Methods of moving robots

Motion Control in FRC

BC Spear
CP Robodogs 2171

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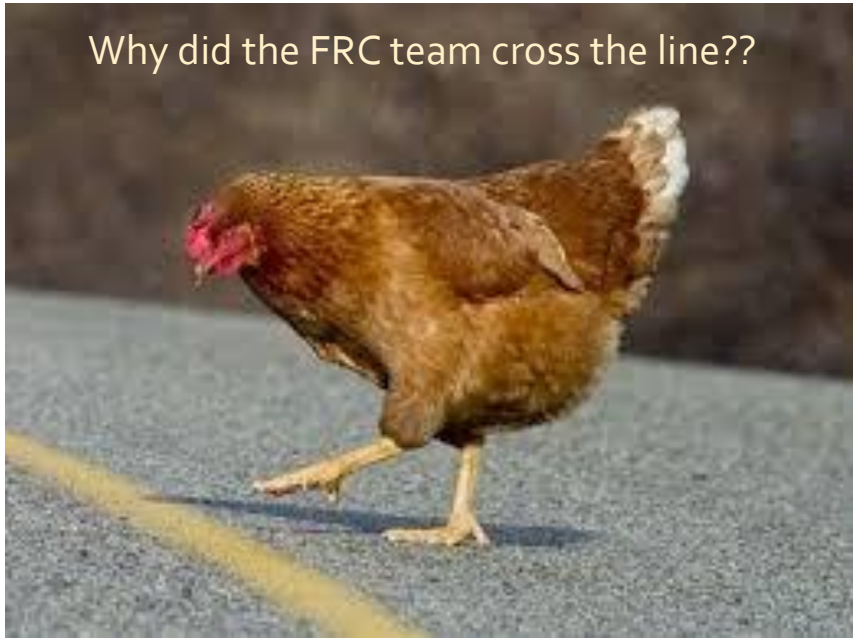
Why automate motion?

- Repeatability
- Allow Driver to concentrate on other things
- For Points in Autonomous



Methods

- Dead Reckoning
- Bang-bang or Deadband Control
- PID
- Motion Profiles

Dead Reckoning

- Turn motor on for X seconds
- Slower speed is better
- Simple
- Works if accuracy and precision are not an issue.

Deadband Control

- Same as Dead Reckoning except with feedback
- Drive if error > zero

```
while (true) {
  error = setpt – pv;
  if (error > 0)
    Forward(1.0);
  else if (error < 0)
    Reverse(1.0);
  else
    Stop();
}
```

