Cardiologist-level Arrhythmia Detection

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Heart Monitoring

12-lead “opportunistic” ECG

Holter monitor, short-term wearable

Long-term wearable

source: www.firstaidforfree.com/recording-a-12-lead-ecgekg/

Awni Hannun
Heart Monitoring

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Wearable Heart Monitor

- Irhythm Heart Monitor
- 2 weeks non-stop per patient
- Technician marks arrhythmia start & stop
- Summary report sent to cardiologist
A Single Beat

1. Atrial depolarization, initiated by the SA node, causes the P wave.
2. With atrial depolarization complete, the impulse is delayed at the AV node.
3. Ventricular depolarization begins at apex, causing the QRS complex. Atrial repolarization occurs.
4. Ventricular depolarization is complete.
5. Ventricular repolarization begins at apex, causing the T wave.
6. Ventricular repolarization is complete.
Detecting Arrhythmias in ECG
Previous Work

- Hand engineered
- Minimal learning from data
- Nearly 85% error rates for some difficult arrhythmias (AV Block)
Neural Networks: Generalization Knobs

Annotated Data

Architecture / Hyperparameters
Challenges /
Key Ingredients

Successful Learning

Model

Data
Compute
Training Data

Annotated Data

<table>
<thead>
<tr>
<th>Dataset</th>
<th>Unique Patients</th>
</tr>
</thead>
<tbody>
<tr>
<td>MIT-BIH</td>
<td>47</td>
</tr>
<tr>
<td>UCI</td>
<td>459</td>
</tr>
<tr>
<td>V1</td>
<td>11,558</td>
</tr>
<tr>
<td>V2</td>
<td>21,582</td>
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<tr>
<td>V3</td>
<td>33,300</td>
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<tr>
<td>V4</td>
<td>53,549</td>
</tr>
</tbody>
</table>
Training Data
Data

Number of Records per Rhythm

Records

NSR
NOISE
AFIB
SVT
VT
WENCKEB
BIGEMINY
TRIGEMINY
AVB_TYPE2
JUNCTIONAL
PAUSE
AFL
EAR
SUDDEN_B
IVR

Rhythm Name
Model

- Input raw EKG
- Prediction over 12 classes
Model

Architecture

8 Layers $\Rightarrow$ 34 Layers
+ Batch Normalization
+ Residual Connections
+ Dropout
+ More context (15 seconds)
Evaluation

- 336 ECG records with 328 patients
- Committee of experts to determine ground truth on test set
Evaluation

- Compare model to individual cardiologists.
- Each record annotated by 6 individuals.
Results

![Graph showing F1 scores for different arrhythmias]

- Model vs Cardiologist comparison
- Arrhythmia categories include AF, AVB, Bigem, EAR, IVR, Junctional, Noise, Sinus, SVT, Trigem, VT, Wenck, Average
Results
Results: Human and Model Confusions
Thank You!