RIT VEXU Core API

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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)

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StateMachine< System, IDType, Message, delay_ms, do_log >
State Machine :)))))) A fun fun way of controlling stateful subsystems - used in the 2023-2024 Over Under game for our overly complex intake-cata subsystem (see there for an example) The statemachine runs in a background thread and a user thread can interact with it through current_state and send_message . . . 145
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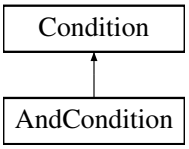
Chapter 5

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:

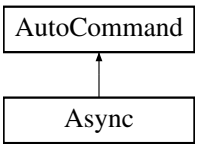
- src/utils/command_structure/auto_command.cpp

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.

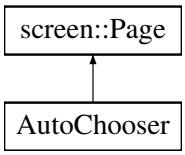
The documentation for this class was generated from the following files:

- 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]
```

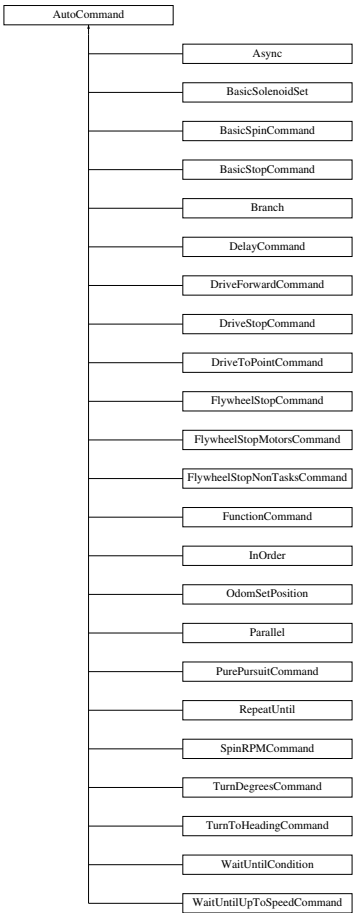
< a list of all possible auto choices

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

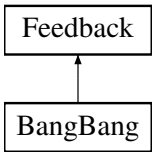
- a drive command hitting a wall and not being able to reach its target
- a command that waits until something is up to speed that never gets up to speed because of battery voltage
- something else...

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.

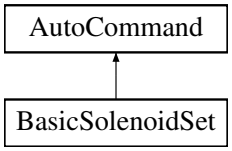
The documentation for this class was generated from the following files:

- 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.

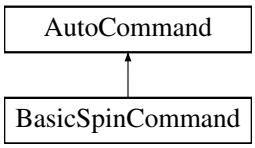
The documentation for this class was generated from the following files:

- 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.

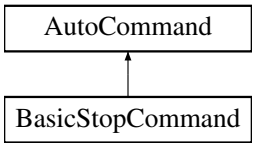
The documentation for this class was generated from the following files:

- 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:

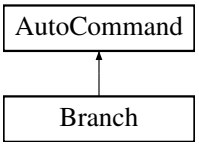
- include/utils/command_structure/basic_command.h
- src/utils/command_structure/basic_command.cpp

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

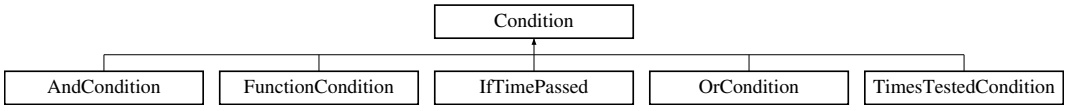
The documentation for this class was generated from the following files:

- 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

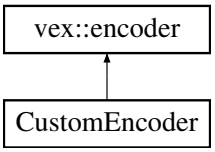
The documentation for this class was generated from the following files:

- 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

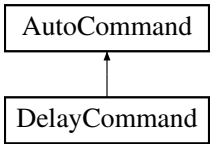
The documentation for this class was generated from the following files:

- 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.

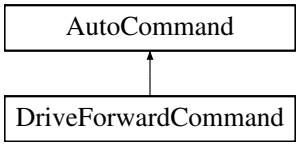
The documentation for this class was generated from the following file:

- 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.

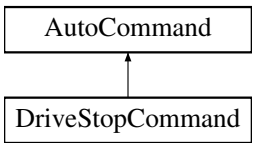
The documentation for this class was generated from the following files:

- 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.

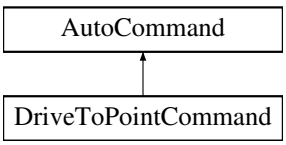
The documentation for this class was generated from the following files:

- 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

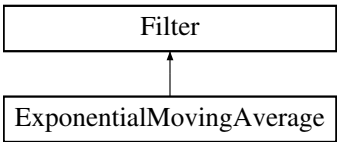
The documentation for this struct was generated from the following file:

- 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.

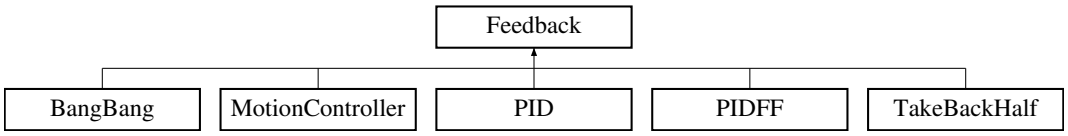
The documentation for this class was generated from the following files:

- 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.

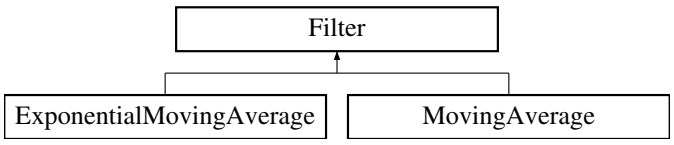
The documentation for this struct was generated from the following file:

- 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]
```

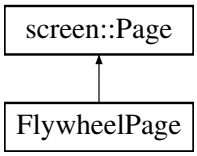
Runs a thread that keeps track of updating flywheel RPM and controlling it accordingly

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.

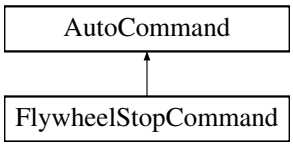
The documentation for this class was generated from the following file:

- 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.

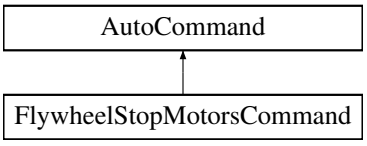
The documentation for this class was generated from the following files:

- 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.

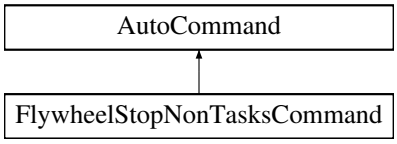
The documentation for this class was generated from the following files:

- 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

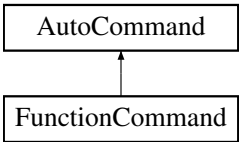
The documentation for this class was generated from the following files:

- 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:

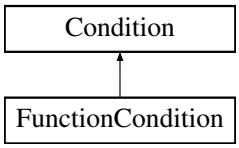
- include/utils/command_structure/auto_command.h

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:

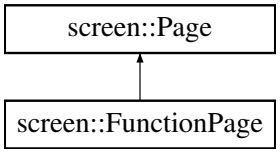
- include/utils/command_structure/auto_command.h
- src/utils/command_structure/auto_command.cpp

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:

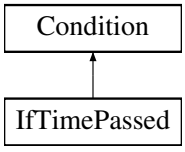
- include/utils/pure_pursuit.h

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:

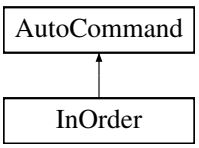
- include/utils/command_structure/auto_command.h
- src/utils/command_structure/auto_command.cpp

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 StateMachine< System, IDType, Message, delay_ms, do_log >::MaybeMessage Class Reference

MaybeMessage a message of Message type or nothing MaybeMessage m = {}; // empty MaybeMessage m = Message::EnumField1.

`#include <state_machine.h>`

Public Member Functions

- **MaybeMessage** ()

  Empty message - when theres no message.
- MaybeMessage (Message msg)

  Create a maybemessage with a message.
- bool has_message ()

  check if the message is here
- Message message ()

  Get the message stored. The return value is invalid unless has_message returned true.

5.45.1 Detailed Description

template<typename System, typename IDType, typename Message, int32_t delay_ms, bool do_log = false>
class StateMachine< System, IDType, Message, delay_ms, do_log >::MaybeMessage

MaybeMessage a message of Message type or nothing MaybeMessage m = {}; // empty MaybeMessage m = Message::EnumField1.

5.45.2 Constructor & Destructor Documentation

5.45.2.1 MaybeMessage()

```
template<typename System , typename IDType , typename Message , int32_t delay_ms, bool do_log
= false>
StateMachine< System, IDType, Message, delay_ms, do_log >::MaybeMessage::MaybeMessage (
            Message msg )  [inline]
```

Create a maybemessage with a message.

Parameters

msg	the message to hold on to

5.45.3 Member Function Documentation

5.45.3.1 has_message()

```
template<typename System , typename IDType , typename Message , int32_t delay_ms, bool do_log
= false>
bool StateMachine< System, IDType, Message, delay_ms, do_log >::MaybeMessage::has_message ( )
[inline]
```

check if the message is here

Returns

true if there is a message

5.45.3.2 message()

```
template<typename System , typename IDType , typename Message , int32_t delay_ms, bool do_log
= false>
Message StateMachine< System, IDType, Message, delay_ms, do_log >::MaybeMessage::message ( )
[inline]
```

Get the message stored. The return value is invalid unless has_message returned true.

Returns

The message if it exists. Undefined otherwise

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

- include/utils/state_machine.h

5.46 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)

5.46.1 Detailed Description

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

5.46.2 Constructor & Destructor Documentation

5.46.2.1 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

5.46.3 Member Function Documentation

5.46.3.1 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.

5.46.3.2 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

5.46.3.3 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)

5.46.3.4 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

5.47 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**

5.47.1 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

5.48 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

5.48.1 Detailed Description

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

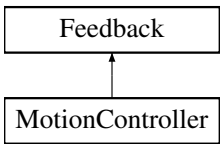
The documentation for this struct was generated from the following file:

- include/utils/controls/trapezoid_profile.h

5.49 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**

5.49.1 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

5.49.2 Constructor & Destructor Documentation

5.49.2.1 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

5.49.3 Member Function Documentation

5.49.3.1 get()

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

Returns

the last saved result from the feedback controller

Implements Feedback.

5.49.3.2 get_motion()

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

Returns

The current postion, velocity and acceleration setpoints

5.49.3.3 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.

5.49.3.4 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.

5.49.3.5 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.

5.49.3.6 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

5.49.3.7 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

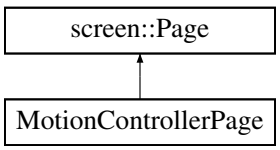
Implements Feedback.

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

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

5.50 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)

5.50.1 Member Function Documentation

5.50.1.1 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.

5.50.1.2 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.

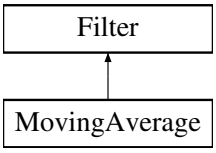
The documentation for this class was generated from the following file:

- src/utils/controls/motion_controller.cpp

5.51 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

5.51.1 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).

5.51.2 Constructor & Destructor Documentation

5.51.2.1 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

5.51.2.2 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

5.51.3 Member Function Documentation

5.51.3.1 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.

5.51.3.2 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

5.51.3.3 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.

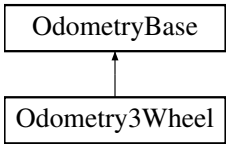
The documentation for this class was generated from the following files:

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

5.52 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

5.52.1 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

5.52.2 Constructor & Destructor Documentation

5.52.2.1 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

5.52.3 Member Function Documentation

5.52.3.1 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

5.52.3.2 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

5.53 Odometry3Wheel::odometry3wheel_cfg_t Struct Reference

```
#include <odometry_3wheel.h>
```

Public Attributes

- double wheelbase_dist
- double off_axis_center_dist
- double wheel_diam

5.53.1 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

5.53.2 Member Data Documentation

5.53.2.1 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

5.53.2.2 wheel_diam

```
double Odometry3Wheel::odometry3wheel_cfg_t::wheel_diam
```

the diameter of the tracking wheel

5.53.2.3 wheelbase_dist

```
double Odometry3Wheel::odometry3wheel_cfg_t::wheelbase_dist
```

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

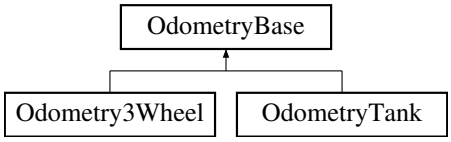
The documentation for this struct was generated from the following file:

- include/subsystems/odometry/odometry_3wheel.h

5.54 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

5.54.1 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

5.54.2 Constructor & Destructor Documentation

5.54.2.1 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

5.54.3 Member Function Documentation

5.54.3.1 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.

5.54.3.2 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.

5.54.3.3 get_accel()

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

Get the current acceleration

Returns

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

5.54.3.4 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)

5.54.3.5 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)

5.54.3.6 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

5.54.3.7 get_speed()

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

Get the current speed

Returns

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

5.54.3.8 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

5.54.3.9 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

5.54.3.10 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.

5.54.3.11 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.

5.54.3.12 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.

5.54.4 Member Data Documentation

5.54.4.1 accel

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

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

5.54.4.2 ang_accel_deg

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

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

5.54.4.3 ang_speed_deg

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

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

5.54.4.4 current_pos

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

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

5.54.4.5 handle

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

handle to the vex task that is running the odometry code

5.54.4.6 mut

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

Mutex to control multithreading

5.54.4.7 speed

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

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

5.54.4.8 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:

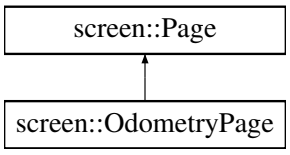
- include/subsystems/odometry/odometry_base.h
- src/subsystems/odometry/odometry_base.cpp

5.55 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

5.55.1 Detailed Description

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

5.55.2 Constructor & Destructor Documentation

5.55.2.1 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

5.55.3 Member Function Documentation

5.55.3.1 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.

5.55.3.2 update()

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

See also

Page::update

Reimplemented from screen::Page.

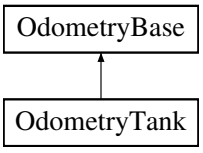
The documentation for this class was generated from the following files:

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

5.56 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

5.56.1 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.

5.56.2 Constructor & Destructor Documentation

5.56.2.1 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().

5.56.2.2 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().

5.56.2.3 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().

5.56.3 Member Function Documentation

5.56.3.1 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.

5.56.3.2 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.

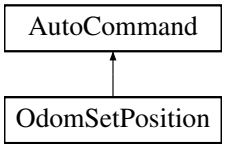
The documentation for this class was generated from the following files:

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

5.57 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

5.57.1 Detailed Description

AutoCommand wrapper class for the set_position function in the Odometry class

5.57.2 Constructor & Destructor Documentation

5.57.2.1 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

5.57.3 Member Function Documentation

5.57.3.1 run()

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

Run set_position Overrides run from AutoCommand

Returns

true when execution is complete, false otherwise

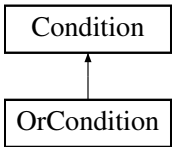
Reimplemented from AutoCommand.

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

5.58 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)

5.58.1 Member Function Documentation

5.58.1.1 test()

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

Implements Condition.

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

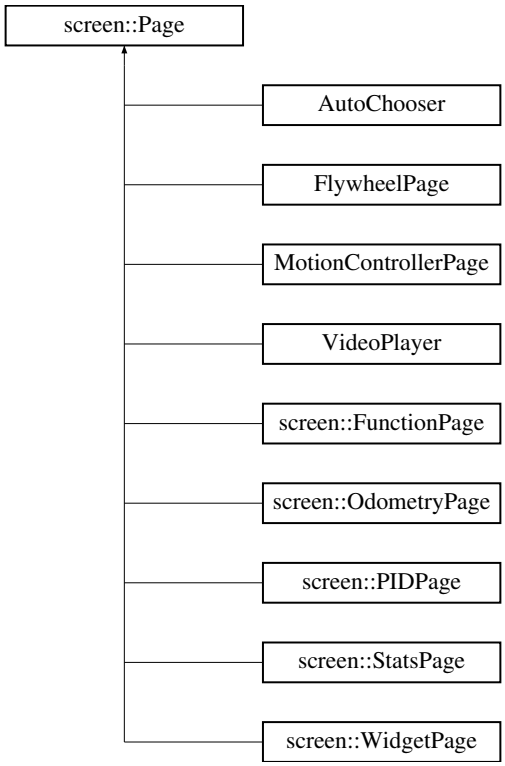
- src/utils/command_structure/auto_command.cpp

5.59 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)

5.59.1 Detailed Description

Page describes one part of the screen slideshow.

