Control Award Sponsored by Arm Inc. Submission Form

Team # 3543	Team Name: Titan Robotics Club

Autonomous objectives:

Using our Choice Menu system, our single autonomous opmode implements 2 different autonomous strategies with many options that provide the most flexibility to compliment our alliance partner's autonomous (max score is **52 pts** for *Near Carousel With Duck* and **48 pts** for *Shuttle Back And Forth*)

- **Common to both autonomous strategies:**
  - Using vision to detect barcode level of TSE during init period and deliver preloaded freight to the correct level on the alliance shipping hub (**6 + 20 pts**)
  - At the end, park at either the alliance storage unit (**6 pts**) or warehouse (**10 pts**)
- **Near Carousel With Duck strategy:**
  - Spin carousel (**10 pts**)
  - Retrieve duck on the floor using vision and deliver to alliance shipping hub level 3 (**6 pts**)
- **Shuttle Back And Forth strategy:**
  - Cycling between the warehouse and alliance shipping hub delivering freight to level 3 with at least 2 cycles (**6 + 6 pts**)

Sensors used:

- **Web cam:** Use TensorFlow vision to recognize TSE, ducks, freights and cargos.
- **Encoders:** 3 for passive-wheel odometry (2 for Y and 1 for X axes), 1 for the arm angle
- **Limit switches:** 2 for arm (1 for lower limit and 1 for upper limit)
- **REV Color sensor:** 1 for intake (used as distance sensor to detect if intake has captured an object)

Key algorithms:

- **Auto Choice Menus:** Alliance - *Red* or *Blue*, Auto Strategies - *Near Carousel With Duck* or *Shuttle Back And Forth*, Start Delay - specifies delay start in seconds, Freight Delivery - *Yes* or *No*, Spin Carousel - *Yes* or *No*, Parking - *Alliance Storage Unit* or *Warehouse*
- **Pure Pursuit:** path following algorithm that follows a path by chasing a look-ahead point on the path
- **Odometry:** passive-wheel encoders and gyro accurately tracking the movement of the robot.
- **Localization:** integrating odometry movements to keep track of the robot's absolute field location.
- **Vision:** Using TensorFlow, our robot can recognize various game elements on the field and their locations. Our code applies smart filtering algorithms to differentiate the best candidate of the detected objects. We use this to find the carousel duck on the floor and differentiate it from the pile of ducks visible outside the perimeter.
- **Homography:** An OpenCV feature that maps the pixel coordinate on the camera screen to real world coordinate. This allows the robot to navigate itself to the detected object very accurately.
- **Stall Detection:** algorithm to detect motor stall (i.e. power has been applied to motor but no significant movement for a period of time). This is useful not only for motor safety (prevent burnout) but to detect PID stalled with steady state error.
- **PID Controlled Arm:** With lower limit switch to zero calibrate lowest limit, PID controlled arm can be controlled smoothly with gravity compensation to compensate for nonlinearity caused by gravity (trigonometry relationship). With PID control slowing down arm movement close to lower or upper limits.
- **Intake Auto-Assist:** Use REV color sensor to detect if an object is in the intake so that the software can automatically stop the intake and perform subsequent actions.
- **Priority LED Indicator:** User REV Blinkin to control a RGB LED strip for displaying robot status for different subsystems. Priority can be given to one subsystem over another so that the higher priority subsystem will determine LED state.
- **Digital Trigger:** A digital trigger monitors the state change of a digital sensor (e.g. limit switches) so that an action can be taken when the state changes (e.g. reset the encoder when zero calibrating the arm).
- **Analog Trigger:** An analog trigger monitors the reading of an analog sensor against a set of threshold values. If the sensor value crosses any of the threshold values, a notification is sent so that action can

be taken (e.g. Intake sensor detects an object has entered or exited).

- **Text To Speech:** By giving the robot the ability to speak, it can send status feedback to the drivers (e.g. Vision has found the TSE at what barcode position).
- **Smart Time Management:** Our autonomous code is aware of match elapsed time and knows how much time each operation may take to decide if we have enough time to do or skip a certain operation. For example, parking at the warehouse would score higher but will only do it if we have enough time to get there, otherwise, it will park at the Alliance Storage Unit instead.

