Robotics@CalU

California University of PA
National **C**enter for **R**obotic
Engineering **T**echnology **E**ducation

Radio Control for Robotic Competition

Introductions

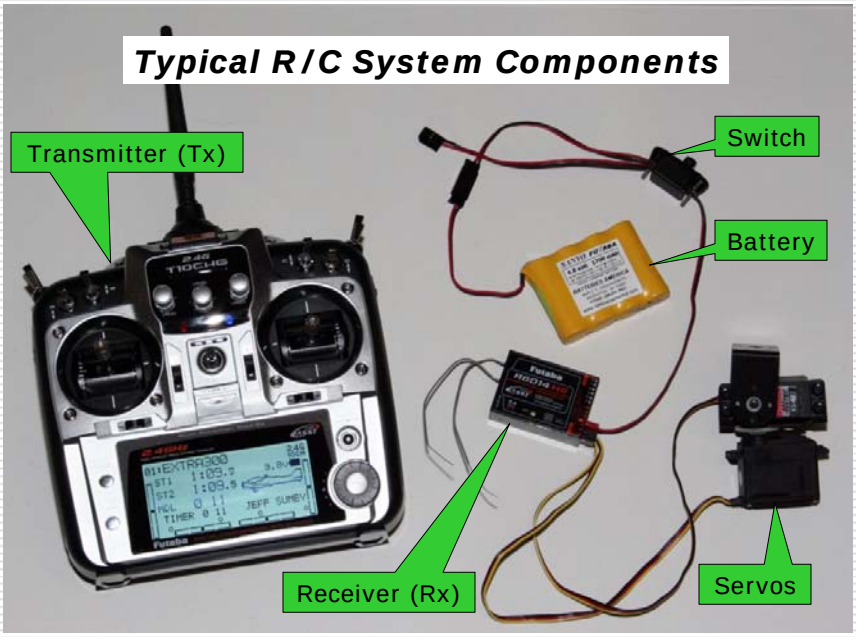
- Jeffrey S. Sumey
  - Assoc. Prof. in Dept. of Applied Engineering & Technology
  - EET, CET, CSC
  - faculty coordinator for new A.S. Robotics Engineering Technology (RET) program (2009)
  - avid R/C enthusiast of over 35 years

Workshop Overview

- R/C components & operation
- RF links – technologies & comparisons
- Servo / controller operation
- R/C channels & functions
- Transmitter features
- Programmable features
- R/C @ CalU

R/C System Components

- Transmitter
- Receiver
- Servos / Motors
- Motor Controllers
- Power Sources
- Miscellaneous



California University of PA / NCRETE *Robotics@CalU*

Transmitter

- interface between operator/pilot and wireless communication link
- "computer" radios
- provides up to 14 separate channels for various functions
- some proportional, some non
- typically come from hobby industry
- ex: Airtronics, Futaba, JR/Spektrum

California University of PA / NCRETE *Robotics@CalU*

Transmitter Orientation

California University of PA / NCRETE *Robotics@CalU*

Receiver

- interface between wireless link and actuators
- decodes received signal and demultiplexes pilot commands to separate channel outputs

California University of PA / NCRETE *Robotics@CalU*

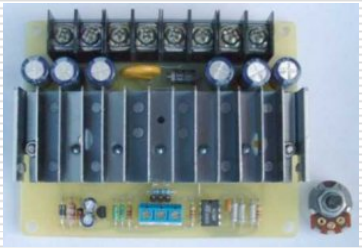
Servos / Motors

- converts pilot command from receiver channel to physical output, i.e. mechanical motion
- **servos**: typically provide rotational output
- **motors**: provide high torque and/or speed for propulsion
- brushed vs. brushless
- analog vs. digital

California University of PA / NCRETE *Robotics@CalU*

Motor Controllers

- a.k.a. Electronic Speed Controller (ESC)
- provides variable motor control (RPM) via power modulation as controlled by pilot
- brushed vs. brushless