5.59.2 Member Function Documentation

5.59.2.1 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, VideoPlayer, and FlywheelPage.

5.59.2.2 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, VideoPlayer, screen::WidgetPage, screen::StatsPage, screen::OdometryPage, screen::FunctionPage, screen::PIDPage, MotionControllerPage, and FlywheelPage.

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

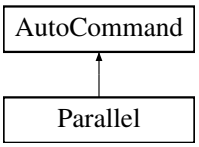
- include/subsystems/screen.h

5.60 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

5.60.1 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.

5.60.2 Member Function Documentation

5.60.2.1 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.

5.60.2.2 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

5.61 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

5.62 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 ()

5.62.1 Detailed Description

Wrapper for a vector of points, checking if any of the points are too close for pure pursuit

5.62.2 Constructor & Destructor Documentation

5.62.2.1 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

5.62.3 Member Function Documentation

5.62.3.1 get_points()

```
std::vector< point_t > PurePursuit::Path::get_points ( )
```

Get the points associated with this Path

5.62.3.2 get_radius()

```
double PurePursuit::Path::get_radius ( )
```

Get the radius associated with this Path

5.62.3.3 is_valid()

```
bool PurePursuit::Path::is_valid ( )
```

Get whether this path will behave as expected

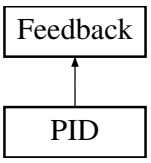
The documentation for this class was generated from the following files:

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

5.63 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

5.63.1 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

5.63.2 Member Enumeration Documentation

5.63.2.1 ERROR_TYPE

```
enum PID::ERROR_TYPE
```

An enum to distinguish between a linear and angular caluclation of PID error.

5.63.3 Constructor & Destructor Documentation

5.63.3.1 PID()

```
PID::PID (
            pid_config_t & config )
```

Create the PID object

Parameters

config	the configuration data for this controller

Create the PID object

5.63.4 Member Function Documentation

5.63.4.1 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.

5.63.4.2 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

5.63.4.3 get_sensor_val()

```
double PID::get_sensor_val ( ) const
```

gets the sensor value that we were last updated with

Returns

sensor_val

5.63.4.4 get_target()

```
double PID::get_target ( ) const
```

Get the PID's target

Returns

the target the PID controller is trying to achieve

5.63.4.5 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.

5.63.4.6 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.

5.63.4.7 reset()

```
void PID::reset ( )
```

Reset the PID loop by resetting time since 0 and accumulated error.

5.63.4.8 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.

5.63.4.9 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

5.63.4.10 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.

5.63.5 Member Data Documentation

5.63.5.1 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

5.64 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

5.64.1 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

5.64.2 Member Data Documentation

5.64.2.1 error_method

```
ERROR_TYPE PID::pid_config_t::error_method
```

Linear or angular. wheter to do error as a simple subtraction or to wrap

5.64.2.2 on_target_time

```
double PID::pid_config_t::on_target_time
```

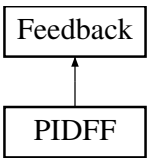
the time in seconds that we have to be on target for to say we are officially at the target

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

- include/utils/controls/pid.h

5.65 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**

5.65.1 Member Function Documentation

5.65.1.1 get()

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

Returns

the last saved result from the feedback controller

Implements Feedback.

5.65.1.2 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.

5.65.1.3 is_on_target()

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

Returns

true if the feedback controller has reached it's setpoint

Implements Feedback.

5.65.1.4 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.

5.65.1.5 set_target()

```
void PIDFF::set_target (
            double set_pt )
```

Set the target of the PID loop

Parameters

set↩ _pt	Setpoint / target value

5.65.1.6 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.

5.65.1.7 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:

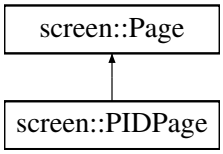
- include/utils/controls/pidff.h
- src/utils/controls/pidff.cpp

5.66 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::string name, 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

5.66.1 Detailed Description

PIDPage provides a way to tune a pid controller on the screen.

5.66.2 Constructor & Destructor Documentation

5.66.2.1 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

5.66.3 Member Function Documentation

5.66.3.1 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.

5.66.3.2 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

5.67 plm_frame_t Struct Reference

Public Attributes

- double **time**
- unsigned int **width**
- unsigned int **height**
- plm_plane_t **y**
- plm_plane_t **cr**
- plm_plane_t **cb**

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

- include/subsystems/fun/pl_mpeg.h

5.68 plm_packet_t Struct Reference

Public Attributes

- int **type**
- double **pts**
- size_t **length**
- uint8_t * **data**

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

- include/subsystems/fun/pl_mpeg.h

5.69 plm_plane_t Struct Reference

Public Attributes

- unsigned int **width**
- unsigned int **height**
- uint8_t * **data**

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

- include/subsystems/fun/pl_mpeg.h

5.70 plm_samples_t Struct Reference

Public Attributes

- double **time**
- unsigned int **count**
- float **interleaved** [PLM_AUDIO_SAMPLES_PER_FRAME *2]

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

- include/subsystems/fun/pl_mpeg.h

5.71 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

5.71.1 Detailed Description

Data structure representing an X,Y coordinate

5.71.2 Member Function Documentation

5.71.2.1 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

5.71.2.2 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)

5.71.2.3 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

5.72 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

5.72.1 Detailed Description

Describes a single position and rotation

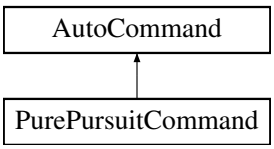
The documentation for this struct was generated from the following file:

- include/utils/geometry.h

5.73 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

5.73.1 Detailed Description

Autocommand wrapper class for pure pursuit function in the TankDrive class

5.73.2 Constructor & Destructor Documentation

5.73.2.1 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)

5.73.3 Member Function Documentation

5.73.3.1 on_timeout()

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

Reset the drive system when it times out

Reimplemented from AutoCommand.

5.73.3.2 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

5.74 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

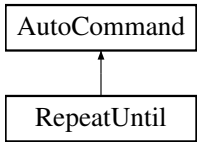
- point_t **min**
- point_t **max**

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

- include/utils/geometry.h

5.75 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

5.75.1 Constructor & Destructor Documentation

5.75.1.1 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

5.75.1.2 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

5.75.2 Member Function Documentation

5.75.2.1 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.

5.75.2.2 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

5.76 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

5.76.1 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

5.77 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**

5.77.1 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

5.78 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

5.79 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

5.79.1 Detailed Description

Serializes Arbitrary data to a file on the SD Card.

5.79.2 Constructor & Destructor Documentation

5.79.2.1 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

5.79.3 Member Function Documentation

5.79.3.1 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

5.79.3.2 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

5.79.3.3 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

5.79.3.4 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

5.79.3.5 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

5.79.3.6 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

5.79.3.7 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

5.79.3.8 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

5.79.3.9 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

5.80 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

5.81 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

5.82 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

5.83 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

5.83.1 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.

5.83.2 Constructor & Destructor Documentation

5.83.2.1 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

5.83.3 Member Function Documentation

5.83.3.1 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

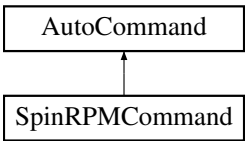
The documentation for this class was generated from the following files:

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

5.84 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

5.84.1 Detailed Description

File: flywheel_commands.h Desc: [insert meaningful desc] AutoCommand wrapper class for the spin_rpm function in the Flywheel class

5.84.2 Constructor & Destructor Documentation

5.84.2.1 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]

5.84.3 Member Function Documentation

5.84.3.1 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

5.85 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**

5.85.1 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

5.86 StateMachine< System, IDType, Message, delay_ms, do_log >::State Struct Reference

`#include <state_machine.h>`

Public Member Functions

- virtual void **entry** (System &)
- virtual MaybeMessage **work** (System &)
- virtual void **exit** (System &)
- virtual State * **respond** (System &s, Message m)=0
- virtual IDType **id** () const =0

5.86.1 Detailed Description

template<typename System, typename IDType, typename Message, int32_t delay_ms, bool do_log = false> struct StateMachine< System, IDType, Message, delay_ms, do_log >::State

Abstract class that all states for this machine must inherit from States MUST override respond() and id() in order to function correctly (the compiler won't have it any other way)

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

- include/utils/state_machine.h

5.87 StateMachine< System, IDType, Message, delay_ms, do_log > Class Template Reference

State Machine :)))))) A fun fun way of controlling stateful subsystems - used in the 2023-2024 Over Under game for our overly complex intake-cata subsystem (see there for an example) The statemachine runs in a background thread and a user thread can interact with it through current_state and send_message.

`#include <state_machine.h>`

Classes

- class MaybeMessage

  MaybeMessage a message of Message type or nothing MaybeMessage m = {}; // empty MaybeMessage m = Message::EnumField1.
- struct State

Public Types

- using **thread_data** = std::pair<State *, StateMachine *>

Public Member Functions

- StateMachine (State *initial)

  Construct a state machine and immediatly start running it.
- IDType current_state () const

  retrieve the current state of the state machine. This is safe to call from external threads
- void send_message (Message msg)

  send a message to the state machine from outside

5.87.1 Detailed Description

template<typename System, typename IDType, typename Message, int32_t delay_ms, bool do_log = false>
class StateMachine< System, IDType, Message, delay_ms, do_log >

State Machine :)))))) A fun fun way of controlling stateful subsystems - used in the 2023-2024 Over Under game for our overly complex intake-cata subsystem (see there for an example) The statemachine runs in a background thread and a user thread can interact with it through current_state and send_message.

Designwise: the System class should hold onto any motors, feedback controllers, etc that are persistent in the system States themselves should hold any data that *only* that state needs. For example if a state should be exitted after a certain amount of time, it should hold a timer rather than the System holding that timer. (see Junder from 2024 for an example of this design)

Template Parameters

System	The system that this is the base class of `class Thing : public StateMachine<Thing> @tparam IDType The ID enum that recognizes states. Hint hint, use an`enum class`
Message	the message enum that a state or an outside can send and that states respond to
delay_ms	the delay to wait between each state processing to allow other threads to work
do_log	true if you want print statements describing incoming messages and current states. If true, it is expected that IDType and Message have a function called to_string that takes them as its only parameter and returns a std::string

5.87.2 Constructor & Destructor Documentation

5.87.2.1 StateMachine()

```
template<typename System , typename IDType , typename Message , int32_t delay_ms, bool do_log
= false>
StateMachine< System, IDType, Message, delay_ms, do_log >::StateMachine (
            State * initial )  [inline]
```

Construct a state machine and immediatly start running it.

Parameters

initial	the state that the machine will begin in

5.87.3 Member Function Documentation

5.87.3.1 current_state()

```
template<typename System , typename IDType , typename Message , int32_t delay_ms, bool do_log
= false>
IDType StateMachine< System, IDType, Message, delay_ms, do_log >::current_state ( ) const
[inline]
```

retrieve the current state of the state machine. This is safe to call from external threads

Returns

the current state

5.87.3.2 send_message()

```
template<typename System , typename IDType , typename Message , int32_t delay_ms, bool do_log
= false>
void StateMachine< System, IDType, Message, delay_ms, do_log >::send_message (
            Message msg )  [inline]
```

send a message to the state machine from outside

Parameters

msg	the message to send This is safe to call from external threads

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

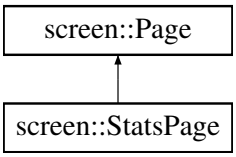
- include/utils/state_machine.h

5.88 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

5.88.1 Detailed Description

Draws motor stats and battery stats to the screen.

5.88.2 Constructor & Destructor Documentation

5.88.2.1 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

5.88.3 Member Function Documentation

5.88.3.1 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.

5.88.3.2 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:

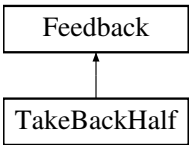
- include/subsystems/screen.h
- src/subsystems/screen.cpp

5.89 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**

5.89.1 Detailed Description

A velocity controller.

Warning

If you try to use this as a position controller, it will fail.

5.89.2 Member Function Documentation

5.89.2.1 get()

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

Returns

the last saved result from the feedback controller

Implements Feedback.

5.89.2.2 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.

5.89.2.3 is_on_target()

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

Returns

true if the feedback controller has reached it's setpoint

Implements Feedback.

5.89.2.4 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.

5.89.2.5 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

5.90 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 * **TurnToPointCmd** (double x, double y, vex::directionType dir=vex::directionType::fwd, 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)
- Condition * **DriveStalledCondition** (double stall_time)
- AutoCommand * **DriveTankCmd** (double left, double right)
- 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)

5.90.1 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

5.90.2 Member Enumeration Documentation

5.90.2.1 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

5.90.3 Constructor & Destructor Documentation

5.90.3.1 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
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

5.90.4 Member Function Documentation

5.90.4.1 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

5.90.4.2 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

5.90.4.3 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

5.90.4.4 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

5.90.4.5 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)

5.90.4.6 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
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

5.90.4.7 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

5.90.4.8 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

5.90.4.9 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

5.90.4.10 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

5.90.4.11 reset_auto()

```
void TankDrive::reset_auto ( )
```

Reset the initialization for autonomous drive functions

5.90.4.12 stop()

```
void TankDrive::stop ( )
```

Stops rotation of all the motors using their "brake mode"

5.90.4.13 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

5.90.4.14 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

5.90.4.15 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

5.90.4.16 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

5.91 screen::TextConfig Struct Reference

Public Attributes

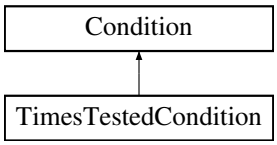
- std::function< std::string()> **text**

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

- include/subsystems/screen.h

5.92 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)

5.92.1 Member Function Documentation

5.92.1.1 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

5.93 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

5.93.1 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

5.94 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

5.94.1 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

5.94.2 Constructor & Destructor Documentation

5.94.2.1 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

5.94.3 Member Function Documentation

5.94.3.1 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

5.94.3.2 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

5.94.3.3 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

5.94.3.4 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

5.94.3.5 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

5.94.3.6 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

5.94.3.7 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

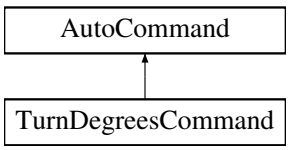
The documentation for this class was generated from the following files:

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

5.95 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

5.95.1 Detailed Description

AutoCommand wrapper class for the turn_degrees function in the TankDrive class

5.95.2 Constructor & Destructor Documentation

5.95.2.1 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

5.95.3 Member Function Documentation

5.95.3.1 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.

5.95.3.2 run()

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

Run turn_degrees Overrides run from AutoCommand

Returns

true when execution is complete, false otherwise

Reimplemented from AutoCommand.

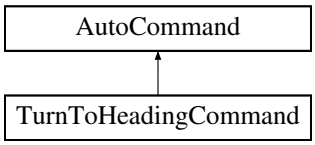
The documentation for this class was generated from the following files:

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

5.96 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

5.96.1 Detailed Description

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

5.96.2 Constructor & Destructor Documentation

5.96.2.1 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

5.96.3 Member Function Documentation

5.96.3.1 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.

5.96.3.2 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

5.97 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)

5.97.1 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

5.97.2 Constructor & Destructor Documentation

5.97.2.1 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.

5.97.2.2 Vector2D() [2/2]

```
Vector2D::Vector2D (
            point_t p )
```

Construct a vector object from a cartesian point.

Parameters

p	point_t.x , point_t.y

5.97.3 Member Function Documentation

5.97.3.1 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.

5.97.3.2 get_mag()

```
double Vector2D::get_mag ( ) const
```

Returns

the magnitude of the vector

Get the magnitude of the vector

5.97.3.3 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.

5.97.3.4 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.

