Ride Replay Kit

Tennessee TECH

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Objectives

The Ride Replay Kit will provide users with an accurate recreation of a recorded bike trail and will have a work-map for each trail. A GUI along with an actively changing resistance will be implemented to control the playback and accurately reflect the work done during a recorded trail. The kit will also have audio, visual, and immersion systems to recreate the sounds, video, and wind speed of the trail on the exercise bike.

The Problems and Solutions

Trail Data Recording:

The main problem with trail recording is reading in the work done by a rider over a specific section of time. Another big issue that was identified was how to secure both a microphone and camera on a bike to allow for audio and video recordings.

The solution to the main issue of recording work done by a user was found in using a formula for potential energy based on weight, altitude change, and gravity ($U = mgh$). Using this formula, a sensor for atmospheric pressure, that checks when the wheel has made a full rotation, and an array to store the atmospheric values at specific distances a work map can be created. Using this work map, the work done by a rider can be accurately recorded. The camera and microphone mounting issue was fixed by creating a 3D printed mount for each device that clamped onto the bike handlebars securely.

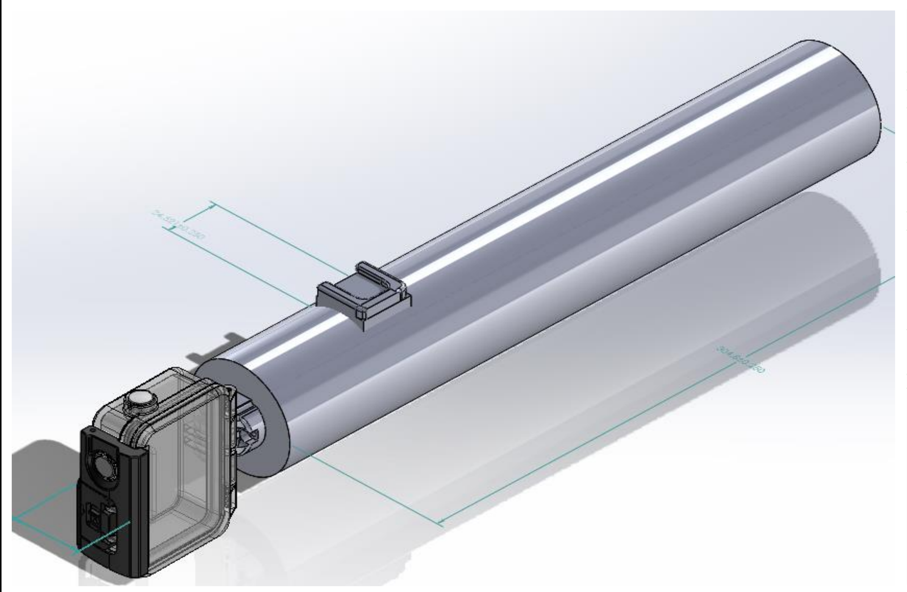

Figure 1. Camera and Microphone 3D Model

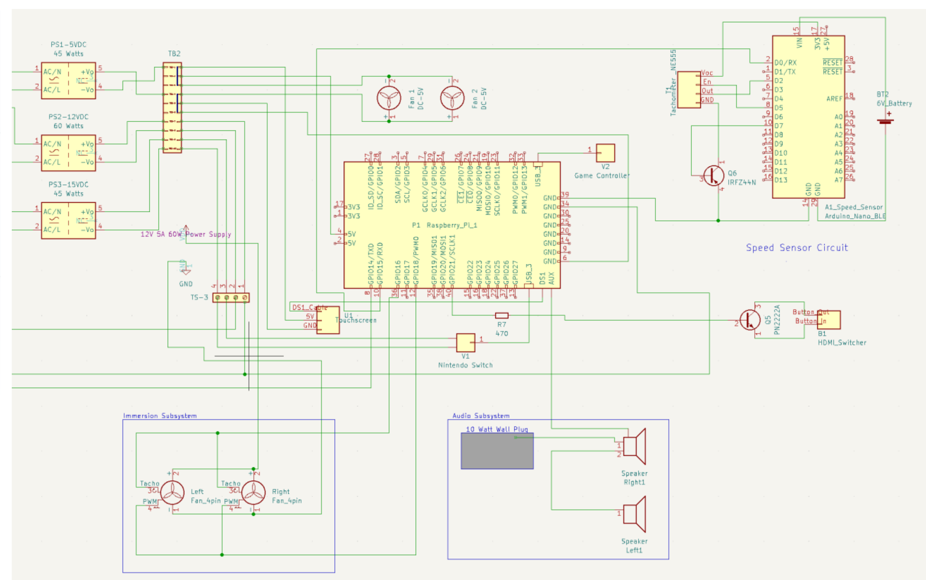

Figure 2. Circuit for recreation of windspeed

Trail Recreation:

