Bob the Thermoplastic Seahorse

ENGR2330 Introduction to Mechanical Prototyping

Team Seahorse

Steven Zhang

April 5, 2010

Table of Contents

Table of Figures

Executive summary

Our team designed and fabricated a rapid prototyped (RP), thermoplastic seahorse named Bob (Figure 1). The preliminary shape of the seahorse came from images of a lined seahorse (*Hippocampus hippocampus*). Each person then took primary responsibility of a certain part of the hippocampus (the author focused on head shell design). After the CAD files of Bob were printed, the resulting RP parts were coated with West Epoxy for added strength. Finally Bob was painted yellow and red to match the color of real seahorses.

The resulting seahorse structure is powered by a motor-gearbox assembly with two output shafts. One shaft actuates a tendon the curl the tail, while the other shaft oscillates the dorsal fins.

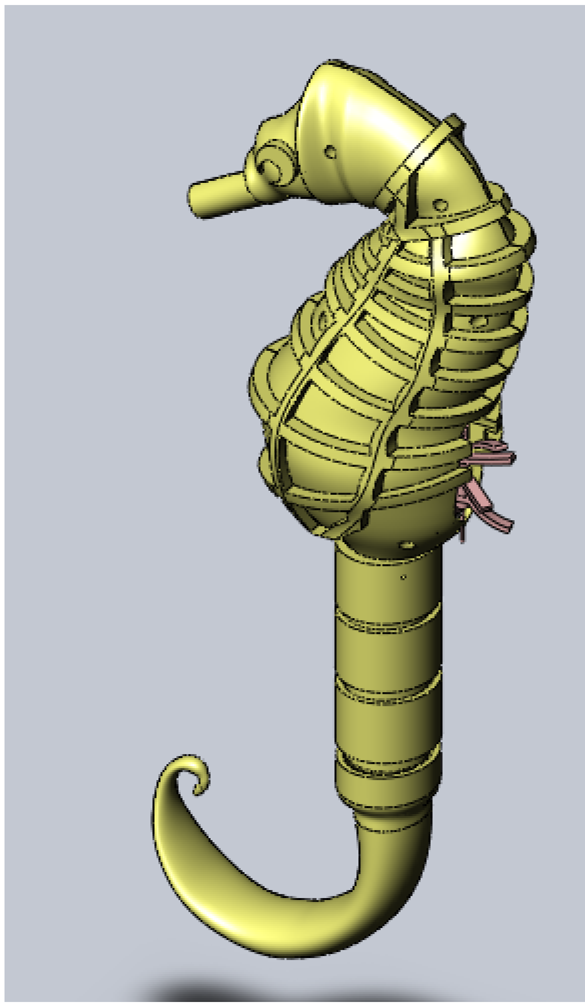

Figure 1 Isometric view of Bob's design

Design

Style

Figure 2 We mimicked the shape of our seahorse after the shape of real seahorses.

The overall structure of Bob was traced from realistic depictions of real lined seahorses (Figure 2). Since we couldn't find a good frontal view of a seahorse, we used artistic styling to determine the frontal profile of the seahorse.

Structure overview

The basic structural elements of Bob are the two halves of the head, and the tail segments (Figure 3). The left and right head shells attach together as a basic box structure to contain most of Bob's transmission and power elements. The bottom of the combined head halves attach to the tail. The tail consists of an initial vertebra that mounts to the bottom of the head, along with 2 more tail vertebrae segments. The bottommost tail vertebra attaches to the tail. These segments attach to each other using a ball and socket joint. All structural elements were made from rapid prototype, printed thermoplastic.

