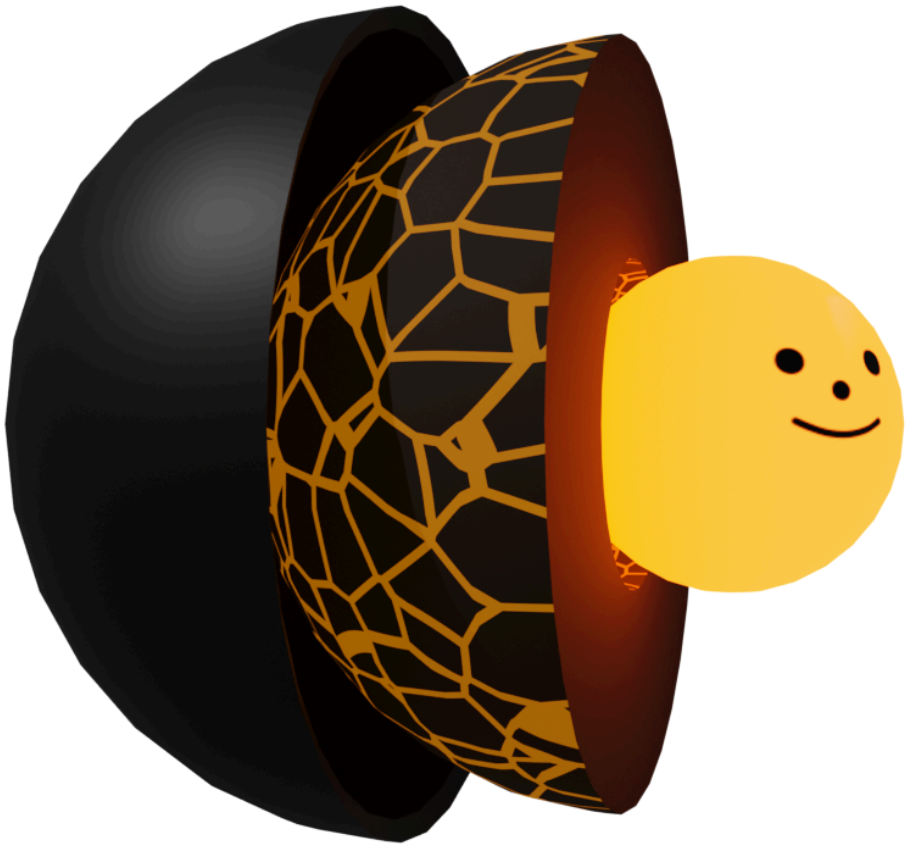
RIT VEXU Software Engineering Notebook

2023-2024



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Overview

Core API

All of the robot code we use is built on top of our own custom library, called the Core API, which itself is built on top of the official VEX V5 library. This API contains template code for common subsystems such as drivetrains, lifts, flywheels, and odometry, and common utilities such as vector math and command-based autonomous functions. This code remains persistent between years and is constantly updated and improved. The library can be found at ***github.com/RIT-VEX-U/Core***

The Core codebase is abstracted in a way that allows for simple use during a hectic build season, and creates a solid foundation for future expansion. Subsystems are divided into layers following an object-oriented approach to software development.

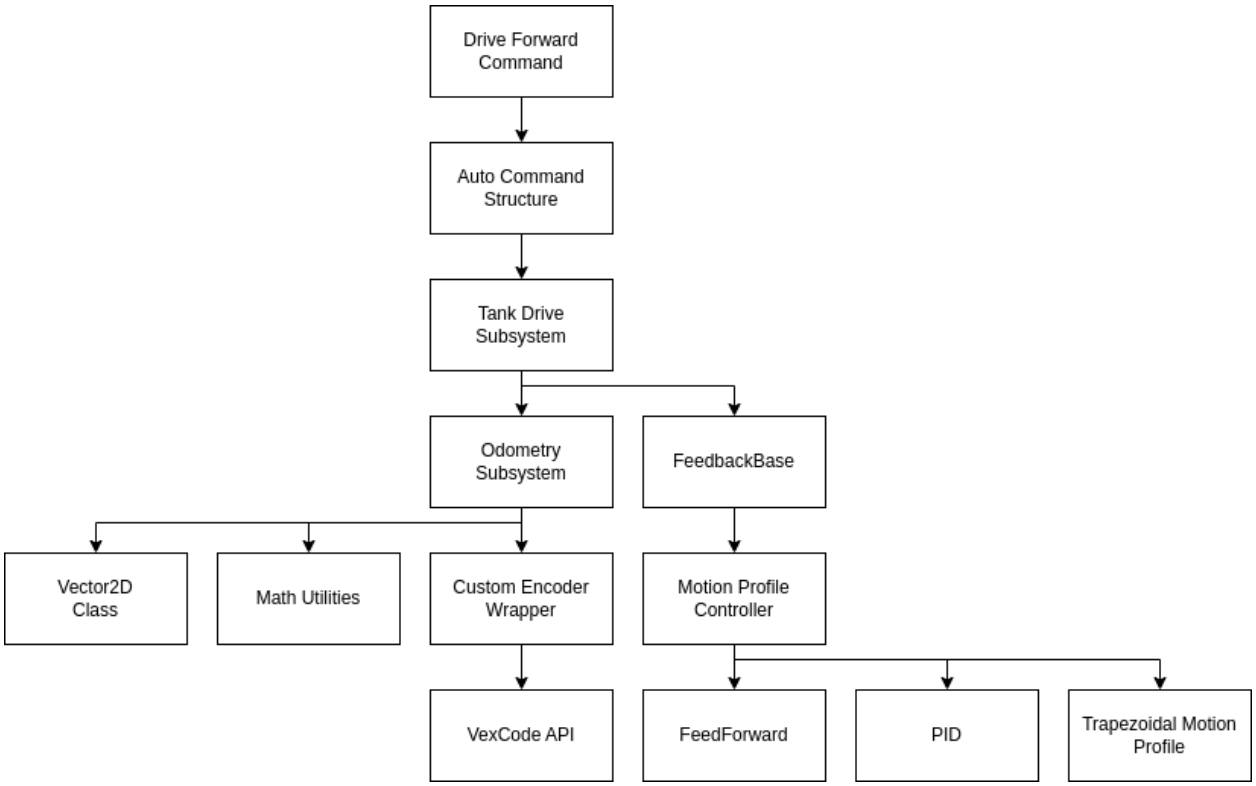


Figure 1 - Example of Object-Oriented Programming

Open Source Software

The Core API is under the MIT open-source license, and is open for other teams to use and improve upon via pull requests. This system was modeled after the Okapi library from the Pros ecosystem, and offers similar functionality for the VexCode ecosystem. Teams that use this API are also encouraged to open source their software.

Project Structure

During the season, there are three repositories (repos) that are actively developed. Two repositories for the two competition robots, and one for the Core API. Development and code building occurs in the robot repos, and any changes to shared code (drivetrain, math utilities, major subsystems) are merged with the Core repo. This method reduces redundant code and development time.

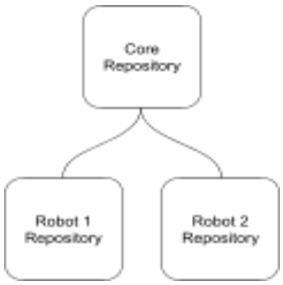


Figure 2 - Project Structure

Git Subrepo

The Core API uses a unique type of version control called Git Subrepo (github.com/ingydotnet/git-subrepo). This allows users to simply clone the repository into an existing VexCode project to have instant access to all the tools. It also allows users to instantly receive updates by pulling from the main branch, and makes sharing code between two robot projects easier with git code merges.

Before choosing Subrepo, the team experimented with using Git Submodules to incorporate the Core API into projects. This however made Core development cumbersome and difficult for anyone unfamiliar with Git submodules specifically. Subrepo made inter-project merges more streamlined, and simplified development.

Github Project Board

In order for our software team to collaborate together with these projects, we use the Github Projects kanban-style project board. This allows us to create and assign tasks, link it to a repository and additionally notify the assigned programmer through a slackbot.

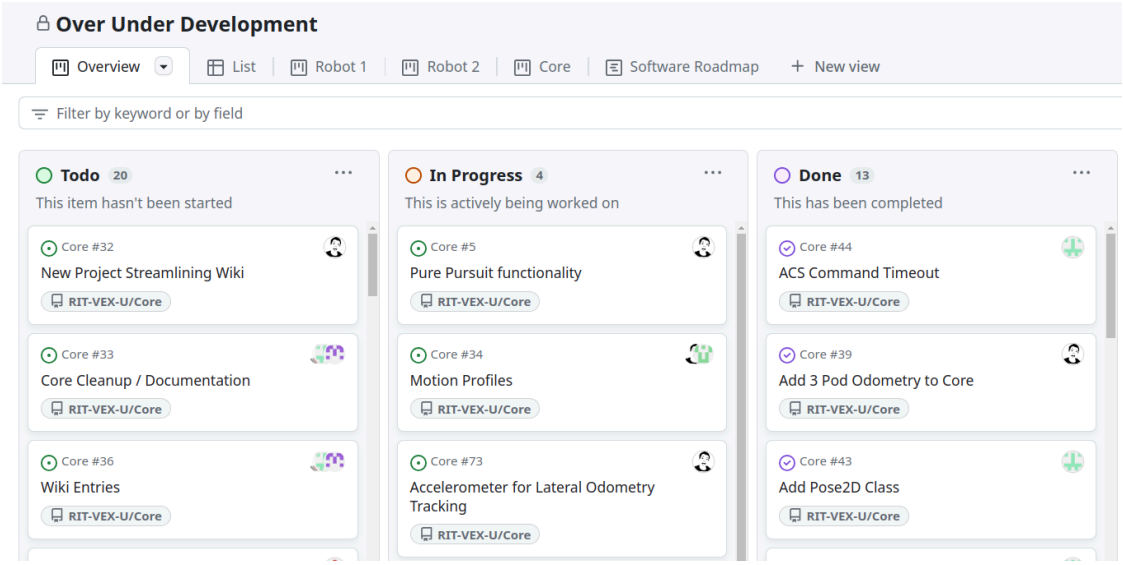


Figure 3 - Software Project Board

Github Actions

This year, our team enhanced our workflow by integrating GitHub Actions into our software development process. One notable addition was an action to build our C/C++ code in the appropriate Vex environment. This automated process involves a series of steps, including checking out the repository, downloading and unzipping the Vex Robotics SDK and toolchain, and compiling the code using a Makefile. A key feature of this GitHub Action is its ability to send a Slack notification to our team channel whenever a build fails, ensuring prompt awareness and response. Furthermore, it helps maintain code integrity by preventing the merging of pull requests with failing builds. This complements our other GitHub Action for building Doxygen documentation and deploying it to GitHub Pages, allowing for seamless documentation and code management. This systematic approach aligns with our commitment to maintaining a neat, organized, and efficient engineering process.

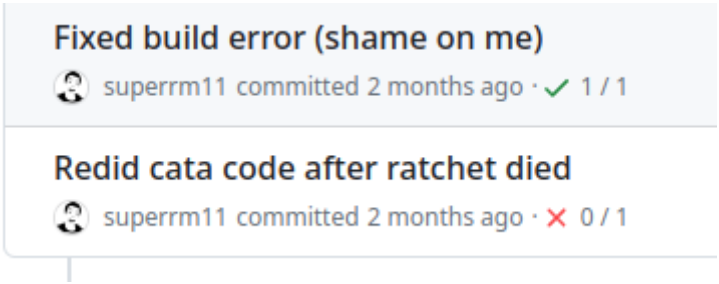


Figure 4: Continuous Integration directly improves the quality of our code.

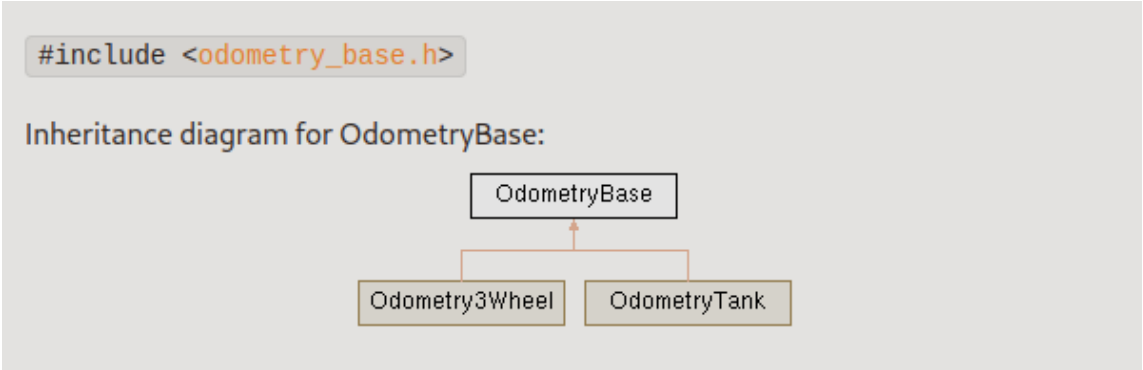


Figure 5: Automatically generated documentation.

Auto-Notebook

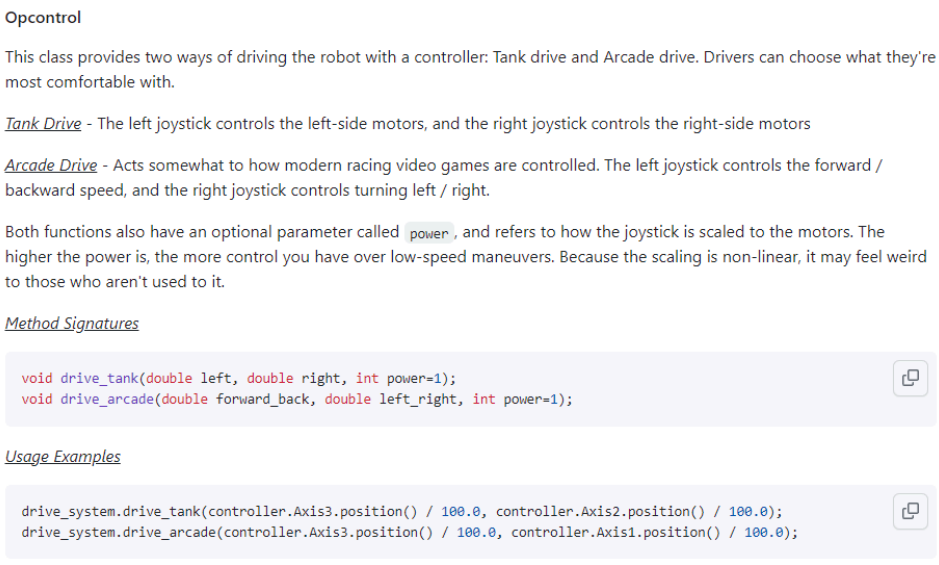
Alongside the automatic documentation, whenever Core is updated or we manually trigger it, a Github Action copies the reference manual, exports the most up to date version of our written notebook document, stitches them together and deploys to a webpage. This is publicly available for any person wishing to see our software development process. The most valuable effect, though, is automating most of the formatting work for our notebook that used to require a team member to use valuable pre-competition time to sit down, append, format and export the notebook.

Clang-Tidy

In an effort to improve the quality, reduce headaches, and make our code easier to read, write, and understand, we enabled many more warnings than what is supplied with the default Vex project Makefile. These warnings deal with uninitialized variables, missing returns, and other simple code errors that nonetheless have the tendency to introduce tiny, hard to track down bugs. However, sometimes these warnings do not explore deep enough and another tool must be used. We integrated clang-tidy, a c++ linter developed by the clang compiler project, to inspect our code. With a simple switch of a variable in the Makefile, we run clang-tidy during builds which gives many insights into the code that plain compiler warnings do not. Though it does increase compilation times, it tells us about code that is bug prone or poor for performance and tests many other checks developed and validated by the wider C++ community.

Wiki

Whenever a new feature is added to Core, we create a Wiki page on the Core Github repository that provides documentation on what the function does, how to use it, and some examples of how it can be used. This documentation is easily accessible as it can be found online within the Core repository itself. This allows for new members to get acquainted with Core faster and easier than before. This allows us to speed up our training process and allow new members to start developing sooner rather than later. In addition it provides us and anyone using Core great documentation that not only goes into method signatures and descriptions, but also detailed explanations of what different methods, classes or functions do.



Opcontrol

This class provides two ways of driving the robot with a controller: Tank drive and Arcade drive. Drivers can choose what they're most comfortable with.

Tank Drive - The left joystick controls the left-side motors, and the right joystick controls the right-side motors

Arcade Drive - Acts somewhat to how modern racing video games are controlled. The left joystick controls the forward / backward speed, and the right joystick controls turning left / right.

Both functions also have an optional parameter called `power`, and refers to how the joystick is scaled to the motors. The higher the power is, the more control you have over low-speed maneuvers. Because the scaling is non-linear, it may feel weird to those who aren't used to it.

Method Signatures

```
void drive_tank(double left, double right, int power=1);
void drive_arcade(double forward_back, double left_right, int power=1);
```

Usage Examples

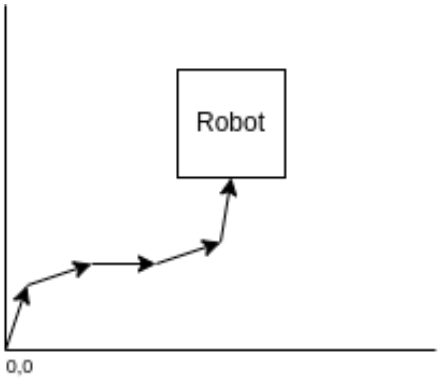
```
drive_system.drive_tank(controller.Axis3.position() / 100.0, controller.Axis2.position() / 100.0);
drive_system.drive_arcade(controller.Axis3.position() / 100.0, controller.Axis1.position() / 100.0);
```

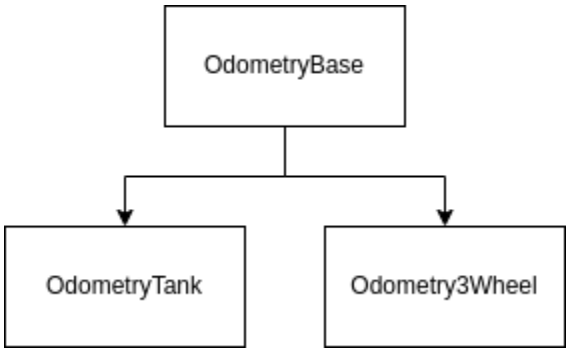
Figure 6: A screenshot of the Core Wiki

Core: Fundamentals

Odometry

In order for the robot to drive autonomously, it needs to know where it is, and constantly monitor changes to sensors. The Odometry subsystem takes inputs from encoders, and using vector math and previous position data, calculates the position and rotation of the robot on the field as a point in space (X, Y), and heading (deg).





The Odometry subsystem is broken down into an OdometryBase class, which controls the asynchronous behavior and getters/setters, and OdometryTank and Odometry3Wheel classes, which both extend OdometryBase and implement a two-encoder algorithm and a three-encoder algorithm, respectively.

GPS + Odometry

In order to fit an 8-motor drivetrain into the 15" size requirement, the robots could not fit non-powered odometry wheels, leaving only the drive encoders to be used for position tracking. This isn't ideal, since sudden changes in acceleration and wheel slippage can easily cause the tracking to drift a substantial amount. To combat drifting, we looked to the GPS sensor for localization.

The GPS sensor uses a tag-based approach for localization, using a coded strip around the perimeter of the field to estimate position. Between pose estimates, the integrated IMU provides inertial information to estimate changes in position and heading for a constant flow of data, presumably using some sort of onboard Kalman filter. The pose (X, Y, Heading) data is sent back to the Brain over the smart port. In addition, the GPS provides a "quality" value, which is a percentage that increases when the camera can see a large amount of tape, and decreases when the camera is blocked and the IMU detects change in position over a period of time.

To properly characterize the GPS sensor, X/Y/Heading data points were gathered at different positions around the field, facing different headings. The following graphs show the data points on the 12' x 12' field grid. Distance error (in inches) to the actual measurements is shown by color.

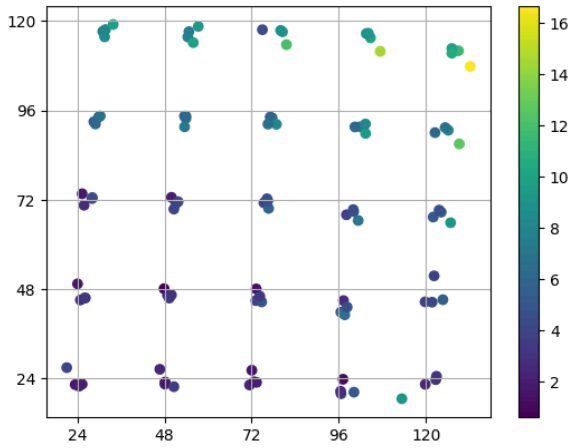


Figure 7 - Raw Data Points

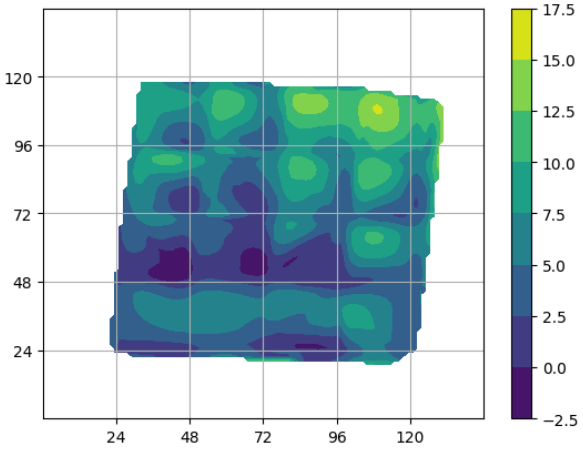


Figure 8 - Error Heat Map

There were some other errors with the GPS sensor, including issues localizing the robot when the sensor could not see enough of the coded tape. To take full advantage of the GPS sensor's localization capability, we'd need a way to perform sensor fusion alongside traditional ground-based odometry. To do this, a complementary filter was chosen - a filter that mixes two sets of data based on a proportional scalar *alpha* (α). the equation for a complementary filter is shown below:

$$out = \alpha * s_1 + (1 - \alpha) * s_2$$

where s_1 is *sensor 1*, s_2 is *sensor 2*, and alpha scales between the two.

To calculate alpha, first the X,Y position of the sensor and heading is taken into account. Since the robot will generally have a more accurate position when it's close to the wall and facing away from it, the following formula will report a score between 0 and 1 for the filter:

$$\alpha = \left(\frac{\vec{c} - \vec{p}}{||\vec{c} - \vec{p}||} \bullet \begin{bmatrix} cos\,\theta \\ sin\,\theta \end{bmatrix} \right) * \frac{||\vec{c} - \vec{p}||}{||\vec{c}||} * q$$

where $\vec{c}$ is the constant vector of a point in the center of the field (x=72in, y=72in), $\vec{p}$ is the robot's position as a vector (x, y), θ is the robot's heading, and x,y is again the robot's position (0 to 144 inches). The left side is the dot product of the normalized vector pointing from the robot to the center with the direction the robot is facing (gives 1 when the directions are aligned and -1 when opposite smoothly changing in between), and the right side is the sensor's distance to the center as a scalar percentage of the distance from corner to corner (between 0 and 1). Finally, q is the GPS's reported quality. We then remap this from the range [-1, 1] to [0, 1] when we do our mixing.

Drivetrain

A drivetrain class has two functions: To control the robot remotely, and autonomously. In the Core API, the TankDrive class allows the operator to control the robot using Tank controls (Left stick controls the left drive wheels, right controls the right), and Arcade controls (Left stick is forward / backwards, right stick is turning). This means drivers can tailor their controls to whichever feels more natural.

Tank Drivetrain

Brake Mode

A VEX driver has many things to keep track of during a match. From game element position, match load status, and partner robot condition there is a great deal going on. Defense is another layer on top of the mental load of playing the game. To ease this burden, we implemented a brake mode on our drive train. It is a multi-modal system that can either bring the robot to a stop or hold the robot in a specific location on the field. We use the motion profiles we developed for auto programming to decelerate the robot when requested and use our auto driving functions to hold the robot's position. We implement a smarter form of position holding than just motor braking as we can return to the exact location on the field. Additionally, we combine our deceleration control with position holding such that we do not immediately “lock the brakes” and skid away thus losing the position we attempt to hold and making driving incredibly difficult.

Autonomous Driving

For autonomous driving, the TankDrive class has multiple functions:

- drive_forward():
    - Drive X inches forward/back from the current position
    - Signature: drive_forward(double inches, directionType dir, double max_speed=1
- turn_degrees():
    - Drive X degrees CW/CCW from the current rotation
    - Signature: turn_degrees(double degrees, double max_speed=1)
- drive_to_point()
    - Drive to an absolute point on the field, using odometry
    - Signature: drive_to_point(double x, double y, vex::directionType dir, double max_speed=1);
- turn_to_heading()
    - Turn to an absolute heading relative to the field, using odometry
    - Signature: turn_to_heading(double heading_deg, double max_speed=1)

Generally, it is better to use drive_to_point and turn_to_heading to avoid compounding errors in position over relative movements. These functions implement the FeedbackBase class, so any control loop can be used to control it.

Drive To Point

The defining feature of a drive to point function is the ability for a robot to calculate a relative direction and distance between its own position and the target position, and navigate to it using tuned control loops. The steps taken for our implementation are listed below.

1 - Gather information

To drive towards a specific point, the robot must know the change in angle between the robot's heading and the target, and the distance to the target. To get this, we first grab the robot's current position and heading and create a positional difference vector between this and the new point.

```
pose_t current_pos = odometry->get_position();
pose_t end_pos = {.x = x, .y = y};

point_t pos_diff_pt =
{
 .x = x - current_pos.x,
 .y = y - current_pos.y
};

Vector2D point_vec(pos_diff_pt);
```

Using this information, grab the distance to the target (using a function in the Odometry subsystem). An issue with the pure distance between points is that it does not represent how far the robot has to travel to be considered "on target" in the control loop. In order to properly reach its target, the robot should report its "aligned distance", and ignore the lateral error, as per Figure 9. This should only hold true when the robot is close to the target, or inside a given radius that is tuned by the user.

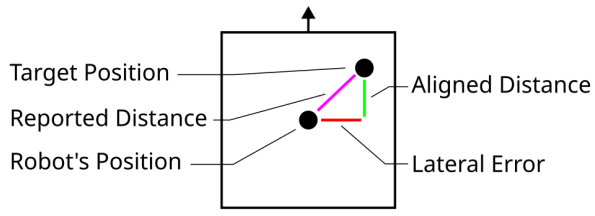


Figure 9 - Distance Modification

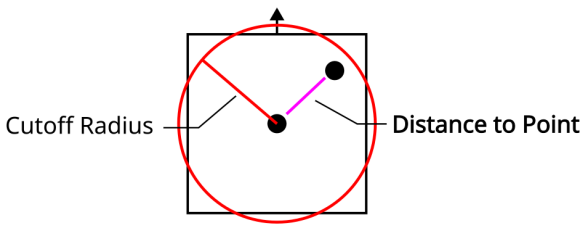


Figure 10 - Correction Cutoff Circle

```
double dist_left = OdometryBase::pos_diff(current_pos, end_pos);

if (fabs(dist_left) < config.drive_correction_cutoff)
{
 dist_left *= fabs(cos(angle * PI / 180.0));
}
```

The next data needed is the difference in angle between the robot's current heading and the vector between the robot's position and the target. This is calculated by using the arctangent of the difference vector, and subtracting it from the robot's current heading. The angle is then wrapped around 360 degrees.

```
double angle_to_point = atan2(y - current_pos.y, x - current_pos.x)
                        * 180.0 / PI;
double angle = fmod(current_pos.rot - angle_to_point, 360.0);
if (angle > 360)
 angle -= 360;
if (angle < 0)
 angle += 360;

double heading = rad2deg(point_vec.get_dir());
double delta_heading = 0;
if (dir == directionType::fwd)
 delta_heading = OdometryBase::smallest_angle(current_pos.rot, heading);
else
 delta_heading = OdometryBase::smallest_angle(current_pos.rot
                 - 180, heading);
```

The last piece of information needed is whether the robot should be moving forwards or backwards. Since the distance is calculated as $\sqrt{x^2 + y^2}$, the sign is lost when squaring. Re-implement the sign based on the angle and initial driving direction.

```
int sign = 1;
if (dir == directionType::fwd && angle > 90 && angle < 270)
 sign = -1;
else if (dir == directionType::rev && (angle < 90 || angle > 270))
 sign = -1;
```

2 - Setting Control Loops

In this section, the robot takes the above information and sets its feedback loops. Since the function takes in a FeedbackBase abstract class, any feedback can be used to drive the robot's correction and linear movements. The most common situation is a trapezoidal motion profile for linear distance with PD for heading correction. Once the robot is close enough to the target point, the correction feedback is ignored to avoid issues with last-minute heading changes.

```
correction_pid.update(delta_heading);
feedback.update(sign * -1 * dist_left);

double correction = 0;
if (is_pure_pursuit || fabs(dist_left) > config.drive_correction_cutoff)
{
 correction = correction_pid.get();
}

double drive_pid_rval;
if (dir == directionType::rev) {
 drive_pid_rval = feedback.get() * -1;
} else {
 drive_pid_rval = feedback.get();
}

double lside = drive_pid_rval + correction;
double rside = drive_pid_rval - correction;

lside = clamp(lside, -max_speed, max_speed);
rside = clamp(rside, -max_speed, max_speed);

drive_tank(lside, rside);
```

Finally, when the linear feedback reports its on target, stop, return and report that the movement is over.

```
if (feedback.is_on_target())
{
 if (end_speed == 0) {
   stop();
 }
 func_initialized = false;
 return true;
}
```

Pure Pursuit

Pure Pursuit is a method of autonomous robot driving that allows the robot to autonomously drive through a set of waypoints without stopping and turning.

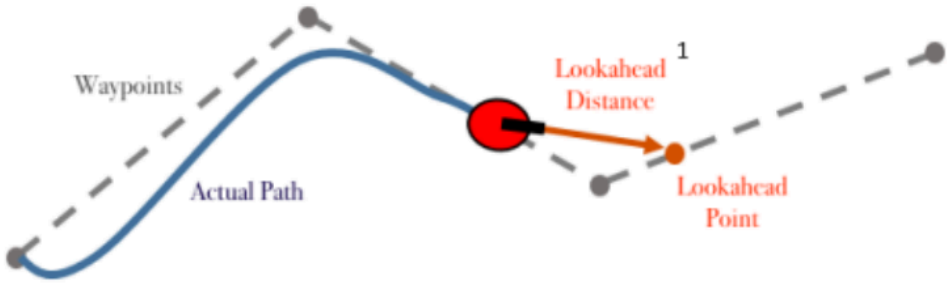


Figure 11 - Pure Pursuit Example

This is accomplished by taking a list of points (x,y), connecting them, and then choosing a "lookahead point" along the lines that the robot will attempt to follow. This will inherently cause the robot to smooth out the point map, and follow without sudden changes in direction.

The lookahead point is chosen by iterating along the path created by connecting the points and finding the furthest point that intersects a circle centered on the robot, with a set radius tuned by the programmer. Increasing this radius smooths the path, while decreasing it ensures the robot more closely follows the path.

The pure pursuit implementation in Core can either use the Autonomous Command System (ACS), or be called directly through the TankDrive class. See the sample code below for examples.

```
// Autonomous Command Controller
CommandController cmd{
   drive_sys.PurePursuitCmd(PurePursuit::Path({
       {.x=19, .y=133},
       {.x=40, .y=136},
       {.x=92, .y=136},
   }, 8), directionType::rev, .5)->withTimeout(4),
};
cmd.run();

// Standalone
while(!drive_sys.pure_pursuit(PurePursuit::Path({
           {.x=19, .y=133},
           {.x=40, .y=136},
           {.x=92, .y=136}}, 8), directionType::fwd, 0.5))
{
   vexDelay(20);
}
```

Control Loops

In order for the Autonomous Command Structure to function, we need a way to tell the robot how we want it to move. There are two broad categories of telling a robot to achieve a requested position - Feedback and Feedforward. Feedback relies on sensors and adjusts the output of the robot according to the error between where it is and where it wants to be. On the other hand, a feedforward controller takes a mathematical model of the system and creates outputs based on what it calculates to be the necessary output to achieve the goal. Additionally, there are simpler methods like Bang-Bang or Take Back Half. These adjust the outputs based on the current position relative to the target, where Take Back Half gradually refines the output until it settles at the desired position. These controller types work for many applications, but a combination of them can achieve an even better control over robot actuators.

PID

A PID controller is perhaps the most common type of Feedback control. It uses measurements of the error at its current state (proportional), measurements of how the error was in the past (integral) and measurements of how the error changes over time(derivative). The controller acts accordingly to bring the errors towards 0. We implemented a standard PID controller but made some alterations to fit our needs. The most important of these are custom error calculations. The standard error calculation function *(target - measured)* works for many of our uses but causes problems when we use a PID controller to control angles. Since angles wrap around at 360 degrees or 2π radians we wrote our own error calculation function that gives the error that accounts for this wrapping.

Feedforward

A feedforward controller differs from a feedback controller in that it does not rely on any measurement of error to command a system. Instead, built into a feedforward controller is a mathematical model of the domain. When a target is requested by the controller, the model is queried to figure out what the robot actuators must output to achieve that target. A key advantage of this form of control is that instead of waiting for an error to build up in the system, the controller acts directly to achieve the target and can reach the target much faster.

Bang-Bang

Bang-Bang control is a straightforward control methodology where the output to the system is either fully on or fully off, with no intermediate states. It's used for systems where fine control isn't necessary or possible. In this method, when the process variable is below the setpoint, the controller output is set to maximum; when above, it's set to minimum. This approach is simple and often used for systems with high inertia or where the precise control of the variable isn't critical. However, it can lead to oscillations around the setpoint and isn't suited for systems requiring precise regulation.

Take Back Half (TBH)

The Take Back Half (TBH) method is an iterative approach used to refine control in systems where overshoot is a concern. This method adjusts the output by taking back half the value of the output each time the controlled variable overshoots the target. The adjustment continues until the system settles close to the desired setpoint. TBH is particularly useful in scenarios where a fine balance between responsiveness and stability is needed, as it reduces the oscillation or overshoot often seen in simpler control methods. It's a practical choice for systems where a PID controller might be too complex or unnecessary. TBH controllers only have one tuning parameter which allows for an incredibly easy tuning experience.

Generic Feedback

Different control systems work best in different environments. Because of this, we found ourselves switching control schemes often enough that rewriting the code each time was time consuming and often led to rushed, worse quality code. To solve this problem we implemented a generic feedback interface so that none of our subsystem code needs to change when we use a different control scheme. Instead, the subsystem reports to the controller where it wants to be, measurements from its environment and some information about the system’s capabilities and the controller will report back the actions needed to achieve that target. This allows for much faster prototyping as well as cleaner, less tightly coupled code.

Motion Profile

As we learn from each event, our team has evolved our approach to robot control systems, transitioning from a simple PID controller to a more sophisticated Motion Profile controller. The PID system, while fundamental, had its drawbacks, such as limited speed specification, poor response to wheel slipping, and slower reaction times. These limitations highlighted the need for a more advanced control mechanism.

Our Motion Profile controller represents a significant upgrade. It integrates precise control over position, acceleration, and velocity, allowing for optimized performance of our robot's subsystems. Unlike the PID controller, which reacts only to discrepancies between actual and desired states, our Motion Profile controller proactively manages the robot's movements. It anticipates the required actions, thereby reducing response lags. Moreover, it avoids the rigidness of a pure feedforward controller by adapting dynamically to changing conditions in competition scenarios.

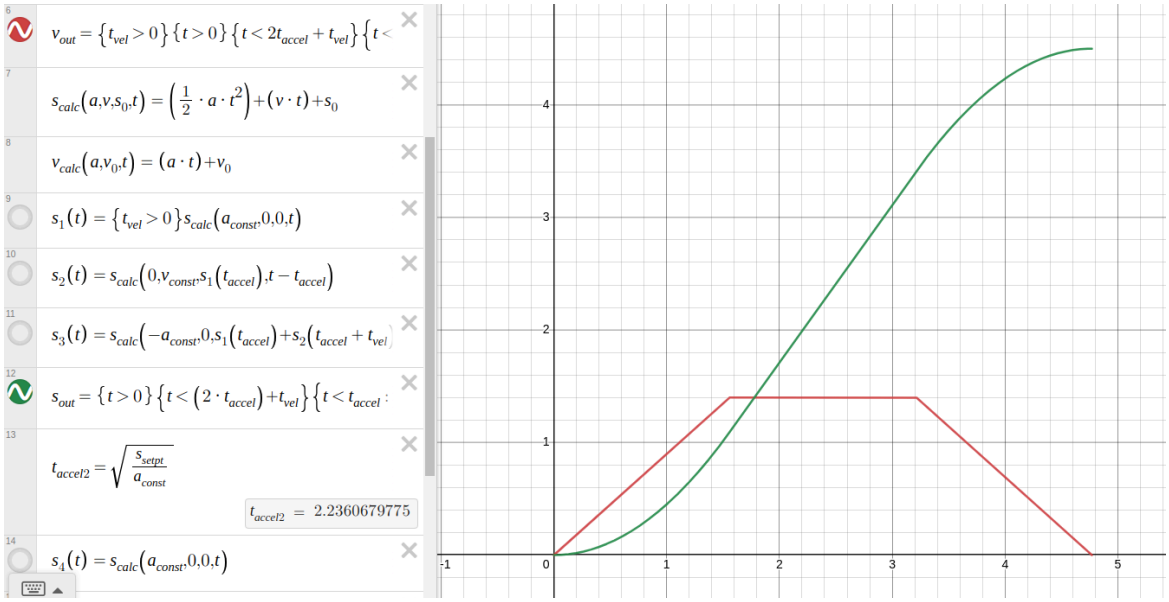


Figure 12: Trapezoidal motion profile

A key feature of the Motion Profile controller is its ability to handle varying accelerations. This functionality enables our robot to accelerate efficiently without wheel slipping, always maintaining optimal acceleration. This year, we've further refined our Motion Profile to accommodate non-zero starting and ending velocities. This enhancement allows for the seamless chaining of complex movements, ensuring smoother transitions and more fluid motion during competition tasks.

Auto Command Structure (ACS)

Principle

A recent addition to our core API was that of the Autonomous Command Structure. No more will our eyes glaze over staring at brackets as we trawl through an ocean of anonymous functions nor lose our way in a labyrinthine state machine constructed not of brick and stone but blocks of ifs and whiles. Instead, we provide named Commands for all the actions that our robot can execute and infrastructure to run them sequentially or concurrently. The API is written in a declarative way allowing even programmers unfamiliar with the code to see a step-by-step, annotated guide to our autonomous path while keeping the procedures of how to execute the actions from hurting the readability of the path.

```
CommandController auto_non_loader_side(){
    int non_loader_side_full_court_shot_rpm = 3000;
    CommandController non_loader_side_auto;

    non_loader_side_auto.add(new SpinRPMCommand(flywheel_sys, non_loader_side_full_court_shot_rpm));
    non_loader_side_auto.add(new WaitUntilUpToSpeedCommand(flywheel_sys, 10));
    non_loader_side_auto.add(new ShootCommand(intake, 2));
    non_loader_side_auto.add(new FlywheelStopCommand(flywheel_sys));
    non_loader_side_auto.add(new TurnDegreesCommand(drive_sys, turn_fast_mprofile, -60, 1));
    non_loader_side_auto.add(new DriveForwardCommand(drive_sys, drive_fast_mprofile, 20, fwd, 1));
    non_loader_side_auto.add(new TurnDegreesCommand(drive_sys, turn_fast_mprofile, -90, 1));
    non_loader_side_auto.add(new DriveForwardCommand(drive_sys, drive_fast_mprofile, 2, fwd, 1));
    non_loader_side_auto.add(new SpinRollerCommand(roller));

    return non_loader_side_auto;
}
```

Figure 13: ACS code from the 2023 competition season

Updates

This season, we found ourselves annoyed with having to repeat basic things such as `path.add(...)` and having to write `new ThingCommand(...)` over and over again. Our first solution to this was “shortcuts”. These were member functions of subsystems that would allocate, initialize and return an auto command for that subsystem. So, instead of `path.add(new DriveForwardCommand(drive_sys, drive_fast_mprofile, 20, fwd)` we could simply write `path.add(drive_sys.DriveForwardCommand(20, fwd))`. This reduced a great deal of typing but still left us with some issues.