The first problem was replicating a recorded hill or change in elevation on the exercise bike. The next issue for trail recreation was to find a way to scale the video and audio replay with the user's speed. The issue with replaying the video through the exercise bike was that the video playback speed needed to scale with the speed of the user, while also maintaining smooth visuals while going slower than the initial recording. The issue with replaying the audio was the playback speed of the user may vary from the recorded speed thus causing the audio to be sped up and pitched differently than the original recording. The final problem was recreating the feeling of wind.

The solution for the problem of recreating elevation changes accurately is to take the input from a force sensor attached to the bike pedals. This would calculate the work being inputted by the user. The work values from the user's input are summed together in real time and compared to the work map mentioned in the previous section. The goal is to replicate the work done on the trail by changing an actuator that either increases or decrease the back wheel's resistance depending on the current value of the work map. The solution for the video playback was to use interpolated frames allowing the user to go slower without loss of visual smoothness. The solution for the audio playback was to loop the audio over a specific time until the user has progressed past that section. The final solution for recreating wind was to use a fan to simulate airflow for a realistic feeling immersive experience.

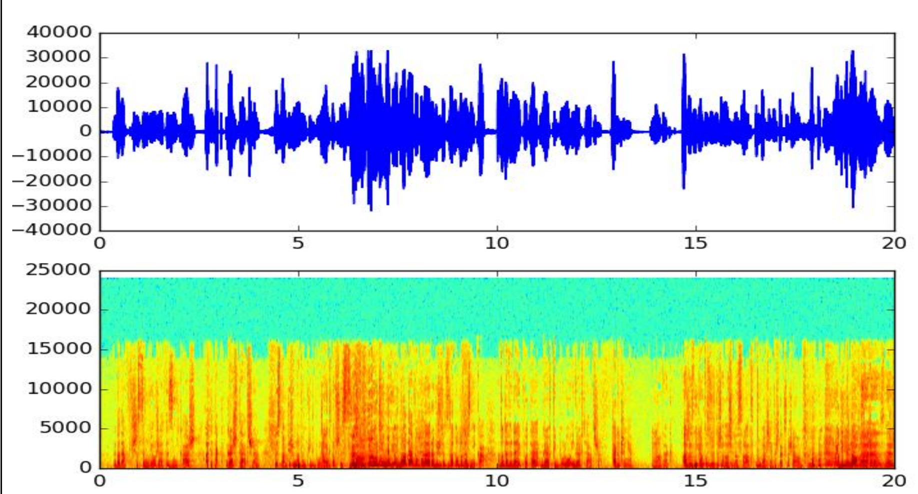

Figure 3. Spectrogram of trail audio for analysis over time

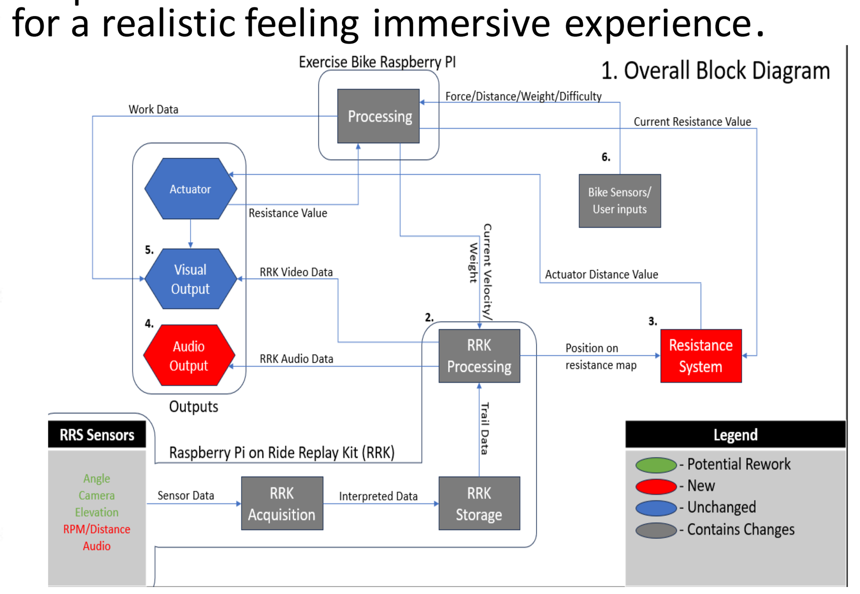

Figure 4. Block Diagram of the Design

Conceptual Analysis

The most interesting result from the conceptual analysis is the result from the calculations of work recreation on the exercise bike. The equation that resulted was a relation between the work from the work map in joules and the actuators distance from the back wheel. The equations used are as follows:

