Wave Interaction in Pools

- We were 7th graders at LAMS
- We never programmed before
- We were participants in the 2009 NM Supercomputing Challenge

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NetLogo

Motivation

- Both of us are competitive swimmers
- We are interested in how waves form and interact in pools
- We are also curious on how waves affect and are affected by lane-lines, walls, and other swimmers

Goals

❖ Create a pool with lanes separated by lane-lines, and put a swimmer in each lane.

❖ Simulate waves that come of each swimmer.

❖ Make variables which change the speed of each swimmer, how long a wave lasts (make the waves realistically die out), and how many waves reflect or go through the lane-lines.

❖ Have swimmers turn and reverse their direction at each end of the pool.

❖ Decide realistic rules for how to slow down a swimmer when encountering a wave agent.

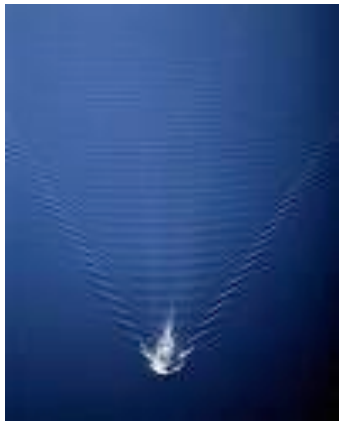
Research

- Matt Biondi's loss in the Olympics: drafting
- During open water swimming most follow the fastest swimmer.
- According to lab tests preformed by Portuguese scientists, if you are 2 ft. behind someone's kick, you experience 44% less drag.
- You can draft from as far as 19 ft.
- Water is 800 times denser than air.
- A wake angle comes off af a swimmer at about 45 degrees.
- The faster you swim the thinner your wake is.
- Waves reflect off lane-lines at about 25% of the time.

Visual Research

Speed boat

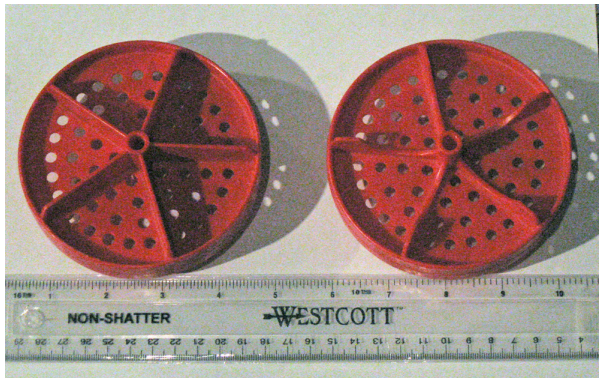
Slow boat



Medium speed boat

Boat wakes are similar to swimmer's wakes. As you can see the speed boat's wake is longer and thinner than the slow boat's wake. The medium speed boat's wake is in between the slow and speed boats wakes.

Lane-line buoys

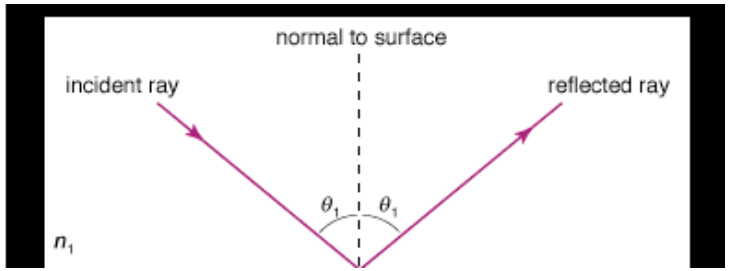


4-inch buoys with shallow radial fins & small circular holes

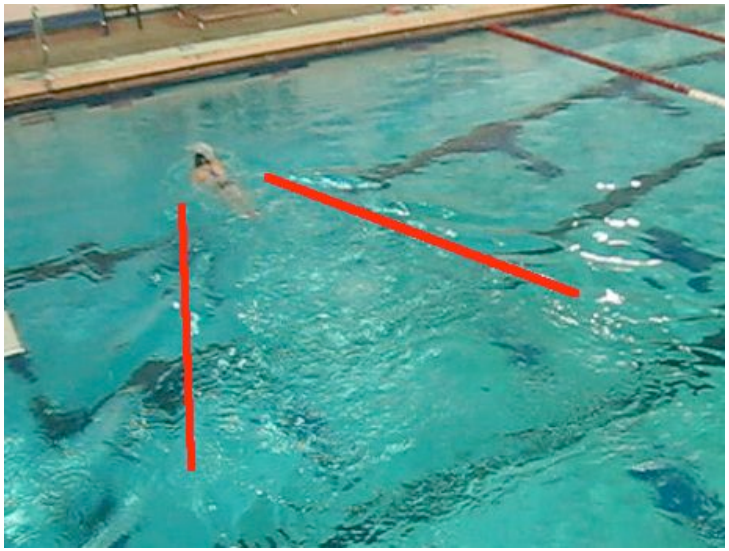
6-inch buoys with bigger radial fins and elongated holes

Physics

❖ Laws of Reflection and Transmission (Snell's Law) - Some wave agents reflect off the lane-lines (see drawing below); others just go through the lane-line.



