Abstract

• Cardiac pacemakers are electrical devices that treat arrhythmias delivering electrical stimuli to the patient heart.
• Rate-adaptation: regulation of pacing rate according to patient’s needs (e.g., increased pacing rate during exercise).
• Programming of rate-adaptation parameters depends on many patient-specific factors (age, lifestyle, tolerance to rapid pacing, …).
• Effective personalisation achievable only through extensive exercise testing: intolerable for a cardiac patient.
• We introduce a data-driven and model-based approach for subject-specific verification of rate-adaptive pacemakers.

Models and methods

• Design and implementation of fully closed-loop model of heart and pacemaker interactions.
• Dual sensors rate-adaptive pacemaker: accelerometer + QT interval.
• Sensors blending: combines quick but inaccurate accelerometer response to activity with accurate but slower QT response.
• Pacemaker personalisation: achieved through estimation of subject-specific QT-RR regression laws.
• Heart model personalisation performed from subject-specific ECG.
• Arrhythmias: Modelling of atrio-ventricular (Wenckebach AV block) and atrial arrhythmias (atrial fibrillation).
• Quantitative model analysis using Cosmos tool for statistical model checking.

Results

• Adequacy under exercise: comparison of three pacing algorithms under ideal exercise curve and Bruce exercise testing protocol.
• Percentage of paced beats vs. AV block: estimation of distribution of number of paced beats under increasing severity of AV block.

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