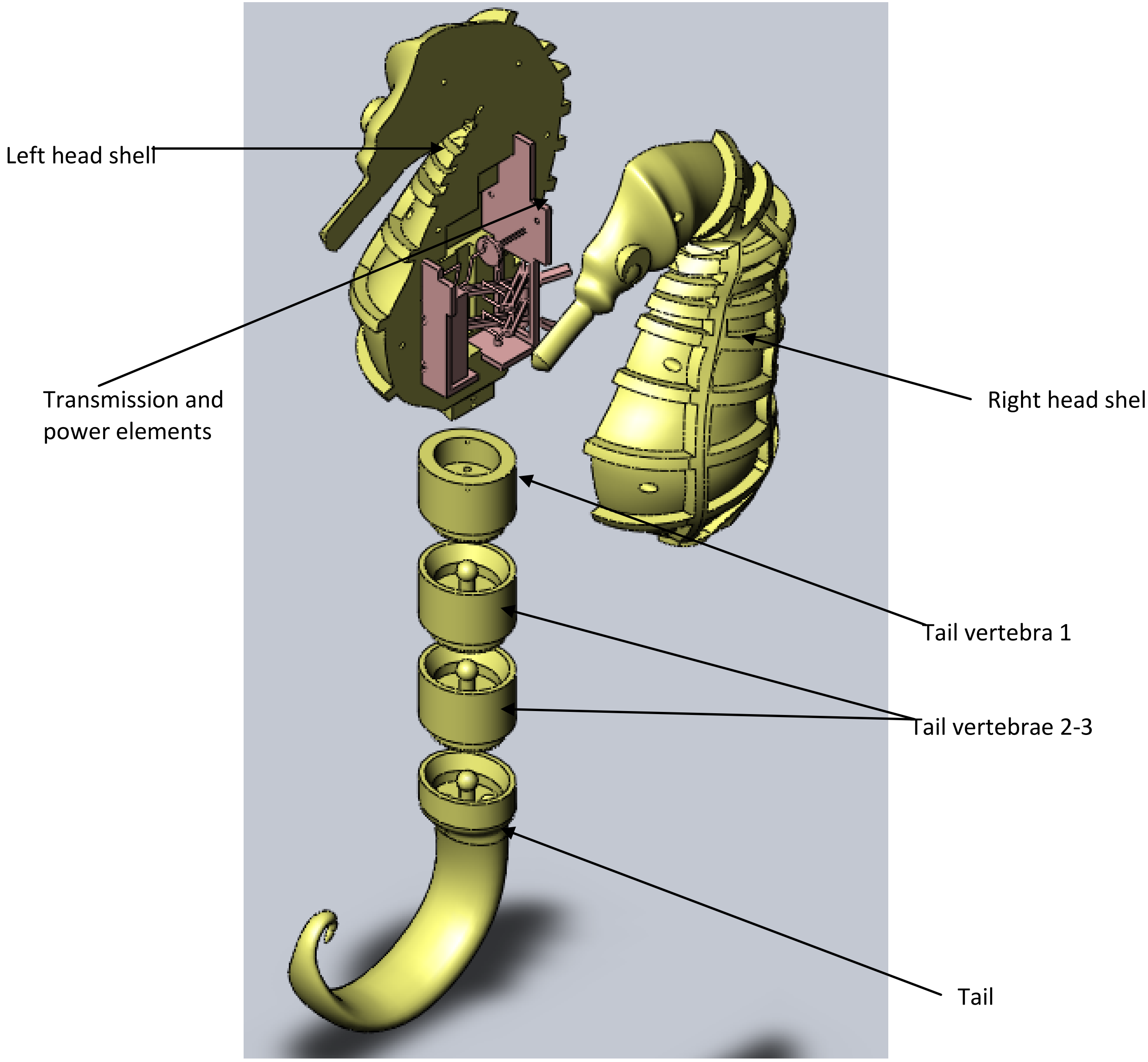

Figure 3 Isometric view of the basic structure of Bob

Head

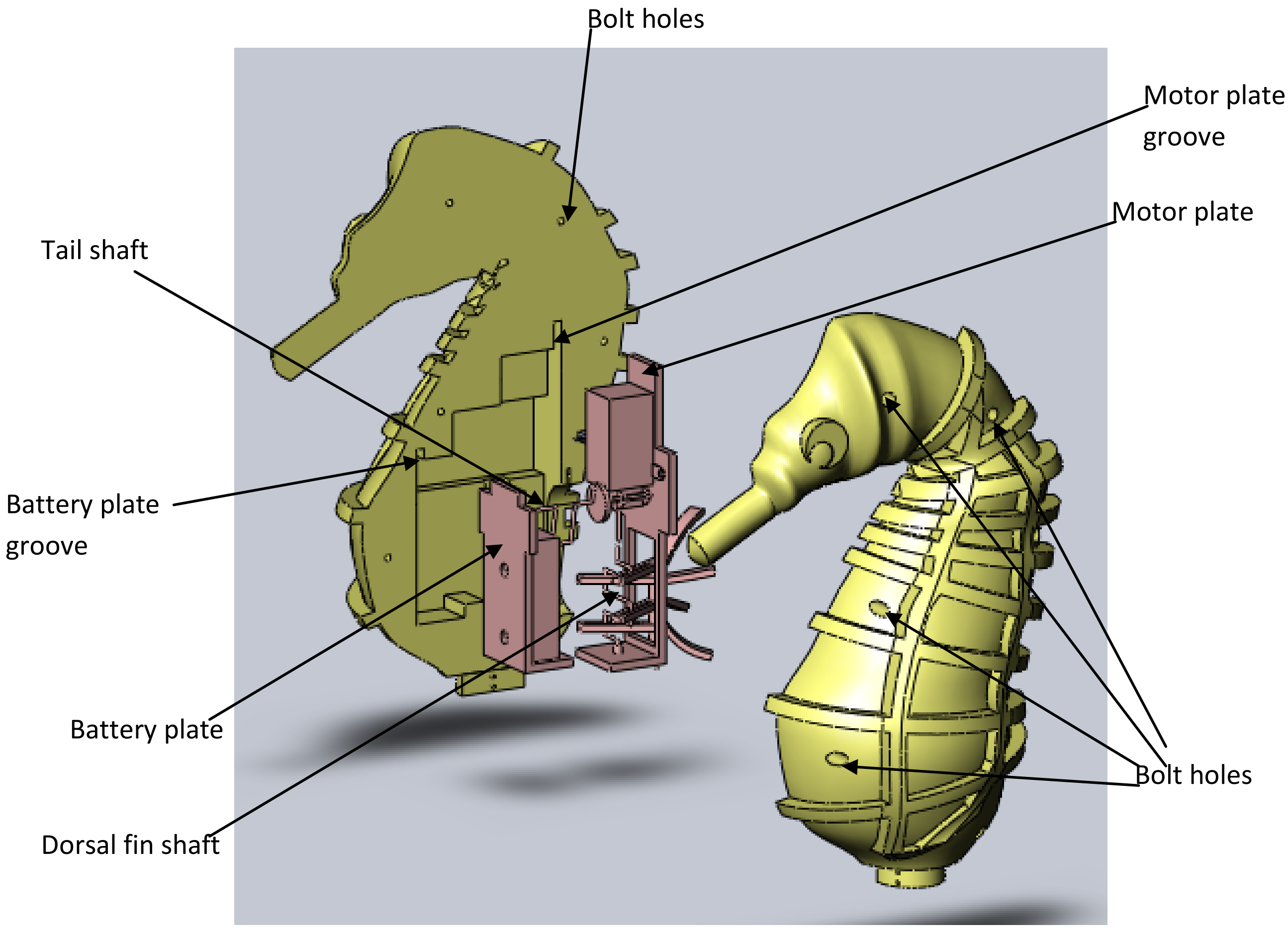

Figure 4 Exploded view of the head of Bob

The head of Bob contains most of the transmission and power elements (Figure 4). The two shells are held together by bolt and nuts (not shown) that fit into six aligned holes in each half. Each shell contains aesthetic ridges and bosses that mimic the shape of the skin and eyes, respectively, of the seahorse.

Each shell also contains grooves and extruded cuts that allow the transmission and power elements to fit in perfectly within the head. The battery pack and motor are mounted to their respective plates (L brackets) with screws (not shown). The battery and motor plates are then each mounted into grooves in the head shells, allowing the motor and battery to be fixed with respect to the entire assembly. The grooves are of a certain size such that the plates are frictionally held into the shell. Finally, the two plates, at a fixed distance apart, effectively create a U structure to allow the tail shaft to be mounted between them.

