FISH SIMULATOR – PHYSICALITY SYSTEM

Swim like a fish

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Contents

Intent Statement

I intend to create a control system for a fish using the mouse that is intuitive, unconventional, and mimics the movement of a fish to give the feeling of moving like a fish.

Research/Thesis

My goal is to create a control system for a fish that mimics the movement of a fish in a way that is easy to understand and use. It is my hope that this will make the player feel more engaged when controlling a fish. There are plenty of games in which the player controls a fish but none of them use a control system which actual communicates what it is to swim. In my experience fish controls commonly follow the same theme as controls for a human character, WASD and mouse or the control sticks on a controller. While this may work just fine and be enjoyable I feel that the full potential of the game medium is not being reached in this area of games.

My game decomposition of *Skate 2* influenced me to pursue this system because of how well it translates the difficult and to many people foreign skill of skateboarding to the controller. The game takes a complex activity and distills it down to something which is easy to understand and pickup.

To begin my process I observed how different fish move. A video on YouTube by matubula shows off a variety of different fish swimming. The clips display the wide variety of locomotion techniques used by fish. It made me realize that I needed to decide what sort of fish I was going to create a control scheme for due to the differences in fish. Ultimately I chose a stereotypical prototype fish so that people would recognize the fish and instinctively understand how it moved. This brought up the question of how a fish actually moves.

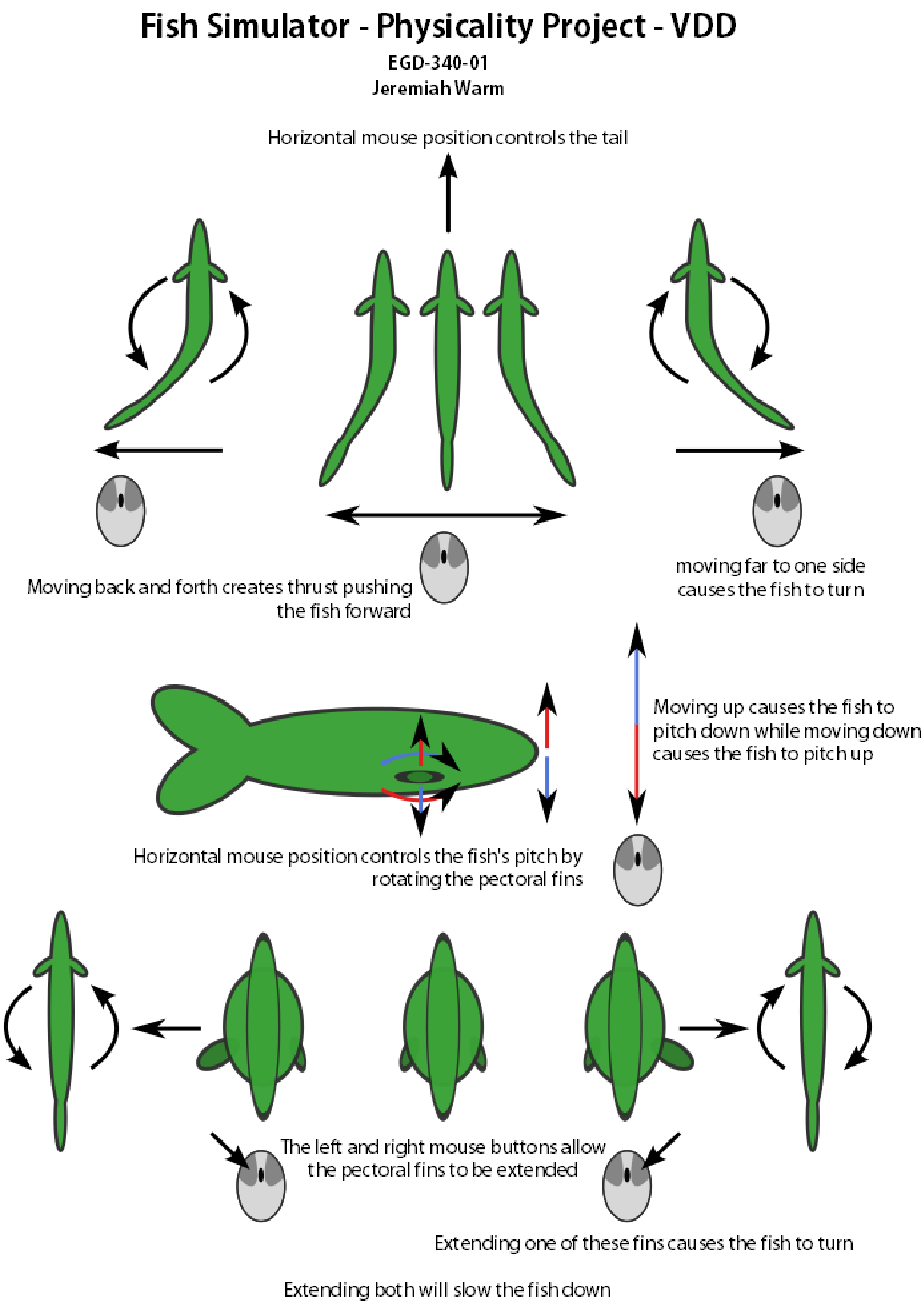
To answer this question I took a look at a book called *Fish Biomechanics*. It discussed how an entire fish worked in great detail, including how it moved. According to the book a common way that fish move is through axial undulation (Shadwick 241). It uses powerful muscles and can be used to swim very quickly. This form of motion contracts muscles along the fish creating a wave down the body which pushes the fish forward. The speed of the fish is primarily controlled by a change in the tail beat frequency (Shadwich 256). As the frequency increases so does the velocity (Shadwich 257). However, this frequency does top out at a certain rate depending on the fish. With this knowledge I began to think about what movement the player could make to mimic this undulation in a fish.

