The Abdus Salam International Centre for Theoretical Physics

Workshop on TinyML for Sustainable Development

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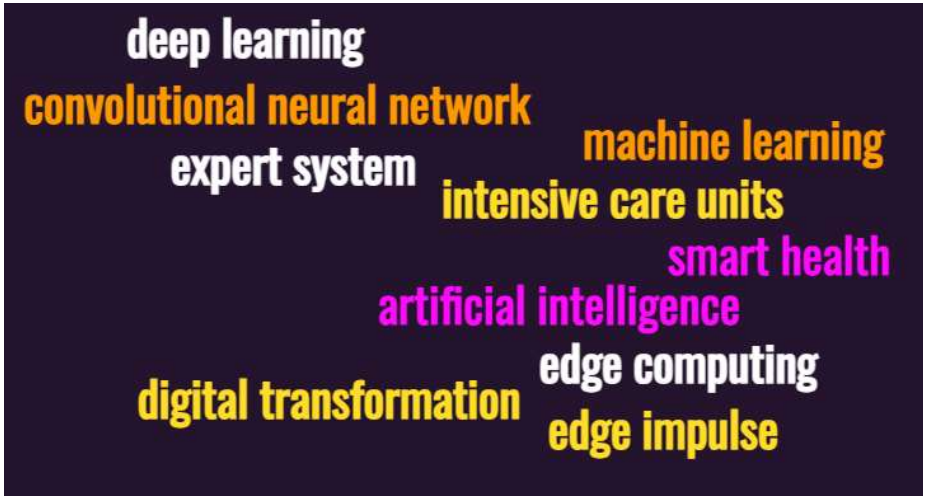

Use of TinyML in Intensive Care Units (ICT)

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Arnaldo de Carvalho Junior held a Postdoctoral (2023) and Doctor of Sciences (D.Sc), Electrical Engineering - Electronic Systems, from Escola Politécnica – Universidade de São Paulo (USP) (2021). He held a Masters in Mechanical Eng. from UNISANTA (2017) and an MBA in Business Management from FGV-RJ (2001). He also got a degree in Electronics Eng. from UNISANTA (1991). Specialist in Wireless, Industrial and Data Networks. 3 Patents published in 2019. He is currently a full professor at the Federal Institute of Education, Science and Technology of São Paulo (IFSP), co-leader of EAILab and member of Labmax and Autom System research groups at IFSP. Currently he develops applied research with artificial intelligence (AI), machine learning (ML), tinyML, non-classic logic (PAL Eτ) and border computing for expert systems.

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SOUND DETECTION IN THE ICU WITH TINYML: PROJECT WITH ARDUINO NANO 33 BLE SENSE AND EDGE IMPULSE

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Summary- This article presents an early warning system for critical events in intensive care units (ICUs). The system uses sound detection techniques with TinyML to quickly identify potentially dangerous events such as suction noises, falls, and cardiac arrests.

Keywords: Sound detection; Artificial Intelligence in Health; TinyML; ICU.

INTRODUCTION

With technological advances in medical care for critically ill patients, intensive care units (ICUs) have become highly complex work environments [1]. However, this complexity also brings challenges such as noise levels [2] and alarm fatigue [3], and the presence of monitoring and life support equipment, together with the traffic of support personnel due to false alarms generated, results in dissatisfaction and discomfort for healthcare professionals and patients in the ICU [2]. Sound detection in the ICU can be vital, providing valuable information for monitoring and

A. Complexity and Challenges of ICUs

ICUs are highly complex work environments equipped with advanced technology to monitor critically ill patients. However, this complexity also brings noise levels, which can cause dissatisfaction and discomfort for patients and healthcare professionals. Sound detection in the ICU can provide vital information for monitoring and medical decision-making [1].

B. The Emerging Field of TinyML

TinyML is a solution that enables the use of machine learning on embedded systems with limited

INTENSIVE CARE UNITS - A COMPLEX ENVIRONMENT

Challenges:

- Noise Level;
- Alarm Fatigue;
- Amount of Monitoring and Life Support Equipments;
- Traffic of people due to false alarms, resulting in:
  - Dissatisfaction for healthcare professionals
  - Disconfort for patients

