# Bender

## Robot for Executing Planned Physics Inspired Path Planner

Gabrielle Sampson
Camden Diskowski
Caleb Schauer
Tony Machuca
Neil Hoffman

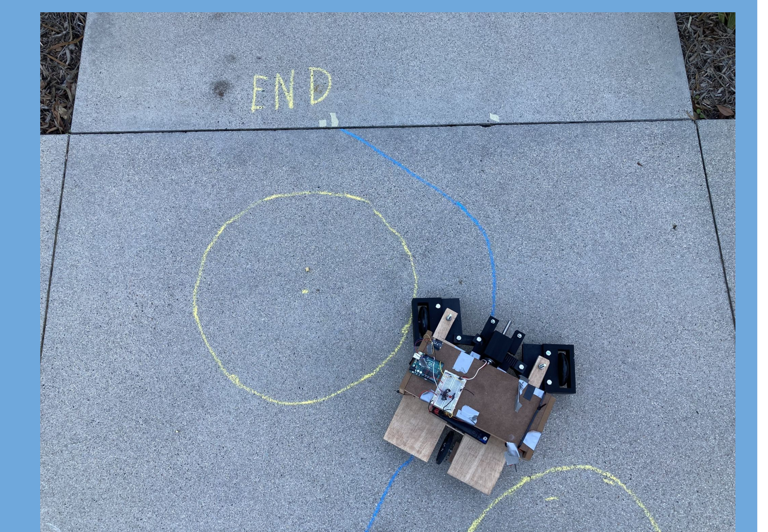
UCI Samueli School of Engineering

## INTRODUCTION / Executive Summary

The name "Bender" is inspired by the robot character from the Futurama TV show. Our robot navigates around circular obstacles, thus "bending" its path. The objective was based around a mission statement: we must create a robot capable of tracking a preplanned path around circular obstacles. It must be self contained, have 30 minutes of battery and stay within 10% error of the preplanned path. Outside of this mission statement, our design was open-ended. We choose the environment, size of the robot, as well as other parameters such as nominal operating velocity

## Robot Solution / Final Desing

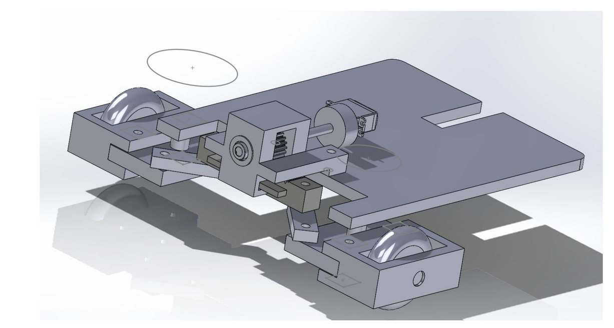
Our design solution is ~12" wide. three-wheeled robot running on an Arduino microcontroller. The front wheels use Ackerman steering, while the rear wheel is connected to a 12V DC motor for propulsion. Our robot's sensors are a magnetometer (electronic compass) and a rotary encoder. It uses these to obtain its heading and distance traveled. An accelerometer and gyroscope are included.. In a future iteration, this hardware could be programmed to further decrease error. Bender uses 3D printed Ackerman steering linkages for smoother turning characteristics; in a turn, the inner wheel turns more aggressively than the outside to eliminate slippage. Bender uses a single rear wheel propelled by a powerful 12-Volt, 5.5 Amp DC motor, which is calculated to achieve a peak velocity of 5.6 ft/s to complete the shortest path as quickly as possible.




Our hardware performed suboptimally. We did not have the time to revise parts that were 3d printed and thus the press fits were too tight. However, we were able to find a partial solution.
Overall, we did not meet the objectives but still learned