Before jumping in and starting up my prototype I took a how fish are modeled in a complex computer simulation. A study called "Artificial Fishes: Physics, Locomotion, Perception, Behavior" had plenty of information for me. It shows off a physics based model made of a large number of point masses and springs which keep the structure of the fish body solid while allowing it to flex (Tu). The paper goes into the specifics of the physics behind the model then explains that by contracting the springs the fish can swim like a real fish. This information was minimally useful since I couldn't set something like it up in Unity. However, the paper also talks about the importance of pectoral fins and their uses in controlling pitch and drag for the fish. That bit of information influenced me to add support for the pectoral fins into the control scheme.

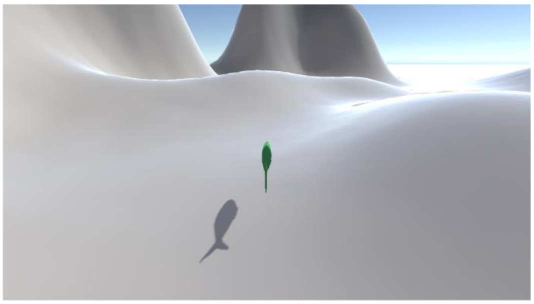
System/Mechanic

The system gives the player control over a fish using only the mouse. The system is designed to mimic how a fish moves. To move forward the player must move the fish's tail back and forth creating a force forward while the tail is moving backward. The tail moves proportionally to the horizontal position of the mouse on the screen. When the tail is moved past a certain angle the fish will turn, rotating around the global y-axis. The force applied to the fish is directly related to its speed and how far past the minimum turn angle the tail has been moved. The faster the speed and the farther the fail has been moved the greater the force. The pectoral fins on the fish are controlled by both the movement of the mouse as well as the left and right mouse buttons. They control the pitch of fish and can be used as a secondary yaw method to supplement the tail. By moving the mouse up the pectoral fins twist pushing the nose of the fish down and vectoring the fish's velocity according. Conversing moving the mouse down causes the pectoral fins push the nose of the fish up. In order to level the fish out any pitch created by pushing the mouse one way must be canceled out by pushing the mouse in the opposite direction. The fish does not level out on its own. There is a large dead-zone in the center of the screen to allow the player to beat the tail without pitching up and down. Using the left and right mouse buttons to control the left and right pectoral fins respectively allows the player to supplement the tail when turning. When each fin is extended by pressing its mouse button it creates drag that rotates the fish around the global y-axis. The drag also slows the fish down. By extending both pectoral fins the drag is balanced and slows the fish down.