❖ Our observations show wake-angles are about 45 degrees depending on the speed of the swimmer.



❖ Huygen's Principal used to create wakes

Programming

- Ran program in Netlogo
- Built a rectangular pool with two parallel lane-lines making three lanes
- Placed three swimmers total (one per lane)
- Wave agents (representing wake) came off each swimmer (Huygen's Principal)
- When a wave encountered a wall or lane-line it could do 1 of 3 things:
  - escape the lane-line (transmission)
  - reflect off the lane-line (Snell's Law)
  - die (be totally damped out)
- Assumptions
  - initially waves and swimmers don't interact
  - waves move at a constant speed
  - at each boundary there is a certain probability that waves will reflect, transmit, or die out
- Our program has variables (located on the sliders) to control:
  - speed of each swimmer
  - how long a wave lasts
  - the percentage of waves that pass through the lane-line

Main code

Code for Main Procedure

```
to go
  ask turtles [
    ifelse leave-trace?
      [ pd ]
      [ pu ]
   move
   set countsteps countsteps + 1
   bounce
   fd 0.1
   if (color = blue) and (countsteps >= wave_lifetime)
    [ die ]
  ]
  tick
end
```

What happens:

- The swimmer agents move forward and create wave agents, which move randomly in the opposite direction (included in sub-procedure "move")
- Wave agents count steps - after individual steps reach wave_lifetime, specific agents die.
- Throughout, agents bounce off of lane-lines, where angle of incidence is equal to angle of reflection ("bounce" sub-procedure)

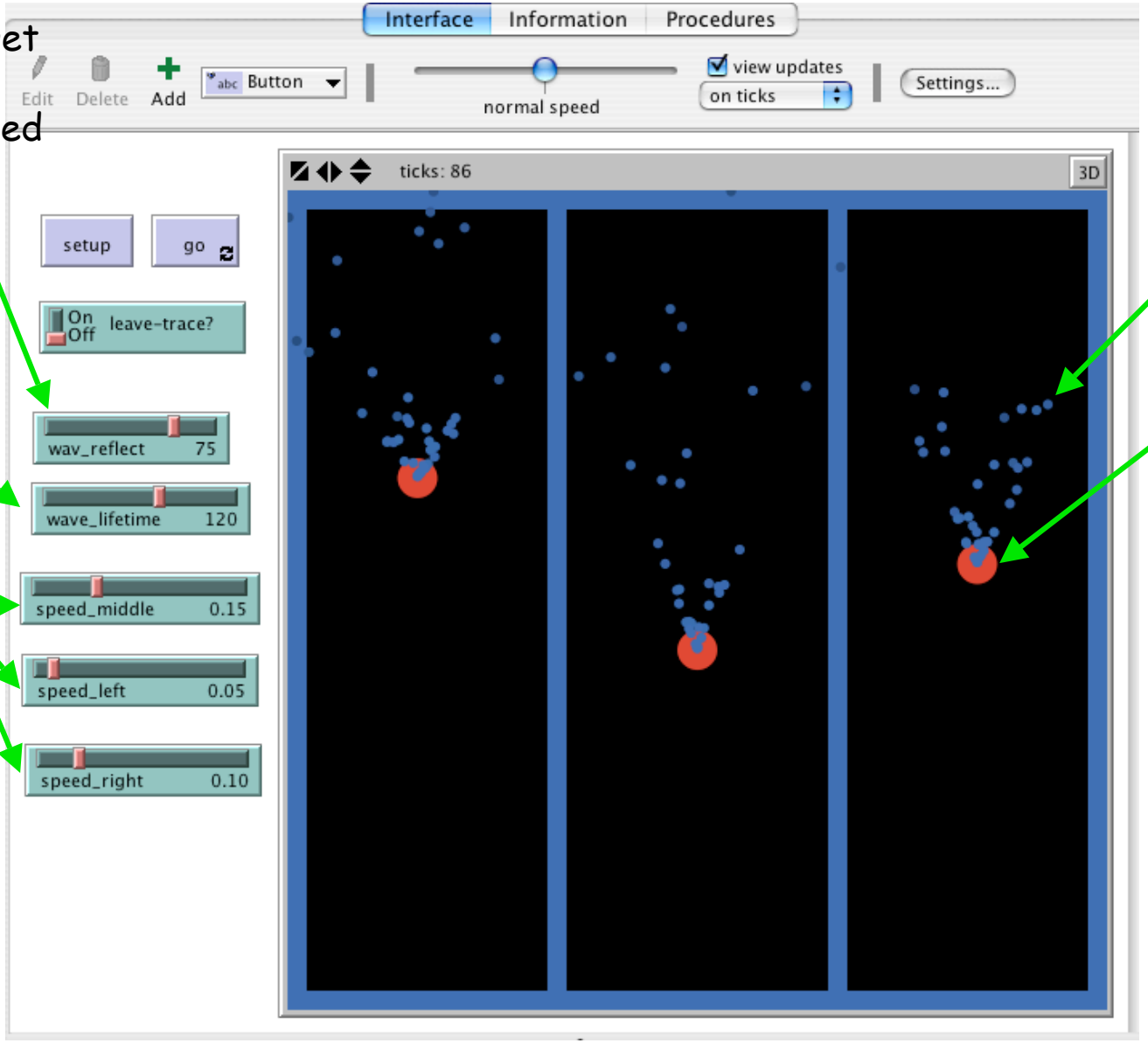
- To **setup** (not included in to go procedure) puts turtles in their places, creates pool and lane-lines.
- The move procedure allows turtles to make waves, sets certain speeds for each swimmer and set initial conditions for wave agents
- To bounce gives rules for how waves and swimmers bounce off lane-lines and boundaries.