- Again, accuracy and precision are weak

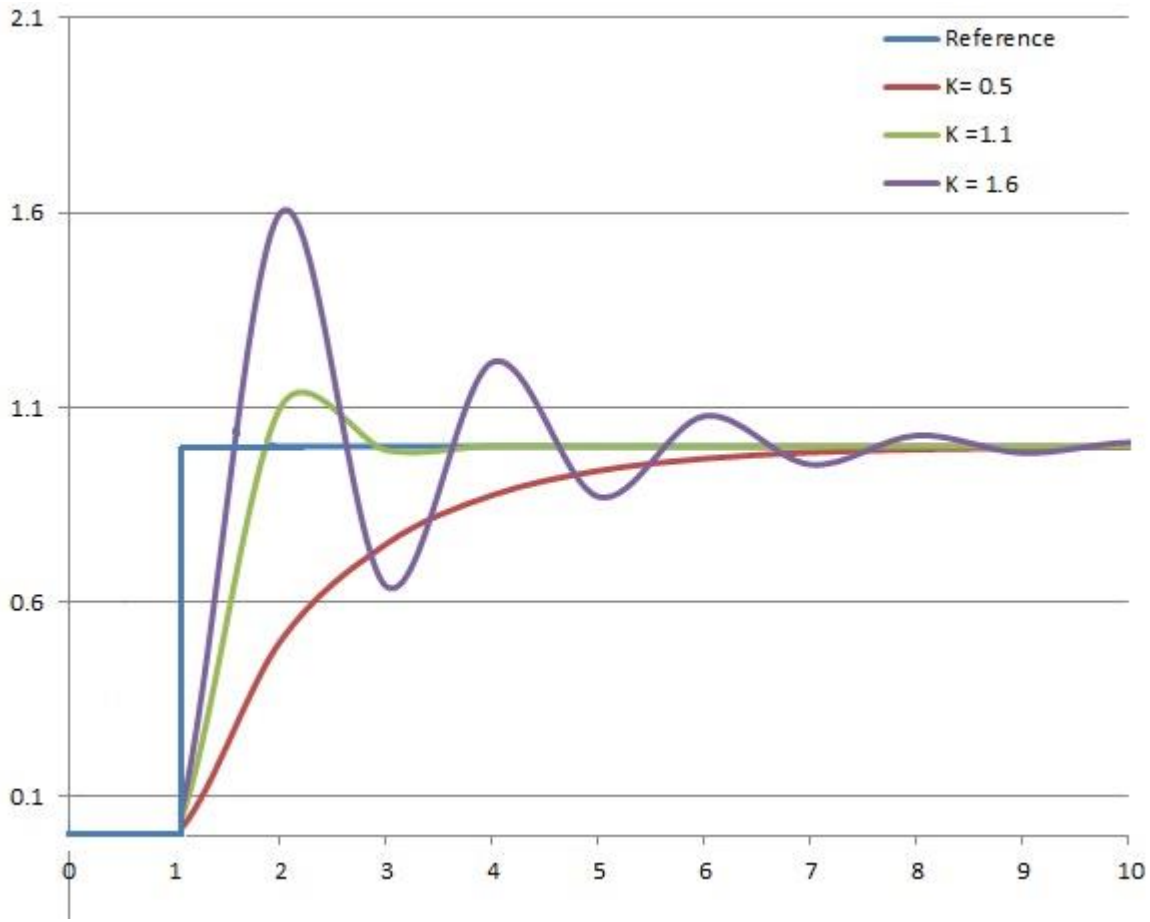
PID Control

- Most common control algorithm
- Based on Error (Target - Position)
