Datalogger development for tipping-bucket throughfall measurement with open-source tools

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1. Introduction

Agroforestry systems (Fig. 1) have considerably increased leaf area compared to traditional agricultural technologies. The planted tree canopies not only intercept rain on the leaf surface, but the part of rain falling through is heavily modified. The net precipitation is redistributed unevenly in time and space.

(a) (b)

Figure 1: Some agroforestry research plots; arable land (a: Fertőd), and silvopasture (b: Kőszeg)

2. Traditional measurement setup

Manual throughfall integrators are commonly used. Trough and funnel type gauges (Fig. 2) can not apply to explore the temporal and spatial distribution of the rain water.

(a) (b)

Figure 2: A throughfall measurement trough (a), and funnel (b)

3. Automation possibilities

The rapid development of digital sensing technology enables to use of automatic data collectors to explore patterns in water income of agroforestry field. Because of the high number of the planned sampling points we try to find low-cost solutions. As a first step into the digital world, we installed new equipment in our riparian alder plot (Fig. 3).

(a) (b)

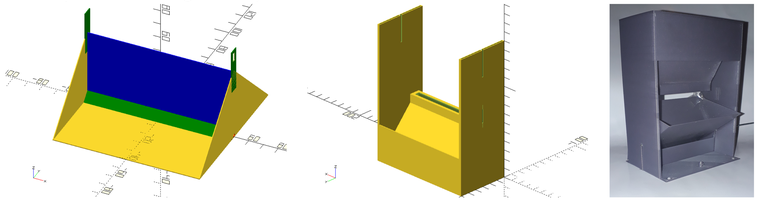
Figure 3: Automated measurements overview (a) a throughfall measurement trough (b)

This gauge works with a expensive commercial data logger which will be used for validation purposes in the current development.

4. Hardware development

We preferred to gain information on the temporal properties of throughfall. To increase the temporal sensitivity we created an own design of customisable tipping bucket. This measurement method provides a digital signal directly.

One of the main goals in the development to use open-source technologies in every step of the development. The mechanical part of the hardware planned with free software called OpenSCAD, Fig. 3 a–b).

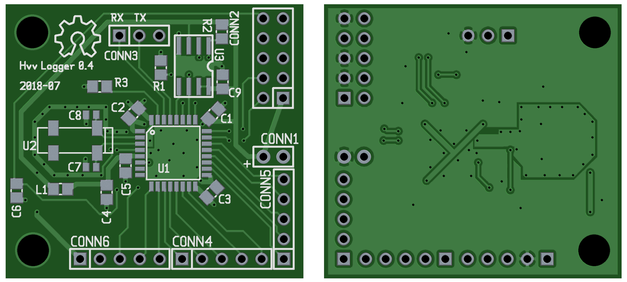


(a) (b) (c)

Figure 4: Tipping bucket flow meter for throughfall measurement (a) 3D model bucket, (b) 3D model base, (c) printing of model, (d) ready print

It is printed with open-source RepRap 3D printing technology (Fig. 3 c). The model is shared with the community (https://github.com/kaliczp/TippingFlow).

The tips are sensed by reed switch which is driven by the magnet fixed on the tipping bucket arm. The simple task is to log the timestamp of the tips when the reed. After many iterations, an ARM Cortex-M0+ based architecture was selected, which has low power consumption and integrates all the necessary components of a simple data logger in one chip. The latest version of the printed circuit (Fig. 5) created with the free pcb-rnd software. The development itself of the electronics is fully open-source too, shared through git (https://github.com/kaliczp/ST32L0 32).



(a) (b)

Figure 5: A throughfall measurement trough (a), and funnel (b)

5. Software development

The firmware of the microcontroller is coded in C programming language and compiled with the free, universal compiler optimised for ARM chip – GNU gcc. The full codebase shared on github (https://github.com/kaliczp/hvlog).

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