ELE 302 – INDEPENDENT PROJECT
FINAL PROPOSAL

TJ Smith Byung-Cheol Cho
(Bench 207)

Due March 31, 2017

1 Overview

- **Aim:** To build a robot/car capable of playing basic ping pong
- **Objectives:**
  - Track a ping pong ball, estimate its trajectory and predict the location where the ball will land
  - Determine (1) when it is the robot's turn to hit the ball and (2) when the ball will hit the net or leave the playing area
  - Move the robot to the required location before the ball bounces twice and hit the ball back over the net
  - Avoid leaving the playing field (area enclosed by table and net)
- **Approach:**
  - We will use a Pixy camera (or two for stereoscopic vision if the size of the ball alone is not accurate enough to determine distance) to track a brightly-colored ping pong ball in 3-D.
  - Based on the history of observed ball positions, we will fit a kinematic model and predict the landing location of the ping pong ball. If the ball is moving towards the robot and the predicted landing location is in the playing area, the robot should move to return the ball.
  - We will then move the robot to the required location using omni wheels. If we can accurately measure the global position of the ping pong ball while the robot is moving, we can continuously update the expected landing location as the robot moves.
  - We will use a combination of dead reckoning and checkerboard pattern or grid laid on the floor measured with a downwards-facing light sensor to determine the position of the robot. This will allow us to avoid leaving the playing field, as well as updating the expected landing position of the ping pong ball.
  - If necessary, we will build in a mechanism to change the angle of the paddle so that the ball can be hit to be returned over the net.

2 Progress steps and checkpoints

Hardware

1. Set up new drive system: build H-bridges and other relevant circuit boards as necessary; set up new power supply if a single 7.6 V NiCd battery is insufficient.
2. Set up interfaces between camera, accelerometer, gyroscope, light sensor, primary processor (a Raspberry Pi) and PSoC

3. Set up ping pong table and grid, and calibrate light sensor to detect grid lines
4. Test driving with the omni chassis and determine aberrances in camera images due to vibration
5. Set up paddle and turning mechanism for hitting ping pong ball

Software

1. Set up schematics and code on the PSoC to implement feedback control to execute movement commands of the form "move to position (x, y) in at most t seconds."
2. Set up communications and software interfaces between Raspberry Pi, PSoC, cameras and other sensors.
3. Set up Raspberry Pi to send movement commands to the PSoC
4. Evaluate accuracy and reliability of dead reckoning; set up grid-based re-calibration as necessary.
5. Determine the location of a static ping pong ball based on camera x/y coordinates and ball size; evaluate the accuracy of purely size-based depth estimation and the need for a second stereoscopic camera.
6. Track and predict the trajectory of a moving ping pong ball based on camera measurements.
7. Calculate position to which the robot should move in order to hit ping pong ball.
8. Based on ball movement direction and expected landing position, determine whether the robot should move to hit the ball.
9. Continuously track position of robot and ball in global 3-D coordinates and update expected landing position of ping pong ball during movement.
10. Implement paddle angle calculations as necessary.

Intermediate goals

1. Execute movement commands and track position
2. Track ping pong ball and rotate to face ball
3. Predict ball landing position X and move to point X in a non-time-dependent manner
4. Track ball and move so that the ball hits the robot's paddle after one bounce
5. Track ball and move to hit the ball back over the net after one bounce

3 Parts list

- Omnidirectional drive, ideally able to move sufficiently fast (2-3 feet/second)
    - If possible, the omni chassis from last year, or an equivalent one from the same vendor. We may need to gear up the motor if necessary
    - Four H-bridges (lots of transistors)
- Raspberry Pi 3
- 2 × Pixy CMUcam5 (two for the possibility of stereo vision)
- Accelerometer and gyroscope

- Light sensor: photoresistor and bright LEDs
- Particle board measuring about $5\,\text{ft} \times 5\,\text{ft}$ to use as playing surface; if this is too large, it can be broken up into several pieces as long as the joins are even and can be taped together
- Table tennis paddle
- Servo for changing angle of table tennis paddle
- Any structural components we will need for the servo