

Jaws the Automaton

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Abstract

Jaws. The name evokes a sense of fear and suspense in every person who has ever seen the movie. But it does more than that. From just the name, you can create an entire story around a giant killer shark. This was our goal for the automaton-- to tell a story about a shark. The story is simple, a lone man in the ocean sees a shark fin move past his boat, so he starts rowing. After a few more passes, there is a pause, and Jaws pops out of the water and grabs his boat. The overall automaton is fairly simple with only a few major components including a shark fin on a rotating belt, a man who rows a boat by way of offset pushrods, and a pop-up shark controlled by a motor and a spring. Most of the mechanical automation was simplified by introducing Crickets to automate the motions. The Crickets control the timing and duration of the actions for the parts. The automaton makes use of three motors, which are controlled by two Crickets that use infrared to communicate with each other.

Section 1: Design

Our automaton is divided into three main components: the basic structure, the rowing man, and the springing shark. At the beginning of the design process, each of these components was broken down further into smaller pieces allowing our team to overcome simple design problems one at a time. Once these pieces were finalized, we then proceeded to draw them out so we could visualize their dimensions. Each team member then began implementing one of the three main components. Will built the structure while Nate constructed the shark and its spring device. Khom developed the rowing man and wrote the code necessary for the crickets to run the automaton.

The first component of the automaton is the structure or base for which all the other parts are connected. This structure supports the mounting brackets for both the rowing man and the springing shark as well as the belt system for the shark fins. Since the base structure houses all the other components, a prototype was developed to learn the appropriate dimensions and characteristics necessary for the other components to work with maximum efficiency. First, the frame was constructed using a combination of bass and balsa wood. The horizontal supports were constructed with two dowels driven into the front and back of two balsa pieces. The frame was erected by cutting slots into the vertical legs. Pushing these legs into the horizontal pieces allowed us to mount the upper and lower horizontal supports of the frame

together. By drilling holes into the front and backside of the horizontal frames, we were able to develop most mounting positions quickly. The belt system, which simulates the swimming motion of the shark, incorporates a pair of wheels slid onto a wooden dowel. Using the aforementioned holes, the belt system was implemented by attaching an elastic band between two wheels. After connecting the shark fin to the elastic band, we were able to observe the belt system complete its cycle, pulling the fin into and out of the plain of sight. The two fin guides were developed since the strength of the elastic was not sufficient to support the weight of the fins. These guides were glued in place to offset the side-to-side motion caused by the weight of the fins. When the construction of the prototype was finished, additional measurements were taken to aid in the compilation of the final automata from its individual parts. Such questions answered by these measurements included: how much space was needed for the rowing man, how plain of sight affected the belt system, and how the springing shark was positioned in relation to the rowing man. The answers to these questions greatly influenced the construction of our final design and layout.

The rowing man is composed of several individual pieces connected by small gauges of wire. The wire is looped through holes drilled into the leg and arm pieces. Since the wire is used sparingly, the rowing man's legs and arms are able to move easily in response to outside forces. Along with the appendages, the head also moves due to the addition of a spring connecting it to the body. The model of the man sits inside a miniature boat constructed of balsa wood. We achieved the rounded shape of the boat by wetting the balsa wood and then molding it to the desired round shape. Two guides are connected to the side of the boat holding the paddles in place. These paddles are also connected via wire to the arm sections of the rowing man. This completes the viewable portion of the rowing man. This entire model sits on top of the mechanical workings or rowing box of the rowing man. The mechanical guts are composed of three rectangular blocks along with four axles. The two outside blocks are connected using an axle running through their front as well as the back of the inside block. The backward areas of the outside blocks are mounted on the rowing box using one axle per block. This allows the inside block to rotate between the outside blocks without interference. Running through the forward side of the inside block is the long axle which protrudes through both sides of the rowing box. This system is connected so that when the outside blocks are rotated by a motor, the inside block is pushed forwards and pulled backwards. To complete the rowing man simulation, the paddles are connected to the long axle of the inside block. Hence, using the motion of the long axle, an illusion is achieved. The rowing man himself does not row, but is moved in a rowing motion due to the movement of the long axle and the loose connection of the model's joints.

The springing shark is the simplest of the components. The plastic shark was modified to allow its jaw to open and close to the forces of gravity. In addition to

the jaw modification, the shark was changed to a curved shape by omitting the middle compartments. Once the shark was modified, a hole was drilled through the back end allowing for a dowel to be inserted. This dowel was then attached to a motor thereby rotating the shark to the back of the boat. Since the motor strength alone was not sufficient to rotate the shark, a spring was mounted to the undercarriage of the shark and to the end of the rowing box. To set the shark to its designated starting position, sandpaper was glued to the base underneath the shark's dowel. The grip of the sandpaper was enough to counteract the effect of the spring thereby keeping the shark in check until the motor engaged. This pulling force of the spring combined with the force of the motor rotated the shark towards the boat in a realistic attacking fashion.