The most hazardous, rather than the simply annoying downside of last year's system, was the memory unsafety of this system. Since our auto commands must use virtual functions, they must be on the other end of a pointer. So, they must be allocated using new or they must be initialized statically before we write the path which is a terrible user experience (Though, if constrained by an embedded system where allocating on the heap was deemed dangerous, the system could work with this). This became a real issue when we began to write more complicated constructs such as branching, asynchronous, and repeated commands as it became dangerously unclear who was responsible for deallocating these objects. As a solution for this, we developed an RAII wrapper for the Auto Command Interface. Inspired by C++’s `std::unique_ptr`, this wrapper provides a memory safe, value based way of using auto commands while still maintaining their adaptability. We used C++’s ideas of move semantics and ‘Resource Allocation Is Initialization’ to practically solve memory management so programmers (and even non programmers) can focus on writing paths.

```
CommandController cmd{
    odom.SetPositionCmd({.x = 16.0, .y = 16.0, .rot = 225}),
    // 1 - Turn and shoot preload
    {
        cata_sys.Fire(),
        drive_sys.DriveForwardCmd(dist, REV),
        DelayCommand(300),
        cata_sys.StopFiring(),
        cata_sys.IntakeFully(),
    },
    // 2 - Turn to matchload zone & begin matchloading
    drive_sys.DriveForwardCmd(dist + 2, FWD,0.5)
        .with_timeout(1.5),

   // Matchloading phase
   Repeat{
       odom.SetPositionCmd({.x = 16.0, .y = 16.0, .rot = 225}),
       intakeToCata.with_timeout(1.75),
       cata_sys.Fire(),
       drive_sys.DriveForwardCmd(10, REV, 0.5),
       cata_sys.StopFiring(),
       cata_sys.IntakeFully(),
       drive_sys.TurnToHeadingCmd(load_angle, 0.5),
       drive_sys.DriveForwardCmd(12, FWD, 0.2).with_timeout(1.7),
   }.until(TimeSinceStartExceeds(30))
};
```

Figure 13: ACS code going into the 2024 competition season

Now that we were free to use auto commands without fear for leaking memory or messing with currently running commands, we began to create more powerful constructs such as branching on runtime information, timeouts so the robot can decide what to do based on how much time is left in the auto or skills period, fearless concurrency (driving and reloading at the same time), and a much much nicer user interface. This declarative, safe, and straightforward method of writing auto paths lets us spend less time writing and debugging custom code and more time exploring and optimizing auto paths.

Serializer

One pain point we found last year was configuring auto paths, color targets, path timeouts, and other parameters that changed often but for the most part should be persistent. Commonly, we found ourselves redeploying code at the last minute before a match. To solve this, we wrote a class that takes control of a file on the SD card to which users can read and write values at runtime using a simple key-value interface. This keeps us from having to change a value, redeploy, repeat which cost us valuable time in the past.

Screen Subsystem

Principle

One of the most powerful elements of the V5 Brain is the fairly substantial touch screen. However, its simple drawing API limits its utility as one person's part of the code will draw over another since there is no larger abstraction controlling who draws when. We have many different subsystems on our robot to observe and debug and many parameters that can be tuned at run time and the screen provides a way to do this. We provide an API that provides a 'page' interface that can be inserted into a slideshow-like interface. Each 'page' provides two functions, an update and a draw. The update runs more frequently allowing touch input and data collection at a reasonably fast rate while the draw function runs less frequently to not cause too much overhead on the system. At startup, users provide the screen subsystem a list of pages and the screen subsystem handles orchestration and input in a background thread while other robot code runs unaffected.

```
pages = {
    new AutoChooser({"Auto 1", "Auto 2", "Auto 3", "Auto 4"}),
    new screen::StatsPage(motor_names),
    new screen::OdometryPage(odom, 12, 12, true),
    cata_sys.Page(),
};

screen::start_screen(Brain.Screen, pages);
```

Figure 14: Configuration for the screen subsystem

Pages

Odometry Page

The odometry page has proved incredibly useful in writing and debugging auto and auto skills paths. It shows a picture of the robot on the field as well as a print out of the actual x,y coordinates and heading of the robot. Since we write our autos with respect to the coordinate system of the field, having a map to look at makes development much simpler.

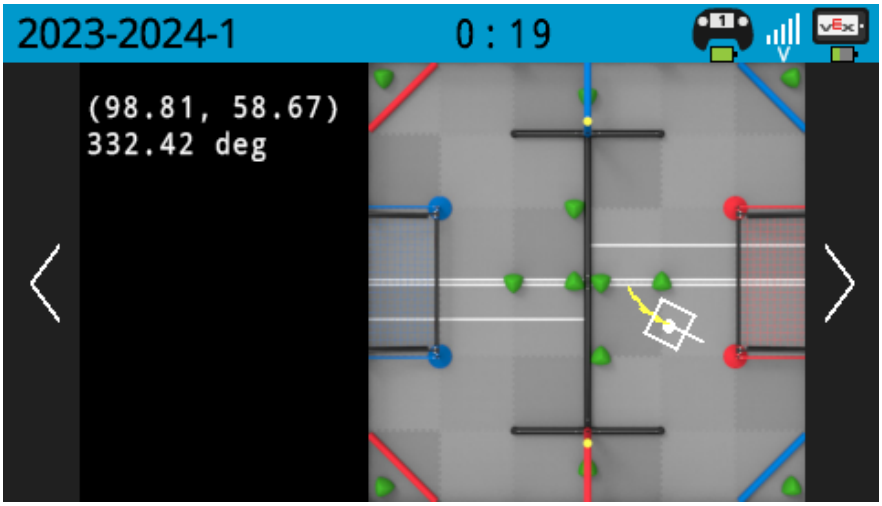


Figure 15: A field display for the Over Under season

PID Tuner

PID controllers are integral to many subsystems on our robots. Our drive code uses them for turning and forward motion, our catapult uses them for reloading, and subsystems across seasons require them for precise control. Tuning them, however, can be incredibly tedious. Changing one value, redeploying, and repeating over and over again is time consuming and unnecessary. Since we have a wonderful touchscreen, we simply added a series of sliders for PID parameters and we can now easily adjust a PID tuning in seconds rather than minutes saving a great deal of time on an already time consuming part of robot development.

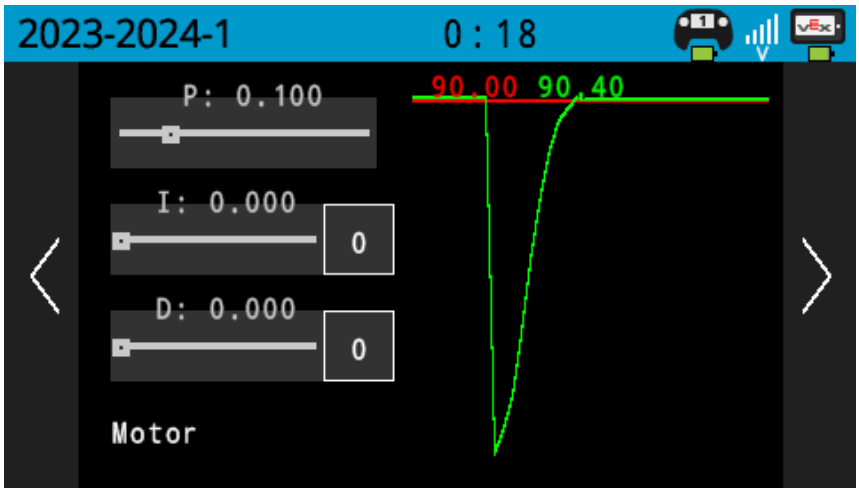


Figure 16: Tuning a motor for reaching an angle

Motor Stats

One would think it an easy step to remember to plug motors in, and yet multiple times this season we have been bewildered and hindered by an unplugged motor. This page was written to continuously display that the motor had been unplugged and was not cancellable like the built-in VEX alert. This screen also displays what port to plug it into as well as a color coded

temperature displaying when the robot needs to cool down. This tool proved extremely useful as we discovered an alarmingly high number of dead or nonfunctioning ports on the brain.

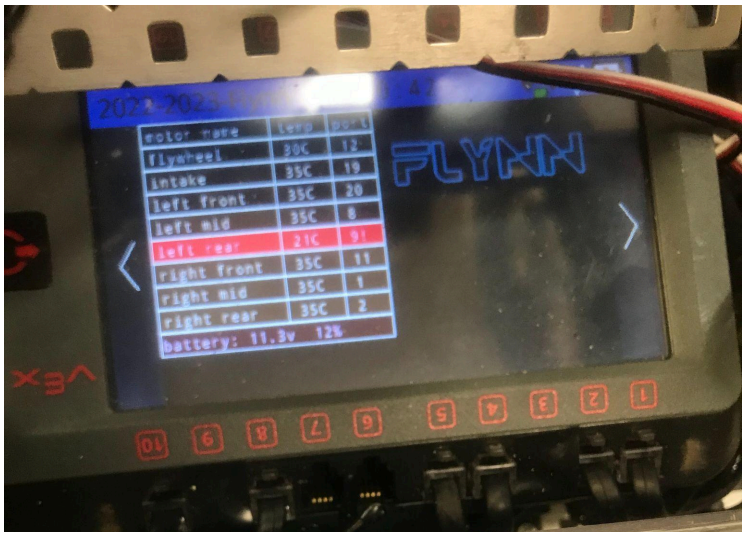


Figure 17: Motor Stats screen from our 2023 robot

Cata System Page

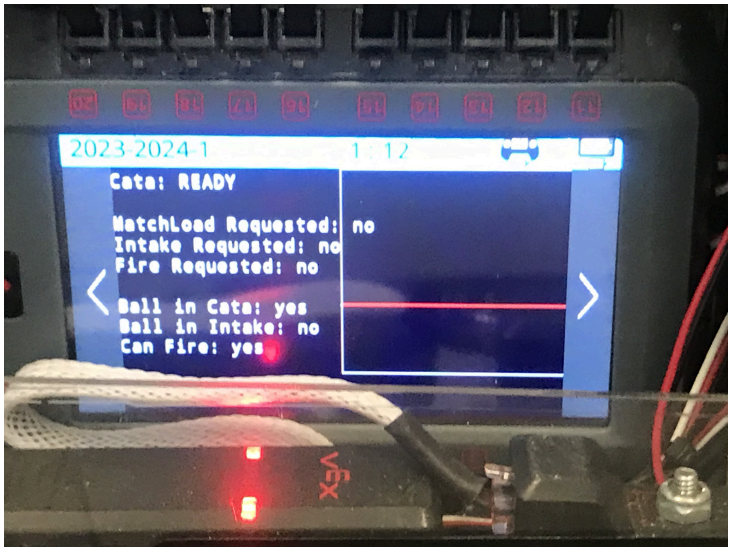


Figure 18: The catapult status page. Includes a graph of Catapult PID values.

Catapult System

Vex's Over Under game requires the effective utilization of the fascinatingly shaped triball. After much deliberation, our team decided on a catapult to launch the game element across the field and a reversible intake for picking up and scoring the triball. This system gives us a great deal of flexibility and power for strategy but does increase the system's complexity. This complexity mostly stems from the orchestration of intaking with catapult reloading such that we do not jam our catapult and never intake multiple game pieces leading to a disqualification.

We implemented a state machine that receives inputs from the controller, a distance sensor in the intake, a distance sensor in the catapult, and a potentiometer for watching the catapult's position. The system runs the appropriate motors to either intake to hold the triball, reset the catapult, intake into the catapult, or shoot depending on its state. Because we have so many sensors, we can determine when intaking would lead to disqualification and simply not honor the intaking command.

These messages are a simple enum that one passes to `CataSys::send_command()`. This was originally intended to make writing multi-threaded code less error-prone as there was one thread-safe and simple way to interact with the subsystem, rather than many disparate methods some of which are meant for internal usage of the class on the running thread and some accessors and setters meant to used from the user thread. Although it started for implementation ease, it naturally brought about a very simple interface for auto. Instead of sending a command on a button press, we simply send a command at a certain point in our auto path and the system reacts accordingly.

Core: Ongoing Projects

Rust

Over the course of the year, we have experimented with rewriting our Core API in Rust, a multi-paradigm programming language focused on performance and safety. Rust offers several potential advantages over C++:

Memory Safety

One of the primary benefits of Rust is its emphasis on memory safety without sacrificing performance. Rust's ownership model ensures that memory is managed correctly at compile time, reducing the risk of memory leaks and buffer overflows which are common issues in C++. This is especially crucial in robotics, where memory management errors can lead to system crashes or unpredictable behavior in real-time operations.

Concurrency

Rust's approach to concurrency is another major advantage. Concurrency errors, like race conditions, are hard to debug and can be catastrophic in robotics, leading to inconsistent states and erratic behavior. Rust's type system and ownership model prevent data races at compile time, making concurrent programming more reliable and easier to reason about.

Performance

In terms of performance, Rust is comparable to C++, which is essential in robotics where processing speed and response time are critical. Rust’s zero-cost abstractions mean that high-level constructs do not add overhead at runtime. This allows developers to write high-level code without compromising on performance, an important consideration in robotics where every millisecond can count.

Improved Code Maintenance and Readability

Rust also offers improved code maintainability and readability. Its modern syntax and language features make it easier to write clear and concise code. This reduces the cognitive load on developers, making it easier to develop and maintain complex robotic systems. The compiler's strictness also ensures that many potential bugs are caught early in the development cycle, reducing the time spent on debugging.

Growing Ecosystem and Community

The Rust ecosystem is rapidly growing, with a strong focus on safety and performance. There are increasing numbers of libraries and tools being developed for Rust, including those specifically for robotics. The Rust community is known for its dedication to improving code quality and security, which aligns well with the needs of robotics development.

Overall

While the transition from C++ to Rust in a robotics context requires investment in terms of learning and codebase modification, the benefits in memory safety, concurrency handling, performance, and maintainability make it a compelling choice. The modern features of Rust, combined with its growing ecosystem and community support, position it well for developing robust, efficient, and safe robotic systems.

N-Pod Odometry

Motivation

Although we have been working on the GPS odometry system, wheel odometry is still vital. It provides great small-scale, quickly updating positions as well as having near-perfect, continuous, local velocity which a GPS system can not achieve. We use odometry in two ways; either tank or differential odometry where there is one wheel on either side of the drivetrain alongside the drive wheels and 3-wheel odometry where we have 3 wheels at ninety degrees to each other. Tank odometry is limited as it can not track horizontal movement and we simply hope that we never move sideways, though it is easiest to implement in the robot so it is our most commonly used system. 3-wheel odometry solves the side-to-side problem but is much harder to implement in hardware owing to the extra wheel where other subsystems would need space.

In a plea for mercy from the hardware team, we agreed that we would take tracking wheels wherever and we could make do. Though we once again got stuck with a tank system, if our dream of more tracking wheels ever comes true we would need code to handle such a system. Also, since tank and 3 wheel odometry are special cases of an n-pod system, we could reduce code duplication.

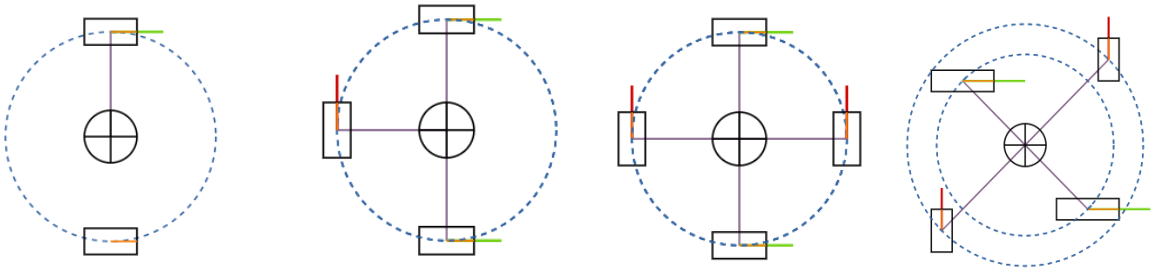


Figure 19: 2 pod, 3 pod, and arbitrary pods such a system could handle.

Syntax

After much brainstorming and many mad scientist whiteboard drawings, we believe that we have the fundamentals of a system figured out. Unfortunately, other responsibilities to the team came up so we do not yet have a functioning implementation of the system.

Imagine a robot with *n* number of tracking omni wheels. We could read encoder values E_1, E_2, …, E_3 from the system in radians from the initial position. As well, each encoder has a configuration $(x_1, y_1, \theta_1, r_1)$, …, $(x_n, y_n, \theta_n, r_1)$ describing its position (*x, y*) relative to the center of rotation, an angle describing its orientation relative to the robot frame (θ), and a radius of the wheel (*r)*.

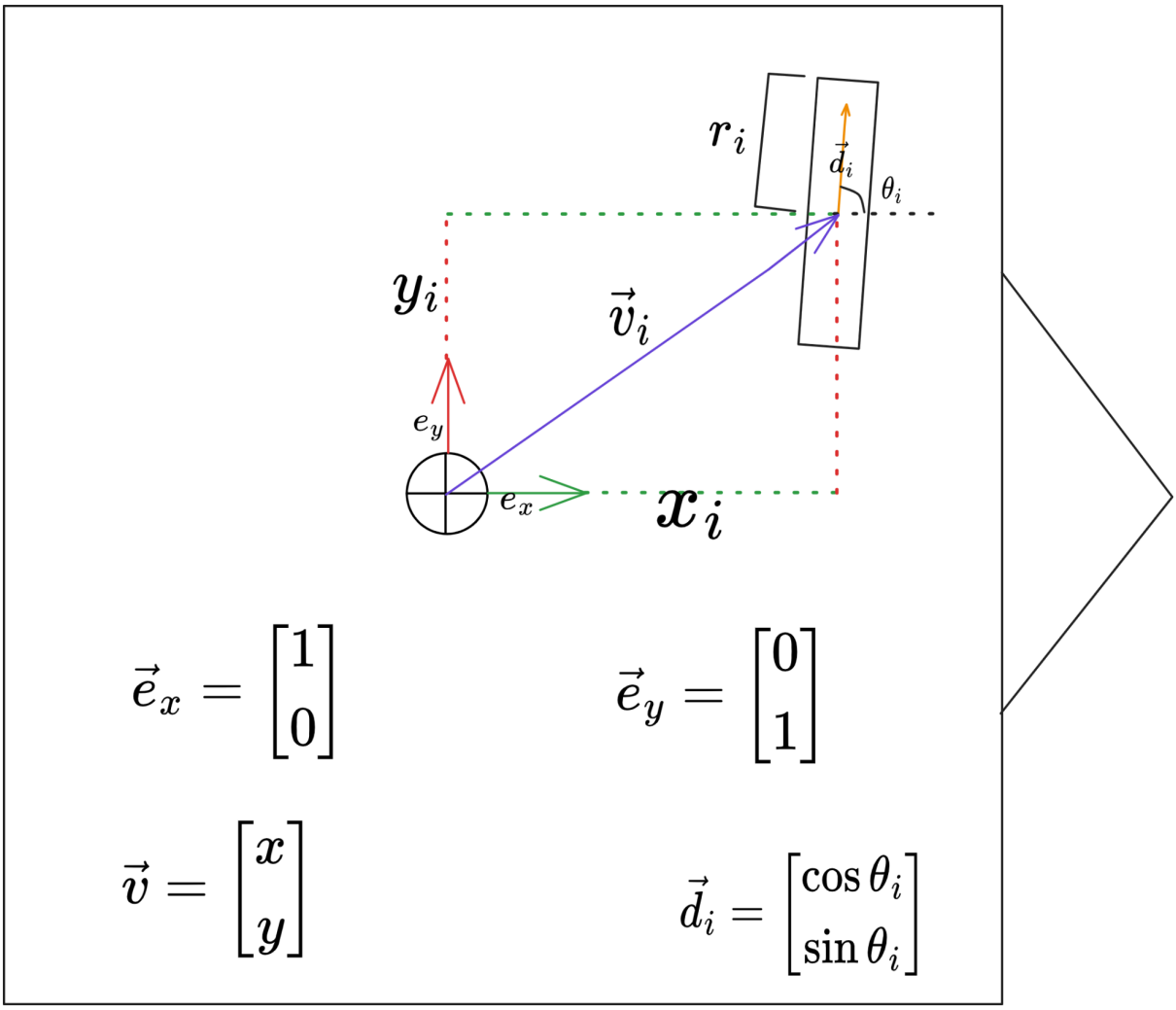


Figure 20: The configuration of a tracking wheel on the robot. (e_x, e_y) are the basis vectors of our coordinate system - the X and Y axes of the robot coordinate frame. d_i is the direction vector of the tracking wheel.

Now, if we pretend that these wheels are powered and we wish to translate and rotate the robot according to some controller input (x, y, θ) we can develop a formula for how much each wheel needs to rotate to move the robot in that direction with that rotation. Luckily, since the tracking wheels are omni wheels that roll freely in the axis against their “forward” direction, we do not need to worry about dragging a wheel so long as it is spinning the correct amount in its “forward” direction. For a desired (x, y, θ) (in the robots reference frame), for the *i*-th

encoder, we say $E_i = xF_{xi}$. That is, for a movement in the x-axis the rotations of the *i*-th encoder, are the desired x movement times some scalar factor (*F)* for how far this specific wheel would rotate. Similarly, for a *y* only and θ only movement, $E_i = yF_{yi}$ and $E_i = \theta F_{\theta i}$ respectively.

Deriving Factors

F_x

F_x depends on the direction vector $\vec{d}$ of the omni-wheel. If the omni-wheel is facing along the x-axis, F_x will be higher whereas if the omni-wheel is directly perpendicular to the x-axis, it will not spin when you move only in the x-direction. Since $\vec{e_x}$ and $\vec{d}$ are unit vectors, how closely they are related is given by $\vec{e_x} \cdot \vec{d} = \cos(angle\ between\ x\ axis\ and\ wheel)$

F_x also depends on the radius of the wheel *r*. One full rotation of the wheel moves a distance of $C = 2\pi r$. If we drive in the direction of the wheel *i* inches, the wheel will complete $\frac{i}{2\pi r}$ revolutions. If we measure the rotations in radians, the wheel will travel $\frac{i}{r}$radians. That is, if the encoder wheel travels *E* radians, we will have traveled *Er* inches in that direction.

So, the distance traveled in the x direction of a wheel pointing in the direction $\vec{d}$, rotating *E* radians is $x = Er(\vec{e_x} \cdot \vec{d})$. This gives since $F_x$as how many inches per radian turned,

$$F_x = \frac{x}{E} = r(\vec{e_x} \cdot \vec{d})$$

F_y

F_y is derived almost identically as F_x just instead of testing against $\vec{e_x}$ we test against $\vec{e_y}$. So,

$$F_y = \frac{y}{E} = r(\vec{e_y} \cdot \vec{d})$$

F_θ

F_θ is a little more complicated since it is determined by the position of the wheel $\vec{v}$as well as the orientation of the wheel $\vec{v}$

Imagine that the robot turns an angle of θ_r measured in radians. A wheel that is perfectly perpendicular to the rotation will travel an arc with distance $S = ||\vec{v}|| \theta_r$ by the arc length formula where the 'radius' of the arc is defined by the length of the vector $\vec{v}$.

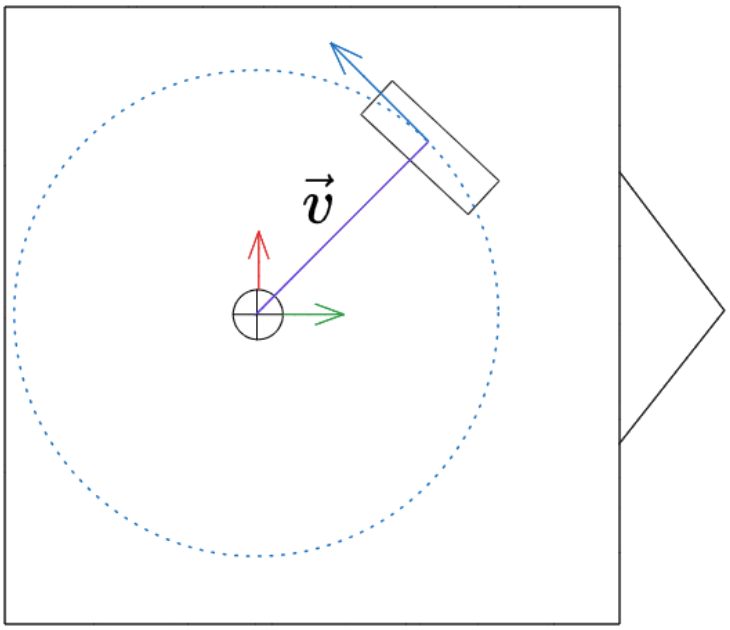
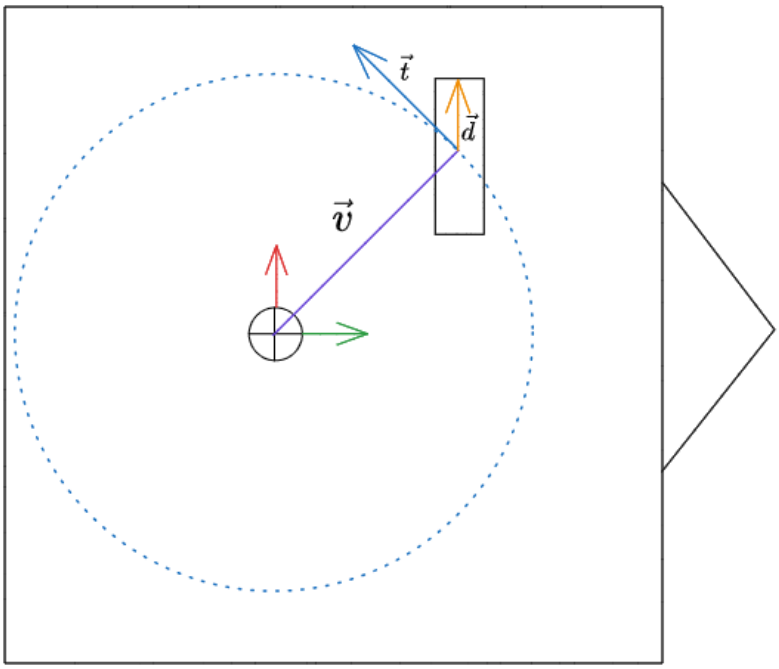


Figure 21: A conceptual perfectly perpendicular wheel

So, if we have a wheel that is always tangent to the rotation, it will travel

$$E_t r = S = ||\vec{v}||\theta_r$$

Since our wheel isn't guaranteed to be perfectly tangent to the arc, we have to use our dot product trick to get the component of its motion that is tangent to the turning circle. That is, instead of comparing to $\vec{e}_x$ or $\vec{e}_y$ we compare to the normalized vector $\vec{t}$ tangent to the turning circle.



$$E_t r = Er(\vec{t} \cdot \vec{d})$$

So

$$Er(\vec{t} \cdot \vec{d}) = S = ||\vec{v}||\theta_t$$

Since $\vec{t}$ is just a unit vector 90 degrees counterclockwise of $\vec{v}$, We can find it by multiplying $\vec{v}$ by the rotation matrix for 90 degrees and normalizing giving

$$\vec{t} = \begin{bmatrix} 0 & -1 \\ 1 & 0 \end{bmatrix} norm(\vec{v}) = \begin{bmatrix} -norm(\vec{v}).y \\ norm(\vec{v}).x \end{bmatrix}$$

So

$$F_\theta = \frac{\theta_r}{E} = \frac{r(\vec{t} \cdot \vec{d})}{||\vec{v}||} = \frac{r(\begin{bmatrix} 0 & -1 \\ 1 & 0 \end{bmatrix} norm(\vec{v}) \cdot \vec{d})}{||\vec{v}||} = \frac{r(\begin{bmatrix} 0 & -1 \\ 1 & 0 \end{bmatrix} \vec{v} \cdot \vec{d})}{||\vec{v}||^2}$$

Why factors

These factors make solving this problem much simpler. For the forward case, for some wheel *i*, its rotation is the sum of all the motions applied to it. So $E_i = F_{xi}x + F_{yi}y + F_{\theta i}\theta$. So, for all the wheels, we plug in the commanded (x, y, θ) to each wheel's factors to get its

necessary rotation. Since the factors depend only on the wheel's pose in the frame, these can be calculated once at the start of the program and are constant (unless the frame breaks apart, in which case the robot has other problems).

Now Do It Backwards

We have now solved the forward system for when we have a delta of our pose and want our wheel deltas. Now we must take our wheel deltas and solve for our pose delta. We have our formulas for each wheel's encoder motion and can consider this as a system of linear equations. At runtime, we have our wheel encoder deltas we can plug in and then we can solve the system of linear equations. This requires that we have enough data to satisfy the equations. That is, we need at least 3 separate wheels with at least some angle between them, or else the system will be not fully constrained. In the case of tank odometry, we only have two wheels but as outside observers we know we can not measure change in one dimension. So, we know one variable is zero and then have two remaining free variables and two equations to satisfy the system. For robots with greater than three encoders, we have an over-constrained system of equations but this is not an issue. Since all the encoders are modeled on a physical system, they should agree on what the solution is. Using the technique of least squares regression, we can find our $(x,\ y,\ \theta)$ to solve the over-constrained system that minimizes the error between equations. This also gives us a way to detect errors in our drive train. If a wheel gets jammed, its encoder reading will disagree with the rest of the system, and the error value will measurably increase. If we monitor this error value we can diagnose mechanical or electrical issues from the code.

$$T = \begin{bmatrix} F_{x1} & F_{y1} & F_{\theta 1} \\ \vdots & \vdots & \vdots \\ F_{xn} & F_{yn} & F_{\theta n} \end{bmatrix}$$

$$\begin{bmatrix} \frac{\text{Length}}{\text{Angle}} & \frac{\text{Length}}{\text{Angle}} & \frac{\text{Angle}}{\text{Angle}} \\ \vdots & \vdots & \vdots \end{bmatrix}$$

transfer matrix from robot velocity to encoder velocities (f for factor)

$$\vec{X} = \begin{bmatrix} \frac{dx_{robot}}{dt} \\ \frac{dy_{robot}}{dt} \\ \frac{d\theta_{robot}}{dt} \end{bmatrix}$$

$$\begin{bmatrix} \frac{\text{Distance}}{\text{Time}} \\ \frac{\text{Distance}}{\text{Time}} \\ \frac{\text{Angle}}{\text{Time}} \end{bmatrix}$$

pose velocity

$$\vec{E} = \begin{bmatrix} E_1 \\ \vdots \\ E_n \end{bmatrix}$$

$$\begin{bmatrix} \frac{\text{Angle}}{\text{Time}} \\ \vdots \\ \frac{\text{Angle}}{\text{Time}} \end{bmatrix}$$

encoder wheel velocities

$$T\vec{X} = \vec{E}$$

$$\vec{X} = T^{-1}\vec{E}$$

or in the case where the matrix is not invertible, find the best solution

The linear algebra behind the solution

V5 Debug Board

The large number of features added to core, while extremely useful, are also very difficult to debug. Without a proper real-time c++ debugger and one stream serial data for print statements, data parsing can get very messy. The improvements to the Screen subsystem have helped, but a remote solution is needed to avoid chasing after the robot to get visual data.

Figure 22 - Debug Board (Back)

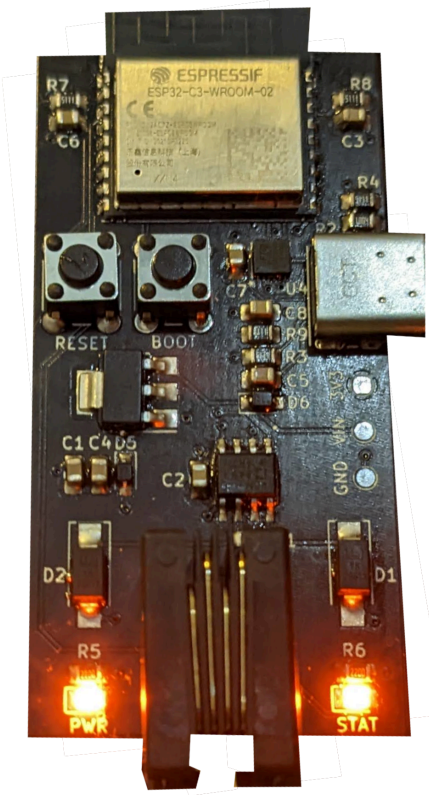


Figure 23 - Debug Board (Front)

The V5 Debug Board is a custom PCB designed by our team specifically to interface with the V5 Smart Ports, host a ROS2 node and a WiFi access point for programmers to connect to with laptops. This board is designed to ingest any kind of data and use it for graphs, real-time tuning and even displaying a 3D model of the robot on a virtual field using odometry data. This data can be viewed using either ROS' RViz or Foxglove visualization software.

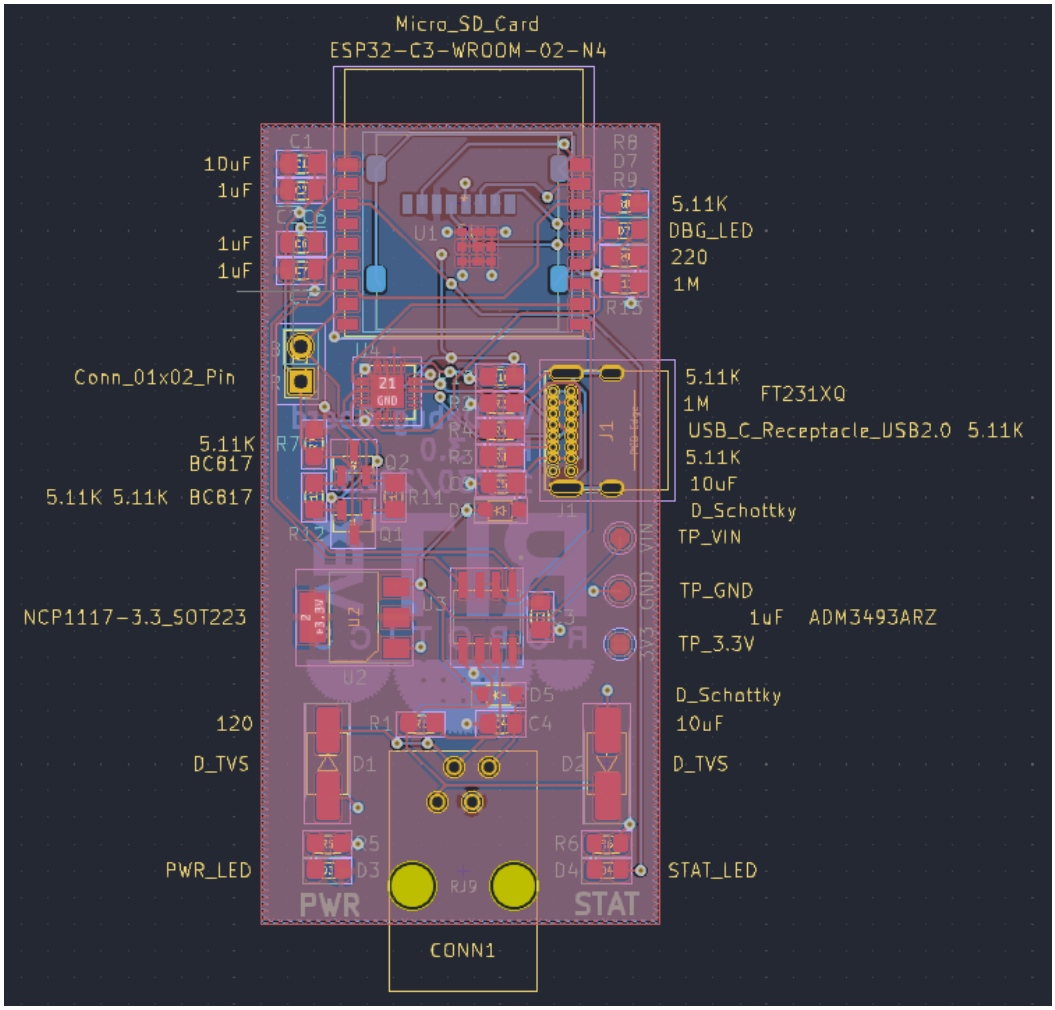


Figure 24 - Debug Board PCB Layout

Hardware design is nearing completion, with 3 revisions built and tested. Revision 3.0 is powered by an ESP32-C3-WROOM2 microcontroller, and uses an RS-485 transceiver to communicate with the Brain over a smart-port. The new addition of a Micro-SD card allows users to upload their own 3D model of the robot, and provides data logging capabilities.

As of now, the hardware design is nearly complete. Software has achieved WiFi AP broadcasting, TCP communications and work is starting on the Micro-ROS implementation. The design is fully open source under the GPL-3 license, and is hosted at ***github.com/superrm11/VexDebugBoard*.**

RIT VEXU Core API

Generated by Doxygen 1.10.0

Chapter 1

Core

This is the host repository for the custom VEX libraries used by the RIT VEXU team

Automatically updated documentation is available at here. There is also a downloadable reference manual.

1.1 Getting Started

In order to simply use this repo, you can either clone it into your VEXcode project folder, or download the .zip and place it into a core/ subfolder. Then follow the instructions for setting up compilation at Wiki/BuildSystem

If you wish to contribute, follow the instructions at Wiki/ProjectSetup

1.2 Features

Here is the current feature list this repo provides:

Subsystems (See Wiki/Subsystems):

- Tank drivetrain (user control / autonomous)
- Mecanum drivetrain (user control / autonomous)
- Odometry
- Flywheel
- Lift
- Custom encoders

Utilities (See Wiki/Utilites):

- PID controller
- FeedForward controller
- Trapezoidal motion profile controller
- Pure Pursuit
- Generic auto program builder
- Auto program UI selector
- Mathematical classes (Vector2D, Moving Average)

Chapter 2

Hierarchical Index

2.1 Class Hierarchy

This inheritance list is sorted roughly, but not completely, alphabetically:

Chapter 3

Class Index

3.1 Class List

Here are the classes, structs, unions and interfaces with brief descriptions:

Chapter 4

File Index

4.1 File List

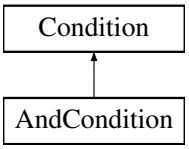
Here is a list of all documented files with brief descriptions:

Chapter 5

Class Documentation

5.1 AndCondition Class Reference

Inheritance diagram for AndCondition:



Public Member Functions

- **AndCondition** (Condition ∗A, Condition ∗B)
- bool test () override

Public Member Functions inherited from Condition

- Condition ∗ **Or** (Condition ∗b)
- Condition ∗ **And** (Condition ∗b)

5.1.1 Member Function Documentation

5.1.1.1 test()

```
bool AndCondition::test ( )  [inline], [override], [virtual]
```

Implements Condition.

The documentation for this class was generated from the following file:

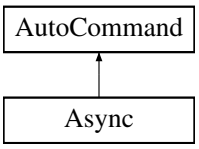
- src/utils/command_structure/auto_command.cpp

5.2 Async Class Reference

Async runs a command asynchronously will simply let it go and never look back THIS HAS A VERY NICHE USE CASE. THINK ABOUT IF YOU REALLY NEED IT.

`#include <auto_command.h>`

Inheritance diagram for Async:



Public Member Functions

- **Async** (AutoCommand ∗cmd)
- bool run () override

Public Member Functions inherited from AutoCommand

- virtual void on_timeout ()
- AutoCommand ∗ **withTimeout** (double t_seconds)
- AutoCommand ∗ **withCancelCondition** (Condition ∗true_to_end)

Additional Inherited Members

Public Attributes inherited from AutoCommand

- double timeout_seconds = default_timeout
- Condition ∗ **true_to_end** = nullptr

Static Public Attributes inherited from AutoCommand

- static constexpr double **default_timeout** = 10.0

5.2.1 Detailed Description

Async runs a command asynchronously will simply let it go and never look back THIS HAS A VERY NICHE USE CASE. THINK ABOUT IF YOU REALLY NEED IT.

5.2.2 Member Function Documentation

5.2.2.1 run()

```
bool Async::run ( )  [override], [virtual]
```

Executes the command Overridden by child classes

Returns

true when the command is finished, false otherwise

Reimplemented from AutoCommand.

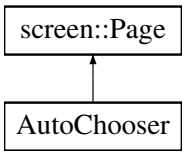
The documentation for this class was generated from the following files:

- include/utils/command_structure/auto_command.h
- src/utils/command_structure/auto_command.cpp

5.3 AutoChooser Class Reference

```
#include <auto_chooser.h>
```

Inheritance diagram for AutoChooser:



Classes

- struct entry_t

Public Member Functions

- AutoChooser (std::vector< std::string > paths, size_t def=0)
- void update (bool was_pressed, int x, int y)

  collect data, respond to screen input, do fast things (runs at 50hz even if you're not focused on this Page (only drawn page gets touch updates))
- void draw (vex::brain::lcd &, bool first_draw, unsigned int frame_number)

  draw stored data to the screen (runs at 10 hz and only runs if this page is in front)
- size_t get_choice ()

Protected Attributes

- size_t choice
- std::vector< entry_t > list

Static Protected Attributes

- static const size_t **width** = 380
- static const size_t **height** = 220

5.3.1 Detailed Description

Autochooser is a utility to make selecting robot autonomous programs easier source: RIT VexU Wiki During a season, we usually code between 4 and 6 autonomous programs. Most teams will change their entire robot program as a way of choosing autonomi but this may cause issues if you have an emergency patch to upload during a competition. This class was built as a way of using the robot screen to list autonomous programs, and the touchscreen to select them.

5.3.2 Constructor & Destructor Documentation

5.3.2.1 AutoChooser()

```
AutoChooser::AutoChooser (
            std::vector< std::string > paths,
            size_t def = 0 )
```

Initialize the auto-chooser. This class places a choice menu on the brain screen, so the driver can choose which autonomous to run.

Parameters

brain	the brain on which to draw the selection boxes

5.3.3 Member Function Documentation

5.3.3.1 draw()

```
void AutoChooser::draw (
            vex::brain::lcd & screen,
            bool first_draw,
            unsigned int frame_number )  [virtual]
```

draw stored data to the screen (runs at 10 hz and only runs if this page is in front)

Parameters

first_draw	true if we just switched to this page
frame_number	frame of drawing we are on (basically an animation tick)

Reimplemented from screen::Page.