Tail

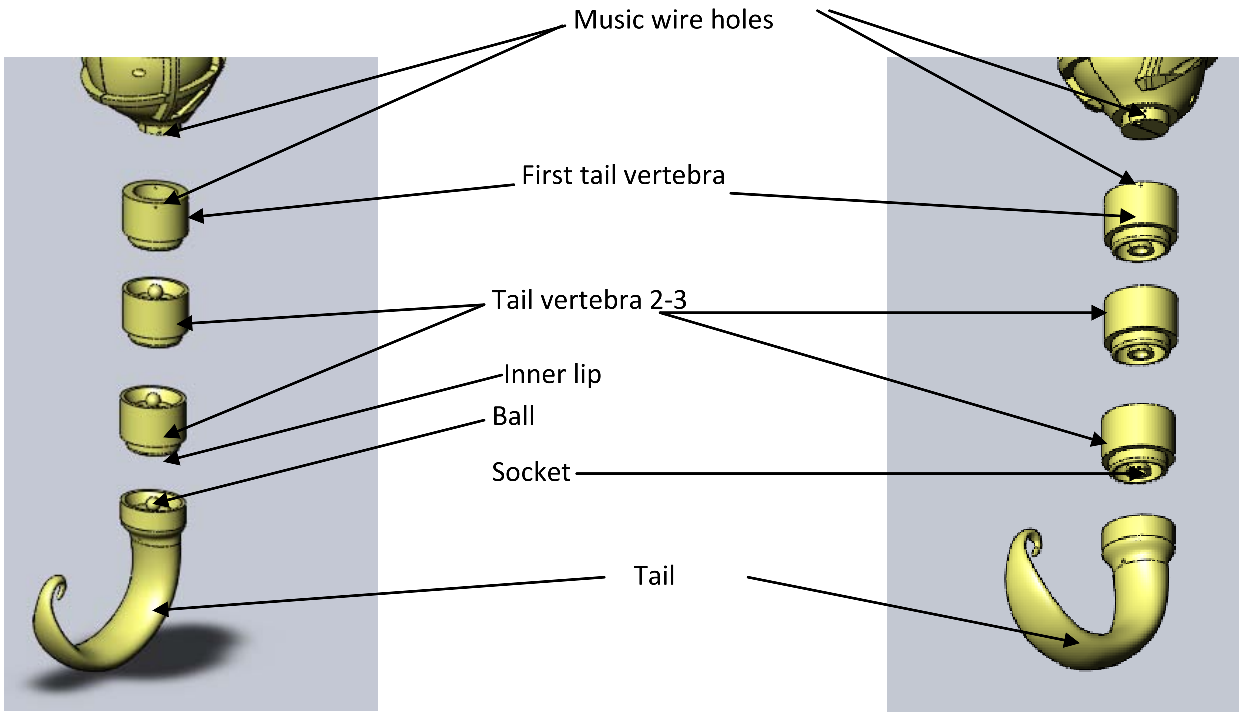

Figure 5 Exploded view of the tail assembly of bob, from different angles

The combined head shell halves attach to the tail assembly at the first tail vertebra (Figure 5). The tail vertebrae are stylized cylindrical box structures. 1/32" diameter music wire (not shown) threads through holes in the first tail vertebra, through holes in the head shells, and out through the back of the first tail vertebra, forming a mortise and tenon joint. The rest of the tail attach to the first tail vertebra sequentially through ball and socket joints. The bottom of each vertebra has a round lip that sits inside the top lip of the vertebra below it, allowing for a sort of movable mortise and tenon joint. Finally, the segments of the tail are held together by rubber band tendons, allowing roughly 20 degrees of movement at each joint (see transmission section on page 10).

