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DIY Bat Detector with Gamification Elements

1. Interdisciplinary Perspectives: Biology, Physics, and Technology

Fig. 1: Broad-winged bat (*Eptesicus serotinus*) (photo: A.-K. Krebs)

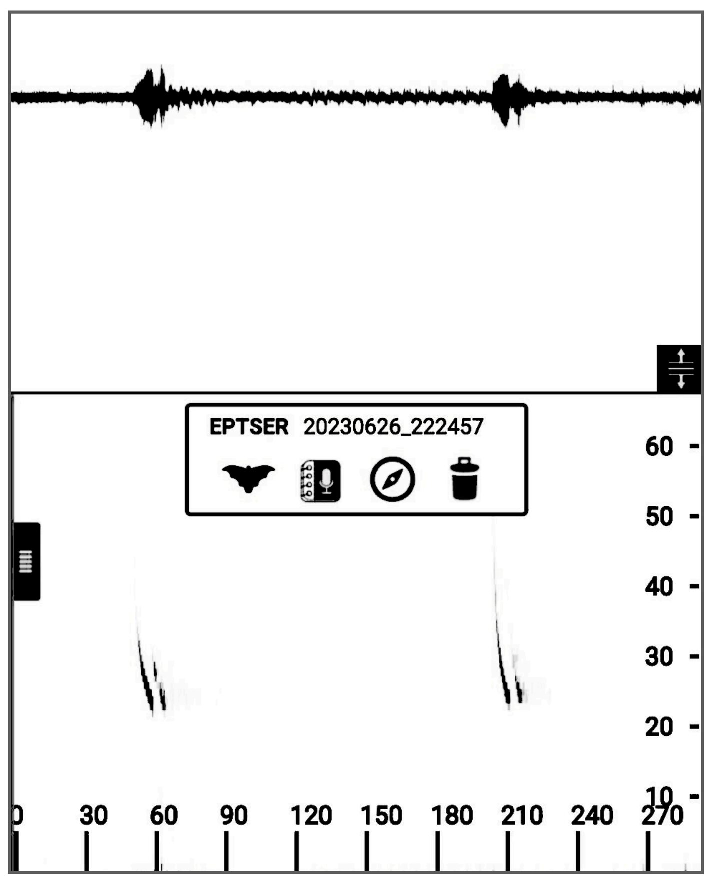

Fig. 2: Screenshot of an acoustic signal of the broad-winged bat (Echo meter app)

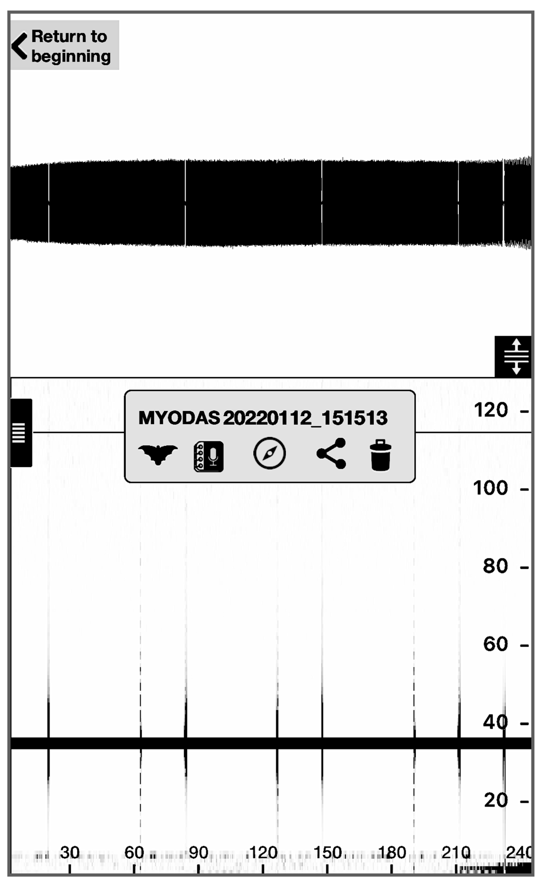

Fig. 4: Screenshot of a continuous technical ultrasound signal (Echo meter app)