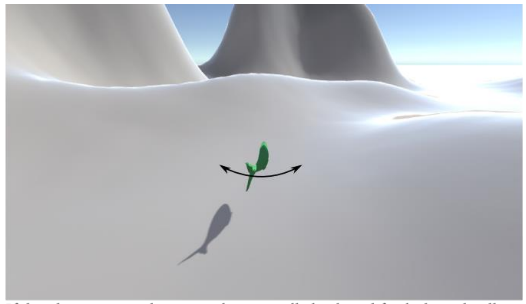
Visual Design Document



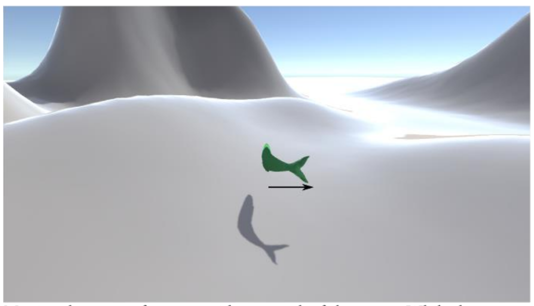
Storyboard



When the mouse is still and centered the fish is in a streamlined shape. It will gradually slow down if moving or stay still if not moving. All the controls to make the fish move are designed to mimic a fish's movement in a very literal way.

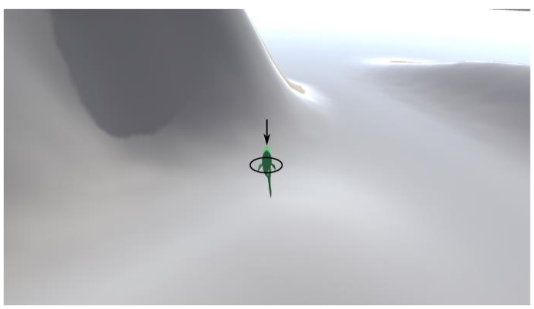


If the player moves the mouse horizontally back and forth the tail will oscillate on the fish causing the fish to move forward. This works best with large, fast, controlled movements. Small, rapid movements will cause the fish to move quickly but at the expense of pitch and yaw control. This is intended as the movement is supposed to be powerful and deliberate.
The problem with it is that because the tail moves with the mouse it appears and feels twitchy and weak which goes against the intent.

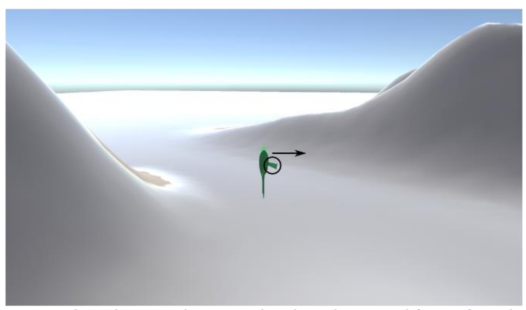


Moving the mouse far to one side causes the fish to turn. While the concept for this part of the system works when turning the fish looks strange since the movment does not mimic the movement of an actual fish.

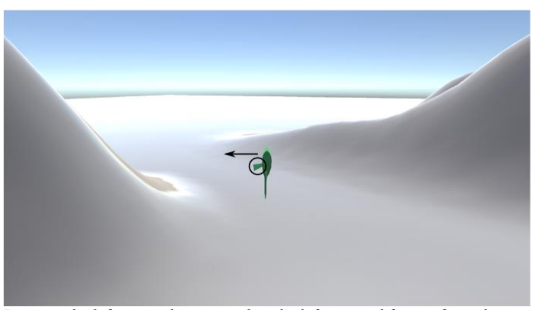
Pulling the mouse down rotates the pectoral fins and moves them slightly away from the body. This forces the fish's nose up and causes the fish to pitch up. This happens slowly and helps to achieve the deliberate feeling of the controls.



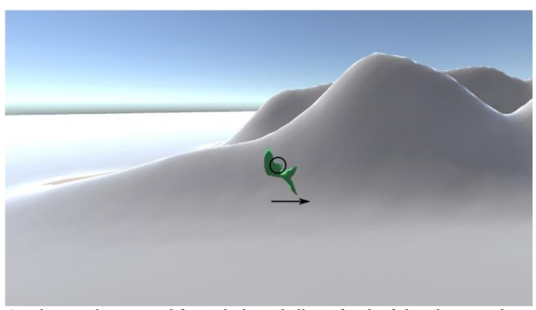
Pushing the mouse up pitches the fish down by rotating the pectoral fins in the opposite direction.



Pressing the right mouse button pushes the right pectoral fin out from the body. The drag created by the fin causes the fish to turn.



Pressing the left mouse button pushes the left pectoral fin out from the body and turns the fish. Pressing both buttons at the same time balances the drag and causes the fish to slow down.



Combining the pectoral fin with the tail allows for the fish to be turned at a faster rate than using just one method.

