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Low Power IoT Sensor with Embedded AI for Healthcare Monitoring

Abstract

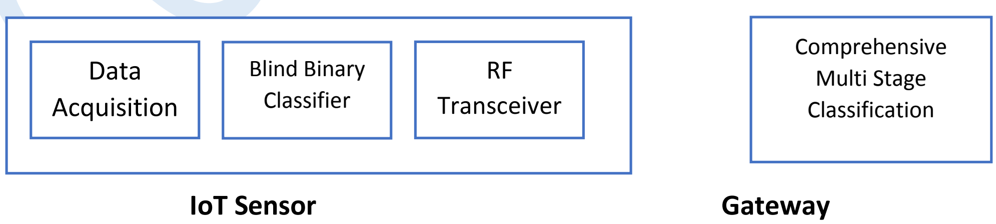
This proposal addresses the high-power consumption issue of wearable devices for CVD patients. Power consumption is too high due to continuous RF transmission of data. The idea is to process the physiological signals locally at the sensor using machine learning techniques to detect potential arrhythmias or health conditions. Wireless transmission can be enabled only when deemed necessary by the processing techniques to save power. Existing machine learning (ML) algorithms are not “light” enough to be implemented in IoT devices. This project aims to develop Edge/Near-Sensor computing techniques in IoT devices to opportunistically disable RF transmission.

Introduction:

To address the above-mentioned issues, we are developing a new algorithm where instead of looking for individual arrhythmias, only anomalies in the data are identified. Anytime an anomaly is detected, the wireless transmission can be enabled for real-time streaming, so that a more comprehensive analysis can be done in a cloud server or manually by a clinician. This solves the problem of computational complexity, personalisation and still achieves the power reduction in the sensor.

We aim to develop distributed ML algorithms for IoT devices in which

- A ***light*** first stage which makes binary decisions to be implemented in an IoT device.
- Doesn’t require a prior information of the subject and is patient adaptive.
- A second stage which makes a more comprehensive classification on a gateway device.



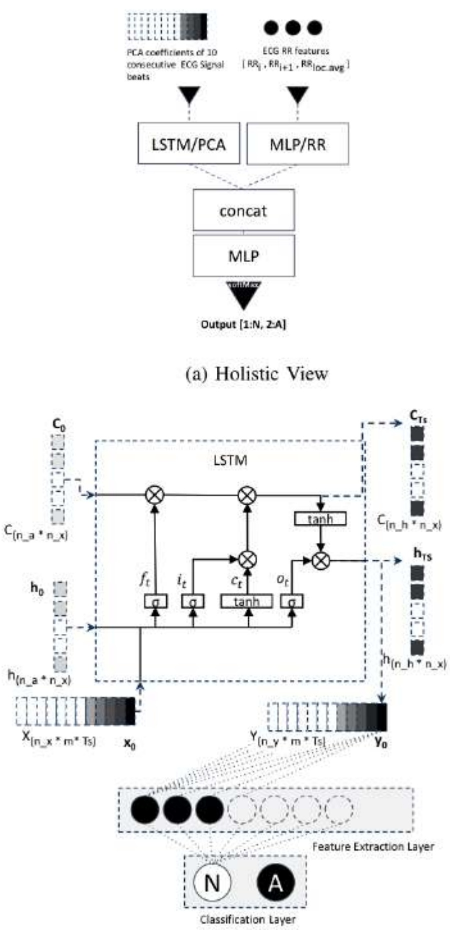
- Research distributed machine learning techniques with 2 stages.
    - Develop blind learning algorithms for binary stage 1 classifiers to be implemented in the IoT

- Develop stage 2 algorithm for comprehensive analysis
- Test the detection accuracy of the techniques at Stage 1 and Stage 2 using public datasets

- Develop a sensor prototype and implement the algorithms in firmware and measure improvements.

Algorithm Development:

LSTM based classifiers have been developed in Matlab from scratch. The algorithm is tested with free and open database. The binary classification accuracy is ~95% . A paper is under preparation.



(a) Holistic View

(b) LSTM Cell Pipelinee

Fig. 2: Neural Network Architecture

TABLE I: Patient Specific Training summary for the MIT-BIH arrhythmia dateset 200-234

Record	TN	FN	TP	FP	Test Acc.
200	1,432	38	692	3	0.981
201	1163	43	282	30	0.952
202	1,668	17	54	128	0.922
203	1,914	168	210	186	0.857
205	2,116	29	51	1	0.986
207	1,245	189	21	1	0.87
208	1,264	285	841	43	0.865
209	2,134	281	92	8	0.885
210	1,988	43	150	19	0.972
212	2,259	0	0	22	0.99
213	2,178	261	230	27	0.893
214	1,660	8	207	0	0.996
215	2,657	29	105	0	0.99
219	1,705	57	0	7	0.964
220	1,594	27	66	2	0.983
221	1,671	5	312	28	0.984
222	1,723	48	161	180	0.892
223	1,663	149	380	3	0.93
228	1,389	8	296	6	0.992
230	1,851	0	1	3	0.998
231	1,264	0	0	8	0.994
232	307	3	1,161	10	0.991
233	1,848	56	646	7	0.975
234	2,234	49	4	0	0.979
Gross	40,927	1,793	5,962	722	0.95

TABLE II: Global Training summary for the MIT-BIH arrhythmia dataset

Record	Total no.of beats	Accuracy
100-124	40,715	0.994
200-234	49,404	0.916
Gross	90,119	0.95

For the experiment we have considered first 20 records in the MIT-BIH Arrythmia database consisting of more than 40 thousand beats. Less than 7,000 beats among the first 1,000 beats of each records (from 20,000 beats) were selected for training the neural network.

The development of version 1 of the prototype sensor is completed. Currently the algorithm is being converted to embedded software to be ported into the IoT device. A second algorithm using a simple rule-based classifier is also being developed.

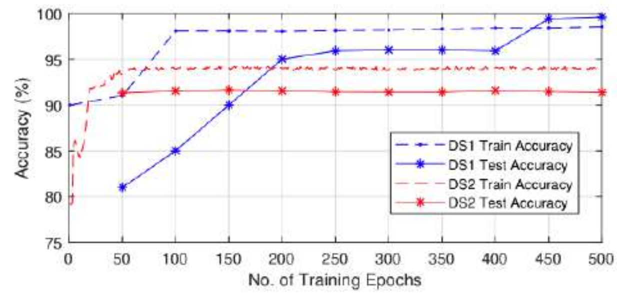


Fig. 4: Training Summary of the proposed Neural Network on DS1 (100 - 124) and DS2 (200 - 234)