5.97.3.5 normalize()

```
Vector2D Vector2D::normalize ( )
```

Changes the magnitude of the vector to 1

Returns

the normalized vector

Changes the magnetude of the vector to 1

5.97.3.6 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

5.97.3.7 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

5.97.3.8 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

5.97.3.9 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

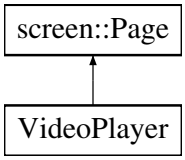
the x, y representation of the vector

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

- include/utils/vector2d.h
- src/utils/vector2d.cpp

5.98 VideoPlayer Class Reference

Inheritance diagram for VideoPlayer:



Public Member Functions

- 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) override

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

5.98.1 Member Function Documentation

5.98.1.1 draw()

```
void VideoPlayer::draw (
            vex::brain::lcd & screen,
            bool first_draw,
            unsigned int frame_number )  [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.

5.98.1.2 update()

```
void VideoPlayer::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 files:

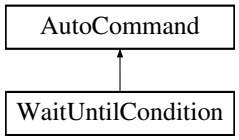
- include/subsystems/fun/video.h
- src/subsystems/fun/video.cpp

5.99 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

5.99.1 Detailed Description

Waits until the condition is true.

5.99.2 Member Function Documentation

5.99.2.1 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.

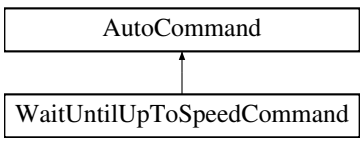
The documentation for this class was generated from the following file:

- include/utils/command_structure/auto_command.h

5.100 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

5.100.1 Detailed Description

AutoCommand that listens to the Flywheel and waits until it is at its target speed +/- the specified threshold

5.100.2 Constructor & Destructor Documentation

5.100.2.1 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

5.100.3 Member Function Documentation

5.100.3.1 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

5.101 screen::WidgetConfig Struct Reference

Public Types

- enum **Type** {
  Col , **Row** , **Slider** , **Button** ,
  Checkbox , **Label** , **Text** , **Graph** }

Public Attributes

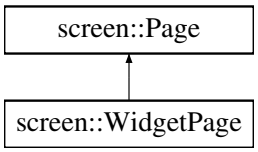
- Type **type**
- union {
  std::vector< SizedWidget > **widgets**
  SliderConfig **slider**
  ButtonConfig **button**
  CheckboxConfig **checkbox**
  LabelConfig **label**
  TextConfig **text**
  GraphDrawer * **graph**
  } **config**

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

- include/subsystems/screen.h

5.102 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)

5.102.1 Member Function Documentation

5.102.1.1 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.