PROJECT'S OBJECTIVE

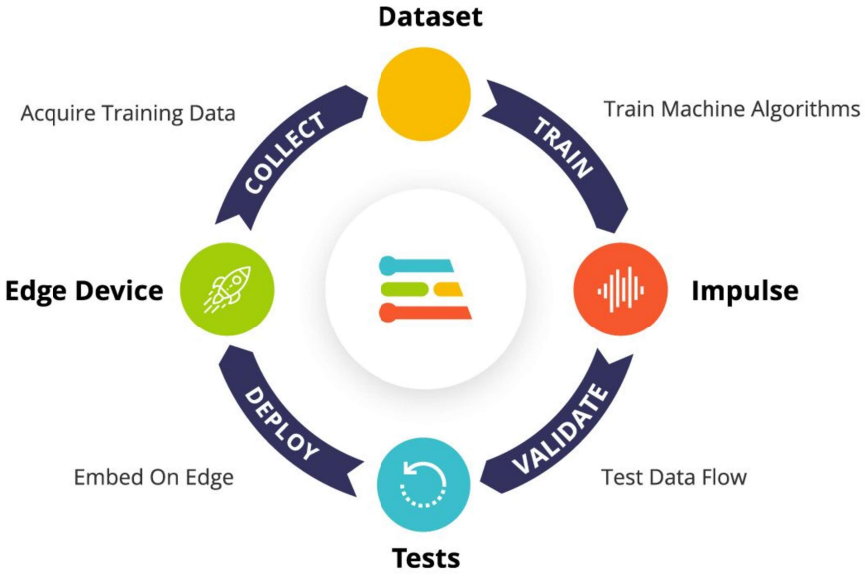
Develop a *TinyML prototype* capable of efficiently *detecting and classifying sounds* in the *ICU* environment, providing vital information for monitoring and medical *decision-making* process.

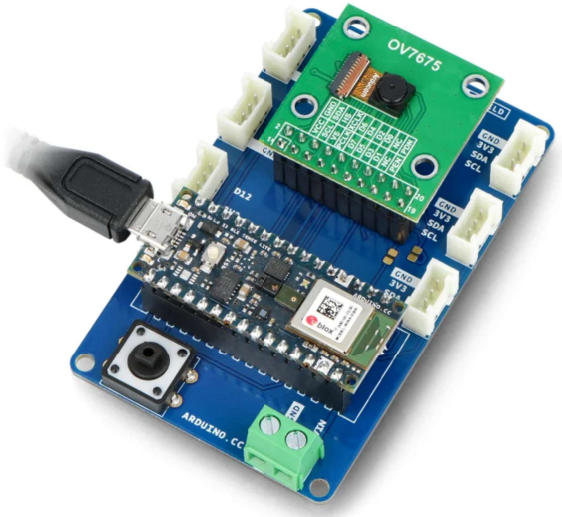
MATERIAL AND METHODS (1/3)

1) Hospital Ambient Noise (Kaggle) with 600 audio samples;

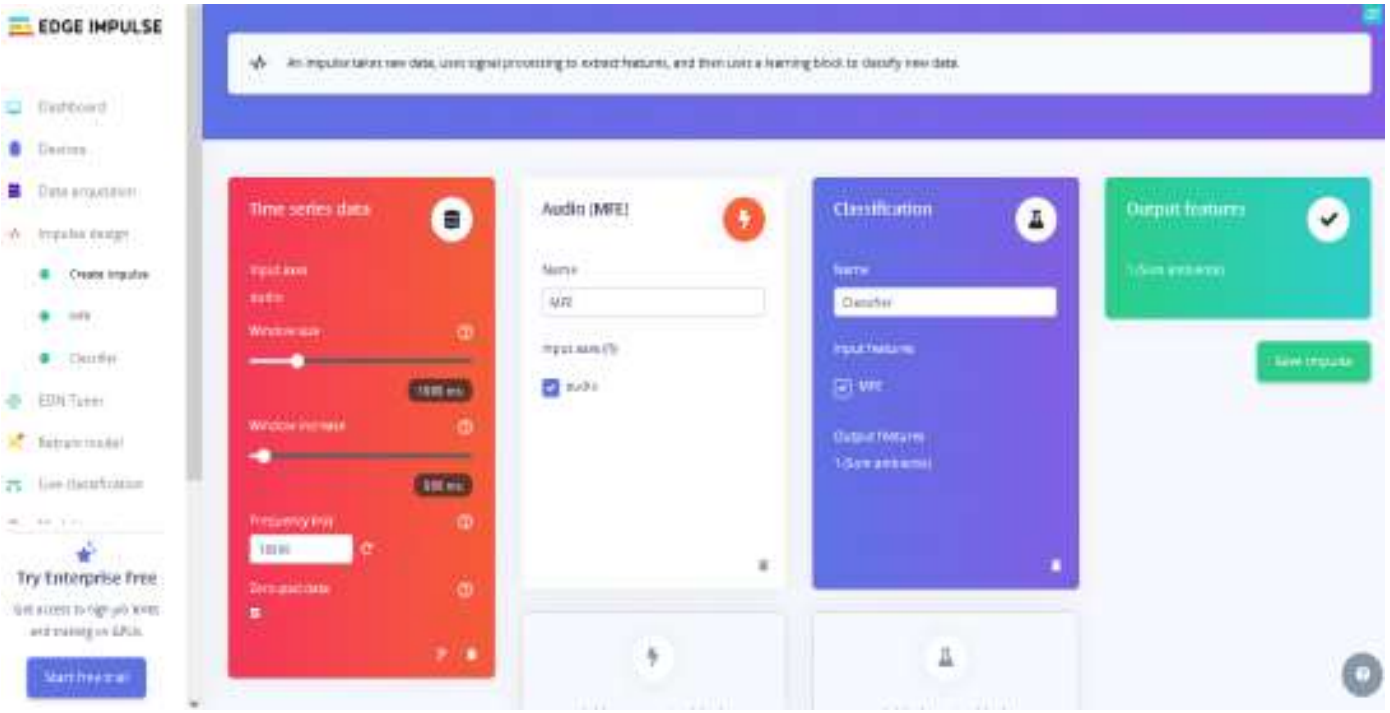
2) Edge Impulse AI Platform;

