Monitoring an ephemeral stream with a Teensy 3.2 + audio shield to determine water level only from the noise of a stream

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ABSTRACT

RESULTS

CONTEXT

Study site: Vallon de Nant (Vaud, CH)
1497.7 meters above sea level

Intermittent and ephemeral streams (IRES) need new measuring technique
• Emerging subject of research in hydrology
• > 50% of the streams globally
• Lack of spatial and temporal data
• Current tool for water level detection = instream guage
• Harsh conditions = sensor destruction

DIY AUDIO SENSOR

• Distance (<5m from stream)
• Calibration with images
• Monitor by day and night (24h) and powered with solar panel
• Self-made and cost-efficient
• Arduino code for Teensy 3.2 + audio shield

3 main components of audio sensor
1. Power supply, with voltage converter, solar panel, and lithium-polymer (LiPo) battery
2. Microcontroller with real-time clock
3. Audio shield with microphone

METHOD

Images of streams with Time-Lapse-Camera

10-second audio files with Teensy 3.2 + audio shield

Fast Fourier Transformation

Sound in Sound Pressure Level in Decibel [SPL dB]

Images of streams with virtual scale

Water level detection with image processing [cm]

Relationship of water level in [cm] of image and sound in [SPL dB] of microphone

Observation period: 01.08.23 - 15.09.23
7 stream flow events monitored whereas 2 happened at night
Image processing can not confirm stream flow events at night

Sensor
• > 95% of the audio files were valid
• Autonomous power supply without problems for 2 months
• Cost: ≈ CHF 155.00

Audio and image method
1. \( f(x) = 5e^{-0.06 \cdot \exp(3e^{-0.1 \cdot x})} \)
2. Use SPL dB values as \( x \) to get Water level in cm

Successful determination of the water level with audio files

Strong relationship between water level of images and SPL dB of audio

Requires calibration by another sensor

Cost-effective sensor to counteract lack of spatial and temporal data

Code improvement required for more stability

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All codes and corresponding thesis are available on Zenodo online available