Smartphone Experiments with External Sensors

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Abstract. Smartphone experiments are more and more used in teaching with diverse available smartphone apps. Most apps have in common that they are limited by the available sensors in the smartphone. This collection of sensors can be extended with external sensors. To do so, the app phyphox supports external Bluetooth Low Energy sensors like the ready-to-use SensorTag by Texas Instrument or self-made sensors, based on the Arduino platform.

1 Introduction

Smartphone-based measurements have become a welcome variation for experimentation in physics education, but the possible experiments are limited by the number and type of sensors inside a smartphone. To extend the selection of sensors, the app phyphox supports external sensors. This enables a large variety of smartphone-assisted experiments by adding new types of usable sensors on the one hand and by overcoming geometrical and practical limitations of built-in sensors in experimental set-ups on the other hand. In addition, the use of external sensors in smartphone-assisted experiments results in a harmonization of experimental set-ups in classroom experiments.

2 The app phyphox

The app phyphox (for “physical phone experiments”, more info on phyphox.org) from the RWTH Aachen University allows a simple read out of the built-in sensors for basic experimental applications. The app comes with several predefined experiments and has helpful features like an onboard data analysis, remote-control and an editor for user-designed experiments. As a new feature, phyphox supports also external sensors via Bluetooth Low Energy.

3 Smartphone Experiments with External Sensors

There are some different sorts of external sensors. For example, there are ready-to-use sensor boxes like the SensorTag by Texas Instrument. This box is available for around 35 € and is offering the basic smartphone sensors and additional new sensors like a temperature sensor, pressure sensor or a humidity sensor. These external sensors allow experiments in the field of thermodynamics. For example, the sensor box can be located inside a glass jar which then gets placed in a pot with boiling water. The temperature and the pressure of the constant air volume inside the glass jar rise while the humidity is decreasing, as one can see in figure 1. Thus, new experiments become possible not only due to the new types of available sensors, but also due to the low cost and size of small sensor units opening the way to new experimental set-ups. Another such experiment could be the measurement of the acceleration in an object which would be too small or unsafe for a smartphone.

Furthermore, self-made external sensors based on an Arduino allow countless new sensor types for new experiments. For example, with a light sensor and a LED, a low budget photometer can be realized. Moreover, a pH-value sensor can be used for new experiments in chemistry as an example on how data acquisition can be extended to other STEM subjects besides physics.

Additionally, the Bluetooth Low Energy standard allows to use devices from our everyday life for data acquisition. For example, a fitness tracker can be used to measure the heart rate or a Bluetooth Low Energy mouse gives access to the measurement of a moved distance.

4 Conclusion

External sensors extend the possibilities for smartphone experiments with a variety of new sensor types. They also enable new experimental set-ups avoiding geometrical and further limitations given by the use of smartphone built-in sensors for data acquisition. This allows new experiments in wide areas of physics but also in other fields of STEM education.

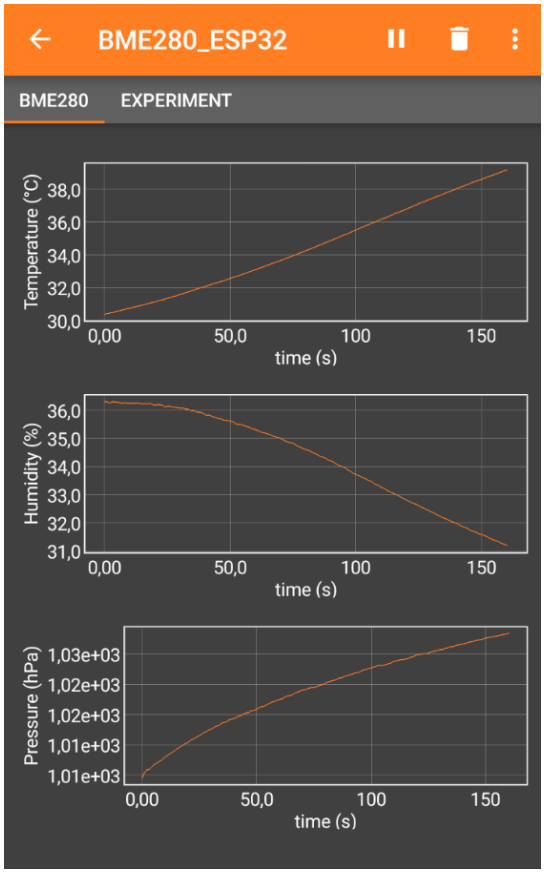

Fig. 1 Measurement of the pressure, temperature and humidity as a function of time inside of a glass jar, which was placed inside a pot of boiling water.