Power

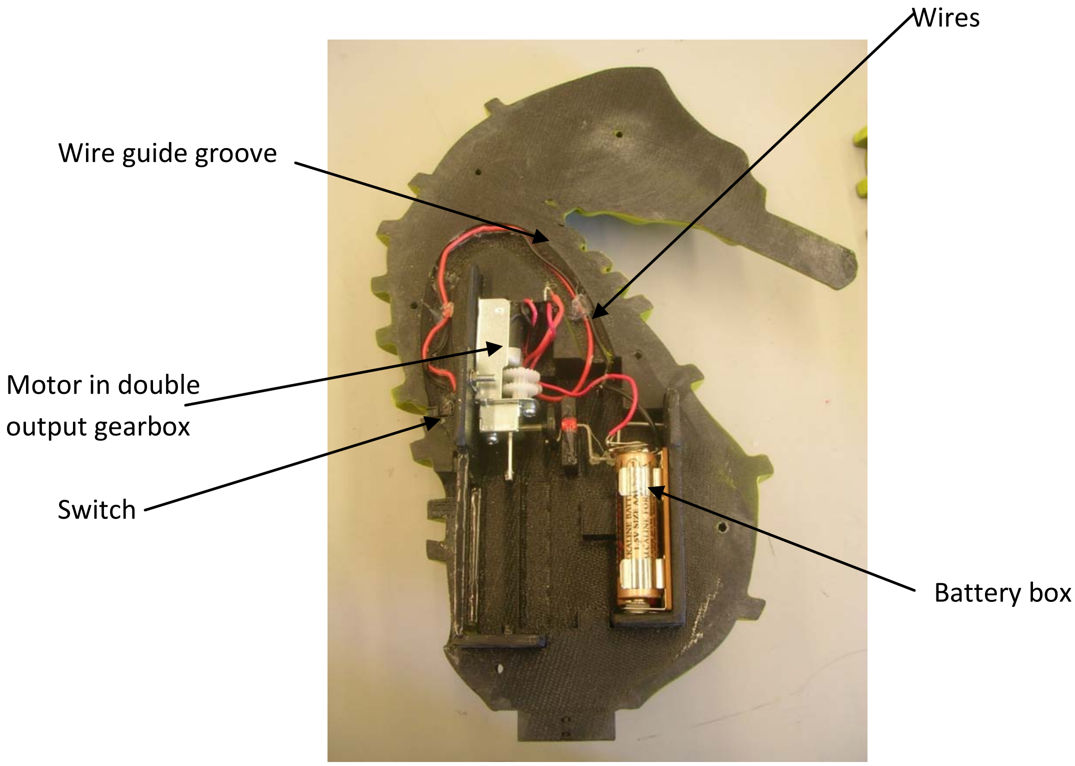

Figure 6 A 3V battery pack powers the motor.

Power is provided by two AA batteries (3V total) which directly powers the gearbox motor (a permanent magnet DC brushed motor) thru two wires (Figure 6). The wires are contained in a special groove in the right head shell. A switch mounted at the surface of the shell allows simple on/off control of Bob's movement. Finally, recall that the battery pack and motor-gearbox assembly are mounted into the seahorse shells via mounting plates.

Transmission

Tail

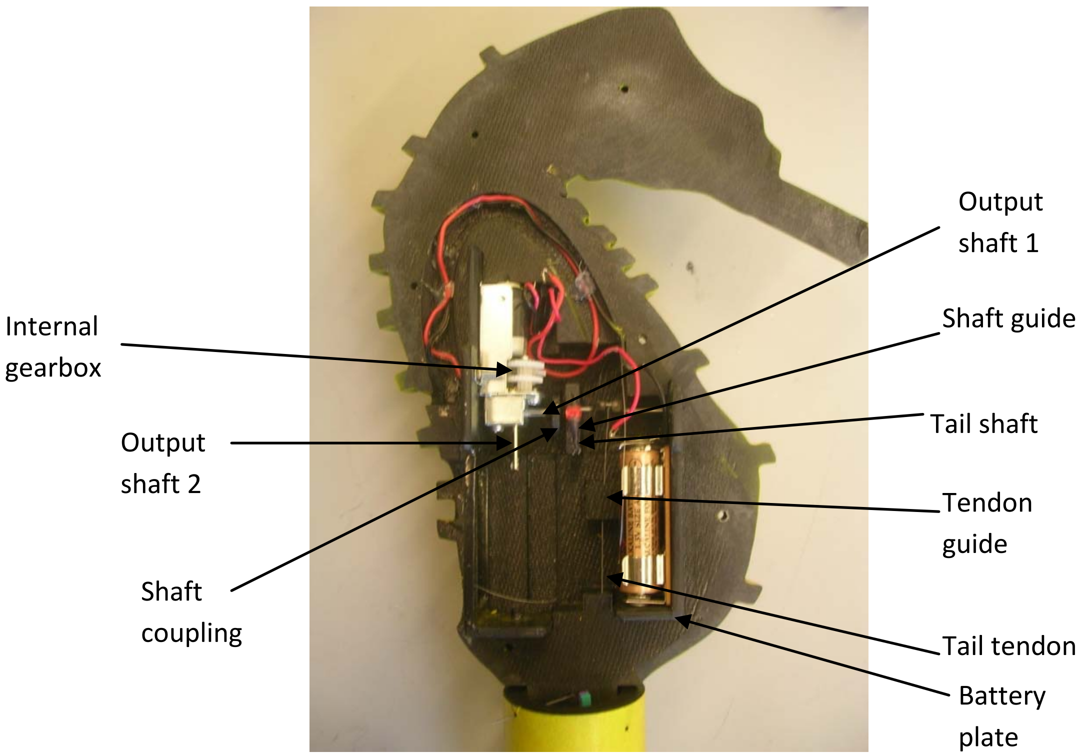

Figure 7 The internal gearbox has two output shafts, actuating the tendon and dorsal fins (not shown)

The motor turns an internal gearbox in the gearbox assembly, which has two output shafts, both of which are geared down (Figure 7). Output shaft 1, at right angles with the motor shaft, turns the tail shaft through a shaft coupling disc. The tail shaft (1/16” diameter spring wire) is bent to translate the rotary motion to the linear motion of pulling the attached tail tendon (monofilament fishing line). The tail shaft is attached on one end to the shaft guide, a raised boss journal bearing. The other end of the tail shaft is mounted in a journal bearing inside the battery box plate. Finally, the tail shaft is guided through vertical holes inside the tendon guide (another raised boss from the right half shell), through holes on the bottom of the shell, to the tail assembly.