$F(x) = \frac{3\mu}{2\pi} M^2 V^2 \frac{1}{x^4}$ *Force Formula

$M = \frac{m}{V}$ *Magnetization

$m = \frac{BrV}{\mu}$ *Magnetic Dipole

Using these Formulas

$x = (\frac{3\mu}{2\pi} M^2 V^2 \frac{d}{W})^{0.25}$ *New Formula for actuator distance based on work

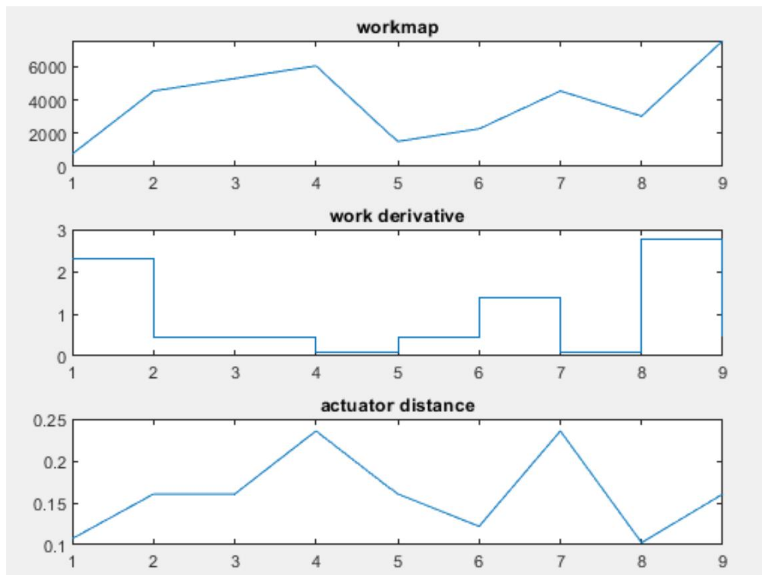

Figure 5. Graph of the new formula for actuator distance

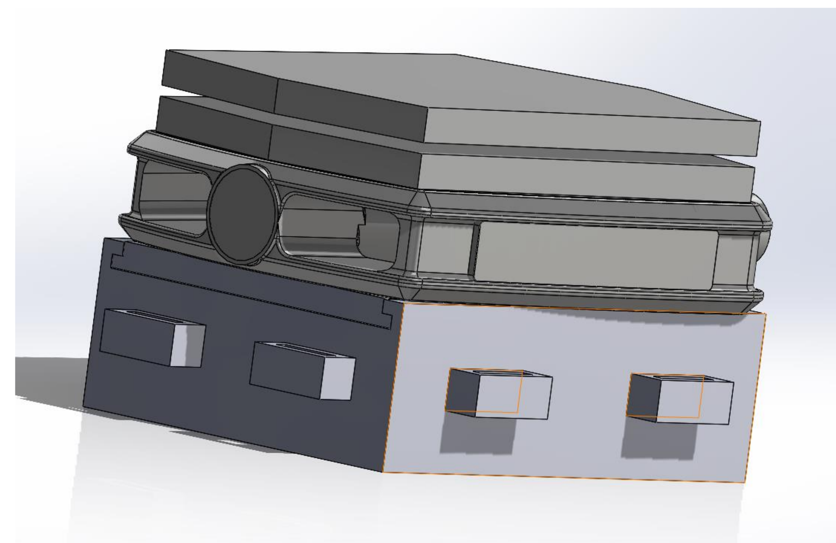

Figure 6. Holder for force sensors on pedal of exercise bike

Experimental Results

The most important result from the experiments is the comparison of the generated work map to the actual work done during the same trail ride. To do this experiment a work map was generated for a specific trail and the total amount of joules was compared to the total amount of joules expended by two people riding the same trail multiple times.

