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Time Series Forecasting Mastery: Intelligent Energy Consumption Analysis for Microcontrollers

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I Overview

Day after day our lives dependent on electronic devices more and more such as smartphones and computers, and this is accompanied by a growing concern for managing the resources needed to power these devices. In order to use energy efficiently, it is important to be able to forecast the energy consumption of a building so that energy production can be optimized for different climatic conditions. This is particularly important in the context of smart cities and networks, which are currently an enthusiastic area of research.

Recent studies [4] have shown that artificial intelligence (AI) algorithms based on long and short-term memory (LSTM) neural networks (NNs) are very accurate at predicting energy consumption. These AI algorithms rely on collecting a long-term history of energy consumption data and associated weather data. However, processing and analyzing such a large amount of data requires significant compute and network resources, resulting in additional power consumption of cloud-based computers.

To solve this problem, low-cost embedded systems can play an important role in predicting energy consumption in different climates. These small systems typically use a microcontroller and present an attractive trade-off in terms of computing power, power consumption, programming flexibility, size, and cost. However, because microcontrollers have limited processing power and memory, it is not possible to use the traditional BackPropagation (BP) algorithm to train NNs on them.

Instead, the AI model is first trained and tested on a computer using a GPU for high computing power. Then, the model parameters are compressed and optimized to reduce computational complexity so that the model can be deployed on the small embedded system. This is done by reducing the number of model parameters and using efficient bit quantization without degrading the accuracy too much. In addition, interesting work has been done to run the BP algorithm on the embedded system itself.

Another promising approach is transfer learning (TL), which involves training and deploying an NN on a small embedded system using pre-trained models from larger computers. TL is a well-suited technique for deploying NNs on small embedded systems completely autonomously.

So, AI algorithms based on LSTM neural networks can greatly contribute to the efficient management of energy resources. Using low-cost embedded systems, these algorithms can be deployed in various climatic contexts, without consuming excessive energy. This presents a promising solution to the challenge of energy resource management, especially in the context of smart cities and smart grids.

IV Acronyms

AI	Artificial Intelligence
LSTM	Long Short-Term Memory
NNs	Neural Networks
TL	Transfer Learning
RNNs	Recurrent Neural Networks
MCU	Microcontroller Unit
IoT	Internet of Things
SoC	System on Chip
ESP-IDF	Espressif IoT Development Framework
GPIO	General Purpose Inputs/Outputs
ADC	Analog to Digital Conversion
SDK	Software Development Kit
FPGAs	Field Programmable Gate Arrays
TinyML	Tiny Machine Learning
IDE	Integrated Development Environment
VS Code	Visual Studio Code
ASICs	Application Specific Integrated Circuits
PULP	Parallel Ultra Low Power
ISA	Instruction Set Architecture
CNN	Convolutional Neural Network
MAC	Multiplication and Accumulation
BNN	Binary Neural Networks
MLP	Multilayer Perceptrons
GRU	Recurrent Gate Unit
DNN	Deep Neural Networks

MAE	Mean Absolute Error
FPU	Floating Point Unit
SVM	Support Vector Machines
ReLU	Rectified Linear Units
mLSTM	Multiplicative LSTM
mRNN	multiplicative recurrent neural network
BLSTM	Bidirectional Long Short-Term Memory
DLSTM	Dense LSTM
GRU	Gated Recurrent Unit
RMSE	Root Mean Square Error
KPI	Key Performance Indicator
BP	Backpropagation