5.3.3.2 get_choice()

```
size_t AutoChooser::get_choice ( )
```

Get the currently selected auto choice

Returns

the identifier to the auto path

Return the selected autonomous

5.3.3.3 update()

```
void AutoChooser::update (
            bool was_pressed,
            int x,
            int y )  [virtual]
```

collect data, respond to screen input, do fast things (runs at 50hz even if you're not focused on this Page (only drawn page gets touch updates))

Parameters

was_pressed	true if the screen has been pressed
x	x position of screen press (if the screen was pressed)
y	y position of screen press (if the screen was pressed)

Reimplemented from screen::Page.

5.3.4 Member Data Documentation

5.3.4.1 choice

```
size_t AutoChooser::choice  [protected]
```

the current choice of auto

5.3.4.2 list

```
std::vector<entry_t> AutoChooser::list  [protected]
```

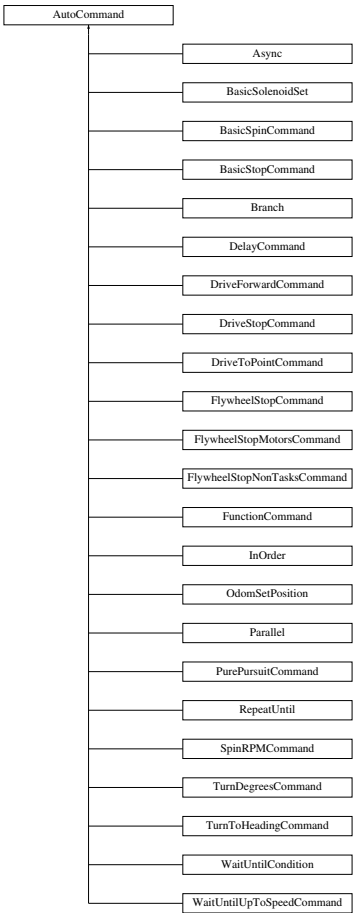
< a list of all possible auto choices

The documentation for this class was generated from the following files:

- include/utils/auto_chooser.h
- src/utils/auto_chooser.cpp

5.4 AutoCommand Class Reference

Inheritance diagram for AutoCommand:



Public Member Functions

- virtual bool run ()
- virtual void on_timeout ()
- AutoCommand * **withTimeout** (double t_seconds)
- AutoCommand * **withCancelCondition** (Condition *true_to_end)

Public Attributes

- double timeout_seconds = default_timeout
- Condition * **true_to_end** = nullptr

Static Public Attributes

- static constexpr double **default_timeout** = 10.0

5.4.1 Member Function Documentation

5.4.1.1 on_timeout()

```
virtual void AutoCommand::on_timeout ( )  [inline], [virtual]
```

What to do if we timeout instead of finishing. timeout is specified by the timeout seconds in the constructor

Reimplemented in InOrder, Parallel, Branch, RepeatUntil, DriveForwardCommand, TurnDegreesCommand, TurnToHeadingCommand, PurePursuitCommand, and DriveStopCommand.

5.4.1.2 run()

```
virtual bool AutoCommand::run ( )  [inline], [virtual]
```

Executes the command Overridden by child classes

Returns

true when the command is finished, false otherwise

Reimplemented in FunctionCommand, WaitUntilCondition, InOrder, Parallel, Branch, Async, RepeatUntil, BasicSpinCommand, BasicStopCommand, BasicSolenoidSet, DelayCommand, DriveForwardCommand, TurnDegreesCommand, DriveToPointCommand, TurnToHeadingCommand, PurePursuitCommand, DriveStopCommand, OdomSetPosition, SpinRPMCommand, WaitUntilUpToSpeedCommand, FlywheelStopCommand, and FlywheelStopMotorsCommand.

5.4.2 Member Data Documentation

5.4.2.1 timeout_seconds

```
double AutoCommand::timeout_seconds = default_timeout
```

How long to run until we cancel this command. If the command is cancelled, on_timeout() is called to allow any cleanup from the function. If the timeout_seconds <= 0, no timeout will be applied and this command will run forever A timeout can come in handy for some commands that can not reach the end due to some physical limitation such as

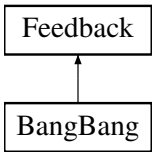
- a drive command hitting a wall and not being able to reach its target
- a command that waits until something is up to speed that never gets up to speed because of battery voltage
- something else...

The documentation for this class was generated from the following file:

- include/utils/command_structure/auto_command.h

5.5 BangBang Class Reference

Inheritance diagram for BangBang:



Public Member Functions

- **BangBang** (double thresshold, double low, double high)
- void init (double start_pt, double set_pt, double start_vel=0.0, double end_vel=0.0) override
- double update (double val) override
- double get () override
- void set_limits (double lower, double upper) override
- bool is_on_target () override

5.5.1 Member Function Documentation

5.5.1.1 get()

```
double BangBang::get ( )  [override], [virtual]
```

Returns

the last saved result from the feedback controller

Implements Feedback.

5.5.1.2 init()

```
void BangBang::init (
            double start_pt,
            double set_pt,
            double start_vel = 0.0,
            double end_vel = 0.0 )  [override], [virtual]
```

Initialize the feedback controller for a movement

Parameters

start_pt	the current sensor value
set_pt	where the sensor value should be
start_vel	Movement starting velocity
end_vel	Movement ending velocity

Implements Feedback.

5.5.1.3 is_on_target()

```
bool BangBang::is_on_target ( )  [override], [virtual]
```

Returns

true if the feedback controller has reached it's setpoint

Implements Feedback.

5.5.1.4 set_limits()

```
void BangBang::set_limits (
            double lower,
            double upper )  [override], [virtual]
```

Clamp the upper and lower limits of the output. If both are 0, no limits should be applied.

Parameters

lower	Upper limit
upper	Lower limit

Implements Feedback.

5.5.1.5 update()

```
double BangBang::update (
            double val )  [override], [virtual]
```

Iterate the feedback loop once with an updated sensor value

Parameters

val	value from the sensor

Returns

feedback loop result

Implements Feedback.

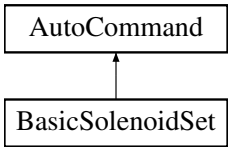
The documentation for this class was generated from the following files:

- include/utils/controls/bang_bang.h
- src/utils/controls/bang_bang.cpp

5.6 BasicSolenoidSet Class Reference

`#include <basic_command.h>`

Inheritance diagram for BasicSolenoidSet:



Public Member Functions

- BasicSolenoidSet (vex::pneumatics &solenoid, bool setting)

  Construct a new BasicSolenoidSet Command.
- bool run () override

  Runs the BasicSolenoidSet Overrides run command from AutoCommand.

Public Member Functions inherited from AutoCommand

- virtual void on_timeout ()
- AutoCommand * **withTimeout** (double t_seconds)
- AutoCommand * **withCancelCondition** (Condition *true_to_end)

Additional Inherited Members

Public Attributes inherited from AutoCommand

- double timeout_seconds = default_timeout
- Condition * **true_to_end** = nullptr

Static Public Attributes inherited from AutoCommand

- static constexpr double **default_timeout** = 10.0

5.6.1 Detailed Description

AutoCommand wrapper class for BasicSolenoidSet Using the Vex hardware functions

5.6.2 Constructor & Destructor Documentation

5.6.2.1 BasicSolenoidSet()

```
BasicSolenoidSet::BasicSolenoidSet (
            vex::pneumatics & solenoid,
            bool setting )
```

Construct a new BasicSolenoidSet Command.

Parameters

solenoid	Solenoid being set
setting	Setting of the solenoid in boolean (true,false)

5.6.3 Member Function Documentation

5.6.3.1 run()

```
bool BasicSolenoidSet::run ( )  [override], [virtual]
```

Runs the BasicSolenoidSet Overrides run command from AutoCommand.

Returns

True Command runs once

Reimplemented from AutoCommand.

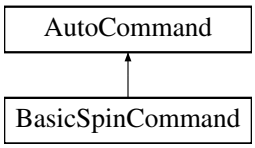
The documentation for this class was generated from the following files:

- include/utils/command_structure/basic_command.h
- src/utils/command_structure/basic_command.cpp

5.7 BasicSpinCommand Class Reference

```
#include <basic_command.h>
```

Inheritance diagram for BasicSpinCommand:



Public Types

- enum **type** { **percent** , **voltage** , **veocity** }

Public Member Functions

- BasicSpinCommand (vex::motor &motor, vex::directionType dir, BasicSpinCommand::type setting, double power)

  Construct a new BasicSpinCommand.
- bool run () override

  Runs the BasicSpinCommand Overrides run from Auto Command.

Public Member Functions inherited from AutoCommand

- virtual void on_timeout ()
- AutoCommand * **withTimeout** (double t_seconds)
- AutoCommand * **withCancelCondition** (Condition *true_to_end)

Additional Inherited Members

Public Attributes inherited from AutoCommand

- double timeout_seconds = default_timeout
- Condition * **true_to_end** = nullptr

Static Public Attributes inherited from AutoCommand

- static constexpr double **default_timeout** = 10.0

5.7.1 Detailed Description

AutoCommand wrapper class for BasicSpinCommand using the vex hardware functions

5.7.2 Constructor & Destructor Documentation

5.7.2.1 BasicSpinCommand()

```
BasicSpinCommand::BasicSpinCommand (
            vex::motor & motor,
            vex::directionType dir,
            BasicSpinCommand::type setting,
            double power )
```

Construct a new BasicSpinCommand.

a BasicMotorSpin Command

Parameters

motor	Motor to spin
direc	Direction of motor spin
setting	Power setting in volts,percentage,velocity
power	Value of desired power
motor	Motor port to spin
dir	Direction for spining
setting	Power setting in volts,percentage,velocity
power	Value of desired power

5.7.3 Member Function Documentation

5.7.3.1 run()

```
bool BasicSpinCommand::run ( )  [override], [virtual]
```

Runs the BasicSpinCommand Overrides run from Auto Command.

Run the BasicSpinCommand Overrides run from Auto Command.

Returns

True Async running command

True Command runs once

Reimplemented from AutoCommand.

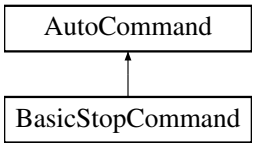
The documentation for this class was generated from the following files:

- include/utils/command_structure/basic_command.h
- src/utils/command_structure/basic_command.cpp

5.8 BasicStopCommand Class Reference

```
#include <basic_command.h>
```

Inheritance diagram for BasicStopCommand:



Public Member Functions

- BasicStopCommand (vex::motor &motor, vex::brakeType setting)

  Construct a new BasicMotorStop Command.
- bool run () override

  Runs the BasicMotorStop Command Overrides run command from AutoCommand.

Public Member Functions inherited from AutoCommand

- virtual void on_timeout ()
- AutoCommand * **withTimeout** (double t_seconds)
- AutoCommand * **withCancelCondition** (Condition *true_to_end)

Additional Inherited Members

Public Attributes inherited from AutoCommand

- double timeout_seconds = default_timeout
- Condition * **true_to_end** = nullptr

Static Public Attributes inherited from AutoCommand

- static constexpr double **default_timeout** = 10.0

5.8.1 Detailed Description

AutoCommand wrapper class for BasicStopCommand Using the Vex hardware functions

5.8.2 Constructor & Destructor Documentation

5.8.2.1 BasicStopCommand()

```
BasicStopCommand::BasicStopCommand (
            vex::motor & motor,
            vex::brakeType setting )
```

Construct a new BasicMotorStop Command.

Construct a BasicMotorStop Command.

Parameters

motor	The motor to stop
setting	The brake setting for the motor
motor	Motor to stop
setting	Braketype setting brake,coast,hold

5.8.3 Member Function Documentation

5.8.3.1 run()

```
bool BasicStopCommand::run ( )  [override], [virtual]
```

Runs the BasicMotorStop Command Overrides run command from AutoCommand.

Runs the BasicMotorStop command Ovverides run command from AutoCommand.

Returns

True Command runs once

Reimplemented from AutoCommand.

The documentation for this class was generated from the following files:

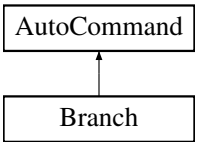
- include/utils/command_structure/basic_command.h
- src/utils/command_structure/basic_command.cpp

5.9 Branch Class Reference

Branch chooses from multiple options at runtime. the function decider returns an index into the choices vector If you wish to make no choice and skip this section, return NO_CHOICE; any choice that is out of bounds set to NO_CHOICE.

`#include <auto_command.h>`

Inheritance diagram for Branch:



Public Member Functions

- **Branch** (Condition *cond, AutoCommand *false_choice, AutoCommand *true_choice)
- bool run () override
- void on_timeout () override

Public Member Functions inherited from AutoCommand

- AutoCommand * **withTimeout** (double t_seconds)
- AutoCommand * **withCancelCondition** (Condition *true_to_end)

Additional Inherited Members

Public Attributes inherited from AutoCommand

- double timeout_seconds = default_timeout
- Condition * **true_to_end** = nullptr

Static Public Attributes inherited from AutoCommand

- static constexpr double **default_timeout** = 10.0

5.9.1 Detailed Description

Branch chooses from multiple options at runtime. the function decider returns an index into the choices vector If you wish to make no choice and skip this section, return NO_CHOICE; any choice that is out of bounds set to NO_CHOICE.

5.9.2 Member Function Documentation

5.9.2.1 on_timeout()

```
void Branch::on_timeout ( )  [override], [virtual]
```

What to do if we timeout instead of finishing. timeout is specified by the timeout seconds in the constructor

Reimplemented from AutoCommand.

5.9.2.2 run()

```
bool Branch::run ( )  [override], [virtual]
```

Executes the command Overridden by child classes

Returns

true when the command is finished, false otherwise

Reimplemented from AutoCommand.

The documentation for this class was generated from the following files:

- include/utils/command_structure/auto_command.h
- src/utils/command_structure/auto_command.cpp

5.10 screen::ButtonConfig Struct Reference

Public Attributes

- std::function< void()> **onclick**

The documentation for this struct was generated from the following file:

- include/subsystems/screen.h

5.11 screen::ButtonWidget Class Reference

Widget that does something when you tap it. The function is only called once when you first tap it.

```
#include <screen.h>
```

Public Member Functions

- ButtonWidget (std::function< void(void)> onpress, Rect rect, std::string name)

  Create a Button widget.
- ButtonWidget (void(*onpress)(), Rect rect, std::string name)

  Create a Button widget.
- bool update (bool was_pressed, int x, int y)

  responds to user input
- void **draw** (vex::brain::lcd &, bool first_draw, unsigned int frame_number)

  draws the button to the screen

5.11.1 Detailed Description

Widget that does something when you tap it. The function is only called once when you first tap it.

5.11.2 Constructor & Destructor Documentation

5.11.2.1 ButtonWidget() [1/2]

```
screen::ButtonWidget::ButtonWidget (
            std::function< void(void)> onpress,
            Rect rect,
            std::string name )  [inline]
```

Create a Button widget.

Parameters

onpress	the function to be called when the button is tapped
rect	the area the button should take up on the screen
name	the label put on the button

5.11.2.2 ButtonWidget() [2/2]

```
screen::ButtonWidget::ButtonWidget (
            void(*)() onpress,
            Rect rect,
            std::string name )  [inline]
```

Create a Button widget.

Parameters

onpress	the function to be called when the button is tapped
rect	the area the button should take up on the screen
name	the label put on the button

5.11.3 Member Function Documentation

5.11.3.1 update()

```
bool screen::ButtonWidget::update (
            bool was_pressed,
            int x,
            int y )
```

responds to user input

Parameters

was_pressed	if the screen is pressed
x	x position if the screen was pressed
y	y position if the screen was pressed

Returns

true if the button was pressed

The documentation for this class was generated from the following files:

- include/subsystems/screen.h
- src/subsystems/screen.cpp

5.12 screen::CheckboxConfig Struct Reference

Public Attributes

- std::function< void(bool)> **onupdate**

The documentation for this struct was generated from the following file:

- include/subsystems/screen.h

5.13 CommandController Class Reference

```
#include <command_controller.h>
```

Public Member Functions

- **CommandController** ()

  Create an empty CommandController. Add Command with CommandController::add()
- CommandController (std::initializer_list< AutoCommand * > cmds)

  Create a CommandController with commands pre added. More can be added with CommandController::add()
- void add (std::vector< AutoCommand * > cmds)
- void add (AutoCommand *cmd, double timeout_seconds=10.0)
- void add (std::vector< AutoCommand * > cmds, double timeout_sec)
- void add_delay (int ms)
- void add_cancel_func (std::function< bool(void)> true_if_cancel)

  add_cancel_func specifies that when this func evaluates to true, to cancel the command controller
- void run ()
- bool last_command_timed_out ()

5.13.1 Detailed Description

File: command_controller.h Desc: A CommandController manages the AutoCommands that make up an autonomous route. The AutoCommands are kept in a queue and get executed and removed from the queue in FIFO order.

5.13.2 Constructor & Destructor Documentation

5.13.2.1 CommandController()

```
CommandController::CommandController (
            std::initializer_list< AutoCommand * > cmds )  [inline]
```

Create a CommandController with commands pre added. More can be added with CommandController::add()

Parameters

cmds	

5.13.3 Member Function Documentation

5.13.3.1 add() [1/3]

```
void CommandController::add (
            AutoCommand * cmd,
            double timeout_seconds = 10.0 )
```

File: command_controller.cpp Desc: A CommandController manages the AutoCommands that make up an autonomous route. The AutoCommands are kept in a queue and get executed and removed from the queue in FIFO order. Adds a command to the queue

Parameters

cmd	the AutoCommand we want to add to our list
timeout_seconds	the number of seconds we will let the command run for. If it exceeds this, we cancel it and run on_timeout

5.13.3.2 add() [2/3]

```
void CommandController::add (
            std::vector< AutoCommand * > cmds )
```

Adds a command to the queue

Parameters

cmd	the AutoCommand we want to add to our list
timeout_seconds	the number of seconds we will let the command run for. If it exceeds this, we cancel it and run on_timeout. if it is <= 0 no time out will be applied

Add multiple commands to the queue. No timeout here.

Parameters

cmds	the AutoCommands we want to add to our list

5.13.3.3 add() [3/3]

```
void CommandController::add (
            std::vector< AutoCommand * > cmds,
            double timeout_sec )
```

Add multiple commands to the queue. No timeout here.

Parameters

cmds	the AutoCommands we want to add to our list Add multiple commands to the queue. No timeout here.
cmds	the AutoCommands we want to add to our list
timeout_sec	timeout in seconds to apply to all commands if they are still the default

Add multiple commands to the queue. No timeout here.

Parameters

cmds	the AutoCommands we want to add to our list
timeout	timeout in seconds to apply to all commands if they are still the default

5.13.3.4 add_cancel_func()

```
void CommandController::add_cancel_func (
            std::function< bool(void)> true_if_cancel )
```

add_cancel_func specifies that when this func evaluates to true, to cancel the command controller

Parameters

true_if_cancel	a function that returns true when we want to cancel the command controller

5.13.3.5 add_delay()

```
void CommandController::add_delay (
            int ms )
```

Adds a command that will delay progression of the queue

Parameters

ms	- number of milliseconds to wait before continuing execution of autonomous

5.13.3.6 last_command_timed_out()

```
bool CommandController::last_command_timed_out ( )
```

last_command_timed_out tells how the last command ended Use this if you want to make decisions based on the end of the last command

Returns

true if the last command timed out. false if it finished regularly

5.13.3.7 run()

```
void CommandController::run ( )
```

Begin execution of the queue Execute and remove commands in FIFO order

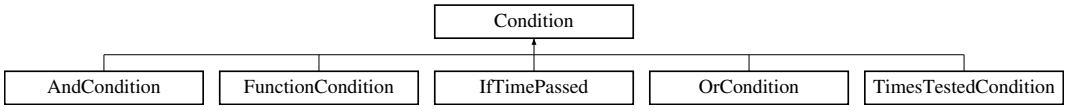
The documentation for this class was generated from the following files:

- include/utils/command_structure/command_controller.h
- src/utils/command_structure/command_controller.cpp

5.14 Condition Class Reference

```
#include <auto_command.h>
```

Inheritance diagram for Condition:



Public Member Functions

- Condition * **Or** (Condition *b)
- Condition * **And** (Condition *b)
- virtual bool **test** ()=0

5.14.1 Detailed Description

File: auto_command.h Desc: Interface for module-specifc commands A Condition is a function that returns true or false is_even is a predicate that would return true if a number is even For our purposes, a Condition is a choice to be made at runtime drive_sys.reached_point(10, 30) is a predicate time.has_elapsed(10, vex::seconds) is a predicate extend this class for different choices you wish to make

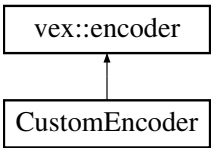
The documentation for this class was generated from the following files:

- include/utils/command_structure/auto_command.h
- src/utils/command_structure/auto_command.cpp

5.15 CustomEncoder Class Reference

`#include <custom_encoder.h>`

Inheritance diagram for CustomEncoder:



Public Member Functions

- CustomEncoder (vex::triport::port &port, double ticks_per_rev)
- void setRotation (double val, vex::rotationUnits units)
- void setPosition (double val, vex::rotationUnits units)
- double rotation (vex::rotationUnits units)
- double position (vex::rotationUnits units)
- double velocity (vex::velocityUnits units)

5.15.1 Detailed Description

A wrapper class for the vex encoder that allows the use of 3rd party encoders with different tick-per-revolution values.

5.15.2 Constructor & Destructor Documentation

5.15.2.1 CustomEncoder()

```
CustomEncoder::CustomEncoder (
            vex::triport::port & port,
            double ticks_per_rev )
```

Construct an encoder with a custom number of ticks

Parameters

port	the triport port on the brain the encoder is plugged into
ticks_per_rev	the number of ticks the encoder will report for one revolution

5.15.3 Member Function Documentation

5.15.3.1 position()

```
double CustomEncoder::position (
            vex::rotationUnits units )
```

get the position that the encoder is at

Parameters

units	the unit we want the return value to be in

Returns

the position of the encoder in the units specified

5.15.3.2 rotation()

```
double CustomEncoder::rotation (
            vex::rotationUnits units )
```

get the rotation that the encoder is at

Parameters

units	the unit we want the return value to be in

Returns

the rotation of the encoder in the units specified

5.15.3.3 setPosition()

```
void CustomEncoder::setPosition (
            double val,
            vex::rotationUnits units )
```

sets the stored position of the encoder. Any further movements will be from this value

Parameters

val	the numerical value of the position we are setting to
units	the unit of val

5.15.3.4 setRotation()

```
void CustomEncoder::setRotation (
            double val,
            vex::rotationUnits units )
```

sets the stored rotation of the encoder. Any further movements will be from this value

Parameters

val	the numerical value of the angle we are setting to
units	the unit of val

5.15.3.5 velocity()

```
double CustomEncoder::velocity (
            vex::velocityUnits units )
```

get the velocity that the encoder is moving at

Parameters

units	the unit we want the return value to be in

Returns

the velocity of the encoder in the units specified

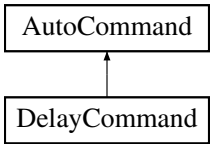
The documentation for this class was generated from the following files:

- include/subsystems/custom_encoder.h
- src/subsystems/custom_encoder.cpp

5.16 DelayCommand Class Reference

`#include <delay_command.h>`

Inheritance diagram for DelayCommand:



Public Member Functions

- DelayCommand (int ms)
- bool run () override

Public Member Functions inherited from AutoCommand

- virtual void on_timeout ()
- AutoCommand * **withTimeout** (double t_seconds)
- AutoCommand * **withCancelCondition** (Condition *true_to_end)

Additional Inherited Members

Public Attributes inherited from AutoCommand

- double timeout_seconds = default_timeout
- Condition * **true_to_end** = nullptr

Static Public Attributes inherited from AutoCommand

- static constexpr double **default_timeout** = 10.0

5.16.1 Detailed Description

File: delay_command.h Desc: A DelayCommand will make the robot wait the set amount of milliseconds before continuing execution of the autonomous route

5.16.2 Constructor & Destructor Documentation

5.16.2.1 DelayCommand()

```
DelayCommand::DelayCommand (
            int ms )  [inline]
```

Construct a delay command

Parameters

ms	the number of milliseconds to delay for

5.16.3 Member Function Documentation

5.16.3.1 run()

```
bool DelayCommand::run ( )  [inline], [override], [virtual]
```

Delays for the amount of milliseconds stored in the command Overrides run from AutoCommand

Returns

true when complete

Reimplemented from AutoCommand.

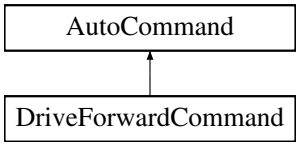
The documentation for this class was generated from the following file:

- include/utils/command_structure/delay_command.h

5.17 DriveForwardCommand Class Reference

`#include <drive_commands.h>`

Inheritance diagram for DriveForwardCommand:



Public Member Functions

- DriveForwardCommand (TankDrive &drive_sys, Feedback &feedback, double inches, directionType dir, double max_speed=1, double end_speed=0)
- bool run () override
- void on_timeout () override

Public Member Functions inherited from AutoCommand

- AutoCommand * **withTimeout** (double t_seconds)
- AutoCommand * **withCancelCondition** (Condition *true_to_end)

Additional Inherited Members

Public Attributes inherited from AutoCommand

- double timeout_seconds = default_timeout
- Condition * **true_to_end** = nullptr

Static Public Attributes inherited from AutoCommand

- static constexpr double **default_timeout** = 10.0

5.17.1 Detailed Description

AutoCommand wrapper class for the drive_forward function in the TankDrive class

5.17.2 Constructor & Destructor Documentation

5.17.2.1 DriveForwardCommand()

```
DriveForwardCommand::DriveForwardCommand (
            TankDrive & drive_sys,
            Feedback & feedback,
            double inches,
            directionType dir,
            double max_speed = 1,
            double end_speed = 0 )
```

File: drive_commands.h Desc: Holds all the AutoCommand subclasses that wrap (currently) TankDrive functions

Currently includes:

- drive_forward
- turn_degrees
- drive_to_point
- turn_to_heading
- stop

Also holds AutoCommand subclasses that wrap OdometryBase functions

Currently includes:

- set_position Construct a DriveForward Command

Parameters

drive_sys	the drive system we are commanding
feedback	the feedback controller we are using to execute the drive
inches	how far forward to drive
dir	the direction to drive
max_speed	0 -> 1 percentage of the drive systems speed to drive at

5.17.3 Member Function Documentation

5.17.3.1 on_timeout()

```
void DriveForwardCommand::on_timeout ( )  [override], [virtual]
```

Cleans up drive system if we time out before finishing

reset the drive system if we timeout

Reimplemented from AutoCommand.

5.17.3.2 run()

```
bool DriveForwardCommand::run ( )  [override], [virtual]
```

Run drive_forward Overrides run from AutoCommand

Returns

true when execution is complete, false otherwise

Reimplemented from AutoCommand.

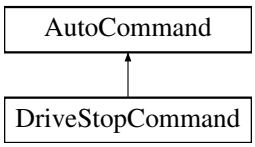
The documentation for this class was generated from the following files:

- include/utils/command_structure/drive_commands.h
- src/utils/command_structure/drive_commands.cpp

5.18 DriveStopCommand Class Reference

```
#include <drive_commands.h>
```

Inheritance diagram for DriveStopCommand:



Public Member Functions

- DriveStopCommand (TankDrive &drive_sys)
- bool run () override
- void on_timeout () override

Public Member Functions inherited from AutoCommand

- AutoCommand * **withTimeout** (double t_seconds)
- AutoCommand * **withCancelCondition** (Condition *true_to_end)

Additional Inherited Members

Public Attributes inherited from AutoCommand

- double timeout_seconds = default_timeout
- Condition * **true_to_end** = nullptr

Static Public Attributes inherited from AutoCommand

- static constexpr double **default_timeout** = 10.0

5.18.1 Detailed Description

AutoCommand wrapper class for the stop() function in the TankDrive class

5.18.2 Constructor & Destructor Documentation

5.18.2.1 DriveStopCommand()

```
DriveStopCommand::DriveStopCommand (
            TankDrive & drive_sys )
```

Construct a DriveStop Command

Parameters

drive_sys	the drive system we are commanding

5.18.3 Member Function Documentation

5.18.3.1 on_timeout()

```
void DriveStopCommand::on_timeout ( )  [override], [virtual]
```

What to do if we timeout instead of finishing. timeout is specified by the timeout seconds in the constructor

Reimplemented from AutoCommand.

5.18.3.2 run()

```
bool DriveStopCommand::run ( )  [override], [virtual]
```

Stop the drive system Overrides run from AutoCommand

Returns

true when execution is complete, false otherwise

Stop the drive train Overrides run from AutoCommand

Returns

true when execution is complete, false otherwise

Reimplemented from AutoCommand.

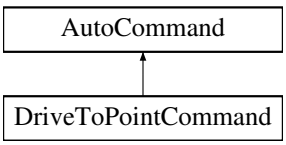
The documentation for this class was generated from the following files:

- include/utils/command_structure/drive_commands.h
- src/utils/command_structure/drive_commands.cpp

5.19 DriveToPointCommand Class Reference

`#include <drive_commands.h>`

Inheritance diagram for DriveToPointCommand:



Public Member Functions

- DriveToPointCommand (TankDrive &drive_sys, Feedback &feedback, double x, double y, directionType dir, double max_speed=1, double end_speed=0)
- DriveToPointCommand (TankDrive &drive_sys, Feedback &feedback, point_t point, directionType dir, double max_speed=1, double end_speed=0)
- bool run () override

Public Member Functions inherited from AutoCommand

- AutoCommand * **withTimeout** (double t_seconds)
- AutoCommand * **withCancelCondition** (Condition *true_to_end)

Additional Inherited Members

Public Attributes inherited from AutoCommand

- double timeout_seconds = default_timeout
- Condition * **true_to_end** = nullptr

Static Public Attributes inherited from AutoCommand

- static constexpr double **default_timeout** = 10.0

5.19.1 Detailed Description

AutoCommand wrapper class for the drive_to_point function in the TankDrive class

5.19.2 Constructor & Destructor Documentation

5.19.2.1 DriveToPointCommand() [1/2]

```
DriveToPointCommand::DriveToPointCommand (
            TankDrive & drive_sys,
            Feedback & feedback,
            double x,
            double y,
            directionType dir,
            double max_speed = 1,
            double end_speed = 0 )
```

Construct a DriveForward Command

Parameters

drive_sys	the drive system we are commanding
feedback	the feedback controller we are using to execute the drive
x	where to drive in the x dimension
y	where to drive in the y dimension
dir	the direction to drive
max_speed	0 -> 1 percentage of the drive systems speed to drive at

5.19.2.2 DriveToPointCommand() [2/2]

```
DriveToPointCommand::DriveToPointCommand (
            TankDrive & drive_sys,
            Feedback & feedback,
            point_t point,
            directionType dir,
            double max_speed = 1,
            double end_speed = 0 )
```

Construct a DriveForward Command

Parameters

drive_sys	the drive system we are commanding
feedback	the feedback controller we are using to execute the drive
point	the point to drive to
dir	the direction to drive
max_speed	0 -> 1 percentage of the drive systems speed to drive at

5.19.3 Member Function Documentation

5.19.3.1 run()

```
bool DriveToPointCommand::run ( )  [override], [virtual]
```

Run drive_to_point Overrides run from AutoCommand

Returns

true when execution is complete, false otherwise

Reimplemented from AutoCommand.

The documentation for this class was generated from the following files:

- include/utils/command_structure/drive_commands.h
- src/utils/command_structure/drive_commands.cpp

5.20 AutoChooser::entry_t Struct Reference

```
#include <auto_chooser.h>
```

Public Attributes

- Rect **rect**
- std::string name

5.20.1 Detailed Description

entry_t is a datatype used to store information that the chooser knows about an auto selection button

5.20.2 Member Data Documentation

5.20.2.1 name

```
std::string AutoChooser::entry_t::name
```

name of the auto repretsented by the block

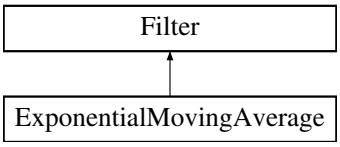
The documentation for this struct was generated from the following file:

- include/utils/auto_chooser.h

5.21 ExponentialMovingAverage Class Reference

`#include <moving_average.h>`

Inheritance diagram for ExponentialMovingAverage:



Public Member Functions

- ExponentialMovingAverage (int buffer_size)
- ExponentialMovingAverage (int buffer_size, double starting_value)
- void add_entry (double n) override
- double get_value () const override
- int get_size ()

5.21.1 Detailed Description

ExponentialMovingAverage

An exponential moving average is a way of smoothing out noisy data. For many sensor readings, the noise is roughly symmetric around the actual value. This means that if you collect enough samples those that are too high are cancelled out by the samples that are too low leaving the real value.

A simple mobing average lags significantly with time as it has to counteract old samples. An exponential moving average keeps more up to date by weighting newer readings higher than older readings so it is more up to date while also still smoothed.

The ExponentialMovingAverage class provides an simple interface to do this smoothing from our noisy sensor values.

5.21.2 Constructor & Destructor Documentation

5.21.2.1 ExponentialMovingAverage() [1/2]

```
ExponentialMovingAverage::ExponentialMovingAverage (
            int buffer_size )
```

Create a moving average calculator with 0 as the default value

Parameters

buffer_size	The size of the buffer. The number of samples that constitute a valid reading

5.21.2.2 ExponentialMovingAverage() [2/2]

```
ExponentialMovingAverage::ExponentialMovingAverage (
            int buffer_size,
            double starting_value )
```

Create a moving average calculator with a specified default value

Parameters

buffer_size	The size of the buffer. The number of samples that constitute a valid reading
starting_value	The value that the average will be before any data is added

5.21.3 Member Function Documentation

5.21.3.1 add_entry()

```
void ExponentialMovingAverage::add_entry (
            double n )  [override], [virtual]
```

Add a reading to the buffer Before: [1 1 2 2 3 3] => 2 ^ After: [2 1 2 2 3 3] => 2.16 ^

Parameters

n	the sample that will be added to the moving average.

Implements Filter.

5.21.3.2 get_size()

```
int ExponentialMovingAverage::get_size ( )
```

How many samples the average is made from

Returns

the number of samples used to calculate this average

5.21.3.3 get_value()

```
double ExponentialMovingAverage::get_value ( ) const  [override], [virtual]
```

Returns the average based off of all the samples collected so far

Returns

the calculated average. sum(samples)/numsamples

How many samples the average is made from

Returns

the number of samples used to calculate this average

Implements Filter.

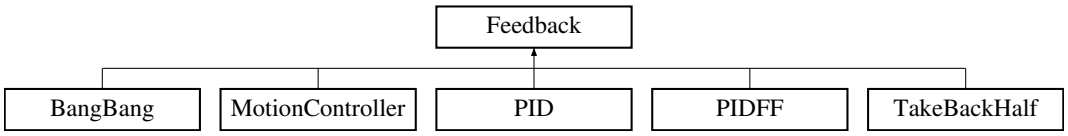
The documentation for this class was generated from the following files:

- include/utils/moving_average.h
- src/utils/moving_average.cpp

5.22 Feedback Class Reference

`#include <feedback_base.h>`

Inheritance diagram for Feedback:



Public Member Functions

- virtual void init (double start_pt, double set_pt, double start_vel=0.0, double end_vel=0.0)=0
- virtual double update (double val)=0
- virtual double get ()=0
- virtual void set_limits (double lower, double upper)=0
- virtual bool is_on_target ()=0

5.22.1 Detailed Description

Interface so that subsystems can easily switch between feedback loops

Author

Ryan McGee

Date

9/25/2022

5.22.2 Member Function Documentation

5.22.2.1 get()

```
virtual double Feedback::get ( )  [pure virtual]
```

Returns

the last saved result from the feedback controller

Implemented in BangBang, MotionController, PID, PIDFF, and TakeBackHalf.

5.22.2.2 init()

```
virtual void Feedback::init (
            double start_pt,
            double set_pt,
            double start_vel = 0.0,
            double end_vel = 0.0 )  [pure virtual]
```

Initialize the feedback controller for a movement

Parameters

start_pt	the current sensor value
set_pt	where the sensor value should be
start_vel	Movement starting velocity
end_vel	Movement ending velocity

Implemented in MotionController, PIDFF, PID, BangBang, and TakeBackHalf.

5.22.2.3 is_on_target()

```
virtual bool Feedback::is_on_target ( )  [pure virtual]
```

Returns

true if the feedback controller has reached it's setpoint

Implemented in BangBang, MotionController, PID, PIDFF, and TakeBackHalf.

5.22.2.4 set_limits()

```
virtual void Feedback::set_limits (
            double lower,
            double upper )  [pure virtual]
```

Clamp the upper and lower limits of the output. If both are 0, no limits should be applied.

Parameters

lower	Upper limit
upper	Lower limit

Implemented in BangBang, MotionController, PID, PIDFF, and TakeBackHalf.

5.22.2.5 update()

```
virtual double Feedback::update (
            double val )  [pure virtual]
```

Iterate the feedback loop once with an updated sensor value

Parameters

val	value from the sensor

Returns

feedback loop result

Implemented in MotionController, PID, BangBang, PIDFF, and TakeBackHalf.

The documentation for this class was generated from the following file:

- include/utils/controls/feedback_base.h

5.23 FeedForward Class Reference

```
#include <feedforward.h>
```

Classes

- struct ff_config_t

Public Member Functions

- FeedForward (ff_config_t &cfg)
- double calculate (double v, double a, double pid_ref=0.0)

  Perform the feedforward calculation.

5.23.1 Detailed Description

FeedForward

Stores the feedfoward constants, and allows for quick computation. Feedfoward should be used in systems that require smooth precise movements and have high inertia, such as drivetrains and lifts.

This is best used alongside a PID loop, with the form: output = pid.get() + feedforward.calculate(v, a);

In this case, the feedforward does the majority of the heavy lifting, and the pid loop only corrects for inconsistencies

For information about tuning feedforward, I reccommend looking at this post: https://www.chiefdelphi.com/t/paper-frc-drivetrain-characterization/160915 (yes I know it's for FRC but trust me, it's useful)

Author

Ryan McGee

Date

6/13/2022

5.23.2 Constructor & Destructor Documentation

5.23.2.1 FeedForward()

```
FeedForward::FeedForward (
            ff_config_t & cfg )  [inline]
```

Creates a FeedForward object.

Parameters

cfg	Configuration Struct for tuning

5.23.3 Member Function Documentation

5.23.3.1 calculate()

```
double FeedForward::calculate (
            double v,
            double a,
            double pid_ref = 0.0 )  [inline]
```

Perform the feedforward calculation.

This calculation is the equation: F = kG + kS∗sgn(v) + kV∗v + kA∗a

Parameters

v	Requested velocity of system
a	Requested acceleration of system

Returns

A feedforward that should closely represent the system if tuned correctly

The documentation for this class was generated from the following file:

- include/utils/controls/feedforward.h

5.24 FeedForward::ff_config_t Struct Reference

`#include <feedforward.h>`

Public Attributes

- double kS
- double kV
- double kA
- double kG

5.24.1 Detailed Description

ff_config_t holds the parameters to make the theoretical model of a real world system equation is of the form kS if the system is not stopped, 0 otherwise

- kV $*$ desired velocity
- kA $*$ desired acceleration
- kG

5.24.2 Member Data Documentation

5.24.2.1 kA

`double FeedForward::ff_config_t::kA`

kA - Acceleration coefficient: the power required to change the mechanism's speed. Multiplied by the requested acceleration.

5.24.2.2 kG

```
double FeedForward::ff_config_t::kG
```

kG - Gravity coefficient: only needed for lifts. The power required to overcome gravity and stay at steady state.

5.24.2.3 kS

```
double FeedForward::ff_config_t::kS
```

Coefficient to overcome static friction: the point at which the motor *starts* to move.

5.24.2.4 kV

```
double FeedForward::ff_config_t::kV
```

Veclocity coefficient: the power required to keep the mechanism in motion. Multiplied by the requested velocity.

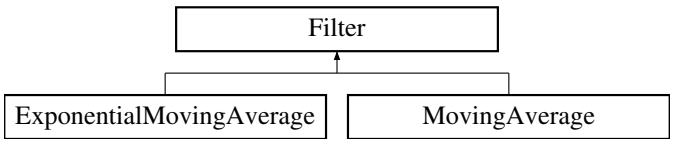
The documentation for this struct was generated from the following file:

- include/utils/controls/feedforward.h

5.25 Filter Class Reference

```
#include <moving_average.h>
```

Inheritance diagram for Filter:



Public Member Functions

- virtual void add_entry (double n)=0
- virtual double get_value () const =0

5.25.1 Detailed Description

Interface for filters Use add_entry to supply data and get_value to retrieve the filtered value

5.25.2 Member Function Documentation

5.25.2.1 add_entry()

```
virtual void Filter::add_entry (
            double n )  [pure virtual]
```

Implemented in MovingAverage, and ExponentialMovingAverage.

5.25.2.2 get_value()

```
virtual double Filter::get_value ( ) const  [pure virtual]
```

Implemented in MovingAverage, and ExponentialMovingAverage.