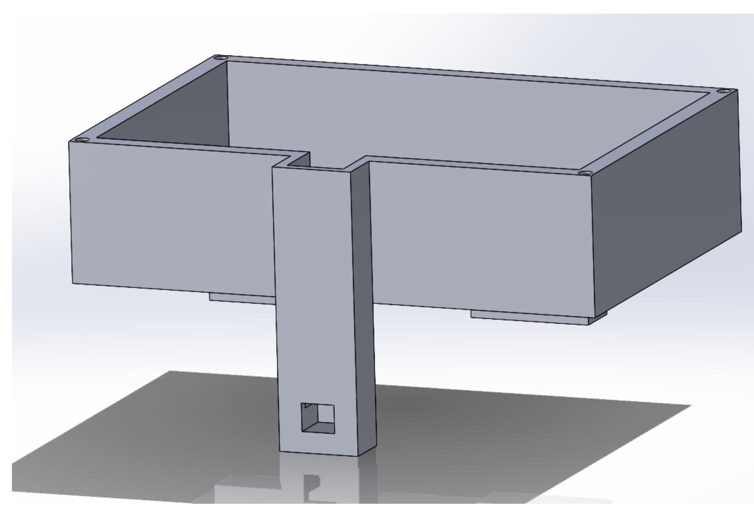

Figure 7 Circuit holder for Work map creation

Figure 8. Graph of the new formula for actuator distance

Software

Python programming language - Used in every aspect of the project to interpret the work data and react accordingly to replicate the recorded trail accurately.

VLC player - Used to vary video playback speeds, and for the playback and looping of particular audio files.

Ableton Live 11 - Used for audio processing and high/low-pass filters.

Flow Frames- Used to interpolate frames and remove duplicate frames

Tkinter - Used to create the User Interface

Final BOM

This is the final BOM for the project. However, this is not the full cost of the project since many of the devices used are from the previous two Mario Kart Teams.

Product Name	Description	Subsystem Used	Part Number	Manufacturer	Quantity	Price
OpAmp IC	General Purpose Amplifier 4 Circuit Rail-to-Rail 14-PDIP	Resistance System	MCP6004-I/P	Microchip Technology	2	$1.18
Potentiometer	100 kOhms 0.5W, 1/2W PC Pins Through Hole Trimmer Potentiometer Cermet 1.0 Turn Top Adjustment	Resistance System	3386P-1-104LF	Bourns Inc	2	$3.22
BATT HOLDER AA	Battery Holder (Open) AA 3 Cell Wire Leads - 6" (152.4mm)	Resistance System	BC3AAW	MPD	2	$4.66
Capacitor	47 pF Mica Capacitor 500 V Radial	Resistance System	CD15ED470JO3	Cornell Dubilier Electronics (CDE)	2	$3.56
Perfboard	Breadboard, General Purpose Plated Through Hole (PTH) Pad Per Hole (Round) 0.1" (2.54mm) Grid	Resistance System	ST-PERF-1-2	SchmalzTech, LLC	2	$7.80
Arduino Nano	Arduino Nano 33 Bluetooth Low Energy Microcontroller	Resistance System	ABX00030	Arduino	2	$55.18
Speaker	Logitech Z207 2.0 Multi Device Stereo Speaker	Audio	B074KJ6JQW	Logitech	1	$59.94
Mic Mount	CAMVATE Super Clamp with Cold Shoe Mount for Camera Flash Light	Audio	B07D9LTNG9	CAMVATE	1	$15.00
Microphone	Logitech Blue Snowball USB Microphone for PC	Audio	B000EOPQ7E	Logitech	1	$69.99
Windshield for Microphone	Deadcat Windshield Wind Cover for Blue Snowball iCE	Audio	B07SF5C6BV	YOUSHARES	1	$9.99
Microphone Mount Adapter	5/8"-27 Male Threaded Cold Shoe Adapter for Microphone Mount	Audio	B014XGA4DE	CAMVATE	1	$5.99
Mounting Bar	Stanley National N180-125 Stanley Slotted Flat Bar, 1-3/8 in W X 36 in L X 0.08 in T, Steel, Galvanized, 1.375	Audio	N180-125	Stanley Natio	1	$17.50
Pole Mount	Universal Stainless Steel Vertical Pole Mount Adapterwith 3 Loops	Audio	B0BVT4J3FF	Lighfast	1	$9.99
Screws	1/4-20 x 3/4" Button Head Socket Cap Bolts Screws, 304 Stainless Steel 18-8	Audio	B0BVT4J3FF	EastLo	1	$7.99
Shock Mount for Microphone	YOUSHARES Snowball Shock Mount, Shockmount Reduces Vibration Noise Matching Mic Boom Arm Stand, Compatible with Blue Snowball iCE USB Microphone	Audio	B08L4DB79P	YOUSHARES	1	$16.88
Hall Effect Sensor	Hall Effect Sensor Single Axis TO-92-3	Work	DRV5056A2ELPGMQ1	Texas Instruments	2	$4.02
Arduino Nano	Arduino Nano 33 BLE with Headers [ABX00034]	Work	TIFC00125	Arduino	2	$59.98
BATT HOLDER AA	Battery holder fo 3 AA batteries	Work	BC3AAW-ND	MPD (Memory Protection Device	1	$2.33
Magnet	Nickel-Plated N52 Magnet	Work	B0CGDTQ64C	Mixia	2	$26.99
Power Supply	DC 12 Volt 5 Amp Power Supply 60W 12Volt 5Amp AC Adapter 100-240V 50-60Hz AC to DC 12V 5A Power Adapter Converter with 5.5mm x 2.5mm Tip & 1 Female Terminal for LED Strip Light CCTV Camera etc.	Immersion	B0BJVVBBMJ	Amazon	1	$10.87
Fans	Fan Tubeaxial 12VDC Square - 120mm L x 120mm H Ball 185.5 CFM (5.19m³/min) 4 Wire Leads	Immersion	CFM-A225BF-158-597-2	DigiKey	2	$71.70
				TOTAL COST:		######
				TOTAL QUANTITY:	31	