- Output change is determined by time, error, and tuning constants

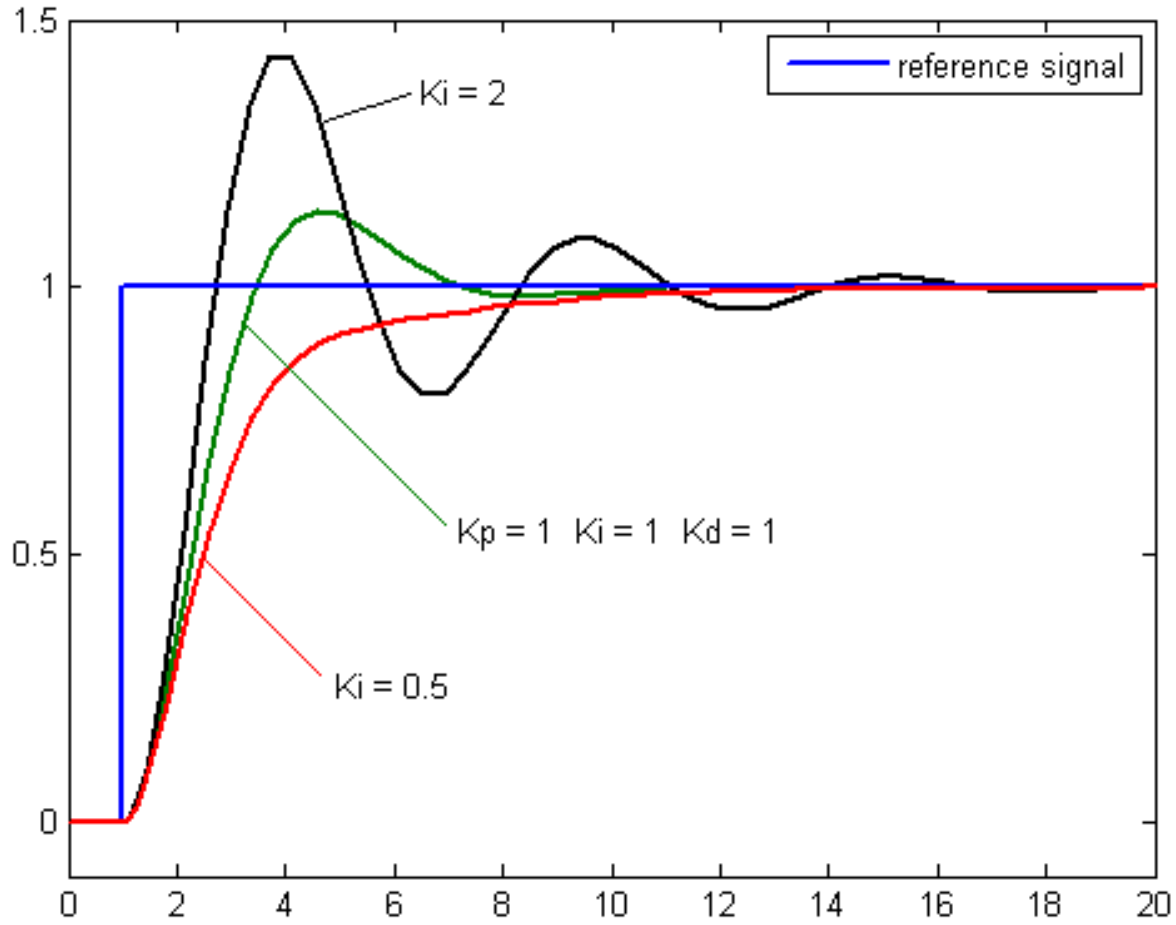
$$u(t) = K_p e(t) + K_i \int_0^t e(t)dt + K_d \frac{d}{dt} e(t)$$

