Optimal Driveline Robot Base

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Abstract

Our team has decided that there is currently a need for a driveline system that is capable of performing a zero radius turn and being maneuverable at low speeds while also maintaining traction, stability, and energy efficiency at high speeds. We designed and prototyped a modified Ackermann steering system driven by a single motor, with an extended range of motion. This driveline system will also incorporate all wheels driven in all conditions. The steering system was integrated into a robot chassis that meets FIRST Robotics Competition requirements.

Project Goals

Primary Goals
- High speed stability
  - At least 10 feet per second speed
  - Maintain 4 foot lane driving a 10 foot radius circle
  - Complete a performance course faster than traditional FRC 190 robot
- Low speed maneuverability
  - Capable of zero radius turning

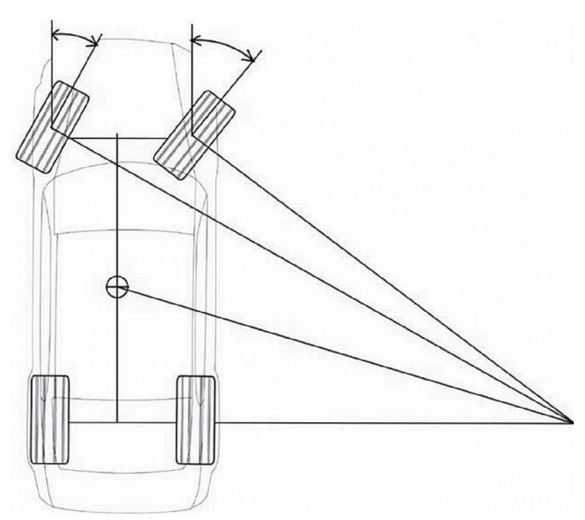
General Goals
- Maximize traction at low speed operation
- Minimize skidding while turning
- Comply with all 2013 FRC design rules
  - 112” perimeter, fit in a 54” cylinder
  - 120lbs without 13lbs FRC battery
  - Number/Type of motors
- System will be as simple as possible
  - Limit degrees of freedom
  - Intuitive driver operation

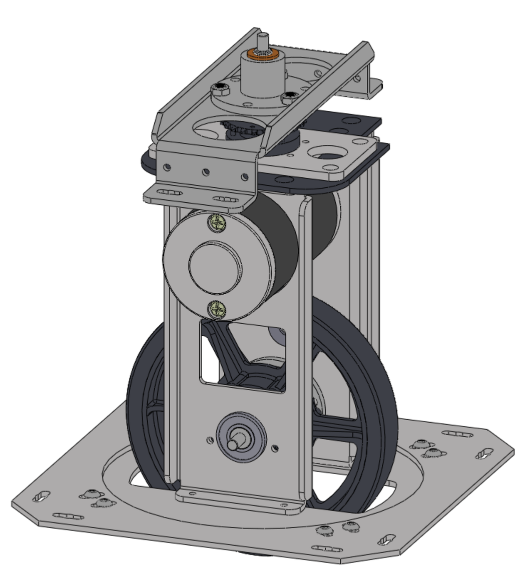
Existing Drivelines

Ackermann Steering
The front wheel angles are controlled simultaneously by a single mechanism. Wheel speeds must vary for different turning radii, which is done using differentials.

Pros
- High speed stability
- Mechanism easily designed for chassis size

Cons
- Limited turning radius
- Limited maneuverability


Ackermann steering geometry


Swerve module

Swerve Steering
Each wheel is both driven and steered independently of the others.
Pros
- Wide range of steer angles
- Capable of high and low speed maneuvers

Cons
- High complexity both mechanically and electronically
- Unintuitive user control

Tank Drive/Skid Steering
Steering controlled by fixed wheels on either side of chassis. Turning is controlled by wheel velocity.
Pros
- Simple implementation
- Zero radius turning is simple and intuitive when stopped

Cons
- Limited maneuverability while moving quickly
- Inefficient due to wheels skidding while turning