Program

This slider controls how many waves get through the lane-line (based on the videos we took)

This slider controls how long a wave lasts

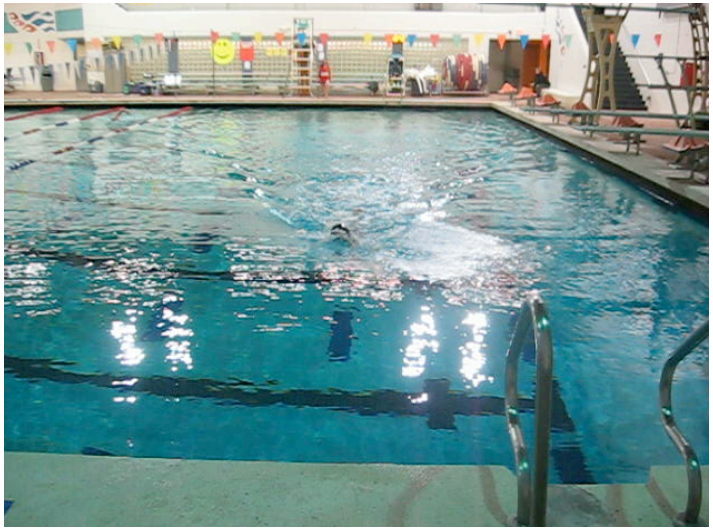
These sliders control the swimmers speed