5.102.1.2 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 pl_mpeg.h

```
00001 #include "vex.h"
00002 /*
00003 PL_MPEG - MPEG1 Video decoder, MP2 Audio decoder, MPEG-PS demuxer
00004
00005 Dominic Szablewski - https://phoboslab.org
00006
00007
```

```
00008 -- LICENSE: The MIT License(MIT)
00009
00010 Copyright(c) 2019 Dominic Szablewski
00011
00012 Permission is hereby granted, free of charge, to any person obtaining a copy of
00013 this software and associated documentation files(the "Software"), to deal in
00014 the Software without restriction, including without limitation the rights to
00015 use, copy, modify, merge, publish, distribute, sublicense, and / or sell copies
00016 of the Software, and to permit persons to whom the Software is furnished to do
00017 so, subject to the following conditions :
00018 The above copyright notice and this permission notice shall be included in all
00019 copies or substantial portions of the Software.
00020 THE SOFTWARE IS PROVIDED "AS IS", WITHOUT WARRANTY OF ANY KIND, EXPRESS OR
00021 IMPLIED, INCLUDING BUT NOT LIMITED TO THE WARRANTIES OF MERCHANTABILITY,
00022 FITNESS FOR A PARTICULAR PURPOSE AND NONINFRINGEMENT.IN NO EVENT SHALL THE
00023 AUTHORS OR COPYRIGHT HOLDERS BE LIABLE FOR ANY CLAIM, DAMAGES OR OTHER
00024 LIABILITY, WHETHER IN AN ACTION OF CONTRACT, TORT OR OTHERWISE, ARISING FROM,
00025 OUT OF OR IN CONNECTION WITH THE SOFTWARE OR THE USE OR OTHER DEALINGS IN THE
00026 SOFTWARE.
00027
00028
00029
00030
00031 -- Synopsis
00032
00033 // Define `PL_MPEG_IMPLEMENTATION` in *one* C/C++ file before including this
00034 // library to create the implementation.
00035
00036 #define PL_MPEG_IMPLEMENTATION
00037 #include "plmpeg.h"
00038
00039 // This function gets called for each decoded video frame
00040 void my_video_callback(plm_t *plm, plm_frame_t *frame, void *user) {
00041     // Do something with frame->y.data, frame->cr.data, frame->cb.data
00042 }
00043
00044 // This function gets called for each decoded audio frame
00045 void my_audio_callback(plm_t *plm, plm_samples_t *frame, void *user) {
00046     // Do something with samples->interleaved
00047 }
00048
00049 // Load a .mpg (MPEG Program Stream) file
00050 plm_t *plm = plm_create_with_filename("some-file.mpg");
00051
00052 // Install the video & audio decode callbacks
00053 plm_set_video_decode_callback(plm, my_video_callback, my_data);
00054 plm_set_audio_decode_callback(plm, my_audio_callback, my_data);
00055
00056
00057 // Decode
00058 do {
00059     plm_decode(plm, time_since_last_call);
00060 } while (!plm_has_ended(plm));
00061
00062 // All done
00063 plm_destroy(plm);
00064
00065
00066
00067 -- Documentation
00068
00069 This library provides several interfaces to load, demux and decode MPEG video
00070 and audio data. A high-level API combines the demuxer, video & audio decoders
00071 in an easy to use wrapper.
00072
00073 Lower-level APIs for accessing the demuxer, video decoder and audio decoder,
00074 as well as providing different data sources are also available.
00075
00076 Interfaces are written in an object oriented style, meaning you create object
00077 instances via various different constructor functions (plm_*create()),
00078 do some work on them and later dispose them via plm_*destroy().
00079
00080 plm_* ......... the high-level interface, combining demuxer and decoders
00081 plm_buffer_* .. the data source used by all interfaces
00082 plm_demux_* ... the MPEG-PS demuxer
00083 plm_video_* ... the MPEG1 Video ("mpeg1") decoder
00084 plm_audio_* ... the MPEG1 Audio Layer II ("mp2") decoder
00085
00086
00087 With the high-level interface you have two options to decode video & audio:
00088
00089  1. Use plm_decode() and just hand over the delta time since the last call.
00090     It will decode everything needed and call your callbacks (specified through
00091     plm_set_{video|audio}_decode_callback()) any number of times.
00092
00093  2. Use plm_decode_video() and plm_decode_audio() to decode exactly one
00094     frame of video or audio data at a time. How you handle the synchronization
```

```
00095     of both streams is up to you.
00096
00097 If you only want to decode video *or* audio through these functions, you should
00098 disable the other stream (plm_set_{video|audio}_enabled(FALSE))
00099
00100 Video data is decoded into a struct with all 3 planes (Y, Cr, Cb) stored in
00101 separate buffers. You can either convert this to RGB on the CPU (slow) via the
00102 plm_frame_to_rgb() function or do it on the GPU with the following matrix:
00103
00104 mat4 bt601 = mat4(
00105     1.16438,  0.00000,  1.59603, -0.87079,
00106     1.16438, -0.39176, -0.81297,  0.52959,
00107     1.16438,  2.01723,  0.00000, -1.08139,
00108     0, 0, 0, 1
00109 );
00110 gl_FragColor = vec4(y, cb, cr, 1.0) * bt601;
00111
00112 Audio data is decoded into a struct with either one single float array with the
00113 samples for the left and right channel interleaved, or if the
00114 PLM_AUDIO_SEPARATE_CHANNELS is defined *before* including this library, into
00115 two separate float arrays - one for each channel.
00116
00117
00118 Data can be supplied to the high level interface, the demuxer and the decoders
00119 in three different ways:
00120
00121  1. Using plm_create_from_filename() or with a file handle with
00122     plm_create_from_file().
00123
00124  2. Using plm_create_with_memory() and supplying a pointer to memory that
00125     contains the whole file.
00126
00127  3. Using plm_create_with_buffer(), supplying your own plm_buffer_t instance and
00128     periodically writing to this buffer.
00129
00130 When using your own plm_buffer_t instance, you can fill this buffer using
00131 plm_buffer_write(). You can either monitor plm_buffer_get_remaining() and push
00132 data when appropriate, or install a callback on the buffer with
00133 plm_buffer_set_load_callback() that gets called whenever the buffer needs more
00134 data.
00135
00136 A buffer created with plm_buffer_create_with_capacity() is treated as a ring
00137 buffer, meaning that data that has already been read, will be discarded. In
00138 contrast, a buffer created with plm_buffer_create_for_appending() will keep all
00139 data written to it in memory. This enables seeking in the already loaded data.
00140
00141
00142 There should be no need to use the lower level plm_demux_*, plm_video_* and
00143 plm_audio_* functions, if all you want to do is read/decode an MPEG-PS file.
00144 However, if you get raw mpeg1video data or raw mp2 audio data from a different
00145 source, these functions can be used to decode the raw data directly. Similarly,
00146 if you only want to analyze an MPEG-PS file or extract raw video or audio
00147 packets from it, you can use the plm_demux_* functions.
00148
00149
00150 This library uses malloc(), realloc() and free() to manage memory. Typically
00151 all allocation happens up-front when creating the interface. However, the
00152 default buffer size may be too small for certain inputs. In these cases plmpeg
00153 will realloc() the buffer with a larger size whenever needed. You can configure
00154 the default buffer size by defining PLM_BUFFER_DEFAULT_SIZE *before*
00155 including this library.
00156
00157 You can also define PLM_MALLOC, PLM_REALLOC and PLM_FREE to provide your own
00158 memory management functions.
00159
00160
00161 See below for detailed the API documentation.
00162
00163 */
00164
00165
00166 #ifndef PL_MPEG_H
00167 #define PL_MPEG_H
00168
00169 #include <stdint.h>
00170 // #include <stdio.h>
00171
00172
00173 #ifdef __cplusplus
00174 extern "C" {
00175 #endif
00176
00177 // -----------------------------------------------------------------------------
00178 // Public Data Types
00179
00180
00181 // Object types for the various interfaces
```

```
00182
00183 typedef struct plm_t plm_t;
00184 typedef struct plm_buffer_t plm_buffer_t;
00185 typedef struct plm_demux_t plm_demux_t;
00186 typedef struct plm_video_t plm_video_t;
00187 typedef struct plm_audio_t plm_audio_t;
00188
00189
00190 // Demuxed MPEG PS packet
00191 // The type maps directly to the various MPEG-PES start codes. PTS is the
00192 // presentation time stamp of the packet in seconds. Note that not all packets
00193 // have a PTS value, indicated by PLM_PACKET_INVALID_TS.
00194
00195 #define PLM_PACKET_INVALID_TS -1
00196
00197 typedef struct {
00198     int type;
00199     double pts;
00200     size_t length;
00201     uint8_t *data;
00202 } plm_packet_t;
00203
00204
00205 // Decoded Video Plane
00206 // The byte length of the data is width * height. Note that different planes
00207 // have different sizes: the Luma plane (Y) is double the size of each of
00208 // the two Chroma planes (Cr, Cb) - i.e. 4 times the byte length.
00209 // Also note that the size of the plane does *not* denote the size of the
00210 // displayed frame. The sizes of planes are always rounded up to the nearest
00211 // macroblock (16px).
00212
00213 typedef struct {
00214     unsigned int width;
00215     unsigned int height;
00216     uint8_t *data;
00217 } plm_plane_t;
00218
00219
00220 // Decoded Video Frame
00221 // width and height denote the desired display size of the frame. This may be
00222 // different from the internal size of the 3 planes.
00223
00224 typedef struct {
00225     double time;
00226     unsigned int width;
00227     unsigned int height;
00228     plm_plane_t y;
00229     plm_plane_t cr;
00230     plm_plane_t cb;
00231 } plm_frame_t;
00232
00233
00234 // Callback function type for decoded video frames used by the high-level
00235 // plm_* interface
00236
00237 typedef void(*plm_video_decode_callback)
00238     (plm_t *self, plm_frame_t *frame, void *user);
00239
00240
00241 // Decoded Audio Samples
00242 // Samples are stored as normalized (-1, 1) float either interleaved, or if
00243 // PLM_AUDIO_SEPARATE_CHANNELS is defined, in two separate arrays.
00244 // The `count` is always PLM_AUDIO_SAMPLES_PER_FRAME and just there for
00245 // convenience.
00246
00247 #define PLM_AUDIO_SAMPLES_PER_FRAME 1152
00248
00249 typedef struct {
00250     double time;
00251     unsigned int count;
00252     #ifdef PLM_AUDIO_SEPARATE_CHANNELS
00253         float left[PLM_AUDIO_SAMPLES_PER_FRAME];
00254         float right[PLM_AUDIO_SAMPLES_PER_FRAME];
00255     #else
00256         float interleaved[PLM_AUDIO_SAMPLES_PER_FRAME * 2];
00257     #endif
00258 } plm_samples_t;
00259
00260
00261 // Callback function type for decoded audio samples used by the high-level
00262 // plm_* interface
00263
00264 typedef void(*plm_audio_decode_callback)
00265     (plm_t *self, plm_samples_t *samples, void *user);
00266
00267
00268 // Callback function for plm_buffer when it needs more data
```

```
00269
00270 typedef void(*plm_buffer_load_callback)(plm_buffer_t *self, void *user);
00271
00272
00273
00274 // -----------------------------------------------------------------------------
00275 // plm_* public API
00276 // High-Level API for loading/demuxing/decoding MPEG-PS data
00277
00278
00279 // Create a plmpeg instance with a filename. Returns NULL if the file could not
00280 // be opened.
00281
00282 plm_t *plm_create_with_filename(const char *filename);
00283
00284
00285 // Create a plmpeg instance with a file handle. Pass TRUE to close_when_done to
00286 // let plmpeg call fclose() on the handle when plm_destroy() is called.
00287
00288 plm_t *plm_create_with_file(FIL *fh, int close_when_done);
00289
00290
00291 // Create a plmpeg instance with a pointer to memory as source. This assumes the
00292 // whole file is in memory. The memory is not copied. Pass TRUE to
00293 // free_when_done to let plmpeg call free() on the pointer when plm_destroy()
00294 // is called.
00295
00296 plm_t *plm_create_with_memory(uint8_t *bytes, size_t length, int free_when_done);
00297
00298
00299 // Create a plmpeg instance with a plm_buffer as source. Pass TRUE to
00300 // destroy_when_done to let plmpeg call plm_buffer_destroy() on the buffer when
00301 // plm_destroy() is called.
00302
00303 plm_t *plm_create_with_buffer(plm_buffer_t *buffer, int destroy_when_done);
00304
00305
00306 // Destroy a plmpeg instance and free all data.
00307
00308 void plm_destroy(plm_t *self);
00309
00310
00311 // Get whether we have headers on all available streams and we can accurately
00312 // report the number of video/audio streams, video dimensions, framerate and
00313 // audio samplerate.
00314 // This returns FALSE if the file is not an MPEG-PS file or - when not using a
00315 // file as source - when not enough data is available yet.
00316
00317 int plm_has_headers(plm_t *self);
00318
00319
00320 // Get or set whether video decoding is enabled. Default TRUE.
00321
00322 int plm_get_video_enabled(plm_t *self);
00323 void plm_set_video_enabled(plm_t *self, int enabled);
00324
00325
00326 // Get the number of video streams (0--1) reported in the system header.
00327
00328 int plm_get_num_video_streams(plm_t *self);
00329
00330
00331 // Get the display width/height of the video stream.
00332
00333 int plm_get_width(plm_t *self);
00334 int plm_get_height(plm_t *self);
00335
00336
00337 // Get the framerate of the video stream in frames per second.
00338
00339 double plm_get_framerate(plm_t *self);
00340
00341
00342 // Get or set whether audio decoding is enabled. Default TRUE.
00343
00344 int plm_get_audio_enabled(plm_t *self);
00345 void plm_set_audio_enabled(plm_t *self, int enabled);
00346
00347
00348 // Get the number of audio streams (0--4) reported in the system header.
00349
00350 int plm_get_num_audio_streams(plm_t *self);
00351
00352
00353 // Set the desired audio stream (0--3). Default 0.
00354
00355 void plm_set_audio_stream(plm_t *self, int stream_index);
```

```
00356
00357
00358 // Get the samplerate of the audio stream in samples per second.
00359
00360 int plm_get_samplerate(plm_t *self);
00361
00362
00363 // Get or set the audio lead time in seconds - the time in which audio samples
00364 // are decoded in advance (or behind) the video decode time. Typically this
00365 // should be set to the duration of the buffer of the audio API that you use
00366 // for output. E.g. for SDL2: (SDL_AudioSpec.samples / samplerate)
00367
00368 double plm_get_audio_lead_time(plm_t *self);
00369 void plm_set_audio_lead_time(plm_t *self, double lead_time);
00370
00371
00372 // Get the current internal time in seconds.
00373
00374 double plm_get_time(plm_t *self);
00375
00376
00377 // Get the video duration of the underlying source in seconds.
00378
00379 double plm_get_duration(plm_t *self);
00380
00381
00382 // Rewind all buffers back to the beginning.
00383
00384 void plm_rewind(plm_t *self);
00385
00386
00387 // Get or set looping. Default FALSE.
00388
00389 int plm_get_loop(plm_t *self);
00390 void plm_set_loop(plm_t *self, int loop);
00391
00392
00393 // Get whether the file has ended. If looping is enabled, this will always
00394 // return FALSE.
00395
00396 int plm_has_ended(plm_t *self);
00397
00398
00399 // Set the callback for decoded video frames used with plm_decode(). If no
00400 // callback is set, video data will be ignored and not be decoded. The *user
00401 // Parameter will be passed to your callback.
00402
00403 void plm_set_video_decode_callback(plm_t *self, plm_video_decode_callback fp, void *user);
00404
00405
00406 // Set the callback for decoded audio samples used with plm_decode(). If no
00407 // callback is set, audio data will be ignored and not be decoded. The *user
00408 // Parameter will be passed to your callback.
00409
00410 void plm_set_audio_decode_callback(plm_t *self, plm_audio_decode_callback fp, void *user);
00411
00412
00413 // Advance the internal timer by seconds and decode video/audio up to this time.
00414 // This will call the video_decode_callback and audio_decode_callback any number
00415 // of times. A frame-skip is not implemented, i.e. everything up to current time
00416 // will be decoded.
00417
00418 void plm_decode(plm_t *self, double seconds);
00419
00420
00421 // Decode and return one video frame. Returns NULL if no frame could be decoded
00422 // (either because the source ended or data is corrupt). If you only want to
00423 // decode video, you should disable audio via plm_set_audio_enabled().
00424 // The returned plm_frame_t is valid until the next call to plm_decode_video()
00425 // or until plm_destroy() is called.
00426
00427 plm_frame_t *plm_decode_video(plm_t *self);
00428
00429
00430 // Decode and return one audio frame. Returns NULL if no frame could be decoded
00431 // (either because the source ended or data is corrupt). If you only want to
00432 // decode audio, you should disable video via plm_set_video_enabled().
00433 // The returned plm_samples_t is valid until the next call to plm_decode_audio()
00434 // or until plm_destroy() is called.
00435
00436 plm_samples_t *plm_decode_audio(plm_t *self);
00437
00438
00439 // Seek to the specified time, clamped between 0 -- duration. This can only be
00440 // used when the underlying plm_buffer is seekable, i.e. for files, fixed
00441 // memory buffers or _for_appending buffers.
00442 // If seek_exact is TRUE this will seek to the exact time, otherwise it will
```

```
00443 // seek to the last intra frame just before the desired time. Exact seeking can
00444 // be slow, because all frames up to the seeked one have to be decoded on top of
00445 // the previous intra frame.
00446 // If seeking succeeds, this function will call the video_decode_callback
00447 // exactly once with the target frame. If audio is enabled, it will also call
00448 // the audio_decode_callback any number of times, until the audio_lead_time is
00449 // satisfied.
00450 // Returns TRUE if seeking succeeded or FALSE if no frame could be found.
00451
00452 int plm_seek(plm_t *self, double time, int seek_exact);
00453
00454
00455 // Similar to plm_seek(), but will not call the video_decode_callback,
00456 // audio_decode_callback or make any attempts to sync audio.
00457 // Returns the found frame or NULL if no frame could be found.
00458
00459 plm_frame_t *plm_seek_frame(plm_t *self, double time, int seek_exact);