Fig. 5: plug-in bat detector (echo meter) mounted on a smartphone

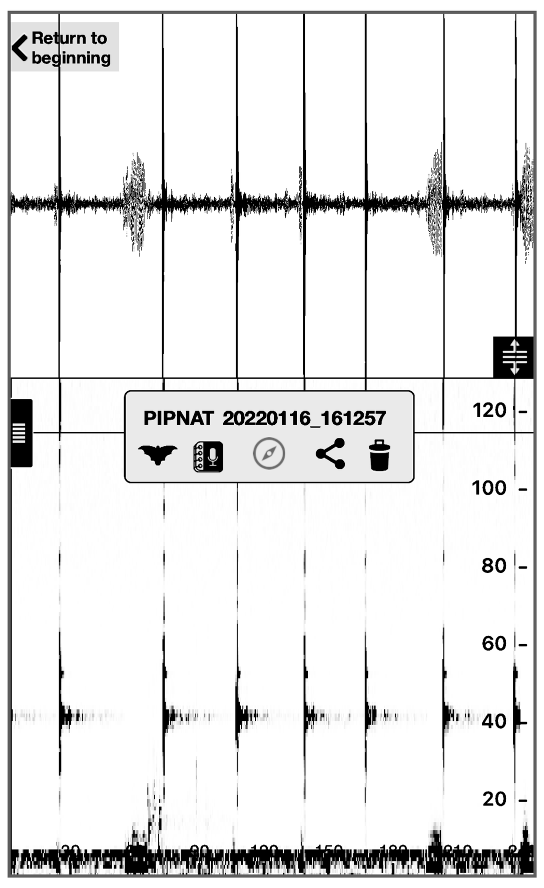

Fig. 6: Screenshot of the ultrasound signal from distance sensor HC-SR04 (echo meter app)

Biological Access

Bats are found almost worldwide. With around 1400 species in 200 genera and 19 families, they are the second largest mammalian order and make up 20 % of known species. Bats are the only land-dwelling and flying mammals that use echolocation. Ultrasonic detectors can be used to record their calls in the frequency range from 20 kHz to 140 kHz (see example in Fig. 2). Bats also use ultrasound to hunt insects. Depending on the species, they emit ultrasonic signals from their mouth or nose. To do this, they press air in their throat over the stretched vocal folds, which vibrate and produce their calls. The animals use the acoustic Doppler effect for orientation and hunting, as they and their prey

Fig. 3: Link to audio sample and video of an active bat

Conversion into audible sound takes place in bat detectors and is perceived from the loudspeaker as a partially slowed-down "rattling" sound. An audio example with a combined video recording of a bat can be found under the QR code (Fig. 3).

Access via Physics and Technology: Oscillations, Waves and Engineering Objects

Some devices can display, visualize and save the measured frequencies directly. Artificial ultrasonic sources such as distance sensors, ultrasonic toothbrushes or the autofocus function of photo lenses with ultrasonic drive can also be examined using the echo meter. With its measuring range of 20-192 kHz, the detector also records such "inanimate" ultrasonic sources.

To test the bat module, we operated an ultrasonic transmitter with a sine wave generator at a frequency of 34 kHz. As expected, the detector displays a strong, continuous signal at the specified frequency (see Fig. 4). The widely used HC-SR04 ultrasonic module, on the other hand, behaves very similarly to a bat. This module is often used, for example, in combination with the open Arduino platform in DIY projects (see Fig. 5). The measurement with the bat detector shows clear differences to the continuous signal in Fig. 4. The HC-SR04 emits burst signals with a frequency of 40 kHz and a pulse length of 200 µs each. This is clearly shown in the sonogram (Fig. 6).