Tank drive chassis

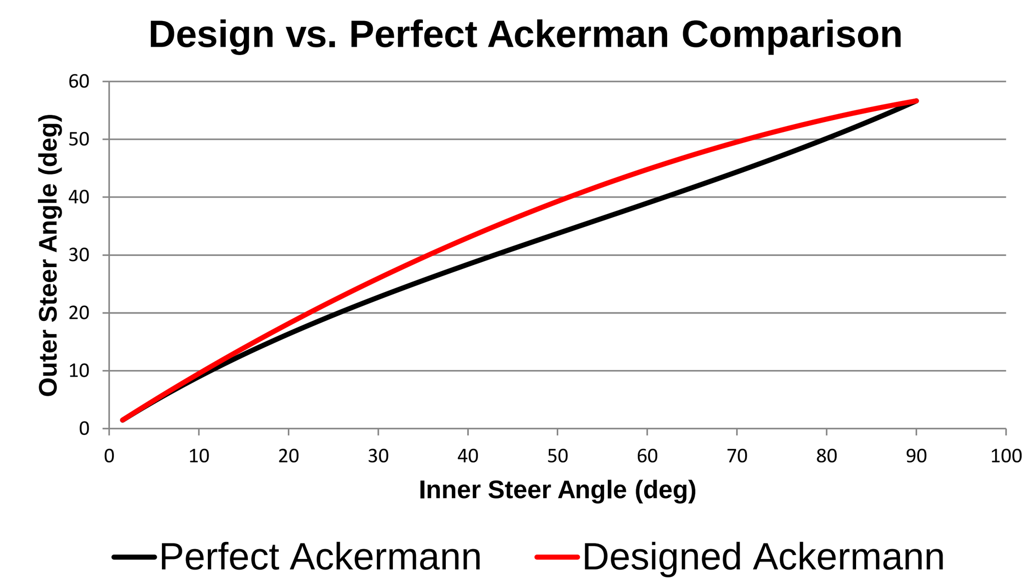
Design

Chassis and Wheel Modules
- Frame made from 1”, 1/8” thick steel angle bars.
- AndyMark Wild Swerve wheel module kits in front.

Steering Assembly
- Combined aspects of Ackermann steering and swerve drive, allowing for the stability and simplicity of Ackermann steering and the wide range of motion and maneuverability of swerve drive.
- A trapezoidal linkage system is optimized for a smaller steering range and then amplified using a 3:1 chain and sprocket assembly.
- The trapezoidal linkage is driven by a steering arm with a pin in slot connection. This allows for a single, high-torque motor to control all steering.

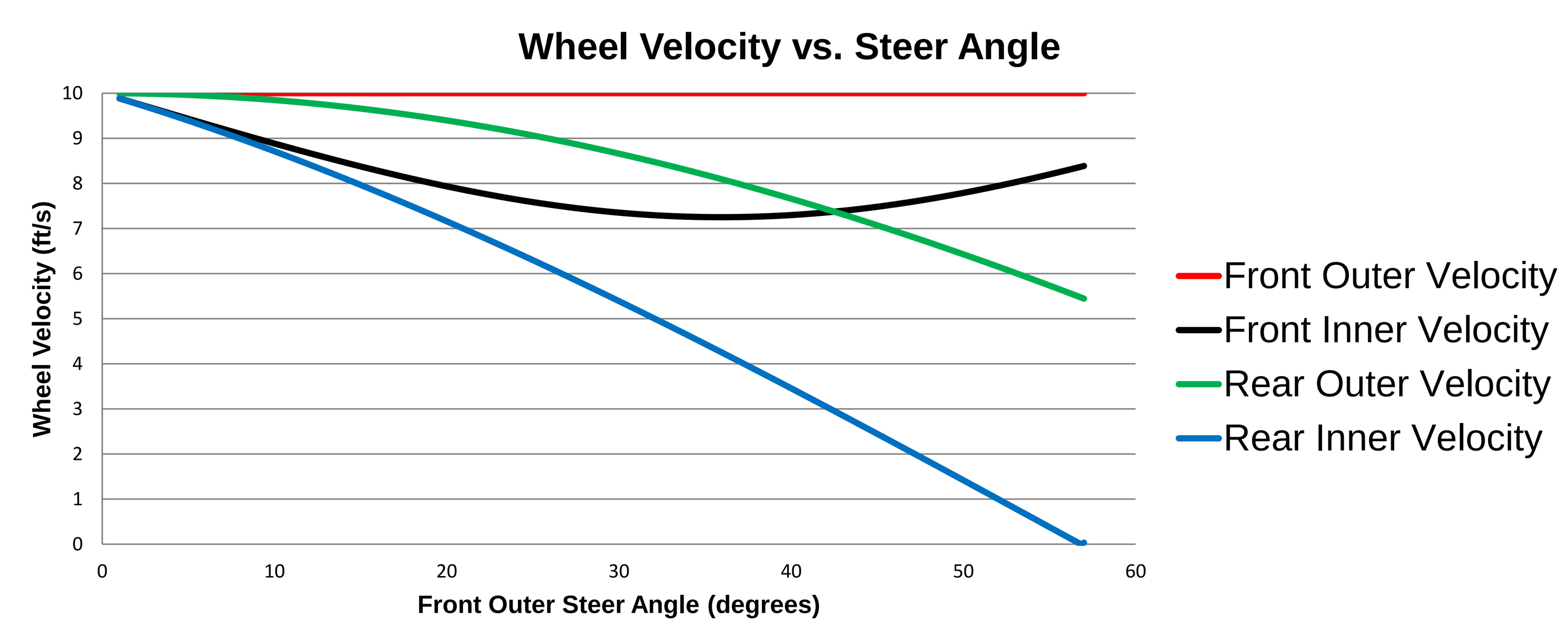
The figure to the right shows the relationship between true Ackermann steering and our steering mechanism.

