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Decision support system for constantly monitoring patients in a comorbid condition

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INTRODUCTION

According to a World Health Organization report, around 50% of people over 65 years old have more than three comorbid conditions. Physicians treating a comorbid patient need to manually reconcile multiple clinical guidelines verifying if these guidelines result in adverse interactions. However, manual reconciliation on guidelines will take physicians much of their invaluable time, which should be used for making diagnosis. This motivates us to design a decision support system, which can automatically reconcile multiple clinical guidelines concurrently and any conflict between guidelines notifies a physician to create an individual treatment plan for a particular patient.

REAL-WORLD SCENARIO: Joint Atrial Fibrillation (AF) and Wolff Parkinsons White (WPW) Conditions

Fig.1 shows the Ontario's clinical practical guidelines for AF and WPW.

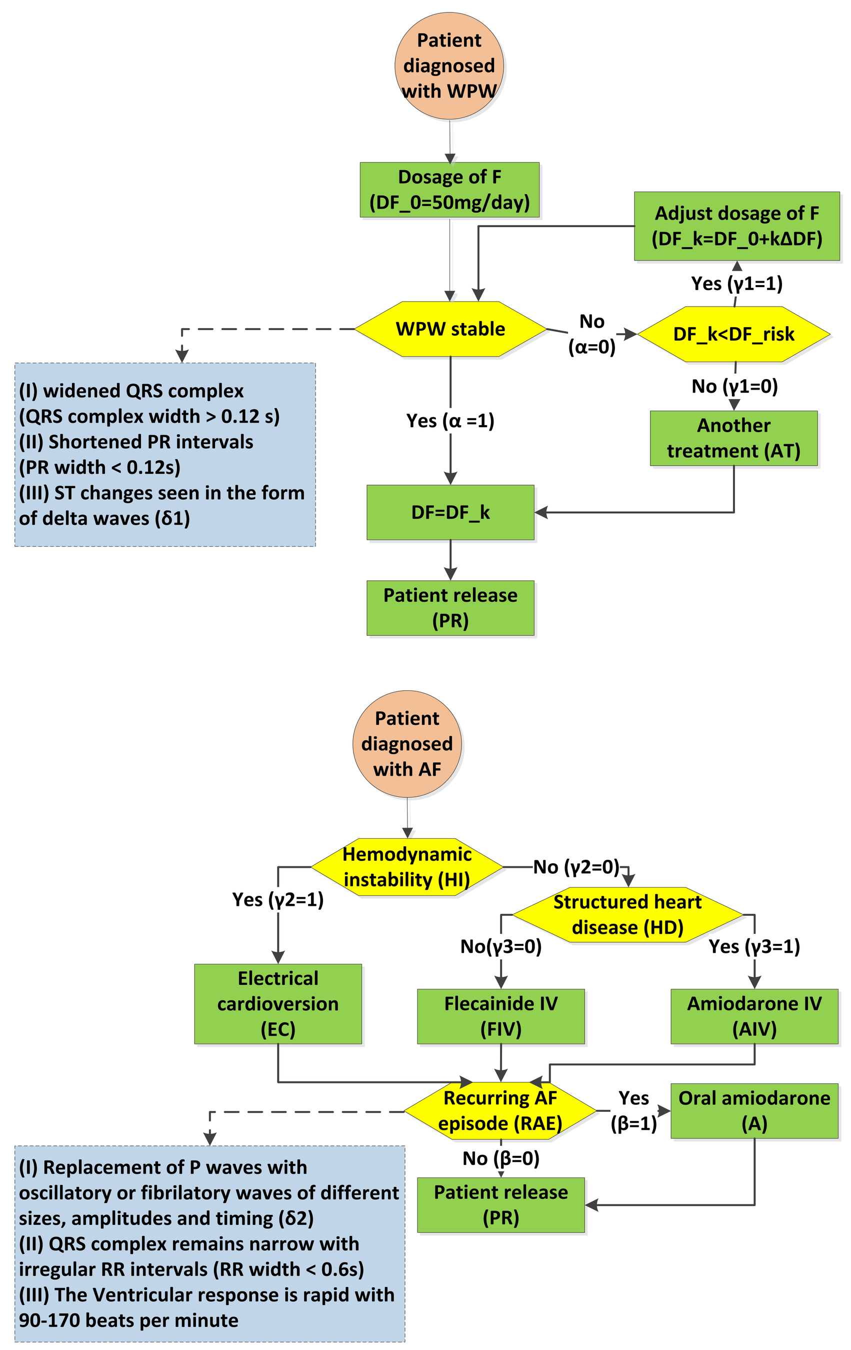

Fig.1 Clinical guidelines

DECISION SUPPORT SYSTEM

Implementing the internal logic a decision support system is composed of three steps: (1) transform paths in the clinical guidelines into logic expressions; (2) transform the inner conditions of each node (in the dashed, blue area of Fig.1) into logic expressions; (3) transform constraints between guidelines into logic expressions.

