Application Example

EV Battery Status prediction using Neural Networks

A customized LSTM neural-network exploits ST SPC5-STUDIO to accurately predict Automotive Li-Ion State of Health and State of Charge using optimised CPU resources

Overview

Lithium-ion batteries (Lib) are extensively used to power a wide range of products: from end-consumer electronic devices such as mobile phones and laptops, to Electric Vehicles such as cars and small aircrafts.
This is due to the high energy density Lib hold compared to other types of electrical batteries.

Extending the life cycle of batteries is of pivotal importance to reach high standard in the value chain of the battery market. These requirements can be ensured through an accurate estimation of its state of health (SoH) and state of charge (SoC).

Modern Battery Management Systems (BMS) integrate advanced analytics capabilities aimed at computing the State of Charge (SoC) of the battery and at managing the cells' voltages and currents during operations.

Solution

Many factors affect the aging mechanism of a LiB cell: not only the chemical properties of its components, but also the environmental conditions (temperature and humidity) as well as the number of cycles and the loads dynamics. All of these non-linear dependencies make the analytical modeling of the cell's behavior a hard task which, upon success, faces the problem of too large model's dimensions and too high execution latency.

We propose an AI-based platform designed to compute the state of Li-Ion batteries of electric vehicles with the ultimate goal of providing real-time and accurate estimation of the battery's autonomy and at the same time fitting the hardware resources constraints.

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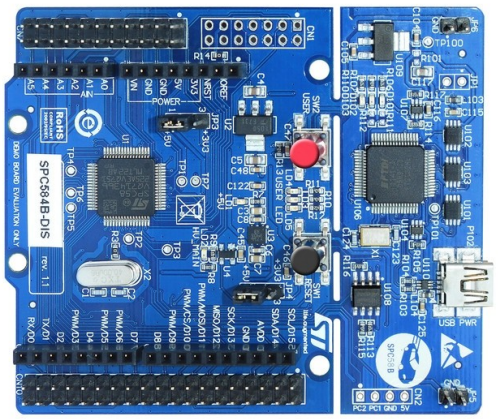
Technology

Machine learning on the edge:
Machine Learning is an application of artificial intelligence (AI) that provides systems the ability to automatically learn and improve from experience without being explicitly programmed.
Today, a vast proportion of ML-based applications are supported by PC platforms, cloud computing or powerful smartphones.
However, the latest trends and achievements in software technologies bring to be the possibility to run artificial intelligence on the edge (as part of the embedded software), while preserving an application's accuracy and reliability.

Data-driven approaches :
The proposed solution involves a machine learning approach and demonstrates how data-driven approaches meet the challenge of reaching high accuracy while being light and computationally efficient.



Implementation

The proposed application task is to compute the State of Health (SoH) and the State of Charge (SoC) of a lithium-ion battery cell. The application is designed to output SoH and SoC from Voltage, Current and Temperature (V, I, T) data streams coming from the battery management system.
The actual computation is performed by a deep learning pipeline composed of two main items:

- a denoising auto-encoder used to compress the data stream
- a recurrent neural network aimed at compute SoH and SoC

The auto-encoder performs dimensionality reduction and replaces analytical frameworks in the purpose of pre-processing data. Moreover, it allows for a lighter model to be trained.

The application was tested on the target hardware: the SPC584b-discovery board from Stmicroelectronics.

The application was developed with the use of SPC5Studio.ai: the new plugin from STmicroelectronics allowing for the integration of pre-trained neural networks within the embedded application targeting SPC5 mcu based products.

Success story

The proposed solution stands as the first fully AI-based solution addressing the problems of deployability and reliability of high accuracy applications targeting real-time environments.
Also, it stands as a real case example of embedded data-driven BMS.

The solution's architecture ensures the easiness of use and stands as a ready to use tool for R&D forces constantly dealing with timings and budgetary constraints while designing the next generation of AI-driven BMSs.

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