Proportional Integral Derivative

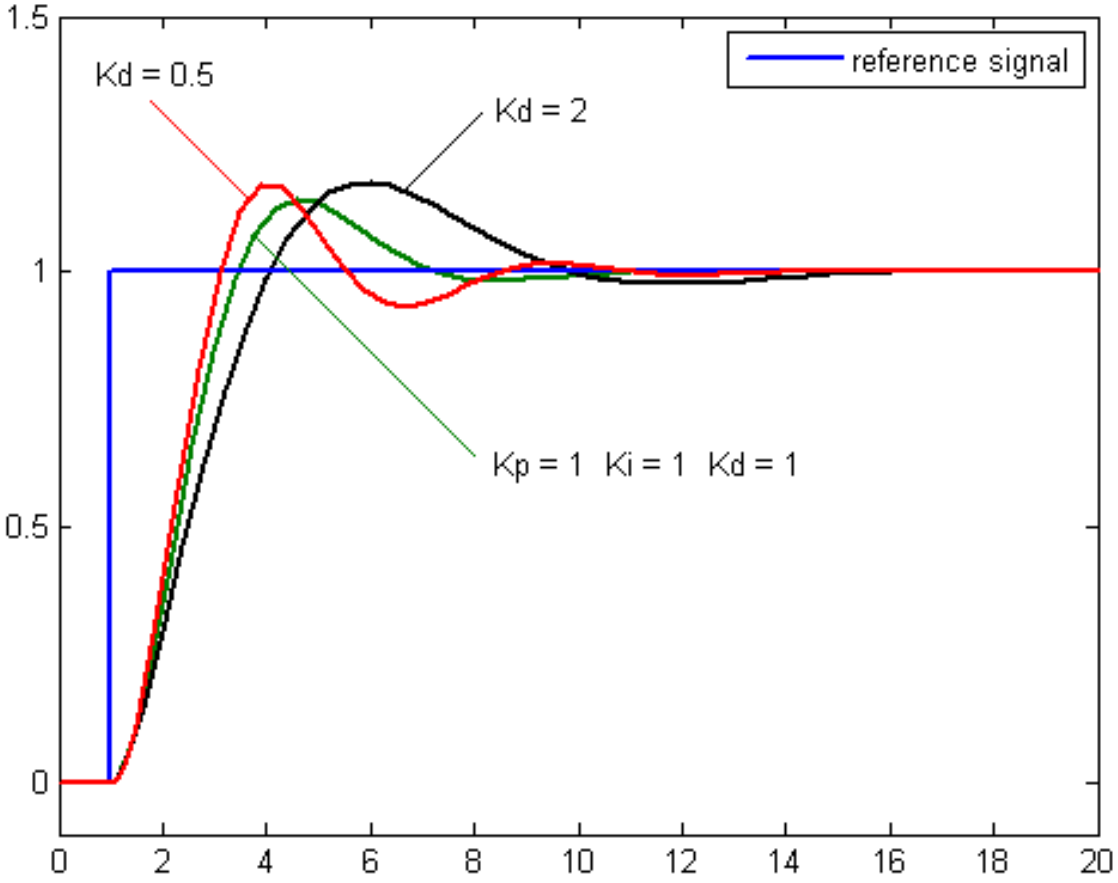
PID Control - Proportional



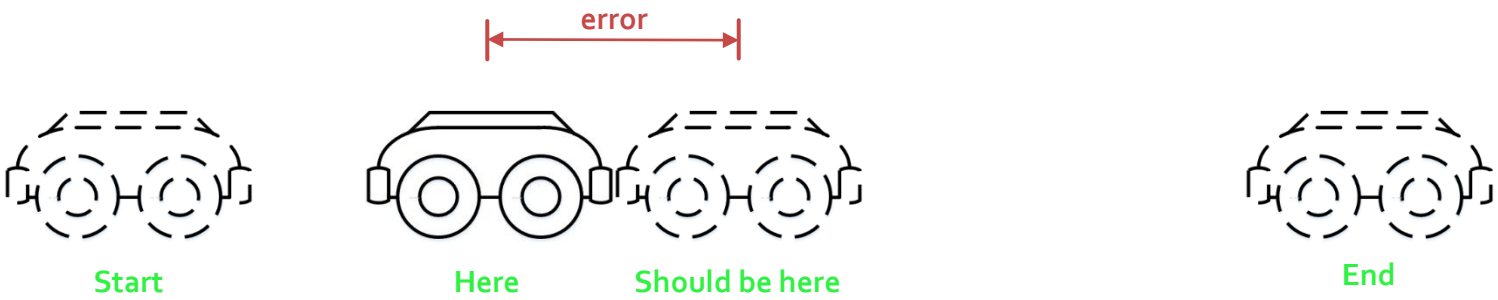
PID Control - Integral



PID - Derivative



Feedforward/Feedback