Transform	CLP expression
Paths (WPW)	(DF_0 = 50) ∧ (α_0 = 1) ∧ (DF = DF_0) ∧ PR, (DF_0 = 50) ∧ (α_0 = 0) ∧ (γ1_0 = 0) ∧ AT ∧ (DF = DF_0) ∧ PR, (DF_0 = 50) ∧ (α_0 = 0) ∧ (γ1_0 = 1) ∧ (DF_1 = DF_0 + ΔDF) ∧ (α_1 = 1) ∧ (DF = DF_1) ∧ PR, (DF 0 = 50) ∧ (α_0 = 0) ∧ (γ1_0 = 1) ∧ (DF_1 = DF_0 + ΔDF) ∧ (α_1 = 0) ∧ (γ1_1 = 0) ∧ AT ∧ (DF = DF_1) ∧ PR, (DF 0 = 50) ∧ (α_0 = 0) ∧ (γ1_0 = 1) ∧ (DF_1 = DF_0 + ΔDF) ∧ (α_1 = 0) ∧ (γ1_1 = 0) ∧ (DF_2 = DF_0 + 2ΔDF) ∧ (α_2 = 1) ∧ (DF = DF_2) ∧ PR, (DF 0 = 50) ∧ (α_0 = 0) ∧ (γ1_0 = 1) ∧ (DF_1 = DF_0 + ΔDF) ∧ (α_1 = 0) ∧ (γ1_1 = 0) ∧ (DF_2 = DF_0 + 2ΔDF) ∧ (α_2 = 0) ∧ (γ1_2 = 0) ∧ AT ∧ (DF = DF_2) ∧ PR
Paths (AF)	(γ2 = 1) ∧ EC ∧ (β = 0) ∧ PR, (γ2 = 0) ∧ (γ3 = 0) ∧ FIV ∧ (β = 0) ∧ PR, (γ2 = 0) ∧ (γ3 = 1) ∧ AIV ∧ (β = 0) ∧ PR, (γ2 = 1) ∧ EC ∧ (β = 1) ∧ A ∧ PR, (γ2 = 0) ∧ (γ3 = 0) ∧ FIV ∧ (β = 1) ∧ A ∧ PR, (γ2 = 0) ∧ (γ3 = 1) ∧ AIV ∧ (β = 1) ∧ A ∧ PR
Inner conditions	(α = 1) ∧ (QRSW > 0.12) ∧ (PRW < 0.12) ∧ (δ1 = 1) , (α = 0) ∧ not((QRSW > 0.12) ∧ (PRW < 0.12) ∧ (δ1 = 1)) , (β = 1) ∧ (δ2 = 1) ∧ (RRW < 0:6) ∧ (VR > 90), (β = 0) ∧ not((δ2 = 1) ∧ (RRW < 0.6) ∧ (V R > 90))
Constraints	not((DF_k > DF_risk) ∧ A)

Table 1. CLP model for combining clinical guidelines

ANALYSIS OF SYSTEM PERFORMANCE

We use PTB database to estimate the distribution of ECG parameters: RR; PR, QRS (see Fig.2) are in skew normal distribution, and VR (see Fig.2) is uniformly distributed. Also ΔRR, ΔPR, ΔQRS are estimated as Gaussian, while the distribution of ΔVR is estimated as Double-exponential, where ΔRR, ΔPR, ΔQRS, ΔVR are the errors between the exact ECG parameters and their estimation values.