Future Work

There are many ways to continue this project. One way is to improve upon the process that the audio segments are split up. Another aspect that could be improved is the visual fidelity. The work system could use a complete redesign of the 3D prints to fit more bikes. The User Interface could be made more visually appealing. The back actuator could receive more precise inputs from the resistance calculations.

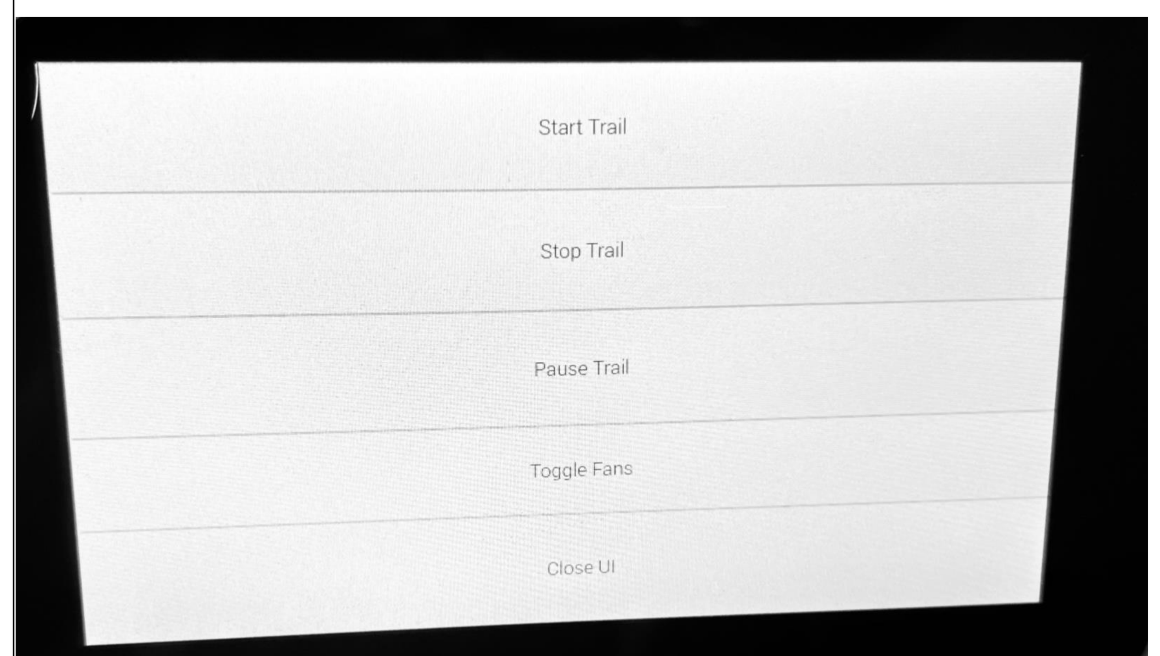

Figure 9. User Interface displayed on monitor

Figure 10. Exercise bike with all items attached

Acknowledgements

We would like to thank Professor Roberts and other faculty for giving us the opportunity to work on this project. We would also like to thank all the people that helped us during this project.