Base
   - Compilation
   - Storage

7. Knowledge Acquisition Process
Knowledge Acquisition for Cardiovascular

Cardiology Guideline

- Taking help from published guideline
- Physician experience and heuristics
- Real practice with existing systems

A + B + C

eCRF

Cardiovascular Disease

ASSESSMENT OF HF PROBABILITY

1. Clinical history
   - History of CAD
   - History of heart failure
   - History of diabetes
   - Hypertension
   - Heart failure due to ischaemic heart disease
   - Pre-existing renal disease
   - Congenital heart disease
   - Congenital heart disease
2. Physical examination
   - Signs of heart failure
   - Pulmonary congestion
   - Hepatomegaly
   - Jugular venous distention
   - Lower extremity oedema
   - ECG:
     - Sinoatrial node disorder
     - Atrial fibrillation
     - Left bundle branch block
     -orenal artery stenosis
     - Peripheral vascular disease
     - Carotid artery disease
     - Lower extremity oedema
     - Echocardiography
     - Cardiac catheterization
     - Cardiac MRI
     - Cardiac CT
     - Cardiac PET
     - Cardiac ultrasound
     - Cardiac nuclear medicine

Perform ECG

1. ECG
   - Normal
   - Abnormal

Perform NT-proBNP or BNP

1. NT-proBNP
   - Normal
   - Abnormal

NT-proBNP Result

1. NT-proBNP ≤ 35 pg/mL
   - Normal
   - Abnormal

NT-proBNP Result

1. NT-proBNP > 125 pg/mL
   - Normal
   - Abnormal

NT-proBNP Result

1. NT-proBNP > 35 pg/mL
   - Normal
   - Abnormal

Perform Echocardiography

Echocardiography NOT available
Knowledge Modeling

Mind Map

Enterprise Architect

Decision Tree
Initial Knowledge Rule Generation

Medical Experts

Production Rules

Decision Tree

Intelligent Knowledge Authoring Tool (I-KAT)

Total Rules: 1309
Total Patient Data: 300
Initial Accuracy: 90%
• Analyzed 600 patients with new set of Rules (15409) based on Modified Decision Tree
  • Correct Decision = 590
  • Incorrect Decision = 10
  • No Decision = 0
  • Overall Accuracy = 98.3%
Provided Data for Knowledge Modeling (for Data-Driven)

Contributing Factors:
(Heart Failure Diagnosis)

P1: Signs & Symptoms
- Breathlessness
- Exercise tolerance
- Tiredness
- Ankle swelling
- Nocturnal cough

P2: Clinical History
- coronary artery disease (CAD)
- Arterial Hypertension
- Exposure to cardio toxic drug/radiation
- Use of diuretics
- Orthopnea

P3: Physical Examination
- Rales
- Bilateral ankle edema
- Heart murmur
- Jugular venous dilatation
- Laterally displaced apical beat

P4: ECG Result
P5: NT-proBNP Result
P6: BNP Result
P7: LVEF
(Left Ventricular Ejection Fraction)
P8: LAVI
(Left Atrial Volume Index)
P9: E/e'
P10: e’ Septal
P11: Longitudinal strain
P12: TRV
(Tricuspid Regurgitation Velocity)
P13: LVMI
(Left Ventricular Mass Index)
P14: Gender
Provided Data for Knowledge Modeling (Data-Driven)

Contributing Factors:
(Heart Failure Diagnosis)

Patient Dataset: 1000

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<td>1</td>
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<td>0</td>
<td>164.6</td>
<td>62.5</td>
<td>33.89</td>
<td>55.64</td>
<td>12.24</td>
<td>6.7</td>
<td>2.8</td>
<td>2.8</td>
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<td>68</td>
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<td>0</td>
<td>0</td>
<td>321.6</td>
<td>65.38</td>
<td>65.57</td>
<td>6.87</td>
<td>8.3</td>
<td>2.7</td>
<td>2.03</td>
<td>2.03</td>
<td></td>
</tr>
</tbody>
</table>

Machine Learning Algorithms

- CRT with 88.55%
- Random Forest with 86%
- Decision Tree with 82%

White Box ML Algorithms

- Naive Bayes = 77%
- Generalized Linear Model = 74%
- Deep Learning = 80%

Black Box ML Algorithms

- 3 features out of 14
- 7 features out of 14
- 1 feature out of 14
**Login Screen:** Only authorized physicians can be logged in to the system