2. DIY- and Gamification Approach

Adaptation of the B@t detector kit

Normally, do-it-yourself kits for bat detectors involve soldering or plugging components onto a prefabricated circuit board and are only suitable for young people aged 14 and over. The newly designed and developed B@t detector (Fig. 7) is also adapted for younger children (e.g. elementary school), but uses the same circuit board.In addition, inclusive aspects of sensory perception are incorporated so that not only acoustic but also visual and haptic signals are emitted during detection. This makes the detector similar to a gamepad.

Further technical development

Based on the desired additional functions for simulating a gamepad, a new circuit board with additional components must be developed for the detector and manufactured as a prototype (Fig. 8 and 9). The individual steps are presented in the block diagram below.

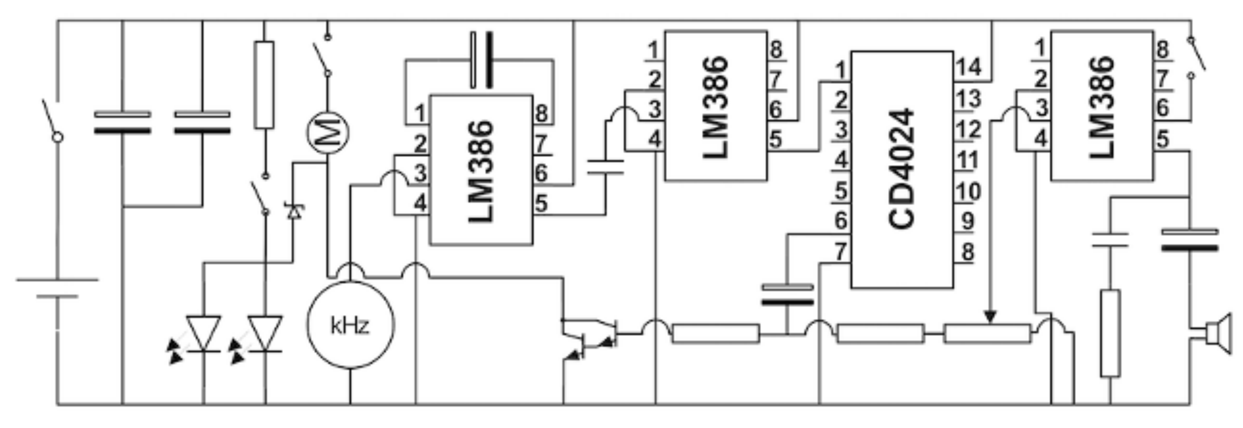

Fig. 8: circuit diagram

Fig. 9: Functional description of the circuit

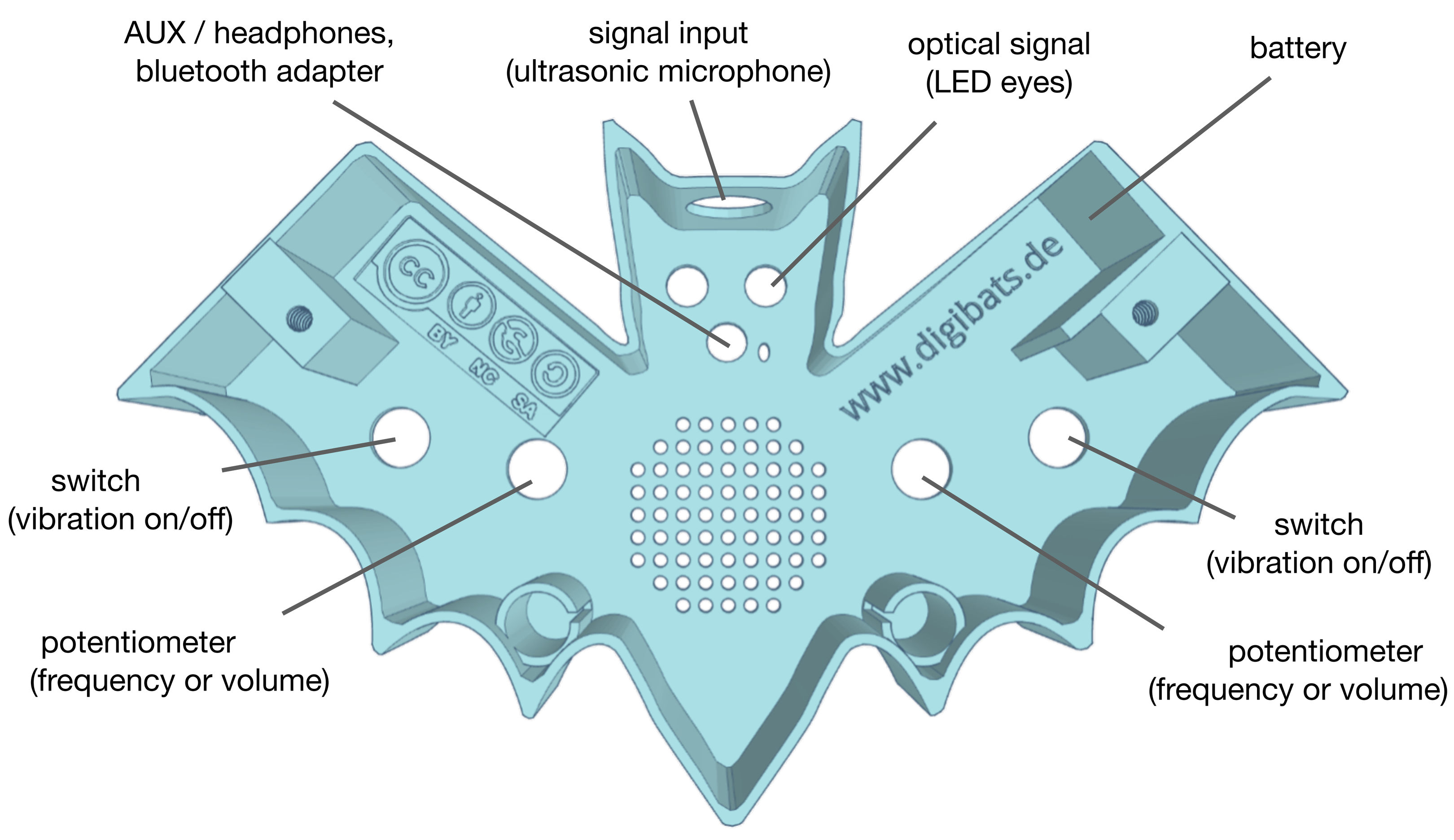

Fig. 7: 3D body of the B@t detector with components and description (design: A.-K. Krebs)

Output functions
- conversion of ultrasound into audible sound;
- output via loudspeaker;
- status LED

1st Implementation
- synchronous visual feedback;
- synchronous haptic feedback

2nd Implementation
- inverted optical feedback
- integration in status LED

1st Optimization
- minimization of software drivers

2nd Optimization
- integration of two functions in one driver
- synchronous control & inversion

3rd Optimization
- connection of the components via coded plug connections

4th Optimization
- reduction in overall height

5th Optimization
- enhanced routing

Objective definition
- insulation-milled PCB for wired components;
- versions with/without sockets
- SMD version, fully integrated

Further development
- production of a prototype;
- debugging;
- testing with students and pupils

References

Krebs, A.-K., Kasper, L., Kuhn, J. & Wilhelm, T. (2022). *Mit Echo Meter auf Fledermauspirsch.* In: Physik in unserer Zeit, 53(2), 96–97. https://doi.org/10.1002/piuz.202270212

Pfeifer, J., Krebs, A.-K. & Nepper, H. H. (2023, submitted). *Konstruktion und Fertigung eines Fledermausdetektors. Gestaltungsgrundlage für die Initiierung immersiver Lernumgebungen.* In: TU - Zeitschrift für Technik im Unterricht.