00460
00461
00462
00463 // -----------------------------------------------------------------------------
00464 // plm_buffer public API
00465 // Provides the data source for all other plm_* interfaces
00466
00467
00468 // The default size for buffers created from files or by the high-level API
00469
00470 #ifndef PLM_BUFFER_DEFAULT_SIZE
00471 #define PLM_BUFFER_DEFAULT_SIZE (128 * 1024)
00472 #endif
00473
00474
00475 // Create a buffer instance with a filename. Returns NULL if the file could not
00476 // be opened.
00477
00478 plm_buffer_t *plm_buffer_create_with_filename(const char *filename);
00479
00480
00481 // Create a buffer instance with a file handle. Pass TRUE to close_when_done
00482 // to let plmpeg call fclose() on the handle when plm_destroy() is called.
00483
00484 plm_buffer_t *plm_buffer_create_with_file(FIL *fh, int close_when_done);
00485
00486
00487 // Create a buffer instance with a pointer to memory as source. This assumes
00488 // the whole file is in memory. The bytes are not copied. Pass 1 to
00489 // free_when_done to let plmpeg call free() on the pointer when plm_destroy()
00490 // is called.
00491
00492 plm_buffer_t *plm_buffer_create_with_memory(uint8_t *bytes, size_t length, int free_when_done);
00493
00494
00495 // Create an empty buffer with an initial capacity. The buffer will grow
00496 // as needed. Data that has already been read, will be discarded.
00497
00498 plm_buffer_t *plm_buffer_create_with_capacity(size_t capacity);
00499
00500
00501 // Create an empty buffer with an initial capacity. The buffer will grow
00502 // as needed. Decoded data will *not* be discarded. This can be used when
00503 // loading a file over the network, without needing to throttle the download.
00504 // It also allows for seeking in the already loaded data.
00505
00506 plm_buffer_t *plm_buffer_create_for_appending(size_t initial_capacity);
00507
00508
00509 // Destroy a buffer instance and free all data
00510
00511 void plm_buffer_destroy(plm_buffer_t *self);
00512
00513
00514 // Copy data into the buffer. If the data to be written is larger than the
00515 // available space, the buffer will realloc() with a larger capacity.
00516 // Returns the number of bytes written. This will always be the same as the
00517 // passed in length, except when the buffer was created _with_memory() for
00518 // which _write() is forbidden.
00519
00520 size_t plm_buffer_write(plm_buffer_t *self, uint8_t *bytes, size_t length);
00521
00522
00523 // Mark the current byte length as the end of this buffer and signal that no
00524 // more data is expected to be written to it. This function should be called
00525 // just after the last plm_buffer_write().
00526 // For _with_capacity buffers, this is cleared on a plm_buffer_rewind().
00527
00528 void plm_buffer_signal_end(plm_buffer_t *self);
00529
```

```
00530
00531 // Set a callback that is called whenever the buffer needs more data
00532
00533 void plm_buffer_set_load_callback(plm_buffer_t *self, plm_buffer_load_callback fp, void *user);
00534
00535
00536 // Rewind the buffer back to the beginning. When loading from a file handle,
00537 // this also seeks to the beginning of the file.
00538
00539 void plm_buffer_rewind(plm_buffer_t *self);
00540
00541
00542 // Get the total size. For files, this returns the file size. For all other
00543 // types it returns the number of bytes currently in the buffer.
00544
00545 size_t plm_buffer_get_size(plm_buffer_t *self);
00546
00547
00548 // Get the number of remaining (yet unread) bytes in the buffer. This can be
00549 // useful to throttle writing.
00550
00551 size_t plm_buffer_get_remaining(plm_buffer_t *self);
00552
00553
00554 // Get whether the read position of the buffer is at the end and no more data
00555 // is expected.
00556
00557 int plm_buffer_has_ended(plm_buffer_t *self);
00558
00559
00560
00561 // -----------------------------------------------------------------------------
00562 // plm_demux public API
00563 // Demux an MPEG Program Stream (PS) data into separate packages
00564
00565
00566 // Various Packet Types
00567
00568 static const int PLM_DEMUX_PACKET_PRIVATE = 0xBD;
00569 static const int PLM_DEMUX_PACKET_AUDIO_1 = 0xC0;
00570 static const int PLM_DEMUX_PACKET_AUDIO_2 = 0xC1;
00571 static const int PLM_DEMUX_PACKET_AUDIO_3 = 0xC2;
00572 static const int PLM_DEMUX_PACKET_AUDIO_4 = 0xC2;
00573 static const int PLM_DEMUX_PACKET_VIDEO_1 = 0xE0;
00574
00575
00576 // Create a demuxer with a plm_buffer as source. This will also attempt to read
00577 // the pack and system headers from the buffer.
00578
00579 plm_demux_t *plm_demux_create(plm_buffer_t *buffer, int destroy_when_done);
00580
00581
00582 // Destroy a demuxer and free all data.
00583
00584 void plm_demux_destroy(plm_demux_t *self);
00585
00586
00587 // Returns TRUE/FALSE whether pack and system headers have been found. This will
00588 // attempt to read the headers if non are present yet.
00589
00590 int plm_demux_has_headers(plm_demux_t *self);
00591
00592
00593 // Returns the number of video streams found in the system header. This will
00594 // attempt to read the system header if non is present yet.
00595
00596 int plm_demux_get_num_video_streams(plm_demux_t *self);
00597
00598
00599 // Returns the number of audio streams found in the system header. This will
00600 // attempt to read the system header if non is present yet.
00601
00602 int plm_demux_get_num_audio_streams(plm_demux_t *self);
00603
00604
00605 // Rewind the internal buffer. See plm_buffer_rewind().
00606
00607 void plm_demux_rewind(plm_demux_t *self);
00608
00609
00610 // Get whether the file has ended. This will be cleared on seeking or rewind.
00611
00612 int plm_demux_has_ended(plm_demux_t *self);
00613
00614
00615 // Seek to a packet of the specified type with a PTS just before specified time.
00616 // If force_intra is TRUE, only packets containing an intra frame will be
```

```
00617 // considered - this only makes sense when the type is PLM_DEMUX_PACKET_VIDEO_1.
00618 // Note that the specified time is considered 0-based, regardless of the first
00619 // PTS in the data source.
00620
00621 plm_packet_t *plm_demux_seek(plm_demux_t *self, double time, int type, int force_intra);
00622
00623
00624 // Get the PTS of the first packet of this type. Returns PLM_PACKET_INVALID_TS
00625 // if not packet of this packet type can be found.
00626
00627 double plm_demux_get_start_time(plm_demux_t *self, int type);
00628
00629
00630 // Get the duration for the specified packet type - i.e. the span between the
00631 // the first PTS and the last PTS in the data source. This only makes sense when
00632 // the underlying data source is a file or fixed memory.
00633
00634 double plm_demux_get_duration(plm_demux_t *self, int type);
00635
00636
00637 // Decode and return the next packet. The returned packet_t is valid until
00638 // the next call to plm_demux_decode() or until the demuxer is destroyed.
00639
00640 plm_packet_t *plm_demux_decode(plm_demux_t *self);
00641
00642
00643
00644 // -----------------------------------------------------------------------------
00645 // plm_video public API
00646 // Decode MPEG1 Video ("mpeg1") data into raw YCrCb frames
00647
00648
00649 // Create a video decoder with a plm_buffer as source.
00650
00651 plm_video_t *plm_video_create_with_buffer(plm_buffer_t *buffer, int destroy_when_done);
00652
00653
00654 // Destroy a video decoder and free all data.
00655
00656 void plm_video_destroy(plm_video_t *self);
00657
00658
00659 // Get whether a sequence header was found and we can accurately report on
00660 // dimensions and framerate.
00661
00662 int plm_video_has_header(plm_video_t *self);
00663
00664
00665 // Get the framerate in frames per second.
00666
00667 double plm_video_get_framerate(plm_video_t *self);
00668
00669
00670 // Get the display width/height.
00671
00672 int plm_video_get_width(plm_video_t *self);
00673 int plm_video_get_height(plm_video_t *self);
00674
00675
00676 // Set "no delay" mode. When enabled, the decoder assumes that the video does
00677 // *not* contain any B-Frames. This is useful for reducing lag when streaming.
00678 // The default is FALSE.
00679
00680 void plm_video_set_no_delay(plm_video_t *self, int no_delay);
00681
00682
00683 // Get the current internal time in seconds.
00684
00685 double plm_video_get_time(plm_video_t *self);
00686
00687
00688 // Set the current internal time in seconds. This is only useful when you
00689 // manipulate the underlying video buffer and want to enforce a correct
00690 // timestamps.
00691
00692 void plm_video_set_time(plm_video_t *self, double time);
00693
00694
00695 // Rewind the internal buffer. See plm_buffer_rewind().
00696
00697 void plm_video_rewind(plm_video_t *self);
00698
00699
00700 // Get whether the file has ended. This will be cleared on rewind.
00701
00702 int plm_video_has_ended(plm_video_t *self);
00703
```

```
00704
00705 // Decode and return one frame of video and advance the internal time by
00706 // 1/framerate seconds. The returned frame_t is valid until the next call of
00707 // plm_video_decode() or until the video decoder is destroyed.
00708
00709 plm_frame_t *plm_video_decode(plm_video_t *self);
00710
00711
00712 // Convert the YCrCb data of a frame into interleaved R G B data. The stride
00713 // specifies the width in bytes of the destination buffer. I.e. the number of
00714 // bytes from one line to the next. The stride must be at least
00715 // (frame->width * bytes_per_pixel). The buffer pointed to by *dest must have a
00716 // size of at least (stride * frame->height).
00717 // Note that the alpha component of the dest buffer is always left untouched.
00718
00719 void plm_frame_to_rgb(plm_frame_t *frame, uint8_t *dest, int stride);
00720 void plm_frame_to_bgr(plm_frame_t *frame, uint8_t *dest, int stride);
00721 void plm_frame_to_rgba(plm_frame_t *frame, uint8_t *dest, int stride);
00722 void plm_frame_to_bgra(plm_frame_t *frame, uint8_t *dest, int stride);
00723 void plm_frame_to_argb(plm_frame_t *frame, uint8_t *dest, int stride);
00724 void plm_frame_to_abgr(plm_frame_t *frame, uint8_t *dest, int stride);
00725
00726
00727 // -----------------------------------------------------------------------------
00728 // plm_audio public API
00729 // Decode MPEG-1 Audio Layer II ("mp2") data into raw samples
00730
00731
00732 // Create an audio decoder with a plm_buffer as source.
00733
00734 plm_audio_t *plm_audio_create_with_buffer(plm_buffer_t *buffer, int destroy_when_done);
00735
00736
00737 // Destroy an audio decoder and free all data.
00738
00739 void plm_audio_destroy(plm_audio_t *self);
00740
00741
00742 // Get whether a frame header was found and we can accurately report on
00743 // samplerate.
00744
00745 int plm_audio_has_header(plm_audio_t *self);
00746
00747
00748 // Get the samplerate in samples per second.
00749
00750 int plm_audio_get_samplerate(plm_audio_t *self);
00751
00752
00753 // Get the current internal time in seconds.
00754
00755 double plm_audio_get_time(plm_audio_t *self);
00756
00757
00758 // Set the current internal time in seconds. This is only useful when you
00759 // manipulate the underlying video buffer and want to enforce a correct
00760 // timestamps.
00761
00762 void plm_audio_set_time(plm_audio_t *self, double time);
00763
00764
00765 // Rewind the internal buffer. See plm_buffer_rewind().
00766
00767 void plm_audio_rewind(plm_audio_t *self);
00768
00769
00770 // Get whether the file has ended. This will be cleared on rewind.
00771
00772 int plm_audio_has_ended(plm_audio_t *self);
00773
00774
00775 // Decode and return one "frame" of audio and advance the internal time by
00776 // (PLM_AUDIO_SAMPLES_PER_FRAME/samplerate) seconds. The returned samples_t
00777 // is valid until the next call of plm_audio_decode() or until the audio
00778 // decoder is destroyed.
00779
00780 plm_samples_t *plm_audio_decode(plm_audio_t *self);
00781
00782
00783
00784 #ifdef __cplusplus
00785 }
00786 #endif
00787
00788 #endif // PL_MPEG_H
00789
00790
```

```
00791
00792
00793
00794 // -----------------------------------------------------------------------------
00795 // -----------------------------------------------------------------------------
00796 // IMPLEMENTATION
00797
00798 #ifdef PL_MPEG_IMPLEMENTATION
00799
00800 #include <string.h>
00801 #include <stdlib.h>
00802
00803 #ifndef TRUE
00804 #define TRUE 1
00805 #define FALSE 0
00806 #endif
00807
00808 #ifndef PLM_MALLOC
00809     #define PLM_MALLOC(sz) malloc(sz)
00810     #define PLM_FREE(p) free(p)
00811     #define PLM_REALLOC(p, sz) realloc(p, sz)
00812 #endif
00813
00814 #define PLM_UNUSED(expr) (void)(expr)
00815
00816
00817 // -----------------------------------------------------------------------------
00818 // plm (high-level interface) implementation
00819
00820 struct plm_t {
00821     plm_demux_t *demux;
00822     double time;
00823     int has_ended;
00824     int loop;
00825     int has_decoders;
00826
00827     int video_enabled;
00828     int video_packet_type;
00829     plm_buffer_t *video_buffer;
00830     plm_video_t *video_decoder;
00831
00832     int audio_enabled;
00833     int audio_stream_index;
00834     int audio_packet_type;
00835     double audio_lead_time;
00836     plm_buffer_t *audio_buffer;
00837     plm_audio_t *audio_decoder;
00838
00839     plm_video_decode_callback video_decode_callback;
00840     void *video_decode_callback_user_data;
00841
00842     plm_audio_decode_callback audio_decode_callback;
00843     void *audio_decode_callback_user_data;
00844 };
00845
00846 int plm_init_decoders(plm_t *self);
00847 void plm_handle_end(plm_t *self);
00848 void plm_read_video_packet(plm_buffer_t *buffer, void *user);
00849 void plm_read_audio_packet(plm_buffer_t *buffer, void *user);
00850 void plm_read_packets(plm_t *self, int requested_type);
00851
00852 plm_t *plm_create_with_filename(const char *filename) {
00853     plm_buffer_t *buffer = plm_buffer_create_with_filename(filename);
00854     if (!buffer) {
00855         return NULL;
00856     }
00857     return plm_create_with_buffer(buffer, TRUE);
00858 }
00859
00860 plm_t *plm_create_with_file(FIL *fh, int close_when_done) {
00861     plm_buffer_t *buffer = plm_buffer_create_with_file(fh, close_when_done);
00862     return plm_create_with_buffer(buffer, TRUE);
00863 }
00864
00865 plm_t *plm_create_with_memory(uint8_t *bytes, size_t length, int free_when_done) {
00866     plm_buffer_t *buffer = plm_buffer_create_with_memory(bytes, length, free_when_done);
00867     return plm_create_with_buffer(buffer, TRUE);
00868 }
00869
00870 plm_t *plm_create_with_buffer(plm_buffer_t *buffer, int destroy_when_done) {
00871     plm_t *self = (plm_t *)PLM_MALLOC(sizeof(plm_t));
00872     memset(self, 0, sizeof(plm_t));
00873
00874     self->demux = plm_demux_create(buffer, destroy_when_done);
00875     self->video_enabled = TRUE;
00876     self->audio_enabled = TRUE;
00877     plm_init_decoders(self);
```

```
00878
00879     return self;
00880 }
00881
00882 int plm_init_decoders(plm_t *self) {
00883     if (self->has_decoders) {
00884         return TRUE;
00885     }
00886
00887     if (!plm_demux_has_headers(self->demux)) {
00888         return FALSE;
00889     }
00890
00891     if (plm_demux_get_num_video_streams(self->demux) > 0) {
00892         if (self->video_enabled) {
00893             self->video_packet_type = PLM_DEMUX_PACKET_VIDEO_1;
00894         }
00895         self->video_buffer = plm_buffer_create_with_capacity(PLM_BUFFER_DEFAULT_SIZE);
00896         plm_buffer_set_load_callback(self->video_buffer, plm_read_video_packet, self);
00897     }
00898
00899     if (plm_demux_get_num_audio_streams(self->demux) > 0) {
00900         if (self->audio_enabled) {
00901             self->audio_packet_type = PLM_DEMUX_PACKET_AUDIO_1 + self->audio_stream_index;
00902         }
00903         self->audio_buffer = plm_buffer_create_with_capacity(PLM_BUFFER_DEFAULT_SIZE);
00904         plm_buffer_set_load_callback(self->audio_buffer, plm_read_audio_packet, self);
00905     }
00906
00907     if (self->video_buffer) {
00908         self->video_decoder = plm_video_create_with_buffer(self->video_buffer, TRUE);
00909     }
00910
00911     if (self->audio_buffer) {
00912         self->audio_decoder = plm_audio_create_with_buffer(self->audio_buffer, TRUE);
00913     }
00914
00915     self->has_decoders = TRUE;
00916     return TRUE;
00917 }
00918
00919 void plm_destroy(plm_t *self) {
00920     if (self->video_decoder) {
00921         plm_video_destroy(self->video_decoder);
00922     }
00923     if (self->audio_decoder) {
00924         plm_audio_destroy(self->audio_decoder);
00925     }
00926
00927     plm_demux_destroy(self->demux);
00928     PLM_FREE(self);
00929 }
00930
00931 int plm_get_audio_enabled(plm_t *self) {
00932     return self->audio_enabled;
00933 }
00934
00935 int plm_has_headers(plm_t *self) {
00936     if (!plm_demux_has_headers(self->demux)) {
00937         return FALSE;
00938     }
00939
00940     if (!plm_init_decoders(self)) {
00941         return FALSE;
00942     }
00943
00944     if (
00945         (self->video_decoder && !plm_video_has_header(self->video_decoder)) ||
00946         (self->audio_decoder && !plm_audio_has_header(self->audio_decoder))
00947     ) {
00948         return FALSE;
00949     }
00950
00951     return TRUE;
00952 }
00953
00954 void plm_set_audio_enabled(plm_t *self, int enabled) {
00955     self->audio_enabled = enabled;
00956
00957     if (!enabled) {
00958         self->audio_packet_type = 0;
00959         return;
00960     }
00961
00962     self->audio_packet_type = (plm_init_decoders(self) && self->audio_decoder)
00963         ? PLM_DEMUX_PACKET_AUDIO_1 + self->audio_stream_index
00964         : 0;
```

```
00965 }
00966
00967 void plm_set_audio_stream(plm_t *self, int stream_index) {
00968     if (stream_index < 0 || stream_index > 3) {
00969         return;
00970     }
00971     self->audio_stream_index = stream_index;
00972
00973     // Set the correct audio_packet_type
00974     plm_set_audio_enabled(self, self->audio_enabled);
00975 }
00976
00977 int plm_get_video_enabled(plm_t *self) {
