Introduction

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About me

- Graduate student from the TU Delft (Netherlands)
- Doing internship at the UC Davis bicycle laboratory

Graduation project

Identifying rider controlling action in bicycling:

- We know a lot about the uncontrolled bicycle dynamics.
- However, in every day life, bicycle are most of the time controlled by human operators.
- Graduation project will be about identifying human rider control during bicycling
- To be more specific, we are especially interested in bike balancing.

Project Description

- Assisting Jason and Luke with performing measurements.
- Prepare system identification procedures for validating bicycle dynamics (Luke) and estimating rider control (Jason)
- Unfortunately I just arrived, so I can't tell you much about it yet.

Bicycle simulation

Instead I will be talking about Matlab bicycle game I recently created. The following contents will be treated.

- Methods
- User input
- Demonstration
- Discussion
- Future work

Methods

- Simulink model (ODE-solving)
- Matlab Real-time windows target
  - Enable real-time simulation by connecting Matlab directly to windows timer.
  - Compilation of simulink code to C-code for faster runs.
  - Analog joystick input supported
  - Compatible with Simulink 3D animation toolbox.
- Simulink 3D animation toolbox
  - Enables connecting Matlab with a 3D VRML enviroment.
  - VRML environments are easy to created using 3D software (e.g. 3D studio max).
- Matlab GUI with visual indicators

User input

- Linear benchmark bicycle equations programmed;

$$\mathbf{M}\ddot{\mathbf{q}} + v\mathbf{C}_1\dot{\mathbf{q}} + \left[g\mathbf{K}_0 + v^2\mathbf{K}_2\right]\mathbf{q} = \mathbf{f} \ , \qquad (1)$$

  where $\mathbf{q} = [\phi, \ \delta]^T$ and $\mathbf{f} = [T_\phi, \ T_\delta]^T$.
- User input:
  - Velocity; v [m/s]
  - Steering torque; T_δ [Nm]
- Lean action omitted, but would be interesting to include in the simulation.

Demonstration

Matlab bicycle simulation

Some discussion

- Dynamic behavior of the bicycle changes as function of the forward velocity; v.
- Capsize instability easy to control.
- At low velocity the weave mode becomes instable and is very hard to control.
- Linear equations only valid for small angles.
- Adding visual cue about roll rate, makes control possible.
- Changing bike parameters would require changing both the Matlab and 3D model, which is a lot of work.

Future work

- Include the nonlinear equations
- Force feedback interface to include proprioceptive feedback loops.
- Include leaning action.
- Experiment with different viewpoints (e.g. camera attached to bicycle).
- Automatic 3D model generation based on bike parameters.
- Multi-player bike balancing mayhem.