

Automatic Gear Shifter

Look Ma, No Hands!





Ever wondered how to optimise your effort-to-result ratio on a geared bicycle?

We have a solution for you

Do you also want to throw your hands in the air and ride in peace?

Not recommended, you are going to fall down



Introduction





Overview

Automation is the creation and application of technologies to produce and deliver goods and services with minimal human intervention.

Optimal performance is achieved by the use of machines and automation which when well-calibrated can assure accuracy and precision to a microsecond timescale.

Thus, the combination of convenience achieved by automation and assurance obtained from optimal performance is conducive towards **human satisfaction**.



What are we attempting to achieve?

An automatic gear shifting system.

And why?

- Climate change is a rising threat: we are promoting use of bicycles.
- Reliable operation of the gear shift mechanism: reducing wear and tear
- Geared cycles provide a better ride than non-geared cycles and our system makes it easier for beginners to ride and start learning to ride geared bicycles as well



Our Approach

Combine different external factors and make an optimal choice

A simplified two-factor model:

Speed

Slope



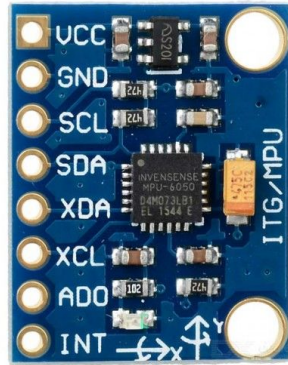
The Framework



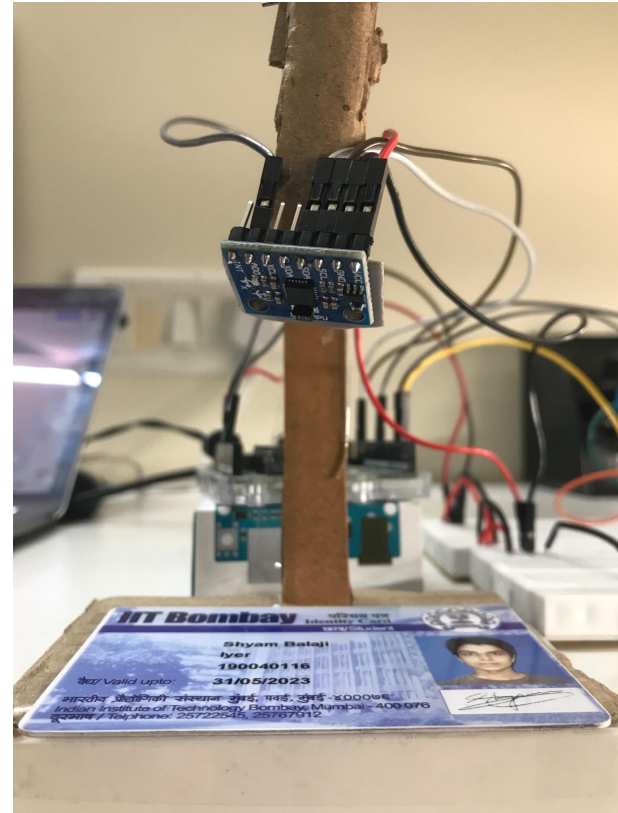


Arduino Uno





MPU6050





Theoretical Foundations

- What is an *accelerometer*?

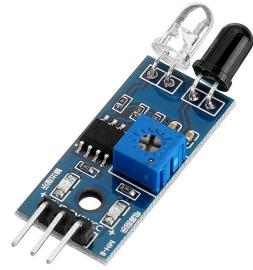
A tool to measure *proper* acceleration → acceleration relative to a free-falling observer momentarily at rest

For our purposes, used to measure the slope

- Interfacing two integrated circuits?

Physical Interface - **Jumpers**, PCB Trace, USB, D-Subminiature, ...

(Serial) Communication Protocols - SPI, **I²C**, PCIe, ...



IR Sensor and Receiver





DC Motor with a Wheel





Theoretical Foundations

- Capturing wheel speed?

