Design and implementation of low-cost data acquisition system for temperature and relative humidity measurements

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Objective

In the present work, the design of a decentralized, low-cost automated data acquisition system is described, based on the ESP32 microcontroller and open-source software. Air temperature and Relative Humidity are measured using a Sensirion SHT20 sensor. . The measurement data are uploaded over Wi-Fi to an MQTT server and then stored to a MySQL database, allowing real-time remote access. The system architecture is presented, and its performance is evaluated in comparison to an existing weather station of higher cost. The proposed datalogger-sensor combination can obtain high-quality measurements that can be used for environmental research.

Results: all combinations

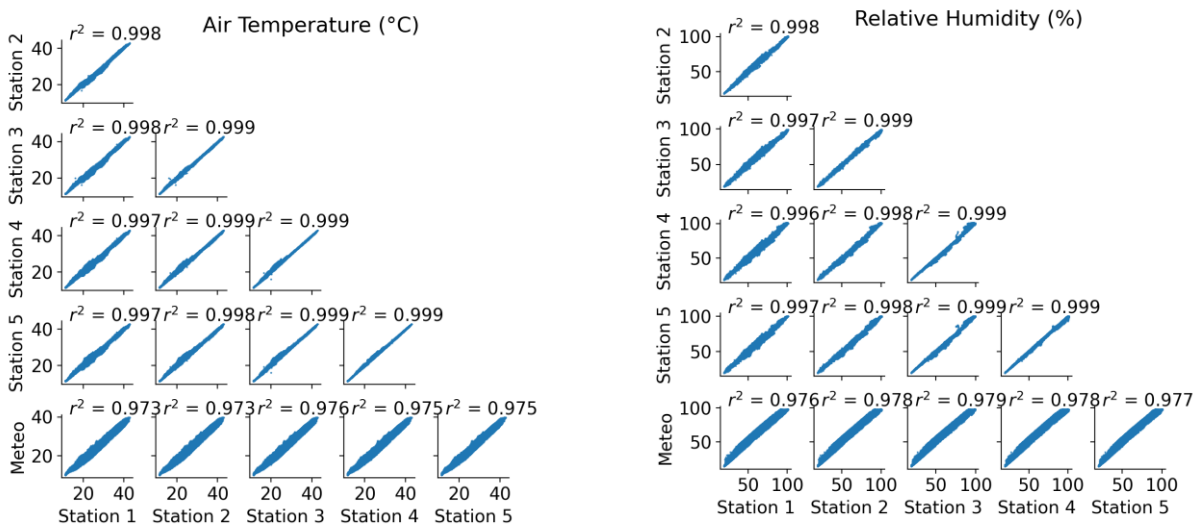

Figure 1. Comparison between the prototype dataloggers (labeled "Station1-5") and the automatic weather station (Meteo) Air temperature (left) Relative Humidity (%) (right)

Acknowledgments

We acknowledge support of this work by the project DeepSky co-financed by the European Union and Greek national funds through the Operational Program Competitiveness, Entrepreneurship and Innovation, under the call RESEARCH – CREATE - INNOVATE (project code: T2EDK - 00681).

Co-financed by Greece and the European Union

System design

The data acquisition system consists of an ESP32 microcontroller. A DFRobot SHT20 thermohygrometer, connected to the ESP32 is placed in a 3D printed radiation shield. The ESP32 is connected to the internet over Wi-Fi and is programmed using the Arduino framework. The ESP32 operates as a client and sends measurements data to the back end of the application for storage in a database.

Experimental setup

Five units were assembled and installed outdoors, at the Laboratory of Atmospheric Physics' premises. The prototypes were compared to each other to ensure consistency of operation. The measurements gathered from each data logger were compared to those from the automatic weather station of the Laboratory of Atmospheric Physics, located at the University of Patras. The air temperature and relative humidity are measured at automatic weather using a Rotronic MP101A-T7-W4W thermohygrometer with an accuracy of ±0.3 K and ±1.5 % RH respectively.

Results: single sensor example

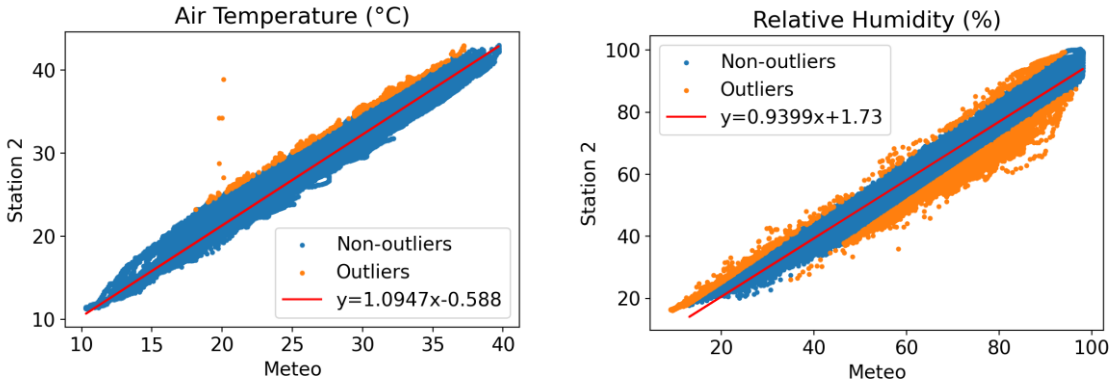

Figure 2. Comparison between a low-cost sensor (Station 2) and the automatic weather station (Meteo). Air temperature (left) Relative Humidity (%) (right)

Conclusions

The system is based on the ESP32 board, which uploads measurement data to a web application's back-end that stores it in a MySQL database. The proposed web-based application provides easy access to real-time data, which can be visualized or processed using custom scripts. Five prototype boards were created using easily available hardware and installed outdoors to collect real-world data. Testing of the prototypes was conducted continuously for six months, demonstrating stable performance without data loss. These results show that the proposed system can collect high-quality measurements and provide real-time data access.