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PROTOTYPE DESCRIPTION

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CART 360

November 8th 2019

PROTOTYPE

The various prototypes built for my project allowed me to come to new and different conclusions. First, I needed to know how to detect the user's breathing. Although the most used method of detecting breathing is by measuring the expansion of the chest, I wished for the device to be wearable on the user's face. The flow of air coming from the mouth or the nose is what needed to be detected. A flick sensor, a microphone and a temperature sensor were first experimented with using a low fidelity prototype. I constructed a tetrahedral mask out of cardboard and poked a hole at the front of it where the air would come in or come out. The flick sensor was placed in front of that hole to see how the air flow would make it move. Medium to strong exhales made the sensor bend nicely, but inhaling did not make it move. The flick sensor was extended by attaching a piece of cardboard to the end of it. Since this increased the surface onto which the air was blown on, the sensor bent much more, both on the inhale or exhale. However, any head movement by the user wobbled the sensor-cardboard combination, creating significant noise. The microphone, on the other hand, was not sensitive enough to be able to detect the sound of relaxed breathing. Finally, the temperature sensor had a few drawbacks as well. The major drawback was that, inside the mask, the temperature increased significantly on exhale, but was maintained on inhale. Relaxed breathing did not circulate enough air inside the mask to allow for it to cool and detect a temperature drop during inhale. This first prototype was critical for understanding of the problem. The design of the mask should account for the stagnation of air inside it. Additionally, normal or relaxed breathing does not create enough physical changes in the air. Either the changes needed to be amplified, either different physical changes should be considered, or the user should be made aware that their breathing should become more volitional, stronger and conscious.

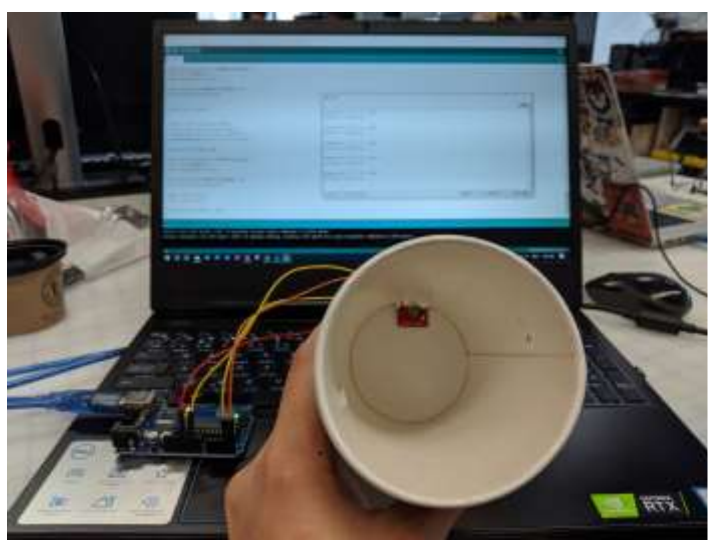

Fig 1. Barometer in second prototype mask

The next prototype for the breathing apparatus was made using a coffee cup and a new set of sensors. The coffee cup was small, thus only covered the user's mouth. This might make the user to understand that they are allowed two methods of breathing, either a relaxed and subconscious one, through their nose, or a conscious one, and consequentially stronger one, through their mouth. The coffee cup had two holes placed near the opening. Since breathing throws air from the mouth forwards, and that there are no holes in the mask at the front of the mask, the air is pushed/pulled from the wholes at the sides. This allows for a circulation of air inside the coffee cup, resolving the previous problem of its stagnation. An improvement of the mask design has thus been made. The sensors used this time were a humidity sensor and a barometer. Those sensors were both much better at detecting inhales and exhales, since pressure and humidity values are specific and quite variable to breathing. Detecting pressure change was much more successful than detecting humidity changes, however, since humidity levels kept rising inside the mask despite the better air circulation.

Once the logistics of breathing detection were solved, the ones for the water movement needed to be addressed. Although there are numerous ways to move water in a tank, I settled on the one used in wave pools where a paddle pushes the water. There are two ways this paddle could move: either up and down or rotating slightly back and forth. The two movements were tested by hand in a low fidelity prototype. The back and forth technique seemed to create better waves with less effort. This approach was thus used for the subsequent prototypes.