3) Arduino Nano 33 BLE Sense





MATERIAL AND METHODS (2/3)



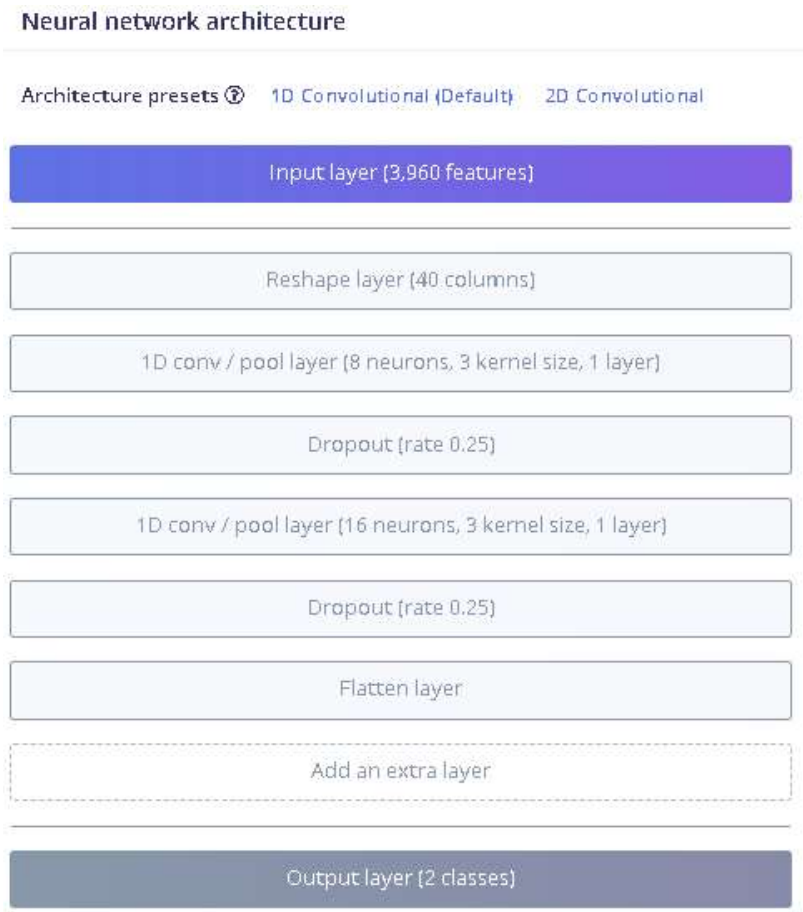
2 Classes Of Sounds

- Environment
- Alerts

MATERIAL AND METHODS (3/3)

Convolutional Neural Network (CNN)

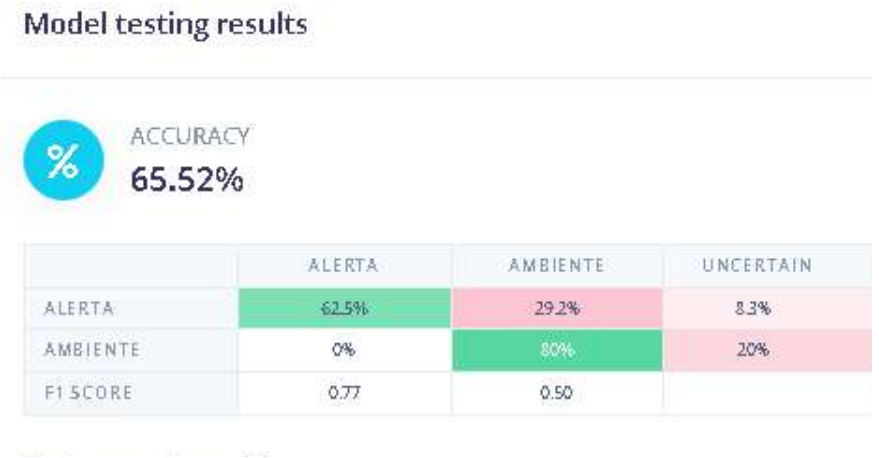
- Input Layer with 16 filters by 3 in kernel;
- 1D conv /pool layer (8 neurons), dropout rate 0.25;
- 1D conv/pool layer (16 neurons) dropout rate 0.25;
- Output Layer with 2 outputs



