RoboRugby 2010

Robotics Design Project

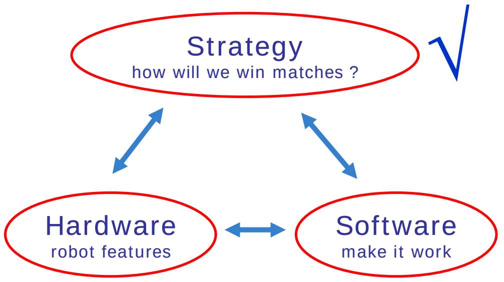
EEEN 10020

Lecture 5 - Robot Design

UCD School of Electrical,
Electronic and Mechanical
Engineering

Scoil na hInnealtóireacta
Leictrí, Leictreonaí agus
Meicniúla UCD

Robot Design



Strategy
how will we win matches ?
√

Hardware
robot features

Software
make it work

Rules - Robot Construction

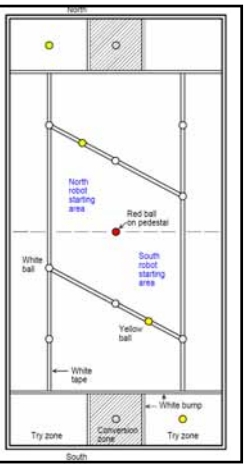
- Assembly
  - must be built from kit of parts provided
  - Lego structure held together using Lego only
  - detailed rules on wire, tape, rubber bands, etc.
  - other *decorative* parts may be added later…
- Dimensions
  - max 400 x 320 mm in plan (at start of match)
  - max 300 mm high (at start of match)
  - gauge box in lab for testing
  - must fit in team box for storage & transport
- Other requirements
  - may separate into at most 3 parts
  - On-Off switch, START, STOP must be accessible
  - yellow LED must be connected and visible
  - "flag-pole" for coloured paper flag

Rules - Impounding and Start-up

- Impounding
  - week 11 - last lab session before competition
  - no further changes to robot or software
  - competition program must be submitted
- Between matches
  - repairs to robot allowed (as time permits)
  - charging of battery allowed (recommended)
  - program can be downloaded again (if needed)
- Start-up
  - robot must be in starting area, see next slide
    - must be able to see beacon
  - we provide software to implement starting rules
    - also provides information on which beacon to use
    - also stops robot after 60 seconds

Table Layout

- Table
  - surface matt black
  - matt grey in conversion zone
  - white tape ~19 mm wide
  - white bumps ~4 mm high
  - black pedestal ~90 mm high
  - detailed dimensions on web
- Balls
  - ~42 mm diameter, ~7 g
- Starting area
  - robot entirely within area
  - must not touch or cover ball, pedestal or any line
  - must get signal from beacon



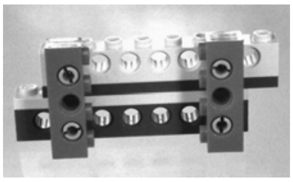
Robot Design

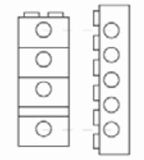
- Decide what you need your robot to do
  - from strategy and rules
  - if strategy throws balls, robot needs thrower…
- Decide how best to make it do it
  - another design process
  - brainstorming - come up with ideas
  - evaluate ideas - build rough model if necessary
  - consider pros/cons/risks
  - choose best solution
- Detail design of robot
  - wheels, gears, pivots, etc.
  - position of sensors
  - centre of gravity…

Good Design

- Follow overall requirements
- Many compromises
  - sturdy, yet light
  - fast, yet strong (forceful)
- Keep it Simple
  - no unnecessary complications!
  - simple = easier to build
  - simple = more reliable
  - simple = easier to program

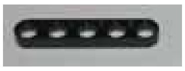
Robot Design - bracing





- Lego bricks pull apart easily - esp. if bend
  - add vertical or diagonal beams - much stronger
- Numbers:
  - brick height = 6/5 hole spacing (or stud spacing)
  - plate height = 1/3 brick height
  - 5 bricks = 6 holes, 1 brick + 2 plates = 2 holes, 3 bricks + 1 plate = 4 holes, etc.