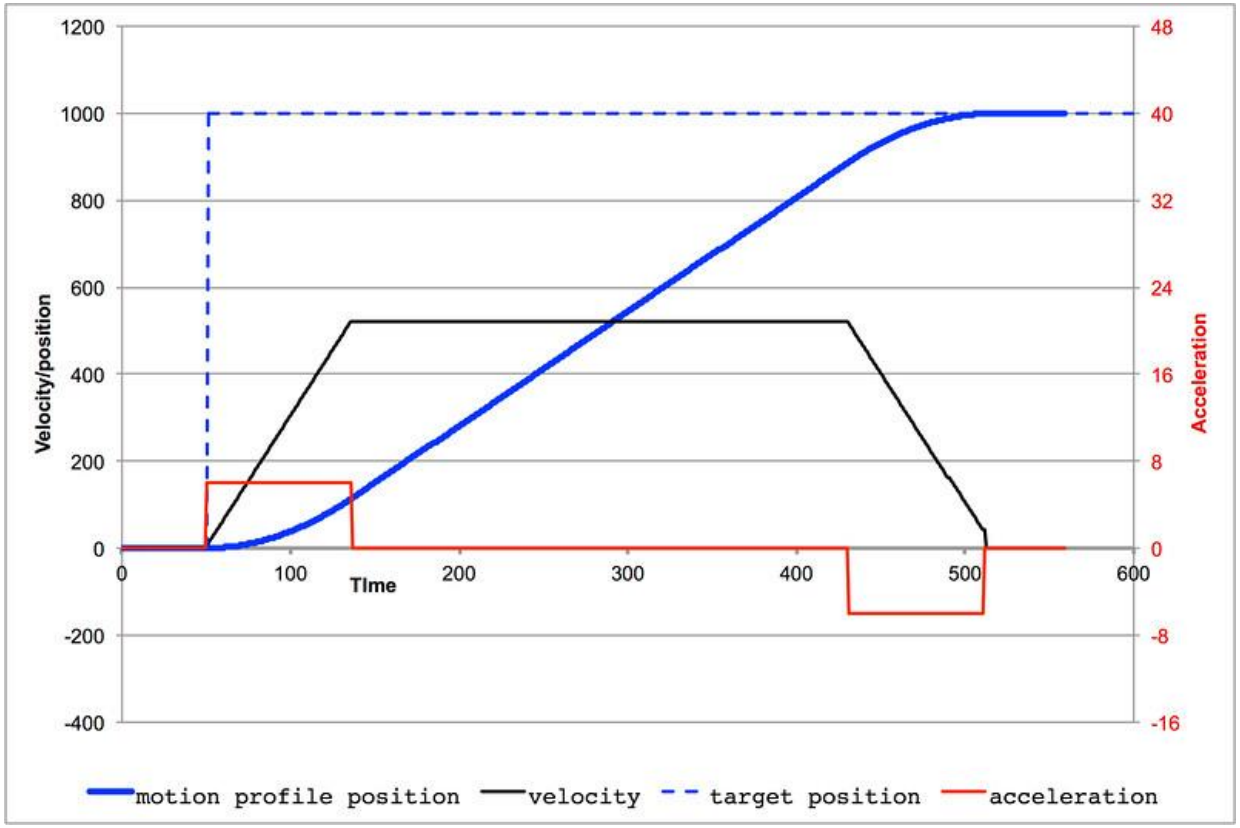


- Feedforward is where you plan to be
- Feedback is correction of the error from where you are to where you should be
- Feedback requires sensors to determine position