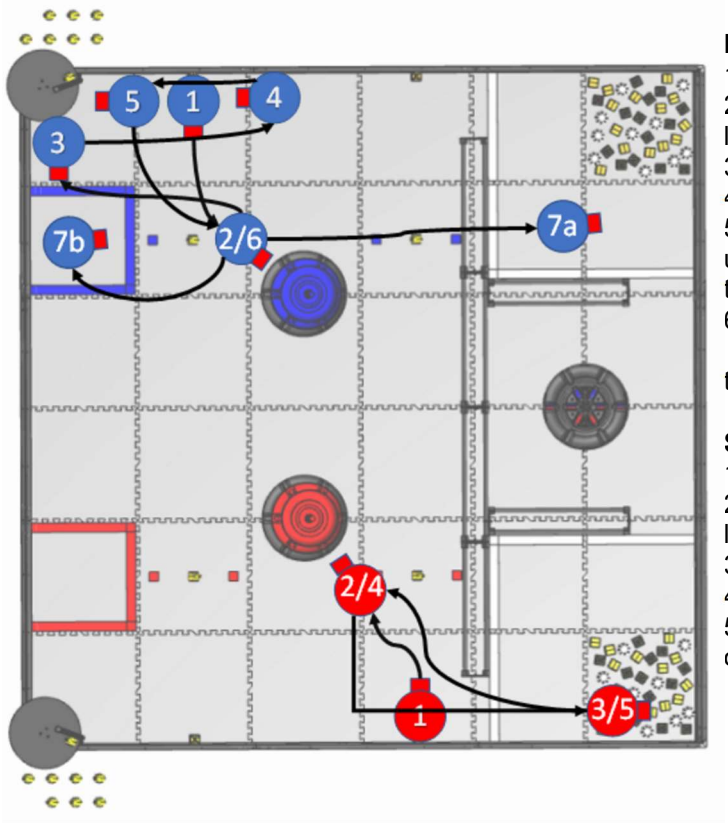
Driver controlled enhancements:

- Retractable passive odometry wheels allow the robot to go over barriers without damaging wheels.
- Gamepad mode allows inverted drive (i.e. robot front and back reversed).
- Gamepad button to manual override PID on the PID controlled arm.
- Gamepad buttons to slow down robot drive or arm movement.
- Gamepad buttons to control the arm to go to preset positions (e.g. different levels of the alliance hub).
- Gamepad button to activate auto-assist intake.

Engineering portfolio references:

- Odometry (p.11): coordinate system, finding robot location.
- Shuttle Back and Forth (p.12): Intake Auto-Assist, Pure pursuit Relocalization.
- Vision(p.13): finding the duck from carousel, detecting barcode level TSE
- Homography (p.14):picking up the duck in near carousel autonomous with duck delivery
- Pure Pursuit Algorithm (p.15): V1 and V2, stall detection.

Autonomous program diagrams:



Near Carousel With Duck (Blue Alliance)

1. Starts at a position near the carousel.
2. Detect TSE on barcode and deliver freight to the correct level at 30-deg approach to make room for our partner.
3. To the carousel and spin the duck.
4. Turn around to look for the duck on the floor.
5. If the duck is not close to the wall, go forward to scoop it up. If it is close to the wall, turn to the wall and scoop it up the front way.(shown in portfolio)
6. Deliver the duck to the shipping hub on level 3.
   7a. Park at the warehouse if we have enough time.
   7b. Otherwise park at the storage unit

Shuttle Back And Forth (Red Alliance)

1. Starts at a position near the warehouse.
2. Detect TSE on barcode and deliver freight to the correct level at 30-deg to make room for our partner.
3. Go into the warehouse to pick up freight.
4. Deliver freight to the alliance hub at level 3.
5. Repeat 3 and 4. Park at the warehouse before we run out of time..