![Login Screen](image)

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**Dashboard:** Shows all the patient data from EMR and EHR systems

<table>
<thead>
<tr>
<th>Patient MR/No</th>
<th>Name</th>
<th>Age</th>
<th>Gender</th>
<th>Initial Symptoms</th>
<th>Encounter Data</th>
<th>Action</th>
</tr>
</thead>
<tbody>
<tr>
<td>P1</td>
<td>John Roe</td>
<td>59</td>
<td>Female</td>
<td>Yes</td>
<td>2017-09-12</td>
<td>Add New Patient</td>
</tr>
<tr>
<td>P2</td>
<td>John Roe</td>
<td>79</td>
<td>Female</td>
<td>Yes</td>
<td>2017-09-12</td>
<td>Update Existing Patient</td>
</tr>
<tr>
<td>P3</td>
<td>John Doe</td>
<td>70</td>
<td>Male</td>
<td>Yes</td>
<td>2017-09-12</td>
<td>Delete Existing Patient</td>
</tr>
<tr>
<td>P4</td>
<td>John Roe</td>
<td>44</td>
<td>Female</td>
<td>Yes</td>
<td>2017-09-12</td>
<td></td>
</tr>
<tr>
<td>P5</td>
<td>John Roe</td>
<td>78</td>
<td>Female</td>
<td>Yes</td>
<td>2017-09-12</td>
<td></td>
</tr>
</tbody>
</table>
Implementation Patient Detail

**Patient Detail Screen:** Shows all detail of patient to add new patient or update existing patient.

**Patient Information And Cardio Information**

<table>
<thead>
<tr>
<th>Patient MN</th>
<th>Patient Name</th>
<th>Age</th>
<th>Sex</th>
<th>SBP</th>
<th>DBP</th>
<th>ECG</th>
<th>Heart Rate</th>
<th>Longitudinal Gravel</th>
</tr>
</thead>
<tbody>
<tr>
<td>P1</td>
<td>John Doe</td>
<td>59</td>
<td>Female</td>
<td>120</td>
<td>80</td>
<td>Abnormal</td>
<td>60</td>
<td>6.8</td>
</tr>
</tbody>
</table>

**Patient Clinical History**

- CAD: No
- Arterial Hypertension: No
- Exposition to Cardiotoxic: No
- Use of Diuretics: No
- Orthopnoea Paroxysmal: No

**Patient Symptoms**

- Breathlessness: No
- Orthopnoea: No
- PND: No
- Reduced Exercise Tolerance: No
- Fatigue: No
- Tiredness: No
- Ankle Swelling: No
- Elevated JVP: No
- S3: No
- Nocturnal Cough: No
- Laterally Displaced Apical: No
- Impulse: No

**Patient Physical Exam**

- Rates: No
- Bilateral Ankle Edema: No
- Heart Murmur: No
- Jugular Venous Dilatation: No
- Laterally Displace Apical: No

**Implementation Patient Detail**
**CDSS Intervention:** Shows the recommendation of a patient based on patient profile and symptoms

The decision comes from knowledge base.
Benefits – Technical Expected Effect

- Evolutionary knowledge base (Incremental Learning(RDR))
  - Domain expert can create, validate, and manage knowledge with minimal involvement of knowledge engineers
  - By acquiring conversation-based knowledge
  - Improved user credibility

- Knowledge Engineering Tools
  - Decrease knowledge engineers dependency

- Hologram based UI technology, UX evaluation technology
  - Improved accessibility and communication among users and system

- SaaS based open knowledge for medical platforms
  - Medical industry ecosystem opens with various solutions integration

- Interoperable standardization technology that can work with various EMR or HIS
  - Knowledge sharing, service sharing
  - Easy to expand business
Summary

- **What to develop?**
  - Intelligent Medical Platform to provide decision making services based on state-of-the-art knowledge acquisition environment.
  - Grand medical platform to integrate other medical services into a uniform platform and share with medical community.

- **What problems?**
  - Lack of commercialization due to difficulty in acquiring, establishing, verifying and managing knowledge base of medical experts
  - Knowledge acquisition dependency on knowledge engineers

- **How to solve?**
  - Development of intelligent medical platform and construction of knowledge engineering environment, it opens the medical knowledge and shares with community
  - SaaS-based healthcare system

- Intelligent Medical Platform
- Grand medical platform
- SaaS-based healthcare system