Testing

Test Plan

Intent:

The goal for this test is to get feedback on and evaluate the success of my prototype for the physicality project. The prototype in question is of a control system for a fish using only the mouse in such a way that simulates a fish's movement. Questions asked to the testers focus on the ease of use, intuitive-ness of the controls, and the effectiveness in simulating the feeling of moving as a fish. I hope to get feedback from six people. The test will be conducted outside of the QA lab.

Procedure:

1. Tell tester that the fish is controlled with the mouse. Do not specify controls past this.
2. Ask tester to swim forward.
3. Ask tester to turn 360 degrees.
4. Ask tester to swim up.
5. Ask tester to swim down.
6. Ask tester to swim through the two peaks.
7. Allow tester to swim around without direction for several minutes.
8. Have tester fill out feedback survey and give any feedback they wish orally.

Questions:

1. How quickly were you able to understand the controls?
2. How intuitive did you find the controls?
3. Were the controls easy or difficult to use?
4. Would you change anything about the controls?
5. Did you find it easy or difficult to move around the level?
6. Did you enjoy using the controls? Why or why not?
7. Did you feel like you were controlling a fish? Why or why not?
8. Comments/Questions/Concerns/Suggestions/Other Feedback?

Survey Link: http://goo.gl/forms/ia3aAGqApd

Test Results

Summary:

The test was a partial success. While I did get feedback from only game majors which may make it more useful and clear I did only get four people to test the prototype. This was mainly due to people in the labs not being cooperative. The feedback I did get tells a lot about the mechanic and what is right and wrong with it.

Results:

9. How quickly were you able to understand the controls?
    a. Very quickly: 1
    b. Sort of quickly: 0
    c. Sort of slowly: 2
    d. Very slowly: 1
10. How intuitive did you find the controls?
    a. Very intuitive: 1
    b. Sort of intuitive: 2
    c. Sort of unintuitive: 1
    d. Very unintuitive: 0
11. Were the controls easy or difficult to use?
    a. Very easy to use: 0
    b. Sort of easy to use: 3
    c. Sort of hard to use: 1
    d. Very hard to use: 0
12. Would you change anything about the controls?
    a. Yes: 2
    b. No: 2
    c. What-
        i. Slower movements might help it feel more like a fish
        ii. Turning with fins seemed unnecessary when it could be done with the tail
        iii. Instructions
13. Did you find it easy or difficult to move around the level?
    a. Very easy: 0
    b. Sort of easy: 2
    c. Sort of difficult: 2
    d. Very difficult: 0
14. Did you enjoy using the controls? Why or why not?
    a. Yes: 2
    b. Sort of: 2
    c. No: 0
    d. Why-
        i. Liked watching the fish moved while it was controlled
        ii. Too slow to be intuitive first time through
15. Did you feel like you were controlling a fish? Why or why not?
    a. Yes: 2
    b. Sort of: 1
    c. No: 1
    d. Why-
        i. Fish was too floppy and felt flimsy

ii. Liked going in circles
iii. Got fun once speed was gained

16. Comments/Questions/Concerns/Suggestions/Other Feedback?
    a. Make tail more sensitive
    b. More feedback for speed
    c. Moving tail slowly seems to do nothing

Observations:

- Turning is very slow
- Mouse buttons needed to be explained
- Unclear that tail is not attached to mouse buttons
- Tried to move mouse up and down like tail control to move up or down
- Tester only used pectorals to turn
- Testers loved holding the mouse buttons while trying to swim and not understanding what they did

Analysis:

The biggest issue with the controls is that they were not very intuitive to learn. Testers needed to be prompted in order to actually understand some of them. Once they learned what the controls were they seemed to have no problem understanding and using them. The biggest problem with this control confusion were the pectoral fins and the mouse buttons. Testers really wanted to hold the mouse buttons and the feedback for the pectoral fins was not clear enough to show them what happened when they did that. The next biggest issue was with how the fish felt as it moved. Most testers had trouble with the pitch and many wanted to go faster. This was not the main focus of the prototype so I am not as disturbed by this issue as I am by the control issue. If this prototype was to move forward I would need to make the fish movement more convincing, tune the controls, and find a new way to provide feedback for the pectorals or else get rid of direct control for them.

