Progress report 2023-08-25

RG Wells – 22961305

What I've been working on:

I met with you to discuss changes made to the experimentation for validating the model. In this meeting we confirmed:

- I can validate the model without using camera position tracking, so long as I ensure that my experiments are objective and repeatable.
- I could still do position tracking if time allows, adding another objective measure of the model's accuracy.
- Measuring the coefficient of friction will not be necessary, I should just keep it constant.
- Using a brushless motor can be justified for gathering information about the system, even if it isn't practical for cost reduction in a mass produced system.

I've implemented the higher gearbox motors in the device, and measured its torque output. Using these motors, the device can climb steps even when the tail is pressed against the edge of a previous step. I'm using Patex, a rubbery contact adhesive, on the surface of the wheels to increase friction, without this coating the device can slip and fall in this loading scenario.

I had been using pulse width modulation for motor control, but I found that PWM signal is not proportional to torque output on the motor, I believe this is because of the shape of the PWM signal combined with the self-locking gearbox, essentially the motor has full torque and can move a load when the PWM signal is high, then locks when the PWM signal is low, causing a steady movement even at low PWM signals.

It is more effective (and easier to model) to vary the motor voltage in order to control the motor. To do this I implemented a buck converter in my power supply, which allows me to control the motor voltage using a potentiometer. I could also have used a low pass filter to shape the PWM signal to approximate a fixed voltage, but this would require quite large components.

I have now measured the gearbox output torques at different motor voltages by using it to lift a lever with a mass attached. The angle of the lever when it stalls can be used to calculate the torque. The relationship in the data is linear.

I have also measured the masses of components of the device, and imported these masses into CAD so that my simulation has the correct inertias. Combining this with the measured motor torques allows me to simulate the device using its real parameters. The simulation has shown that it moves similarly to the device, and needs similar torques to start movement.

What I’m working on next:

Model validation: I have identified several individual stages in the climbing motion. I will test the stalling torques required to move the device in each stage and use these to validate the math model and simulation. Some of these stages involve slipping and collision which is difficult to model mathematically, but I can test that the simulation shows similar results.

Improve models: I want to improve the structure of my math model so that it is easier to use and consider different loading scenarios. I will likely identify shortcomings in the model in the validation stage, and have to update it to match the mechanics of the physical device.

Unchanged:

Next iteration: While building and testing the device I have been considering potential improvements for a future version. If time allows, I would like to build a second device after I have validated the model using the first device. The design of this device would consider lessons learned from the model, and multiple concepts could be quickly tested in simulation. The ideas I’m currently pondering include using bearings, herringbone gears, brushless dc motors, and possibly even connecting the two LIMs together with a bolt so they move rigidly together, eliminating the possibility that one moves ahead of the other.