Motion Profiles

- Start at zero velocity
- Accelerate to a maximum
- Travel required distance
- Accelerate to a stop

Motion Profile



- Trapezoidal velocity profile

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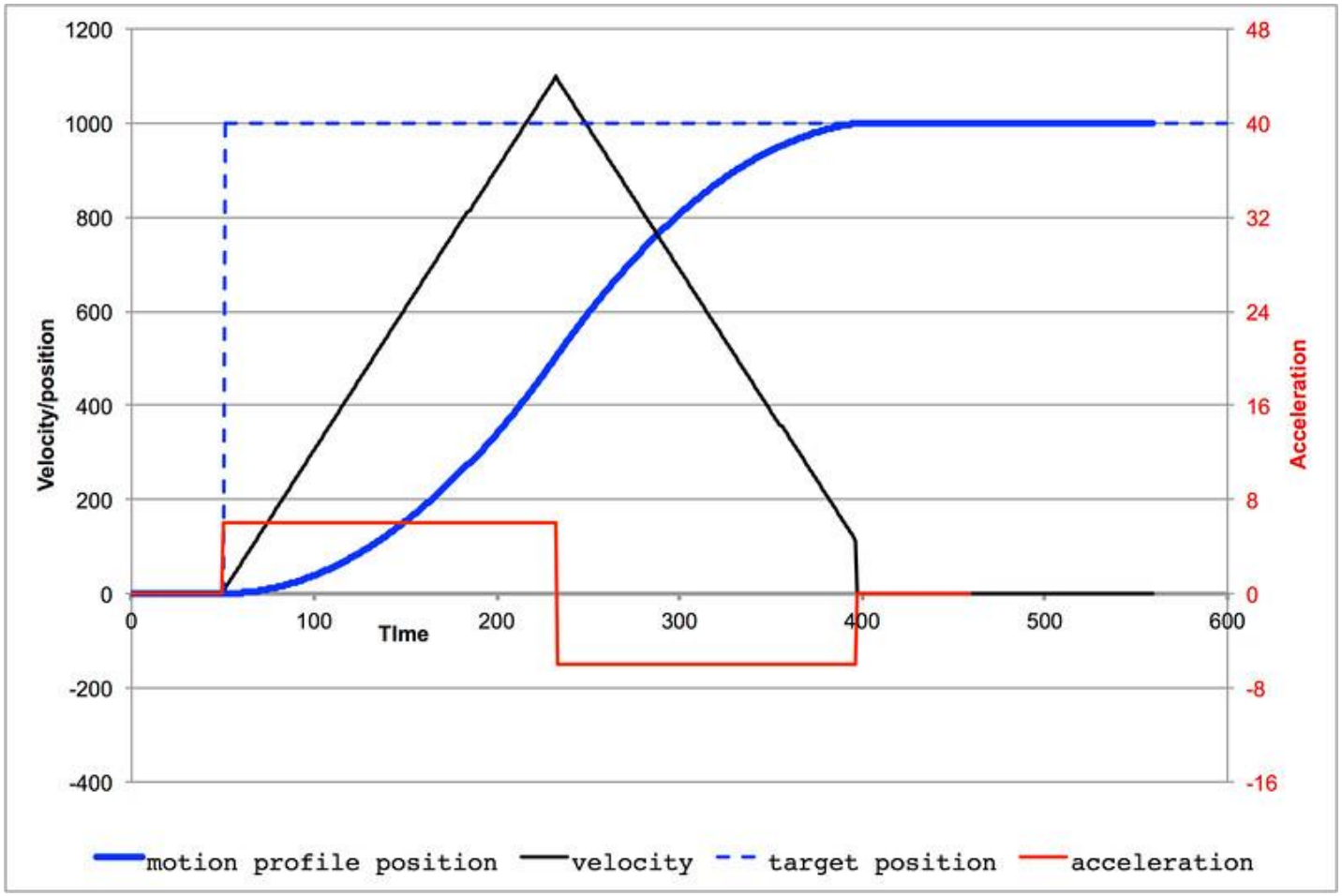
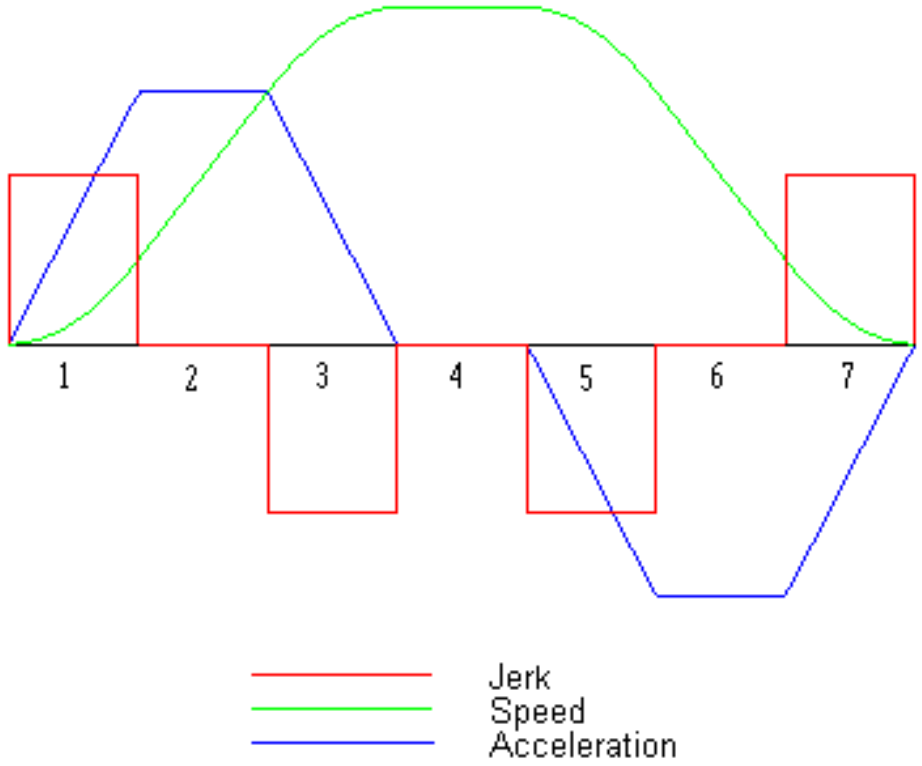
Motion Profile