The documentation for this class was generated from the following file:

- include/utils/moving_average.h

5.26 Flywheel Class Reference

```
#include <flywheel.h>
```

Public Member Functions

- Flywheel (vex::motor_group &motors, Feedback &feedback, FeedForward &helper, const double ratio, Filter &filt)
- double get_target () const
- double getRPM () const
- vex::motor_group & get_motors () const
- void spin_manual (double speed, directionType dir=fwd)
- void spin_rpm (double rpm)
- void stop ()
- bool is_on_target ()

  check if the feedback controller thinks the flywheel is on target
- screen::Page * Page () const

  Creates a page displaying info about the flywheel.
- AutoCommand * SpinRpmCmd (int rpm)

  Creates a new auto command to spin the flywheel at the desired velocity.
- AutoCommand * WaitUntilUpToSpeedCmd ()

  Creates a new auto command that will hold until the flywheel has its target as defined by its feedback controller.

Friends

- class **FlywheelPage**
- int spinRPMTask (void *wheelPointer)

5.26.1 Detailed Description

a Flywheel class that handles all control of a high inertia spinning disk It gives multiple options for what control system to use in order to control wheel velocity and functions alerting the user when the flywheel is up to speed. Flywheel is a set and forget class. Once you create it you can call spin_rpm or stop on it at any time and it will take all necessary steps to accomplish this

5.26.2 Constructor & Destructor Documentation

5.26.2.1 Flywheel()

```
Flywheel::Flywheel (
            vex::motor_group & motors,
            Feedback & feedback,
            FeedForward & helper,
            const double ratio,
            Filter & filt )
```

Create the Flywheel object using PID + feedforward for control.

Parameters

motors	pointer to the motors on the fly wheel
feedback	a feedback controleller
helper	a feedforward config (only kV is used) to help the feedback controller along
ratio	ratio of the gears from the motor to the flywheel just multiplies the velocity
filter	the filter to use to smooth noisy motor readings

5.26.3 Member Function Documentation

5.26.3.1 get_motors()

```
motor_group & Flywheel::get_motors ( ) const
```

Returns the motors

Returns

the motors used to run the flywheel

5.26.3.2 get_target()

```
double Flywheel::get_target ( ) const
```

Return the target_rpm that the flywheel is currently trying to achieve

Returns

target_rpm the target rpm

Return the current value that the target_rpm should be set to

5.26.3.3 getRPM()

```
double Flywheel::getRPM ( ) const
```

return the velocity of the flywheel

5.26.3.4 is_on_target()

```
bool Flywheel::is_on_target ( )  [inline]
```

check if the feedback controller thinks the flywheel is on target

Returns

true if on target

5.26.3.5 Page()

```
screen::Page * Flywheel::Page ( ) const
```

Creates a page displaying info about the flywheel.

Returns

the page should be used for `screen::start_screen(screen, {fw.Page()});

5.26.3.6 spin_manual()

```
void Flywheel::spin_manual (
            double speed,
            directionType dir = fwd )
```

Spin motors using voltage; defaults forward at 12 volts FOR USE BY OPCONTROL AND AUTONOMOUS - this only applies if the target_rpm thread is not running

Parameters

speed	- speed (between -1 and 1) to set the motor
dir	- direction that the motor moves in; defaults to forward

Spin motors using voltage; defaults forward at 12 volts FOR USE BY OPCONTROL AND AUTONOMOUS - this only applies if the RPM thread is not running

Parameters

speed	- speed (between -1 and 1) to set the motor
dir	- direction that the motor moves in; defaults to forward

5.26.3.7 spin_rpm()

```
void Flywheel::spin_rpm (
            double input_rpm )
```

starts or sets the target_rpm thread at new value what control scheme is dependent on control_style

Parameters

rpm	- the target_rpm we want to spin at

starts or sets the RPM thread at new value what control scheme is dependent on control_style

Parameters

input_rpm	- set the current RPM

5.26.3.8 SpinRpmCmd()

```
AutoCommand * Flywheel::SpinRpmCmd (
            int rpm )  [inline]
```

Creates a new auto command to spin the flywheel at the desired velocity.

Parameters

rpm	the rpm to spin at

Returns

an auto command to add to a command controller

5.26.3.9 stop()

```
void Flywheel::stop ( )
```

Stops the motors. If manually spinning, this will do nothing just call spin_mainual(0.0) to send 0 volts

stop the RPM thread and the wheel

5.26.3.10 WaitUntilUpToSpeedCmd()

```
AutoCommand * Flywheel::WaitUntilUpToSpeedCmd ( )  [inline]
```

Creates a new auto command that will hold until the flywheel has its target as defined by its feedback controller.

Returns

an auto command to add to a command controller

5.26.4 Friends And Related Symbol Documentation

5.26.4.1 spinRPMTask

```
int spinRPMTask (
            void * wheelPointer )  [friend]
```

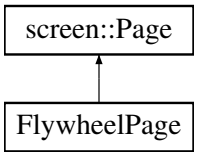
Runs a thread that keeps track of updating flywheel RPM and controlling it accordingly

The documentation for this class was generated from the following files:

- include/subsystems/flywheel.h
- src/subsystems/flywheel.cpp

5.27 FlywheelPage Class Reference

Inheritance diagram for FlywheelPage:



Public Member Functions

- **FlywheelPage** (const Flywheel &fw)
- void update (bool, int, int) override
- void draw (vex::brain::lcd &screen, bool, unsigned int) override

Static Public Attributes

- static const size_t **window_size** = 40

5.27.1 Member Function Documentation

5.27.1.1 draw()

```
void FlywheelPage::draw (
            vex::brain::lcd & screen,
            bool ,
            unsigned int  )  [inline], [override], [virtual]
```

See also

Page::draw

Reimplemented from screen::Page.

5.27.1.2 update()

```
void FlywheelPage::update (
            bool ,
            int ,
            int  )  [inline], [override], [virtual]
```

See also

Page::update

Reimplemented from screen::Page.

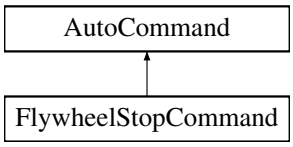
The documentation for this class was generated from the following file:

- src/subsystems/flywheel.cpp

5.28 FlywheelStopCommand Class Reference

```
#include <flywheel_commands.h>
```

Inheritance diagram for FlywheelStopCommand:



Public Member Functions

- FlywheelStopCommand (Flywheel &flywheel)
- bool run () override

Public Member Functions inherited from AutoCommand

- virtual void on_timeout ()
- AutoCommand * **withTimeout** (double t_seconds)
- AutoCommand * **withCancelCondition** (Condition *true_to_end)

Additional Inherited Members

Public Attributes inherited from AutoCommand

- double timeout_seconds = default_timeout
- Condition * **true_to_end** = nullptr

Static Public Attributes inherited from AutoCommand

- static constexpr double **default_timeout** = 10.0

5.28.1 Detailed Description

AutoCommand wrapper class for the stop function in the Flywheel class

5.28.2 Constructor & Destructor Documentation

5.28.2.1 FlywheelStopCommand()

```
FlywheelStopCommand::FlywheelStopCommand (
            Flywheel & flywheel )
```

Construct a FlywheelStopCommand

Parameters

flywheel	the flywheel system we are commanding

5.28.3 Member Function Documentation

5.28.3.1 run()

```
bool FlywheelStopCommand::run ( )  [override], [virtual]
```

Run stop Overrides run from AutoCommand

Returns

true when execution is complete, false otherwise

Reimplemented from AutoCommand.

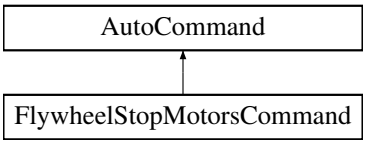
The documentation for this class was generated from the following files:

- include/utils/command_structure/flywheel_commands.h
- src/utils/command_structure/flywheel_commands.cpp

5.29 FlywheelStopMotorsCommand Class Reference

```
#include <flywheel_commands.h>
```

Inheritance diagram for FlywheelStopMotorsCommand:



Public Member Functions

- FlywheelStopMotorsCommand (Flywheel &flywheel)
- bool run () override

Public Member Functions inherited from AutoCommand

- virtual void on_timeout ()
- AutoCommand * **withTimeout** (double t_seconds)
- AutoCommand * **withCancelCondition** (Condition *true_to_end)

Additional Inherited Members

Public Attributes inherited from AutoCommand

- double timeout_seconds = default_timeout
- Condition * **true_to_end** = nullptr

Static Public Attributes inherited from AutoCommand

- static constexpr double **default_timeout** = 10.0

5.29.1 Detailed Description

AutoCommand wrapper class for the stopMotors function in the Flywheel class

5.29.2 Constructor & Destructor Documentation

5.29.2.1 FlywheelStopMotorsCommand()

```
FlywheelStopMotorsCommand::FlywheelStopMotorsCommand (
            Flywheel & flywheel )
```

Construct a FlywheeStopMotors Command

Parameters

flywheel	the flywheel system we are commanding

5.29.3 Member Function Documentation

5.29.3.1 run()

```
bool FlywheelStopMotorsCommand::run ( )  [override], [virtual]
```

Run stop Overrides run from AutoCommand

Returns

true when execution is complete, false otherwise

Reimplemented from AutoCommand.

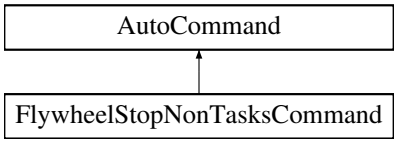
The documentation for this class was generated from the following files:

- include/utils/command_structure/flywheel_commands.h
- src/utils/command_structure/flywheel_commands.cpp

5.30 FlywheelStopNonTasksCommand Class Reference

`#include <flywheel_commands.h>`

Inheritance diagram for FlywheelStopNonTasksCommand:



Additional Inherited Members

Public Member Functions inherited from AutoCommand

- virtual void on_timeout ()
- AutoCommand * **withTimeout** (double t_seconds)
- AutoCommand * **withCancelCondition** (Condition *true_to_end)

Public Attributes inherited from AutoCommand

- double timeout_seconds = default_timeout
- Condition * **true_to_end** = nullptr

Static Public Attributes inherited from AutoCommand

- static constexpr double **default_timeout** = 10.0

5.30.1 Detailed Description

AutoCommand wrapper class for the stopNonTasks function in the Flywheel class

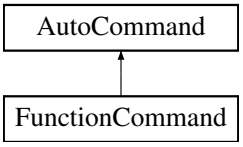
The documentation for this class was generated from the following files:

- include/utils/command_structure/flywheel_commands.h
- src/utils/command_structure/flywheel_commands.cpp

5.31 FunctionCommand Class Reference

`#include <auto_command.h>`

Inheritance diagram for FunctionCommand:



Public Member Functions

- **FunctionCommand** (std::function< bool(void)> f)
- bool run ()

Public Member Functions inherited from AutoCommand

- virtual void on_timeout ()
- AutoCommand * **withTimeout** (double t_seconds)
- AutoCommand * **withCancelCondition** (Condition *true_to_end)

Additional Inherited Members

Public Attributes inherited from AutoCommand

- double timeout_seconds = default_timeout
- Condition * **true_to_end** = nullptr

Static Public Attributes inherited from AutoCommand

- static constexpr double **default_timeout** = 10.0

5.31.1 Detailed Description

FunctionCommand is fun and good way to do simple things Printing, launching nukes, and other quick and dirty one time things

5.31.2 Member Function Documentation

5.31.2.1 run()

```
bool FunctionCommand::run ( )  [inline], [virtual]
```

Executes the command Overridden by child classes

Returns

true when the command is finished, false otherwise

Reimplemented from AutoCommand.

The documentation for this class was generated from the following file:

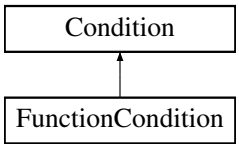
- include/utils/command_structure/auto_command.h

5.32 FunctionCondition Class Reference

FunctionCondition is a quick and dirty Condition to wrap some expression that should be evaluated at runtime.

```
#include <auto_command.h>
```

Inheritance diagram for FunctionCondition:



Public Member Functions

- **FunctionCondition** (std::function< bool()> cond, std::function< void(void)> timeout=[]() {})
- bool test () override

Public Member Functions inherited from Condition

- Condition * **Or** (Condition *b)
- Condition * **And** (Condition *b)

5.32.1 Detailed Description

FunctionCondition is a quick and dirty Condition to wrap some expression that should be evaluated at runtime.

5.32.2 Member Function Documentation

5.32.2.1 test()

```
bool FunctionCondition::test ( )  [override], [virtual]
```

Implements Condition.

The documentation for this class was generated from the following files:

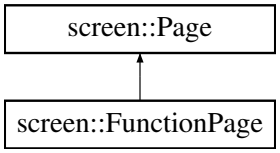
- include/utils/command_structure/auto_command.h
- src/utils/command_structure/auto_command.cpp

5.33 screen::FunctionPage Class Reference

Simple page that stores no internal data. the draw and update functions use only global data rather than storing anything.

```
#include <screen.h>
```

Inheritance diagram for screen::FunctionPage:



Public Member Functions

- FunctionPage (update_func_t update_f, draw_func_t draw_t)
  Creates a function page.
- void update (bool was_pressed, int x, int y) override
  update uses the supplied update function to update this page
- void draw (vex::brain::lcd &, bool first_draw, unsigned int frame_number) override
  draw uses the supplied draw function to draw to the screen

5.33.1 Detailed Description

Simple page that stores no internal data. the draw and update functions use only global data rather than storing anything.

5.33.2 Constructor & Destructor Documentation

5.33.2.1 FunctionPage()

```
screen::FunctionPage::FunctionPage (
            update_func_t update_f,
            draw_func_t draw_f )
```

Creates a function page.

FunctionPage.

Parameters

update_f	the function called every tick to respond to user input or do data collection
draw_t	the function called to draw to the screen
update_f	drawing function
draw_f	drawing function

5.33.3 Member Function Documentation

5.33.3.1 draw()

```
void screen::FunctionPage::draw (
            vex::brain::lcd & screen,
            bool first_draw,
            unsigned int frame_number )  [override], [virtual]
```

draw uses the supplied draw function to draw to the screen

See also

Page::draw

Reimplemented from screen::Page.

5.33.3.2 update()

```
void screen::FunctionPage::update (
            bool was_pressed,
            int x,
            int y )  [override], [virtual]
```

update uses the supplied update function to update this page

See also

Page::update

Reimplemented from screen::Page.

The documentation for this class was generated from the following files:

- include/subsystems/screen.h
- src/subsystems/screen.cpp

5.34 GenericAuto Class Reference

```
#include <generic_auto.h>
```

Public Member Functions

- bool run (bool blocking)
- void add (state_ptr new_state)
- void add_async (state_ptr async_state)
- void add_delay (int ms)

5.34.1 Detailed Description

GenericAuto provides a pleasant interface for organizing an auto path steps of the path can be added with add() and when ready, calling run() will begin executing the path

5.34.2 Member Function Documentation

5.34.2.1 add()

```
void GenericAuto::add (
            state_ptr new_state )
```

Add a new state to the autonomous via function point of type "bool (ptr∗)()"

Parameters

new_state	the function to run

5.34.2.2 add_async()

```
void GenericAuto::add_async (
            state_ptr async_state )
```

Add a new state to the autonomous via function point of type "bool (ptr∗)()" that will run asynchronously

Parameters

async_state	the function to run

5.34.2.3 add_delay()

```
void GenericAuto::add_delay (
            int ms )
```

add_delay adds a period where the auto system will simply wait for the specified time

Parameters

ms	how long to wait in milliseconds

5.34.2.4 run()

```
bool GenericAuto::run (
            bool blocking )
```

The method that runs the autonomous. If 'blocking' is true, then this method will run through every state until it finished.

If blocking is false, then assuming every state is also non-blocking, the method will run through the current state in the list and return immediately.

Parameters

blocking	Whether or not to block the thread until all states have run

Returns

true after all states have finished.

The documentation for this class was generated from the following files:

- include/utils/generic_auto.h
- src/utils/generic_auto.cpp

5.35 GraphDrawer Class Reference

Public Member Functions

- GraphDrawer (int num_samples, double lower_bound, double upper_bound, std::vector< vex::color > colors, size_t num_series=1)

  Creates a graph drawer with the specified number of series (each series is a separate line)
- void add_samples (std::vector< point_t > sample)
- void add_samples (std::vector< double > sample)
- void draw (vex::brain::lcd &screen, int x, int y, int width, int height)

5.35.1 Constructor & Destructor Documentation

5.35.1.1 GraphDrawer()

```
GraphDrawer::GraphDrawer (
            int num_samples,
            double lower_bound,
            double upper_bound,
            std::vector< vex::color > colors,
            size_t num_series = 1 )
```

Creates a graph drawer with the specified number of series (each series is a separate line)

Parameters

num_samples	the number of samples to graph at a time (40 will graph the last 40 data points)
lower_bound	the bottom of the window when displaying (if upper_bound = lower_bound, auto calculate bounds)
upper_bound	the top of the window when displaying (if upper_bound = lower_bound, auto calculate bounds)
colors	the colors of the series. must be of size num_series
num_series	the number of series to graph

5.35.2 Member Function Documentation

5.35.2.1 add_samples() [1/2]

```
void GraphDrawer::add_samples (
            std::vector< double > sample )
```

add_samples adds a point to the graph, removing one from the back

Parameters

sample	a y coordinate of the next point to graph, the x coordinate is gotten from vex::timer::system(); (time in ms)

5.35.2.2 add_samples() [2/2]

```
void GraphDrawer::add_samples (
            std::vector< point_t > new_samples )
```

add_samples adds a point to the graph, removing one from the back

Parameters

sample	an x, y coordinate of the next point to graph

5.35.2.3 draw()

```
void GraphDrawer::draw (
            vex::brain::lcd & screen,
            int x,
            int y,
            int width,
            int height )
```

draws the graph to the screen in the constructor

Parameters

x	x position of the top left of the graphed region

Parameters

y	y position of the top left of the graphed region
width	the width of the graphed region
height	the height of the graphed region

The documentation for this class was generated from the following files:

- include/utils/graph_drawer.h
- src/utils/graph_drawer.cpp

5.36 PurePursuit::hermite_point Struct Reference

`#include <pure_pursuit.h>`

Public Member Functions

- point_t **getPoint** () const
- Vector2D **getTangent** () const

Public Attributes

- double **x**
- double **y**
- double **dir**
- double **mag**

5.36.1 Detailed Description

a position along the hermite path contains a position and orientation information that the robot would be at at this point

The documentation for this struct was generated from the following file:

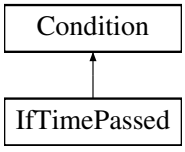
- include/utils/pure_pursuit.h

5.37 IfTimePassed Class Reference

IfTimePassed tests based on time since the command controller was constructed. Returns true if elapsed time > time_s.

`#include <auto_command.h>`

Inheritance diagram for IfTimePassed:



Public Member Functions

- **IfTimePassed** (double time_s)
- bool test () override

Public Member Functions inherited from Condition

- Condition * **Or** (Condition *b)
- Condition * **And** (Condition *b)

5.37.1 Detailed Description

IfTimePassed tests based on time since the command controller was constructed. Returns true if elapsed time > time_s.

5.37.2 Member Function Documentation

5.37.2.1 test()

```
bool IfTimePassed::test ( )  [override], [virtual]
```

Implements Condition.

The documentation for this class was generated from the following files:

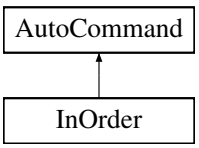
- include/utils/command_structure/auto_command.h
- src/utils/command_structure/auto_command.cpp

5.38 InOrder Class Reference

InOrder runs its commands sequentially then continues. How to handle timeout in this case. Automatically set it to sum of commands timouts?

```
#include <auto_command.h>
```

Inheritance diagram for InOrder:



Public Member Functions

- **InOrder** (const InOrder &other)=default
- **InOrder** (std::queue< AutoCommand * > cmds)
- **InOrder** (std::initializer_list< AutoCommand * > cmds)
- bool run () override
- void on_timeout () override

Public Member Functions inherited from AutoCommand

- AutoCommand * **withTimeout** (double t_seconds)
- AutoCommand * **withCancelCondition** (Condition *true_to_end)

Additional Inherited Members

Public Attributes inherited from AutoCommand

- double timeout_seconds = default_timeout
- Condition * **true_to_end** = nullptr

Static Public Attributes inherited from AutoCommand

- static constexpr double **default_timeout** = 10.0

5.38.1 Detailed Description

InOrder runs its commands sequentially then continues. How to handle timeout in this case. Automatically set it to sum of commands timouts?

InOrder runs its commands sequentially then continues. How to handle timeout in this case. Automatically set it to sum of commands timouts?

5.38.2 Member Function Documentation

5.38.2.1 on_timeout()

```
void InOrder::on_timeout ( )  [override], [virtual]
```

What to do if we timeout instead of finishing. timeout is specified by the timeout seconds in the constructor

Reimplemented from AutoCommand.

5.38.2.2 run()

```
bool InOrder::run ( )  [override], [virtual]
```

Executes the command Overridden by child classes

Returns

true when the command is finished, false otherwise

Reimplemented from AutoCommand.

The documentation for this class was generated from the following files:

- include/utils/command_structure/auto_command.h
- src/utils/command_structure/auto_command.cpp

5.39 screen::LabelConfig Struct Reference

Public Attributes

- std::string **label**

The documentation for this struct was generated from the following file:

- include/subsystems/screen.h

5.40 Lift< T > Class Template Reference

`#include <lift.h>`

Classes

- struct lift_cfg_t

Public Member Functions

- Lift (motor_group &lift_motors, lift_cfg_t &lift_cfg, map< T, double > &setpoint_map, limit *homing_switch=NULL)
- void control_continuous (bool up_ctrl, bool down_ctrl)
- void control_manual (bool up_btn, bool down_btn, int volt_up, int volt_down)
- void control_setpoints (bool up_step, bool down_step, vector< T > pos_list)
- bool set_position (T pos)
- bool set_setpoint (double val)
- double get_setpoint ()
- void hold ()
- void home ()
- bool get_async ()
- void set_async (bool val)
- void set_sensor_function (double(*fn_ptr)(void))
- void set_sensor_reset (void(*fn_ptr)(void))

5.40.1 Detailed Description

template<typename T>
class Lift< T >

LIFT A general class for lifts (e.g. 4bar, dr4bar, linear, etc) Uses a PID to hold the lift at a certain height under load, and to move the lift to different heights

Author

Ryan McGee

5.40.2 Constructor & Destructor Documentation

5.40.2.1 Lift()

```
template<typename T >
Lift< T >::Lift (
            motor_group & lift_motors,
            lift_cfg_t & lift_cfg,
            map< T, double > & setpoint_map,
            limit * homing_switch = NULL )  [inline]
```

Construct the Lift object and begin the background task that controls the lift.

Usage example: /code{.cpp} enum Positions {UP, MID, DOWN}; map<Positions, double> setpt_map { {DOWN, 0.0}, {MID, 0.5}, {UP, 1.0} }; Lift<Positions> my_lift(motors, lift_cfg, setpt_map); /endcode

Parameters

lift_motors	A set of motors, all set that positive rotation correlates with the lift going up
lift_cfg	Lift characterization information; PID tunings and movement speeds
setpoint_map	A map of enum type T, in which each enum entry corresponds to a different lift height

5.40.3 Member Function Documentation

5.40.3.1 control_continuous()

```
template<typename T >
void Lift< T >::control_continuous (
            bool up_ctrl,
            bool down_ctrl )  [inline]
```

Control the lift with an "up" button and a "down" button. Use PID to hold the lift when letting go.

Parameters

up_ctrl	Button controlling the "UP" motion
down_ctrl	Button controlling the "DOWN" motion

5.40.3.2 control_manual()

```
template<typename T >
void Lift< T >::control_manual (
            bool up_btn,
            bool down_btn,
            int volt_up,
            int volt_down )  [inline]
```

Control the lift with manual controls (no holding voltage)

Parameters

up_btn	Raise the lift when true
down_btn	Lower the lift when true
volt_up	Motor voltage when raising the lift
volt_down	Motor voltage when lowering the lift

5.40.3.3 control_setpoints()

```
template<typename T >
void Lift< T >::control_setpoints (
            bool up_step,
            bool down_step,
            vector< T > pos_list )  [inline]
```

Control the lift in "steps". When the "up" button is pressed, the lift will go to the next position as defined by pos_list. Order matters!

Parameters

up_step	A button that increments the position of the lift.
down_step	A button that decrements the position of the lift.
pos_list	A list of positions for the lift to go through. The higher the index, the higher the lift should be (generally).

5.40.3.4 get_async()

```
template<typename T >
bool Lift< T >::get_async ( )  [inline]
```

Returns

whether or not the background thread is running the lift

5.40.3.5 get_setpoint()

```
template<typename T >
double Lift< T >::get_setpoint ( )  [inline]
```

Returns

The current setpoint for the lift

5.40.3.6 hold()

```
template<typename T >
void Lift< T >::hold ( )  [inline]
```

Target the class's setpoint. Calculate the PID output and set the lift motors accordingly.

5.40.3.7 home()

```
template<typename T >
void Lift< T >::home ( )  [inline]
```

A blocking function that automatically homes the lift based on a sensor or hard stop, and sets the position to 0. A watchdog times out after 3 seconds, to avoid damage.

5.40.3.8 set_async()

```
template<typename T >
void Lift< T >::set_async (
            bool val )  [inline]
```

Enables or disables the background task. Note that running the control functions, or set_position functions will immediately re-enable the task for autonomous use.

Parameters

val	Whether or not the background thread should run the lift

5.40.3.9 set_position()

```
template<typename T >
bool Lift< T >::set_position (
            T pos )  [inline]
```

Enable the background task, and send the lift to a position, specified by the setpoint map from the constructor.

Parameters

pos	A lift position enum type

Returns

True if the pid has reached the setpoint

5.40.3.10 set_sensor_function()

```
template<typename T >
void Lift< T >::set_sensor_function (
            double(*)(void) fn_ptr )  [inline]
```

Creates a custom hook for any other type of sensor to be used on the lift. Example: /code{.cpp} my_lift.set_↩ sensor_function([](){return my_sensor.position();}); /endcode

Parameters

fn_ptr	Pointer to custom sensor function

5.40.3.11 set_sensor_reset()

```
template<typename T >
void Lift< T >::set_sensor_reset (
            void(*)(void) fn_ptr )  [inline]
```

Creates a custom hook to reset the sensor used in set_sensor_function(). Example: /code{.cpp} my_lift.set_↩ sensor_reset(my_sensor.resetPosition); /endcode

5.40.3.12 set_setpoint()

```
template<typename T >
bool Lift< T >::set_setpoint (
            double val )  [inline]
```

Manually set a setpoint value for the lift PID to go to.

Parameters

val	Lift setpoint, in motor revolutions or sensor units defined by get_sensor. Cannot be outside the softstops.

Returns

True if the pid has reached the setpoint

The documentation for this class was generated from the following file:

- include/subsystems/lift.h

5.41 Lift< T >::lift_cfg_t Struct Reference

`#include <lift.h>`

Public Attributes

- double **up_speed**
- double **down_speed**
- double **softstop_up**
- double **softstop_down**
- PID::pid_config_t **lift_pid_cfg**

5.41.1 Detailed Description

template<typename T>
struct Lift< T >::lift_cfg_t

lift_cfg_t holds the physical parameter specifications of a lify system. includes:

- maximum speeds for the system
- softstops to stop the lift from hitting the hard stops too hard

The documentation for this struct was generated from the following file:

- include/subsystems/lift.h

5.42 Logger Class Reference

Class to simplify writing to files.

`#include <logger.h>`

Public Member Functions

- Logger (const std::string &filename)
  Create a logger that will save to a file.
- **Logger** (const Logger &l)=delete
  copying not allowed
- Logger & **operator=** (const Logger &l)=delete
  copying not allowed
- void Log (const std::string &s)
  Write a string to the log.
- void Log (LogLevel level, const std::string &s)
  Write a string to the log with a loglevel.
- void LogIn (const std::string &s)
  Write a string and newline to the log.
- void LogIn (LogLevel level, const std::string &s)
  Write a string and a newline to the log with a loglevel.
- void Logf (const char *fmt,...)
  Write a formatted string to the log.
- void Logf (LogLevel level, const char *fmt,...)
  Write a formatted string to the log with a loglevel.

Static Public Attributes

- static constexpr int **MAX_FORMAT_LEN** = 512
  maximum size for a string to be before it's written

5.42.1 Detailed Description

Class to simplify writing to files.

5.42.2 Constructor & Destructor Documentation

5.42.2.1 Logger()

```
Logger::Logger (
            const std::string & filename )  [explicit]
```

Create a logger that will save to a file.

Parameters

filename	the file to save to

5.42.3 Member Function Documentation

5.42.3.1 Log() [1/2]

```
void Logger::Log (
            const std::string & s )
```

Write a string to the log.

Parameters

s	the string to write

5.42.3.2 Log() [2/2]

```
void Logger::Log (
            LogLevel level,
            const std::string & s )
```

Write a string to the log with a loglevel.

Parameters

level	the level to write. DEBUG, NOTICE, WARNING, ERROR, CRITICAL, TIME
s	the string to write

5.42.3.3 Logf() [1/2]

```
void Logger::Logf (
            const char * fmt,
             ...  )
```

Write a formatted string to the log.

Parameters

fmt	the format string (like printf)
...	the args

5.42.3.4 Logf() [2/2]

```
void Logger::Logf (
             LogLevel level,
             const char * fmt,
              ...  )
```

Write a formatted string to the log with a loglevel.

Parameters

level	the level to write. DEBUG, NOTICE, WARNING, ERROR, CRITICAL, TIME
fmt	the format string (like printf)
...	the args

5.42.3.5 Logln() [1/2]

```
void Logger::Logln (
             const std::string & s )
```

Write a string and newline to the log.

Parameters

s	the string to write

5.42.3.6 Logln() [2/2]

```
void Logger::Logln (
             LogLevel level,
             const std::string & s )
```

Write a string and a newline to the log with a loglevel.

Parameters

level	the level to write. DEBUG, NOTICE, WARNING, ERROR, CRITICAL, TIME
s	the string to write

The documentation for this class was generated from the following files:

- include/utils/logger.h
- src/utils/logger.cpp

5.43 MotionController::m_profile_cfg_t Struct Reference

```
#include <motion_controller.h>
```

Public Attributes

- double **max_v**

  the maximum velocity the robot can drive
- double **accel**

  the most acceleration the robot can do
- PID::pid_config_t **pid_cfg**

  configuration parameters for the internal PID controller
- FeedForward::ff_config_t **ff_cfg**

  configuration parameters for the internal

5.43.1 Detailed Description

m_profile_config holds all data the motion controller uses to plan paths When motion pofile is given a target to drive to, max_v and accel are used to make the trapezoid profile instructing the controller how to drive pid_cfg, ff_cfg are used to find the motor outputs necessary to execute this path

The documentation for this struct was generated from the following file:

- include/utils/controls/motion_controller.h

5.44 Mat2 Struct Reference

Public Member Functions

- point_t **operator*** (const point_t p) const

Static Public Member Functions

- static Mat2 **FromRotationDegrees** (double degrees)

Public Attributes

- double **X11**
- double **X12**
- double **X21**
- double **X22**

The documentation for this struct was generated from the following file:

- include/utils/geometry.h

5.45 MecanumDrive Class Reference

```
#include <mecanum_drive.h>
```

Classes

- struct mecanumdrive_config_t

Public Member Functions

- MecanumDrive (vex::motor &left_front, vex::motor &right_front, vex::motor &left_rear, vex::motor &right_rear, vex::rotation *lateral_wheel=NULL, vex::inertial *imu=NULL, mecanumdrive_config_t *config=NULL)
- void drive_raw (double direction_deg, double magnitude, double rotation)
- void drive (double left_y, double left_x, double right_x, int power=2)
- bool auto_drive (double inches, double direction, double speed, bool gyro_correction=true)
- bool auto_turn (double degrees, double speed, bool ignore_imu=false)

5.45.1 Detailed Description

A class representing the Mecanum drivetrain. Contains 4 motors, a possible IMU (intertial), and a possible undriven perpendicular wheel.

5.45.2 Constructor & Destructor Documentation

5.45.2.1 MecanumDrive()

```
MecanumDrive::MecanumDrive (
            vex::motor & left_front,
            vex::motor & right_front,
            vex::motor & left_rear,
            vex::motor & right_rear,
            vex::rotation * lateral_wheel = NULL,
            vex::inertial * imu = NULL,
            mecanumdrive_config_t * config = NULL )
```

Create the Mecanum drivetrain object

5.45.3 Member Function Documentation

5.45.3.1 auto_drive()

```
bool MecanumDrive::auto_drive (
            double inches,
            double direction,
            double speed,
            bool gyro_correction = true )
```

Drive the robot in a straight line automatically. If the inertial was declared in the constructor, use it to correct while driving. If the lateral wheel was declared in the constructor, use it for more accurate positioning while strafing.

Parameters

inches	How far the robot should drive, in inches
direction	What direction the robot should travel in, in degrees. 0 is forward, +/-180 is reverse, clockwise is positive.
speed	The maximum speed the robot should travel, in percent: -1.0->+1.0
gyro_correction	=true Whether or not to use the gyro to help correct while driving. Will always be false if no gyro was declared in the constructor.

Drive the robot in a straight line automatically. If the inertial was declared in the constructor, use it to correct while driving. If the lateral wheel was declared in the constructor, use it for more accurate positioning while strafing.

Parameters

inches	How far the robot should drive, in inches
direction	What direction the robot should travel in, in degrees. 0 is forward, +/-180 is reverse, clockwise is positive.
speed	The maximum speed the robot should travel, in percent: -1.0->+1.0
gyro_correction	= true Whether or not to use the gyro to help correct while driving. Will always be false if no gyro was declared in the constructor.

Returns

Whether or not the maneuver is complete.

5.45.3.2 auto_turn()

```
bool MecanumDrive::auto_turn (
            double degrees,
            double speed,
            bool ignore_imu = false )
```

Autonomously turn the robot X degrees over it's center point. Uses a closed loop for control.

Parameters

degrees	How many degrees to rotate the robot. Clockwise postive.
speed	What percentage to run the motors at: 0.0 -> 1.0
ignore_imu	=false Whether or not to use the Inertial for determining angle. Will instead use circumference formula + robot's wheelbase + encoders to determine.

Returns

whether or not the robot has finished the maneuver

Autonomously turn the robot X degrees over it's center point. Uses a closed loop for control.

Parameters

degrees	How many degrees to rotate the robot. Clockwise postive.
speed	What percentage to run the motors at: 0.0 -> 1.0
ignore_imu	= false Whether or not to use the Inertial for determining angle. Will instead use circumference formula + robot's wheelbase + encoders to determine.

Returns

whether or not the robot has finished the maneuver

5.45.3.3 drive()

```
void MecanumDrive::drive (
            double left_y,
            double left_x,
            double right_x,
            int power = 2 )
```

Drive the robot with a mecanum-style / arcade drive. Inputs are in percent (-100.0 -> 100.0) straight from the controller. Controls are mixed, so the robot can drive forward / strafe / rotate all at the same time.

Parameters

left_y	left joystick, Y axis (forward / backwards)
left_x	left joystick, X axis (strafe left / right)
right_x	right joystick, X axis (rotation left / right)
power	=2 how much of a "curve" there should be on drive controls; better for low speed maneuvers. Leave blank for a default curve of 2 (higher means more fidelity)

Drive the robot with a mecanum-style / arcade drive. Inputs are in percent (-100.0 -> 100.0) straight from the controller. Controls are mixed, so the robot can drive forward / strafe / rotate all at the same time.

Parameters

left_y	left joystick, Y axis (forward / backwards)
left_x	left joystick, X axis (strafe left / right)
right_x	right joystick, X axis (rotation left / right)
power	= 2 how much of a "curve" there should be on drive controls; better for low speed maneuvers. Leave blank for a default curve of 2 (higher means more fidelity)

5.45.3.4 drive_raw()

```
void MecanumDrive::drive_raw (
            double direction_deg,
            double magnitude,
            double rotation )
```

Drive the robot using vectors. This handles all the math required for mecanum control.

Parameters

direction_deg	the direction to drive the robot, in degrees. 0 is forward, 180 is back, clockwise is positive, counterclockwise is negative.
magnitude	How fast the robot should drive, in percent: 0.0->1.0
rotation	How fast the robot should rotate, in percent: -1.0->+1.0

The documentation for this class was generated from the following files:

- include/subsystems/mecanum_drive.h

- src/subsystems/mecanum_drive.cpp

5.46 MecanumDrive::mecanumdrive_config_t Struct Reference

`#include <mecanum_drive.h>`

Public Attributes

- PID::pid_config_t **drive_pid_conf**
- PID::pid_config_t **drive_gyro_pid_conf**
- PID::pid_config_t **turn_pid_conf**
- double **drive_wheel_diam**
- double **lateral_wheel_diam**
- double **wheelbase_width**

5.46.1 Detailed Description

Configure the Mecanum drive PID tunings and robot configurations

The documentation for this struct was generated from the following file:

- include/subsystems/mecanum_drive.h

5.47 motion_t Struct Reference

`#include <trapezoid_profile.h>`

Public Attributes

- double **pos**

  1d position at this point in time
- double **vel**

  1d velocity at this point in time
- double **accel**

  1d acceleration at this point in time

5.47.1 Detailed Description

motion_t is a description of 1 dimensional motion at a point in time.

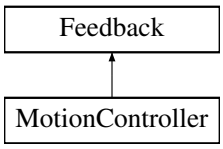
The documentation for this struct was generated from the following file:

- include/utils/controls/trapezoid_profile.h

5.48 MotionController Class Reference

`#include <motion_controller.h>`

Inheritance diagram for MotionController:



Classes

- struct m_profile_cfg_t

Public Member Functions

- MotionController (m_profile_cfg_t &config)

  Construct a new Motion Controller object.
- void init (double start_pt, double end_pt, double start_vel, double end_vel) override

  Initialize the motion profile for a new movement This will also reset the PID and profile timers.
- double update (double sensor_val) override

  Update the motion profile with a new sensor value.
- double get () override
- void set_limits (double lower, double upper) override
- bool is_on_target () override
- motion_t get_motion () const
- screen::Page * **Page** ()

Static Public Member Functions

- static FeedForward::ff_config_t tune_feedforward (TankDrive &drive, OdometryTank &odometry, double pct=0.6, double duration=2)

Friends

- class **MotionControllerPage**

5.48.1 Detailed Description

Motion Controller class

This class defines a top-level motion profile, which can act as an intermediate between a subsystem class and the motors themselves

This takes the constants kS, kV, kA, kP, kI, kD, max_v and acceleration and wraps around a feedforward, PID and trapezoid profile. It does so with the following formula:

out = feedfoward.calculate(motion_profile.get(time_s)) + pid.get(motion_profile.get(time_s))

For PID and Feedforward specific formulae, see pid.h, feedforward.h, and trapezoid_profile.h

Author

Ryan McGee

Date

7/13/2022

5.48.2 Constructor & Destructor Documentation

5.48.2.1 MotionController()

```
MotionController::MotionController (
            m_profile_cfg_t & config )
```

Construct a new Motion Controller object.

Parameters

config	The definition of how the robot is able to move max_v Maximum velocity the movement is capable of accel Acceleration / deceleration of the movement pid_cfg Definitions of kP, kI, and kD ff_cfg Definitions of kS, kV, and kA

5.48.3 Member Function Documentation

5.48.3.1 get()

```
double MotionController::get ( )  [override], [virtual]
```

Returns

the last saved result from the feedback controller

Implements Feedback.

5.48.3.2 get_motion()

```
motion_t MotionController::get_motion ( ) const
```

Returns

The current postion, velocity and acceleration setpoints

5.48.3.3 init()

```
void MotionController::init (
            double start_pt,
            double end_pt,
            double start_vel,
            double end_vel )  [override], [virtual]
```

Initialize the motion profile for a new movement This will also reset the PID and profile timers.

Parameters

start_pt	Movement starting position
end_pt	Movement ending posiiton
start_vel	Movement starting velocity
end_vel	Movement ending velocity

Implements Feedback.

5.48.3.4 is_on_target()

```
bool MotionController::is_on_target ( )  [override], [virtual]
```

Returns

Whether or not the movement has finished, and the PID confirms it is on target

Implements Feedback.

5.48.3.5 set_limits()

```
void MotionController::set_limits (
            double lower,
            double upper )  [override], [virtual]
```

Clamp the upper and lower limits of the output. If both are 0, no limits should be applied. if limits are applied, the controller will not target any value below lower or above upper

Parameters

lower	upper limit
upper	lower limiet

Clamp the upper and lower limits of the output. If both are 0, no limits should be applied.

Parameters

lower	Upper limit
upper	Lower limit

Implements Feedback.

5.48.3.6 tune_feedforward()

```
FeedForward::ff_config_t MotionController::tune_feedforward (
            TankDrive & drive,
            OdometryTank & odometry,
            double pct = 0.6,
            double duration = 2 )  [static]
```

This method attempts to characterize the robot's drivetrain and automatically tune the feedforward. It does this by first calculating the kS (voltage to overcome static friction) by slowly increasing the voltage until it moves.