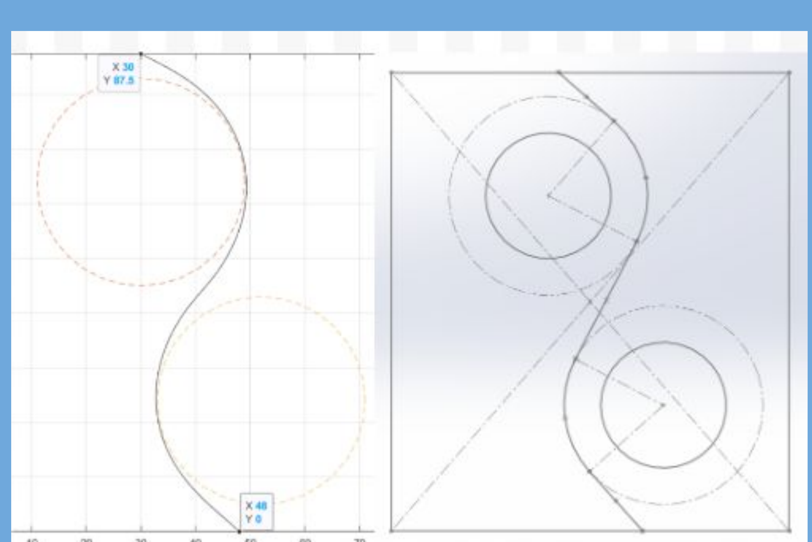
## INNOVATIONS IN DESIGN

- This design implement ackerman steering with a rack and pinion actuation. This powerful and accurate steering system directs Bender through the course
- A multitiered chassis to reduce magnetic interference with magnetometer, for more accurate heading readings and reduced control error.



## Environment

While Bender can theoretically process and execute any 2D path with circular obstacles, our chosen environment is an 87-½" x 76" concrete slab outside the Garbonzo restaurant on the southwest side of campus. It contains two 38" diameter "virtual" obstacles.



hysics-inspired pathplanner vs. path simplified for Arduino. There is 2.9% error between the paths.

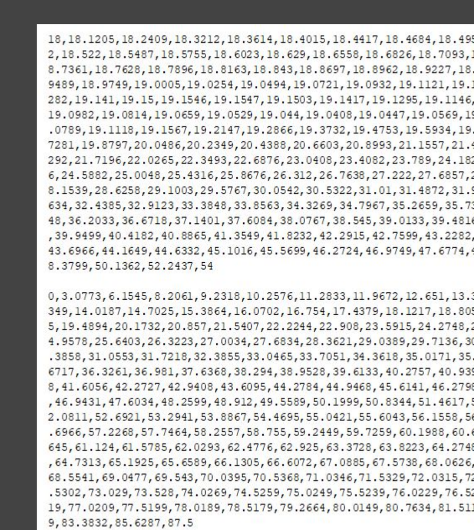
## Engineering Analysis

We followed the engineering design Process for this project.
There wree several proposed solutions, and we weighed the benefits and disadvantages of each one. Ultimately this is how we arrived to our existing solution
For example, a four wheel design would provide more stability but complicate encoder tracking needlessly

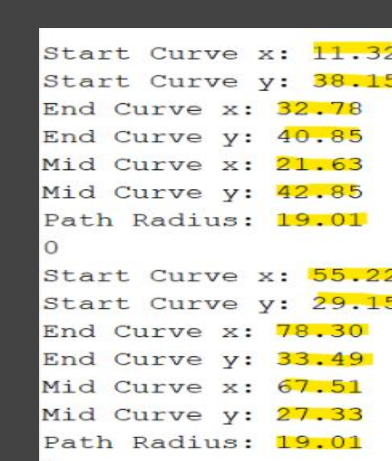
P

## Programming

UCI graduate students provide the path data using an innovative physics-inspired path planner. Our control system script simplifies the provided points into a series of straight lines and constant-radius curves, which can be translated into controls for Bender This solution fits well to the scope of the project while minimizing error.
The initialization process is largely automated. C++ requires that arrays have a defined size at runtime (no appending) so the user must manually input the number of obstacles, as well as paste in the data from a csv file



Code displaying readings for sensor and switch.



```
Start Curve x: 11.32
Start Curve y: 38.15
End Curve x: 32.78
End Curve y: 40.85
Mid Curve x: 21.63
Mid Curve y: 42.85
Path Radius: 19.01
0
Start Curve x: 55.22
Start Curve y: 29.15
End Curve x: 78.30
End Curve y: 33.49
Mid Curve x: 67.51
Mid Curve y: 27.33
Path Radius: 19.01
1
```

## RESULTS AND FUTURE WORK

The final product is a robot weighing approx. 2lbs with a max. velocity of 5.6ft/s, it includes a magnetometer (digital compass), a limit switch The course can be completed in >5 minutes. We hope to see a camera, ultrasonic sensor, and RaspberryPi for more expansive programming integrated with the design of the robot as well as a smaller model. With the inclusion of more time, our group is confident that this project will be an amazing feat!

## ACKNOWLEDGEMENTS

Sincere and utmost gratitude to The Henry Samueli School of Engineering, Donald Bren School of Information and Computer Science, and our sponsor Mohamed Shorbady. A special thanks should be awarded to each of the team members and the extraordinary staff for mentoring us and for providing a challenging space in order to grow academically and personally.