California University of PA / NCRETE *Robotics@CalU*

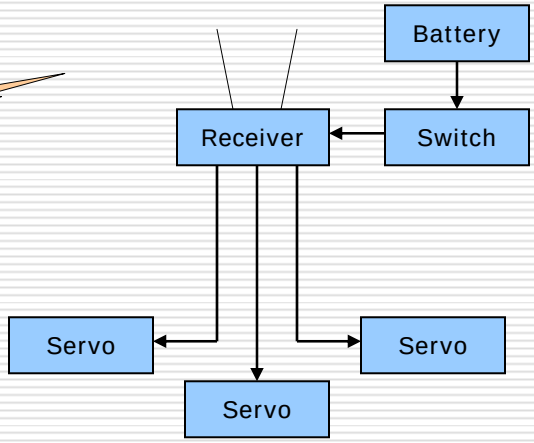
Power Sources

- typically on-board rechargeable battery for both transmitter and remote platform
- various chemistry / characteristic options
  - NiCad / NiMH
  - lead acid / gel cell
  - LiIon / LiPo (not for BotsIQ) / LiFe

Miscellaneous

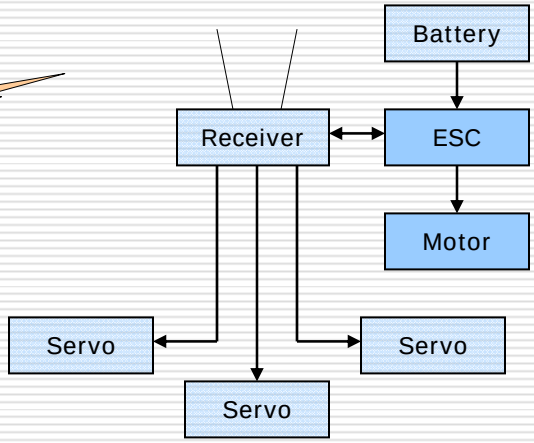
- chargers
- switches
- servo extensions
- transport cases

R/C System Operation - 1



California University of PA / NCRETE *Robotics@CalU*

R/C System Operation - 2



California University of PA / NCRETE *Robotics@CalU*

R/F Links

- 72/75 MHz
  - AM/FM/PPM/PCM
  - crystal-based
  - channels 11-60 (72MHz) for **Air**
  - channels 61-90 (75MHz) for **Surface**
  - some recent systems added freq. synthesis
  - more vulnerable to interference
  - vulnerable to "shoot downs"
- 2.4 GHz
  - spread spectrum (SS)
  - no crystals
  - digital, packet-based system
  - less vulnerable to interference
  - Rx **binds** to Tx
  - impervious to "shoot downs"

California University of PA / NCRETE *Robotics@CalU*

"Binding"

- act of associating a given Rx to a particular Tx
  - only that Tx can control the Rx
  - 100% effective at preventing "shoot downs"
- procedure is specific to manufacturer
  - JR/Spektrum uses a **bind plug**
  - Futuba uses an "**EasyLink**" button on Rx

California University of PA / NCRETE *Robotics@CalU*

Servo operation

- motor is controlled by a circuit using feedback of motor's position
- circuit uses **pulse width** from Rx for "desired position"
  - 1~2ms positive pulse
  - 1.5ms = "center"
  - sent from Rx @ 20-70Hz

California University of PA / NCRETE *Robotics@CalU*

Pulse Width Modulation (PWM)

Fail Safe

- what happens if Tx or RF link fails?
  - what should Rx do with servo outputs???
    a) stay at last known position
    b) go to predetermined setpoint
- FailSafe addresses this scenario!
- implemented differently by different manufacturers
  - Futaba: F/S menu
  - JR/Spektrum: bind procedure