Fig 2. Up and down technique of moving water

Fig 3. Back and forth technique of moving water

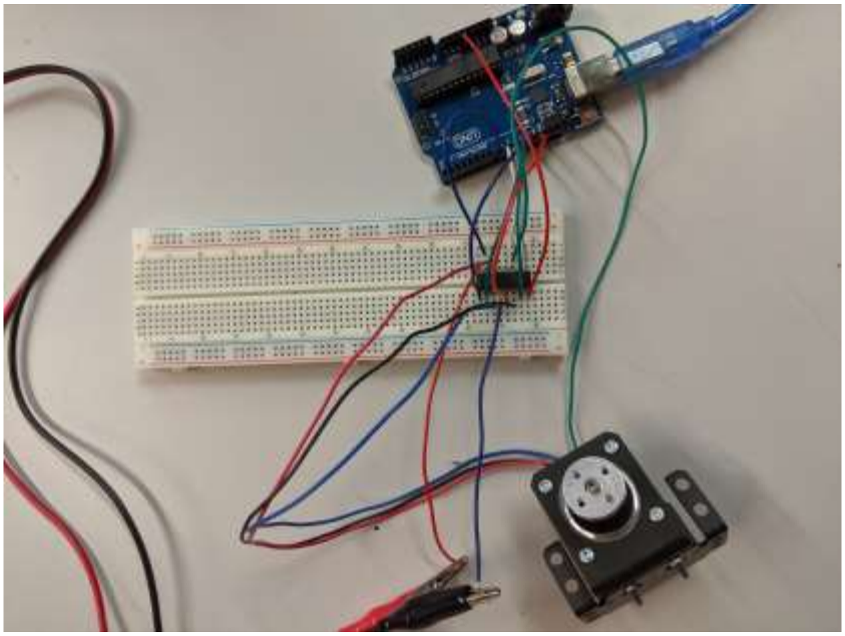

Fig 4. Testing the stepper motor

A stepper motor seemed to be the best motor to use for this project because of its high torque, the capacity to maintain its position despite the applied weight and the ability to control the amount of rotation with high precision. Such abilities are necessary to give the user the possibility to stop the paddle movement midway, to control its speed or the amount of movement. A circuit assembly was built to test how the breathing mask could control the motor's rotation and responsiveness. This prototype not only allowed to test the motor, but also to communicate the generalities of this specific interaction with classmates and see their reaction.

A final prototype was made to test the motor activating the paddle. This prototype uses some materials that I would like to use for the final version of the project. The prototype uses translucent plastic as a container of water, as well as a reflective and holographic silver sheet at the bottom of it. This sheet is meant to reflect light coming towards it and distort it through the water as to create caustic patters on the walls and ceiling. The prototype uses a rack and pinion movement transmission to transform the rotational movement from the motor into the translational movement of the paddle. The paddle has been angled by 45 degrees from the vertical position as to push more water.

