Control Award Submission #19953 Scrap Metal

Autonomous objectives

We knew that in this season's game, **auto compatibility** with alliance partners was going to be very important in order to obtain the heavily weighted randomization points. Owing to this, our autonomous programs are structured piecewise in order to be highly composable, with paths automatically regenerated based on our starting configuration.

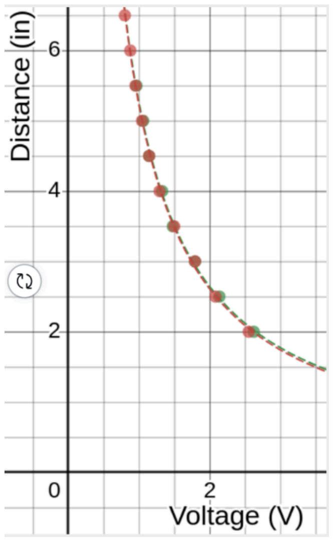
This enables us to quickly **adapt to our alliance partners** and easily restructure our autonomous based on our alliance partner's needs. We can complete both the purple and yellow pixel randomizations in any starting position, optionally score 1 more white pixel if starting on the audience side, and 2 more white pixels if starting on the backdrop side.

Sensors used

We used a total of **17 sensors** on our robot.

Accurate autonomous localization: 2 odometry encoders, 1 REV Control Hub IMU
Lift PID/control: 1 lift motor encoder
Lift encoder reset: 2 lift motor current sensors
Drivetrain characterization and robot profiling: 4 drive motor current sensors
Backdrop distance detection: 2 infrared analog voltage distance sensors
Outtake arm automation: 2 Axon Max+ servo analog encoders
Intake automation: 2 REV color sensors
Team prop detection: 1 camera

We **enhance our sensor data** through **increasing our loop frequency** and **regressing our sensor measurements**. In order to have well performing control algorithms, we need high loop frequencies for odometry accuracy and less feedback lag. We do this through avoiding hardware calls, like only performing hardware reads from other sensors when necessary and caching hardware writes. Through this, we improved our average loop frequencies from **30 hz** to **250 hz**. We were able to **double the aggression** of the gains were in our PIDF controllers and **got rid of multiple inches of drift** in our auto.



Additionally, our distance sensors output an analog voltage as an inverse of the distance measured. Instead of trusting the data given by the manufacturer, we plotted the received voltage to the corresponding actual distance for each individual sensor and created a regression on that data, and **getting rid of the 10% error** between them.

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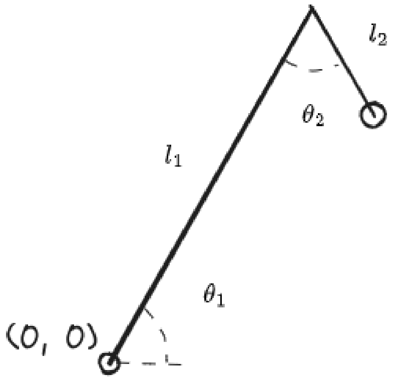
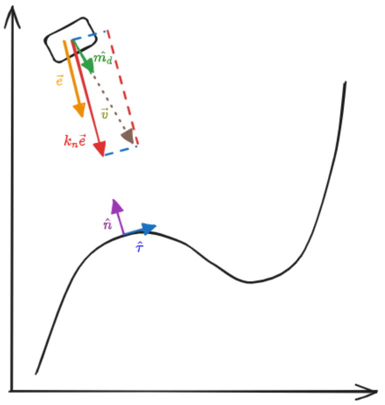
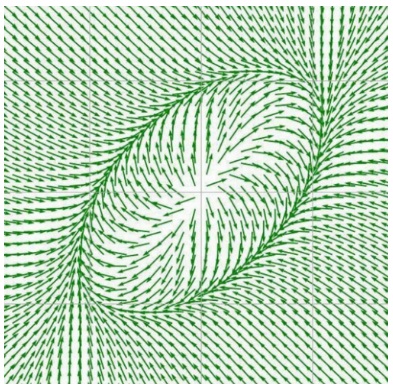
Key Algorithms



Inverse kinematics: Our scoring sequence is highly automated, which is detailed further below. One of the major parts of this is using inverse kinematics to automatically compensate for varying distances from the backdrop. We used trigonometry to derive equations to solve for the required lift extension and arm angle of our 2 degree of freedom outtake. This sped up our autonomous reliability and teleop cycle times, as the robot only needs to align within a 6 inch range from the backdrop and our drivers simply press one button to automatically bring our outtake to the scoring position pressed against the backdrop.



Guiding vector fields (GVF): This season, we developed our own custom path following system using an algorithm called a guiding vector field. This adds the unit tangent vector of the nearest point of the path to a weighted error vector in order to a produce a final vector that converges to the path. For paths, our system can take any parametric function, but we primarily use cubic Hermite splines (a form of Beziér spline) to achieve smooth movement and easy path creation. Because we developed our own system, we were able to exactly match our own specifications and requirements as opposed to using a pre-built library like Roadrunner.



Driver Controlled Enhancements

Both our intake and outtake sequences are heavily automated. The intake will automatically stop, lock the pixels, and send a rumble to both of our driver controllers when it detects that 2 pixels have been intaked through a pair of color sensors. Our desired scoring height is queued instead of manually controlled by the second driver. When the primary driver is ready, they hit one button to automatically align the angle of the robot to the backdrop via a heading PIDF controller, hit the button again to bring the outtake to the backdrop at the previously queued height and automatically compensate for forward/back error via the inverse kinematics, and finally hit it one more time to release the pixels. This system greatly reduces the cognitive load on our drivers and allows our cycle times to be much more smooth and efficient.

Engineering Portfolio References

Loop frequency + sensor regression: pg. 14
Inverse kinematics + GVF: pg. 15

Autonomous Program Diagrams

1. Score purple preload on spike marks
2. Score yellow preload on backdrop -> park