Tiny Machine Learning (TinyML) Based Self Diagnostic Kit for Respiratory Diseases

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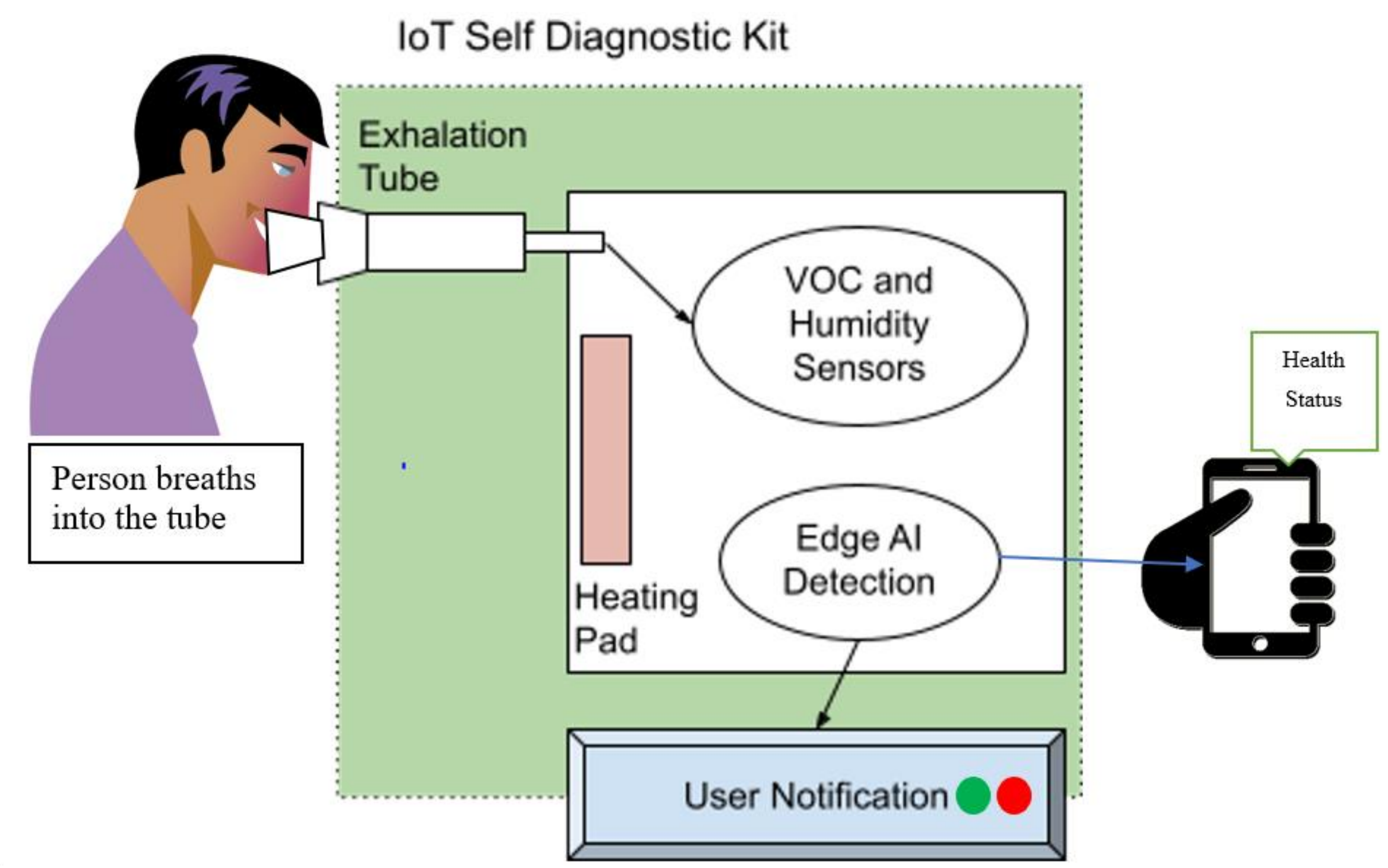
Abstract

The use of latest technologies of Machine Learning (ML) and Internet of Things (IoT) provide capabilities that can enable cheap and convenient detection and monitoring of respiratory diseases. However, existing solutions are cloud based and thus depend on the availability of internet connectivity to function. This poses privacy, security and even connectivity challenges especially in Africa. The concept of using an emerging ML technique for inferencing on resource-constrained devices known as TinyML was used as solution enabling the development of a self-diagnostic kit. The system captures breath Volatile Organic Compounds (VOC) with the collected data will be processed on the device and a TinyML algorithm used to detect if the sample is infected or not. The ML model predicts respiratory diseases with and accuracy of 96.2% using 30% of the device resources.