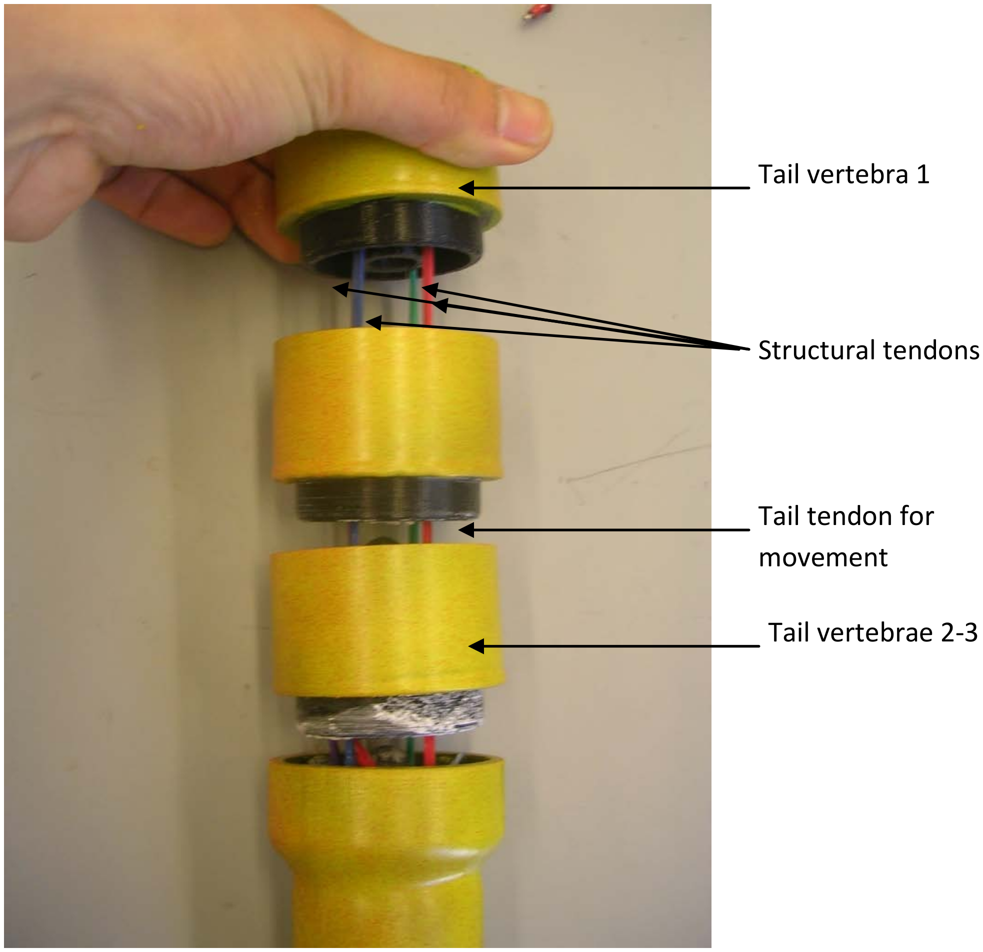

Figure 8 The tail assembly is held together by rubber band tendons and actuated by the fishing line tendon.

Bob's tail assembly is held together by 4 rubber band structural tendons (Figure 8). These tendons thread through vertebrae through separate holes in each vertebrae, allowing each ball and socket joint to engage while providing enough elasticity for joint movement (Figure 9). The tendons attach at anchor points on the tail and are self-knotted at vertebra 1 (Figure 10). Likewise, the tail tendon is threaded through each vertebra, but offset from the center.