A simple **IR interrupt**-based RPM counter that's translated to distance covered

- Basis for changing gears?

$$\text{weight} = \text{Speed}/a - \text{Slope}/b$$

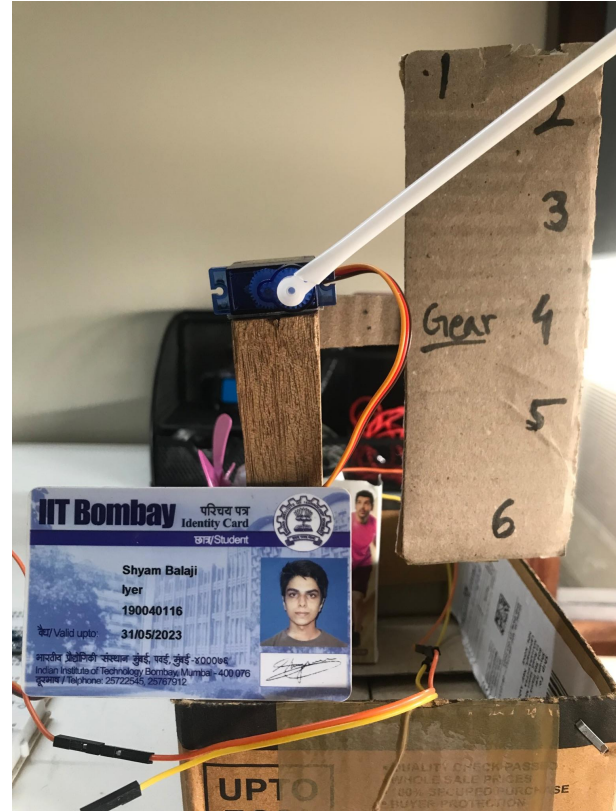
where a and b are calibration constants

Thresholds have been set which, when exceeded, toggles the gear

To deal with edge cases, buffer regions are in place → the system is stable and convergent to the feedback it obtains

