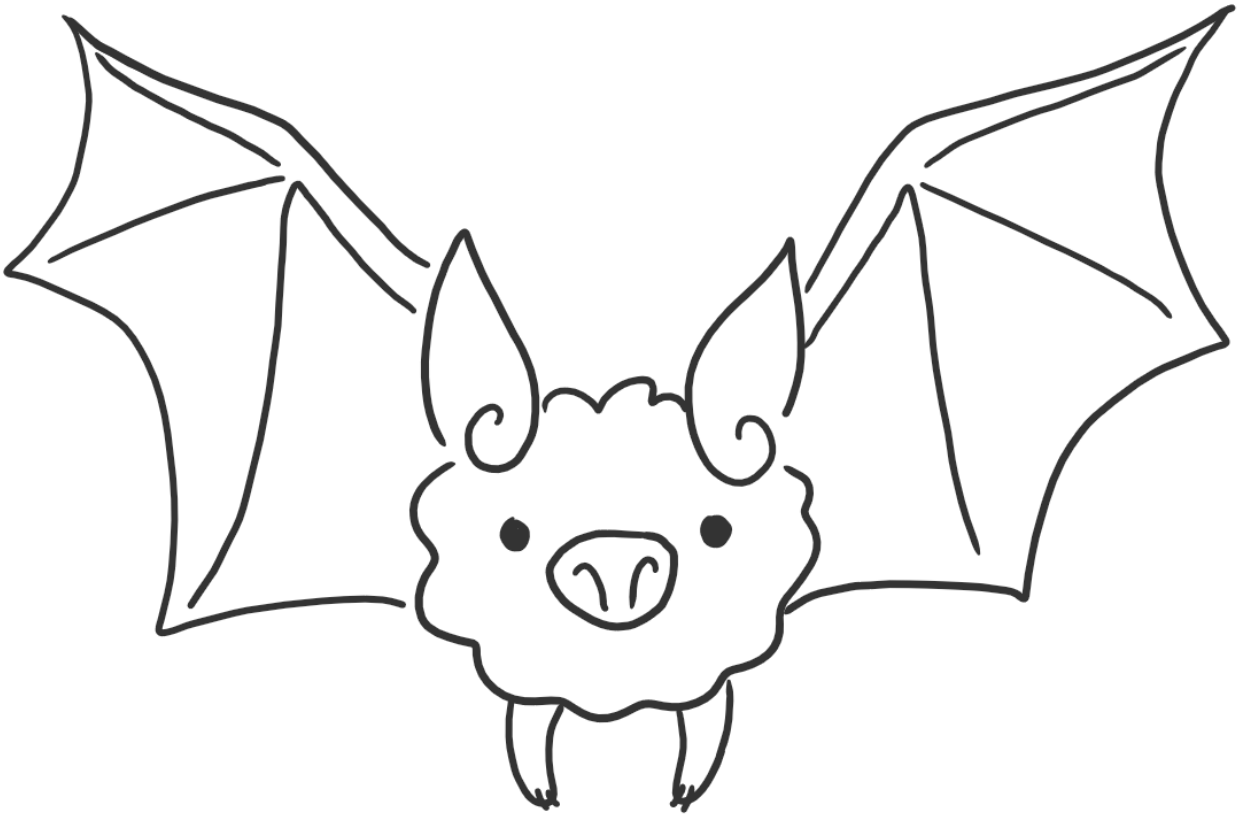
A bat sensory experience



Group members team 米 (rice/5)

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INITIAL PLAN

With various Arduino sensors, we aimed to evoke a new understanding of our physical space and consciousness by adapting the interesting sensory experience that bats have, to humans[1]. Bats navigate their environment using echolocation, they listen to ultrasonic sound that echoes off objects in a space for three-dimensional localization[2]. We were inspired by this unique way of perceiving. By using the ultrasonic distance sensor in combination with headphones, we aim to make echolocation available to humans. By making the device wearable, humans can navigate through space as a bat. We used various other sensors and motors to make the bat experience complete.

WHO DID WHAT

The coding and installation were created through a team effort. For the documentation, Anna is responsible for the sections 'Initial plan' and 'Result', Yiming is responsible for the 'Schematic diagrams', and Xiaotian is responsible for the section 'Problems encountered'.