Futaba Fail Safe Menu

JR/Spektrum Fail Safe

- AR7xxx, JR9xx (DSM2)receivers feature both SmartSafe™ and Preset Failsafe
  - SmartSafe drives throttle to low and *maintains last command* to all other channels
    - **not appropriate!**
- Preset failsafe stores Tx stick/switch settings during binding for use during failsafe condition
  - procedure is different from manual!
- BR6000 Rx (DSM1) has Preset Failsafe only

California University of PA / NCRETE *Robotics@CalU*

JR/Spektrum **Preset** Failsafe

1. connect bind plug to Rx.
2. power up Rx, wait for blinking LED
3. disconnect bind plug
4. set all Tx sticks/switches as desired
5. power up Tx while holding Bind button
6. wait for LED to indicate bind complete
7. cycle all power and test!

California University of PA / NCRETE *Robotics@CalU*

Servo connection

- 3-pin connection
  - power (4.8~6V), Ground, Signal
  - various standards are used

Func.	Futaba	JR	Hitec
Sig	White	Orange	Yellow
V+	Red	Red	Red
GND	Black	Brown	Black

California University of PA / NCRETE *Robotics@CalU*

R/C Channels & Functions

- *what do I hook to which channel?*
- most manufacturers assign fixed channels to particular functions
  - i.e. sticks, switches, dials
  - some radios are user programmable
- certain Tx functions only apply to certain channels
  - (need to know some flight control terminology)

California University of PA / NCRETE *Robotics@CalU*

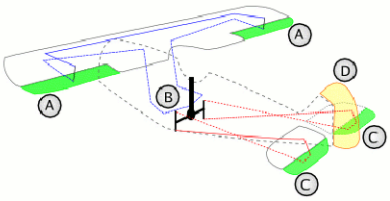
Aircraft Flight Control Dynamics

Flight Control Surfaces

A = **Ailerons**
- controls roll axis
- i.e. “bank”

C = **Elevators**
- controls pitch axis
- i.e. altitude

D = **Rudder**
- controls yaw axis
- i.e. heading



Other Functions

- Throttle
  - thrust
- Gear (landing)
  - up / down
- Flaps
  - deployed / not

California University of PA / NCRETE *Robotics@CalU*

R/C Channel Assignments

Channel	Futaba	JR / Spektrum
1	Aileron	Throttle
2	Elevator	Aileron
3	Throttle	Elevator
4	Rudder	Rudder
5	Gear / Ail2	Gear
6	Spare / Flap	Aux1 / Flap
7	Spare / Ail2	Aux2
8	Spare / Ele2	

California University of PA / NCRETE *Robotics@CalU*

Transmitter Features

- stick centering – internal springs
- throttle ratchet
- stick tension & length
- trims
  - allow fine adjustment of centering
  - electronic vs. manual sliders
- auxiliary functions
  - switches – 2 or 3 positions
  - dials - continuous

California University of PA / NCRETE *Robotics@CalU*

Programmable Features

- computers are programmable, right?
- computer radios are programmable!
  - you can use radio programmability for your *secret advantages*!

California University of PA / NCRETE *Robotics@CalU*

Programmable Features

- **model memory**
  - radios support multiple model memories
  - Futaba 10C: 15 (expandable via CamPac)
  - JR 9303: 30
  - Spectrum DX7: 20
- battlebot uses:
  - backup programs
  - different driver/pilots
  - application modes: practice, competition

California University of PA / NCRETE *Robotics@CalU*

Programmable Features

- **channel mixing**
  - aircraft: 1 stick controls 2 aileron servos on 2 separate channels → *flaperons*
  - also: elevons, ailevators, rudder → aileron
- battlebot uses:
  - weapon → propulsion override (battery consideration)
  - tank vs. arcade mode!