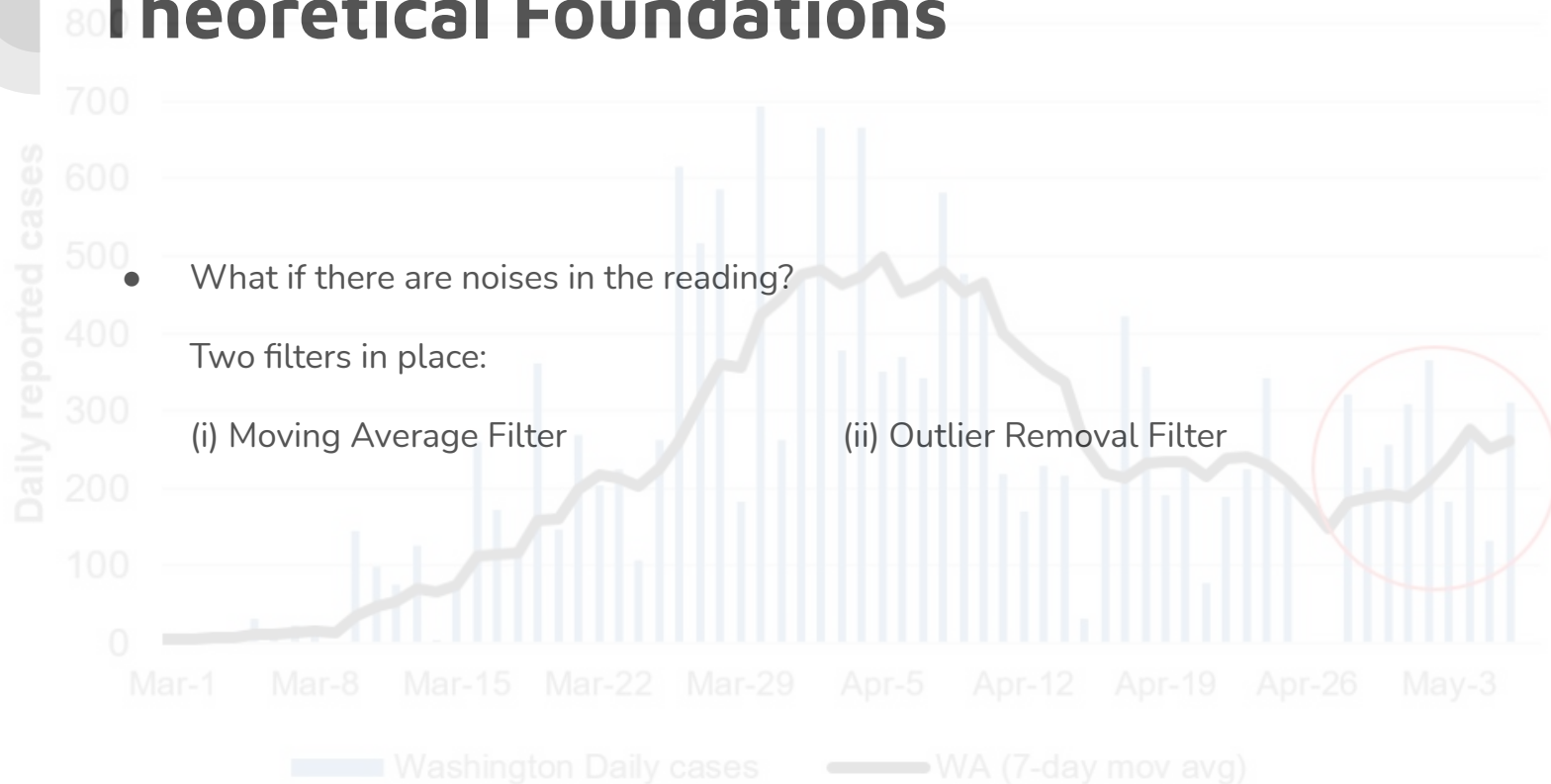


Servo Motor

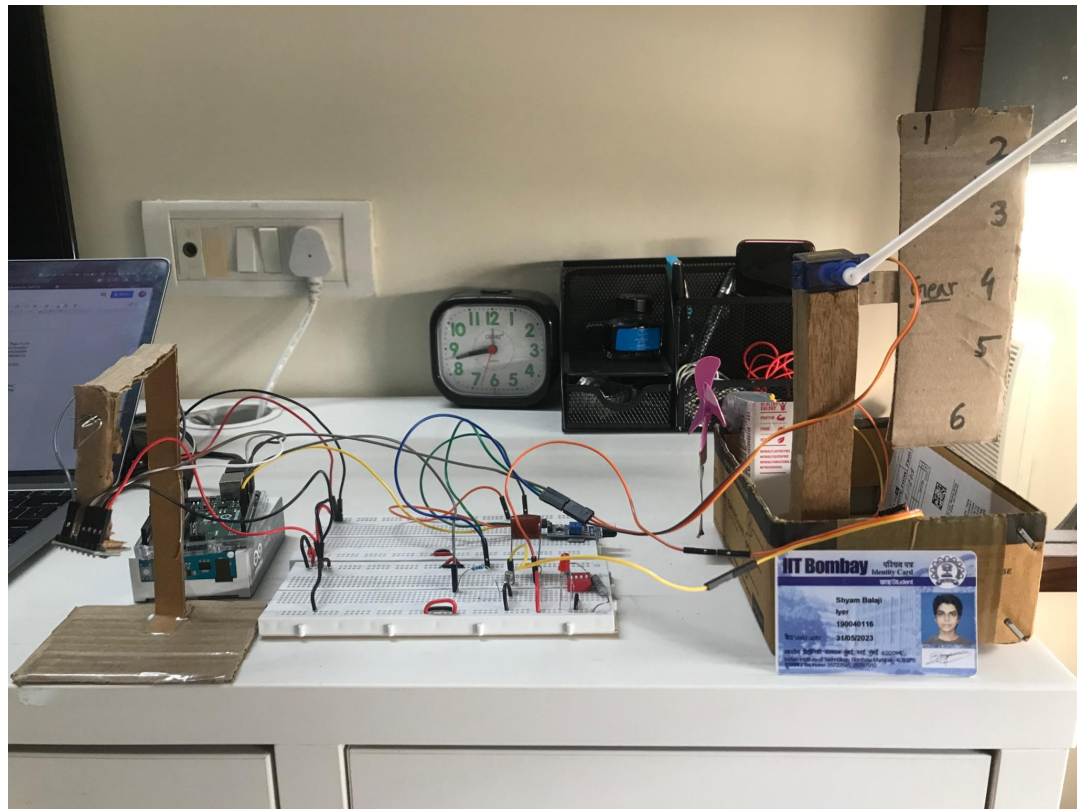


Washington State daily Covid-19 cases and 7-day moving average of daily cases

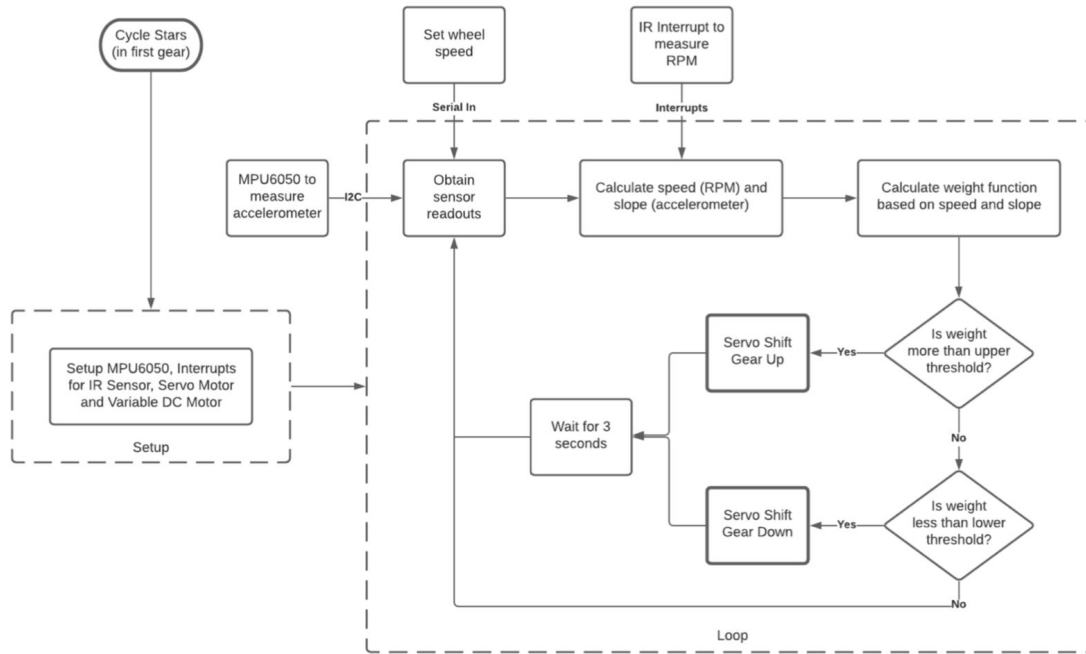
Theoretical Foundations



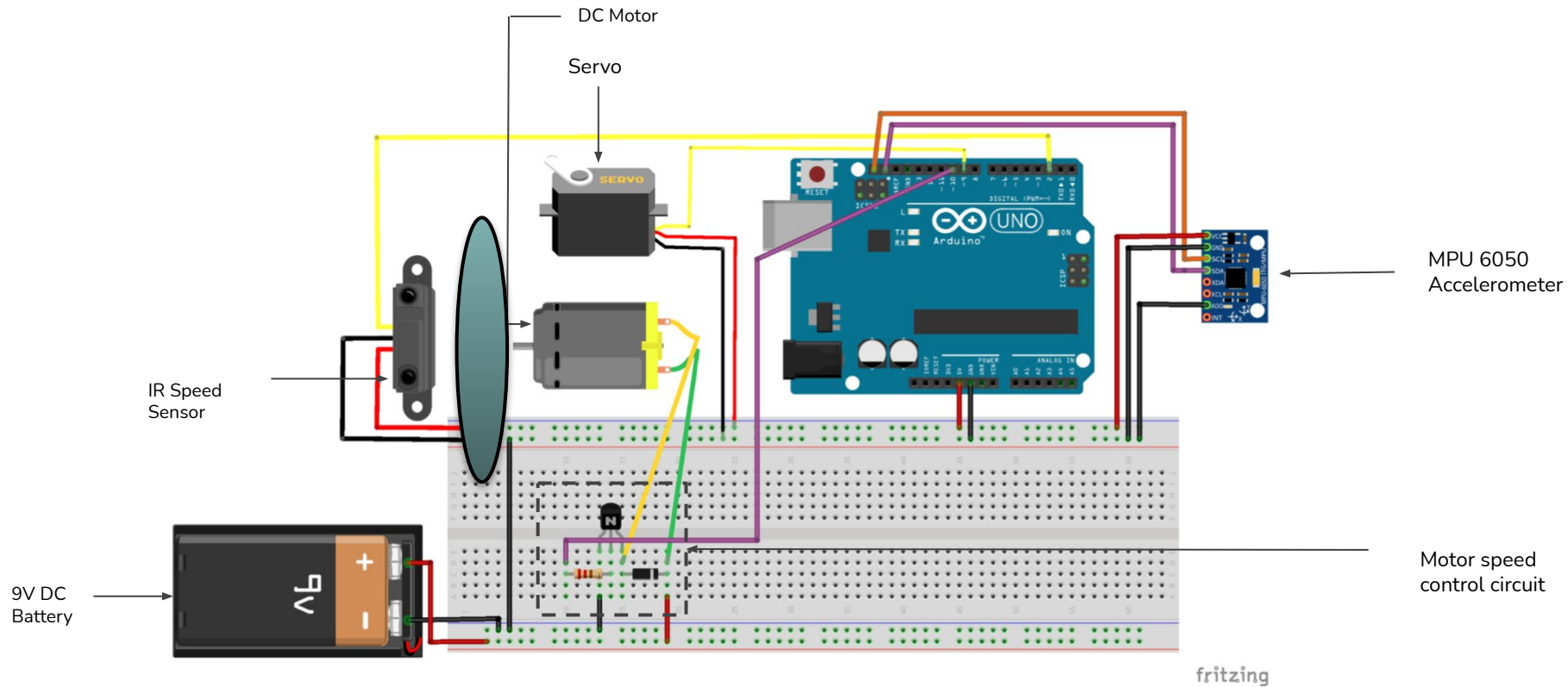
Source: CDC; Bloomberg; RSM US



The Complete Setup



Flowchart

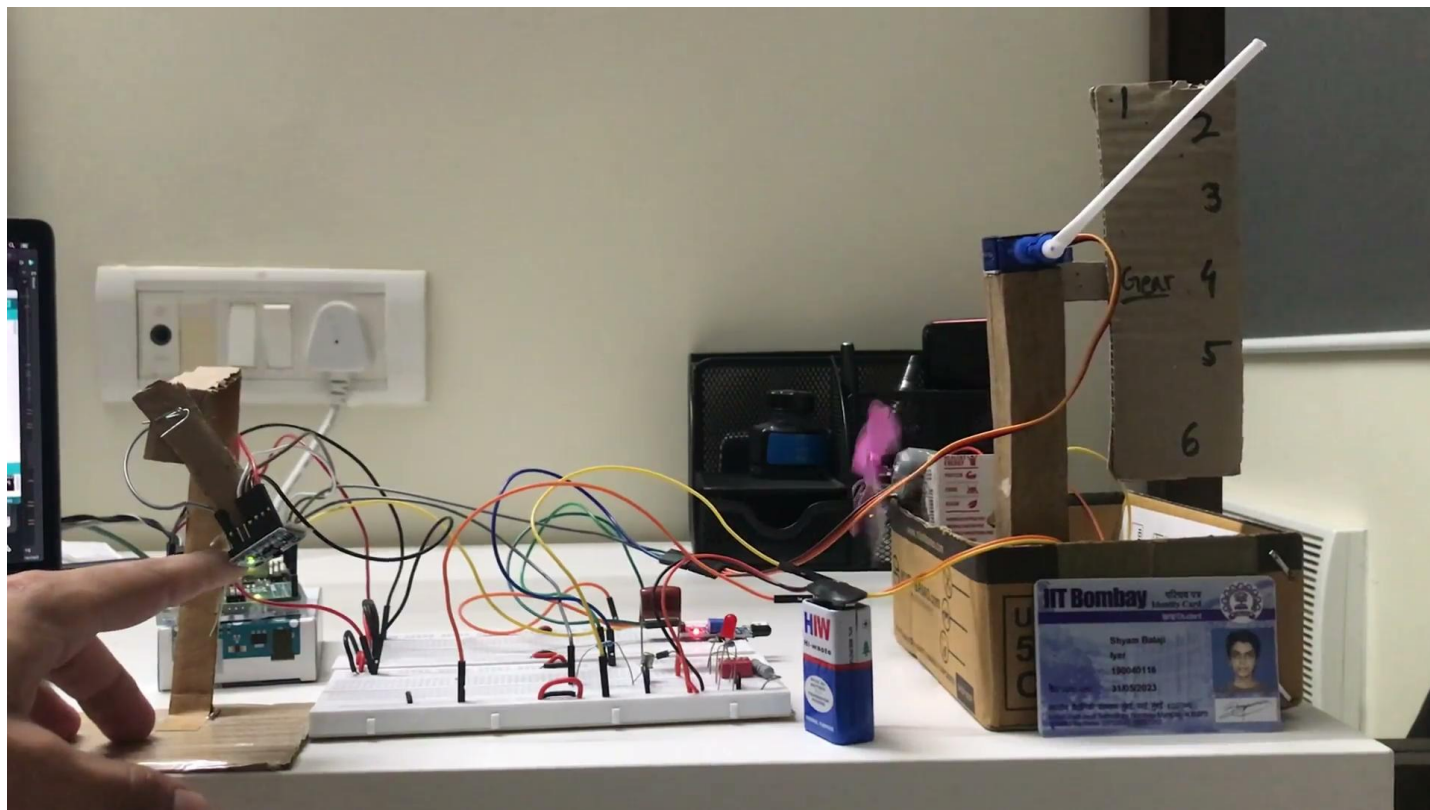


Circuit Diagram



Demonstration





Hardware is Hard

The Big Picture



