Sudden Cardiac Death Prevention Using a Pacemaker

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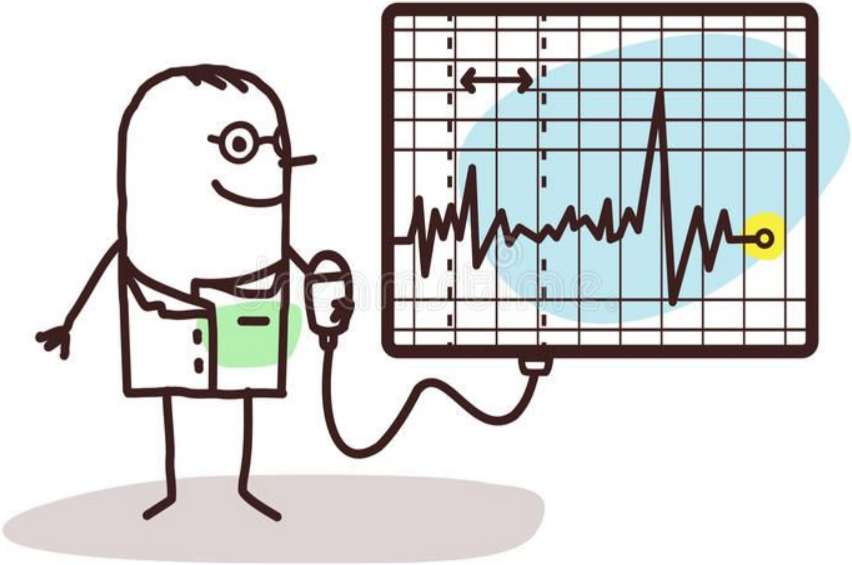
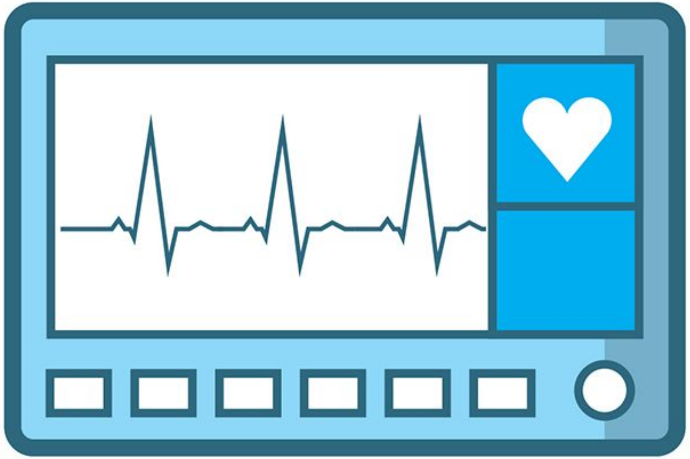


MOTIVATION

- Cardiac pacemaker as prevention for sudden cardiac death (SCD)
- More than 7,000 children and teens in the U.S. die from SCD
- Prevent SCD due to bradyarrhythmias, torsade de pointes, etc.
- Permanent pacing
- Heart rate PID controller

INTRODUCTION

- Pacemaker composed of two functional units
  - "Sensing circuit"
  - "Output circuit"
- Error signal
- PID controller parameters
  - Proportional gain
  - Integral gain
  - Derivative gain



