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Software-Hardware Co-Design Approach For Gas Identification

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Abstract

Gas detection is one of the major processes that has to be taken into consideration as an important part of a monitoring system for production and distribution of gases. Gas is a critical resource. Therefore, for safety reason, it is imperative to keep monitoring in real time all parameters such as temperature, concentration and mixture. The presented research in this abstract on gas identification is part of an ongoing research project aiming at the development of a low power reconfigurable self-calibrated multi-sensing platform for gas applications.

Gas identification system can be described as a pattern recognition problem. Decision tree classifier is a widely used classification technique in data mining due to its low implementation complexity. It is a supervised learning that consists in a succession of splits that leads to the identification of the predefined classes. The decision tree algorithm has been applied and evaluated for the hardware implementation of a gas identification system.

The data used for training is collected from a 16-Array SnO_2 gas sensor, the sensor array is exposed to three types of gases (CO, Ethanol and H_2) at ten different concentrations (20, 40, 60, 80, 100, 120, 140, 160, 180 and 200ppm), the experiment is repeated twice to generate 30 patterns for training and another 30 patterns for testing.

Training is performed in MATLAB. It is first done using the raw data, which is the steady states, and then using transformed data by applying principal component analysis. Table 1 shows the decision tree training results. These include the trees obtained from the learning on the original data and on different combinations of principal components.

The resulted models are implemented in C and synthesised using Vivado High Level Synthesis (HLS) tool for a quick prototyping on the heterogeneous Zynq platform. Table 2 illustrates the on-chip resources usage, maximum running frequency and latency for the implementation of the trained decision tree models. The use of Vivado HLS helped to optimise the hardware design by applying different directives such as the one that allow loop unrolling for a better parallelism.

The best performance is obtained when the first three principal components were used for the training which resulted in an accuracy of 90%. The hardware implementation illustrated that a trade-off is to be found between the accuracy of the identification and the performance in terms of processing time. It is planned to use drift compensation techniques to get more accurate steady states and increase the performance of the system. The system can be easily adapted to other types of gases by exposing the new gas to the sensor array, collecting the data, performing the training and finally implementing the model.