California University of PA / NCRETE *Robotics@CalU*

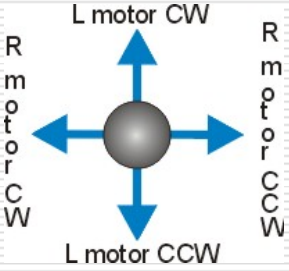
Bot Control Methods

- ***tank*** mode
  - left/right tx. sticks (vertical only) control left/right drive motors respectively
    - using throttle & elevator channels
  - easy setup
  - ratchet/no spring on throttle stick
    - not so good for robot motor control
- ***arcade*** / joystick mode
  - use both axes of right stick only
  - more intuitive control, but trickier to program
    - because motors typically face apart

California University of PA / NCRETE *Robotics@CalU*

Arcade Mode Guru Setup

- straight arcade mode requires motion commands be entered with 45° offset
  - ☹

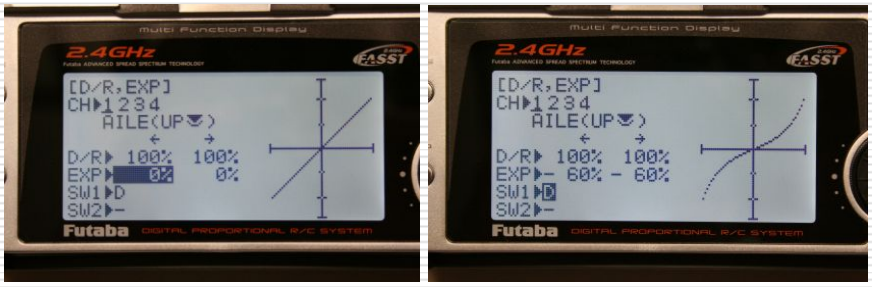


- use of ***delta-wing mixing*** (DX7) function solves this problem!
  - 2 channels (aileron & elevator) are used in coupled fashion; vis: delta wings
  - Futaba calls this ***elevons***

California University of PA / NCRETE *Robotics@CalU*

Programmable Features

- **exponential**
  - used to “soften” pilot inputs near center stick → adds low speed precision!



Programmable Features

- **flight modes**
  - aircraft: pattern vs. aerobatic mode
  - helicopter: normal, idle-up, autorotation
- battlebot uses:
  - steering sensitivity vs. weapon deployment

Other Programmable Functions

- model type – airplane or heli
- wing type – flaperon, V-tail, or delta
- servo reversing – normal or reverse for each channel
- sub-trim – precise servo centering adjustments
- travel adjustment – controls maximum servo deflection
- dual rates – switch-selectable throw volume
- dedicated mixes – as defined by model type
- programmable mixes – user-defined mixing from master channel to slave channel

California University of PA / NCRETE *Robotics@CalU*

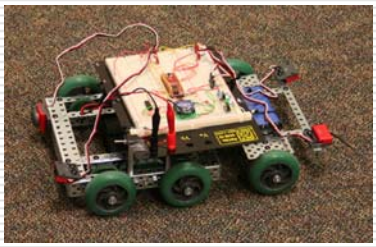
Robotic Applications

- *servo reversing* – to get the motors going in right directions for given commands
- *offset / trim* – to eliminate motor movement at center stick on tx.
- *travel adjustment* – to eliminate veering and get the tracking straight
  - this compensates for unmatched motors and/or motor controllers
- *exponential* – to "soften" small stick control inputs near neutral

California University of PA / NCRETE *Robotics@CalU*

R/C Applications & CalU

- senior projects



- R/C club – launched Sep. 2009

References

- http://www.easyrc.com (Tower Hobbies)
- Battery University: http://batteryuniversity.com
- Airtronics: http://www.airtronics.net
- Futaba: http://futabarc.com
- JR: http://www.jrradios.com
- Spectrum: http://www.spektrumrc.com
- SWPA BotsIQ: http://www.botsiqpa.org (home of BotsIQ Wiki)

Additional Contact Info

- NCRETE:

  Mr. Mike Amrhein
  amrhein@calu.edu

- Robotics Engineering Technology:

  Prof. Jeff Sumey
  sumey@calu.edu

California University of PA / NCRETE *Robotics@CalU*