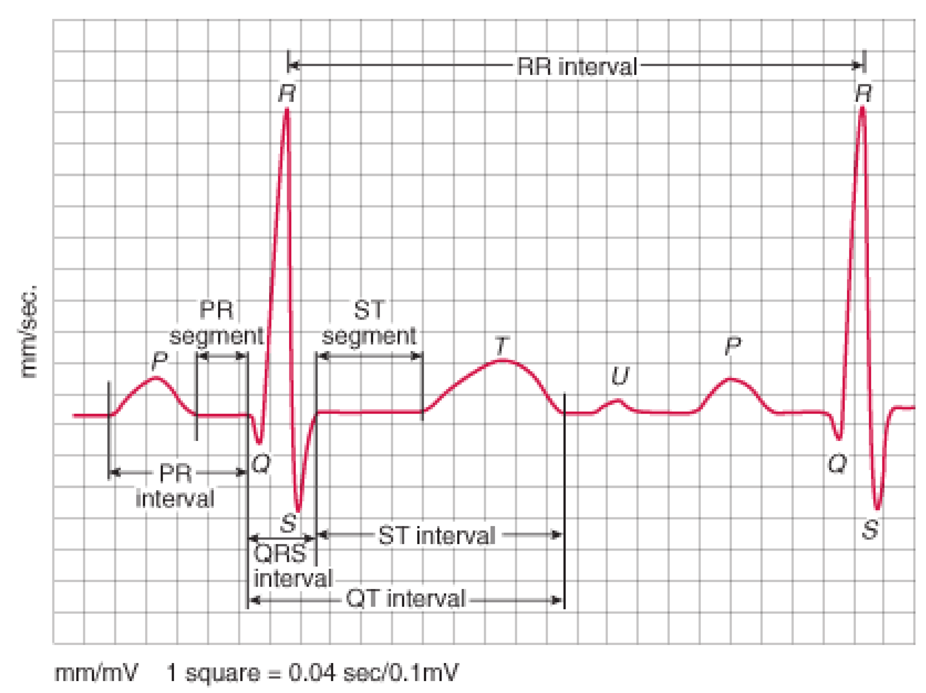

Fig.2 ECG waves

Fig.3 shows the average system accuracy, which is defined as the confidence of our system to generate a correct diagnosis on patient conditions. SNR is defined as the power ratio between ECG signal and the background noise.

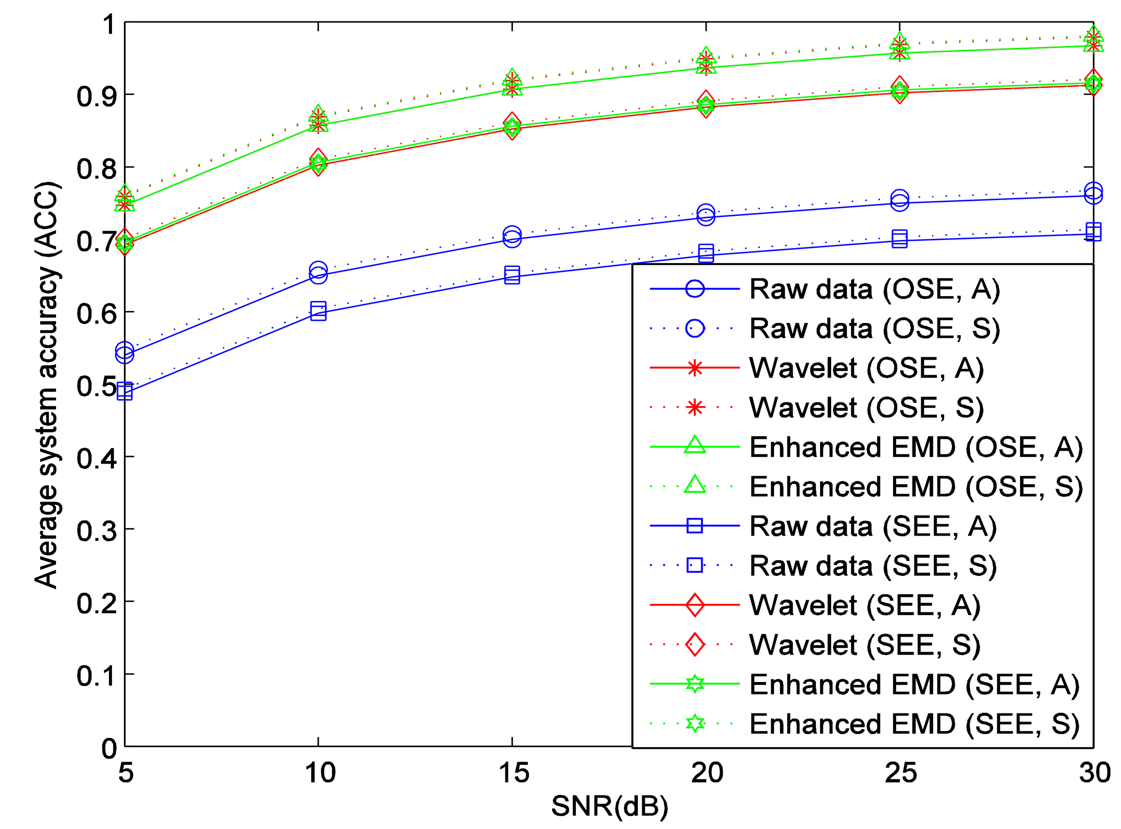

Fig.3 Average system accuracy VS. SNR ('OSE' represents only sensing errors, 'SEE' represents both sensing errors and entry errors, 'A' represents analytical result, 'S' represents simulation result).

CONCLUSION

In this paper, we develop a telecommunication and computer aided decision support system to monitor the patients in a comorbid condition, taking the patients with both WPW and AF as an example. We originally propose a decision support system in view of combining multiple clinical guidelines concurrently. This decision support system can make diagnosis on patient conditions as well as detect conflicts between clinical guidelines, and the detailed process of designing and implementing this decision support system is presented in our paper. Also we present the issues about system performance in consideration of potential error sources: both ECG sensing errors and manual entry errors. The results show that the SNR of ECG should be higher than 18dB to achieve both the system accuracy above 90%. The methodology and analysis in this paper can help healthcare staff and system designers evaluate the system performance or select appropriate sensors for a healthcare monitoring system.