00978     return self->video_enabled;
00979 }
00980
00981 void plm_set_video_enabled(plm_t *self, int enabled) {
00982     self->video_enabled = enabled;
00983
00984     if (!enabled) {
00985         self->video_packet_type = 0;
00986         return;
00987     }
00988
00989     self->video_packet_type = (plm_init_decoders(self) && self->video_decoder)
00990         ? PLM_DEMUX_PACKET_VIDEO_1
00991         : 0;
00992 }
00993
00994 int plm_get_num_video_streams(plm_t *self) {
00995     return plm_demux_get_num_video_streams(self->demux);
00996 }
00997
00998 int plm_get_width(plm_t *self) {
00999     return (plm_init_decoders(self) && self->video_decoder)
01000         ? plm_video_get_width(self->video_decoder)
01001         : 0;
01002 }
01003
01004 int plm_get_height(plm_t *self) {
01005     return (plm_init_decoders(self) && self->video_decoder)
01006         ? plm_video_get_height(self->video_decoder)
01007         : 0;
01008 }
01009
01010 double plm_get_framerate(plm_t *self) {
01011     return (plm_init_decoders(self) && self->video_decoder)
01012         ? plm_video_get_framerate(self->video_decoder)
01013         : 0;
01014 }
01015
01016 int plm_get_num_audio_streams(plm_t *self) {
01017     return plm_demux_get_num_audio_streams(self->demux);
01018 }
01019
01020 int plm_get_samplerate(plm_t *self) {
01021     return (plm_init_decoders(self) && self->audio_decoder)
01022         ? plm_audio_get_samplerate(self->audio_decoder)
01023         : 0;
01024 }
01025
01026 double plm_get_audio_lead_time(plm_t *self) {
01027     return self->audio_lead_time;
01028 }
01029
01030 void plm_set_audio_lead_time(plm_t *self, double lead_time) {
01031     self->audio_lead_time = lead_time;
01032 }
01033
01034 double plm_get_time(plm_t *self) {
01035     return self->time;
01036 }
01037
01038 double plm_get_duration(plm_t *self) {
01039     return plm_demux_get_duration(self->demux, PLM_DEMUX_PACKET_VIDEO_1);
01040 }
01041
01042 void plm_rewind(plm_t *self) {
01043     if (self->video_decoder) {
01044         plm_video_rewind(self->video_decoder);
01045     }
01046
01047     if (self->audio_decoder) {
01048         plm_audio_rewind(self->audio_decoder);
01049     }
01050
01051     plm_demux_rewind(self->demux);
```

```
01052     self->time = 0;
01053 }
01054
01055 int plm_get_loop(plm_t *self) {
01056     return self->loop;
01057 }
01058
01059 void plm_set_loop(plm_t *self, int loop) {
01060     self->loop = loop;
01061 }
01062
01063 int plm_has_ended(plm_t *self) {
01064     return self->has_ended;
01065 }
01066
01067 void plm_set_video_decode_callback(plm_t *self, plm_video_decode_callback fp, void *user) {
01068     self->video_decode_callback = fp;
01069     self->video_decode_callback_user_data = user;
01070 }
01071
01072 void plm_set_audio_decode_callback(plm_t *self, plm_audio_decode_callback fp, void *user) {
01073     self->audio_decode_callback = fp;
01074     self->audio_decode_callback_user_data = user;
01075 }
01076
01077 void plm_decode(plm_t *self, double tick) {
01078     if (!plm_init_decoders(self)) {
01079         return;
01080     }
01081
01082     int decode_video = (self->video_decode_callback && self->video_packet_type);
01083     int decode_audio = (self->audio_decode_callback && self->audio_packet_type);
01084
01085     if (!decode_video && !decode_audio) {
01086         // Nothing to do here
01087         return;
01088     }
01089
01090     int did_decode = FALSE;
01091     int decode_video_failed = FALSE;
01092     int decode_audio_failed = FALSE;
01093
01094     double video_target_time = self->time + tick;
01095     double audio_target_time = self->time + tick + self->audio_lead_time;
01096
01097     do {
01098         did_decode = FALSE;
01099
01100         if (decode_video && plm_video_get_time(self->video_decoder) < video_target_time) {
01101             plm_frame_t *frame = plm_video_decode(self->video_decoder);
01102             if (frame) {
01103                 self->video_decode_callback(self, frame, self->video_decode_callback_user_data);
01104                 did_decode = TRUE;
01105             }
01106             else {
01107                 decode_video_failed = TRUE;
01108             }
01109         }
01110
01111         if (decode_audio && plm_audio_get_time(self->audio_decoder) < audio_target_time) {
01112             plm_samples_t *samples = plm_audio_decode(self->audio_decoder);
01113             if (samples) {
01114                 self->audio_decode_callback(self, samples, self->audio_decode_callback_user_data);
01115                 did_decode = TRUE;
01116             }
01117             else {
01118                 decode_audio_failed = TRUE;
01119             }
01120         }
01121     } while (did_decode);
01122
01123     // Did all sources we wanted to decode fail and the demuxer is at the end?
01124     if (
01125         (!decode_video || decode_video_failed) &&
01126         (!decode_audio || decode_audio_failed) &&
01127         plm_demux_has_ended(self->demux)
01128     ) {
01129         plm_handle_end(self);
01130         return;
01131     }
01132
01133     self->time += tick;
01134 }
01135
01136 plm_frame_t *plm_decode_video(plm_t *self) {
01137     if (!plm_init_decoders(self)) {
01138         return NULL;
```

```
01139     }
01140
01141     if (!self->video_packet_type) {
01142         return NULL;
01143     }
01144
01145     plm_frame_t *frame = plm_video_decode(self->video_decoder);
01146     if (frame) {
01147         self->time = frame->time;
01148     }
01149     else if (plm_demux_has_ended(self->demux)) {
01150         plm_handle_end(self);
01151     }
01152     return frame;
01153 }
01154
01155 plm_samples_t *plm_decode_audio(plm_t *self) {
01156     if (!plm_init_decoders(self)) {
01157         return NULL;
01158     }
01159
01160     if (!self->audio_packet_type) {
01161         return NULL;
01162     }
01163
01164     plm_samples_t *samples = plm_audio_decode(self->audio_decoder);
01165     if (samples) {
01166         self->time = samples->time;
01167     }
01168     else if (plm_demux_has_ended(self->demux)) {
01169         plm_handle_end(self);
01170     }
01171     return samples;
01172 }
01173
01174 void plm_handle_end(plm_t *self) {
01175     if (self->loop) {
01176         plm_rewind(self);
01177     }
01178     else {
01179         self->has_ended = TRUE;
01180     }
01181 }
01182
01183 void plm_read_video_packet(plm_buffer_t *buffer, void *user) {
01184     PLM_UNUSED(buffer);
01185     plm_t *self = (plm_t *)user;
01186     plm_read_packets(self, self->video_packet_type);
01187 }
01188
01189 void plm_read_audio_packet(plm_buffer_t *buffer, void *user) {
01190     PLM_UNUSED(buffer);
01191     plm_t *self = (plm_t *)user;
01192     plm_read_packets(self, self->audio_packet_type);
01193 }
01194
01195 void plm_read_packets(plm_t *self, int requested_type) {
01196     plm_packet_t *packet;
01197     while ((packet = plm_demux_decode(self->demux))) {
01198         if (packet->type == self->video_packet_type) {
01199             plm_buffer_write(self->video_buffer, packet->data, packet->length);
01200         }
01201         else if (packet->type == self->audio_packet_type) {
01202             plm_buffer_write(self->audio_buffer, packet->data, packet->length);
01203         }
01204
01205         if (packet->type == requested_type) {
01206             return;
01207         }
01208     }
01209
01210     if (plm_demux_has_ended(self->demux)) {
01211         if (self->video_buffer) {
01212             plm_buffer_signal_end(self->video_buffer);
01213         }
01214         if (self->audio_buffer) {
01215             plm_buffer_signal_end(self->audio_buffer);
01216         }
01217     }
01218 }
01219
01220 plm_frame_t *plm_seek_frame(plm_t *self, double time, int seek_exact) {
01221     if (!plm_init_decoders(self)) {
01222         return NULL;
01223     }
01224
01225     if (!self->video_packet_type) {
```

```
01226         return NULL;
01227     }
01228
01229     int type = self->video_packet_type;
01230
01231     double start_time = plm_demux_get_start_time(self->demux, type);
01232     double duration = plm_demux_get_duration(self->demux, type);
01233
01234     if (time < 0) {
01235         time = 0;
01236     }
01237     else if (time > duration) {
01238         time = duration;
01239     }
01240
01241     plm_packet_t *packet = plm_demux_seek(self->demux, time, type, TRUE);
01242     if (!packet) {
01243         return NULL;
01244     }
01245
01246     // Disable writing to the audio buffer while decoding video
01247     int previous_audio_packet_type = self->audio_packet_type;
01248     self->audio_packet_type = 0;
01249
01250     // Clear video buffer and decode the found packet
01251     plm_video_rewind(self->video_decoder);
01252     plm_video_set_time(self->video_decoder, packet->pts - start_time);
01253     plm_buffer_write(self->video_buffer, packet->data, packet->length);
01254     plm_frame_t *frame = plm_video_decode(self->video_decoder);
01255
01256     // If we want to seek to an exact frame, we have to decode all frames
01257     // on top of the intra frame we just jumped to.
01258     if (seek_exact) {
01259         while (frame && frame->time < time) {
01260             frame = plm_video_decode(self->video_decoder);
01261         }
01262     }
01263
01264     // Enable writing to the audio buffer again?
01265     self->audio_packet_type = previous_audio_packet_type;
01266
01267     if (frame) {
01268         self->time = frame->time;
01269     }
01270
01271     self->has_ended = FALSE;
01272     return frame;
01273 }
01274
01275 int plm_seek(plm_t *self, double time, int seek_exact) {
01276     plm_frame_t *frame = plm_seek_frame(self, time, seek_exact);
01277
01278     if (!frame) {
01279         return FALSE;
01280     }
01281
01282     if (self->video_decode_callback) {
01283         self->video_decode_callback(self, frame, self->video_decode_callback_user_data);
01284     }
01285
01286     // If audio is not enabled we are done here.
01287     if (!self->audio_packet_type) {
01288         return TRUE;
01289     }
01290
01291     // Sync up Audio. This demuxes more packets until the first audio packet
01292     // with a PTS greater than the current time is found. plm_decode() is then
01293     // called to decode enough audio data to satisfy the audio_lead_time.
01294
01295     double start_time = plm_demux_get_start_time(self->demux, self->video_packet_type);
01296     plm_audio_rewind(self->audio_decoder);
01297
01298     plm_packet_t *packet = NULL;
01299     while ((packet = plm_demux_decode(self->demux))) {
01300         if (packet->type == self->video_packet_type) {
01301             plm_buffer_write(self->video_buffer, packet->data, packet->length);
01302         }
01303         else if (
01304             packet->type == self->audio_packet_type &&
01305             packet->pts - start_time > self->time
01306         ) {
01307             plm_audio_set_time(self->audio_decoder, packet->pts - start_time);
01308             plm_buffer_write(self->audio_buffer, packet->data, packet->length);
01309             plm_decode(self, 0);
01310             break;
01311         }
01312     }
```

```
01313
01314     return TRUE;
01315 }
01316
01317
01318
01319 // -----------------------------------------------------------------------------
01320 // plm_buffer implementation
01321
01322 enum plm_buffer_mode {
01323     PLM_BUFFER_MODE_FILE,
01324     PLM_BUFFER_MODE_FIXED_MEM,
01325     PLM_BUFFER_MODE_RING,
01326     PLM_BUFFER_MODE_APPEND
01327 };
01328
01329 struct plm_buffer_t {
01330     size_t bit_index;
01331     size_t capacity;
01332     size_t length;
01333     size_t total_size;
01334     int discard_read_bytes;
01335     int has_ended;
01336     int free_when_done;
01337     int close_when_done;
01338     FIL *fh;
01339     plm_buffer_load_callback load_callback;
01340     void *load_callback_user_data;
01341     uint8_t *bytes;
01342     enum plm_buffer_mode mode;
01343 };
01344
01345 typedef struct {
01346     int16_t index;
01347     int16_t value;
01348 } plm_vlc_t;
01349
01350 typedef struct {
01351     int16_t index;
01352     uint16_t value;
01353 } plm_vlc_uint_t;
01354
01355
01356 void plm_buffer_seek(plm_buffer_t *self, size_t pos);
01357 size_t plm_buffer_tell(plm_buffer_t *self);
01358 void plm_buffer_discard_read_bytes(plm_buffer_t *self);
01359 void plm_buffer_load_file_callback(plm_buffer_t *self, void *user);
01360
01361 int plm_buffer_has(plm_buffer_t *self, size_t count);
01362 int plm_buffer_read(plm_buffer_t *self, int count);
01363 void plm_buffer_align(plm_buffer_t *self);
01364 void plm_buffer_skip(plm_buffer_t *self, size_t count);
01365 int plm_buffer_skip_bytes(plm_buffer_t *self, uint8_t v);
01366 int plm_buffer_next_start_code(plm_buffer_t *self);
01367 int plm_buffer_find_start_code(plm_buffer_t *self, int code);
01368 int plm_buffer_no_start_code(plm_buffer_t *self);
01369 int16_t plm_buffer_read_vlc(plm_buffer_t *self, const plm_vlc_t *table);
01370 uint16_t plm_buffer_read_vlc_uint(plm_buffer_t *self, const plm_vlc_uint_t *table);
01371
01372 plm_buffer_t *plm_buffer_create_with_filename(const char *filename) {
01373     FIL *fh =vexFileOpen(filename, "rb"); //fopen(filename, "rb");
01374     if (!fh) {
01375         return NULL;
01376     }
01377     return plm_buffer_create_with_file(fh, TRUE);
01378 }
01379
01380 plm_buffer_t *plm_buffer_create_with_file(FIL *fh, int close_when_done) {
01381     plm_buffer_t *self = plm_buffer_create_with_capacity(PLM_BUFFER_DEFAULT_SIZE);
01382     self->fh = fh;
01383     self->close_when_done = close_when_done;
01384     self->mode = PLM_BUFFER_MODE_FILE;
01385     self->discard_read_bytes = TRUE;
01386
01387     vexFileSeek(self->fh, 0, SEEK_END);
01388     self->total_size = vexFileTell(self->fh);
01389     vexFileSeek(self->fh, 0, SEEK_SET);
01390
01391     plm_buffer_set_load_callback(self, plm_buffer_load_file_callback, NULL);
01392     return self;
01393 }
01394
01395 plm_buffer_t *plm_buffer_create_with_memory(uint8_t *bytes, size_t length, int free_when_done) {
01396     plm_buffer_t *self = (plm_buffer_t *)PLM_MALLOC(sizeof(plm_buffer_t));
01397     memset(self, 0, sizeof(plm_buffer_t));
01398     self->capacity = length;
01399     self->length = length;
```

```
01400     self->total_size = length;
01401     self->free_when_done = free_when_done;
01402     self->bytes = bytes;
01403     self->mode = PLM_BUFFER_MODE_FIXED_MEM;
01404     self->discard_read_bytes = FALSE;
01405     return self;
01406 }
01407
01408 plm_buffer_t *plm_buffer_create_with_capacity(size_t capacity) {
01409     plm_buffer_t *self = (plm_buffer_t *)PLM_MALLOC(sizeof(plm_buffer_t));
01410     memset(self, 0, sizeof(plm_buffer_t));
01411     self->capacity = capacity;
01412     self->free_when_done = TRUE;
01413     self->bytes = (uint8_t *)PLM_MALLOC(capacity);
01414     self->mode = PLM_BUFFER_MODE_RING;
01415     self->discard_read_bytes = TRUE;
01416     return self;
01417 }
01418
01419 plm_buffer_t *plm_buffer_create_for_appending(size_t initial_capacity) {
01420     plm_buffer_t *self = plm_buffer_create_with_capacity(initial_capacity);
01421     self->mode = PLM_BUFFER_MODE_APPEND;
01422     self->discard_read_bytes = FALSE;
01423     return self;
01424 }
01425
01426 void plm_buffer_destroy(plm_buffer_t *self) {
01427     if (self->fh && self->close_when_done) {
01428         vexFileClose(self->fh);
01429     }
01430     if (self->free_when_done) {
01431         PLM_FREE(self->bytes);
01432     }
01433     PLM_FREE(self);
01434 }
01435
01436 size_t plm_buffer_get_size(plm_buffer_t *self) {
01437     return (self->mode == PLM_BUFFER_MODE_FILE)
01438         ? self->total_size
01439         : self->length;
01440 }
01441
01442 size_t plm_buffer_get_remaining(plm_buffer_t *self) {
01443     return self->length - (self->bit_index >> 3);
01444 }
01445
01446 size_t plm_buffer_write(plm_buffer_t *self, uint8_t *bytes, size_t length) {
01447     if (self->mode == PLM_BUFFER_MODE_FIXED_MEM) {
01448         return 0;
01449     }
01450
01451     if (self->discard_read_bytes) {
01452         // This should be a ring buffer, but instead it just shifts all unread
01453         // data to the beginning of the buffer and appends new data at the end.
01454         // Seems to be good enough.
01455
01456         plm_buffer_discard_read_bytes(self);
01457         if (self->mode == PLM_BUFFER_MODE_RING) {
01458             self->total_size = 0;
01459         }
01460     }
01461
01462     // Do we have to resize to fit the new data?
01463     size_t bytes_available = self->capacity - self->length;
01464     if (bytes_available < length) {
01465         size_t new_size = self->capacity;
01466         do {
01467             new_size *= 2;
01468         } while (new_size - self->length < length);
01469         self->bytes = (uint8_t *)PLM_REALLOC(self->bytes, new_size);
01470         self->capacity = new_size;
01471     }
01472
01473     memcpy(self->bytes + self->length, bytes, length);
01474     self->length += length;
01475     self->has_ended = FALSE;
01476     return length;
01477 }
01478
01479 void plm_buffer_signal_end(plm_buffer_t *self) {
01480     self->total_size = self->length;
01481 }
01482
01483 void plm_buffer_set_load_callback(plm_buffer_t *self, plm_buffer_load_callback fp, void *user) {
01484     self->load_callback = fp;
01485     self->load_callback_user_data = user;
01486 }
```

```
01487
01488 void plm_buffer_rewind(plm_buffer_t *self) {
01489     plm_buffer_seek(self, 0);
01490 }
01491
01492 void plm_buffer_seek(plm_buffer_t *self, size_t pos) {
01493     self->has_ended = FALSE;
01494
01495     if (self->mode == PLM_BUFFER_MODE_FILE) {
01496         vexFileSeek(self->fh, pos, SEEK_SET);
01497         self->bit_index = 0;
01498         self->length = 0;
01499     }
01500     else if (self->mode == PLM_BUFFER_MODE_RING) {
01501         if (pos != 0) {
01502             // Seeking to non-0 is forbidden for dynamic-mem buffers
01503             return;
01504         }
01505         self->bit_index = 0;
01506         self->length = 0;
01507         self->total_size = 0;