Motion Profile

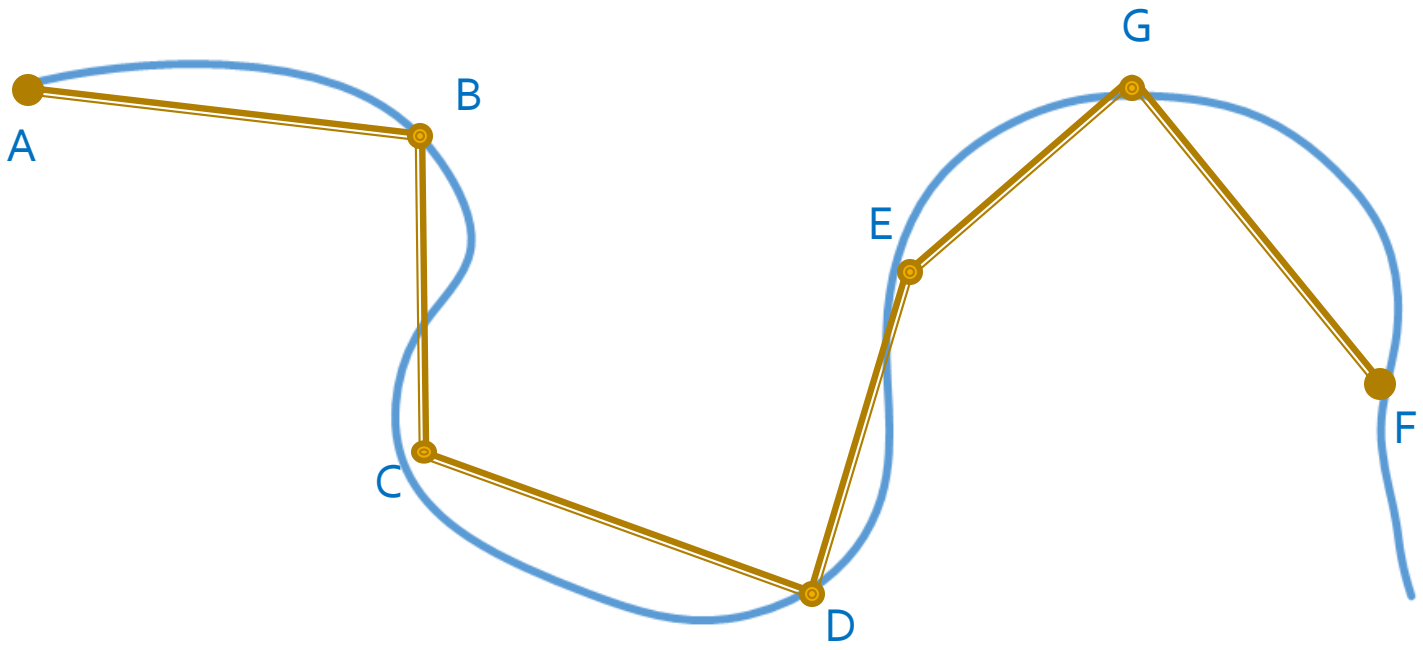


- S-curve velocity profile

Setting up for Motion Profile

- Determine the start and end point.
- Determine the path

What about two dimensions?



Determining Path

- What is the sequence of movements or positions the robot will move through between start and end?
- The 1D case is usually easy
- The 2D case can be a little more challenging

Simple Path Planning

- Connect the dots – lots of way to do it.
- Curve fitting
  - Cubic splines
  - Quintic splines
- Code for determining path:
  - Team 236 Autonomous Planner

2D Hermite Spline fitting

- Cubic and Quintic
- Team 254 Presentation
- Presentation Video
- Chief Delphi Forums

Setting up for Motion Profile

- Determine the start and end point.
- Determine the path
- Find the maximum velocities

Maximum Velocity

- How fast can (should) we go?
  - Get there as fast as possible
  - Good Control means obeying limits
- Find your maximum constant velocity
- Distance to get to top speed
- Distance to stop

Maximum Velocity

- Back to basics
- Kinematic equations to determine limits
- Conservative to start or use tuning factor (good for early build)
- Track information using sensors and logging

$$v_f = v_o + at$$
$$x_f = x_o + v_o t + \tfrac{1}{2}at^2$$
$$v_f^2 = v_o^2 + 2a(x_f - x_o)$$
$$x_f = x_o + \tfrac{1}{2}(v_f + v_o)t$$

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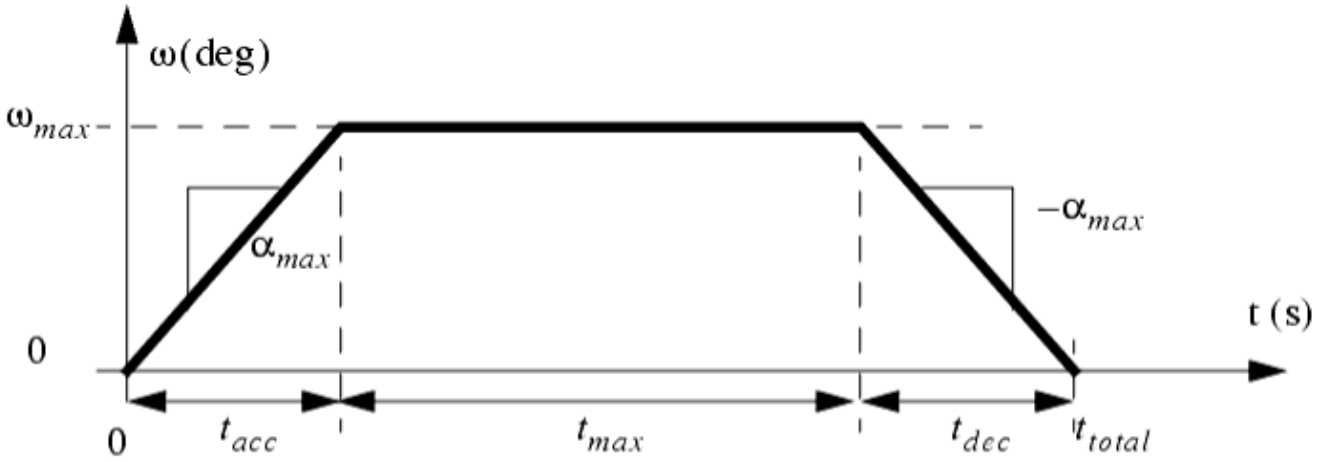
Maximum Velocity