Bracing Options



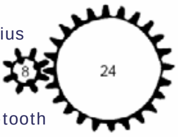
- Bricks
  - available in even lengths (number of studs)
  - odd number of holes
- Beams
  - holes only - no studs
  - mostly odd number of holes
- Flat arms
  - thinner and lighter than beams
  - odd and even hole counts
  - use with special short pins (don't confuse with pin-studs)

Robot Design - moving

- Tank tracks:
  - good grip on table, precise turns
  - low ground clearance - careful!
- Two wheels:
  - very agile robot
  - need castor(s) - weakness?
- Four wheels:
  - sturdy, hard to turn - friction
  - drive two, others small, less weight ?
  - all 4 driven ?
- Larger wheel diameter:
  - faster for given axle speed
  - need more torque to drive

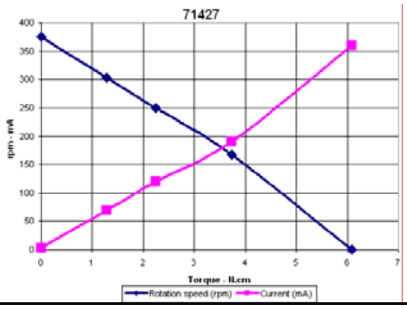
Robot Design - gears

- Speed ratio = inverse of gear tooth ratio
  - 8-tooth gear turns 3 times faster than 24-tooth
  - in opposite direction
- Torque = turning force (Nm)
  - torque = driving force x wheel radius
  - force x speed = power
- Torque ratio = gear tooth ratio
  - 24-tooth gear 3 times torque of 8-tooth
- Gear spacing important
  - too tight, high friction - too loose, slip under load
  - 8, 24, 40-tooth gears mesh nicely along beam
  - 16-tooth gears mesh with each other
  - other combinations possible on diagonal

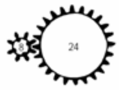


Robot Design - motors

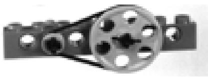
- Speed of motor falls as opposing torque increases
- Current consumed proportional to torque
- Torque depends on gearing, wheel size, friction, ...



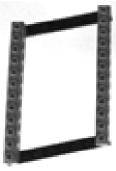
Robot Design – power transfer



- Gears allow you to trade speed for torque
  - choose gear ratio to optimise performance
  - best compromise depends on your strategy
- Pulleys also possible for power transfer
  - 3 pulleys available
    - smallest is short bush
  - speed ratio inverse of pulley diameter ratio
  - torque ratio equal to pulley diameter ratio
  - use rubber band - light duty - slip under load
  - use tank tread - heavy duty
  - same direction of rotation
  - not recommended for main robot drive…



Robot Design - friction



- Wanted friction
  - tyres/tracks grip table to drive robot
- Unwanted friction
  - tyres/tracks grip table when trying to turn
  - gears - more gears = more friction
  - gears - badly assembled = severe friction
  - axles - bind if not perpendicular to beams
  - axles - friction if gears or bushes too tight
  - pins - grey pins turn freely, black pins stiff
  - axle pins - beige turns freely, blue stiff
- See "The Art of Lego Design" by Fred Martin

Robot Design - ball handling

- "Collector" robots
  - need scoop or arms?
  - need holding area
  - keep balls in when reversing
  - get balls out in scoring area
  - protect scored balls?
- "Kicking" robots
  - arm, paddles, wheels?
  - width and location?
  - drive with motor or servo?
  - avoid kick towards own goal
- Many other possibilities…
  - you design to suit your strategy!

Project Plan

- Plan - what do you have to do?
  - design a good robot
  - build the robot
  - write programs for the robot
  - test as you go along
  - re-design if needed, etc., etc.
- When will you do it?
  - ~20 lab hours before competition
  - set targets for each week, and keep to them…
- Who will do it?
  - team members may choose to specialise
  - everyone must be familiar with everything

Homework

- Read "Art of Lego Design" - Fred Martin
  - quick look - see what's useful
- Look at MIT "6.270 Course Notes":
  - chapters 6 & 7 - robot construction and control
- Team meeting - before lab session on Wednesday
- Robot design - needed to implement strategy
- Project plan
- Write it all down - needed for reports!
- Strategy report due on Wednesday – 3pm…

Lab Session

- No written instructions - plenty to do!
  - up to you to plan your lab session
- Try out ideas - experiment
  - e.g. if strategy depends on kicking, try kicking…
- Select good ideas
- When ideas fairly definite, start building robot
  - existing robot no longer needed – dismantle?
- Test as you go
- Keep notes - needed for reports!