The individual components of the structure, rowing man, and springing shark are the building blocks of the automaton. Using the lessons learned from the structure prototype, the final structure was assembled to incorporate both rowing man and the springing shark. The final structure's dimensions were approximately twenty-four inches long, sixteen inches wide, and eight inches tall. The greatest difference between the prototype and the final structure was the belt system. Runners were employed instead of guides to allow for better control of the fins. The sacrifice for control was friction. Since the motors employed could not handle the new stresses, the far side's belt system was discontinued. Along with the belt system, the motor orientation was also changed. Instead of a pulley system to rotate the axle, a direct drive system was instituted. The direct drive reduced friction by lessening the pull on the axle mounts. To further reduce friction, the belt itself was changed from an elastic band to a flat nylon material. Since the nylon did not pull the wheels together, a smoother fin flow was produced. These reductions in friction coupled with the added grip of rubber cement on the wheel grooves resulted in a working belt system. The next steps in construction were easily achieved by mounting the rowing man and shark to the flat base of the finalized structure design. After mounting the basic pieces, the motors were connected to the crickets for timing purposes. Finally, all pieces and their respective motors were nailed or glued to the base of the finalized structure.

Section 2: Evaluation & Education

We designed our automaton much in the same fashion as classical mechanical automaton. We used the same principles as most of the automaton builders, but simplified much of the mechanical processes through computer controls. It was our goal to allow the automaton to tell a story that an audience could easily perceive and understand in a somewhat mystical fashion. We wanted the viewer to be able to see the parts of our automaton, but still be surprised when something happened-- for example, when the rower starts to row or the shark pops out of the water. Both the storytelling and the surprise help to evoke a sense of awe and an interest in the audience to investigate the inner workings of our automaton. From the outside, it is quite

difficult to tell how everything is put together and how everything works on our automaton, but once the cover is removed, things become much more understandable. The mechanics are quite simple on all of the parts in our automaton, most of which people would easily pick up on. The only pieces that might cause some confusion are the crickets-- since they are not easily recognizable components, there will probably be quite a bit of confusion as to how they play into the activity of the automaton. It seems reasonable, however, that many people would be able to guess the roles of each of our crickets based on the timing of the motions and the electrical connections of components within the automaton. If the mechanics and controls of our automaton is not immediately obvious, it merely takes watching the story a few times to make those realizations.

The purpose of our automaton was to tell a simple story about Jaws (or perhaps the cousin of Jaws). A lone man is sitting in the middle of the ocean, suddenly he notices a shark fin moving past the waves. Frightened, he starts to row his boat. The shark fin disappears below the waves and he relaxes. Again, the shark fin appears and the man again begins to row. The shark disappears once more. There is an uneasy pause... almost too long. Then, without warning, Jaws pops out of the water and grabs the back of the boat! Although our original idea called for more complex components and more detailed storytelling, our final automaton performed the role of storyteller quite well. The actual automaton has nowhere near the level of suspense and fear that was evoked in the movie, but our purpose was to entertain not to scare. Although the automaton was good, we still have ideas for improvement. One of the things we were unable to accomplish was making a second fin that would move in the opposite direction behind the boat. This would provide the viewer with the appearance that the shark is actually circling the rower. We were also hoping to be able to make the waves move, which would have improved the impression of being on the open ocean. Originally, we were considering causing the shark to bite the boat in half, but after viewing the automaton in action, it seems that this idea could have been a distraction more than an enhancement.

In the course of building the automaton, we did end up adding some components to our original design, or at least changing them, that ended up enhancing the overall impression provided by the automaton. Since we were running short on time and having problems with automation, we decided to simplify the original design and remove the moving waves. Instead, we simply mounted waves on springs in the hopes that the random motion of the motors in the automaton might make them move. It ended up that the waves moved enough from the jitters in the system to provide the impression of movement without distracting the observer from the real story-- an unexpected but not unwanted surprise. Another change that really enhanced the storytelling ability of the automaton was the cover over the shark. Originally, the top was just going to be covered to give the appearance of the surface of the ocean.

However, once built, we realized that the shark was easily visible from the top. This destroyed the element of surprise and defeated the entire purpose of telling a story. So, we added a piece of plastic to the surface of the water that would allow the shark to pop out, but not allow the observers to see the shark before we wanted them to. This allowed us to preserve the sense of suspense and enhance the surprise of the finale. Both of these changes to the original design helped to improve the overall ability of the automaton to tell the story of a lone man rowing his way to oblivion...

Section 3: Computation & Future Direction

The computation involved in our automaton is the communication between the crickets that produces a timed sequence of events. Our automaton uses two crickets to power the three motors needed to animate the 3 parts. Both the shark and the rowing man's motors are controlled/driven by cricket A. Cricket B controls the shark fin that rotates on the front of the automaton. Cricket B is also the active cricket in the setup. By active, we mean that the cricket is responsible for signaling the other cricket to perform certain actions at the correct time. Cricket A is the passive cricket in that it waits for an IR signal from the active cricket, Cricket B. Upon receiving the signal from Cricket B, Cricket A will perform the task signaled by Cricket B. The following code shows how this communications process was coded and implemented.