Next is kV (voltage to sustain a certain velocity), where the robot will record it's steady-state velocity at 'pct' speed.

Finally, kA (voltage needed to accelerate by a certain rate), where the robot will record the entire movement's velocity and acceleration, record a plot of [X=(pct-kV∗V-kS), Y=(Acceleration)] along the movement, and since kA∗Accel = pct-kV∗V-kS, the reciprocal of the linear regression is the kA value.

Parameters

drive	The tankdrive to operate on
odometry	The robot's odometry subsystem
pct	Maximum velocity in percent (0->1.0)
duration	Amount of time the robot should be moving for the test

Returns

A tuned feedforward object

5.48.3.7 update()

```
double MotionController::update (
            double sensor_val )  [override], [virtual]
```

Update the motion profile with a new sensor value.

Parameters

sensor_val	Value from the sensor

Returns

the motor input generated from the motion profile

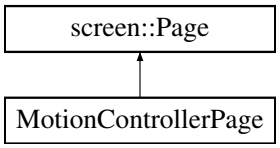
Implements Feedback.

The documentation for this class was generated from the following files:

- include/utils/controls/motion_controller.h
- src/utils/controls/motion_controller.cpp

5.49 MotionControllerPage Class Reference

Inheritance diagram for MotionControllerPage:



Public Member Functions

- **MotionControllerPage** (const MotionController &mc)
- void update (bool was_pressed, int x, int y) override

  collect data, respond to screen input, do fast things (runs at 50hz even if you're not focused on this Page (only drawn page gets touch updates))
- void draw (vex::brain::lcd &screen, bool first_draw, unsigned int frame_number)

  draw stored data to the screen (runs at 10 hz and only runs if this page is in front)

5.49.1 Member Function Documentation

5.49.1.1 draw()

```
void MotionControllerPage::draw (
            vex::brain::lcd & screen,
            bool first_draw,
            unsigned int frame_number )  [inline], [virtual]
```

draw stored data to the screen (runs at 10 hz and only runs if this page is in front)

Parameters

first_draw	true if we just switched to this page
frame_number	frame of drawing we are on (basically an animation tick)

Reimplemented from screen::Page.

5.49.1.2 update()

```
void MotionControllerPage::update (
            bool was_pressed,
            int x,
            int y )  [inline], [override], [virtual]
```

collect data, respond to screen input, do fast things (runs at 50hz even if you're not focused on this Page (only drawn page gets touch updates))

Parameters

was_pressed	true if the screen has been pressed
x	x position of screen press (if the screen was pressed)
y	y position of screen press (if the screen was pressed)

Reimplemented from screen::Page.

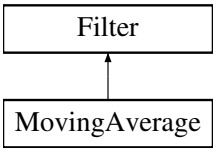
The documentation for this class was generated from the following file:

- src/utils/controls/motion_controller.cpp

5.50 MovingAverage Class Reference

```
#include <moving_average.h>
```

Inheritance diagram for MovingAverage:



Public Member Functions

- MovingAverage (int buffer_size)
- MovingAverage (int buffer_size, double starting_value)
- void add_entry (double n) override
- double get_value () const override
- int get_size () const

5.50.1 Detailed Description

MovingAverage

A moving average is a way of smoothing out noisy data. For many sensor readings, the noise is roughly symmetric around the actual value. This means that if you collect enough samples those that are too high are cancelled out by the samples that are too low leaving the real value.

The MovingAverage class provides a simple interface to do this smoothing from our noisy sensor values.

WARNING: because we need a lot of samples to get the actual value, the value given by the MovingAverage will 'lag' behind the actual value that the sensor is reading. Using a MovingAverage is thus a tradeoff between accuracy and lag time (more samples) vs. less accuracy and faster updating (less samples).

5.50.2 Constructor & Destructor Documentation

5.50.2.1 MovingAverage() [1/2]

```
MovingAverage::MovingAverage (
            int buffer_size )
```

Create a moving average calculator with 0 as the default value

Parameters

buffer_size	The size of the buffer. The number of samples that constitute a valid reading

5.50.2.2 MovingAverage() [2/2]

```
MovingAverage::MovingAverage (
            int buffer_size,
            double starting_value )
```

Create a moving average calculator with a specified default value

Parameters

buffer_size	The size of the buffer. The number of samples that constitute a valid reading
starting_value	The value that the average will be before any data is added

5.50.3 Member Function Documentation

5.50.3.1 add_entry()

```
void MovingAverage::add_entry (
            double n )  [override], [virtual]
```

Add a reading to the buffer Before: [1 1 2 2 3 3] => 2 ^ After: [2 1 2 2 3 3] => 2.16 ^

Parameters

n	the sample that will be added to the moving average.

Implements Filter.

5.50.3.2 get_size()

```
int MovingAverage::get_size ( ) const
```

How many samples the average is made from

Returns

the number of samples used to calculate this average

5.50.3.3 get_value()

```
double MovingAverage::get_value ( ) const  [override], [virtual]
```

Returns the average based off of all the samples collected so far

Returns

the calculated average. sum(samples)/numsamples

How many samples the average is made from

Returns

the number of samples used to calculate this average

Implements Filter.

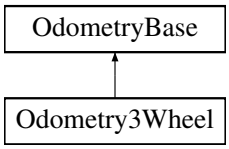
The documentation for this class was generated from the following files:

- include/utils/moving_average.h
- src/utils/moving_average.cpp

5.51 Odometry3Wheel Class Reference

`#include <odometry_3wheel.h>`

Inheritance diagram for Odometry3Wheel:



Classes

- struct odometry3wheel_cfg_t

Public Member Functions

- Odometry3Wheel (CustomEncoder &lside_fwd, CustomEncoder &rside_fwd, CustomEncoder &off_axis, odometry3wheel_cfg_t &cfg, bool is_async=true)
- pose_t update () override
- void tune (vex::controller &con, TankDrive &drive)

Public Member Functions inherited from OdometryBase

- OdometryBase (bool is_async)
- pose_t get_position (void)
- virtual void set_position (const pose_t &newpos=zero_pos)
- AutoCommand * **SetPositionCmd** (const pose_t &newpos=zero_pos)
- void end_async ()
- double get_speed ()
- double get_accel ()
- double get_angular_speed_deg ()
- double get_angular_accel_deg ()

Additional Inherited Members

Static Public Member Functions inherited from OdometryBase

- static int background_task (void *ptr)
- static double pos_diff (pose_t start_pos, pose_t end_pos)
- static double rot_diff (pose_t pos1, pose_t pos2)
- static double smallest_angle (double start_deg, double end_deg)

Public Attributes inherited from OdometryBase

- bool **end_task** = false

  end_task is true if we instruct the odometry thread to shut down

Static Public Attributes inherited from OdometryBase

- static constexpr pose_t zero_pos = {.x=0.0L, .y=0.0L, .rot=90.0L}

Protected Attributes inherited from OdometryBase

- vex::task * handle
- vex::mutex mut
- pose_t current_pos
- double speed
- double accel
- double ang_speed_deg
- double ang_accel_deg

5.51.1 Detailed Description

Odometry3Wheel

This class handles the code for a standard 3-pod odometry setup, where there are 3 "pods" made up of undriven (dead) wheels connected to encoders in the following configuration:

+Y ----------— ^ | | | | | | | || O || | | | | | | | === | | ----------— | +------------------> + X

Where O is the center of rotation. The robot will monitor the changes in rotation of these wheels and calculate the robot's X, Y and rotation on the field.

This is a "set and forget" class, meaning once the object is created, the robot will immediately begin tracking it's movement in the background.

Author

Ryan McGee

Date

Oct 31 2022

5.51.2 Constructor & Destructor Documentation

5.51.2.1 Odometry3Wheel()

```
Odometry3Wheel::Odometry3Wheel (
            CustomEncoder & lside_fwd,
            CustomEncoder & rside_fwd,
            CustomEncoder & off_axis,
            odometry3wheel_cfg_t & cfg,
            bool is_async = true )
```

Construct a new Odometry 3 Wheel object

Parameters

lside_fwd	left-side encoder reference
rside_fwd	right-side encoder reference
off_axis	off-axis (perpendicular) encoder reference
cfg	robot odometry configuration
is_async	true to constantly run in the background

5.51.3 Member Function Documentation

5.51.3.1 tune()

```
void Odometry3Wheel::tune (
            vex::controller & con,
            TankDrive & drive )
```

A guided tuning process to automatically find tuning parameters. This method is blocking, and returns when tuning has finished. Follow the instructions on the controller to complete the tuning process

Parameters

con	Controller reference, for screen and button control
drive	Drivetrain reference for robot control

A guided tuning process to automatically find tuning parameters. This method is blocking, and returns when tuning has finished. Follow the instructions on the controller to complete the tuning process

It is assumed the gear ratio and encoder PPR have been set correctly

5.51.3.2 update()

```
pose_t Odometry3Wheel::update ( )  [override], [virtual]
```

Update the current position of the robot once, using the current state of the encoders and the previous known location

Returns

the robot's updated position

Implements OdometryBase.

The documentation for this class was generated from the following files:

- include/subsystems/odometry/odometry_3wheel.h
- src/subsystems/odometry/odometry_3wheel.cpp

5.52 Odometry3Wheel::odometry3wheel_cfg_t Struct Reference

`#include <odometry_3wheel.h>`

Public Attributes

- double wheelbase_dist
- double off_axis_center_dist
- double wheel_diam

5.52.1 Detailed Description

odometry3wheel_cfg_t holds all the specifications for how to calculate position with 3 encoders See the core wiki for what exactly each of these parameters measures

5.52.2 Member Data Documentation

5.52.2.1 off_axis_center_dist

`double Odometry3Wheel::odometry3wheel_cfg_t::off_axis_center_dist`

distance from the center of the robot to the center off axis wheel

5.52.2.2 wheel_diam

`double Odometry3Wheel::odometry3wheel_cfg_t::wheel_diam`

the diameter of the tracking wheel

5.52.2.3 wheelbase_dist

`double Odometry3Wheel::odometry3wheel_cfg_t::wheelbase_dist`

distance from the center of the left wheel to the center of the right wheel

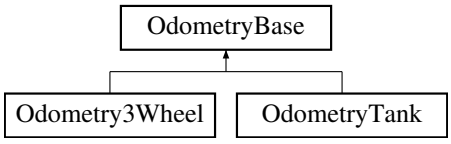
The documentation for this struct was generated from the following file:

- include/subsystems/odometry/odometry_3wheel.h

5.53 OdometryBase Class Reference

`#include <odometry_base.h>`

Inheritance diagram for OdometryBase:



Public Member Functions

- OdometryBase (bool is_async)
- pose_t get_position (void)
- virtual void set_position (const pose_t &newpos=zero_pos)
- AutoCommand * **SetPositionCmd** (const pose_t &newpos=zero_pos)
- virtual pose_t update ()=0
- void end_async ()
- double get_speed ()
- double get_accel ()
- double get_angular_speed_deg ()
- double get_angular_accel_deg ()

Static Public Member Functions

- static int background_task (void *ptr)
- static double pos_diff (pose_t start_pos, pose_t end_pos)
- static double rot_diff (pose_t pos1, pose_t pos2)
- static double smallest_angle (double start_deg, double end_deg)

Public Attributes

- bool **end_task** = false

  end_task is true if we instruct the odometry thread to shut down

Static Public Attributes

- static constexpr pose_t zero_pos = {.x=0.0L, .y=0.0L, .rot=90.0L}

Protected Attributes

- vex::task * handle
- vex::mutex mut
- pose_t current_pos
- double speed
- double accel
- double ang_speed_deg
- double ang_accel_deg

5.53.1 Detailed Description

OdometryBase

This base class contains all the shared code between different implementations of odometry. It handles the asynchronous management, position input/output and basic math functions, and holds positional types specific to field orientation.

All future odometry implementations should extend this file and redefine update() function.

Author

Ryan McGee

Date

Aug 11 2021

5.53.2 Constructor & Destructor Documentation

5.53.2.1 OdometryBase()

```
OdometryBase::OdometryBase (
            bool is_async )
```

Construct a new Odometry Base object

Parameters

is_async	True to run constantly in the background, false to call update() manually

5.53.3 Member Function Documentation

5.53.3.1 background_task()

```
int OdometryBase::background_task (
            void * ptr )  [static]
```

Function that runs in the background task. This function pointer is passed to the vex::task constructor.

Parameters

ptr	Pointer to OdometryBase object

Returns

Required integer return code. Unused.

5.53.3.2 end_async()

```
void OdometryBase::end_async ( )
```

End the background task. Cannot be restarted. If the user wants to end the thread but keep the data up to date, they must run the update() function manually from then on.

5.53.3.3 get_accel()

```
double OdometryBase::get_accel ( )
```

Get the current acceleration

Returns

the acceleration rate of the robot (inch/s^2)

5.53.3.4 get_angular_accel_deg()

```
double OdometryBase::get_angular_accel_deg ( )
```

Get the current angular acceleration in degrees

Returns

the angular acceleration at which we are turning (deg/s^2)

5.53.3.5 get_angular_speed_deg()

```
double OdometryBase::get_angular_speed_deg ( )
```

Get the current angular speed in degrees

Returns

the angular velocity at which we are turning (deg/s)

5.53.3.6 get_position()

```
pose_t OdometryBase::get_position (
            void  )
```

Gets the current position and rotation

Returns

the position that the odometry believes the robot is at

Gets the current position and rotation

5.53.3.7 get_speed()

```
double OdometryBase::get_speed ( )
```

Get the current speed

Returns

the speed at which the robot is moving and grooving (inch/s)

5.53.3.8 pos_diff()

```
double OdometryBase::pos_diff (
            pose_t start_pos,
            pose_t end_pos )  [static]
```

Get the distance between two points

Parameters

start_pos	distance from this point
end_pos	to this point

Returns

the euclidean distance between start_pos and end_pos

5.53.3.9 rot_diff()

```
double OdometryBase::rot_diff (
            pose_t pos1,
            pose_t pos2 )  [static]
```

Get the change in rotation between two points

Parameters

pos1	position with initial rotation
pos2	position with final rotation

Returns

change in rotation between pos1 and pos2

Get the change in rotation between two points

5.53.3.10 set_position()

```
void OdometryBase::set_position (
            const pose_t & newpos = zero_pos )  [virtual]
```

Sets the current position of the robot

Parameters

newpos	the new position that the odometry will believe it is at

Sets the current position of the robot

Reimplemented in OdometryTank.

5.53.3.11 smallest_angle()

```
double OdometryBase::smallest_angle (
            double start_deg,
            double end_deg )  [static]
```

Get the smallest difference in angle between a start heading and end heading. Returns the difference between -180 degrees and +180 degrees, representing the robot turning left or right, respectively.

Parameters

start_deg	intitial angle (degrees)
end_deg	final angle (degrees)

Returns

the smallest angle from the initial to the final angle. This takes into account the wrapping of rotations around 360 degrees

Get the smallest difference in angle between a start heading and end heading. Returns the difference between -180 degrees and +180 degrees, representing the robot turning left or right, respectively.

5.53.3.12 update()

```
virtual pose_t OdometryBase::update ( )  [pure virtual]
```

Update the current position on the field based on the sensors

Returns

the location that the robot is at after the odometry does its calculations

Implemented in Odometry3Wheel, and OdometryTank.

5.53.4 Member Data Documentation

5.53.4.1 accel

```
double OdometryBase::accel  [protected]
```

the rate at which we are accelerating (inch/s^2)

5.53.4.2 ang_accel_deg

```
double OdometryBase::ang_accel_deg  [protected]
```

the rate at which we are accelerating our turn (deg/s^2)

5.53.4.3 ang_speed_deg

```
double OdometryBase::ang_speed_deg  [protected]
```

the speed at which we are turning (deg/s)

5.53.4.4 current_pos

```
pose_t OdometryBase::current_pos  [protected]
```

Current position of the robot in terms of x,y,rotation

5.53.4.5 handle

```
vex::task* OdometryBase::handle  [protected]
```

handle to the vex task that is running the odometry code

5.53.4.6 mut

```
vex::mutex OdometryBase::mut  [protected]
```

Mutex to control multithreading

5.53.4.7 speed

```
double OdometryBase::speed  [protected]
```

the speed at which we are travelling (inch/s)

5.53.4.8 zero_pos

```
constexpr pose_t OdometryBase::zero_pos = {.x=0.0L, .y=0.0L, .rot=90.0L}  [inline], [static],
[constexpr]
```

Zeroed position. X=0, Y=0, Rotation= 90 degrees

The documentation for this class was generated from the following files:

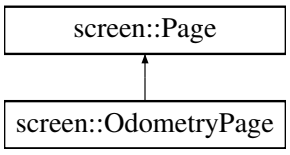
- include/subsystems/odometry/odometry_base.h
- src/subsystems/odometry/odometry_base.cpp

5.54 screen::OdometryPage Class Reference

a page that shows odometry position and rotation and a map (if an sd card with the file is on)

```
#include <screen.h>
```

Inheritance diagram for screen::OdometryPage:



Public Member Functions

- OdometryPage (OdometryBase &odom, double robot_width, double robot_height, bool do_trail)

  Create an odometry trail. Make sure odometry is initilized before now.
- void update (bool was_pressed, int x, int y) override
- void draw (vex::brain::lcd &, bool first_draw, unsigned int frame_number) override

5.54.1 Detailed Description

a page that shows odometry position and rotation and a map (if an sd card with the file is on)

5.54.2 Constructor & Destructor Documentation

5.54.2.1 OdometryPage()

```
screen::OdometryPage::OdometryPage (
            OdometryBase & odom,
            double robot_width,
            double robot_height,
            bool do_trail )
```

Create an odometry trail. Make sure odometry is initilized before now.

Parameters

odom	the odometry system to monitor
robot_width	the width (side to side) of the robot in inches. Used for visualization
robot_height	the robot_height (front to back) of the robot in inches. Used for visualization
do_trail	whether or not to calculate and draw the trail. Drawing and storing takes a very *slight* extra amount of processing power

5.54.3 Member Function Documentation

5.54.3.1 draw()

```
void screen::OdometryPage::draw (
            vex::brain::lcd & scr,
            bool first_draw,
            unsigned int frame_number )  [override], [virtual]
```

See also

Page::draw

Reimplemented from screen::Page.

5.54.3.2 update()

```
void screen::OdometryPage::update (
            bool was_pressed,
            int x,
            int y )  [override], [virtual]
```

See also

Page::update

Reimplemented from screen::Page.

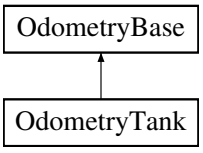
The documentation for this class was generated from the following files:

- include/subsystems/screen.h
- src/subsystems/screen.cpp

5.55 OdometryTank Class Reference

```
#include <odometry_tank.h>
```

Inheritance diagram for OdometryTank:



Public Member Functions

- OdometryTank (vex::motor_group &left_side, vex::motor_group &right_side, robot_specs_t &config, vex↩ ::inertial *imu=NULL, bool is_async=true)
- OdometryTank (CustomEncoder &left_custom_enc, CustomEncoder &right_custom_enc, robot_specs_t &config, vex::inertial *imu=NULL, bool is_async=true)
- OdometryTank (vex::encoder &left_vex_enc, vex::encoder &right_vex_enc, robot_specs_t &config, vex↩ ::inertial *imu=NULL, bool is_async=true)
- pose_t update () override
- void set_position (const pose_t &newpos=zero_pos) override

Public Member Functions inherited from OdometryBase

- OdometryBase (bool is_async)
- pose_t get_position (void)
- AutoCommand * **SetPositionCmd** (const pose_t &newpos=zero_pos)
- void end_async ()
- double get_speed ()
- double get_accel ()
- double get_angular_speed_deg ()
- double get_angular_accel_deg ()

Additional Inherited Members

Static Public Member Functions inherited from OdometryBase

- static int background_task (void *ptr)
- static double pos_diff (pose_t start_pos, pose_t end_pos)
- static double rot_diff (pose_t pos1, pose_t pos2)
- static double smallest_angle (double start_deg, double end_deg)

Public Attributes inherited from OdometryBase

- bool **end_task** = false

  end_task is true if we instruct the odometry thread to shut down

Static Public Attributes inherited from OdometryBase

- static constexpr pose_t zero_pos = {.x=0.0L, .y=0.0L, .rot=90.0L}

Protected Attributes inherited from OdometryBase

- vex::task * handle
- vex::mutex mut
- pose_t current_pos
- double speed
- double accel
- double ang_speed_deg
- double ang_accel_deg

5.55.1 Detailed Description

OdometryTank defines an odometry system for a tank drivetrain This requires encoders in the same orientation as the drive wheels Odometry is a "start and forget" subsystem, which means once it's created and configured, it will constantly run in the background and track the robot's X, Y and rotation coordinates.

5.55.2 Constructor & Destructor Documentation

5.55.2.1 OdometryTank() [1/3]

```
OdometryTank::OdometryTank (
            vex::motor_group & left_side,
            vex::motor_group & right_side,
            robot_specs_t & config,
            vex::inertial * imu = NULL,
            bool is_async = true )
```

Initialize the Odometry module, calculating position from the drive motors.

Parameters

left_side	The left motors
right_side	The right motors
config	the specifications that supply the odometry with descriptions of the robot. See robot_specs_t for what is contained
imu	The robot's inertial sensor. If not included, rotation is calculated from the encoders.
is_async	If true, position will be updated in the background continuously. If false, the programmer will have to manually call update().

5.55.2.2 OdometryTank() [2/3]

```
OdometryTank::OdometryTank (
            CustomEncoder & left_custom_enc,
            CustomEncoder & right_custom_enc,
            robot_specs_t & config,
            vex::inertial * imu = NULL,
            bool is_async = true )
```

Initialize the Odometry module, calculating position from the drive motors.

Parameters

left_custom_enc	The left custom encoder
right_custom_enc	The right custom encoder
config	the specifications that supply the odometry with descriptions of the robot. See robot_specs_t for what is contained
imu	The robot's inertial sensor. If not included, rotation is calculated from the encoders.
is_async	If true, position will be updated in the background continuously. If false, the programmer will have to manually call update().

5.55.2.3 OdometryTank() [3/3]

```
OdometryTank::OdometryTank (
            vex::encoder & left_vex_enc,
            vex::encoder & right_vex_enc,
            robot_specs_t & config,
            vex::inertial * imu = NULL,
            bool is_async = true )
```

Initialize the Odometry module, calculating position from the drive motors.

Parameters

left_vex_enc	The left vex encoder
right_vex_enc	The right vex encoder
config	the specifications that supply the odometry with descriptions of the robot. See robot_specs_t for what is contained
imu	The robot's inertial sensor. If not included, rotation is calculated from the encoders.
is_async	If true, position will be updated in the background continuously. If false, the programmer will have to manually call update().

5.55.3 Member Function Documentation

5.55.3.1 set_position()

```
void OdometryTank::set_position (
            const pose_t & newpos = zero_pos )  [override], [virtual]
```

set_position tells the odometry to place itself at a position

Parameters

newpos	the position the odometry will take

Resets the position and rotational data to the input.

Reimplemented from OdometryBase.

5.55.3.2 update()

```
pose_t OdometryTank::update ( )  [override], [virtual]
```

Update the current position on the field based on the sensors

Returns

the position that odometry has calculated itself to be at

Update, store and return the current position of the robot. Only use if not initializing with a separate thread.

Implements OdometryBase.

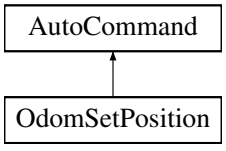
The documentation for this class was generated from the following files:

- include/subsystems/odometry/odometry_tank.h
- src/subsystems/odometry/odometry_tank.cpp

5.56 OdomSetPosition Class Reference

```
#include <drive_commands.h>
```

Inheritance diagram for OdomSetPosition:



Public Member Functions

- OdomSetPosition (OdometryBase &odom, const pose_t &newpos=OdometryBase::zero_pos)
- bool run () override

Public Member Functions inherited from AutoCommand

- virtual void on_timeout ()
- AutoCommand * **withTimeout** (double t_seconds)
- AutoCommand * **withCancelCondition** (Condition *true_to_end)

Additional Inherited Members

Public Attributes inherited from AutoCommand

- double timeout_seconds = default_timeout
- Condition * **true_to_end** = nullptr

Static Public Attributes inherited from AutoCommand

- static constexpr double **default_timeout** = 10.0

5.56.1 Detailed Description

AutoCommand wrapper class for the set_position function in the Odometry class

5.56.2 Constructor & Destructor Documentation

5.56.2.1 OdomSetPosition()

```
OdomSetPosition::OdomSetPosition (
            OdometryBase & odom,
            const pose_t & newpos = OdometryBase::zero_pos )
```

constructs a new OdomSetPosition command

Parameters

odom	the odometry system we are setting
newpos	the position we are telling the odometry to take. defaults to (0, 0), angle = 90

Construct an Odometry set pos

Parameters

odom	the odometry system we are setting
newpos	the now position to set the odometry to

5.56.3 Member Function Documentation

5.56.3.1 run()

```
bool OdomSetPosition::run ( )  [override], [virtual]
```

Run set_position Overrides run from AutoCommand

Returns

true when execution is complete, false otherwise

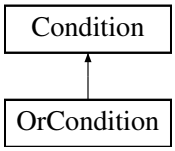
Reimplemented from AutoCommand.

The documentation for this class was generated from the following files:

- include/utils/command_structure/drive_commands.h
- src/utils/command_structure/drive_commands.cpp

5.57 OrCondition Class Reference

Inheritance diagram for OrCondition:



Public Member Functions

- **OrCondition** (Condition *A, Condition *B)
- bool test () override

Public Member Functions inherited from Condition

- Condition * **Or** (Condition *b)
- Condition * **And** (Condition *b)

5.57.1 Member Function Documentation

5.57.1.1 test()

```
bool OrCondition::test ( )  [inline], [override], [virtual]
```

Implements Condition.

The documentation for this class was generated from the following file:

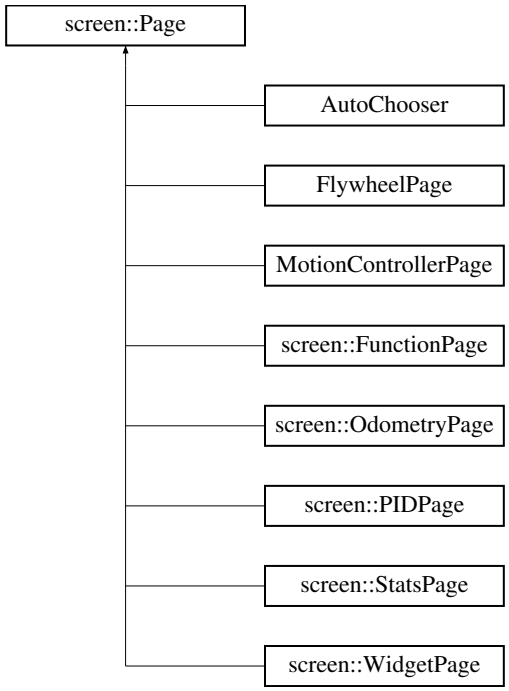
- src/utils/command_structure/auto_command.cpp

5.58 screen::Page Class Reference

Page describes one part of the screen slideshow.

`#include <screen.h>`

Inheritance diagram for screen::Page:



Public Member Functions

- virtual void update (bool was_pressed, int x, int y)

  collect data, respond to screen input, do fast things (runs at 50hz even if you're not focused on this Page (only drawn page gets touch updates))
- virtual void draw (vex::brain::lcd &screen, bool first_draw, unsigned int frame_number)

  draw stored data to the screen (runs at 10 hz and only runs if this page is in front)

5.58.1 Detailed Description

Page describes one part of the screen slideshow.

5.58.2 Member Function Documentation

5.58.2.1 draw()

```
virtual void screen::Page::draw (
            vex::brain::lcd & screen,
            bool first_draw,
            unsigned int frame_number )  [virtual]
```

draw stored data to the screen (runs at 10 hz and only runs if this page is in front)

Parameters

first_draw	true if we just switched to this page
frame_number	frame of drawing we are on (basically an animation tick)

Reimplemented in AutoChooser, screen::WidgetPage, screen::StatsPage, screen::OdometryPage, screen::FunctionPage, screen::PIDPage, MotionControllerPage, and FlywheelPage.

5.58.2.2 update()

```
virtual void screen::Page::update (
            bool was_pressed,
            int x,
            int y )  [virtual]
```

collect data, respond to screen input, do fast things (runs at 50hz even if you're not focused on this Page (only drawn page gets touch updates))

Parameters

was_pressed	true if the screen has been pressed
x	x position of screen press (if the screen was pressed)
y	y position of screen press (if the screen was pressed)

Reimplemented in AutoChooser, screen::WidgetPage, screen::StatsPage, screen::OdometryPage, screen::FunctionPage, screen::PIDPage, MotionControllerPage, and FlywheelPage.

The documentation for this class was generated from the following file:

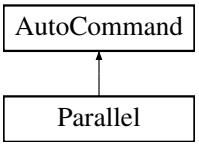
- include/subsystems/screen.h

5.59 Parallel Class Reference

Parallel runs multiple commands in parallel and waits for all to finish before continuing. if none finish before this command's timeout, it will call on_timeout on all children continue.

```
#include <auto_command.h>
```

Inheritance diagram for Parallel:



Public Member Functions

- **Parallel** (std::initializer_list< AutoCommand * > cmds)
- bool run () override
- void on_timeout () override

Public Member Functions inherited from AutoCommand

- AutoCommand * **withTimeout** (double t_seconds)
- AutoCommand * **withCancelCondition** (Condition *true_to_end)

Additional Inherited Members

Public Attributes inherited from AutoCommand

- double timeout_seconds = default_timeout
- Condition * **true_to_end** = nullptr

Static Public Attributes inherited from AutoCommand

- static constexpr double **default_timeout** = 10.0

5.59.1 Detailed Description

Parallel runs multiple commands in parallel and waits for all to finish before continuing. if none finish before this command's timeout, it will call on_timeout on all children continue.

5.59.2 Member Function Documentation

5.59.2.1 on_timeout()

```
void Parallel::on_timeout ( )  [override], [virtual]
```

What to do if we timeout instead of finishing. timeout is specified by the timeout seconds in the constructor

Reimplemented from AutoCommand.

5.59.2.2 run()

```
bool Parallel::run ( )  [override], [virtual]
```

Executes the command Overridden by child classes

Returns

true when the command is finished, false otherwise

Reimplemented from AutoCommand.

The documentation for this class was generated from the following files:

- include/utils/command_structure/auto_command.h
- src/utils/command_structure/auto_command.cpp

5.60 parallel_runner_info Struct Reference

Public Attributes

- int **index**
- std::vector< vex::task * > * **runners**
- AutoCommand * **cmd**

The documentation for this struct was generated from the following file:

- src/utils/command_structure/auto_command.cpp

5.61 PurePursuit::Path Class Reference

```
#include <pure_pursuit.h>
```

Public Member Functions

- Path (std::vector< point_t > points, double radius)
- std::vector< point_t > get_points ()
- double get_radius ()
- bool is_valid ()

5.61.1 Detailed Description

Wrapper for a vector of points, checking if any of the points are too close for pure pursuit

5.61.2 Constructor & Destructor Documentation

5.61.2.1 Path()

```
PurePursuit::Path::Path (
            std::vector< point_t > points,
            double radius )
```

Create a Path

Parameters

points	the points that make up the path
radius	the lookahead radius for pure pursuit

5.61.3 Member Function Documentation

5.61.3.1 get_points()

```
std::vector< point_t > PurePursuit::Path::get_points ( )
```

Get the points associated with this Path

5.61.3.2 get_radius()

```
double PurePursuit::Path::get_radius ( )
```

Get the radius associated with this Path

5.61.3.3 is_valid()

```
bool PurePursuit::Path::is_valid ( )
```

Get whether this path will behave as expected

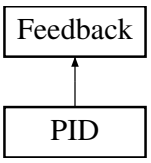
The documentation for this class was generated from the following files:

- include/utils/pure_pursuit.h
- src/utils/pure_pursuit.cpp

5.62 PID Class Reference

```
#include <pid.h>
```

Inheritance diagram for PID:



Classes

- struct pid_config_t

Public Types

- enum ERROR_TYPE { **LINEAR** , **ANGULAR** }

Public Member Functions

- PID (pid_config_t &config)
- void init (double start_pt, double set_pt, double start_vel=0, double end_vel=0) override
- double update (double sensor_val) override
- double get_sensor_val () const

  gets the sensor value that we were last updated with
- double get () override
- void set_limits (double lower, double upper) override
- bool is_on_target () override
- void reset ()
- double get_error ()
- double get_target () const
- void set_target (double target)

Public Attributes

- pid_config_t & config

5.62.1 Detailed Description

PID Class

Defines a standard feedback loop using the constants kP, kI, kD, deadband, and on_target_time. The formula is:

out = kP∗error + kI∗integral(d Error) + kD∗(dError/dt)

The PID object will determine it is "on target" when the error is within the deadband, for a duration of on_target_time

Author

Ryan McGee

Date

4/3/2020

5.62.2 Member Enumeration Documentation

5.62.2.1 ERROR_TYPE

```
enum PID::ERROR_TYPE
```

An enum to distinguish between a linear and angular caluclation of PID error.

5.62.3 Constructor & Destructor Documentation

5.62.3.1 PID()

```
PID::PID (
            pid_config_t & config )
```

Create the PID object

Parameters

config	the configuration data for this controller

Create the PID object

5.62.4 Member Function Documentation

5.62.4.1 get()

```
double PID::get ( )  [override], [virtual]
```

Gets the current PID out value, from when update() was last run

Returns

the Out value of the controller (voltage, RPM, whatever the PID controller is controlling)

Gets the current PID out value, from when update() was last run

Implements Feedback.

5.62.4.2 get_error()

```
double PID::get_error ( )
```

Get the delta between the current sensor data and the target

Returns

the error calculated. how it is calculated depends on error_method specified in pid_config_t

Get the delta between the current sensor data and the target

5.62.4.3 get_sensor_val()

```
double PID::get_sensor_val ( ) const
```

gets the sensor value that we were last updated with

Returns

sensor_val

5.62.4.4 get_target()

```
double PID::get_target ( ) const
```

Get the PID's target

Returns

the target the PID controller is trying to achieve

5.62.4.5 init()

```
void PID::init (
            double start_pt,
            double set_pt,
            double start_vel = 0,
            double end_vel = 0 )  [override], [virtual]
```

Inherited from Feedback for interoperability. Update the setpoint and reset integral accumulation

start_pt can be safely ignored in this feedback controller

Parameters

start_pt	commpletely ignored for PID. necessary to satisfy Feedback base
set_pt	sets the target of the PID controller
start_vel	completely ignored for PID. necessary to satisfy Feedback base
end_vel	sets the target end velocity of the PID controller

Implements Feedback.

5.62.4.6 is_on_target()

```
bool PID::is_on_target ( )  [override], [virtual]
```

Checks if the PID controller is on target.

Returns

true if the loop is within [deadband] for [on_target_time] seconds

Returns true if the loop is within [deadband] for [on_target_time] seconds

Implements Feedback.

5.62.4.7 reset()

```
void PID::reset ( )
```

Reset the PID loop by resetting time since 0 and accumulated error.

5.62.4.8 set_limits()

```
void PID::set_limits (
            double lower,
            double upper )  [override], [virtual]
```

Set the limits on the PID out. The PID out will "clip" itself to be between the limits.

Parameters

lower	the lower limit. the PID controller will never command the output go below `lower`
upper	the upper limit. the PID controller will never command the output go higher than `upper`

Set the limits on the PID out. The PID out will "clip" itself to be between the limits.

Implements Feedback.

5.62.4.9 set_target()

```
void PID::set_target (
            double target )
```

Set the target for the PID loop, where the robot is trying to end up

Parameters

target	the sensor reading we would like to achieve

Set the target for the PID loop, where the robot is trying to end up

5.62.4.10 update()

```
double PID::update (
            double sensor_val )  [override], [virtual]
```

Update the PID loop by taking the time difference from last update, and running the PID formula with the new sensor data

Parameters

sensor_val	the distance, angle, encoder position or whatever it is we are measuring

Returns

the new output. What would be returned by PID::get()

Implements Feedback.

5.62.5 Member Data Documentation

5.62.5.1 config

```
pid_config_t& PID::config
```

configuration struct for this controller. see pid_config_t for information about what this contains

The documentation for this class was generated from the following files:

- include/utils/controls/pid.h
- src/utils/controls/pid.cpp

5.63 PID::pid_config_t Struct Reference

```
#include <pid.h>
```

Public Attributes

- double **p**

  proportional coeffecient p ∗ error()
- double **i**

  integral coeffecient i ∗ integral(error)
- double **d**

  derivitave coeffecient d ∗ derivative(error)
- double **deadband**

  at what threshold are we close enough to be finished
- double on_target_time
- ERROR_TYPE error_method

5.63.1 Detailed Description

pid_config_t holds the configuration parameters for a pid controller In addtion to the constant of proportional, integral and derivative, these parameters include:

- deadband -
- on_target_time - for how long do we have to be at the target to stop As well, pid_config_t holds an error type which determines whether errors should be calculated as if the sensor position is a measure of distance or an angle

5.63.2 Member Data Documentation

5.63.2.1 error_method

```
ERROR_TYPE PID::pid_config_t::error_method
```

Linear or angular. wheter to do error as a simple subtraction or to wrap

5.63.2.2 on_target_time

```
double PID::pid_config_t::on_target_time
```

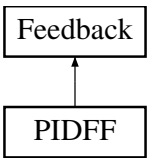
the time in seconds that we have to be on target for to say we are officially at the target

The documentation for this struct was generated from the following file:

- include/utils/controls/pid.h

5.64 PIDFF Class Reference

Inheritance diagram for PIDFF:



Public Member Functions

- **PIDFF** (PID::pid_config_t &pid_cfg, FeedForward::ff_config_t &ff_cfg)
- void init (double start_pt, double set_pt, double start_vel, double end_vel) override
- void set_target (double set_pt)
- double **get_target** () const
- double **get_sensor_val** () const
- double update (double val) override
- double update (double val, double vel_setpt, double a_setpt=0)
- double get () override
- void set_limits (double lower, double upper) override
- bool is_on_target () override
- void **reset** ()

Public Attributes

- PID **pid**

5.64.1 Member Function Documentation

5.64.1.1 get()

```
double PIDFF::get ( )  [override], [virtual]
```

Returns

the last saved result from the feedback controller

Implements Feedback.

5.64.1.2 init()

```
void PIDFF::init (
            double start_pt,
            double set_pt,
            double start_vel,
            double end_vel )  [override], [virtual]
```

Initialize the feedback controller for a movement

Parameters

start_pt	the current sensor value
set_pt	where the sensor value should be
start_vel	the current rate of change of the sensor value
end_vel	the desired ending rate of change of the sensor value

Initialize the feedback controller for a movement

Parameters

start_pt	the current sensor value
set_pt	where the sensor value should be

Implements Feedback.

5.64.1.3 is_on_target()

```
bool PIDFF::is_on_target ( )  [override], [virtual]
```

Returns

true if the feedback controller has reached it's setpoint

Implements Feedback.

5.64.1.4 set_limits()

```
void PIDFF::set_limits (
            double lower,
            double upper )  [override], [virtual]
```

Clamp the upper and lower limits of the output. If both are 0, no limits should be applied.

Parameters

lower	Upper limit
upper	Lower limit

Implements Feedback.

5.64.1.5 set_target()

```
void PIDFF::set_target (
            double set_pt )
```

Set the target of the PID loop

Parameters

set↩ _pt	Setpoint / target value

5.64.1.6 update() [1/2]

```
double PIDFF::update (
            double val )  [override], [virtual]
```

Iterate the feedback loop once with an updated sensor value. Only kS for feedfoward will be applied.

Parameters

val	value from the sensor

Returns

feedback loop result

Implements Feedback.

5.64.1.7 update() [2/2]

```
double PIDFF::update (
            double val,
            double vel_setpt,
            double a_setpt = 0 )
```

Iterate the feedback loop once with an updated sensor value

Parameters

val	value from the sensor
vel_setpt	Velocity for feedforward
a_setpt	Acceleration for feedfoward

Returns

feedback loop result

The documentation for this class was generated from the following files:

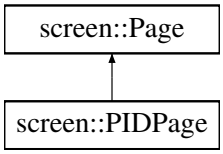
- include/utils/controls/pidff.h
- src/utils/controls/pidff.cpp

5.65 screen::PIDPage Class Reference

PIDPage provides a way to tune a pid controller on the screen.

`#include <screen.h>`

Inheritance diagram for screen::PIDPage:



Public Member Functions

- PIDPage (PID &pid, std::function< void(void)> onchange=[]() {})
  Create a PIDPage.
- **PIDPage** (PIDFF &pidff, std::string name, std::function< void(void)> onchange=[]() {})
- void update (bool was_pressed, int x, int y) override
- void draw (vex::brain::lcd &, bool first_draw, unsigned int frame_number) override

5.65.1 Detailed Description

PIDPage provides a way to tune a pid controller on the screen.

5.65.2 Constructor & Destructor Documentation

5.65.2.1 PIDPage()

```
screen::PIDPage::PIDPage (
            PID & pid,
            std::string name,
            std::function< void(void)> onchange = [](){} )
```

Create a PIDPage.

