Computational methods for Tele-monitoring of heart health

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Tele-monitoring of heart health involves two steps - monitoring specific health parameters and communicating the data with the specialist (See Figure-1 for details). Cardiovascular conditions require the monitoring of multiple parameters such as heart beat, blood pressure etc., and reliable and meaningful diagnosis can be obtained only by judiciously combining these various results.

First-generation tele-cardiology systems were made of hand-held ECG machines that could be hooked on to the patient like a regular ECG machine and the results were transmitted in their entirety to the specialist for diagnosis. The drawback is that only the experts at the receiving end of the data would be able to detect abnormalities from the large amount of data transmitted to them. What if the detector system at the patient's site could analyze the data as it was acquired, and directly communicate only anomalies/problem areas to the specialist, instead of the entire data?

The collaborative work of Dr. S. Jana, Dr. B.S. Chandra and Dr. C. S. Sastry at IIT-Hyderabad has developed algorithms (computer programs) for two purposes - one for the extraction of abnormal signals from ECG data and transmit them to a remote expert, and the other, for combining blood pressure and ECG data into a meaningful output that is easier for the expert to diagnose.

In the first case, their effort, with cardiology guidance by Dr. Laxminarayana Anumandla, a cardiac surgeon from Maxcare Hospital, Warangal, has resulted in an algorithm that not only detects abnormal heart beat in the ECG, but also compresses this data so that it can be sent easily over limited bandwidth internet, such as those in rural areas. For this, the researchers have used a data compression and classification algorithm called "Dictionary-based categorisation and compression" (See Figure-2 for details). The compressed data can be easily decompressed and interpreted at the receiving end. This algorithm has been shown to have a low error rate - maximum of 1 undetected beat per 100 heartbeats. It also reduces the cost of bandwidth by 99.15%, accounting for 118-fold savings over first-generation tele-cardiology. An added benefit of this type of tele-monitoring is that the workload of the specialist is reduced by at least 85.9% for noncritical cases because the expert has to look only at the anomalies that have already been extracted by the algorithm.

In the second study, the IIT-H research group has developed a procedure by which they can combine data from multiple physiological signals - in this case, they have combined the ECG data with blood pressure data - to predict heart health. In real life, cardiologists do not rely on results of a single test (say, ECG) to look for heart diseases; instead, they look at multiple biometric parameters such as blood pressure and plethysmogram signals, and by experience, they know how to combine the various parameters to arrive at the health status.

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The group has mimicked the human thinking process involved in analyzing and combining multiple input data into a realistic output, in using a form of computing system called Artificial Neural Networking (ANN). ANN, a rudimentary form of Artificial Intelligence (AI), obtains multiple inputs and "learns" through training steps to recognize patterns and anomalies, to process them into a reliable and accurate output. The team has used a form of ANN called Convolutional Neural Network (CNN). The CNN-based information fusion (CIF) algorithm is generalizable, robust and efficient in detecting heart characteristics from multiple input parameters.

References:

[1] B.S. Chandra, C. S. Sastry, S. Jana; IEEE transactions on bio-medical engineering [2018], *Robust Heartbeat Detection From Multimodal Data via CNN-Based Generalizable Information Fusion,* Volume: 66 , Issue: 3, Pg.: 710 – 717, March 2019. *DOI:10.1109/TBME.2018.2854899*

[2] B. S. Chandra, C. S. Sastry, A. Laxminarayana, S. Jana; *Dictionary-based monitoring of premature ventricular contractions: An ultra-low-cost point-of-care service*, Volume 87, Pages 91-104, April 2018. *DOI: 10.1016/j.artmed.2018.04.003*