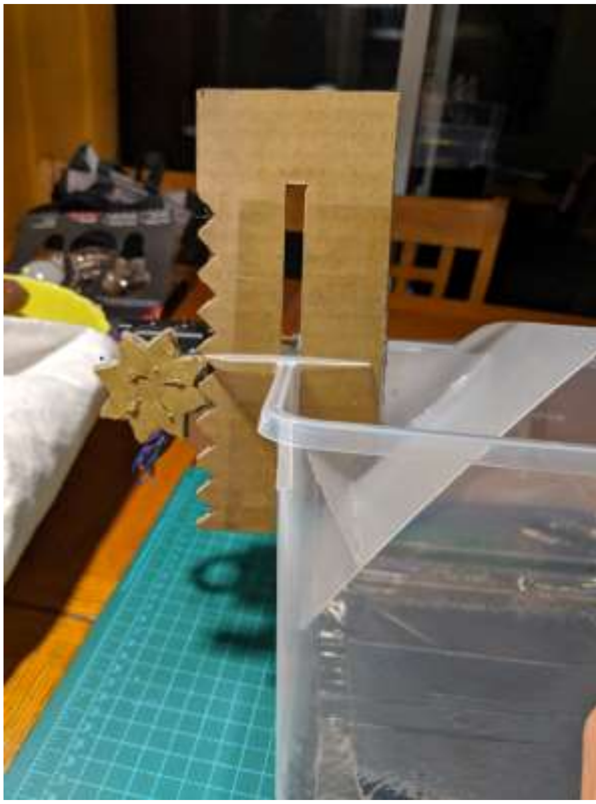

Fig 5. Rack and pinion mechanism, side

Fig 6. Rack and pinion mechanism, front

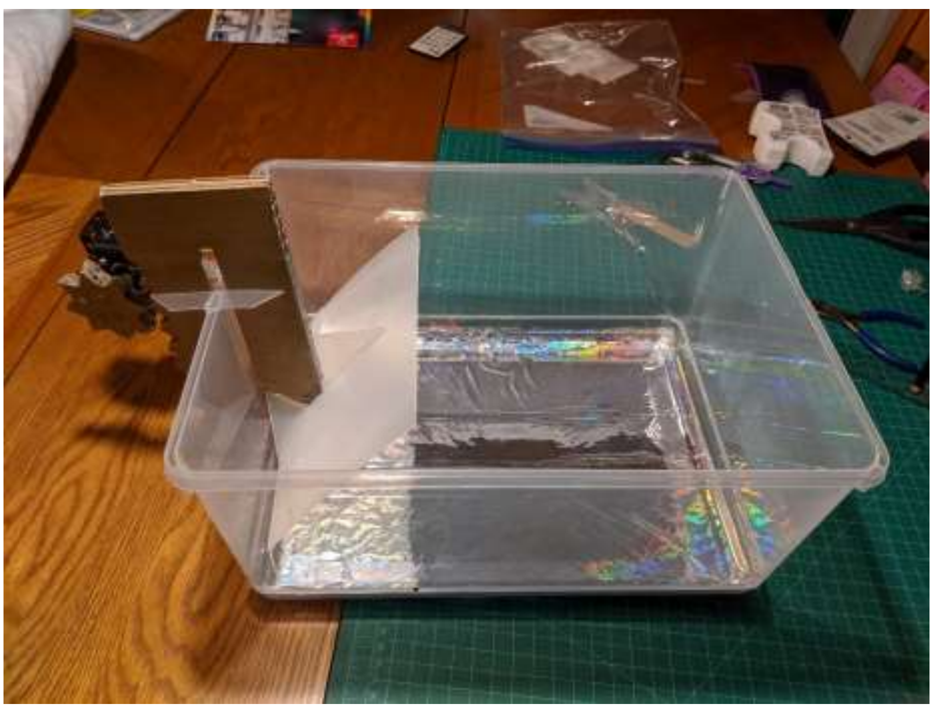

Fig 7. Water tank and paddle and iridescent material

SENSORS

Two major sensors are involved in the project: one to detect breathing and one to detect sound. For the detection of breathing, multiple sensors were tested. The flick sensor was tested first. A significant benefit of the flick sensor is its size. The sensor itself practically weightless and would've made the mask less cumbersome. A drawback of it is that it needs space to move. This would make it necessary for the mask, or at least a portion of it, to be solid, as to not constrain the sensor. A certain amount of space would've been needed for its movement and the placement and volume of that space on the mask would've been considered. However, this sensor could not only detect the presence of breathing, but also the strength of it, since the harder one breathes, the more the sensor bends.

Another sensor that could detect breathing is an adjustable sound detection sensor. The use of such sensor would also allow to detect variation in breathing strength, since the harder one breathes, the louder the resulting sound is. Another affordance of this sensor is that it does not necessitate containment in a mask. The microphone could just be placed in front of a mouth, allowing the user to breathe more freely. However, a drawback of that sensor is that it may not distinguish an inhale from an exhale, which would defeat the goal of the project. Additionally, the user is expected to use their voice, which would interfere with the breathing detection. The microphone will thus be of better use for voice detection rather than breathing detection.

An analog temperature sensor, i.e. a thermistor, is a viable sensor for breathing detection. Exhalation projects very warm air to the front of the mouth. Inhalation draws the surrounding air in, which might result in a drop in temperature. Such variations could be detected by a thermistor, though a higher change in temperature could not be associated with a stronger breathing pattern. Additionally, it must be placed quite close to the mouth or nose, since the temperature of the surrounding air (from a previous exhale, for example) can alter the readings. However, a thermistor is light, small and has no moving components. Therefore, it could be embedded into many materials. Similar affordances could be found in a digital temperature and humidity sensor, i.e. the tested DHT11. It is small and static, but it can only perform a reading every two seconds, which is a sampling rate too slow for a breathing pattern.

The last sensor that could be used for breathing is a barometric pressure sensor. The one tested, the BMP085, is combined with a temperature sensor. Since it senses pressure changes, it absolutely needs to be contained in a mask, since the user's breath needs the change the pressure inside it. However, the sampling rate is fast and the data is quite accurate. Variability is thus easily detected. The sensor is static and thus only needs the space that it takes. It is light and relatively small. If higher accuracy is needed, a BMP sensor from a more recent generation can be taken.

INTENTION

The idea of the project and some of its particularities have evolved from the original proposition. First, It might be of interest to make the shape of the tank hexagonal as to prevent the user to stick to a side of the tank and encourage them to explore it from every side. Additionally, two paddles might be controlled but two different users, but the remaining two paddles might be controlled by the microcontroller. However, those movements would not be random, but mimic movements of previous users of the installation. It is to reinforce the idea of the ripples of an action through time. Even though a user is no longer present, the actions that they have done still have an impact on those who are present. Another idea might be that the paddle that a user controls changes place. A user might control the paddle in front of them at first, but that paddle might be suddenly taken over by the microcontroller. The user now has the task to discover which paddle belongs to them. This might keep the user alert and interested into the installation beyond the initial interaction with it. It puts them under a loss of control, though not a loss of agency. The interaction thus may become more complex and variable.

A general theme or aesthetic is in mind. The installation should remind users of a scientific experiment. The environment should look sterile and organized. This theme might allow the user to be more comfortable with putting on a breathing mask and become a performer. Such a theme might make the idea of cause and effect, the idea of controlled variables and external forces, and the idea of collaboration or competition, more explicit.