Parameters

pid	the pid controller we're changing
name	a name to recognize this pid controller if we've got multiple pid screens
onchange	a function that is called when a tuning parameter is changed. If you need to update stuff on that change register a handler here

5.65.3 Member Function Documentation

5.65.3.1 draw()

```
void screen::PIDPage::draw (
            vex::brain::lcd & scr,
            bool first_draw,
            unsigned int frame_number )  [override], [virtual]
```

See also

Page::draw

Reimplemented from screen::Page.

5.65.3.2 update()

```
void screen::PIDPage::update (
            bool was_pressed,
            int x,
            int y )  [override], [virtual]
```

See also

Page::update

Reimplemented from screen::Page.

The documentation for this class was generated from the following files:

- include/subsystems/screen.h
- src/subsystems/screen.cpp

5.66 point_t Struct Reference

```
#include <geometry.h>
```

Public Member Functions

- double dist (const point_t other) const
- point_t operator+ (const point_t &other) const
- point_t operator- (const point_t &other) const
- point_t **operator**∗ (double s) const
- point_t **operator**/ (double s) const
- point_t **operator-** () const
- point_t **operator+** () const
- bool **operator==** (const point_t &rhs)

Public Attributes

- double **x**

  the x position in space
- double **y**

  the y position in space

5.66.1 Detailed Description

Data structure representing an X,Y coordinate

5.66.2 Member Function Documentation

5.66.2.1 dist()

```
double point_t::dist (
            const point_t other ) const  [inline]
```

dist calculates the euclidian distance between this point and another point using the pythagorean theorem

Parameters

other	the point to measure the distance from

Returns

the euclidian distance between this and other

5.66.2.2 operator+()

```
point_t point_t::operator+ (
            const point_t & other ) const  [inline]
```

Vector2D addition operation on points

Parameters

other	the point to add on to this

Returns

this + other (this.x + other.x, this.y + other.y)

5.66.2.3 operator-()

```
point_t point_t::operator- (
            const point_t & other ) const  [inline]
```

Vector2D subtraction operation on points

Parameters

other	the point_t to subtract from this

Returns

this - other (this.x - other.x, this.y - other.y)

The documentation for this struct was generated from the following file:

- include/utils/geometry.h

5.67 pose_t Struct Reference

`#include <geometry.h>`

Public Member Functions

- point_t **get_point** ()

Public Attributes

- double **x**

  x position in the world
- double **y**

  y position in the world
- double **rot**

  rotation in the world

5.67.1 Detailed Description

Describes a single position and rotation

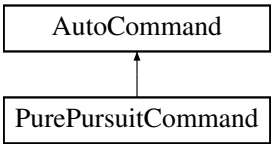
The documentation for this struct was generated from the following file:

- include/utils/geometry.h

5.68 PurePursuitCommand Class Reference

`#include <drive_commands.h>`

Inheritance diagram for PurePursuitCommand:



Public Member Functions

- PurePursuitCommand (TankDrive &drive_sys, Feedback &feedback, PurePursuit::Path path, directionType dir, double max_speed=1, double end_speed=0)
- bool run () override
- void on_timeout () override

Public Member Functions inherited from AutoCommand

- AutoCommand * **withTimeout** (double t_seconds)
- AutoCommand * **withCancelCondition** (Condition *true_to_end)

Additional Inherited Members

Public Attributes inherited from AutoCommand

- double timeout_seconds = default_timeout
- Condition * **true_to_end** = nullptr

Static Public Attributes inherited from AutoCommand

- static constexpr double **default_timeout** = 10.0

5.68.1 Detailed Description

Autocommand wrapper class for pure pursuit function in the TankDrive class

5.68.2 Constructor & Destructor Documentation

5.68.2.1 PurePursuitCommand()

```
PurePursuitCommand::PurePursuitCommand (
            TankDrive & drive_sys,
            Feedback & feedback,
            PurePursuit::Path path,
            directionType dir,
            double max_speed = 1,
            double end_speed = 0 )
```

Construct a Pure Pursuit AutoCommand

Parameters

path	The list of coordinates to follow, in order
dir	Run the bot forwards or backwards
feedback	The feedback controller determining speed
max_speed	Limit the speed of the robot (for pid / pidff feedbacks)

5.68.3 Member Function Documentation

5.68.3.1 on_timeout()

```
void PurePursuitCommand::on_timeout ( )  [override], [virtual]
```

Reset the drive system when it times out

Reimplemented from AutoCommand.

5.68.3.2 run()

```
bool PurePursuitCommand::run ( )  [override], [virtual]
```

Direct call to TankDrive::pure_pursuit

Reimplemented from AutoCommand.

The documentation for this class was generated from the following files:

- include/utils/command_structure/drive_commands.h
- src/utils/command_structure/drive_commands.cpp

5.69 Rect Struct Reference

Public Member Functions

- point_t **dimensions** () const
- point_t **center** () const
- double **width** () const
- double **height** () const
- bool **contains** (point_t p) const

Static Public Member Functions

- static Rect **from_min_and_size** (point_t min, point_t size)

Public Attributes

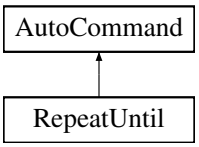
- point_t **min**
- point_t **max**

The documentation for this struct was generated from the following file:

- include/utils/geometry.h

5.70 RepeatUntil Class Reference

Inheritance diagram for RepeatUntil:



Public Member Functions

- RepeatUntil (InOrder cmds, size_t repeats)

  RepeatUntil that runs a fixed number of times.
- RepeatUntil (InOrder cmds, Condition *true_to_end)

  RepeatUntil the condition.
- bool run () override
- void on_timeout () override

Public Member Functions inherited from AutoCommand

- AutoCommand * **withTimeout** (double t_seconds)
- AutoCommand * **withCancelCondition** (Condition *true_to_end)

Additional Inherited Members

Public Attributes inherited from AutoCommand

- double timeout_seconds = default_timeout
- Condition * **true_to_end** = nullptr

Static Public Attributes inherited from AutoCommand

- static constexpr double **default_timeout** = 10.0

5.70.1 Constructor & Destructor Documentation

5.70.1.1 RepeatUntil() [1/2]

```
RepeatUntil::RepeatUntil (
            InOrder cmds,
            size_t repeats )
```

RepeatUntil that runs a fixed number of times.

Parameters

cmds	the cmds to repeat
repeats	the number of repeats to do

5.70.1.2 RepeatUntil() [2/2]

```
RepeatUntil::RepeatUntil (
            InOrder cmds,
            Condition * true_to_end )
```

RepeatUntil the condition.

Parameters

cmds	the cmds to run
true_to_end	we will repeat until true_or_end.test() returns true

5.70.2 Member Function Documentation

5.70.2.1 on_timeout()

```
void RepeatUntil::on_timeout ( )  [override], [virtual]
```

What to do if we timeout instead of finishing. timeout is specified by the timeout seconds in the constructor

Reimplemented from AutoCommand.

5.70.2.2 run()

```
bool RepeatUntil::run ( )  [override], [virtual]
```

Executes the command Overridden by child classes

Returns

true when the command is finished, false otherwise

Reimplemented from AutoCommand.

The documentation for this class was generated from the following files:

- include/utils/command_structure/auto_command.h
- src/utils/command_structure/auto_command.cpp

5.71 robot_specs_t Struct Reference

`#include <robot_specs.h>`

Public Attributes

- double **robot_radius**

  if you were to draw a circle with this radius, the robot would be entirely contained within it
- double **odom_wheel_diam**

  the diameter of the wheels used for
- double **odom_gear_ratio**

  the ratio of the odometry wheel to the encoder reading odometry data
- double **dist_between_wheels**

  the distance between centers of the central drive wheels
- double **drive_correction_cutoff**

  the distance at which to stop trying to turn towards the target. If we are less than this value, we can continue driving forward to minimize our distance but will not try to spin around to point directly at the target
- Feedback * **drive_feedback**

  the default feedback for autonomous driving
- Feedback * **turn_feedback**

  the defualt feedback for autonomous turning
- PID::pid_config_t **correction_pid**

  the pid controller to keep the robot driving in as straight a line as possible

5.71.1 Detailed Description

Main robot characterization struct. This will be passed to all the major subsystems that require info about the robot. All distance measurements are in inches.

The documentation for this struct was generated from the following file:

- include/robot_specs.h

5.72 screen::ScreenData Struct Reference

The ScreenData class holds the data that will be passed to the screen thread you probably shouldnt have to use it.

Public Member Functions

- **ScreenData** (const std::vector< Page * > &m_pages, int m_page, vex::brain::lcd &m_screen)

Public Attributes

- std::vector< Page * > **pages**
- int **page** = 0
- vex::brain::lcd **screen**

5.72.1 Detailed Description

The ScreenData class holds the data that will be passed to the screen thread you probably shouldnt have to use it.

The documentation for this struct was generated from the following file:

- src/subsystems/screen.cpp

5.73 screen::ScreenRect Struct Reference

Public Attributes

- uint32_t **x1**
- uint32_t **y1**
- uint32_t **x2**
- uint32_t **y2**

The documentation for this struct was generated from the following file:

- include/subsystems/screen.h

5.74 Serializer Class Reference

Serializes Arbitrary data to a file on the SD Card.

`#include <serializer.h>`

Public Member Functions

- ~**Serializer** ()

  Save and close upon destruction (bc of vex, this doesnt always get called when the program ends. To be sure, call save_to_disk)
- Serializer (const std::string &filename, bool flush_always=true)

  create a Serializer
- void save_to_disk () const

  saves current Serializer state to disk
- void set_int (const std::string &name, int i)

  Setters - not saved until save_to_disk is called.
- void set_bool (const std::string &name, bool b)

  sets a bool by the name of name to b. If flush_always == true, this will save to the sd card
- void set_double (const std::string &name, double d)

  sets a double by the name of name to d. If flush_always == true, this will save to the sd card
- void set_string (const std::string &name, std::string str)

  sets a string by the name of name to s. If flush_always == true, this will save to the sd card
- int int_or (const std::string &name, int otherwise)

  gets a value stored in the serializer. If not found, sets the value to otherwise
- bool bool_or (const std::string &name, bool otherwise)

  gets a value stored in the serializer. If not, sets the value to otherwise
- double double_or (const std::string &name, double otherwise)

  gets a value stored in the serializer. If not, sets the value to otherwise
- std::string string_or (const std::string &name, std::string otherwise)

  gets a value stored in the serializer. If not, sets the value to otherwise

5.74.1 Detailed Description

Serializes Arbitrary data to a file on the SD Card.

5.74.2 Constructor & Destructor Documentation

5.74.2.1 Serializer()

```
Serializer::Serializer (
            const std::string & filename,
            bool flush_always = true )  [inline], [explicit]
```

create a Serializer

Parameters

filename	the file to read from. If filename does not exist we will create that file
flush_always	If true, after every write flush to a file. If false, you are responsible for calling save_to_disk

5.74.3 Member Function Documentation

5.74.3.1 bool_or()

```
bool Serializer::bool_or (
            const std::string & name,
            bool otherwise )
```

gets a value stored in the serializer. If not, sets the value to otherwise

Parameters

name	name of value
otherwise	value if the name is not specified

Returns

the value if found or otherwise

5.74.3.2 double_or()

```
double Serializer::double_or (
            const std::string & name,
            double otherwise )
```

gets a value stored in the serializer. If not, sets the value to otherwise

Parameters

name	name of value
otherwise	value if the name is not specified

Returns

the value if found or otherwise

5.74.3.3 int_or()

```
int Serializer::int_or (
            const std::string & name,
            int otherwise )
```

gets a value stored in the serializer. If not found, sets the value to otherwise

Getters Return value if it exists in the serializer

Parameters

name	name of value
otherwise	value if the name is not specified

Returns

the value if found or otherwise

5.74.3.4 save_to_disk()

```
void Serializer::save_to_disk ( ) const
```

saves current Serializer state to disk

forms data bytes then saves to filename this was openned with

5.74.3.5 set_bool()

```
void Serializer::set_bool (
            const std::string & name,
            bool b )
```

sets a bool by the name of name to b. If flush_always == true, this will save to the sd card

Parameters

name	name of bool
b	value of bool

5.74.3.6 set_double()

```
void Serializer::set_double (
            const std::string & name,
            double d )
```

sets a double by the name of name to d. If flush_always == true, this will save to the sd card

Parameters

name	name of double
d	value of double

5.74.3.7 set_int()

```
void Serializer::set_int (
            const std::string & name,
            int i )
```

Setters - not saved until save_to_disk is called.

sets an integer by the name of name to i. If flush_always == true, this will save to the sd card

Parameters

name	name of integer
i	value of integer

5.74.3.8 set_string()

```
void Serializer::set_string (
            const std::string & name,
            std::string str )
```

sets a string by the name of name to s. If flush_always == true, this will save to the sd card

Parameters

name	name of string
i	value of string

5.74.3.9 string_or()

```
std::string Serializer::string_or (
            const std::string & name,
            std::string otherwise )
```

gets a value stored in the serializer. If not, sets the value to otherwise

Parameters

name	name of value
otherwise	value if the name is not specified

Returns

the value if found or otherwise

The documentation for this class was generated from the following files:

- include/utils/serializer.h
- src/utils/serializer.cpp

5.75 screen::SizedWidget Struct Reference

Public Attributes

- int **size**
- WidgetConfig & **widget**

The documentation for this struct was generated from the following file:

- include/subsystems/screen.h

5.76 SliderCfg Struct Reference

Public Attributes

- double & **val**
- double **min**
- double **max**

The documentation for this struct was generated from the following file:

- include/subsystems/layout.h

5.77 screen::SliderConfig Struct Reference

Public Attributes

- double & **val**
- double **low**
- double **high**

The documentation for this struct was generated from the following file:

- include/subsystems/screen.h

5.78 screen::SliderWidget Class Reference

Widget that updates a double value. Updates by reference so watch out for race conditions cuz the screen stuff lives on another thread.

`#include <screen.h>`

Public Member Functions

- SliderWidget (double &val, double low, double high, Rect rect, std::string name)

  Creates a slider widget.
- bool update (bool was_pressed, int x, int y)

  responds to user input
- void **draw** (vex::brain::lcd &, bool first_draw, unsigned int frame_number)

  Page::draws the slide to the screen

5.78.1 Detailed Description

Widget that updates a double value. Updates by reference so watch out for race conditions cuz the screen stuff lives on another thread.

5.78.2 Constructor & Destructor Documentation

5.78.2.1 SliderWidget()

```
screen::SliderWidget::SliderWidget (
            double & val,
            double low,
            double high,
            Rect rect,
            std::string name )  [inline]
```

Creates a slider widget.

Parameters

val	reference to the value to modify
low	minimum value to go to
high	maximum value to go to
rect	rect to draw it
name	name of the value

5.78.3 Member Function Documentation

5.78.3.1 update()

```
bool screen::SliderWidget::update (
```

```
bool was_pressed,
int x,
int y )
```

responds to user input

Parameters

was_pressed	if the screen is pressed
x	x position if the screen was pressed
y	y position if the screen was pressed

Returns

true if the value updated

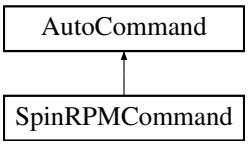
The documentation for this class was generated from the following files:

- include/subsystems/screen.h
- src/subsystems/screen.cpp

5.79 SpinRPMCommand Class Reference

`#include <flywheel_commands.h>`

Inheritance diagram for SpinRPMCommand:



Public Member Functions

- SpinRPMCommand (Flywheel &flywheel, int rpm)
- bool run () override

Public Member Functions inherited from AutoCommand

- virtual void on_timeout ()
- AutoCommand * **withTimeout** (double t_seconds)
- AutoCommand * **withCancelCondition** (Condition *true_to_end)

Additional Inherited Members

Public Attributes inherited from AutoCommand

- double timeout_seconds = default_timeout
- Condition * **true_to_end** = nullptr

Static Public Attributes inherited from AutoCommand

- static constexpr double **default_timeout** = 10.0

5.79.1 Detailed Description

File: flywheel_commands.h Desc: [insert meaningful desc] AutoCommand wrapper class for the spin_rpm function in the Flywheel class

5.79.2 Constructor & Destructor Documentation

5.79.2.1 SpinRPMCommand()

```
SpinRPMCommand::SpinRPMCommand (
            Flywheel & flywheel,
            int rpm )
```

Construct a SpinRPM Command

Parameters

flywheel	the flywheel sys to command
rpm	the rpm that we should spin at

File: flywheel_commands.cpp Desc: [insert meaningful desc]

5.79.3 Member Function Documentation

5.79.3.1 run()

```
bool SpinRPMCommand::run ( )  [override], [virtual]
```

Run spin_manual Overrides run from AutoCommand

Returns

true when execution is complete, false otherwise

Reimplemented from AutoCommand.

The documentation for this class was generated from the following files:

- include/utils/command_structure/flywheel_commands.h
- src/utils/command_structure/flywheel_commands.cpp

5.80 PurePursuit::spline Struct Reference

`#include <pure_pursuit.h>`

Public Member Functions

- double **getY** (double x)

Public Attributes

- double **a**
- double **b**
- double **c**
- double **d**
- double **x_start**
- double **x_end**

5.80.1 Detailed Description

Represents a piece of a cubic spline with s(x) = a(x-xi)^3 + b(x-xi)^2 + c(x-xi) + d The x_start and x_end shows where the equation is valid.

The documentation for this struct was generated from the following file:

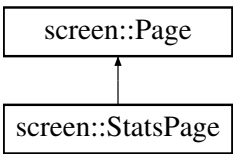
- include/utils/pure_pursuit.h

5.81 screen::StatsPage Class Reference

Draws motor stats and battery stats to the screen.

`#include <screen.h>`

Inheritance diagram for screen::StatsPage:



Public Member Functions

- StatsPage (std::map< std::string, vex::motor & > motors)

  Creates a stats page.
- void update (bool was_pressed, int x, int y) override
- void draw (vex::brain::lcd &, bool first_draw, unsigned int frame_number) override

5.81.1 Detailed Description

Draws motor stats and battery stats to the screen.

5.81.2 Constructor & Destructor Documentation

5.81.2.1 StatsPage()

```
screen::StatsPage::StatsPage (
            std::map< std::string, vex::motor & > motors )
```

Creates a stats page.

Parameters

motors	a map of string to motor that we want to draw on this page

5.81.3 Member Function Documentation

5.81.3.1 draw()

```
void screen::StatsPage::draw (
            vex::brain::lcd & scr,
            bool first_draw,
            unsigned int frame_number )  [override], [virtual]
```

See also

Page::draw

Reimplemented from screen::Page.

5.81.3.2 update()

```
void screen::StatsPage::update (
            bool was_pressed,
            int x,
            int y )  [override], [virtual]
```

See also

Page::update

Reimplemented from screen::Page.

The documentation for this class was generated from the following files:

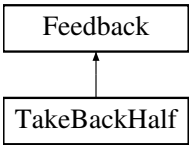
- include/subsystems/screen.h
- src/subsystems/screen.cpp

5.82 TakeBackHalf Class Reference

A velocity controller.

`#include <take_back_half.h>`

Inheritance diagram for TakeBackHalf:



Public Member Functions

- **TakeBackHalf** (double TBH_gain, double first_cross_split, double on_target_threshold)
- void init (double start_pt, double set_pt, double, double)
- double update (double val) override
- double get () override
- void set_limits (double lower, double upper) override
- bool is_on_target () override

Public Attributes

- double **TBH_gain**

  tuned parameter
- double **first_cross_split**

5.82.1 Detailed Description

A velocity controller.

Warning

If you try to use this as a position controller, it will fail.

5.82.2 Member Function Documentation

5.82.2.1 get()

```
double TakeBackHalf::get ( )  [override], [virtual]
```

Returns

the last saved result from the feedback controller

Implements Feedback.

5.82.2.2 init()

```
void TakeBackHalf::init (
            double start_pt,
            double set_pt,
            double ,
            double  )  [virtual]
```

Initialize the feedback controller for a movement

Parameters

start_pt	the current sensor value
set_pt	where the sensor value should be
start_vel	Movement starting velocity (IGNORED)
end_vel	Movement ending velocity (IGNORED)

Implements Feedback.

5.82.2.3 is_on_target()

```
bool TakeBackHalf::is_on_target ( )  [override], [virtual]
```

Returns

true if the feedback controller has reached it's setpoint

Implements Feedback.

5.82.2.4 set_limits()

```
void TakeBackHalf::set_limits (
            double lower,
            double upper )  [override], [virtual]
```

Clamp the upper and lower limits of the output. If both are 0, no limits should be applied.

Parameters

lower	Upper limit
upper	Lower limit

Implements Feedback.

5.82.2.5 update()

```
double TakeBackHalf::update (
            double val )  [override], [virtual]
```

Iterate the feedback loop once with an updated sensor value

Parameters

val	value from the sensor

Returns

feedback loop result

Implements Feedback.

The documentation for this class was generated from the following files:

- include/utils/controls/take_back_half.h
- src/utils/controls/take_back_half.cpp

5.83 TankDrive Class Reference

`#include <tank_drive.h>`

Public Types

- enum class BrakeType { None , ZeroVelocity , Smart }

Public Member Functions

- TankDrive (motor_group &left_motors, motor_group &right_motors, robot_specs_t &config, OdometryBase *odom=NULL)
- AutoCommand * **DriveToPointCmd** (point_t pt, vex::directionType dir=vex::forward, double max_speed=1.0, double end_speed=0.0)
- AutoCommand * **DriveToPointCmd** (Feedback &fb, point_t pt, vex::directionType dir=vex::forward, double max_speed=1.0, double end_speed=0.0)
- AutoCommand * **DriveForwardCmd** (double dist, vex::directionType dir=vex::forward, double max_speed=1.0, double end_speed=0.0)
- AutoCommand * **DriveForwardCmd** (Feedback &fb, double dist, vex::directionType dir=vex::forward, double max_speed=1.0, double end_speed=0.0)
- AutoCommand * **TurnToHeadingCmd** (double heading, double max_speed=1.0, double end_speed=0.0)
- AutoCommand * **TurnToHeadingCmd** (Feedback &fb, double heading, double max_speed=1.0, double end_speed=0.0)
- AutoCommand * **TurnDegreesCmd** (double degrees, double max_speed=1.0, double start_speed=0.0)
- AutoCommand * **TurnDegreesCmd** (Feedback &fb, double degrees, double max_speed=1.0, double end_speed=0.0)
- AutoCommand * **PurePursuitCmd** (PurePursuit::Path path, directionType dir, double max_speed=1, double end_speed=0)
- AutoCommand * **PurePursuitCmd** (Feedback &feedback, PurePursuit::Path path, directionType dir, double max_speed=1, double end_speed=0)
- void stop ()
- void drive_tank (double left, double right, int power=1, BrakeType bt=BrakeType::None)
- void drive_tank_raw (double left, double right)
- void drive_arcade (double forward_back, double left_right, int power=1, BrakeType bt=BrakeType::None)
- bool drive_forward (double inches, directionType dir, Feedback &feedback, double max_speed=1, double end_speed=0)
- bool drive_forward (double inches, directionType dir, double max_speed=1, double end_speed=0)
- bool turn_degrees (double degrees, Feedback &feedback, double max_speed=1, double end_speed=0)
- bool turn_degrees (double degrees, double max_speed=1, double end_speed=0)

- bool drive_to_point (double x, double y, vex::directionType dir, Feedback &feedback, double max_speed=1, double end_speed=0)
- bool drive_to_point (double x, double y, vex::directionType dir, double max_speed=1, double end_speed=0)
- bool turn_to_heading (double heading_deg, Feedback &feedback, double max_speed=1, double end_↩ speed=0)
- bool turn_to_heading (double heading_deg, double max_speed=1, double end_speed=0)
- void reset_auto ()
- bool pure_pursuit (PurePursuit::Path path, directionType dir, Feedback &feedback, double max_speed=1, double end_speed=0)
- bool pure_pursuit (PurePursuit::Path path, directionType dir, double max_speed=1, double end_speed=0)

Static Public Member Functions

- static double modify_inputs (double input, int power=2)

5.83.1 Detailed Description

TankDrive is a class to run a tank drive system. A tank drive system, sometimes called differential drive, has a motor (or group of synchronized motors) on the left and right side

5.83.2 Member Enumeration Documentation

5.83.2.1 BrakeType

```
enum class TankDrive::BrakeType  [strong]
```

Enumerator

None	just send 0 volts to the motors
ZeroVelocity	try to bring the robot to rest. But don't try to hold position
Smart	bring the robot to rest and once it's stopped, try to hold that position

5.83.3 Constructor & Destructor Documentation

5.83.3.1 TankDrive()

```
TankDrive::TankDrive (
            motor_group & left_motors,
            motor_group & right_motors,
            robot_specs_t & config,
            OdometryBase * odom = NULL )
```

Create the TankDrive object

Parameters

left_motors	left side drive motors

Parameters

right_motors	right side drive motors
config	the configuration specification defining physical dimensions about the robot. See robot_specs_t for more info
odom	an odometry system to track position and rotation. this is necessary to execute autonomous paths

5.83.4 Member Function Documentation

5.83.4.1 drive_arcade()

```
void TankDrive::drive_arcade (
            double forward_back,
            double left_right,
            int power = 1,
            BrakeType bt = BrakeType::None )
```

Drive the robot using arcade style controls. forward_back controls the linear motion, left_right controls the turning.

forward_back and left_right are in "percent": -1.0 -> 1.0

Parameters

forward_back	the percent to move forward or backward
left_right	the percent to turn left or right
power	modifies the input velocities left^power, right^power
bt	breaktype. What to do if the driver lets go of the sticks

Drive the robot using arcade style controls. forward_back controls the linear motion, left_right controls the turning.

left_motors and right_motors are in "percent": -1.0 -> 1.0

5.83.4.2 drive_forward() [1/2]

```
bool TankDrive::drive_forward (
            double inches,
            directionType dir,
            double max_speed = 1,
            double end_speed = 0 )
```

Autonomously drive the robot forward a certain distance

Parameters

inches	degrees by which we will turn relative to the robot (+) turns ccw, (-) turns cw
dir	the direction we want to travel forward and backward
max_speed	the maximum percentage of robot speed at which the robot will travel. 1 = full power
end_speed	the movement profile will attempt to reach this velocity by its completion

Autonomously drive the robot forward a certain distance

Parameters

inches	degrees by which we will turn relative to the robot (+) turns ccw, (-) turns cw
dir	the direction we want to travel forward and backward
max_speed	the maximum percentage of robot speed at which the robot will travel. 1 = full power
end_speed	the movement profile will attempt to reach this velocity by its completion

Returns

true if we have finished driving to our point

5.83.4.3 drive_forward() [2/2]

```
bool TankDrive::drive_forward (
            double inches,
            directionType dir,
            Feedback & feedback,
            double max_speed = 1,
            double end_speed = 0 )
```

Use odometry to drive forward a certain distance using a custom feedback controller

Returns whether or not the robot has reached it's destination.

Parameters

inches	the distance to drive forward
dir	the direction we want to travel forward and backward
feedback	the custom feedback controller we will use to travel. controls the rate at which we accelerate and drive.
max_speed	the maximum percentage of robot speed at which the robot will travel. 1 = full power
end_speed	the movement profile will attempt to reach this velocity by its completion

Returns

true when we have reached our target distance

Use odometry to drive forward a certain distance using a custom feedback controller

Returns whether or not the robot has reached it's destination.

Parameters

inches	the distance to drive forward
dir	the direction we want to travel forward and backward
feedback	the custom feedback controller we will use to travel. controls the rate at which we accelerate and drive.
max_speed	the maximum percentage of robot speed at which the robot will travel. 1 = full power
end_speed	the movement profile will attempt to reach this velocity by its completion

5.83.4.4 drive_tank()

```
void TankDrive::drive_tank (
            double left,
            double right,
            int power = 1,
            BrakeType bt = BrakeType::None )
```

Drive the robot using differential style controls. left_motors controls the left motors, right_motors controls the right motors.

left_motors and right_motors are in "percent": -1.0 -> 1.0

Parameters

left	the percent to run the left motors
right	the percent to run the right motors
power	modifies the input velocities left^power, right^power
bt	breaktype. What to do if the driver lets go of the sticks

5.83.4.5 drive_tank_raw()

```
void TankDrive::drive_tank_raw (
            double left,
            double right )
```

Drive the robot raw-ly

Parameters

left	the percent to run the left motors (-1, 1)
right	the percent to run the right motors (-1, 1)

5.83.4.6 drive_to_point() [1/2]

```
bool TankDrive::drive_to_point (
            double x,
            double y,
            vex::directionType dir,
            double max_speed = 1,
            double end_speed = 0 )
```

Use odometry to automatically drive the robot to a point on the field. X and Y is the final point we want the robot. Here we use the default feedback controller from the drive_sys

Returns whether or not the robot has reached it's destination.

Parameters

x	the x position of the target

Parameters

y	the y position of the target
dir	the direction we want to travel forward and backward
max_speed	the maximum percentage of robot speed at which the robot will travel. 1 = full power
end_speed	the movement profile will attempt to reach this velocity by its completion

Use odometry to automatically drive the robot to a point on the field. X and Y is the final point we want the robot. Here we use the default feedback controller from the drive_sys

Returns whether or not the robot has reached it's destination.

Parameters

x	the x position of the target
y	the y position of the target
dir	the direction we want to travel forward and backward
max_speed	the maximum percentage of robot speed at which the robot will travel. 1 = full power
end_speed	the movement profile will attempt to reach this velocity by its completion

Returns

true if we have reached our target point

5.83.4.7 drive_to_point() [2/2]

```
bool TankDrive::drive_to_point (
            double x,
            double y,
            vex::directionType dir,
            Feedback & feedback,
            double max_speed = 1,
            double end_speed = 0 )
```

Use odometry to automatically drive the robot to a point on the field. X and Y is the final point we want the robot.

Returns whether or not the robot has reached it's destination.

Parameters

x	the x position of the target
y	the y position of the target
dir	the direction we want to travel forward and backward
feedback	the feedback controller we will use to travel. controls the rate at which we accelerate and drive.
max_speed	the maximum percentage of robot speed at which the robot will travel. 1 = full power
end_speed	the movement profile will attempt to reach this velocity by its completion

Use odometry to automatically drive the robot to a point on the field. X and Y is the final point we want the robot.

Returns whether or not the robot has reached it's destination.

Parameters

x	the x position of the target
y	the y position of the target
dir	the direction we want to travel forward and backward
feedback	the feedback controller we will use to travel. controls the rate at which we accelerate and drive.
max_speed	the maximum percentage of robot speed at which the robot will travel. 1 = full power
end_speed	the movement profile will attempt to reach this velocity by its completion

Returns

true if we have reached our target point

5.83.4.8 modify_inputs()

```
double TankDrive::modify_inputs (
            double input,
            int power = 2 )  [static]
```

Create a curve for the inputs, so that drivers have more control at lower speeds. Curves are exponential, with the default being squaring the inputs.

Parameters

input	the input before modification
power	the power to raise input to

Returns

input ^ power (accounts for negative inputs and odd numbered powers)

Modify the inputs from the controller by squaring / cubing, etc Allows for better control of the robot at slower speeds

Parameters

input	the input signal -1 -> 1
power	the power to raise the signal to

Returns

input^power accounting for any sign issues that would arise with this naive solution

5.83.4.9 pure_pursuit() [1/2]

```
bool TankDrive::pure_pursuit (
            PurePursuit::Path path,
            directionType dir,
```

```
            double max_speed = 1,
            double end_speed = 0 )
```

Drive the robot autonomously using a pure-pursuit algorithm - Input path with a set of waypoints - the robot will attempt to follow the points while cutting corners (radius) to save time (compared to stop / turn / start)

Use the default drive feedback

Parameters

path	The list of coordinates to follow, in order
dir	Run the bot forwards or backwards
max_speed	Limit the speed of the robot (for pid / pidff feedbacks)
end_speed	the movement profile will attempt to reach this velocity by its completion

Returns

True when the path is complete

Drive the robot autonomously using a pure-pursuit algorithm - Input path with a set of waypoints - the robot will attempt to follow the points while cutting corners (radius) to save time (compared to stop / turn / start)

Use the default drive feedback

Parameters

path	The list of coordinates to follow, in order
dir	Run the bot forwards or backwards
max_speed	Limit the speed of the robot (for pid / pidff feedbacks)

Returns

True when the path is complete

5.83.4.10 pure_pursuit() [2/2]

```
bool TankDrive::pure_pursuit (
            PurePursuit::Path path,
            directionType dir,
            Feedback & feedback,
            double max_speed = 1,
            double end_speed = 0 )
```

Drive the robot autonomously using a pure-pursuit algorithm - Input path with a set of waypoints - the robot will attempt to follow the points while cutting corners (radius) to save time (compared to stop / turn / start)

Parameters

path	The list of coordinates to follow, in order
dir	Run the bot forwards or backwards
feedback	The feedback controller determining speed
max_speed	Limit the speed of the robot (for pid / pidff feedbacks)
end_speed	the movement profile will attempt to reach this velocity by its completion

Returns

True when the path is complete

Drive the robot autonomously using a pure-pursuit algorithm - Input path with a set of waypoints - the robot will attempt to follow the points while cutting corners (radius) to save time (compared to stop / turn / start)

Parameters

path	The list of coordinates to follow, in order
dir	Run the bot forwards or backwards
feedback	The feedback controller determining speed
max_speed	Limit the speed of the robot (for pid / pidff feedbacks)

Returns

True when the path is complete

5.83.4.11 reset_auto()

```
void TankDrive::reset_auto ( )
```

Reset the initialization for autonomous drive functions

5.83.4.12 stop()

```
void TankDrive::stop ( )
```

Stops rotation of all the motors using their "brake mode"

5.83.4.13 turn_degrees() [1/2]

```
bool TankDrive::turn_degrees (
            double degrees,
            double max_speed = 1,
            double end_speed = 0 )
```

Autonomously turn the robot X degrees to counterclockwise (negative for clockwise), with a maximum motor speed of percent_speed (-1.0 -> 1.0)

Uses the defualt turning feedback of the drive system.

Parameters

degrees	degrees by which we will turn relative to the robot (+) turns ccw, (-) turns cw
max_speed	the maximum percentage of robot speed at which the robot will travel. 1 = full power
end_speed	the movement profile will attempt to reach this velocity by its completion

Autonomously turn the robot X degrees to counterclockwise (negative for clockwise), with a maximum motor speed of percent_speed (-1.0 -> 1.0)

Uses the defualt turning feedback of the drive system.

Parameters

degrees	degrees by which we will turn relative to the robot (+) turns ccw, (-) turns cw
max_speed	the maximum percentage of robot speed at which the robot will travel. 1 = full power
end_speed	the movement profile will attempt to reach this velocity by its completion

Returns

true if we turned te target number of degrees

5.83.4.14 turn_degrees() [2/2]

```
bool TankDrive::turn_degrees (
            double degrees,
            Feedback & feedback,
            double max_speed = 1,
            double end_speed = 0 )
```

Autonomously turn the robot X degrees counterclockwise (negative for clockwise), with a maximum motor speed of percent_speed (-1.0 -> 1.0)

Uses PID + Feedforward for it's control.

Parameters

degrees	degrees by which we will turn relative to the robot (+) turns ccw, (-) turns cw
feedback	the feedback controller we will use to travel. controls the rate at which we accelerate and drive.
max_speed	the maximum percentage of robot speed at which the robot will travel. 1 = full power

Autonomously turn the robot X degrees to counterclockwise (negative for clockwise), with a maximum motor speed of percent_speed (-1.0 -> 1.0)

Uses the specified feedback for it's control.

Parameters

degrees	degrees by which we will turn relative to the robot (+) turns ccw, (-) turns cw
feedback	the feedback controller we will use to travel. controls the rate at which we accelerate and drive.
max_speed	the maximum percentage of robot speed at which the robot will travel. 1 = full power
end_speed	the movement profile will attempt to reach this velocity by its completion

Returns

true if we have turned our target number of degrees

5.83.4.15 turn_to_heading() [1/2]

```
bool TankDrive::turn_to_heading (
            double heading_deg,
            double max_speed = 1,
            double end_speed = 0 )
```

Turn the robot in place to an exact heading relative to the field. 0 is forward. Uses the defualt turn feedback of the drive system

Parameters

heading_deg	the heading to which we will turn
max_speed	the maximum percentage of robot speed at which the robot will travel. 1 = full power
end_speed	the movement profile will attempt to reach this velocity by its completion

Turn the robot in place to an exact heading relative to the field. 0 is forward. Uses the defualt turn feedback of the drive system

Parameters

heading_deg	the heading to which we will turn
max_speed	the maximum percentage of robot speed at which the robot will travel. 1 = full power
end_speed	the movement profile will attempt to reach this velocity by its completion

Returns

true if we have reached our target heading

5.83.4.16 turn_to_heading() [2/2]

```
bool TankDrive::turn_to_heading (
            double heading_deg,
            Feedback & feedback,
            double max_speed = 1,
            double end_speed = 0 )
```

Turn the robot in place to an exact heading relative to the field. 0 is forward.

Parameters

heading_deg	the heading to which we will turn
feedback	the feedback controller we will use to travel. controls the rate at which we accelerate and drive.
max_speed	the maximum percentage of robot speed at which the robot will travel. 1 = full power
end_speed	the movement profile will attempt to reach this velocity by its completion

Turn the robot in place to an exact heading relative to the field. 0 is forward.

Parameters

heading_deg	the heading to which we will turn
feedback	the feedback controller we will use to travel. controls the rate at which we accelerate and drive.
max_speed	the maximum percentage of robot speed at which the robot will travel. 1 = full power
end_speed	the movement profile will attempt to reach this velocity by its completion

Returns

true if we have reached our target heading

The documentation for this class was generated from the following files:

- include/subsystems/tank_drive.h
- src/subsystems/tank_drive.cpp

5.84 screen::TextConfig Struct Reference

Public Attributes

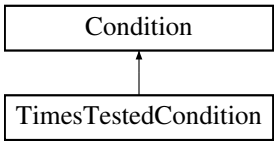
- std::function< std::string()> **text**

The documentation for this struct was generated from the following file:

- include/subsystems/screen.h

5.85 TimesTestedCondition Class Reference

Inheritance diagram for TimesTestedCondition:



Public Member Functions

- **TimesTestedCondition** (size_t N)
- bool test () override

Public Member Functions inherited from Condition

- Condition * **Or** (Condition *b)
- Condition * **And** (Condition *b)

5.85.1 Member Function Documentation

5.85.1.1 test()

```
bool TimesTestedCondition::test ( )  [inline], [override], [virtual]
```

Implements Condition.

The documentation for this class was generated from the following file:

- include/utils/command_structure/auto_command.h

5.86 trapezoid_profile_segment_t Struct Reference

```
#include <trapezoid_profile.h>
```

Public Attributes

- double **pos_after**
  1d position after this segment concludes
- double **vel_after**
  1d velocity after this segment concludes
- double **accel**
  1d acceleration during the segment
- double **duration**
  duration of the segment

5.86.1 Detailed Description

trapezoid_profile_segment_t is a description of one constant acceleration segment of a trapezoid motion profile

The documentation for this struct was generated from the following file:

- include/utils/controls/trapezoid_profile.h

5.87 TrapezoidProfile Class Reference

```
#include <trapezoid_profile.h>
```

Public Member Functions

- TrapezoidProfile (double max_v, double accel)

  Construct a new Trapezoid Profile object.
- motion_t calculate (double time_s, double pos_s)

  Run the trapezoidal profile based on the time and distance that's elapsed.
- motion_t calculate_time_based (double time_s)

  Run the trapezoidal profile based on the time that's elapsed.
- void set_endpts (double start, double end)

  set_endpts defines a start and end position
- void set_vel_endpts (double start, double end)

  set start and end velocities
- void set_accel (double accel)

  set_accel sets the acceleration this profile will use (the left and right legs of the trapezoid)
- void set_max_v (double max_v)

  sets the maximum velocity for the profile (the height of the top of the trapezoid)
- double get_movement_time () const

  uses the kinematic equations to and specified accel and max_v to figure out how long moving along the profile would take
- double **get_max_v** () const
- double **get_accel** () const

5.87.1 Detailed Description

Trapezoid Profile

This is a motion profile defined by:

- maximum acceleration
- maximum velocity
- start position and velocity
- end position and velocity

Using this information, a parametric function is generated, with a period of acceleration, constant velocity, and deceleration. The velocity graph usually looks like a trapezoid, giving it its name.

If the maximum velocity is set high enough, this will become a S-curve profile, with only acceleration and deceleration.

If the initial velocity is in the wrong direction, the profile will first come to a stop, then continue a normal trapezoid profile.

If the initial velocity is higher than the maximum velocity, the profile will first try to achieve the maximum velocity.

If the end velocity is not achievable, the profile will try to get as close as possible. The end velocity must be in the direction of the end point.

This class is designed for use in properly modelling the motion of the robots to create a feedfoward and target for PID. Acceleration and Maximum velocity should be measured on the robot and tuned down slightly to account for battery drop.

Here are the equations graphed for ease of understanding: https://www.desmos.com/calculator/rkm3ivu1yk

Author

Ryan McGee

Date

7/12/2022

5.87.2 Constructor & Destructor Documentation

5.87.2.1 TrapezoidProfile()

```
TrapezoidProfile::TrapezoidProfile (
            double max_v,
            double accel )
```

Construct a new Trapezoid Profile object.

