CardioGAN: An Attention-based Generative Adversarial Network for Generation of Electrocardiograms

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**PROBLEM**

Here, we propose a deep generative architecture which can generate synthetic electrocardiograms (ECGs) that possess human-like characteristics.

ECGs convey important information regarding a patient's heart. As the demand for automatic diagnostic systems are increasing, so is the requirement of large amounts of labelled training data. This causes a data-imbalance problem. Additionally, the risk of privacy breaches increases too.

The drawback of previous approaches lies in the fact that:
- Lack of human-like characteristics
- Lack of consistent nature of the curves

**APPROACH**

The architecture follows a Wasserstein GAN-style training strategy. The Critic learns to generate high/low scores depending on the "realness" of the output of the Generator. This score helps the generator to learn to create better samples.

1. **The Generator:**
   - Comprising the Pre-Attention Layers, the Attention Layer and the Post-Attention Layer
   - Helps generate the synthetic ECGs from a given Gaussian noise.
   1. Pre-Attention Layer comprises a stack of 2 bidirectional LSTM layers
   2. Attention Layer is made of a dense feed-forward neural network to calculate the contexts
   3. Post-Attention layer consists of a single LSTM layers to model the final ECGs depending upon the latent information and the contexts from previous layers.

2. **The Attention module as a dense feedforward neural network.** It helps understand the intricate inter-dependencies in the signals.

3. **Loss Function:**

\[
L = E_{x’ \sim P_{\theta}} [D(x’)] - E_{x \sim P_x} [D(x)] + \lambda E_{x \sim P_{\theta}} [\| \Delta x \|_2 - 1]^2
\]

(Wasserstein Loss)

4. **The Critic helps to assign a "realness" score to the samples generated by the Generator, that helps the generator to learn, in turn.

**RESULTS**

- Fig - Visual representation of ECG signals. Blue - GT, Red - Generated.
- Fig - A generalized schematic representation of the architecture.
- Fig - The generator of the architecture
- Fig - The Attention module
- Fig - The architetcture follows a Wasserstein GAN-style training strategy.