Toadfish Behavioral Robot for Fish Aggression Study

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Why Toadfish

The biology researchers are trying to obtain a deeper understanding of aggressive behaviour between fish. The reasons why toadfish chosen are the following 3 points. 1. Male toadfish defend their nest site against other male fish with aggressive behavior. 2. Toadfish can product loud sounds with different vocalization (growling or grunting). 3. Simple vocalization mechanism.

Building Toadfish Model

To get all the data for 3d printing, we firstly used CT to scan the whole fish body to get the dcm formatted files, which are the segmentation of fish body data files. The following figure shows the real fish we used in CT scanning.

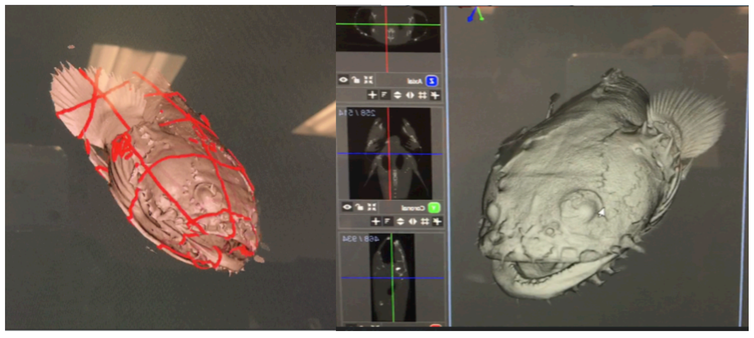
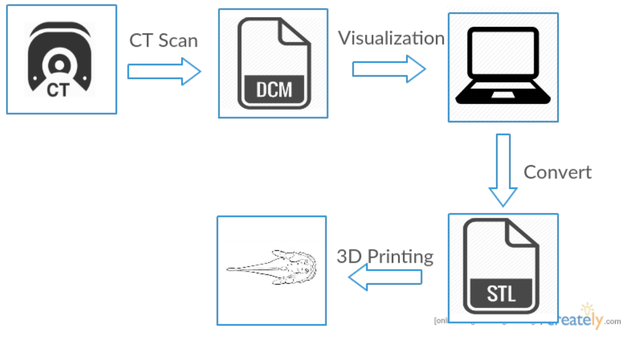


Figure 1. Convert the DCM file to STL file for 3D printing

Then we use Seg3D software to combine all the segmentation dcm files to restore the 3D fish model. We use ImageVis3D software (tool for interaction visualization of very large volume datasets) to make the 3D visualized, and then we use Meshmixer software to adjust the model and generate a toadfish model stl file. Finally we printed the toadfish model by Fortus 250mc 3D printer. The toadfish model has a very high accuracy based on the dcm file we got from CT scan.



We also make a soft silicone fish model by casting technique. This soft silicone toadfish model perfectly improves the limitations of 3D printing by using prototyping plastic material, and it is more like a real toadfish.

Figure 2. 3D printed (lower) and silicon casted (upper) fish models. The accuracy of the fish model is around 90% in dimensions, and enough details, such as dorsal fin and pectoral fins are presented.

How Model Make Sound

This audio amplifier can amplify sound that is given from a computer. The main component in this circuit is LM386, which is a low voltage audio amplifier and frequently powered music devices like radios, guitars etc.. The audio amplifier circuit is shown below.

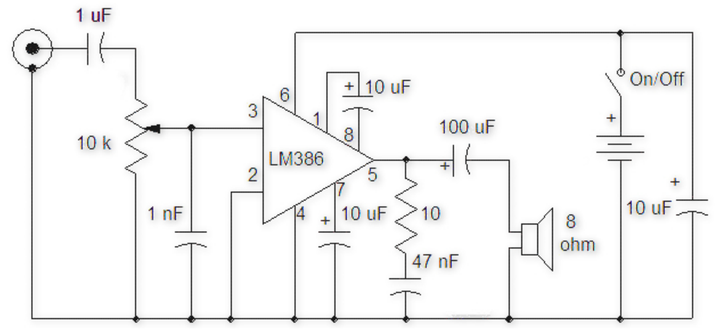


Figure 3. Audio amplifier circuit

The gain range is 20 to 200. In our case, we use a 500 ohm resistor and a 10uF capacitor to increase the voltage gain.. LM386 has a wide supply voltage range 4-12v, and we use a 12V power supply, which gives loud sounds without much distortion. The 10k ohm potentiometer will give the amplifier a variable from zero up to that maximum.

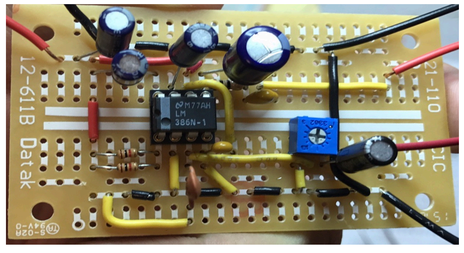


Figure 4. Real audio amplifier circuit

Sound System

To produce loud sounds underwater, the speaker needs to vibrate strongly to generate enough energy to push the water vibrate as well. However, the toadfish model is very small, which means placing a loudspeaker, which can meet the standard of vibration, into the fish body is almost impossible. So, we come up with an alternative solution, using a balloon as the interface between air and water to transfer sound wave. By using this method, the small balloon can be fitted into the fish body and sound wave can also be propagated successfully.

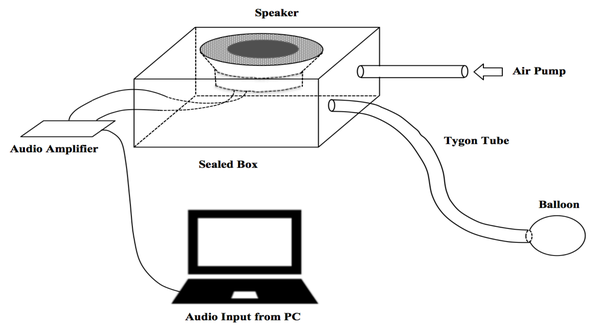


Figure 6. Schematic of toadfish sound simulation system

The key point is the sound simulation system must be completely sealed. We use a waterproof sealed electric cabled entries junction box and sealed it tightly using waterproof glue. To blow the balloon, another tygon tube is attached to the box with an air pump at the end to pump air into the box. When sound is produced, sound waves are propagated through the tygon tube to make the balloon vibrates, and then sound waves are transferred into water. The image below shows the real sound system.

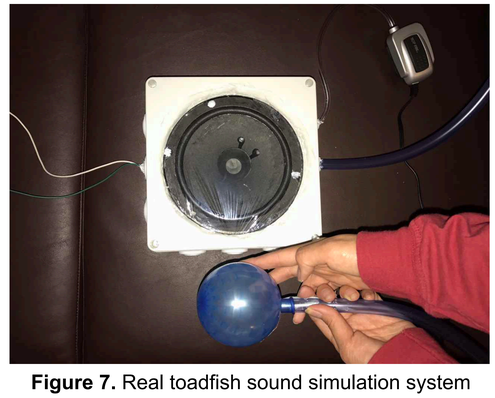


Figure 7. Real toadfish sound simulation system

Future Work

- Improvement on toadfish model to make the fish fins and tails automatically move underwater like real fish
- Improvement on audio amplifier circuit to produce louder sounds
- Adding an underwater video camera embedded in the fish model