

The Clinical Application of an XML-Based 12 Lead ECG Structure Report System

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Abstract

The need for hospitals to develop a 12-lead ECG report system is vital. A 12-lead ECG report system should summarize cardiologists' ECG diagnoses including waveform interpretations, treatment strategies, and disease confirmation. The major objective of this study is to develop a 12-lead ECG documentary system that can facilitate ECG waveform pattern search based on documented clinical cases and consequently enhance the accuracy of heart disease diagnoses. First, an SQL-based database is used to collect clinically-used XML 12-lead ECG files, which are processed to extract ECG waveform data. Second, an interactive ECG browser allowing online ECG waveform measurement is created by using Silverlight technology of vector-based graph visualization. Third, a tree-like XML-based document, which is based on the waveform template of DICOM structure report, is developed to record ECG waveform measurement, treatment strategies, and relative diseases. Results indicate that clinicians can greatly benefit from ECG waveform pattern search. By using this developed system, clinicians can significantly enhance their ability to find out correlations between ECG morphologies and heart diseases. Additionally, this developed ECG report system can be used to improve the 12-lead ECG e-learning in clinical ECG education.

1. Introduction

It is crucial to develop a computerized 12-lead ECG report that can provide clinicians with interactive ECG waveform measurement and report editing in clinical practice. With the help of computer-assisted ECG waveform measurement, the errors resulting from visual interpretation can be reduced. In addition, an ECG report with the detail description of ECG patterns, cardiologist's interpretation, and treatment strategies will enhance ECG diagnostic efficiency and decrease medical errors. Until now, most clinically-used 12-lead ECG information systems do not provide clinicians with a tool that can interpret ECG waveform and edit ECG report

simultaneously.

One frequently-used medical informatics standard, Digital Imaging Communications in Medicine (DICOM) [1], has defined various clinically-used structured reports including image- and waveform-based clinical tests [2]. The DICOM structured report is a binary format which is composed of elements with number-based identifiers. The required elements and data types for a structured report are summarized in DICOM part 16 [3-4]. The DICOM structured report enables the link between DICOM-based image and text-based clinical diagnostic information. With the use of DICOM structured reports, clinicians can easily find out the correlations between abnormal images and diseases.

Extensible Markup Language (XML) based ECG data formats have been employed on most of clinically-used 12-lead ECGs. Until now, there is not any computerized ECG information system that can enable the link between ECG waveform characteristics and heart diseases. There are several successful applications of DICOM-XML conversion [5-7]. The major object of this study is to develop a XML-based 12-lead ECG reporting system which is based on DICOM-defined 12-lead ECG structured report. The XML-based 12-lead ECG report system can be used to improve the efficiency of 12-lead ECG diagnoses.

2. Methods

As shown in Table 1, the required elements of a general 12-lead ECG DICOM structured report is summarized. The 12-lead ECG DICOM structured report is composed of 12 structured report templates including TID 3700 in the root level, TID 1002, TID 3701, TID 3702, TID 3708, TID 3713, TID 3714, TID 3717, and TID 3719 in the first level, TID 1003, TID 3715, and TID 3718 in the second level. The major function of each template is summarized as below:

1. TID 3700: TID 3700 represents the ECG study, which is used for global ECG measurement and waveform information.
2. TID 3701: TID 3701 represents the ECG clinical context, which is used to describe the

Table 1. 12-lead ECG DICOM structured report templates.

Structured Report Template	Function
TID 3700	Main ECG study for waveform storage and ECG interpretation
TID 3701	The reasons for ECG exam
TID 3702	The link between current and prior ECG reports
TID 3708	ECG acquisition information
TID 3713	ECG global measurement
TID 3714	Individual ECG measurement
TID 3715	ECG measurement source
TID 3717	ECG qualitative analysis,
TID 3718	ECG interpretative statement,
TID 3719	he summary of ECG,

- reasons for ECG exam.
3. TID 3702: TID 3702 represent prior ECG exam, which is used to link prior ECG records.
 4. TID 3708: TID 3708 represents ECG acquisition information, which is used to describe the ECG instrument setting such as filter bandwidth.
 5. TID 3713: TID 3713 represents ECG global measurement, which is used for the references of ECG interpretations such as RR interval, QT interval, and R axis.
 6. TID 3714: TID 3714 represents the individual ECG measurement, which is used to describe the patterns and measured values of abnormal ECG waveform characteristics.
 7. TID 3715: TID 3715 represents the ECG measurement source, which is used to indicate the abnormalities of a specific waveform with exact location in the ECG chart.
 8. TID 3717: TID 3717 represents ECG qualitative analysis, which is used to summarize clinical ECG interpretation.
 9. TID 3718: TID 3718 represents ECG interpretative statement, which is used to summarize the probability and statement of ECG interpretation.
 10. TID 3719: TID 3719 represents the summary of ECG, which is used to summarize the finding of this ECG exam.
 11. TID 1002: TID 1002 represents the observer context.
 12. TID 1003: TID 1003 represents person observer identifying attributes.
- The 12-lead ECG DICOM templates as shown in Table 1 are then converted into an XML schema for clinical applications. The Table 2 lists the XML sample code for 12-lead ECG structured report.

Table 2. 12-lead ECG XML schema.