$$C(s) = K_p + \frac{K_i}{S} + K_d s$$

$$= K_P\left(1 + \frac{1}{T_i s} + T_d s\right) \ldots\ldots (1)$$

PERFORMANCE GOALS & CONSTRAINTS

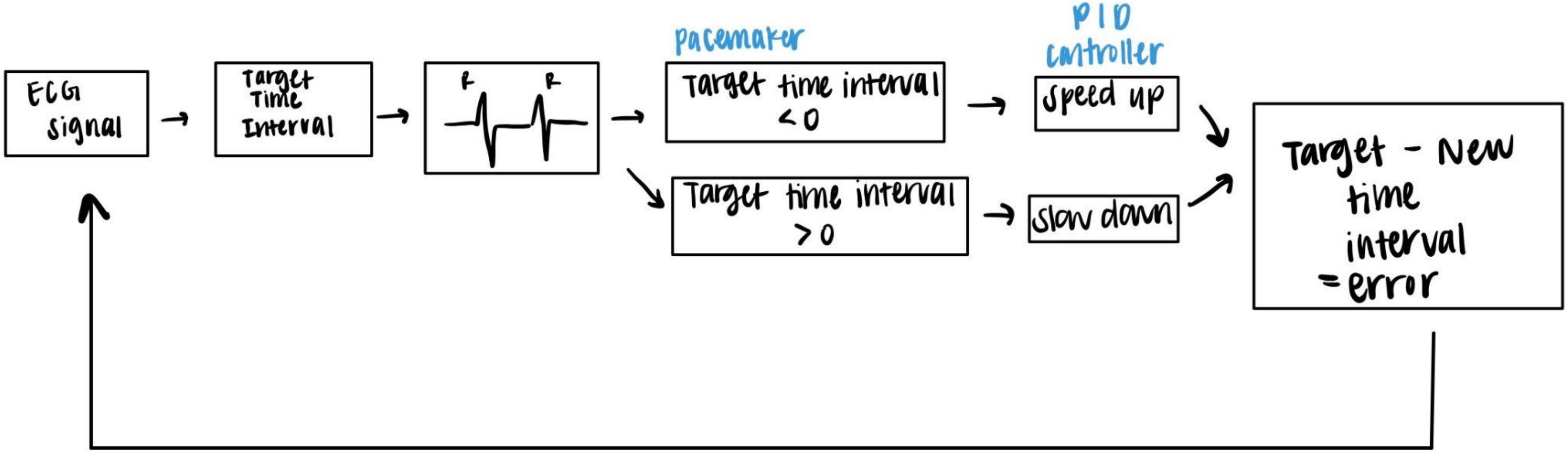
Goals:

- Control abnormal heart rate with a pacemaker and understand how an error signal (desired/set vs actual heart rate) is controlled by a PID to stimulate the heart

Constraints:

- Closed loop system

PACEMAKER SIGNALING PROCESS



BLOCK DIAGRAM (TIME DOMAIN)

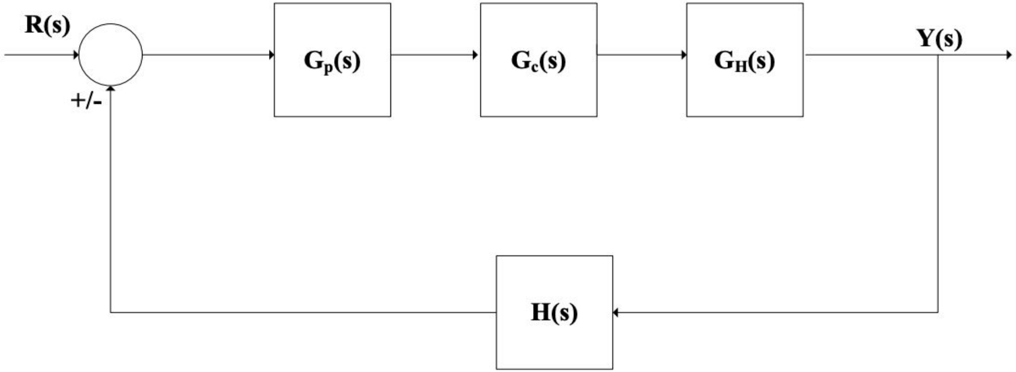


Figure 1: Block diagram of Heart Rate Controller for Cardiac Pacemaker

$G_P(s)$ = Transfer function of Pacemaker
$G_C(s)$ = Transfer function of controller
$G_H(s)$ = Transfer function of Heart
$R(s)$ = Actual heart rate
$H(s) = 1$
$Y(s)$ = Desired heart rate

ASSUMPTIONS:

- Simulink model and its pacing through the block diagram are assumed to have a continuous signal
- Transfer function of the Pacemaker is a low pass filter transfer function
- Pacemaker assumes average heart rate would be between 50 to 70 beats per minute
- Individuals with pre-existing conditions

ADVANTAGES & LIMITATIONS

Advantages:

- Using a PID controller - takes error as an input signal and adjusts the process control inputs by minimizing error
- Pacemaker allows people with heart defects to live longer

Limitations:

- Pacemaker can only last up to 8.5 years
- Some natural added noise within the body could affect the measured heart rate
- Assuming heart rate is a certain value (different for certain ages/gender)

NEXT STEPS

- Incorporate transfer functions into design
- Take the Laplace transform of our transfer functions to run the simulink in the Laplace domain
- Fully develop the simulink model and implement ECG data of an individual with cardiac issues

THANKS FOR LISTENING!

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