01508     }
01509     else if (pos < self->length) {
01510         self->bit_index = pos « 3;
01511     }
01512 }
01513
01514 size_t plm_buffer_tell(plm_buffer_t *self) {
01515     return self->mode == PLM_BUFFER_MODE_FILE
01516         ? vexFileTell(self->fh) + (self->bit_index » 3) - self->length
01517         : self->bit_index » 3;
01518 }
01519
01520 void plm_buffer_discard_read_bytes(plm_buffer_t *self) {
01521     size_t byte_pos = self->bit_index » 3;
01522     if (byte_pos == self->length) {
01523         self->bit_index = 0;
01524         self->length = 0;
01525     }
01526     else if (byte_pos > 0) {
01527         memmove(self->bytes, self->bytes + byte_pos, self->length - byte_pos);
01528         self->bit_index -= byte_pos « 3;
01529         self->length -= byte_pos;
01530     }
01531 }
01532
01533 void plm_buffer_load_file_callback(plm_buffer_t *self, void *user) {
01534     PLM_UNUSED(user);
01535
01536     if (self->discard_read_bytes) {
01537         plm_buffer_discard_read_bytes(self);
01538     }
01539
01540     size_t bytes_available = self->capacity - self->length;
01541     size_t bytes_read = vexFileRead((char *)self->bytes + self->length, 1, bytes_available, self->fh);
01542     self->length += bytes_read;
01543
01544     if (bytes_read == 0) {
01545         self->has_ended = TRUE;
01546     }
01547 }
01548
01549 int plm_buffer_has_ended(plm_buffer_t *self) {
01550     return self->has_ended;
01551 }
01552
01553 int plm_buffer_has(plm_buffer_t *self, size_t count) {
01554     if (((self->length « 3) - self->bit_index) >= count) {
01555         return TRUE;
01556     }
01557
01558     if (self->load_callback) {
01559         self->load_callback(self, self->load_callback_user_data);
01560
01561         if (((self->length « 3) - self->bit_index) >= count) {
01562             return TRUE;
01563         }
01564     }
01565
01566     if (self->total_size != 0 && self->length == self->total_size) {
01567         self->has_ended = TRUE;
01568     }
01569     return FALSE;
01570 }
01571
01572 int plm_buffer_read(plm_buffer_t *self, int count) {
01573     if (!plm_buffer_has(self, count)) {
```

```
01574         return 0;
01575     }
01576
01577     int value = 0;
01578     while (count) {
01579         int current_byte = self->bytes[self->bit_index » 3];
01580
01581         int remaining = 8 - (self->bit_index & 7); // Remaining bits in byte
01582         int read = remaining < count ? remaining : count; // Bits in self run
01583         int shift = remaining - read;
01584         int mask = (0xff » (8 - read));
01585
01586         value = (value « read) | ((current_byte & (mask « shift)) » shift);
01587
01588         self->bit_index += read;
01589         count -= read;
01590     }
01591
01592     return value;
01593 }
01594
01595 void plm_buffer_align(plm_buffer_t *self) {
01596     self->bit_index = ((self->bit_index + 7) » 3) « 3; // Align to next byte
01597 }
01598
01599 void plm_buffer_skip(plm_buffer_t *self, size_t count) {
01600     if (plm_buffer_has(self, count)) {
01601         self->bit_index += count;
01602     }
01603 }
01604
01605 int plm_buffer_skip_bytes(plm_buffer_t *self, uint8_t v) {
01606     plm_buffer_align(self);
01607     int skipped = 0;
01608     while (plm_buffer_has(self, 8) && self->bytes[self->bit_index » 3] == v) {
01609         self->bit_index += 8;
01610         skipped++;
01611     }
01612     return skipped;
01613 }
01614
01615 int plm_buffer_next_start_code(plm_buffer_t *self) {
01616     plm_buffer_align(self);
01617
01618     while (plm_buffer_has(self, (5 « 3))) {
01619         size_t byte_index = (self->bit_index) » 3;
01620         if (
01621             self->bytes[byte_index] == 0x00 &&
01622             self->bytes[byte_index + 1] == 0x00 &&
01623             self->bytes[byte_index + 2] == 0x01
01624         ) {
01625             self->bit_index = (byte_index + 4) « 3;
01626             return self->bytes[byte_index + 3];
01627         }
01628         self->bit_index += 8;
01629     }
01630     return -1;
01631 }
01632
01633 int plm_buffer_find_start_code(plm_buffer_t *self, int code) {
01634     int current = 0;
01635     while (TRUE) {
01636         current = plm_buffer_next_start_code(self);
01637         if (current == code || current == -1) {
01638             return current;
01639         }
01640     }
01641     return -1;
01642 }
01643
01644 int plm_buffer_has_start_code(plm_buffer_t *self, int code) {
01645     size_t previous_bit_index = self->bit_index;
01646     int previous_discard_read_bytes = self->discard_read_bytes;
01647
01648     self->discard_read_bytes = FALSE;
01649     int current = plm_buffer_find_start_code(self, code);
01650
01651     self->bit_index = previous_bit_index;
01652     self->discard_read_bytes = previous_discard_read_bytes;
01653     return current;
01654 }
01655
01656 int plm_buffer_peek_non_zero(plm_buffer_t *self, int bit_count) {
01657     if (!plm_buffer_has(self, bit_count)) {
01658         return FALSE;
01659     }
01660
```

```
01661     int val = plm_buffer_read(self, bit_count);
01662     self->bit_index -= bit_count;
01663     return val != 0;
01664 }
01665
01666 int16_t plm_buffer_read_vlc(plm_buffer_t *self, const plm_vlc_t *table) {
01667     plm_vlc_t state = {0, 0};
01668     do {
01669         state = table[state.index + plm_buffer_read(self, 1)];
01670     } while (state.index > 0);
01671     return state.value;
01672 }
01673
01674 uint16_t plm_buffer_read_vlc_uint(plm_buffer_t *self, const plm_vlc_uint_t *table) {
01675     return (uint16_t)plm_buffer_read_vlc(self, (const plm_vlc_t *)table);
01676 }
01677
01678
01679
01680 // -----------------------------------------------------------------------------
01681 // plm_demux implementation
01682
01683 static const int PLM_START_PACK = 0xBA;
01684 static const int PLM_START_END = 0xB9;
01685 static const int PLM_START_SYSTEM = 0xBB;
01686
01687 struct plm_demux_t {
01688     plm_buffer_t *buffer;
01689     int destroy_buffer_when_done;
01690     double system_clock_ref;
01691
01692     size_t last_file_size;
01693     double last_decoded_pts;
01694     double start_time;
01695     double duration;
01696
01697     int start_code;
01698     int has_pack_header;
01699     int has_system_header;
01700     int has_headers;
01701
01702     int num_audio_streams;
01703     int num_video_streams;
01704     plm_packet_t current_packet;
01705     plm_packet_t next_packet;
01706 };
01707
01708
01709 void plm_demux_buffer_seek(plm_demux_t *self, size_t pos);
01710 double plm_demux_decode_time(plm_demux_t *self);
01711 plm_packet_t *plm_demux_decode_packet(plm_demux_t *self, int type);
01712 plm_packet_t *plm_demux_get_packet(plm_demux_t *self);
01713
01714 plm_demux_t *plm_demux_create(plm_buffer_t *buffer, int destroy_when_done) {
01715     plm_demux_t *self = (plm_demux_t *)PLM_MALLOC(sizeof(plm_demux_t));
01716     memset(self, 0, sizeof(plm_demux_t));
01717
01718     self->buffer = buffer;
01719     self->destroy_buffer_when_done = destroy_when_done;
01720
01721     self->start_time = PLM_PACKET_INVALID_TS;
01722     self->duration = PLM_PACKET_INVALID_TS;
01723     self->start_code = -1;
01724
01725     plm_demux_has_headers(self);
01726     return self;
01727 }
01728
01729 void plm_demux_destroy(plm_demux_t *self) {
01730     if (self->destroy_buffer_when_done) {
01731         plm_buffer_destroy(self->buffer);
01732     }
01733     PLM_FREE(self);
01734 }
01735
01736 int plm_demux_has_headers(plm_demux_t *self) {
01737     if (self->has_headers) {
01738         return TRUE;
01739     }
01740
01741     // Decode pack header
01742     if (!self->has_pack_header) {
01743         if (
01744             self->start_code != PLM_START_PACK &&
01745             plm_buffer_find_start_code(self->buffer, PLM_START_PACK) == -1
01746         ) {
01747             return FALSE;
```

```
01748         }
01749
01750         self->start_code = PLM_START_PACK;
01751         if (!plm_buffer_has(self->buffer, 64)) {
01752             return FALSE;
01753         }
01754         self->start_code = -1;
01755
01756         if (plm_buffer_read(self->buffer, 4) != 0x02) {
01757             return FALSE;
01758         }
01759
01760         self->system_clock_ref = plm_demux_decode_time(self);
01761         plm_buffer_skip(self->buffer, 1);
01762         plm_buffer_skip(self->buffer, 22); // mux_rate * 50
01763         plm_buffer_skip(self->buffer, 1);
01764
01765         self->has_pack_header = TRUE;
01766     }
01767
01768     // Decode system header
01769     if (!self->has_system_header) {
01770         if (
01771             self->start_code != PLM_START_SYSTEM &&
01772             plm_buffer_find_start_code(self->buffer, PLM_START_SYSTEM) == -1
01773         ) {
01774             return FALSE;
01775         }
01776
01777         self->start_code = PLM_START_SYSTEM;
01778         if (!plm_buffer_has(self->buffer, 56)) {
01779             return FALSE;
01780         }
01781         self->start_code = -1;
01782
01783         plm_buffer_skip(self->buffer, 16); // header_length
01784         plm_buffer_skip(self->buffer, 24); // rate bound
01785         self->num_audio_streams = plm_buffer_read(self->buffer, 6);
01786         plm_buffer_skip(self->buffer, 5); // misc flags
01787         self->num_video_streams = plm_buffer_read(self->buffer, 5);
01788
01789         self->has_system_header = TRUE;
01790     }
01791
01792     self->has_headers = TRUE;
01793     return TRUE;
01794 }
01795
01796 int plm_demux_get_num_video_streams(plm_demux_t *self) {
01797     return plm_demux_has_headers(self)
01798         ? self->num_video_streams
01799         : 0;
01800 }
01801
01802 int plm_demux_get_num_audio_streams(plm_demux_t *self) {
01803     return plm_demux_has_headers(self)
01804         ? self->num_audio_streams
01805         : 0;
01806 }
01807
01808 void plm_demux_rewind(plm_demux_t *self) {
01809     plm_buffer_rewind(self->buffer);
01810     self->current_packet.length = 0;
01811     self->next_packet.length = 0;
01812     self->start_code = -1;
01813 }
01814
01815 int plm_demux_has_ended(plm_demux_t *self) {
01816     return plm_buffer_has_ended(self->buffer);
01817 }
01818
01819 void plm_demux_buffer_seek(plm_demux_t *self, size_t pos) {
01820     plm_buffer_seek(self->buffer, pos);
01821     self->current_packet.length = 0;
01822     self->next_packet.length = 0;
01823     self->start_code = -1;
01824 }
01825
01826 double plm_demux_get_start_time(plm_demux_t *self, int type) {
01827     if (self->start_time != PLM_PACKET_INVALID_TS) {
01828         return self->start_time;
01829     }
01830
01831     int previous_pos = plm_buffer_tell(self->buffer);
01832     int previous_start_code = self->start_code;
01833
01834     // Find first video PTS
```

```
01835     plm_demux_rewind(self);
01836     do {
01837         plm_packet_t *packet = plm_demux_decode(self);
01838         if (!packet) {
01839             break;
01840         }
01841         if (packet->type == type) {
01842             self->start_time = packet->pts;
01843         }
01844     } while (self->start_time == PLM_PACKET_INVALID_TS);
01845
01846     plm_demux_buffer_seek(self, previous_pos);
01847     self->start_code = previous_start_code;
01848     return self->start_time;
01849 }
01850
01851 double plm_demux_get_duration(plm_demux_t *self, int type) {
01852     size_t file_size = plm_buffer_get_size(self->buffer);
01853
01854     if (
01855         self->duration != PLM_PACKET_INVALID_TS &&
01856         self->last_file_size == file_size
01857     ) {
01858         return self->duration;
01859     }
01860
01861     size_t previous_pos = plm_buffer_tell(self->buffer);
01862     int previous_start_code = self->start_code;
01863
01864     // Find last video PTS. Start searching 64kb from the end and go further
01865     // back if needed.
01866     long start_range = 64 * 1024;
01867     long max_range = 4096 * 1024;
01868     for (long range = start_range; range <= max_range; range *= 2) {
01869         long seek_pos = file_size - range;
01870         if (seek_pos < 0) {
01871             seek_pos = 0;
01872             range = max_range; // Make sure to bail after this round
01873         }
01874         plm_demux_buffer_seek(self, seek_pos);
01875         self->current_packet.length = 0;
01876
01877         double last_pts = PLM_PACKET_INVALID_TS;
01878         plm_packet_t *packet = NULL;
01879         while ((packet = plm_demux_decode(self))) {
01880             if (packet->pts != PLM_PACKET_INVALID_TS && packet->type == type) {
01881                 last_pts = packet->pts;
01882             }
01883         }
01884         if (last_pts != PLM_PACKET_INVALID_TS) {
01885             self->duration = last_pts - plm_demux_get_start_time(self, type);
01886             break;
01887         }
01888     }
01889
01890     plm_demux_buffer_seek(self, previous_pos);
01891     self->start_code = previous_start_code;
01892     self->last_file_size = file_size;
01893     return self->duration;
01894 }
01895
01896 plm_packet_t *plm_demux_seek(plm_demux_t *self, double seek_time, int type, int force_intra) {
01897     if (!plm_demux_has_headers(self)) {
01898         return NULL;
01899     }
01900
01901     // Using the current time, current byte position and the average bytes per
01902     // second for this file, try to jump to a byte position that hopefully has
01903     // packets containing timestamps within one second before to the desired
01904     // seek_time.
01905
01906     // If we hit close to the seek_time scan through all packets to find the
01907     // last one (just before the seek_time) containing an intra frame.
01908     // Otherwise we should at least be closer than before. Calculate the bytes
01909     // per second for the jumped range and jump again.
01910
01911     // The number of retries here is hard-limited to a generous amount. Usually
01912     // the correct range is found after 1--5 jumps, even for files with very
01913     // variable bitrates. If significantly more jumps are needed, there's
01914     // probably something wrong with the file and we just avoid getting into an
01915     // infinite loop. 32 retries should be enough for anybody.
01916
01917     double duration = plm_demux_get_duration(self, type);
01918     long file_size = plm_buffer_get_size(self->buffer);
01919     long byterate = file_size / duration;
01920
01921     double cur_time = self->last_decoded_pts;
```

```
01922     double scan_span = 1;
01923
01924     if (seek_time > duration) {
01925         seek_time = duration;
01926     }
01927     else if (seek_time < 0) {
01928         seek_time = 0;
01929     }
01930     seek_time += self->start_time;
01931
01932     for (int retry = 0; retry < 32; retry++) {
01933         int found_packet_with_pts = FALSE;
01934         int found_packet_in_range = FALSE;
01935         long last_valid_packet_start = -1;
01936         double first_packet_time = PLM_PACKET_INVALID_TS;
01937
01938         long cur_pos = plm_buffer_tell(self->buffer);
01939
01940         // Estimate byte offset and jump to it.
01941         long offset = (seek_time - cur_time - scan_span) * byterate;
01942         long seek_pos = cur_pos + offset;
01943         if (seek_pos < 0) {
01944             seek_pos = 0;
01945         }
01946         else if (seek_pos > file_size - 256) {
01947             seek_pos = file_size - 256;
01948         }
01949
01950         plm_demux_buffer_seek(self, seek_pos);
01951
01952         // Scan through all packets up to the seek_time to find the last packet
01953         // containing an intra frame.
01954         while (plm_buffer_find_start_code(self->buffer, type) != -1) {
01955             long packet_start = plm_buffer_tell(self->buffer);
01956             plm_packet_t *packet = plm_demux_decode_packet(self, type);
01957
01958             // Skip packet if it has no PTS
01959             if (!packet || packet->pts == PLM_PACKET_INVALID_TS) {
01960                 continue;
01961             }
01962
01963             // Bail scanning through packets if we hit one that is outside
01964             // seek_time - scan_span.
01965             // We also adjust the cur_time and byterate values here so the next
01966             // iteration can be a bit more precise.
01967             if (packet->pts > seek_time || packet->pts < seek_time - scan_span) {
01968                 found_packet_with_pts = TRUE;
01969                 byterate = (seek_pos - cur_pos) / (packet->pts - cur_time);
01970                 cur_time = packet->pts;
01971                 break;
01972             }
01973
01974             // If we are still here, it means this packet is in close range to
01975             // the seek_time. If this is the first packet for this jump position
01976             // record the PTS. If we later have to back off, when there was no
01977             // intra frame in this range, we can lower the seek_time to not scan
01978             // this range again.
01979             if (!found_packet_in_range) {
01980                 found_packet_in_range = TRUE;
01981                 first_packet_time = packet->pts;
01982             }
01983
01984             // Check if this is an intra frame packet. If so, record the buffer
01985             // position of the start of this packet. We want to jump back to it
01986             // later, when we know it's the last intra frame before desired
01987             // seek time.
01988             if (force_intra) {
01989                 for (size_t i = 0; i < packet->length - 6; i++) {
01990                     // Find the START_PICTURE code
01991                     if (
01992                         packet->data[i] == 0x00 &&
01993                         packet->data[i + 1] == 0x00 &&
01994                         packet->data[i + 2] == 0x01 &&
01995                         packet->data[i + 3] == 0x00
01996                     ) {
01997                         // Bits 11--13 in the picture header contain the frame
01998                         // type, where 1=Intra
01999                         if ((packet->data[i + 5] & 0x38) == 8) {
