University of Virginia Engineering
Dept. of Mechanical & Aerospace Engineering

Capstone Design Team | Mechanical Engineering | Dec 2018

The Sands of Time: UVA's Robotic Clock

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"Lives of great men all remind us We can make our lives sublime, And, departing, leave behind us Footprints on the sands of time"

– Henry Wadsworth Longfellow

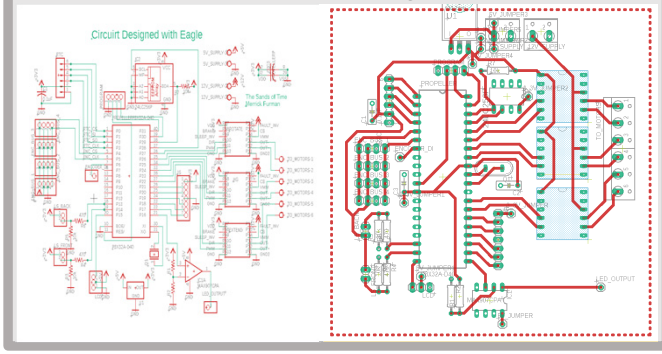
Objectives and Overview

The overarching goal of this project was to design and build a mesmerizing kinetic art clock as a testament to UVA's Mechanical Engineering prowess. This machine will be mounted on a wall on the second floor hallway in the Mechanical Engineering Building. A second iteration of this clock will also be permanently on display at the Science Museum of Virginia in Richmond. These two clocks should help to foster curiosity in engineering and inspire the next generation of potential engineers.

Electrical Design

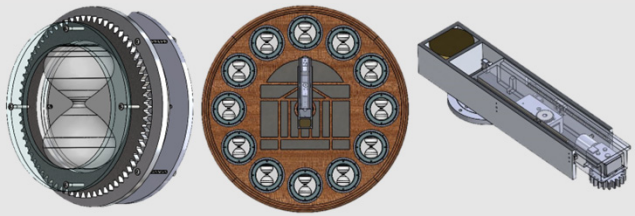
We used a Parallax Propeller, an 8-core micro-controller chip, to the orchestrate the clock's control system. The Propeller interfaces with a wide variety of external circuitry:

- Thirteen Bourns 10-bit, absolute encoders report both arm and hourglass angular positions
- 1,104 individually-addressable WS2812B RGB Light Emitting Diodes allow for a wide variety of interesting colors and patterns
- DS3234 Real Time Clock chip provides extremely accurate time and date information
- DRV8801 H-bridge motor drivers control the speed and direction of the three DC motors in the clock via Pulse Width Modulation signals



Mechanical Design - Hourglasses

- Twelve 5-minute sand hourglasses function as the minute hand for the purpose of telling time
- Clear acrylic enclosures give the illusion that each hourglass is floating in midair
- LED rings help to display the time and provide entertainment
- Absolute encoders monitor the correct upright positions of each hourglass



Mechanical Design - Arm

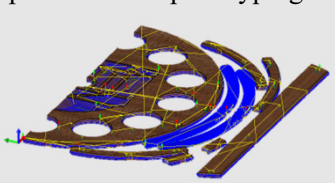
- DC Brush motors with worm gear transmissions for arm extension, arm rotation, and hourglass rotation
- Rack-and-Pinion gearing system combined with linear guide rails ensure smooth hour-hand arm extension

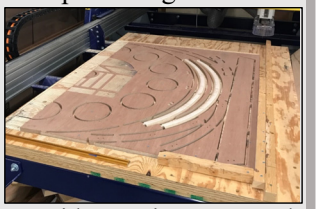
Software Design

The software was developed for the Parallax Propeller microcontroller chip. Over 2,600 lines of code were developed to interface sensor data, process the information, and direct motors to move to certain locations and lights to show desired patterns.

Manufacturing

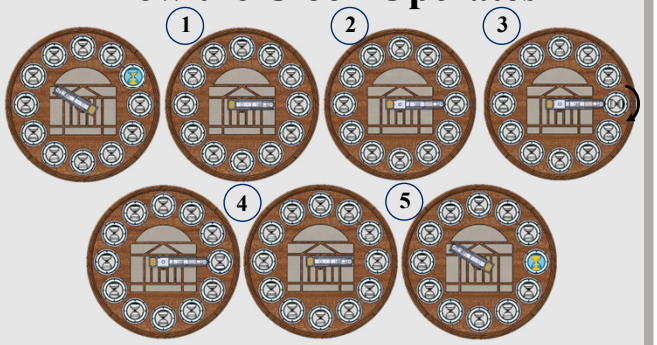
In manufacturing The Sands of Time, a number of Advanced Manufacturing methods were implemented:
ShopBot CNC Router cut out complicated, three-dimensional wooden pieces from CAD/CAM files
OMAX Waterjet Cutter cut gears, back plates, and the hour-hand arm's outer channel out of aluminum
ULS Laser Cutter cut acrylic rings, LED diffusers, and the hour arm's inner channel
Dimension uPrint 3D printer created ABS plastic parts used for prototyping and as spacer rings





A special thank you to Sebring Smith, Lewis Steva, and Kevin Knight for their help with manufacturing

How the Clock Operates



This graphic shows the steps the clock goes through every 5 minutes. The example here is for **10:15 AM**.

1. Rotate from 10 o'clock hourglass to 3 o'clock
2. Extend arm to mesh arm gear with hourglass gear
3. Rotate 3 o'clock hourglass 180° to begin timing
4. Retract arm
5. Rotate back to 10 o'clock hourglass to show hour