Enabling Feedback Force Control for Cooperative Towing Robots

Research Advisors: Prof. Vijay Kumar & Jim Keller
Graduate Student: Soonkyum Kim
Student Researcher: Clarence Agbi
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Overview

Cooperative Robotics:
Multiple robots working in coordination through sensory perception or explicit communication, to accomplish a set task
Cooperative Towing Robots
Pros of Cooperative Towing

- Multiple robots doing the same task is faster than just one robot
- Decentralized system, shares load/work equally
- Easily adaptable to changes in environment
- Increased accuracy & autonomy in simple tasks
Cons of Cooperative Towing

- Our model assumes quasi-static manipulation (i.e. manipulation at low speeds)
- Errors in location and position due to dry frictions on the payload and lack of feedback
Motivation

To implement a fully autonomous and accurate cooperative towing system in the real world.
Problem

To implement a feedback system that reduces positional error ($\delta$) and increases the accuracy of towing objects to a specific destination ($X_f, Y_f$).

Start
$(X_0, Y_0)$

Robots tow @ Velocity $<V_i>$

Payload moves to $(X_i, Y_i)$

Finish $(X_f + \delta, Y_f + \delta)$
Feedback is the process of feeding part of the output back into the input to control the behavior of the system.
Create a force feedback system to maintain constant cable tension and reduce error ($\delta$) in the final position/destination.
Outline of Feedback System

Measure tension w/ Force Sensor

Read & Process tension data

Send force data w/ RF Transmitter

Receive force data w/ RF Receiver

Adjust robot velocity to maintain tension
Measure tension w/ Force Sensor

**Force Sensor: iLoad Mini Load Sensor**

- Outputs frequency in proportion to the applied load
- Range of 180-250 kHz (depending on sensor)
- Compensated for temperature & calibrated for tensile forces
Force Data Processing: BASIC Stamp 2 Module

- Easily programmed with PBASIC 2.5.
- Compatible w/ sensors and well-documented
- Small RAM size: 32 bytes (stores only 26 one-byte variables)
- Single-threaded microprocessor
Wireless Communication: RF Transmitter & Receiver

- Operate at 433.92 MHz
- Transmission range of a couple hundred feet
- Compatible with BASIC Stamp 2
- High baud rates (up to 19.2 k baud)

Send force data w/ RF Transmitter

Receive force data w/ RF Receiver
Feedback System: Tower

Towers have cables attached to the iLoad Mini Load Sensors, using screws with holes. They are also built to align and read the cable tension.
Frictional Errors in the Tower

There was significant frictional error between the cable and the top of the Tower. Attempts to reduce the error did not work as well as hoped.
Feedback System: BASIC Stamp 2

Reads, processes, sends, and receives tension data at approximately 3x a second.
Future Work

- Integration of all three towers into the cooperative towing system
- Implementation of an interface between BASIC Stamp 2 and the robot’s positioning system
- Reduce frictional errors
- Test w/ different revisions of the BASIC Stamp 2 or multi-threaded microprocessors
- Test w/ different load cells
Impact

Our research furthers the reality of a fully autonomous cooperative system that is both accurate and efficient.
Student Researcher  CLARNECE AGBI
Research Advisors  VIJAY KUMAR
           JIM KELLER
Graduate Student  SOONKYUM KIM
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