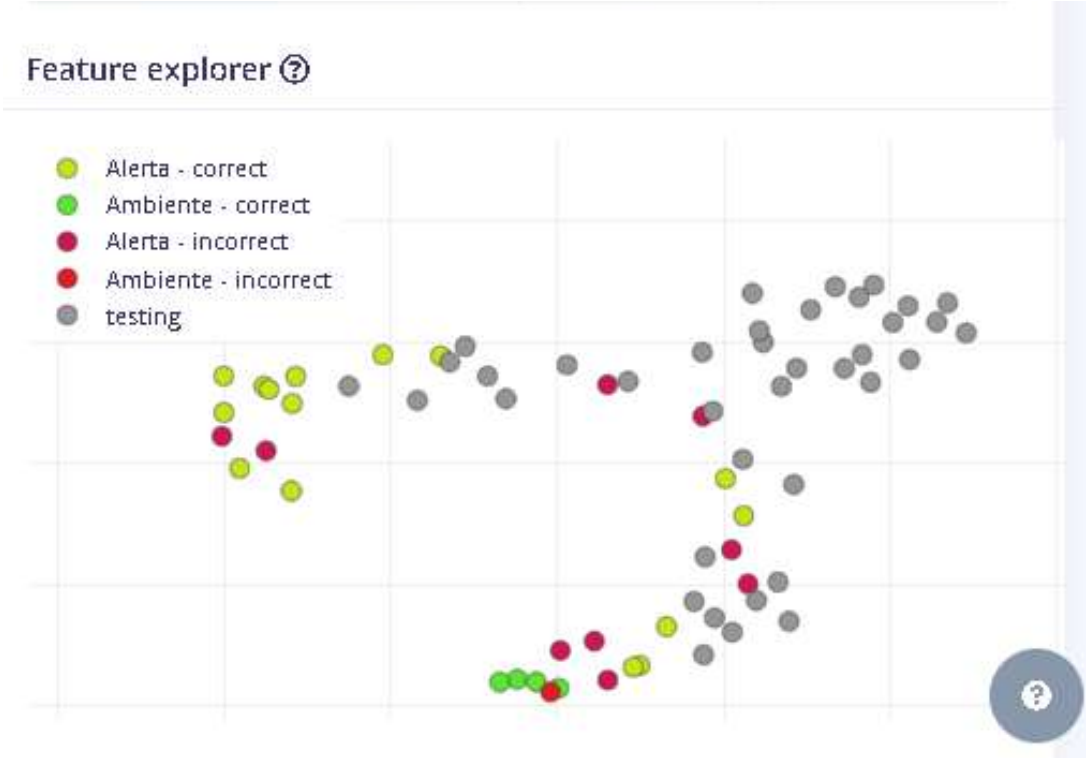
RESULTS AND COMMENTS (1/2)

Positive Aspects

- Test realized in an public hospital for adult patients (8 bed capacity) to validate sound detection in the ICU.
- Different relevant types of sounds: as medical equipment alarms, nurse calls, and critical events like patient falls.
- Success Rate of **65.52%**;
- Low rate of false positives and negatives



RESULTS AND COMMENTS (2/2)



Aspects to Improve:

- Quality of the dataset;
- Improve sound detection hardware;
- sound captured due to environmental noise.

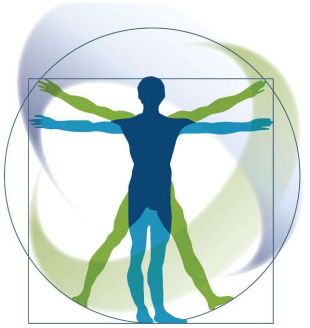
CONCLUSION

- The objective was achieved and a TinyML sound detection prototype for ICU environment was designed.

- A Sound detection in the ICU enables faster actions in emergencies, ensures quality patient care and minimize risks.

What´s Next?

- A Health partnership to support the deployment in the real world scenario;
- Increase accuracy of the model by:
  - # of samples for the dataset;
  - Sample of sounds with better quality;
  - Embedded digital filters to improve the quality of the sound captured in real-time;
  - More classes according to the health partner needs;
- Integrate the system with other medical devices and the ICU routine.



Health 4.0

TinyML in Intensive Care Units (Podcast in Portuguese)

Recorded at: March, 03, 2024

Podcast FIT Tecnologia: https://www.youtube.com/watch?v=ISH9T7nDva8&t=9s

Thank you!
Let´s keep in touch...

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