CHAPTER 1

Conclusions

1.1 Results

1.2 Future work

The following is a non-comprehensive list of potential future work which could be performed to improve the capabilities of the test platform or supplement the control studies already performed on the test platform.

- Optimize sample interval of hardware.
  - Determine limiting factors in the reduction of the board sampling interval.
  - Improve upon these factors, if possible.
  - Determine alternative model algorithms such that processing *(per sample interval)* is significantly minimized.

    [*Example: Use binary classes wherever possible.*]
- Optimize serial communication.
  - Implement bluetooth wireless transmission.
  - Determine limiting factors in the reduction of the serial transmission interval.
    - Determine if increasing the serial communication sample interval improves limits on hardware sample interval.

      This is already performed when sending a high number of signals,

      but improved performance has not been verified.
    - Determine if increasing the BAUD frequency on the board will remove limits on the serial transmission interval.
  - Determine how to begin a read without resetting the hardware.
  - Determine if dynamic/real-time plotting is worthwhile. If so, implement.

- Implement alternate linear controllers.
  - Implement pole-placement controller(s).
  - Implement LQG controller(s).
  - Implement H_N controller(s). [*Where N is an integer or infinity.*]
- Implement a nonlinear plant model.
  - Develop nonlinear controller(s).
  - Demonstrate operation in nonlinear states.

    Example: Operating in a state with a significantly increased component of horizontal pitch.
- Improve model parameters measurements.
  - Improve mass measurements.
    - Use scale with improved precision. [*Current precision is 0.01 [lb].*]
  - Improve motor transfer function measurement. [*Angular velocity vs. Input Voltage*]

    Hardware must remain perfectly upright while in motion to perform this measurement.

    The original measurement was taken while balancing the in-motion device by hand.

    Since a pitch controller has been developed, the measurement may be taken more accurately.
  - Verify conflicting motor parameters derived from References [0], [0]:
    - *Resistance,* R_{mtr}
    - *Torque constant,* $k_{mtr.T}$
    - *Back EMF constant,* $k_{mtr.bEMF}$
- Increase MinSeg power-source voltage-maximum. [*See Section* **??**.]

  Current voltage source maximum: 09 [V].

  Motor driver operating maximum: 36 [V].

- Construct alternate physical models via simple variants.
  - Alternate mass distribution.
    - Reduce number of batteries to less than 6. [*Requires use of USB cable for power.*]
  - Alternate geometry.
    - Alternate wheel component.

      [*Search for Lego tires with differing radius, mass, and/or coefficient of friction. See [0]*]
    - Incorporation of a second mass on the pendulum.
- Perform movement on an uneven surface.
- Optimize filter design.
  - Determine tradeoffs between no filter vs 1^{st} to 6^{th} order bessel filters.
  - Determine tradeoffs between state-space and transfer function blocks, if any.
  - Determine tradeoffs between Matlab besself and bessel poles, if any?
- Optimization of observable data
  - Implement voltage sensor across battery holster.

    Use this voltage reading to determine the true voltage of the power source in operation.
  - Incorporate use of accelerometer?

    Incorporate use of Kalman filter?

    Compare effects.
- Test Windows and Linux compatibility. [*Document necessary changes, if any.*]
- Improve overrun detection.

  If the board cannot complete all of its processes before the sampling interval completes,

  then it performs incorrectly. Detection of this is possible and desirable for the user.

  Currently, overrun detection requires that the the user manually view an LED on the board.

  The LED is very small and almost entirely masked by the bluetooth module.

(Simulink also currently prevents status reads of the overrun LED pin.)

An alternative method should exist which alert the user more conveniently.