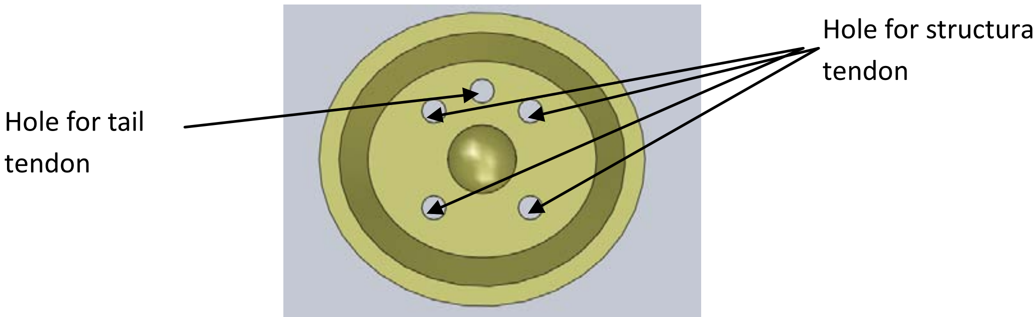

Figure 9 Top view of tail vertebra

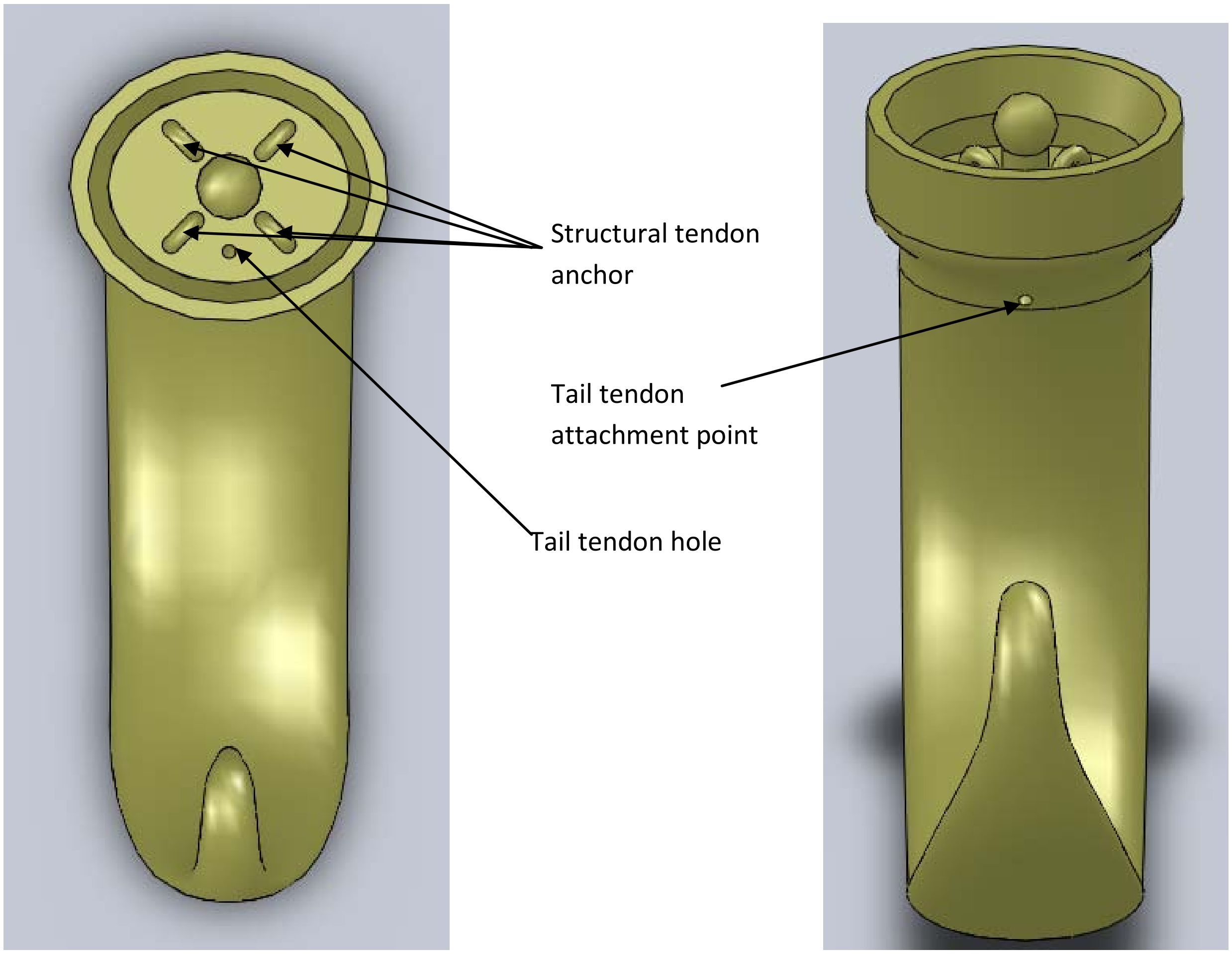

Figure 10 The tail, viewed from two angles, with attachment points for the five tendons

The tail tendon threads through the tail and attaches to the outside of the tail via a screw (not shown) through the attachment point (Figure 10).

Figure 11 Fully assembled tail assembly

Thus, when the tendon is pulled by the tail shaft, the tail assembly can curl (indicated by the red arrow in Figure 11).