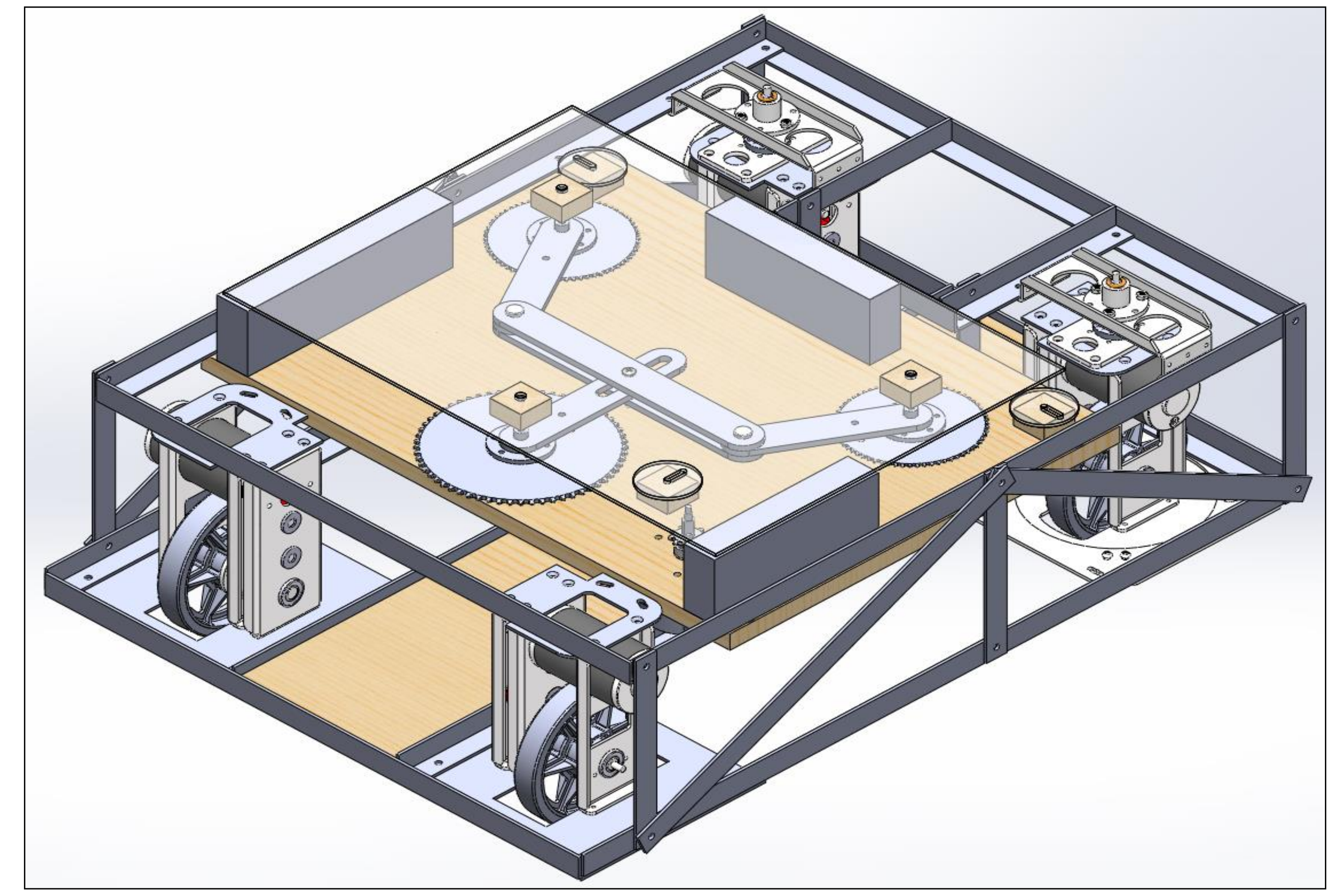
The average error is 3.9°



Electrical System
- Microcontroller: Arduino Mega 2560
- Wheels driven independently by CIM motors
  - 5310 free speed RPM, 21.5 lb·ft stall torque
- Steering mechanism driven by a Bosch Van Door motor
  - 48 free speed RPM, 360 lb·ft stall torque
- Powered by 12 Volt lead acid battery
- Turnigy Tx/Rx operating on 2.4GHz band
- 30 Amp fuse box for CIM motors, 20 Amp for Van Door motor, and 1 Amp for Arduino
- 300 degree potentiometer used to measure turns
- Two limit switches to stop turns at maximum range
- 5 Volt regulator used for Arduino Voltage In

Programming
- Programmed in Arduino development environment, in language based on C
- PID system used to control turning Van Door motor
- CIM motors driven using servo values, converted to PWM via Victor speed controllers
- Used case statements to calculate and send separate servo values to each wheel based upon equations for front outer steer angle





Results

- Capable of zero radius turning about either of the back wheels
- Vehicle can maintain circle at 10 ft/sec
- Performance test against typical tank drive FRC 190 robot
  - 9 test drivers- 6 were experienced with tank drive, 3 inexperienced
  - FRC 190 was 1.8% faster on average (without penalties)
  - 2.4x more obstacles hit with ODRB robot- indicates that fine control was a problem
  - ODRB was 4 times more energy efficient than FRC 190
  - Feedback from drivers: mechanical operation was great but controls were too sensitive