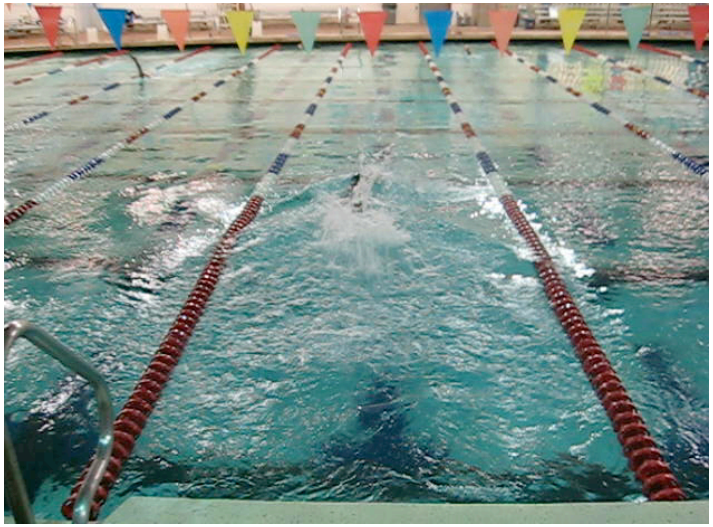
Wave agent

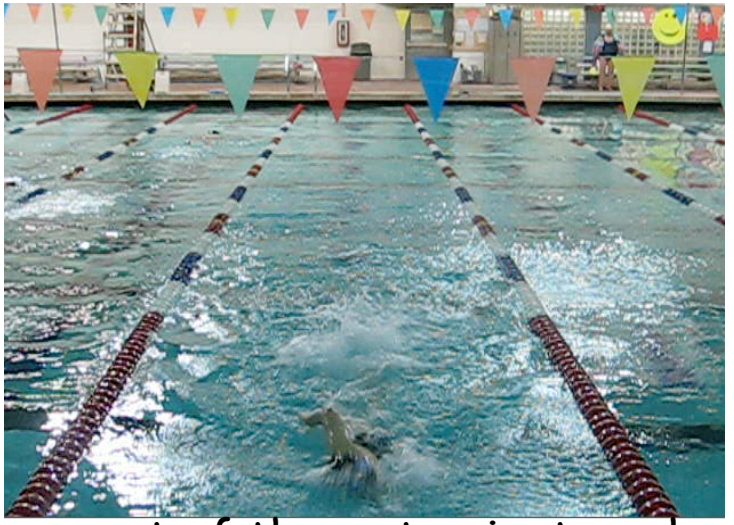
Swimmer

Open water



Lines with 6-Inch Floats

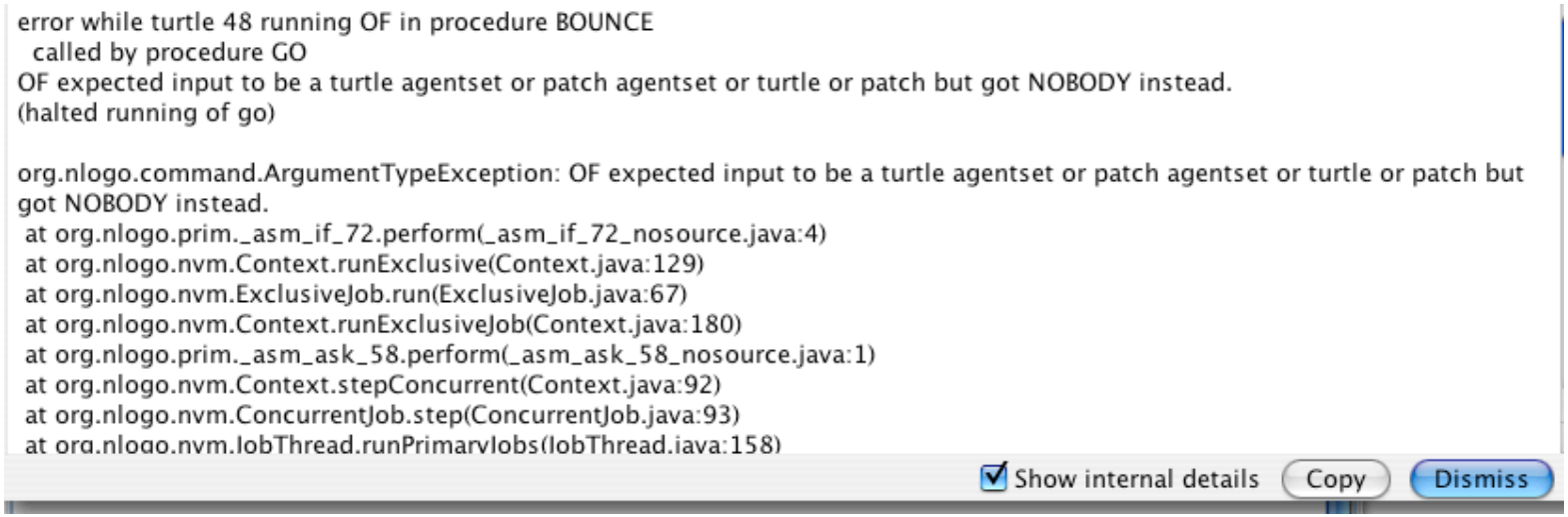




Shown are wave fronts. In the open water one, most of the water just washes through the gutter. With the lane-lines there is still some reflection and transmission because the lane-line can't handle all the water coming at it so fast. Also it can't prevent excess water from big waves washing over it.

Issues

- There is a run-time error whenever we run the program.



- With lots of wave agents and 8 swimmers (like in a real life swim meet) the program slows down to a crawl and skips on a 1.8 GHz G4 laptop)

Discussion

We can't think of a way for the wave agents to slow down swimmers by turbulence while still including the factor of drafting. We have tried to assign the swimmer's energy but for some reason it doesn't work. We are here to explore ideas for next year to extend our program.

Thank you.

Any suggestions?

References

- www.seafriends.org.na/oceano/waves.htm
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- www.spaceandmotion.com/science-phusics-wsm-wave-diagram.htm
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- Philipp Coe, USA-Swimming coach (pajaritoswim.org) and certified pool technician, Maintenance Director, Larry R. Walkup Aquatic Center, Los Alamos NM