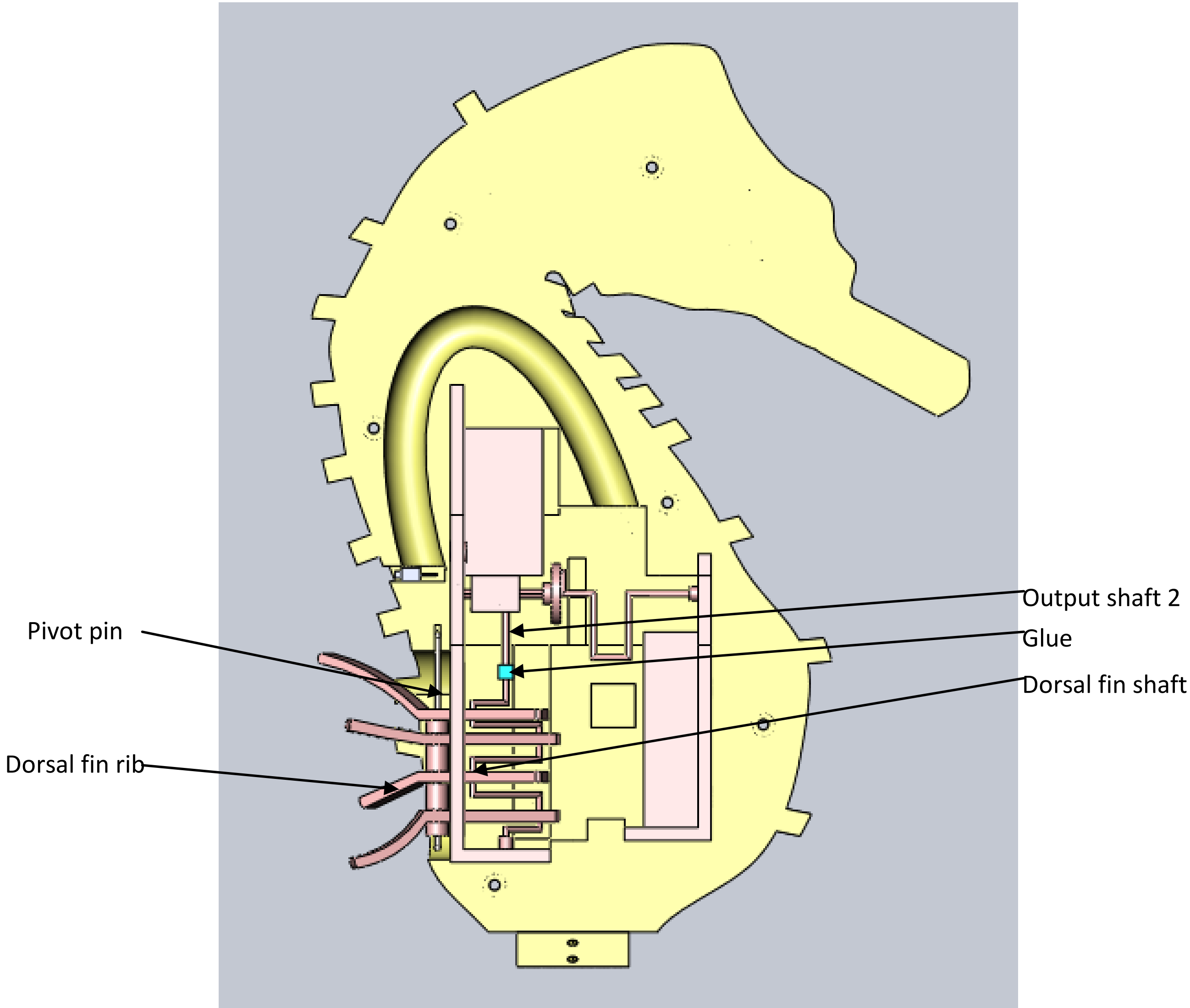

Figure 12 Transmission to dorsal fin movement

Actuation of the dorsal fins is powered by the output shaft 2, which connects to the dorsal fin shaft using hot glue. The dorsal fin shaft is bent in four places to create a cam that pushes each dorsal fin rib back and forth about the pivot pin. The alignment is such that neighboring dorsal fin ribs move in opposite motion, creating a rippling effect on the dorsal fin cover (not shown).

Drawings

See attached. They are in the following order:

1. HEAD-HALF
2. HEX-SHAFT
3. PIVOT-PIN