Code for Cricket A:

```

global [temp-ir]                ; temporary variable for the storage
of the IR signal

to shark-or-boat                ; main subroutine
  ; this section is repeated 3 times to allow for 3 messages
  waituntil [newir?]            ; checks for the IR byte
  settemp-ir ir                 ; sets the value of temp-ir to
ir
  if temp-ir = 2 [shark]        ; if 2 is received then activate the
shark
                                ; routine
  if temp-ir = 1 [boat]         ; if 1 is received then activate the
boat
                                ; routine

  waituntil [newir?]            ; checks for the IR byte
  settemp-ir ir                 ; sets the value of temp-ir to
ir
  if temp-ir = 2 [shark]        ; if 2 is received then activate the
shark
                                ; routine
  if temp-ir = 1 [boat]         ; if 1 is received then activate the
boat
                                ; routine

  waituntil [newir?]            ; checks for the IR byte
  settemp-ir ir                 ; sets the value of temp-ir to

```

```

ir
    if temp-ir = 2 [shark]          ; if 2 is received then activate the
shark                                ; routine
    if temp-ir = 1 [boat]          ; if 1 is received then activate the
boat                                ; routine
end                                  ; end of main subroutine

to shark
    a, onfor 50                    ; this turns on the shark
motor for 5 seconds
end

to boat
    b, onfor 100                   ; this turns on the rowing
man's motor for 10 secs.
end

End of Code for Cricket A

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Code for Cricket B:

```

to wait-fin                          ; main subroutine
    fin2                              ; rotate the fins 2 times around
    send 1                             ; tell Cricket A to turn on the rowing man
    wait 120                           ; wait 12 secs, for the man to row for 10secs
and 2 sec
    ; buffer
    fin1                              ; rotate the fins 1 time around
    wait 120                           ; wait 12 secs, for the man to row for 10secs
and 2 sec
    ; buffer
    send 1                             ; tell Cricket A to turn on the rowing man
    send 2                             ; tell Cricket A to turn on the shark
motor
end                                    ; end of main subroutine

to fin1
    a, onfor 65                       ; turns fin motor on for 6.5 secs, 1 loop
end

to fin2
    a, onfor 130                      ; turns fin motor on for 13 seconds, 2 loops
end

```

End of Code for Cricket B

The code above shows how the passive cricket, Cricket A waits for commands sent via IR from Cricket B. The communication between crickets was relatively easy to code since the crickets were designed with this functionality in mind. The hardest part of the coding was the setting of the times needed to run the shark fin motor. It took several iterations of timings before a time of 6.5 seconds was achieved for the motor time of 1 loop around the front flywheels. Even using 6.5 seconds as a time, the fin does still have some timing issues,

due to the inconsistent movement of the fin on the flywheel itself. This results in the fin sometimes not performing a full loop around the flywheel track. This irregular movement occurs a very small portion of the time, and is somewhat acceptable. With better materials that produce less friction, we could have possibly achieved a more accurate timing of the fin moving around the track. One method to determine the timing is to use the average of several runs to determine the run time used.

In the future, we plan to add one more motor to drive an additional fin on the second set of flywheels. This motor can be controlled/driven by motor bus B on Cricket B. It would be a minor change to the code, possibly the addition of another subroutine called fin1B and/or fin2B. These subroutines would simply drive motor B on the cricket for a determined amount of time based on the time required to perform a loop on the rear flywheel.

Additionally, the crickets could also be used to add a randomness to the sequence of action taken by the automaton. The fins and man rowing combination could be alternated for an undetermined, random number of times. This may provide the user with a more interesting set of actions that the automaton performs.

One suggestion that we received during the presentation would involve the use of sound sensors on the cricket to detect the sound patterns from the user, more specifically, the theme to jaws. As the volume or the speed of the jaws theme song is increased, the man may row faster or upon reaching a certain sound level, the shark would attack the boat.

More simply the theme of jaws may be played using the cricket's on-board speakers. This would be a simple matter of programming the theme into one of the already present 2 crickets or adding an additional cricket that plays music.

A scheme that would enhance the movements of the waves would also be a possible enhancement to our automaton. Currently, the waves are mounted on springs on the top cover. This only provides a slight shaking, from the vibrations of the motors being turned on. We would probably like to make the wave move back and forth more, give the waves a more realistic motion. In terms of enhancing the movements of aspects of our automaton, we would probably add additional motion to the rowing man itself.

We believe that the rowing man's head could be made to move, possibly tracking the shark by turning left or right, even possible, opening his mouth in shock. This may be done with some cams below the rowing man and could be controlled using additional motors and crickets. One other modification to the rowing man may be the ability for the tail end of the boat to crack and break off after the shark attacks the boat. This could possibly be done with some hinges

and cams that limit the motion of the hinges till a determined time. Again, the motors that control this may be attached to crickets and activated after the shark attacks.