Challenges and Takeaways

- The MPU 6050 came in without being soldered. We learnt the additional skill of soldering in the process.
- Although this was a table-top simulation, unexpected jerks necessitated an outlier removal filter
- The servo motor needs a large, stable current supply
- We speculate that we may have faced stack overflow issues on the Arduino



Features We Could Have Included

- A manual user override
- Consider adding more factors



Look Ma, I'm Racing!

Video Credits: <https://www.youtube.com/watch?v=o7vxsNJ2Uk8>

Appendix



Dependencies

Components:

- Arduino Uno R3
- DC Motor 6V
- Servo Motor SG90
- Infrared Sensor and Receiver
- 3-Axis Accelerometer (MPU6050)

Libraries:

- Wire.h (for I²C)
- Servo.h (for the Servo Motor)
- [MPU6050.h](#) (for MPU6050)

Repository:

- <https://github.com/aravindbharathi/Automatic-Gear-Shifter>



References

1. Shift4Me is an automatic bicycle shifter - ARDUINO TEAM — September 9th, 2020
<https://blog.arduino.cc/2020/09/09/shift4me-is-an-automatic-bicycle-shifter/>
2. Auto Gear Shifter for Bikes With Speed Feedback
<https://www.instructables.com/Auto-Gear-Shifter-for-Bikes-With-Speed-Feedback/>
3. Auto-gear Changer for Bicycles
<https://create.arduino.cc/projecthub/shift4me/auto-gear-changer-for-bicycles-53e9d3>



Image Credits (in order of appearance)

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