Parameters

max_v	Maximum velocity the robot can run at
accel	Maximum acceleration of the robot

5.87.3 Member Function Documentation

5.87.3.1 calculate()

```
motion_t TrapezoidProfile::calculate (
            double time_s,
            double pos_s )
```

Run the trapezoidal profile based on the time and distance that's elapsed.

Parameters

time_s	Time since start of movement
pos_s	The current position

Returns

motion_t Position, velocity and acceleration

5.87.3.2 calculate_time_based()

```
motion_t TrapezoidProfile::calculate_time_based (
            double time_s )
```

Run the trapezoidal profile based on the time that's elapsed.

Parameters

time_s	Time since start of movement

Returns

motion_t Position, velocity and acceleration

5.87.3.3 get_movement_time()

```
double TrapezoidProfile::get_movement_time ( ) const
```

uses the kinematic equations to and specified accel and max_v to figure out how long moving along the profile would take

Returns

the time the path will take to travel

5.87.3.4 set_accel()

```
void TrapezoidProfile::set_accel (
            double accel )
```

set_accel sets the acceleration this profile will use (the left and right legs of the trapezoid)

Parameters

accel	the acceleration amount to use

5.87.3.5 set_endpts()

```
void TrapezoidProfile::set_endpts (
            double start,
            double end )
```

set_endpts defines a start and end position

Parameters

start	the starting position of the path
end	the ending position of the path

5.87.3.6 set_max_v()

```
void TrapezoidProfile::set_max_v (
            double max_v )
```

sets the maximum velocity for the profile (the height of the top of the trapezoid)

Parameters

max↩ _v	the maximum velocity the robot can travel at

5.87.3.7 set_vel_endpts()

```
void TrapezoidProfile::set_vel_endpts (
            double start,
            double end )
```

set start and end velocities

Parameters

start	the starting velocity of the path
end	the ending velocity of the path

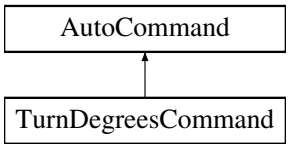
The documentation for this class was generated from the following files:

- include/utils/controls/trapezoid_profile.h
- src/utils/trapezoid_profile.cpp

5.88 TurnDegreesCommand Class Reference

```
#include <drive_commands.h>
```

Inheritance diagram for TurnDegreesCommand:



Public Member Functions

- TurnDegreesCommand (TankDrive &drive_sys, Feedback &feedback, double degrees, double max_speed=1, double end_speed=0)
- bool run () override
- void on_timeout () override

Public Member Functions inherited from AutoCommand

- AutoCommand * **withTimeout** (double t_seconds)
- AutoCommand * **withCancelCondition** (Condition *true_to_end)

Additional Inherited Members

Public Attributes inherited from AutoCommand

- double timeout_seconds = default_timeout
- Condition * **true_to_end** = nullptr

Static Public Attributes inherited from AutoCommand

- static constexpr double **default_timeout** = 10.0

5.88.1 Detailed Description

AutoCommand wrapper class for the turn_degrees function in the TankDrive class

5.88.2 Constructor & Destructor Documentation

5.88.2.1 TurnDegreesCommand()

```
TurnDegreesCommand::TurnDegreesCommand (
            TankDrive & drive_sys,
            Feedback & feedback,
            double degrees,
            double max_speed = 1,
            double end_speed = 0 )
```

Construct a TurnDegreesCommand Command

Parameters

drive_sys	the drive system we are commanding
feedback	the feedback controller we are using to execute the turn
degrees	how many degrees to rotate
max_speed	0 -> 1 percentage of the drive systems speed to drive at

5.88.3 Member Function Documentation

5.88.3.1 on_timeout()

```
void TurnDegreesCommand::on_timeout ( )  [override], [virtual]
```

Cleans up drive system if we time out before finishing

reset the drive system if we timeout

Reimplemented from AutoCommand.

5.88.3.2 run()

```
bool TurnDegreesCommand::run ( )  [override], [virtual]
```

Run turn_degrees Overrides run from AutoCommand

Returns

true when execution is complete, false otherwise

Reimplemented from AutoCommand.

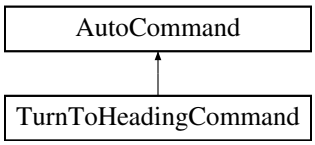
The documentation for this class was generated from the following files:

- include/utils/command_structure/drive_commands.h
- src/utils/command_structure/drive_commands.cpp

5.89 TurnToHeadingCommand Class Reference

```
#include <drive_commands.h>
```

Inheritance diagram for TurnToHeadingCommand:



Public Member Functions

- TurnToHeadingCommand (TankDrive &drive_sys, Feedback &feedback, double heading_deg, double speed=1, double end_speed=0)
- bool run () override
- void on_timeout () override

Public Member Functions inherited from AutoCommand

- AutoCommand * **withTimeout** (double t_seconds)
- AutoCommand * **withCancelCondition** (Condition *true_to_end)

Additional Inherited Members

Public Attributes inherited from AutoCommand

- double timeout_seconds = default_timeout
- Condition * **true_to_end** = nullptr

Static Public Attributes inherited from AutoCommand

- static constexpr double **default_timeout** = 10.0

5.89.1 Detailed Description

AutoCommand wrapper class for the turn_to_heading() function in the TankDrive class

5.89.2 Constructor & Destructor Documentation

5.89.2.1 TurnToHeadingCommand()

```
TurnToHeadingCommand::TurnToHeadingCommand (
            TankDrive & drive_sys,
            Feedback & feedback,
            double heading_deg,
            double max_speed = 1,
            double end_speed = 0 )
```

Construct a TurnToHeadingCommand Command

Parameters

drive_sys	the drive system we are commanding
feedback	the feedback controller we are using to execute the drive
heading_deg	the heading to turn to in degrees
max_speed	0 -> 1 percentage of the drive systems speed to drive at

5.89.3 Member Function Documentation

5.89.3.1 on_timeout()

```
void TurnToHeadingCommand::on_timeout ( )  [override], [virtual]
```

Cleans up drive system if we time out before finishing

reset the drive system if we don't hit our target

Reimplemented from AutoCommand.

5.89.3.2 run()

```
bool TurnToHeadingCommand::run ( )  [override], [virtual]
```

Run turn_to_heading Overrides run from AutoCommand

Returns

true when execution is complete, false otherwise

Reimplemented from AutoCommand.

The documentation for this class was generated from the following files:

- include/utils/command_structure/drive_commands.h
- src/utils/command_structure/drive_commands.cpp

5.90 Vector2D Class Reference

`#include <vector2d.h>`

Public Member Functions

- Vector2D (double dir, double mag)
- Vector2D (point_t p)
- double get_dir () const
- double get_mag () const
- double get_x () const
- double get_y () const
- Vector2D normalize ()
- point_t point ()
- Vector2D operator* (const double &x)
- Vector2D operator+ (const Vector2D &other)
- Vector2D operator- (const Vector2D &other)

5.90.1 Detailed Description

Vector2D is an x,y pair Used to represent 2D locations on the field. It can also be treated as a direction and magnitude

5.90.2 Constructor & Destructor Documentation

5.90.2.1 Vector2D() [1/2]

```
Vector2D::Vector2D (
            double dir,
            double mag )
```

Construct a vector object.

Parameters

dir	Direction, in radians. 'foward' is 0, clockwise positive when viewed from the top.
mag	Magnitude.

5.90.2.2 Vector2D() [2/2]

```
Vector2D::Vector2D (
            point_t p )
```

Construct a vector object from a cartesian point.

Parameters

p	point_t.x , point_t.y

5.90.3 Member Function Documentation

5.90.3.1 get_dir()

```
double Vector2D::get_dir ( ) const
```

Get the direction of the vector, in radians. '0' is forward, clockwise positive when viewed from the top.

Use r2d() to convert.

Returns

the direction of the vetctor in radians

Get the direction of the vector, in radians. '0' is forward, clockwise positive when viewed from the top.

Use r2d() to convert.

5.90.3.2 get_mag()

```
double Vector2D::get_mag ( ) const
```

Returns

the magnitude of the vector

Get the magnitude of the vector

5.90.3.3 get_x()

```
double Vector2D::get_x ( ) const
```

Returns

the X component of the vector; positive to the right.

Get the X component of the vector; positive to the right.

5.90.3.4 get_y()

```
double Vector2D::get_y ( ) const
```

Returns

the Y component of the vector, positive forward.

Get the Y component of the vector, positive forward.

5.90.3.5 normalize()

```
Vector2D Vector2D::normalize ( )
```

Changes the magnitude of the vector to 1

Returns

the normalized vector

Changes the magnetude of the vector to 1

5.90.3.6 operator∗()

```
Vector2D Vector2D::operator* (
            const double & x )
```

Scales a Vector2D by a scalar with the ∗ operator

Parameters

x	the value to scale the vector by

Returns

the this Vector2D scaled by x

5.90.3.7 operator+()

```
Vector2D Vector2D::operator+ (
            const Vector2D & other )
```

Add the components of two vectors together Vector2D + Vector2D = (this.x + other.x, this.y + other.y)

Parameters

other	the vector to add to this

Returns

the sum of the vectors

5.90.3.8 operator-()

```
Vector2D Vector2D::operator- (
            const Vector2D & other )
```

Subtract the components of two vectors together Vector2D - Vector2D = (this.x - other.x, this.y - other.y)

Parameters

other	the vector to subtract from this

Returns

the difference of the vectors

5.90.3.9 point()

```
point_t Vector2D::point ( )
```

Returns a point from the vector

Returns

the point represented by the vector

Convert a direction and magnitude representation to an x, y representation

Returns

the x, y representation of the vector

The documentation for this class was generated from the following files:

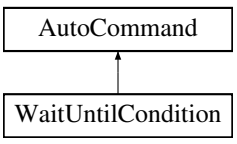
- include/utils/vector2d.h
- src/utils/vector2d.cpp

5.91 WaitUntilCondition Class Reference

Waits until the condition is true.

`#include <auto_command.h>`

Inheritance diagram for WaitUntilCondition:



Public Member Functions

- **WaitUntilCondition** (Condition *cond)
- bool run () override

Public Member Functions inherited from AutoCommand

- virtual void on_timeout ()
- AutoCommand * **withTimeout** (double t_seconds)
- AutoCommand * **withCancelCondition** (Condition *true_to_end)

Additional Inherited Members

Public Attributes inherited from AutoCommand

- double timeout_seconds = default_timeout
- Condition * **true_to_end** = nullptr

Static Public Attributes inherited from AutoCommand

- static constexpr double **default_timeout** = 10.0

5.91.1 Detailed Description

Waits until the condition is true.

5.91.2 Member Function Documentation

5.91.2.1 run()

```
bool WaitUntilCondition::run ( )  [inline], [override], [virtual]
```

Executes the command Overridden by child classes

Returns

true when the command is finished, false otherwise

Reimplemented from AutoCommand.

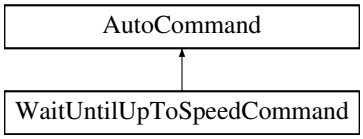
The documentation for this class was generated from the following file:

- include/utils/command_structure/auto_command.h

5.92 WaitUntilUpToSpeedCommand Class Reference

`#include <flywheel_commands.h>`

Inheritance diagram for WaitUntilUpToSpeedCommand:



Public Member Functions

- WaitUntilUpToSpeedCommand (Flywheel &flywheel, int threshold_rpm)
- bool run () override

Public Member Functions inherited from AutoCommand

- virtual void on_timeout ()
- AutoCommand * **withTimeout** (double t_seconds)
- AutoCommand * **withCancelCondition** (Condition *true_to_end)

Additional Inherited Members

Public Attributes inherited from AutoCommand

- double timeout_seconds = default_timeout
- Condition * **true_to_end** = nullptr

Static Public Attributes inherited from AutoCommand

- static constexpr double **default_timeout** = 10.0

5.92.1 Detailed Description

AutoCommand that listens to the Flywheel and waits until it is at its target speed +/- the specified threshold

5.92.2 Constructor & Destructor Documentation

5.92.2.1 WaitUntilUpToSpeedCommand()

```
WaitUntilUpToSpeedCommand::WaitUntilUpToSpeedCommand (
            Flywheel & flywheel,
            int threshold_rpm )
```

Creat a WaitUntilUpToSpeedCommand

Parameters

flywheel	the flywheel system we are commanding
threshold_rpm	the threshold over and under the flywheel target RPM that we define to be acceptable

5.92.3 Member Function Documentation

5.92.3.1 run()

```
bool WaitUntilUpToSpeedCommand::run ( )  [override], [virtual]
```

Run spin_manual Overrides run from AutoCommand

Returns

true when execution is complete, false otherwise

Reimplemented from AutoCommand.

The documentation for this class was generated from the following files:

- include/utils/command_structure/flywheel_commands.h
- src/utils/command_structure/flywheel_commands.cpp

5.93 screen::WidgetConfig Struct Reference

Public Types

- enum **Type** {
  Col , **Row** , **Slider** , **Button** ,
  Checkbox , **Label** , **Text** , **Graph** }

Public Attributes

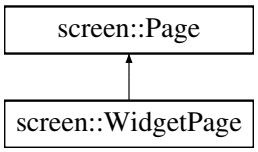
- Type **type**
- union {
  std::vector< SizedWidget > **widgets**
  SliderConfig **slider**
  ButtonConfig **button**
  CheckboxConfig **checkbox**
  LabelConfig **label**
  TextConfig **text**
  GraphDrawer * **graph**
  } **config**

The documentation for this struct was generated from the following file:

- include/subsystems/screen.h

5.94 screen::WidgetPage Class Reference

Inheritance diagram for screen::WidgetPage:



Public Member Functions

- **WidgetPage** (WidgetConfig &cfg)
- void update (bool was_pressed, int x, int y) override

  collect data, respond to screen input, do fast things (runs at 50hz even if you're not focused on this Page (only drawn page gets touch updates))
- void draw (vex::brain::lcd &, bool first_draw, unsigned int frame_number) override

  draw stored data to the screen (runs at 10 hz and only runs if this page is in front)

5.94.1 Member Function Documentation

5.94.1.1 draw()

```
void screen::WidgetPage::draw (
            vex::brain::lcd & screen,
            bool first_draw,
            unsigned int frame_number )  [inline], [override], [virtual]
```

draw stored data to the screen (runs at 10 hz and only runs if this page is in front)

Parameters

first_draw	true if we just switched to this page
frame_number	frame of drawing we are on (basically an animation tick)

Reimplemented from screen::Page.

5.94.1.2 update()

```
void screen::WidgetPage::update (
            bool was_pressed,
            int x,
            int y )  [override], [virtual]
```

collect data, respond to screen input, do fast things (runs at 50hz even if you're not focused on this Page (only drawn page gets touch updates))

Parameters

was_pressed	true if the screen has been pressed
x	x position of screen press (if the screen was pressed)
y	y position of screen press (if the screen was pressed)

Reimplemented from screen::Page.

The documentation for this class was generated from the following file:

- include/subsystems/screen.h

Chapter 6

File Documentation

6.1 robot_specs.h

```
00001 #pragma once
00002 #include "../core/include/utils/controls/pid.h"
00003 #include "../core/include/utils/controls/feedback_base.h"
00004
00011 typedef struct
00012 {
00013   double robot_radius;
00014
00015   double odom_wheel_diam;
00016   double odom_gear_ratio;
00017   double dist_between_wheels;
00018
00019   double drive_correction_cutoff;
00020
00021   Feedback *drive_feedback;
00022   Feedback *turn_feedback;
00023   PID::pid_config_t correction_pid;
00024
00025 } robot_specs_t;
```

6.2 custom_encoder.h

```
00001 #pragma once
00002 #include "vex.h"
00003
00008 class CustomEncoder : public vex::encoder
00009 {
00010   typedef vex::encoder super;
00011
00012   public:
00018   CustomEncoder(vex::triport::port &port, double ticks_per_rev);
00019
00025   void setRotation(double val, vex::rotationUnits units);
00026
00032   void setPosition(double val, vex::rotationUnits units);
00033
00039   double rotation(vex::rotationUnits units);
00040
00046   double position(vex::rotationUnits units);
00047
00053   double velocity(vex::velocityUnits units);
00054
00055
00056   private:
00057   double tick_scalar;
00058 };
```

6.3 flywheel.h

```
00001 #pragma once
00002
00003 #include "../core/include/utils/controls/feedforward.h"
00004 #include "vex.h"
00005 #include "../core/include/robot_specs.h"
00006 #include "../core/include/utils/controls/pid.h"
00007 #include "../core/include/utils/command_structure/auto_command.h"
00008 #include "../core/include/subsystems/screen.h"
00009 #include <atomic>
00010
00018 class Flywheel
00019 {
00020
00021 public:
00022   // CONSTRUCTORS, GETTERS, AND SETTERS
00031   Flywheel(vex::motor_group &motors, Feedback &feedback, FeedForward &helper, const double ratio,
      Filter &filt);
00032
00037   double get_target() const;
00038
00042   double getRPM() const;
00043
00047   vex::motor_group &get_motors() const;
00048
00055   void spin_manual(double speed, directionType dir = fwd);
00056
00062   void spin_rpm(double rpm);
00063
00067   void stop();
00068
00073   bool is_on_target()
00074   {
00075     return fb.is_on_target();
00076   }
00077
00082   screen::Page *Page() const;
00083
00089   AutoCommand *SpinRpmCmd(int rpm)
00090   {
00091
00092     return new FunctionCommand([this, rpm]()
00093                                {spin_rpm(rpm); return true; });
00094   }
00095
00100   AutoCommand *WaitUntilUpToSpeedCmd()
00101   {
00102     return new WaitUntilCondition(
00103         new FunctionCondition([this]()
00104                               { return is_on_target(); }));
00105   }
00106
00107 private:
00108   friend class FlywheelPage;
00109   friend int spinRPMTask(void *wheelPointer);
00110
00111   vex::motor_group &motors;
00112   bool task_running = false;
00113   Feedback &fb;
00114   FeedForward &ff;
00115   vex::mutex fb_mut;
00116   double ratio;
00117   std::atomic<double> target_rpm;
00118   task rpm_task;
00119   Filter &avger;
00120
00121   // Functions for internal use only
00126   void set_target(double value);
00130   double measure_RPM();
00131
00138   void spin_raw(double speed, directionType dir = fwd);
00139 };
```

6.4 layout.h

```
00001 #include <cmath>
00002 #include <functional>
00003
00004 struct SliderCfg{
00005     double &val;
00006     double min;
00007     double max;
```

```
00008 };
00009
00010
00011
```

6.5 lift.h

```
00001 #pragma once
00002
00003 #include "vex.h"
00004 #include "../core/include/utils/controls/pid.h"
00005 #include <iostream>
00006 #include <map>
00007 #include <atomic>
00008 #include <vector>
00009
00010 using namespace vex;
00011 using namespace std;
00012
00020 template <typename T>
00021 class Lift
00022 {
00023   public:
00024
00031   struct lift_cfg_t
00032   {
00033     double up_speed, down_speed;
00034     double softstop_up, softstop_down;
00035
00036     PID::pid_config_t lift_pid_cfg;
00037   };
00038
00060   Lift(motor_group &lift_motors, lift_cfg_t &lift_cfg, map<T, double> &setpoint_map, limit
      *homing_switch=NULL)
00061   : lift_motors(lift_motors), cfg(lift_cfg), lift_pid(cfg.lift_pid_cfg), setpoint_map(setpoint_map),
      homing_switch(homing_switch)
00062   {
00063
00064     is_async = true;
00065     setpoint = 0;
00066
00067     // Create a background task that is constantly updating the lift PID, if requested.
00068     // Set once, and forget.
00069     task t([](void* ptr){
00070       Lift &lift = *((Lift*) ptr);
00071
00072       while(true)
00073       {
00074         if(lift.get_async())
00075           lift.hold();
00076
00077         vexDelay(50);
00078       }
00079
00080       return 0;
00081     }, this);
00082
00083   }
00084
00093   void control_continuous(bool up_ctrl, bool down_ctrl)
00094   {
00095     static timer tmr;
00096
00097     double cur_pos = 0;
00098
00099     // Check if there's a hook for a custom sensor. If not, use the motors.
00100     if(get_sensor == NULL)
00101       cur_pos = lift_motors.position(rev);
00102     else
00103       cur_pos = get_sensor();
00104
00105     if(up_ctrl && cur_pos < cfg.softstop_up)
00106     {
00107       lift_motors.spin(directionType::fwd, cfg.up_speed, volt);
00108       setpoint = cur_pos + .3;
00109
00110       // std::cout « "DEBUG OUT: UP " « setpoint « ", " « tmr.time(sec) « ", " « cfg.down_speed «
      "\n";
00111
00112       // Disable the PID while going UP.
00113       is_async = false;
00114     } else if(down_ctrl && cur_pos > cfg.softstop_down)
00115     {
```

```
00116       // Lower the lift slowly, at a rate defined by down_speed
00117       if(setpoint > cfg.softstop_down)
00118         setpoint = setpoint - (tmr.time(sec) * cfg.down_speed);
00119       // std::cout « "DEBUG OUT: DOWN " « setpoint « ", " « tmr.time(sec) « ", " « cfg.down_speed «
    "\n";
00120       is_async = true;
00121     } else
00122     {
00123       // Hold the lift at the last setpoint
00124       is_async = true;
00125     }
00126
00127     tmr.reset();
00128   }
00129
00138   void control_manual(bool up_btn, bool down_btn, int volt_up, int volt_down)
00139   {
00140     static bool down_hold = false;
00141     static bool init = true;
00142
00143     // Allow for setting position while still calling this function
00144     if(init || up_btn || down_btn)
00145     {
00146       init = false;
00147       is_async = false;
00148     }
00149
00150     double rev = lift_motors.position(rotationUnits::rev);
00151
00152     if(rev < cfg.softstop_down && down_btn)
00153       down_hold = true;
00154     else if( !down_btn )
00155       down_hold = false;
00156
00157     if(up_btn && rev < cfg.softstop_up)
00158       lift_motors.spin(directionType::fwd, volt_up, voltageUnits::volt);
00159     else if(down_btn && rev > cfg.softstop_down && !down_hold)
00160       lift_motors.spin(directionType::rev, volt_down, voltageUnits::volt);
00161     else
00162       lift_motors.spin(directionType::fwd, 0, voltageUnits::volt);
00163
00164   }
00165
00177   void control_setpoints(bool up_step, bool down_step, vector<T> pos_list)
00178   {
00179     // Make sure inputs are only processed on the rising edge of the button
00180     static bool up_last = up_step, down_last = down_step;
00181
00182     bool up_rising = up_step && !up_last;
00183     bool down_rising = down_step && !down_last;
00184
00185     up_last = up_step;
00186     down_last = down_step;
00187
00188     static int cur_index = 0;
00189
00190     // Avoid an index overflow. Shouldn't happen unless the user changes pos_list between calls.
00191     if(cur_index >= pos_list.size())
00192       cur_index = pos_list.size() - 1;
00193
00194     // Increment or decrement the index of the list, bringing it up or down.
00195     if(up_rising && cur_index < (pos_list.size() - 1))
00196       cur_index++;
00197     else if(down_rising && cur_index > 0)
00198       cur_index--;
00199
00200     // Set the lift to hold the position in the background with the PID loop
00201     set_position(pos_list[cur_index]);
00202     is_async = true;
00203
00204   }
00205
00214   bool set_position(T pos)
00215   {
00216     this->setpoint = setpoint_map[pos];
00217     is_async = true;
00218
00219     return (lift_pid.get_target() == this->setpoint) && lift_pid.is_on_target();
00220   }
00221
00228   bool set_setpoint(double val)
00229   {
00230     this->setpoint = val;
00231     return (lift_pid.get_target() == this->setpoint) && lift_pid.is_on_target();
00232   }
00233
00237   double get_setpoint()
```

```
00238   {
00239     return this->setpoint;
00240   }
00241
00246   void hold()
00247   {
00248     lift_pid.set_target(setpoint);
00249     // std::cout « "DEBUG OUT: SETPOINT " « setpoint « "\n";
00250
00251     if(get_sensor != NULL)
00252       lift_pid.update(get_sensor());
00253     else
00254       lift_pid.update(lift_motors.position(rev));
00255
00256     // std::cout « "DEBUG OUT: ROTATION " « lift_motors.rotation(rev) « "\n\n";
00257
00258     lift_motors.spin(fwd, lift_pid.get(), volt);
00259   }
00260
00265   void home()
00266   {
00267     static timer tmr;
00268     tmr.reset();
00269
00270     while(tmr.time(sec) < 3)
00271     {
00272       lift_motors.spin(directionType::rev, 6, volt);
00273
00274       if (homing_switch == NULL && lift_motors.current(currentUnits::amp) > 1.5)
00275         break;
00276       else if (homing_switch != NULL && homing_switch->pressing())
00277         break;
00278     }
00279
00280     if(reset_sensor != NULL)
00281       reset_sensor();
00282
00283     lift_motors.resetPosition();
00284     lift_motors.stop();
00285
00286   }
00287
00291   bool get_async()
00292   {
00293     return is_async;
00294   }
00295
00301   void set_async(bool val)
00302   {
00303     this->is_async = val;
00304   }
00305
00315   void set_sensor_function(double (*fn_ptr) (void))
00316   {
00317     this->get_sensor = fn_ptr;
00318   }
00319
00326   void set_sensor_reset(void (*fn_ptr) (void))
00327   {
00328     this->reset_sensor = fn_ptr;
00329   }
00330
00331   private:
00332
00333   motor_group &lift_motors;
00334   lift_cfg_t &cfg;
00335   PID lift_pid;
00336   map<T, double> &setpoint_map;
00337   limit *homing_switch;
00338
00339   atomic<double> setpoint;
00340   atomic<bool> is_async;
00341
00342   double (*get_sensor)(void) = NULL;
00343   void (*reset_sensor)(void) = NULL;
00344
00345
00346 };
```

6.6 mecanum_drive.h

```
00001 #pragma once
00002
```

```
00003 #include "vex.h"
00004 #include "../core/include/utils/controls/pid.h"
00005
00006 #ifndef PI
00007 #define PI 3.141592654
00008 #endif
00009
00014 class MecanumDrive
00015 {
00016
00017   public:
00018
00022   struct mecanumdrive_config_t
00023   {
00024     // PID configurations for autonomous driving
00025     PID::pid_config_t drive_pid_conf;
00026     PID::pid_config_t drive_gyro_pid_conf;
00027     PID::pid_config_t turn_pid_conf;
00028
00029     // Diameter of the mecanum wheels
00030     double drive_wheel_diam;
00031
00032     // Diameter of the perpendicular undriven encoder wheel
00033     double lateral_wheel_diam;
00034
00035     // Width between the center of the left and right wheels
00036     double wheelbase_width;
00037
00038   };
00039
00043   MecanumDrive(vex::motor &left_front, vex::motor &right_front, vex::motor &left_rear, vex::motor
      &right_rear,
00044                vex::rotation *lateral_wheel=NULL, vex::inertial *imu=NULL, mecanumdrive_config_t
      *config=NULL);
00045
00054   void drive_raw(double direction_deg, double magnitude, double rotation);
00055
00066   void drive(double left_y, double left_x, double right_x, int power=2);
00067
00080   bool auto_drive(double inches, double direction, double speed, bool gyro_correction=true);
00081
00092   bool auto_turn(double degrees, double speed, bool ignore_imu=false);
00093
00094   private:
00095
00096   vex::motor &left_front, &right_front, &left_rear, &right_rear;
00097
00098   mecanumdrive_config_t *config;
00099   vex::rotation *lateral_wheel;
00100   vex::inertial *imu;
00101
00102   PID *drive_pid = NULL;
00103   PID *drive_gyro_pid = NULL;
00104   PID *turn_pid = NULL;
00105
00106   bool init = true;
00107
00108 };
```

6.7 odometry_3wheel.h

```
00001 #pragma once
00002 #include "../core/include/subsystems/odometry/odometry_base.h"
00003 #include "../core/include/subsystems/tank_drive.h"
00004 #include "../core/include/subsystems/custom_encoder.h"
00005
00032 class Odometry3Wheel : public OdometryBase
00033 {
00034     public:
00035
00040     typedef struct
00041     {
00042         double wheelbase_dist;
00043         double off_axis_center_dist;
00044         double wheel_diam;
00046     } odometry3wheel_cfg_t;
00047
00057     Odometry3Wheel(CustomEncoder &lside_fwd, CustomEncoder &rside_fwd, CustomEncoder &off_axis,
      odometry3wheel_cfg_t &cfg, bool is_async=true);
00058
00065     pose_t update() override;
00066
00075     void tune(vex::controller &con, TankDrive &drive);
```

```
00076
00077     private:
00078
00091     static pose_t calculate_new_pos(double lside_delta_deg, double rside_delta_deg, double
      offax_delta_deg, pose_t old_pos, odometry3wheel_cfg_t cfg);
00092
00093     CustomEncoder &lside_fwd, &rside_fwd, &off_axis;
00094     odometry3wheel_cfg_t &cfg;
00095
00096
00097 };
```

6.8 odometry_base.h

```
00001 #pragma once
00002
00003 #include "vex.h"
00004 #include "../core/include/utils/geometry.h"
00005 #include "../core/include/robot_specs.h"
00006 #include "../core/include/utils/command_structure/auto_command.h"
00007
00008 #ifndef PI
00009 #define PI 3.141592654
00010 #endif
00011
00012
00013
00026 class OdometryBase
00027 {
00028 public:
00029
00035     OdometryBase(bool is_async);
00036
00041     pose_t get_position(void);
00042
00047     virtual void set_position(const pose_t& newpos=zero_pos);
00048     AutoCommand *SetPositionCmd(const pose_t& newpos=zero_pos);
00053     virtual pose_t update() = 0;
00054
00062     static int background_task(void* ptr);
00063
00069     void end_async();
00070
00077     static double pos_diff(pose_t start_pos, pose_t end_pos);
00078
00085     static double rot_diff(pose_t pos1, pose_t pos2);
00086
00095     static double smallest_angle(double start_deg, double end_deg);
00096
00098     bool end_task = false;
00099
00104     double get_speed();
00105
00110     double get_accel();
00111
00116     double get_angular_speed_deg();
00117
00122     double get_angular_accel_deg();
00123
00127     inline static constexpr pose_t zero_pos = {.x=0.0L, .y=0.0L, .rot=90.0L};
00128
00129 protected:
00133     vex::task *handle;
00134
00138     vex::mutex mut;
00139
00143     pose_t current_pos;
00144
00145     double speed;
00146     double accel;
00147     double ang_speed_deg;
00148     double ang_accel_deg;
00149 };
```

6.9 odometry_tank.h

```
00001 #pragma once
00002
00003 #include "../core/include/subsystems/odometry/odometry_base.h"
```

```
00004 #include "../core/include/subsystems/custom_encoder.h"
00005 #include "../core/include/utils/geometry.h"
00006 #include "../core/include/utils/vector2d.h"
00007 #include "../core/include/utils/moving_average.h"
00008
00009 #include "../core/include/robot_specs.h"
00010
00011 static int background_task(void* odom_obj);
00012
00013
00020 class OdometryTank : public OdometryBase
00021 {
00022 public:
00031     OdometryTank(vex::motor_group &left_side, vex::motor_group &right_side, robot_specs_t &config,
      vex::inertial *imu=NULL, bool is_async=true);
00032
00042     OdometryTank(CustomEncoder &left_custom_enc, CustomEncoder &right_custom_enc, robot_specs_t
      &config, vex::inertial *imu=NULL, bool is_async=true);
00043
00053     OdometryTank(vex::encoder &left_vex_enc, vex::encoder &right_vex_enc, robot_specs_t &config,
      vex::inertial *imu=NULL, bool is_async=true);
00054
00059     pose_t update() override;
00060
00065     void set_position(const pose_t &newpos=zero_pos) override;
00066
00067
00068
00069 private:
00073     static pose_t calculate_new_pos(robot_specs_t &config, pose_t &stored_info, double lside_diff,
      double rside_diff, double angle_deg);
00074
00075     vex::motor_group *left_side, *right_side;
00076     CustomEncoder *left_custom_enc, *right_custom_enc;
00077     vex::encoder *left_vex_enc, *right_vex_enc;
00078     vex::inertial *imu;
00079     robot_specs_t &config;
00080
00081     double rotation_offset = 0;
00082     ExponentialMovingAverage ema = ExponentialMovingAverage(3);
00083
00084 };
```

6.10 screen.h

```
00001 #pragma once
00002 #include "vex.h"
00003 #include <vector>
00004 #include <functional>
00005 #include <map>
00006 #include <cassert>
00007 #include "../core/include/subsystems/odometry/odometry_base.h"
00008 #include "../core/include/utils/graph_drawer.h"
00009 #include "../core/include/utils/controls/pid.h"
00010 #include "../core/include/utils/controls/pidff.h"
00011
00012 namespace screen
00013 {
00015     class ButtonWidget
00016     {
00017     public:
00022         ButtonWidget(std::function<void(void)> onpress, Rect rect, std::string name) :
      onpress(onpress), rect(rect), name(name) {}
00027         ButtonWidget(void (*onpress)(), Rect rect, std::string name) : onpress(onpress), rect(rect),
      name(name) {}
00028
00034         bool update(bool was_pressed, int x, int y);
00036         void draw(vex::brain::lcd &, bool first_draw, unsigned int frame_number);
00037
00038     private:
00039         std::function<void(void)> onpress;
00040         Rect rect;
00041         std::string name = "";
00042         bool was_pressed_last = false;
00043     };
00044
00046     class SliderWidget
00047     {
00048     public:
00055         SliderWidget(double &val, double low, double high, Rect rect, std::string name) : value(val),
      low(low), high(high), rect(rect), name(name) {}
00056
00062         bool update(bool was_pressed, int x, int y);
```

```
00064         void draw(vex::brain::lcd &, bool first_draw, unsigned int frame_number);
00065
00066     private:
00067         double &value;
00068
00069         double low;
00070         double high;
00071
00072         Rect rect;
00073         std::string name = "";
00074     };
00075
00076     struct WidgetConfig;
00077
00078     struct SliderConfig
00079     {
00080         double &val;
00081         double low;
00082         double high;
00083     };
00084     struct ButtonConfig
00085     {
00086         std::function<void()> onclick;
00087     };
00088     struct CheckboxConfig
00089     {
00090         std::function<void(bool)> onupdate;
00091     };
00092     struct LabelConfig
00093     {
00094         std::string label;
00095     };
00096
00097     struct TextConfig
00098     {
00099         std::function<std::string()> text;
00100     };
00101     struct SizedWidget
00102     {
00103         int size;
00104         WidgetConfig &widget;
00105     };
00106     struct WidgetConfig
00107     {
00108         enum Type
00109         {
00110             Col,
00111             Row,
00112             Slider,
00113             Button,
00114             Checkbox,
00115             Label,
00116             Text,
00117             Graph,
00118         };
00119         Type type;
00120         union
00121         {
00122             std::vector<SizedWidget> widgets;
00123             SliderConfig slider;
00124             ButtonConfig button;
00125             CheckboxConfig checkbox;
00126             LabelConfig label;
00127             TextConfig text;
00128             GraphDrawer *graph;
00129         } config;
00130     };
00131
00132     class Page;
00134     class Page
00135     {
00136     public:
00145         virtual void update(bool was_pressed, int x, int y);
00153         virtual void draw(vex::brain::lcd &screen, bool first_draw,
00154                           unsigned int frame_number);
00155     };
00156
00157     struct ScreenRect
00158     {
00159         uint32_t x1;
00160         uint32_t y1;
00161         uint32_t x2;
00162         uint32_t y2;
00163     };
00164     void draw_widget(WidgetConfig &widget, ScreenRect rect);
00165
00166     class WidgetPage : public Page
```

```
00167     {
00168     public:
00169         WidgetPage(WidgetConfig &cfg) : base_widget(cfg) {}
00170         void update(bool was_pressed, int x, int y) override;
00171 
00172         void draw(vex::brain::lcd &, bool first_draw, unsigned int frame_number) override
00173         {
00174             draw_widget(base_widget, {.x1 = 20, .y1 = 0, .x2 = 440, .y2 = 240});
00175         }
00176 
00177     private:
00178         WidgetConfig &base_widget;
00179     };
00180 
00187     void start_screen(vex::brain::lcd &screen, std::vector<Page *> pages, int first_page = 0);
00188 
00189 
00190     void next_page();
00191     void prev_page();
00192 
00194     void stop_screen();
00195 
00197     using update_func_t = std::function<void(bool, int, int)>;
00198 
00200     using draw_func_t = std::function<void(vex::brain::lcd &screen, bool, unsigned int)>;
00201 
00203     class StatsPage : public Page
00204     {
00205     public:
00208         StatsPage(std::map<std::string, vex::motor &> motors);
00210         void update(bool was_pressed, int x, int y) override;
00212         void draw(vex::brain::lcd &, bool first_draw, unsigned int frame_number) override;
00213 
00214     private:
00215         void draw_motor_stats(const std::string &name, vex::motor &mot, unsigned int frame, int x, int
      y, vex::brain::lcd &scr);
00216 
00217         std::map<std::string, vex::motor &> motors;
00218         static const int y_start = 0;
00219         static const int per_column = 4;
00220         static const int row_height = 20;
00221         static const int row_width = 200;
00222     };
00223 
00227     class OdometryPage : public Page
00228     {
00229     public:
00235         OdometryPage(OdometryBase &odom, double robot_width, double robot_height, bool do_trail);
00237         void update(bool was_pressed, int x, int y) override;
00239         void draw(vex::brain::lcd &, bool first_draw, unsigned int frame_number) override;
00240 
00241     private:
00242         static const int path_len = 40;
00243         static constexpr char const *field_filename = "vex_field_240p.png";
00244 
00245         OdometryBase &odom;
00246         double robot_width;
00247         double robot_height;
00248         uint8_t *buf = nullptr;
00249         int buf_size = 0;
00250         pose_t path[path_len];
00251         int path_index = 0;
00252         bool do_trail;
00253         GraphDrawer velocity_graph;
00254     };
00255 
00257     class FunctionPage : public Page
00258     {
00259     public:
00263         FunctionPage(update_func_t update_f, draw_func_t draw_t);
00265         void update(bool was_pressed, int x, int y) override;
00267         void draw(vex::brain::lcd &, bool first_draw, unsigned int frame_number) override;
00268 
00269     private:
00270         update_func_t update_f;
00271         draw_func_t draw_f;
00272     };
00273 
00275     class PIDPage : public Page
00276     {
00277     public:
00282         PIDPage(
00283             PID &pid, std::string name, std::function<void(void)> onchange = [](){});
00284         PIDPage(
00285             PIDFF &pidff, std::string name, std::function<void(void)> onchange = [](){});
00286 
00288         void update(bool was_pressed, int x, int y) override;
```

```
00290         void draw(vex::brain::lcd &, bool first_draw, unsigned int frame_number) override;
00291
00292     private:
00294         void zero_d_f() { cfg.d = 0; }
00296         void zero_i_f() { cfg.i = 0; }
00297
00298         PID::pid_config_t &cfg;
00299         PID &pid;
00300         const std::string name;
00301         std::function<void(void)> onchange;
00302
00303         SliderWidget p_slider;
00304         SliderWidget i_slider;
00305         SliderWidget d_slider;
00306         ButtonWidget zero_i;
00307         ButtonWidget zero_d;
00308
00309         GraphDrawer graph;
00310     };
00311
00312 }
```