RESULT

The resulting wearable bat suit consists of two main pieces. Most importantly, the headpiece with the ultrasonic distance sensor. This sensor is mounted at eye height to a sleeping mask, making the wearer blind as a bat. The headpiece is connected to the Arduino and power supply (Power bank). To make this hardware easy to carry for the wearer, it is safely secured in a small backpack. Three LED lights (red, yellow, green) are visible in the backpack and show the status in distance levels (useful for testing and debugging). Feedback from the ultrasonic distance sensor can be heard through the headphone, that we advise to wear around the shoulders instead of the head due to the loud sound. The feedback consists of beeps that start when there is an object within one meter (as a car parking sensor), when you get closer to an object the pitch of the sound becomes higher to show the urgency[3]. To make the bat experience complete, we also created two paper wings that are fastened to each side of the backpack. The wings are created with coloured paper and skewers and move with two servomotors. The wings begin to flap when an object is within 180 cm. If the object is closer than one meter the wings, will flap faster.

The wearable hardware and sensors make it possible for humans to explore space in a new way, based on the echolocation that bats use to navigate. To showcase our creation, we created a room-sized head-levelled maze made with big obstacles that a human wearing the Batpack™ could navigate through relying only on the provided bat sensors.

VIDEO OF THE WORKING OBJECT

Follow the link for videos and photos of the final object: https://leidenuniv1-my.sharepoint.com/:f:/g/personal/s3652254_vuw_leidenuniv_nl/EoR6Z7RTZJpNnMMS5bjnqFYBVcs5lyfyYxB11jAbxCrmRg?e=VLwyC0.

PROBLEMS ENCOUNTERED

Problem 1: In the feedback on our proposed idea, the lecturer mentioned that an Arduino may not be enough to support the simultaneous connection of power, sound, and sensor devices. However, after connecting the physical circuit, we discovered that it worked well with one Arduino. The only problem was that we could not connect the two servomotors simultaneously. To solve this, we changed the Arduino output voltage from 5V to 3.3V, after which the servomotor worked normally.

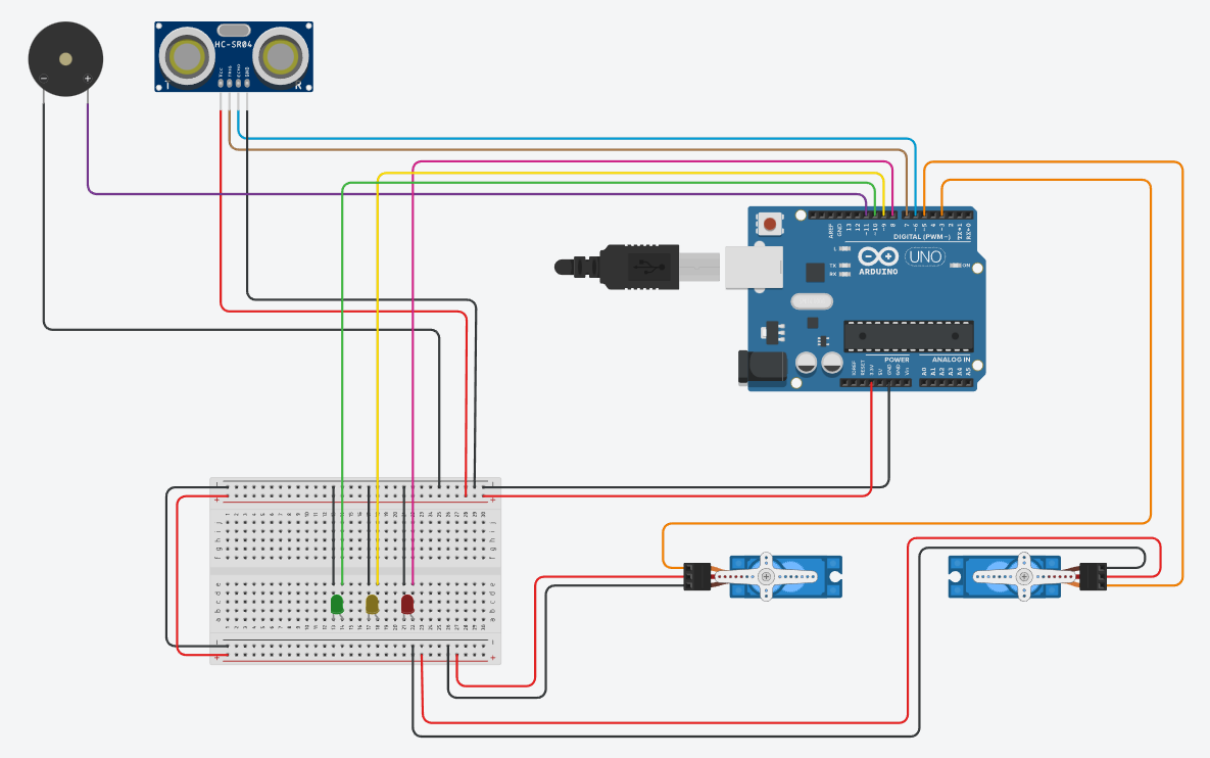
Problem 2: In the code, we combined the different functionalities in loops. In this way, each function has its own looped piece of code and does not interfere much with other parts. We had to debug some code for the wings. We wanted the wings to move slowly when obstacles are farther away and faster when obstacles are close. We first used pos +- 0.5 in the code instead of pos +-1 to make the wings move slower, but it did not work. Instead, we changed the delay time to make the wings flap slower.