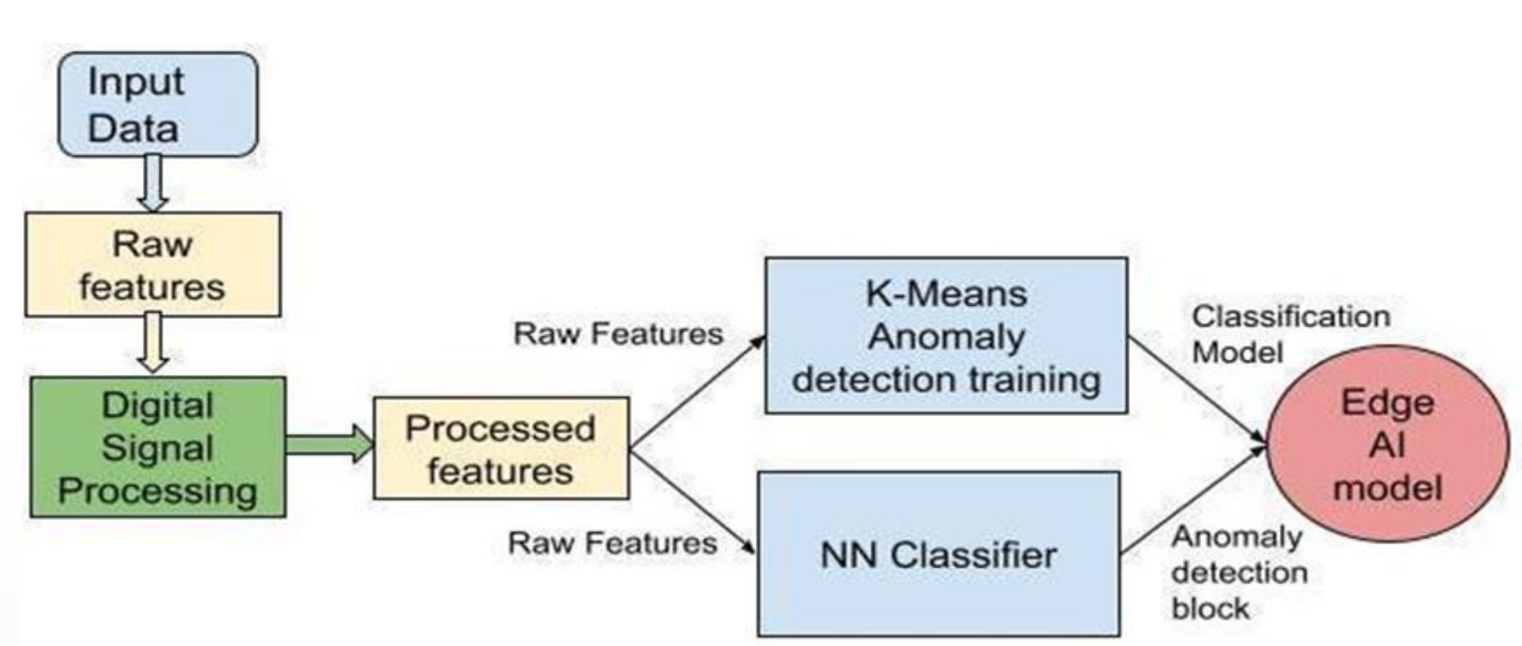
Background

Considering this particular case of detecting respiratory diseases, the researchers recently validated in a previous study the concept of using an emerging AI technique for inferencing on resource-constrained devices known as TinyML. Using an open source dataset of Volatile Organic Compounds (VOCs) exhaled by humans when breathing, the researchers trained a TinyML model to infer Chronic Obstructive Pulmonary Disease (COPD). This study was a next step in maturing the findings of the previous study. The study consisted of implementing the physical hardware embedding the previously trained TinyML model and therefore validate the onboard inference in real settings. A given person breathes into a tube that canalizes the exhaled air towards VOC sensors which collect VOC from the exhaled breath. The collected data is processed on the device and a TinyML algorithm used to detect if the sample is infected or not. A feedback will be shown on the device in real-time. The study also explored scaling the solution to other diseases.

Materials and Methods



Raw data is taken into the pipeline and slashed into smaller windows, signal processing blocks are then used to for feature extraction, and then a learning block is used for the classification of the new data. For same inputs the same values are always returned by the Signal processing blocks and are used to make processing of raw data easier. The learning blocks learn from past experiences. The learning block has two parallel training processes, one for detecting abdominal observations and the second one for classifying observations as healthy against or not



Results

ACCURACY 95.3%

LOSS 0.16

Confusion matrix (validation set)

	COPD	HEALTHY
COPD	96.7%	3.3%
HEALTHY	5.9%	94.1%
F1 SCORE	0.95	0.96

The resulting library is integrated into our COPD disease prediction application as a library dependency before compiling and building the full application into an embedded executable to be deployed in our embedded prototype based on Arduino Nano 33 BLE Sense.

Conclusion

validated the edge AI inference accuracy to predict RD to be very similar to the optimal accuracy when using the cloud for inferencing and analyzed the impact of varying different embedded real-time resources such as the number of exhaled breath sensors on both inference accuracy and embedded processor memory needs.

Future Direction

Future works will involve the collection of datasets from volunteers suffering from other respiratory diseases to predict more diseases. We will also explore synthetic data generation to produce artificial data for other respiratory diseases.

Acknowledgments

This work was supported by DSA in close collaboration with the Deep Learning Indaba and AI4D Africa with the generous support of the IDRC