6.11 tank_drive.h

```
00001 #pragma once
00002
00003 #ifndef PI
00004 #define PI 3.141592654
00005 #endif
00006
00007 #include "vex.h"
00008 #include "../core/include/subsystems/odometry/odometry_tank.h"
00009 #include "../core/include/utils/controls/pid.h"
00010 #include "../core/include/utils/controls/feedback_base.h"
00011 #include "../core/include/robot_specs.h"
00012 #include "../core/include/utils/pure_pursuit.h"
00013 #include "../core/include/utils/command_structure/auto_command.h"
00014 #include <vector>
00015
00016 using namespace vex;
00017
00022 class TankDrive
00023 {
00024 public:
00025   enum class BrakeType
00026   {
00027     None,
00028     ZeroVelocity,
00029     Smart,
00030   };
00038   TankDrive(motor_group &left_motors, motor_group &right_motors, robot_specs_t &config, OdometryBase
      *odom = NULL);
00039
00040   AutoCommand *DriveToPointCmd(point_t pt, vex::directionType dir = vex::forward, double max_speed =
      1.0, double end_speed = 0.0);
00041   AutoCommand *DriveToPointCmd(Feedback &fb, point_t pt, vex::directionType dir = vex::forward, double
      max_speed = 1.0, double end_speed = 0.0);
00042
00043   AutoCommand *DriveForwardCmd(double dist, vex::directionType dir = vex::forward, double max_speed =
      1.0, double end_speed = 0.0);
00044   AutoCommand *DriveForwardCmd(Feedback &fb, double dist, vex::directionType dir = vex::forward,
      double max_speed = 1.0, double end_speed = 0.0);
00045
00046   AutoCommand *TurnToHeadingCmd(double heading, double max_speed = 1.0, double end_speed = 0.0);
00047   AutoCommand *TurnToHeadingCmd(Feedback &fb, double heading, double max_speed = 1.0, double end_speed
      = 0.0);
00048
00049   AutoCommand *TurnDegreesCmd(double degrees, double max_speed = 1.0, double start_speed = 0.0);
00050   AutoCommand *TurnDegreesCmd(Feedback &fb, double degrees, double max_speed = 1.0, double end_speed =
      0.0);
00051
00052   AutoCommand *PurePursuitCmd(PurePursuit::Path path, directionType dir, double max_speed = 1, double
      end_speed = 0);
00053   AutoCommand *PurePursuitCmd(Feedback &feedback, PurePursuit::Path path, directionType dir, double
      max_speed = 1, double end_speed = 0);
00054
00058   void stop();
00059
00070   void drive_tank(double left, double right, int power = 1, BrakeType bt = BrakeType::None);
00076   void drive_tank_raw(double left, double right);
00077
00089   void drive_arcade(double forward_back, double left_right, int power = 1, BrakeType bt =
      BrakeType::None);
```

```
00090
00102   bool drive_forward(double inches, directionType dir, Feedback &feedback, double max_speed = 1,
      double end_speed = 0);
00103
00113   bool drive_forward(double inches, directionType dir, double max_speed = 1, double end_speed = 0);
00114
00125   bool turn_degrees(double degrees, Feedback &feedback, double max_speed = 1, double end_speed = 0);
00126
00137   bool turn_degrees(double degrees, double max_speed = 1, double end_speed = 0);
00138
00151   bool drive_to_point(double x, double y, vex::directionType dir, Feedback &feedback, double max_speed
      = 1, double end_speed = 0);
00152
00165   bool drive_to_point(double x, double y, vex::directionType dir, double max_speed = 1, double
      end_speed = 0);
00166
00176   bool turn_to_heading(double heading_deg, Feedback &feedback, double max_speed = 1, double end_speed
      = 0);
00185   bool turn_to_heading(double heading_deg, double max_speed = 1, double end_speed = 0);
00186
00190   void reset_auto();
00191
00200   static double modify_inputs(double input, int power = 2);
00201
00214   bool pure_pursuit(PurePursuit::Path path, directionType dir, Feedback &feedback, double max_speed =
      1, double end_speed = 0);
00215
00229   bool pure_pursuit(PurePursuit::Path path, directionType dir, double max_speed = 1, double end_speed
      = 0);
00230
00231 private:
00232   motor_group &left_motors;
00233   motor_group &right_motors;
00234
00235   PID correction_pid;
00236   Feedback *drive_default_feedback = NULL;
00237   Feedback *turn_default_feedback = NULL;
00238
00239   OdometryBase *odometry;
00240
00241   robot_specs_t &config;
00242
00243   bool func_initialized = false;
00244   bool is_pure_pursuit = false;
00245 };
```

6.12 auto_chooser.h

```
00001 #pragma once
00002 #include "vex.h"
00003 #include <string>
00004 #include <vector>
00005 #include "../core/include/subsystems/screen.h"
00006 #include "../core/include/utils/geometry.h"
00007
00016 class AutoChooser : public screen::Page
00017 {
00018 public:
00024   AutoChooser(std::vector<std::string> paths, size_t def = 0);
00025
00026   void update(bool was_pressed, int x, int y);
00027   void draw(vex::brain::lcd &, bool first_draw, unsigned int frame_number);
00028
00033   size_t get_choice();
00034
00035 protected:
00039   struct entry_t
00040   {
00041     Rect rect;
00042     std::string name;
00043   };
00044
00045   static const size_t width = 380;
00046   static const size_t height = 220;
00047
00048   size_t choice;
00049   std::vector<entry_t> list ;
00050 };
```

6.13 auto_command.h

```
00001
00007 #pragma once
00008
00009 #include "vex.h"
00010 #include <functional>
00011 #include <vector>
00012 #include <queue>
00013 #include <atomic>
00014
00015
00025 class Condition
00026 {
00027 public:
00028   Condition *Or(Condition *b);
00029   Condition *And(Condition *b);
00030   virtual bool test() = 0;
00031 };
00032
00033
00034 class AutoCommand
00035 {
00036 public:
00037   static constexpr double default_timeout = 10.0;
00043   virtual bool run() { return true; }
00047   virtual void on_timeout() {}
00048   AutoCommand *withTimeout(double t_seconds)
00049   {
00050     if (this->timeout_seconds < 0)
00051     {
00052       // should never be timed out
00053       return this;
00054     }
00055     this->timeout_seconds = t_seconds;
00056     return this;
00057   }
00058   AutoCommand *withCancelCondition(Condition *true_to_end){
00059     this->true_to_end = true_to_end;
00060     return this;
00061   }
00071   double timeout_seconds = default_timeout;
00072   Condition *true_to_end = nullptr;
00073 };
00074
00079 class FunctionCommand : public AutoCommand
00080 {
00081 public:
00082   FunctionCommand(std::function<bool(void)> f) : f(f) {}
00083   bool run()
00084   {
00085     return f();
00086   }
00087
00088 private:
00089   std::function<bool(void)> f;
00090 };
00091
00092 // Times tested 3
00093 // Test 1 -> false
00094 // Test 2 -> false
00095 // Test 3 -> true
00096 // Returns false until the Nth time that it is called
00097 // This is pretty much only good for implementing RepeatUntil
00098 class TimesTestedCondition : public Condition
00099 {
00100 public:
00101   TimesTestedCondition(size_t N) : max(N) {}
00102   bool test() override
00103   {
00104     count++;
00105     if (count >= max)
00106     {
00107       return true;
00108     }
00109     return false;
00110   }
00111
00112 private:
00113   size_t count = 0;
00114   size_t max;
00115 };
00116
00118 class FunctionCondition : public Condition
00119 {
00120 public:
00121   FunctionCondition(
```

```
00122       std::function<bool()> cond, std::function<void(void)> timeout = []() {}) : cond(cond),
      timeout(timeout)
00123   {
00124   }
00125   bool test() override;
00126
00127 private:
00128   std::function<bool()> cond;
00129   std::function<void(void)> timeout;
00130 };
00131
00133 class IfTimePassed : public Condition
00134 {
00135 public:
00136   IfTimePassed(double time_s);
00137   bool test() override;
00138
00139 private:
00140   double time_s;
00141   vex::timer tmr;
00142 };
00143
00145 class WaitUntilCondition : public AutoCommand
00146 {
00147 public:
00148   WaitUntilCondition(Condition *cond) : cond(cond) {}
00149   bool run() override
00150   {
00151     return cond->test();
00152   }
00153
00154 private:
00155   Condition *cond;
00156 };
00157
00160
00163 class InOrder : public AutoCommand
00164 {
00165 public:
00166   InOrder(const InOrder &other) = default;
00167   InOrder(std::queue<AutoCommand *> cmds);
00168   InOrder(std::initializer_list<AutoCommand *> cmds);
00169   bool run() override;
00170   void on_timeout() override;
00171
00172 private:
00173   AutoCommand *current_command = nullptr;
00174   std::queue<AutoCommand *> cmds;
00175   vex::timer tmr;
00176 };
00177
00180 class Parallel : public AutoCommand
00181 {
00182 public:
00183   Parallel(std::initializer_list<AutoCommand *> cmds);
00184   bool run() override;
00185   void on_timeout() override;
00186
00187 private:
00188   std::vector<AutoCommand *> cmds;
00189   std::vector<vex::task *> runners;
00190 };
00191
00195 class Branch : public AutoCommand
00196 {
00197 public:
00198   Branch(Condition *cond, AutoCommand *false_choice, AutoCommand *true_choice);
00199   ~Branch();
00200   bool run() override;
00201   void on_timeout() override;
00202
00203 private:
00204   AutoCommand *false_choice;
00205   AutoCommand *true_choice;
00206   Condition *cond;
00207   bool choice = false;
00208   bool chosen = false;
00209   vex::timer tmr;
00210 };
00211
00215 class Async : public AutoCommand
00216 {
00217 public:
00218   Async(AutoCommand *cmd) : cmd(cmd) {}
00219   bool run() override;
00220
00221 private:
```

```
00222   AutoCommand *cmd = nullptr;
00223 };
00224
00225 class RepeatUntil : public AutoCommand
00226 {
00227 public:
00231   RepeatUntil(InOrder cmds, size_t repeats);
00235   RepeatUntil(InOrder cmds, Condition *true_to_end);
00236   bool run() override;
00237   void on_timeout() override;
00238
00239 private:
00240   const InOrder cmds;
00241   InOrder *working_cmds;
00242   Condition *cond;
00243 };
```

6.14 basic_command.h

```
00001
00014 #pragma once
00015
00016 #include "../core/include/utils/command_structure/auto_command.h"
00017
00018 //Basic Motor Classes-----------------------------------------------
00019
00024 class BasicSpinCommand : public AutoCommand {
00025     public:
00026
00027      //Enumurator for the type of power setting in the motor
00028      enum type {percent,voltage,veocity};
00029
00038      BasicSpinCommand(vex::motor &motor, vex::directionType dir, BasicSpinCommand::type setting,
      double power);
00039
00046      bool run() override;
00047
00048     private:
00049
00050      vex::motor &motor;
00051
00052      type setting;
00053
00054      vex::directionType dir;
00055
00056      double power;
00057 };
00062 class BasicStopCommand : public AutoCommand{
00063     public:
00064
00071      BasicStopCommand(vex::motor &motor, vex::brakeType setting);
00072
00079      bool run() override;
00080
00081     private:
00082
00083      vex::motor &motor;
00084
00085      vex::brakeType setting;
00086 };
00087
00088 //Basic Solenoid Commands-------------------------------
00089
00094 class BasicSolenoidSet : public AutoCommand{
00095     public:
00096
00103      BasicSolenoidSet(vex::pneumatics &solenoid, bool setting);
00104
00111      bool run() override;
00112
00113     private:
00114
00115      vex::pneumatics &solenoid;
00116
00117      bool setting;
00118 };
```

6.15 command_controller.h

```
00001
```

```
00010 #pragma once
00011 #include <vector>
00012 #include <queue>
00013 #include "../core/include/utils/command_structure/auto_command.h"
00014
00015 class CommandController
00016 {
00017 public:
00019   [[deprecated("Use list constructor instead.")]] CommandController() : command_queue({}) {}
00020
00023   CommandController(std::initializer_list<AutoCommand *> cmds) : command_queue(cmds) {}
00029   [[deprecated("Use list constructor instead. If you need to make a decision before adding new
      commands, use Branch (https://github.com/RIT-VEX-U/Core/wiki/3-%7C-Utilites#commandcontroller)")]]
      void add(std::vector<AutoCommand *> cmds);
00030   void add(AutoCommand *cmd, double timeout_seconds = 10.0);
00031
00042   [[deprecated("Use list constructor instead. If you need to make a decision before adding new
      commands, use Branch (https://github.com/RIT-VEX-U/Core/wiki/3-%7C-Utilites#commandcontroller)")]]
      void
00043   add(std::vector<AutoCommand *> cmds, double timeout_sec);
00050   void add_delay(int ms);
00051
00054   void add_cancel_func(std::function<bool(void)> true_if_cancel);
00055
00060   void run();
00061
00067   bool last_command_timed_out();
00068
00069 private:
00070   std::queue<AutoCommand *> command_queue;
00071   bool command_timed_out = false;
00072   std::function<bool()> should_cancel = []()
00073   { return false; };
00074 };
```

6.16 delay_command.h

```
00001
00008 #pragma once
00009
00010 #include "../core/include/utils/command_structure/auto_command.h"
00011
00012 class DelayCommand: public AutoCommand {
00013   public:
00018     DelayCommand(int ms): ms(ms) {}
00019
00025     bool run() override {
00026       vexDelay(ms);
00027       return true;
00028     }
00029
00030   private:
00031     // amount of milliseconds to wait
00032     int ms;
00033 };
```

6.17 drive_commands.h

```
00001
00019 #pragma once
00020
00021 #include "vex.h"
00022 #include "../core/include/utils/geometry.h"
00023 #include "../core/include/utils/command_structure/auto_command.h"
00024 #include "../core/include/subsystems/tank_drive.h"
00025
00026 using namespace vex;
00027
00028
00029 // ==== DRIVING ====
00030
00036 class DriveForwardCommand: public AutoCommand
00037 {
00038   public:
00039     DriveForwardCommand(TankDrive &drive_sys, Feedback &feedback, double inches, directionType dir,
      double max_speed=1, double end_speed=0);
00040
00046     bool run() override;
00050     void on_timeout() override;
```

```
00051
00052   private:
00053     // drive system to run the function on
00054     TankDrive &drive_sys;
00055
00056     // feedback controller to use
00057     Feedback &feedback;
00058
00059     // parameters for drive_forward
00060     double inches;
00061     directionType dir;
00062     double max_speed;
00063     double end_speed;
00064 };
00065
00070 class TurnDegreesCommand: public AutoCommand
00071 {
00072   public:
00073     TurnDegreesCommand(TankDrive &drive_sys, Feedback &feedback, double degrees, double max_speed = 1,
      double end_speed = 0);
00074
00080     bool run() override;
00084     void on_timeout() override;
00085
00086
00087   private:
00088     // drive system to run the function on
00089     TankDrive &drive_sys;
00090
00091     // feedback controller to use
00092     Feedback &feedback;
00093
00094     // parameters for turn_degrees
00095     double degrees;
00096     double max_speed;
00097     double end_speed;
00098 };
00099
00104 class DriveToPointCommand: public AutoCommand
00105 {
00106   public:
00107     DriveToPointCommand(TankDrive &drive_sys, Feedback &feedback, double x, double y, directionType
      dir, double max_speed = 1, double end_speed = 0);
00108     DriveToPointCommand(TankDrive &drive_sys, Feedback &feedback, point_t point, directionType dir,
      double max_speed=1, double end_speed = 0);
00109
00115     bool run() override;
00116
00117   private:
00118     // drive system to run the function on
00119     TankDrive &drive_sys;
00120
00124     void on_timeout() override;
00125
00126
00127     // feedback controller to use
00128     Feedback &feedback;
00129
00130     // parameters for drive_to_point
00131     double x;
00132     double y;
00133     directionType dir;
00134     double max_speed;
00135     double end_speed;
00136
00137 };
00138
00144 class TurnToHeadingCommand: public AutoCommand
00145 {
00146   public:
00147     TurnToHeadingCommand(TankDrive &drive_sys, Feedback &feedback, double heading_deg, double speed =
      1, double end_speed = 0);
00148
00154     bool run() override;
00158     void on_timeout() override;
00159
00160
00161   private:
00162     // drive system to run the function on
00163     TankDrive &drive_sys;
00164
00165     // feedback controller to use
00166     Feedback &feedback;
00167
00168     // parameters for turn_to_heading
00169     double heading_deg;
00170     double max_speed;
```

```
00171     double end_speed;
00172 };
00173
00177 class PurePursuitCommand: public AutoCommand
00178 {
00179   public:
00188   PurePursuitCommand(TankDrive &drive_sys, Feedback &feedback, PurePursuit::Path path, directionType
      dir, double max_speed=1, double end_speed=0);
00189
00193   bool run() override;
00194
00198   void on_timeout() override;
00199
00200   private:
00201   TankDrive &drive_sys;
00202   PurePursuit::Path path;
00203   directionType dir;
00204   Feedback &feedback;
00205   double max_speed;
00206   double end_speed;
00207
00208 };
00209
00214 class DriveStopCommand: public AutoCommand
00215 {
00216   public:
00217     DriveStopCommand(TankDrive &drive_sys);
00218
00224     bool run() override;
00225     void on_timeout() override;
00226
00227   private:
00228     // drive system to run the function on
00229     TankDrive &drive_sys;
00230 };
00231
00232
00233 // ==== ODOMETRY ====
00234
00239 class OdomSetPosition: public AutoCommand
00240 {
00241   public:
00247     OdomSetPosition(OdometryBase &odom, const pose_t &newpos=OdometryBase::zero_pos);
00248
00254     bool run() override;
00255
00256   private:
00257     // drive system with an odometry config
00258     OdometryBase &odom;
00259     pose_t newpos;
00260 };
```

6.18 flywheel_commands.h

```
00001
00007 #pragma once
00008
00009 #include "../core/include/subsystems/flywheel.h"
00010 #include "../core/include/utils/command_structure/auto_command.h"
00011
00017 class SpinRPMCommand: public AutoCommand {
00018   public:
00024   SpinRPMCommand(Flywheel &flywheel, int rpm);
00025
00031     bool run() override;
00032
00033   private:
00034     // Flywheel instance to run the function on
00035     Flywheel &flywheel;
00036
00037     // parameters for spin_rpm
00038     int rpm;
00039 };
00040
00045 class WaitUntilUpToSpeedCommand: public AutoCommand {
00046   public:
00052     WaitUntilUpToSpeedCommand(Flywheel &flywheel, int threshold_rpm);
00053
00059     bool run() override;
00060
00061   private:
00062     // Flywheel instance to run the function on
00063     Flywheel &flywheel;
```

```
00064
00065     // if the actual speed is equal to the desired speed +/- this value, we are ready to fire
00066     int threshold_rpm;
00067 };
00068
00074 class FlywheelStopCommand: public AutoCommand {
00075   public:
00080   FlywheelStopCommand(Flywheel &flywheel);
00081
00087     bool run() override;
00088
00089   private:
00090     // Flywheel instance to run the function on
00091     Flywheel &flywheel;
00092 };
00093
00099 class FlywheelStopMotorsCommand: public AutoCommand {
00100   public:
00105   FlywheelStopMotorsCommand(Flywheel &flywheel);
00106
00112     bool run() override;
00113
00114   private:
00115     // Flywheel instance to run the function on
00116     Flywheel &flywheel;
00117 };
00118
00124 class FlywheelStopNonTasksCommand: public AutoCommand {
00125   FlywheelStopNonTasksCommand(Flywheel &flywheel);
00126
00132     bool run() override;
00133
00134   private:
00135     // Flywheel instance to run the function on
00136     Flywheel &flywheel;
00137 };
```

6.19 bang_bang.h

```
00001 #include "../core/include/utils/controls/feedback_base.h"
00002
00003 class BangBang : public Feedback
00004 {
00005
00006 public:
00007     BangBang(double thresshold, double low, double high);
00016     void init(double start_pt, double set_pt, double start_vel [[maybe_unused]] = 0.0, double end_vel
      [[maybe_unused]] = 0.0) override;
00017
00024     double update(double val) override;
00025
00029     double get() override;
00030
00037     void set_limits(double lower, double upper) override;
00038
00042     bool is_on_target() override;
00043
00044 private:
00045     double setpt;
00046     double sensor_val;
00047     double lower_bound, upper_bound;
00048     double last_output;
00049     double threshhold;
00050 };
```

6.20 feedback_base.h

```
00001 #pragma once
00002
00010 class Feedback
00011 {
00012 public:
00021     virtual void init(double start_pt, double set_pt, double start_vel = 0.0, double end_vel = 0.0) =
      0;
00022
00029     virtual double update(double val) = 0;
00030
00034     virtual double get() = 0;
00035
```

```
00042     virtual void set_limits(double lower, double upper) = 0;
00043
00047     virtual bool is_on_target() = 0;
00048
00049
00050 };
```

6.21 feedforward.h

```
00001 #pragma once
00002
00003 #include <math.h>
00004 #include <vector>
00005 #include "../core/include/utils/math_util.h"
00006 #include "../core/include/utils/moving_average.h"
00007 #include "vex.h"
00008
00029 class FeedForward
00030 {
00031     public:
00032
00041     typedef struct
00042     {
00043         double kS;
00044         double kV;
00045         double kA;
00046         double kG;
00047     } ff_config_t;
00048
00049
00054     FeedForward(ff_config_t &cfg) : cfg(cfg) {}
00055
00066     double calculate(double v, double a, double pid_ref=0.0)
00067     {
00068         double ks_sign = 0;
00069         if(v != 0)
00070             ks_sign = sign(v);
00071         else if(pid_ref != 0)
00072             ks_sign = sign(pid_ref);
00073
00074         return (cfg.kS * ks_sign) + (cfg.kV * v) + (cfg.kA * a) + cfg.kG;
00075     }
00076
00077     private:
00078
00079     ff_config_t &cfg;
00080
00081 };
00082
00083
00091 FeedForward::ff_config_t tune_feedforward(vex::motor_group &motor, double pct, double duration);
```

6.22 motion_controller.h

```
00001 #pragma once
00002 #include "../core/include/utils/controls/pid.h"
00003 #include "../core/include/utils/controls/feedforward.h"
00004 #include "../core/include/utils/controls/trapezoid_profile.h"
00005 #include "../core/include/utils/controls/feedback_base.h"
00006 #include "../core/include/subsystems/tank_drive.h"
00007 #include "../core/include/subsystems/screen.h"
00008
00009 #include "vex.h"
00010
00027 class MotionController : public Feedback
00028 {
00029     public:
00030
00036     typedef struct
00037     {
00038         double max_v;
00039         double accel;
00040         PID::pid_config_t pid_cfg;
00041         FeedForward::ff_config_t ff_cfg;
00042     } m_profile_cfg_t;
00043
00053     MotionController(m_profile_cfg_t &config);
00054
00059     void init(double start_pt, double end_pt, double start_vel, double end_vel) override;
```

```
00060
00067     double update(double sensor_val) override;
00068
00072     double get() override;
00073
00081     void set_limits(double lower, double upper) override;
00082
00087     bool is_on_target() override;
00088
00092     motion_t get_motion() const;
00093
00094
00095     screen::Page *Page();
00096
00115     static FeedForward::ff_config_t tune_feedforward(TankDrive &drive, OdometryTank &odometry, double
      pct=0.6, double duration=2);
00116
00117     private:
00118
00119     m_profile_cfg_t config;
00120
00121     PID pid;
00122     FeedForward ff;
00123     TrapezoidProfile profile;
00124
00125     double current_pos;
00126     double end_pt;
00127
00128     double lower_limit = 0, upper_limit = 0;
00129     double out = 0;
00130     motion_t cur_motion;
00131
00132     vex::timer tmr;
00133     friend class MotionControllerPage;
00134
00135 };
```

6.23 pid.h

```
00001 #pragma once
00002
00003 #include "../core/include/utils/controls/feedback_base.h"
00004 #include "vex.h"
00005 #include <cmath>
00006
00007 using namespace vex;
00008
00023 class PID : public Feedback {
00024 public:
00029   enum ERROR_TYPE {
00030     LINEAR,
00031     ANGULAR // assumes degrees
00032   };
00043   struct pid_config_t {
00044     double p;
00045     double i;
00046     double d;
00047     double deadband;
00048     double on_target_time;
00050     ERROR_TYPE error_method;
00052   };
00053
00058   PID(pid_config_t &config);
00059
00072   void init(double start_pt, double set_pt, double start_vel = 0,
00073             double end_vel = 0) override;
00074
00082   double update(double sensor_val) override;
00083
00088   double get_sensor_val() const;
00089
00095   double get() override;
00096
00105   void set_limits(double lower, double upper) override;
00106
00111   bool is_on_target() override;
00112
00116   void reset();
00117
00123   double get_error();
00124
00129   double get_target() const;
00130
```

```
00135   void set_target(double target);
00136
00137   pid_config_t
00138       &config;
00140
00141 private:
00142   double last_error =
00143       0;
00144   double accum_error =
00145       0;
00146
00147   double last_time = 0;
00148   double on_target_last_time =
00149       0;
00150
00151   double lower_limit =
00152       0;
00153   double upper_limit =
00154       0;
00155
00156   double target = 0;
00158   double target_vel = 0;
00160   double sensor_val = 0;
00162   double out = 0;
00165
00166   bool is_checking_on_target =
00167       false;
00168
00169   timer pid_timer;
00172 };
```

6.24 pidff.h

```
00001 #pragma once
00002 #include "../core/include/utils/controls/feedback_base.h"
00003 #include "../core/include/utils/controls/feedforward.h"
00004 #include "../core/include/utils/controls/pid.h"
00005
00006 class PIDFF : public Feedback {
00007 public:
00008   PIDFF(PID::pid_config_t &pid_cfg, FeedForward::ff_config_t &ff_cfg);
00009
00018   void init(double start_pt, double set_pt, double start_vel,
00019             double end_vel) override;
00020
00025   void set_target(double set_pt);
00026
00027   double get_target() const;
00028   double get_sensor_val() const;
00036   double update(double val) override;
00037
00046   double update(double val, double vel_setpt, double a_setpt = 0);
00047
00051   double get() override;
00052
00060   void set_limits(double lower, double upper) override;
00061
00065   bool is_on_target() override;
00066
00067   void reset();
00068
00069   PID pid;
00070
00071 private:
00072   FeedForward::ff_config_t &ff_cfg;
00073
00074   FeedForward ff;
00075
00076   double out;
00077   double lower_lim, upper_lim;
00078 };
```

6.25 take_back_half.h

```
00001 #pragma once
00002 #include "../core/include/utils/controls/feedback_base.h"
00003
00006 class TakeBackHalf : public Feedback
00007 {
```

```
00008
00009 public:
00010     TakeBackHalf(double TBH_gain, double first_cross_split, double on_target_threshold);
00019     void init(double start_pt, double set_pt, double, double);
00026     double update(double val) override;
00027
00031     double get() override;
00032
00039     void set_limits(double lower, double upper) override;
00040
00044     bool is_on_target() override;
00045
00046     double TBH_gain;
00047     double first_cross_split;
00048 private:
00049     double on_target_threshhold;
00050
00051     double target = 0.0;
00052
00053     bool first_cross = true;
00054     double tbh = 0.0;
00055     double prev_error = 0.0;
00056
00057     double output = 0.0;
00058     double lower = 0.0, upper = 0.0;
00059 };
```

6.26 trapezoid_profile.h

```
00001 #pragma once
00002
00003 const int MAX_TRAPEZOID_PROFILE_SEGMENTS = 4;
00004
00008 typedef struct {
00009   double pos;
00010   double vel;
00011   double accel;
00012
00013 } motion_t;
00014
00019 typedef struct {
00020   double pos_after;
00021   double vel_after;
00022   double accel;
00023   double duration;
00024 } trapezoid_profile_segment_t;
00025
00063 class TrapezoidProfile {
00064 public:
00071   TrapezoidProfile(double max_v, double accel);
00072
00081   motion_t calculate(double time_s, double pos_s);
00082
00089   motion_t calculate_time_based(double time_s);
00090
00097   void set_endpts(double start, double end);
00098
00105   void set_vel_endpts(double start, double end);
00106
00113   void set_accel(double accel);
00114
00121   void set_max_v(double max_v);
00122
00129   double get_movement_time() const;
00130
00131   double get_max_v() const;
00132   double get_accel() const;
00133
00134 private:
00135   double si, sf;
00136   double vi, vf;
00137   double max_v;
00138   double accel;
00139   double duration;
00140
00141   trapezoid_profile_segment_t segments[MAX_TRAPEZOID_PROFILE_SEGMENTS];
00142   int num_acceleration_phases;
00143
00144   bool precalculated;
00145
00151   bool precalculate();
00152
00163   trapezoid_profile_segment_t calculate_kinetic_motion(double si, double vi,
```

```
00164                                                   double v_target);
00165
00173   trapezoid_profile_segment_t calculate_next_segment(double s, double v);
00174 };
```

6.27 generic_auto.h

```
00001 #pragma once
00002
00003 #include <queue>
00004 #include <map>
00005 #include "vex.h"
00006 #include <functional>
00007
00008 typedef std::function<bool(void)> state_ptr;
00009
00014 class GenericAuto
00015 {
00016   public:
00017
00031   [[deprecated("Use CommandController instead.")]]
00032   bool run(bool blocking);
00033
00038   [[deprecated("Use CommandController instead.")]]
00039   void add(state_ptr new_state);
00040
00045   [[deprecated("Use CommandController instead.")]]
00046   void add_async(state_ptr async_state);
00047
00052   [[deprecated("Use CommandController instead.")]]
00053   void add_delay(int ms);
00054
00055   private:
00056
00057   std::queue<state_ptr> state_list;
00058
00059 };
```

6.28 geometry.h

```
00001 #pragma once
00002 #include <cmath>
00003
00007 struct point_t
00008 {
00009     double x;
00010     double y;
00011
00017     double dist(const point_t other) const
00018     {
00019         return std::sqrt(std::pow(this->x - other.x, 2) + pow(this->y - other.y, 2));
00020     }
00021
00027     point_t operator+(const point_t &other) const
00028     {
00029         point_t p{
00030             .x = this->x + other.x,
00031             .y = this->y + other.y};
00032         return p;
00033     }
00034
00040     point_t operator-(const point_t &other) const
00041     {
00042         point_t p{
00043             .x = this->x - other.x,
00044             .y = this->y - other.y};
00045         return p;
00046     }
00047
00048     point_t operator*(double s) const
00049     {
00050         return {x * s, y * s};
00051     }
00052     point_t operator/(double s) const
00053     {
00054         return {x / s, y / s};
00055     }
00056
00057     point_t operator-() const
```

```
00058     {
00059         return {-x, -y};
00060     }
00061     point_t operator+() const
00062     {
00063         return {x, y};
00064     }
00065 
00066     bool operator==(const point_t &rhs)
00067     {
00068         return x == rhs.x && y == rhs.y;
00069     }
00070 };
00071 
00075 struct pose_t
00076 {
00077     double x;
00078     double y;
00079     double rot;
00080 
00081     point_t get_point()
00082     {
00083         return point_t{.x = x, .y = y};
00084     }
00085 
00086 } ;
00087 
00088 struct Rect
00089 {
00090     point_t min;
00091     point_t max;
00092     static Rect from_min_and_size(point_t min, point_t size){
00093         return {min, min+size};
00094     }
00095     point_t dimensions() const
00096     {
00097         return max - min;
00098     }
00099     point_t center() const{
00100         return (min + max)/2;
00101     }
00102     double width() const{
00103         return max.x - min.x;
00104     }
00105     double height() const{
00106         return max.y - min.y;
00107     }
00108     bool contains(point_t p) const
00109     {
00110         bool xin = p.x > min.x && p.x < max.x;
00111         bool yin = p.y > min.y && p.y < max.y;
00112         return xin && yin;
00113     }
00114 
00115 };
00116 
00117 struct Mat2
00118 {
00119     double X11, X12;
00120     double X21, X22;
00121     point_t operator*(const point_t p) const
00122     {
00123         double outx = p.x * X11 + p.y * X12;
00124         double outy = p.x * X21 + p.y * X22;
00125         return {outx, outy};
00126     }
00127 
00128     static Mat2 FromRotationDegrees(double degrees)
00129     {
00130         double rad = degrees * (M_PI / 180.0);
00131         double c = cos(rad);
00132         double s = sin(rad);
00133         return {c, -s, s, c};
00134     }
00135 };
```

6.29 graph_drawer.h

```
00001 #pragma once
00002 
00003 #include <string>
00004 #include <stdio.h>
00005 #include <vector>
```

```
00006 #include <cmath>
00007 #include "vex.h"
00008 #include "../core/include/utils/geometry.h"
00009 #include "../core/include/utils/vector2d.h"
00010
00011 class GraphDrawer
00012 {
00013 public:
00020   GraphDrawer(int num_samples, double lower_bound, double upper_bound, std::vector<vex::color> colors,
      size_t num_series = 1);
00025   void add_samples(std::vector<point_t> sample);
00026
00031   void add_samples(std::vector<double> sample);
00032
00040   void draw(vex::brain::lcd &screen, int x, int y, int width, int height);
00041
00042 private:
00043   std::vector<std::vector<point_t» series;
00044   int sample_index = 0;
00045   std::vector<vex::color> cols;
00046   vex::color bgcol = vex::transparent;
00047   bool border;
00048   double upper;
00049   double lower;
00050   bool auto_fit = false;
00051 };
```

6.30 logger.h

```
00001 #pragma once
00002
00003 #include <cstdarg>
00004 #include <cstdio>
00005 #include <string>
00006 #include "vex.h"
00007
00009 enum LogLevel
00010 {
00011     DEBUG,
00012     NOTICE,
00013     WARNING,
00014     ERROR,
00015     CRITICAL,
00016     TIME
00017 };
00018
00020 class Logger
00021 {
00022 private:
00023     const std::string filename;
00024     vex::brain::sdcard sd;
00025     void write_level(LogLevel l);
00026
00027 public:
00029     static constexpr int MAX_FORMAT_LEN = 512;
00032     explicit Logger(const std::string &filename);
00033
00035     Logger(const Logger &l) = delete;
00037     Logger &operator=(const Logger &l) = delete;
00038
00039
00042     void Log(const std::string &s);
00043
00047     void Log(LogLevel level, const std::string &s);
00048
00051     void Logln(const std::string &s);
00052
00056     void Logln(LogLevel level, const std::string &s);
00057
00061     void Logf(const char *fmt, ...);
00062
00067     void Logf(LogLevel level, const char *fmt, ...);
00068 };
```

6.31 math_util.h

```
00001 #pragma once
00002 #include <vector>
00003 #include "math.h"
```

```
00004 #include "vex.h"
00005 #include "../core/include/utils/geometry.h"
00006
00007
00015 double clamp(double value, double low, double high);
00016
00023 double lerp(double a, double b, double t);
00030 double sign(double x);
00031
00032 double wrap_angle_deg(double input);
00033 double wrap_angle_rad(double input);
00034
00035 /*
00036 Calculates the variance of  a set of numbers (needed for linear regression)
00037 https://en.wikipedia.org/wiki/Variance
00038 @param values   the values for which the variance is taken
00039 @param mean     the average of values
00040 */
00041 double variance(std::vector<double> const &values, double mean);
00042
00043
00044 /*
00045 Calculates the average of a vector of doubles
00046 @param values   the list of values for which the average is taken
00047 */
00048 double mean(std::vector<double> const &values);
00049
00050 /*
00051 Calculates the covariance of a set of points (needed for linear regression)
00052 https://en.wikipedia.org/wiki/Covariance
00053
00054 @param points   the points for which the covariance is taken
00055 @param meanx    the mean value of all x coordinates in points
00056 @param meany    the mean value of all y coordinates in points
00057 */
00058 double covariance(std::vector<std::pair<double, double» const &points, double meanx, double meany);
00059
00060 /*
00061 Calculates the slope and y intercept of the line of best fit for the data
00062 @param points the points for the data
00063 */
00064 std::pair<double, double> calculate_linear_regression(std::vector<std::pair<double, double» const
      &points);
00065
00066 double estimate_path_length(const std::vector<point_t> &points);
```

6.32 moving_average.h

```
00001 #pragma once
00002 #include <vector>
00003
00008 class Filter
00009 {
00010 public:
00011   virtual void add_entry(double n) = 0;
00012   virtual double get_value() const = 0;
00013 };
00014
00027 class MovingAverage : public Filter
00028 {
00029 public:
00030   /*
00031    * Create a moving average calculator with 0 as the default value
00032    *
00033    * @param buffer_size    The size of the buffer. The number of samples that constitute a valid
      reading
00034    */
00035   MovingAverage(int buffer_size);
00036   /*
00037    * Create a moving average calculator with a specified default value
00038    * @param buffer_size    The size of the buffer. The number of samples that constitute a valid
      reading
00039    * @param starting_value The value that the average will be before any data is added
00040    */
00041   MovingAverage(int buffer_size, double starting_value);
00042
00043   /*
00044    * Add a reading to the buffer
00045    * Before:
00046    * [ 1 1 2 2 3 3] => 2
00047    *   ^
00048    * After:
00049    * [ 2 1 2 2 3 3] => 2.16
```

```
00050     *      ^
00051     * @param n  the sample that will be added to the moving average.
00052     */
00053   void add_entry(double n) override;
00054
00059   double get_value() const override;
00060
00065   int get_size() const;
00066
00067 private:
00068   int buffer_index;           // index of the next value to be overridden
00069   std::vector<double> buffer; // all current data readings we've taken
00070   double current_avg;         // the current value of the data
00071 };
00072
00085 class ExponentialMovingAverage : public Filter
00086 {
00087 public:
00088   /*
00089    * Create a moving average calculator with 0 as the default value
00090    *
00091    * @param buffer_size    The size of the buffer. The number of samples that constitute a valid
      reading
00092    */
00093   ExponentialMovingAverage(int buffer_size);
00094   /*
00095    * Create a moving average calculator with a specified default value
00096    * @param buffer_size    The size of the buffer. The number of samples that constitute a valid
      reading
00097    * @param starting_value The value that the average will be before any data is added
00098    */
00099   ExponentialMovingAverage(int buffer_size, double starting_value);
00100
00101   /*
00102    * Add a reading to the buffer
00103    * Before:
00104    * [ 1 1 2 2 3 3] => 2
00105    *   ^
00106    * After:
00107    * [ 2 1 2 2 3 3] => 2.16
00108    *     ^
00109    * @param n  the sample that will be added to the moving average.
00110    */
00111   void add_entry(double n) override;
00112
00117   double get_value() const override;
00118
00123   int get_size();
00124
00125 private:
00126   int buffer_index;           // index of the next value to be overridden
00127   std::vector<double> buffer; // all current data readings we've taken
00128   double current_avg;         // the current value of the data
00129 };
```

6.33 pure_pursuit.h

```
00001 #pragma once
00002
00003 #include <vector>
00004 #include "../core/include/utils/geometry.h"
00005 #include "../core/include/utils/vector2d.h"
00006 #include "vex.h"
00007
00008 using namespace vex;
00009
00010 namespace PurePursuit {
00014   class Path
00015   {
00016     public:
00022       Path(std::vector<point_t> points, double radius);
00023
00027       std::vector<point_t> get_points();
00028
00032       double get_radius();
00033
00037       bool is_valid();
00038
00039     private:
00040       std::vector<point_t> points;
00041       double radius;
00042       bool valid;
00043   };
```

```
00048   struct spline
00049   {
00050     double a, b, c, d, x_start, x_end;
00051
00052     double getY(double x) {
00053       return a * pow((x - x_start), 3) + b * pow((x - x_start), 2) + c * (x - x_start) + d;
00054     }
00055   };
00060   struct hermite_point
00061   {
00062     double x;
00063     double y;
00064     double dir;
00065     double mag;
00066
00067     point_t getPoint() const {
00068       return {x, y};
00069     }
00070
00071     Vector2D getTangent() const {
00072       return Vector2D(dir, mag);
00073     }
00074   };
00075
00080   extern std::vector<point_t> line_circle_intersections(point_t center, double r, point_t point1,
      point_t point2);
00084   extern point_t get_lookahead(const std::vector<point_t> &path, pose_t robot_loc, double radius);
00085
00089   extern std::vector<point_t> inject_path(const std::vector<point_t> &path, double spacing);
00090
00102   extern std::vector<point_t> smooth_path(const std::vector<point_t> &path, double weight_data, double
      weight_smooth, double tolerance);
00103
00104   extern std::vector<point_t> smooth_path_cubic(const std::vector<point_t> &path, double res);
00105
00114   extern std::vector<point_t> smooth_path_hermite(const std::vector<hermite_point> &path, double
      step);
00115
00126   extern double estimate_remaining_dist(const std::vector<point_t> &path, pose_t robot_pose, double
      radius);
00127
00128 }
```

6.34 serializer.h

```
00001 #pragma once
00002 #include <algorithm>
00003 #include <map>
00004 #include <string>
00005 #include <vector>
00006 #include <stdio.h>
00007 #include <vex.h>
00008
00010 const char serialization_separator = '$';
00012 const std::size_t MAX_FILE_SIZE = 4096;
00013
00015 class Serializer
00016 {
00017 private:
00018     bool flush_always;
00019     std::string filename;
00020     std::map<std::string, int> ints;
00021     std::map<std::string, bool> bools;
00022     std::map<std::string, double> doubles;
00023     std::map<std::string, std::string> strings;
00024
00026     bool read_from_disk();
00027
00028 public:
00030     ~Serializer()
00031     {
00032         save_to_disk();
00033         printf("Saving %s\n", filename.c_str());
00034         fflush(stdout);
00035     }
00036
00040     explicit Serializer(const std::string &filename, bool flush_always = true) :
      flush_always(flush_always), filename(filename), ints({}), bools({}), doubles({}), strings({})
00041
00042     {
00043         read_from_disk();
00044     }
00045
```

```
00047     void save_to_disk() const;
00048
00050
00054     void set_int(const std::string &name, int i);
00055
00059     void set_bool(const std::string &name, bool b);
00060
00064     void set_double(const std::string &name, double d);
00065
00069     void set_string(const std::string &name, std::string str);
00070
00073
00078     int int_or(const std::string &name, int otherwise);
00079
00084     bool bool_or(const std::string &name, bool otherwise);
00085
00090     double double_or(const std::string &name, double otherwise);
00091
00096     std::string string_or(const std::string &name, std::string otherwise);
00097 };
```

6.35 vector2d.h

```
00001 #pragma once
00002
00003
00004 #include <cmath>
00005 #include "../core/include/utils/geometry.h"
00006
00007 #ifndef PI
00008 #define PI 3.141592654
00009 #endif
00015 class Vector2D
00016 {
00017 public:
00024     Vector2D(double dir, double mag);
00025
00031     Vector2D(point_t p);
00032
00040     double get_dir() const;
00041
00045     double get_mag() const;
00046
00050     double get_x() const;
00051
00055     double get_y() const;
00056
00061     Vector2D normalize();
00062
00067     point_t point();
00068
00074     Vector2D operator*(const double &x);
00081     Vector2D operator+(const Vector2D &other);
00088     Vector2D operator-(const Vector2D &other);
00089
00090 private:
00091
00092     double dir, mag;
00093
00094 };
00095
00101 double deg2rad(double deg);
00102
00109 double rad2deg(double r);
```

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