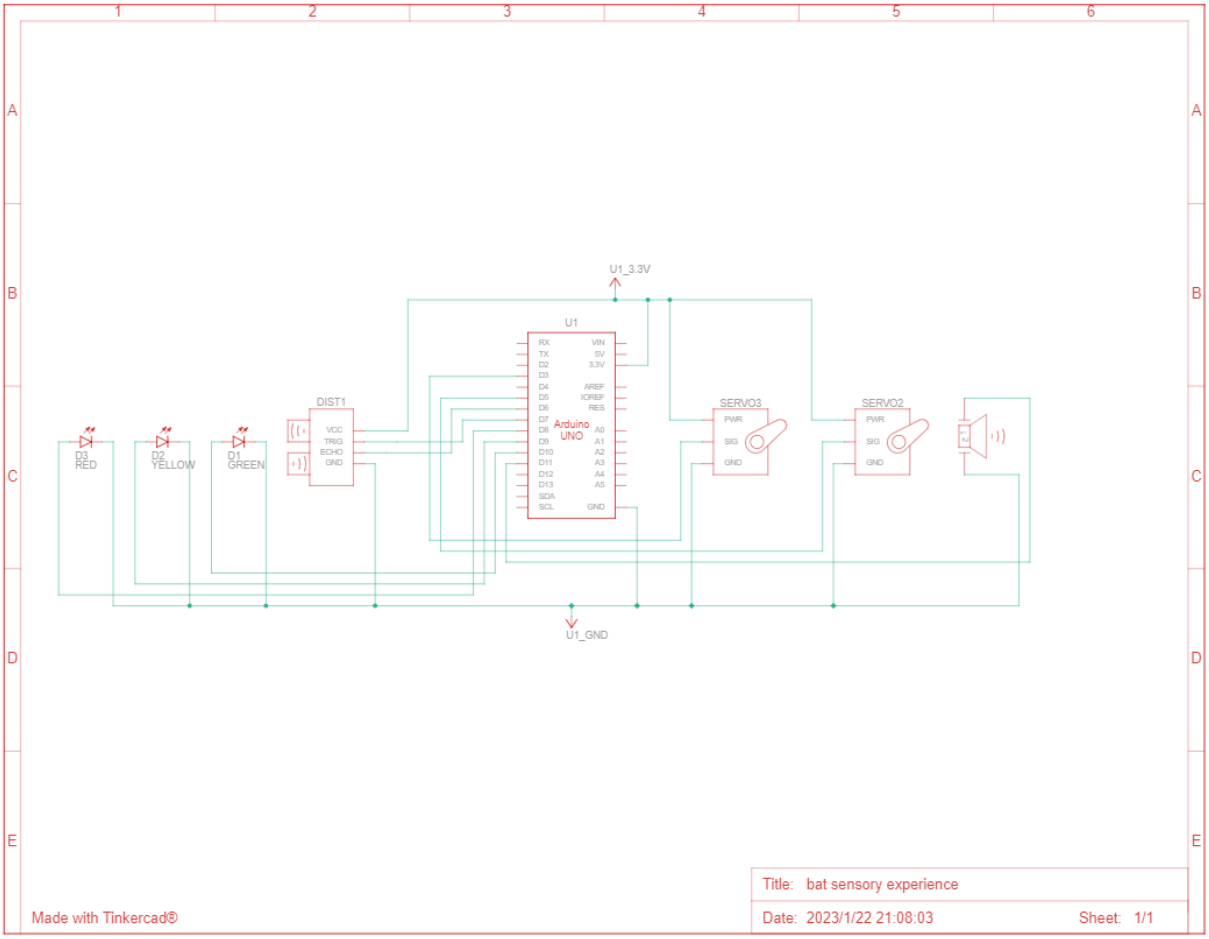
Problem 3: Since we had a lot of physical equipment and wanted to simulate the form and movement of the bat as realistically as possible, we had to make the equipment wearable. This caused some challenges. For example, making it possible for one person to wear all the equipment. We used a small backpack to put the Arduino and breadboard in. At first, this did not work. Due to its weight, the hardware pulled on the external devices outside the backpack. We solved this by cutting out a small cardboard box and putting it at the bottom of the bag to lift the hardware up. The distance sensor needed to be placed on the head and was fixed to an eye mask. To connect it to the hardware in the backpack, we extended the wire connecting the sensor and the circuit, with the wire running over the head to the back. Finally, the bat wings with the two servomotors. We used tape and rubber bands to fasten the wings to the sides of the bag.