[3] http://www.healthdata.org/india

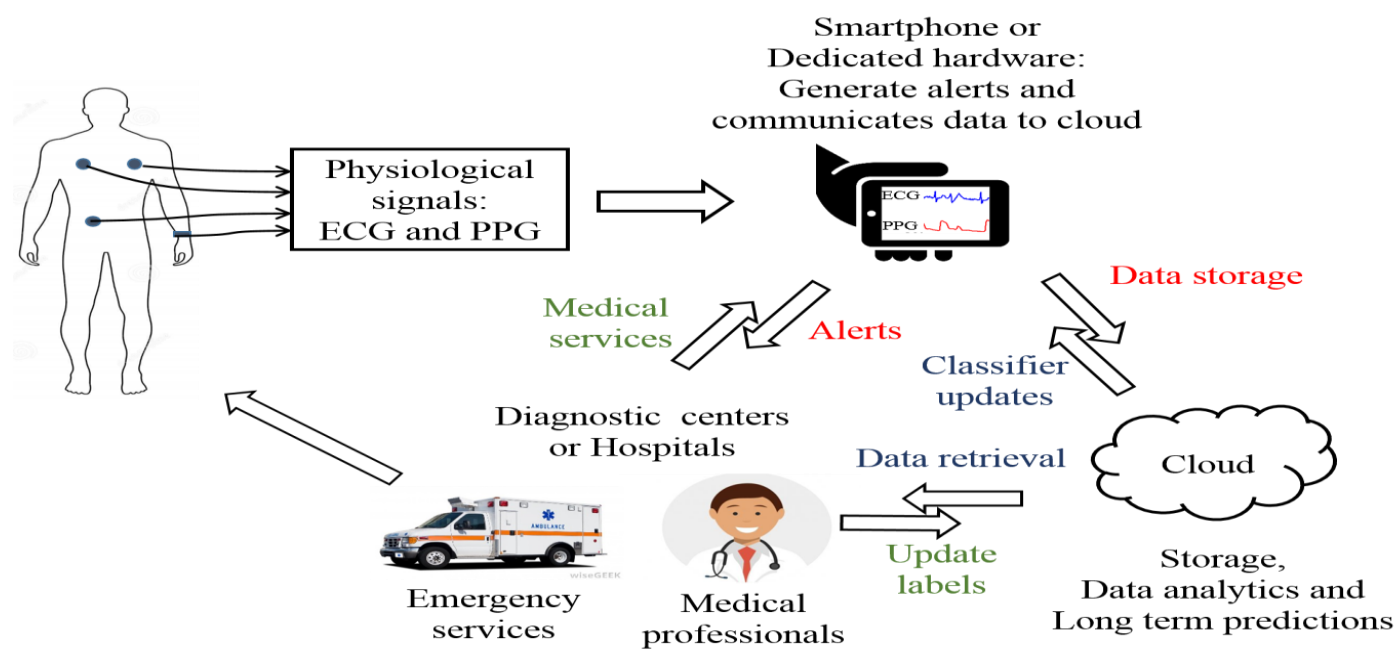

Figure 3: AI based tele-monitoring of heart health

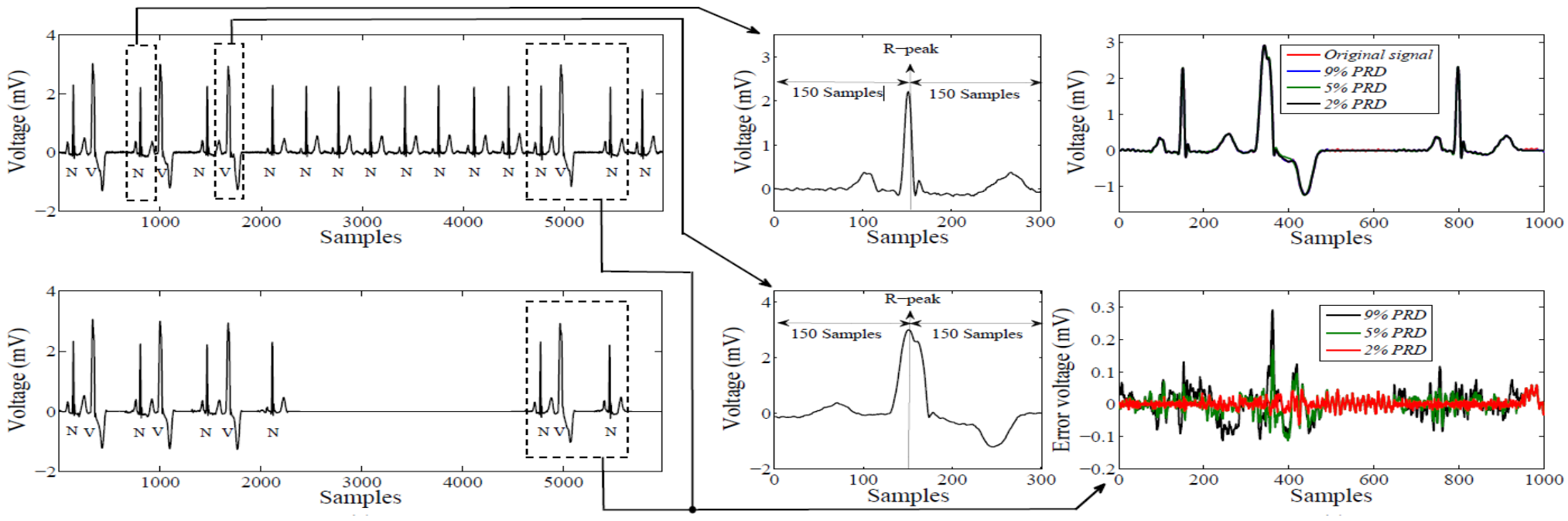

Figure 4: Dictionary-based categorization and compression