<xsd:schema	xmlns:xsd	=
"http://www.w3.org/2001/XMLSchema">		
<xsd:element	name	= "ECG_REPORT"
type="ECGREPORTType">		
<xsd:complexType	name="ECGREPORTType">	
<xsd:element	name = "Procedurereported"	type = "ECG_Procedure_Types" minOccurs = "0" />
<xsd:element	name	= "LanguageofContentItemandDescendants" type = "xsd:string" />
<xsd:element	ref	= "ObserverContext" minOccurs = "1" maxOccurs="unbounded"/>
<xsd:element	ref	= "ClinicalContextECG" minOccurs = "0"/>
<xsd:element	ref = "PriorECGExam"	minOccurs = "0"/>
<xsd:element	ref	= "ECGWaveformInformation" />
<xsd:element	name="	"QuantitativeAnalysis" type="xsd:string"/>
<xsd:element	ref	= "GlobalMeasurements" minOccurs = "0" maxOccurs="unbounded"/>
<xsd:element	ref	= "ECGLeadMeasurements" minOccurs = "0" maxOccurs="unbounded"/>
<xsd:element	ref	= "ECGQualitativeAnalysis" minOccurs = "0"/>
<xsd:element	ref = "SummaryECG"	minOccurs = "0"/>
</xsd:complexType>		
<xsd:complexType	name="ECG_Procedure_Types">	

```

<xsd:element
name="CodingSchemeDesignator"
type="xsd:string"/>
</xsd:complexType>
<xsd:complexType name="ObserverContext">
<xsd:element
ref="Personobserveridentifyingattributes"
minOccurs="0" maxOccurs="1"/>
<xsd:element
ref="Deviceobserveridentifyingattributes"
minOccurs="0" maxOccurs="1"/>
</xsd:complexType>
<xsd:complexType
name="Personobserveridentifyingattributes">
<xsd:element name="PersonObserverName"

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```

type="xsd:string"/>
<xsd:element
name="PersonObserversOrganizationName"
type="xsd:string"/>
<xsd:element
name="PersonObserversRoleintheOrganization"
type="Organizational_Roles_Type"/>
<xsd:element
name="PersonObserversRoleinthisProcedure"
type="Performing_Roles_Type"/>
</xsd:complexType>
.....
</xsd:element>
</xsd:schema>

```

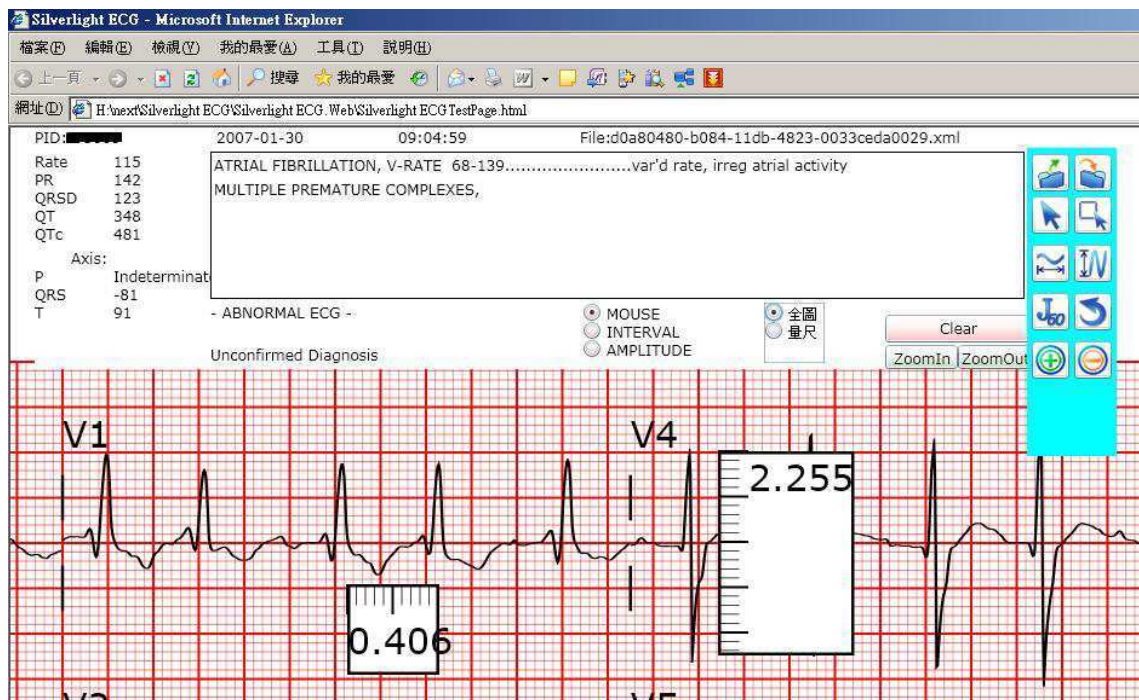


Figure 1. The Silverlight-based ECG editor. This editor can provide clinicians with waveform measurement and text-based interpretation editing.

3. Results

In this study, a vector graph visualization technology, Silverlight, is employed to display ECG waveform [8]. In addition, a web-based XML ECG editor is developed to provide clinicians with on-line ECG report editing and waveform measurement. As shown in Figure 1, the physicians can summarize ECG interpretation and finding based on the XML schema on the foreground-web directly. The corresponding background-XML ECG file will be changed, and which is followed by the changes of foreground in real time.

4. Discussion and conclusions

By using this developed XML 12-lead ECG reporting system, clinicians will be able to benefit from ECG waveform pattern search. In addition, clinicians can significantly enhance their ability to find out correlations between ECG characteristics and related heart diseases.

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