Problem 4: While testing, we discovered that the two wings of the bat flapped asymmetrically when moving. Even when the initial angles were manually set, they moved in the same direction instead of opposites. To solve this, we changed the code of one of the wings, making the two servomotors move in opposite directions and at the same time.

SCHEMATIC DIAGRAM(S)

The figure below is a circuit diagram made using Tinkercad. LED lights are connected to signal pins 8 (red), 9 (yellow), and 10 (green). Ultrasonic distance Sensor Trig is connected to signal pin7, Echo is connected to pin6. Servo is connected to pin5 (Right) and pin3 (Left). The sound output is connected to pin11. Unlike the schematic diagram, we used the headphone jack and headphones instead of the buzzer for better audible sound and sound quality (Tinkercad does not provide a headphone jack component).


HC-SR04
UNO
ARDUINO


U1_3.3V
U1
Arduino UNO
DIST1
VCC
TRIG
ECHO
GND
D3 RED
D2 YELLOW
D1 GREEN
SERVO3
SERVO2
PWR
SIG
GND
U1_GND
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PICTURES OF THE HARDWARE USED

Sensor(s)

- Ultrasonic Sensor 1x

Actuator(s)

- Servomotor x2
- LED lights x3
- Headphone jack 1x

Interface

- Headphone
- Sleeping mask
- Paper wings
- Backpack (small)

Power needs

- Power bank battery

ARDUINO CODE

Follow the link for the Arduino code file: https://leidenuniv1-my.sharepoint.com/:f:/g/personal/s3652254_vuw_leidenuniv_nl/EhMAOTKEt3pHmbuBorSQBCQBA4kw4N5rzRhRp1PM-e8pXw?e=c95SRd

REFERENCES AND LICENSING

[1] Nagel, Thomas. "What is it like to be a bat?." *The philosophical review* 83.4 (1974): 435-450.

[2] Melville J Wohlgemuth, Jinhong Luo, Cynthia F Moss, Three-dimensional auditory localization in the echolocating bat, Current Opinion in Neurobiology, Volume 41, 2016, Pages 78-86, ISSN 0959-4388, https://doi.org/10.1016/j.conb.2016.08.002.

[3] Haas, Ellen C., and Judy Edworthy. "Designing urgency into auditory warnings using pitch, speed and loudness." *Computing & Control Engineering Journal* 7.4 (1996): 193-198.