Survey Results:
https://docs.google.com/spreadsheets/d/1fFts3tBV83s8Zn0qpwVWbK1dniKqpa3QK0Scfv9YBtQ/edit?usp=sharing

Post Mortem

Overall this system was a partial success. While 75% of testers reported that the controls were sort of easy to use and at least sort of intuitive most had trouble learning the controls. This seems to indicate that perhaps the controls weren't all that intuitive. The biggest problem came in the form of the controls for the pectoral fins. When I told testers that the mouse buttons could be used they immediately pressed them and didn't let go. The feedback for the pectoral fins just wasn't enough to make them notice what they were doing. Testers were split on a lot of other issues like if they enjoyed the controls and if it was difficult to move around the level. The main success that was indicated by testing was that the majority of testers felt like they were controlling a fish. That was a huge part of the goal of the system. This response may be related to the response about how intuitive the controls were. Once the players figured out what did what in the control scheme moving as a fish may have made sense to them. I feel that the controls for movement with the exception of the pectoral fin buttons made sense if it was clear what each did. The issue arose in the actual movement of the fish which was not a focus of mine while making the prototype. My research found that fish movement is incredibly complex so rather than attempt to simulate it exactly I chose to fake it. It didn't work. The movement didn't look convincing enough which confused the player because they didn't know if what they were doing was right. The feedback for the fish's movement just wasn't there. This result has driven home the importance of accurate and informative feedback for a movement system. Even if the control system makes some sense if the movement system isn't giving awesome feedback the player will question their actions. The project also showed me just how difficult it is to create a physics-based movement system, especially when simulating such a complex activity. When a fish swims they use their entire body. This is something I thought I could fake and couldn't. There is so much going on in a system like this that three weeks just isn't enough time to create a convincing version of it.

Bibliography

matubula. "Diversity in Fish Locomotion." Online video clip. *YouTube*. Youtube, 27 Oct. 2013. Web. 10 Feb. 2016.

This YouTube video is an edit of various different fish swimming. It was recorded at Sea Life in Manchester, UK.

The video shows a wide variety of fish swimming to display the different forms of fish locomotion. Fish in the video swim in a number of different ways each using roughly the same body parts in different ways. While fish all exist in the same environment they have developed many different ways to navigate it.

Studying this video gave me a better understanding for the way that fish move and made is easier for me to simulate it in my system.

EA Black Box. *Skate 2*. Electronic Arts. 8 Jan. 2009. Game.

Skate 2 is a skateboarding game created for Playstation 3 and Xbox 360 which released in 2009. It is the sequel to *Skate*, a previous skateboarding game from the same studio.

The game features a unique control system which makes the player move the right control stick quickly through a certain path to do tricks. The player is able to use this mechanic to do a variety of flip tricks and grinds in a large open world. The story revolves around the main character restarting their skating career after spending time in prison. There are a variety of competitions the player can take part in to accomplish this goal.

The control system of the *Skate* series is a large inspiration for my control system. It mimics skateboarding in a way that feels right, is intuitive, and makes the player feel powerful and cool.

Shadwick, Robert Edward, and George V. Lauder, eds. *Fish Biomechanics*. Vol. 23. Boston: Academic Press, 2006. Web. 31 Jan. 2016. Fish Physiology.

This book is a complete guide to the biomechanics of fish edited by the Canadian research chair in the department of zoology at the University of British Columbia and a professor of organismic and evolutionary biology at Harvard.

The book covers a variety of topics from respiratory pumps to fisheries conservation. More importantly it covers the kinematics and hydrodynamics of various forms of locomotion in fish.

This book tells me a lot about how a fish actually works. While much of the information is not directly useable the concepts are useful in creating a convincing fish and picking movement technique.

Tu, Xiaoyuan, and Demetri Terzopoulos. "Artificial Fishes: Physics, Locomotion, Perception, Behavior." *Proceedings of the 21st Annual Conference on Computer Graphics and Interactive Techniques*. New York, NY, USA: ACM, 1994. 43–50. *ACM Digital Library*. Web. 10 Feb. 2016. SIGGRAPH '94.

This paper proposes a method for simulating fish which covers all aspects of the fish from their behavior to their movement. It was written by two professors of computer science from the University of Toronto and published as part of a conference in 1994.

The paper discusses a variety of topics concerning the simulation of fish. This includes the overall architecture of the system, the intention of the system, the way that fish move through water and how to achieve it, the importance of pectoral fins, what a fish senses, the modeling and animation of the fish, the behavior of fish depending on their role in the ecosystem, and the state machines associated with their decision making processes.

The information on the movement of fish in the paper within a computer space helps me develop my own system to move the fish. While their system is much more complex than mine it helps me understand the physics behind a fish's movement.