where,

ω_{max} = *the maximum velocity*

α_{max} = *the maximum acceleration*

t_{acc}, t_{dec} = *the acceleration and deceleration times*

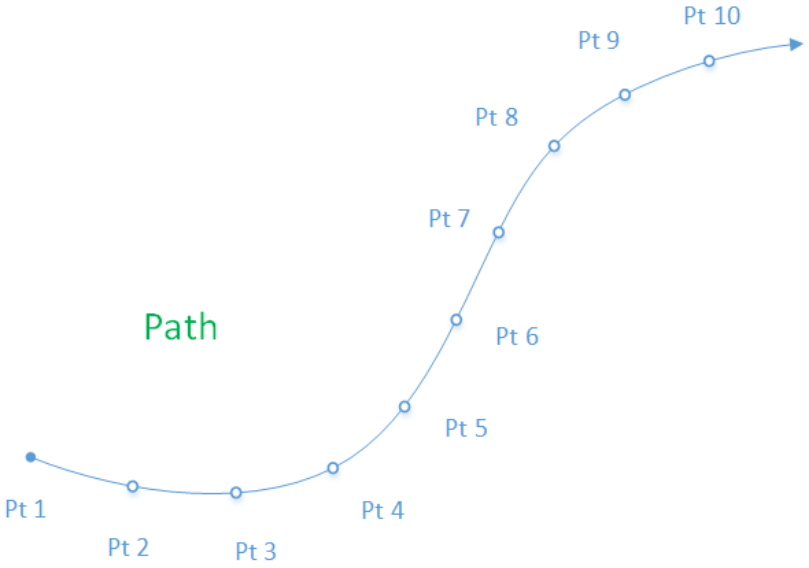
t_{max} = *the times at the maximum velocity*

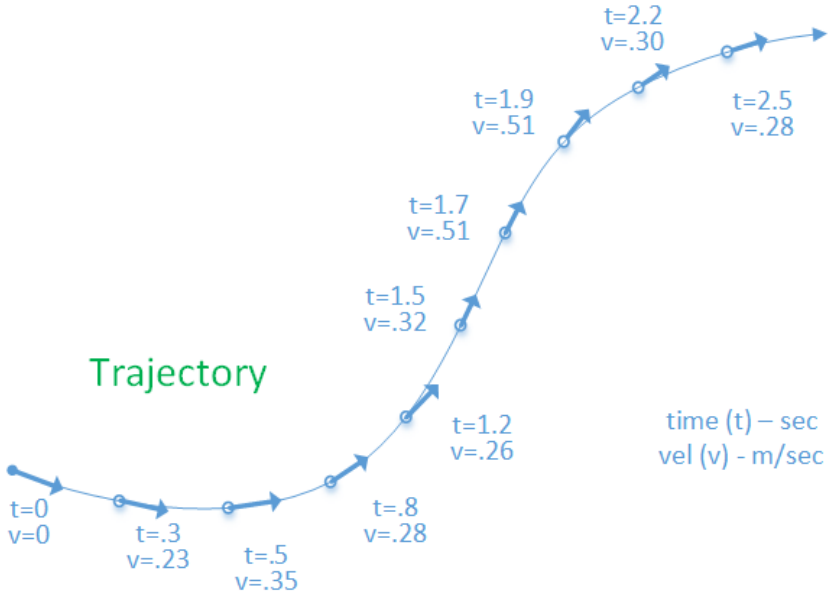
t_{total} = *the total motion time*

Setting up for Motion Profile

- Determine the start and end point.
- Determine the path
- Find the maximum velocities
- Develop a Trajectory

Path vs Trajectory





- Path is just how we get there
- Trajectory includes time and velocity

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Setting up for Motion Profile

- Determine the start and end point.
- Determine the path
- Find the maximum velocities
- Develop a Trajectory
- Follow the Trajectory

Following the Trajectory

- TalonSRX provides motion profile
  - Firmware version 2.0
- Excel spreadsheet to create profile
  - CTR Link
- Uses CAN bus to load profile points
  - Holds 128 trajectory points
  - Loads more while executing
- Recommend feedback signal

More Information

- Good white paper – Team 900
  - http://team900.org
  - Paper
- BC Spear
  - bc@engineer.com