02000                             last_valid_packet_start = packet_start;
02001                         }
02002                         break;
02003                     }
02004                 }
02005             }
02006
02007             // If we don't want intra frames, just use the last PTS found.
02008             else {
```

```
02009                 last_valid_packet_start = packet_start;
02010             }
02011         }
02012 
02013         // If there was at least one intra frame in the range scanned above,
02014         // our search is over. Jump back to the packet and decode it again.
02015         if (last_valid_packet_start != -1) {
02016             plm_demux_buffer_seek(self, last_valid_packet_start);
02017             return plm_demux_decode_packet(self, type);
02018         }
02019 
02020         // If we hit the right range, but still found no intra frame, we have
02021         // to increases the scan_span. This is done exponentially to also handle
02022         // video files with very few intra frames.
02023         else if (found_packet_in_range) {
02024             scan_span *= 2;
02025             seek_time = first_packet_time;
02026         }
02027 
02028         // If we didn't find any packet with a PTS, it probably means we reached
02029         // the end of the file. Estimate byterate and cur_time accordingly.
02030         else if (!found_packet_with_pts) {
02031             byterate = (seek_pos - cur_pos) / (duration - cur_time);
02032             cur_time = duration;
02033         }
02034     }
02035 
02036     return NULL;
02037 }
02038 
02039 plm_packet_t *plm_demux_decode(plm_demux_t *self) {
02040     if (!plm_demux_has_headers(self)) {
02041         return NULL;
02042     }
02043 
02044     if (self->current_packet.length) {
02045         size_t bits_till_next_packet = self->current_packet.length << 3;
02046         if (!plm_buffer_has(self->buffer, bits_till_next_packet)) {
02047             return NULL;
02048         }
02049         plm_buffer_skip(self->buffer, bits_till_next_packet);
02050         self->current_packet.length = 0;
02051     }
02052 
02053     // Pending packet waiting for data?
02054     if (self->next_packet.length) {
02055         return plm_demux_get_packet(self);
02056     }
02057 
02058     // Pending packet waiting for header?
02059     if (self->start_code != -1) {
02060         return plm_demux_decode_packet(self, self->start_code);
02061     }
02062 
02063     do {
02064         self->start_code = plm_buffer_next_start_code(self->buffer);
02065         if (
02066             self->start_code == PLM_DEMUX_PACKET_VIDEO_1 ||
02067             self->start_code == PLM_DEMUX_PACKET_PRIVATE || (
02068                 self->start_code >= PLM_DEMUX_PACKET_AUDIO_1 &&
02069                 self->start_code <= PLM_DEMUX_PACKET_AUDIO_4
02070             )
02071         ) {
02072             return plm_demux_decode_packet(self, self->start_code);
02073         }
02074     } while (self->start_code != -1);
02075 
02076     return NULL;
02077 }
02078 
02079 double plm_demux_decode_time(plm_demux_t *self) {
02080     int64_t clock = plm_buffer_read(self->buffer, 3) << 30;
02081     plm_buffer_skip(self->buffer, 1);
02082     clock |= plm_buffer_read(self->buffer, 15) << 15;
02083     plm_buffer_skip(self->buffer, 1);
02084     clock |= plm_buffer_read(self->buffer, 15);
02085     plm_buffer_skip(self->buffer, 1);
02086     return (double)clock / 90000.0;
02087 }
02088 
02089 plm_packet_t *plm_demux_decode_packet(plm_demux_t *self, int type) {
02090     if (!plm_buffer_has(self->buffer, 16 << 3)) {
02091         return NULL;
02092     }
02093 
02094     self->start_code = -1;
02095 
```

```
02096     self->next_packet.type = type;
02097     self->next_packet.length = plm_buffer_read(self->buffer, 16);
02098     self->next_packet.length -= plm_buffer_skip_bytes(self->buffer, 0xff); // stuffing
02099
02100     // skip P-STD
02101     if (plm_buffer_read(self->buffer, 2) == 0x01) {
02102         plm_buffer_skip(self->buffer, 16);
02103         self->next_packet.length -= 2;
02104     }
02105
02106     int pts_dts_marker = plm_buffer_read(self->buffer, 2);
02107     if (pts_dts_marker == 0x03) {
02108         self->next_packet.pts = plm_demux_decode_time(self);
02109         self->last_decoded_pts = self->next_packet.pts;
02110         plm_buffer_skip(self->buffer, 40); // skip dts
02111         self->next_packet.length -= 10;
02112     }
02113     else if (pts_dts_marker == 0x02) {
02114         self->next_packet.pts = plm_demux_decode_time(self);
02115         self->last_decoded_pts = self->next_packet.pts;
02116         self->next_packet.length -= 5;
02117     }
02118     else if (pts_dts_marker == 0x00) {
02119         self->next_packet.pts = PLM_PACKET_INVALID_TS;
02120         plm_buffer_skip(self->buffer, 4);
02121         self->next_packet.length -= 1;
02122     }
02123     else {
02124         return NULL; // invalid
02125     }
02126
02127     return plm_demux_get_packet(self);
02128 }
02129
02130 plm_packet_t *plm_demux_get_packet(plm_demux_t *self) {
02131     if (!plm_buffer_has(self->buffer, self->next_packet.length << 3)) {
02132         return NULL;
02133     }
02134
02135     self->current_packet.data = self->buffer->bytes + (self->buffer->bit_index >> 3);
02136     self->current_packet.length = self->next_packet.length;
02137     self->current_packet.type = self->next_packet.type;
02138     self->current_packet.pts = self->next_packet.pts;
02139
02140     self->next_packet.length = 0;
02141     return &self->current_packet;
02142 }
02143
02144
02145
02146 // -----------------------------------------------------------------------------
02147 // plm_video implementation
02148
02149 // Inspired by Java MPEG-1 Video Decoder and Player by Zoltan Korandi
02150 // https://sourceforge.net/projects/javampeg1video/
02151
02152 static const int PLM_VIDEO_PICTURE_TYPE_INTRA = 1;
02153 static const int PLM_VIDEO_PICTURE_TYPE_PREDICTIVE = 2;
02154 static const int PLM_VIDEO_PICTURE_TYPE_B = 3;
02155
02156 static const int PLM_START_SEQUENCE = 0xB3;
02157 static const int PLM_START_SLICE_FIRST = 0x01;
02158 static const int PLM_START_SLICE_LAST = 0xAF;
02159 static const int PLM_START_PICTURE = 0x00;
02160 static const int PLM_START_EXTENSION = 0xB5;
02161 static const int PLM_START_USER_DATA = 0xB2;
02162
02163 #define PLM_START_IS_SLICE(c) \
02164     (c >= PLM_START_SLICE_FIRST && c <= PLM_START_SLICE_LAST)
02165
02166 static const double PLM_VIDEO_PICTURE_RATE[] = {
02167     0.000, 23.976, 24.000, 25.000, 29.970, 30.000, 50.000, 59.940,
02168     60.000, 0.000, 0.000, 0.000, 0.000, 0.000, 0.000, 0.000
02169 };
02170
02171 static const uint8_t PLM_VIDEO_ZIG_ZAG[] = {
02172      0,  1,  8, 16,  9,  2,  3, 10,
02173     17, 24, 32, 25, 18, 11,  4,  5,
02174     12, 19, 26, 33, 40, 48, 41, 34,
02175     27, 20, 13,  6,  7, 14, 21, 28,
02176     35, 42, 49, 56, 57, 50, 43, 36,
02177     29, 22, 15, 23, 30, 37, 44, 51,
02178     58, 59, 52, 45, 38, 31, 39, 46,
02179     53, 60, 61, 54, 47, 55, 62, 63
02180 };
02181
02182 static const uint8_t PLM_VIDEO_INTRA_QUANT_MATRIX[] = {
```

```
02183      8, 16, 19, 22, 26, 27, 29, 34,
02184     16, 16, 22, 24, 27, 29, 34, 37,
02185     19, 22, 26, 27, 29, 34, 34, 38,
02186     22, 22, 26, 27, 29, 34, 37, 40,
02187     22, 26, 27, 29, 32, 35, 40, 48,
02188     26, 27, 29, 32, 35, 40, 48, 58,
02189     26, 27, 29, 34, 38, 46, 56, 69,
02190     27, 29, 35, 38, 46, 56, 69, 83
02191 };
02192
02193 static const uint8_t PLM_VIDEO_NON_INTRA_QUANT_MATRIX[] = {
02194     16, 16, 16, 16, 16, 16, 16, 16,
02195     16, 16, 16, 16, 16, 16, 16, 16,
02196     16, 16, 16, 16, 16, 16, 16, 16,
02197     16, 16, 16, 16, 16, 16, 16, 16,
02198     16, 16, 16, 16, 16, 16, 16, 16,
02199     16, 16, 16, 16, 16, 16, 16, 16,
02200     16, 16, 16, 16, 16, 16, 16, 16,
02201     16, 16, 16, 16, 16, 16, 16, 16
02202 };
02203
02204 static const uint8_t PLM_VIDEO_PREMULTIPLIER_MATRIX[] = {
02205     32, 44, 42, 38, 32, 25, 17,  9,
02206     44, 62, 58, 52, 44, 35, 24, 12,
02207     42, 58, 55, 49, 42, 33, 23, 12,
02208     38, 52, 49, 44, 38, 30, 20, 10,
02209     32, 44, 42, 38, 32, 25, 17,  9,
02210     25, 35, 33, 30, 25, 20, 14,  7,
02211     17, 24, 23, 20, 17, 14,  9,  5,
02212      9, 12, 12, 10,  9,  7,  5,  2
02213 };
02214
02215 static const plm_vlc_t PLM_VIDEO_MACROBLOCK_ADDRESS_INCREMENT[] = {
02216     {  1 << 1,     0}, {        0,     1},  //   0: x
02217     {  2 << 1,     0}, {  3 << 1,     0},  //   1: 0x
02218     {  4 << 1,     0}, {  5 << 1,     0},  //   2: 00x
02219     {        0,    3}, {        0,     2},  //   3: 01x
02220     {  6 << 1,     0}, {  7 << 1,     0},  //   4: 000x
02221     {        0,    5}, {        0,     4},  //   5: 001x
02222     {  8 << 1,     0}, {  9 << 1,     0},  //   6: 0000x
02223     {        0,    7}, {        0,     6},  //   7: 0001x
02224     { 10 << 1,     0}, { 11 << 1,     0},  //   8: 0000 0x
02225     { 12 << 1,     0}, { 13 << 1,     0},  //   9: 0000 1x
02226     { 14 << 1,     0}, { 15 << 1,     0},  //  10: 0000 00x
02227     { 16 << 1,     0}, { 17 << 1,     0},  //  11: 0000 01x
02228     { 18 << 1,     0}, { 19 << 1,     0},  //  12: 0000 10x
02229     {        0,    9}, {        0,     8},  //  13: 0000 11x
02230     {       -1,    0}, { 20 << 1,     0},  //  14: 0000 000x
02231     {       -1,    0}, { 21 << 1,     0},  //  15: 0000 001x
02232     { 22 << 1,     0}, { 23 << 1,     0},  //  16: 0000 010x
02233     {        0,   15}, {        0,    14},  //  17: 0000 011x
02234     {        0,   13}, {        0,    12},  //  18: 0000 100x
02235     {        0,   11}, {        0,    10},  //  19: 0000 101x
02236     { 24 << 1,     0}, { 25 << 1,     0},  //  20: 0000 0001x
02237     { 26 << 1,     0}, { 27 << 1,     0},  //  21: 0000 0011x
02238     { 28 << 1,     0}, { 29 << 1,     0},  //  22: 0000 0100x
02239     { 30 << 1,     0}, { 31 << 1,     0},  //  23: 0000 0101x
02240     { 32 << 1,     0}, {       -1,    0},  //  24: 0000 0001 0x
02241     {       -1,    0}, { 33 << 1,     0},  //  25: 0000 0001 1x
02242     { 34 << 1,     0}, { 35 << 1,     0},  //  26: 0000 0011 0x
02243     { 36 << 1,     0}, { 37 << 1,     0},  //  27: 0000 0011 1x
02244     { 38 << 1,     0}, { 39 << 1,     0},  //  28: 0000 0100 0x
02245     {        0,   21}, {        0,    20},  //  29: 0000 0100 1x
02246     {        0,   19}, {        0,    18},  //  30: 0000 0101 0x
02247     {        0,   17}, {        0,    16},  //  31: 0000 0101 1x
02248     {        0,   35}, {       -1,    0},  //  32: 0000 0001 00x
02249     {       -1,    0}, {        0,    34},  //  33: 0000 0001 11x
02250     {        0,   33}, {        0,    32},  //  34: 0000 0011 00x
02251     {        0,   31}, {        0,    30},  //  35: 0000 0011 01x
02252     {        0,   29}, {        0,    28},  //  36: 0000 0011 10x
02253     {        0,   27}, {        0,    26},  //  37: 0000 0011 11x
02254     {        0,   25}, {        0,    24},  //  38: 0000 0100 00x
02255     {        0,   23}, {        0,    22},  //  39: 0000 0100 01x
02256 };
02257
02258 static const plm_vlc_t PLM_VIDEO_MACROBLOCK_TYPE_INTRA[] = {
02259     {  1 << 1,     0}, {        0,  0x01},  //   0: x
02260     {       -1,    0}, {        0,  0x11},  //   1: 0x
02261 };
02262
02263 static const plm_vlc_t PLM_VIDEO_MACROBLOCK_TYPE_PREDICTIVE[] = {
02264     {  1 << 1,     0}, {        0, 0x0a},  //   0: x
02265     {  2 << 1,     0}, {        0, 0x02},  //   1: 0x
02266     {  3 << 1,     0}, {        0, 0x08},  //   2: 00x
02267     {  4 << 1,     0}, {  5 << 1,     0},  //   3: 000x
02268     {  6 << 1,     0}, {        0, 0x12},  //   4: 0000x
02269     {        0, 0x1a}, {        0, 0x01},  //   5: 0001x
```

```
02270     {      -1,    0}, {       0, 0x11},  //   6: 0000 0x
02271 };
02272
02273 static const plm_vlc_t PLM_VIDEO_MACROBLOCK_TYPE_B[] = {
02274     {  1 << 1,    0}, {  2 << 1,    0},  //   0: x
02275     {  3 << 1,    0}, {  4 << 1,    0},  //   1: 0x
02276     {       0, 0x0c}, {       0, 0x0e},  //   2: 1x
02277     {  5 << 1,    0}, {  6 << 1,    0},  //   3: 00x
02278     {       0, 0x04}, {       0, 0x06},  //   4: 01x
02279     {  7 << 1,    0}, {  8 << 1,    0},  //   5: 000x
02280     {       0, 0x08}, {       0, 0x0a},  //   6: 001x
02281     {  9 << 1,    0}, { 10 << 1,    0},  //   7: 0000x
02282     {       0, 0x1e}, {       0, 0x01},  //   8: 0001x
02283     {      -1,    0}, {       0, 0x11},  //   9: 0000 0x
02284     {       0, 0x16}, {       0, 0x1a},  //  10: 0000 1x
02285 };
02286
02287 static const plm_vlc_t *PLM_VIDEO_MACROBLOCK_TYPE[] = {
02288     NULL,
02289     PLM_VIDEO_MACROBLOCK_TYPE_INTRA,
02290     PLM_VIDEO_MACROBLOCK_TYPE_PREDICTIVE,
02291     PLM_VIDEO_MACROBLOCK_TYPE_B
02292 };
02293
02294 static const plm_vlc_t PLM_VIDEO_CODE_BLOCK_PATTERN[] = {
02295     {  1 << 1,    0}, {  2 << 1,    0},  //   0: x
02296     {  3 << 1,    0}, {  4 << 1,    0},  //   1: 0x
02297     {  5 << 1,    0}, {  6 << 1,    0},  //   2: 1x
02298     {  7 << 1,    0}, {  8 << 1,    0},  //   3: 00x
02299     {  9 << 1,    0}, { 10 << 1,    0},  //   4: 01x
02300     { 11 << 1,    0}, { 12 << 1,    0},  //   5: 10x
02301     { 13 << 1,    0}, {       0,   60},  //   6: 11x
02302     { 14 << 1,    0}, { 15 << 1,    0},  //   7: 000x
02303     { 16 << 1,    0}, { 17 << 1,    0},  //   8: 001x
02304     { 18 << 1,    0}, { 19 << 1,    0},  //   9: 010x
02305     { 20 << 1,    0}, { 21 << 1,    0},  //  10: 011x
02306     { 22 << 1,    0}, { 23 << 1,    0},  //  11: 100x
02307     {       0,   32}, {       0,   16},  //  12: 101x
02308     {       0,    8}, {       0,    4},  //  13: 110x
02309     { 24 << 1,    0}, { 25 << 1,    0},  //  14: 0000x
02310     { 26 << 1,    0}, { 27 << 1,    0},  //  15: 0001x
02311     { 28 << 1,    0}, { 29 << 1,    0},  //  16: 0010x
02312     { 30 << 1,    0}, { 31 << 1,    0},  //  17: 0011x
02313     {       0,   62}, {       0,    2},  //  18: 0100x
02314     {       0,   61}, {       0,    1},  //  19: 0101x
02315     {       0,   56}, {       0,   52},  //  20: 0110x
02316     {       0,   44}, {       0,   28},  //  21: 0111x
02317     {       0,   40}, {       0,   20},  //  22: 1000x
02318     {       0,   48}, {       0,   12},  //  23: 1001x
02319     { 32 << 1,    0}, { 33 << 1,    0},  //  24: 0000 0x
02320     { 34 << 1,    0}, { 35 << 1,    0},  //  25: 0000 1x
02321     { 36 << 1,    0}, { 37 << 1,    0},  //  26: 0001 0x
02322     { 38 << 1,    0}, { 39 << 1,    0},  //  27: 0001 1x
02323     { 40 << 1,    0}, { 41 << 1,    0},  //  28: 0010 0x
02324     { 42 << 1,    0}, { 43 << 1,    0},  //  29: 0010 1x
02325     {       0,   63}, {       0,    3},  //  30: 0011 0x
02326     {       0,   36}, {       0,   24},  //  31: 0011 1x
02327     { 44 << 1,    0}, { 45 << 1,    0},  //  32: 0000 00x
02328     { 46 << 1,    0}, { 47 << 1,    0},  //  33: 0000 01x
02329     { 48 << 1,    0}, { 49 << 1,    0},  //  34: 0000 10x
02330     { 50 << 1,    0}, { 51 << 1,    0},  //  35: 0000 11x
02331     { 52 << 1,    0}, { 53 << 1,    0},  //  36: 0001 00x
02332     { 54 << 1,    0}, { 55 << 1,    0},  //  37: 0001 01x
02333     { 56 << 1,    0}, { 57 << 1,    0},  //  38: 0001 10x
02334     { 58 << 1,    0}, { 59 << 1,    0},  //  39: 0001 11x
02335     {       0,   34}, {       0,   18},  //  40: 0010 00x
02336     {       0,   10}, {       0,    6},  //  41: 0010 01x
02337     {       0,   33}, {       0,   17},  //  42: 0010 10x
02338     {       0,    9}, {       0,    5},  //  43: 0010 11x
02339     {      -1,    0}, { 60 << 1,    0},  //  44: 0000 000x
02340     { 61 << 1,    0}, { 62 << 1,    0},  //  45: 0000 001x
02341     {       0,   58}, {       0,   54},  //  46: 0000 010x
02342     {       0,   46}, {       0,   30},  //  47: 0000 011x
02343     {       0,   57}, {       0,   53},  //  48: 0000 100x
02344     {       0,   45}, {       0,   29},  //  49: 0000 101x
02345     {       0,   38}, {       0,   26},  //  50: 0000 110x
02346     {       0,   37}, {       0,   25},  //  51: 0000 111x
02347     {       0,   43}, {       0,   23},  //  52: 0001 000x
02348     {       0,   51}, {       0,   15},  //  53: 0001 001x
02349     {       0,   42}, {       0,   22},  //  54: 0001 010x
02350     {       0,   50}, {       0,   14},  //  55: 0001 011x
02351     {       0,   41}, {       0,   21},  //  56: 0001 100x
02352     {       0,   49}, {       0,   13},  //  57: 0001 101x
02353     {       0,   35}, {       0,   19},  //  58: 0001 110x
02354     {       0,   11}, {       0,    7},  //  59: 0001 111x
02355     {       0,   39}, {       0,   27},  //  60: 0000 0001x
02356     {       0,   59}, {       0,   55},  //  61: 0000 0010x
```

```
02357     {       0,   47}, {       0,   31},  //  62: 0000 0011x
02358 };
02359
02360 static const plm_vlc_t PLM_VIDEO_MOTION[] = {
02361     {  1 « 1,    0}, {       0,    0},  //   0: x
02362     {  2 « 1,    0}, {  3 « 1,    0},  //   1: 0x
02363     {  4 « 1,    0}, {  5 « 1,    0},  //   2: 00x
02364     {       0,   1}, {       0,   -1},  //   3: 01x
02365     {  6 « 1,    0}, {  7 « 1,    0},  //   4: 000x
02366     {       0,   2}, {       0,   -2},  //   5: 001x
02367     {  8 « 1,    0}, {  9 « 1,    0},  //   6: 0000x
02368     {       0,   3}, {       0,   -3},  //   7: 0001x
02369     { 10 « 1,    0}, { 11 « 1,    0},  //   8: 0000 0x
02370     { 12 « 1,    0}, { 13 « 1,    0},  //   9: 0000 1x
02371     {      -1,   0}, { 14 « 1,    0},  //  10: 0000 00x
02372     { 15 « 1,    0}, { 16 « 1,    0},  //  11: 0000 01x
02373     { 17 « 1,    0}, { 18 « 1,    0},  //  12: 0000 10x
02374     {       0,   4}, {       0,   -4},  //  13: 0000 11x
02375     {      -1,   0}, { 19 « 1,    0},  //  14: 0000 001x
02376     { 20 « 1,    0}, { 21 « 1,    0},  //  15: 0000 010x
02377     {       0,   7}, {       0,   -7},  //  16: 0000 011x
02378     {       0,   6}, {       0,   -6},  //  17: 0000 100x
02379     {       0,   5}, {       0,   -5},  //  18: 0000 101x
02380     { 22 « 1,    0}, { 23 « 1,    0},  //  19: 0000 0011x
02381     { 24 « 1,    0}, { 25 « 1,    0},  //  20: 0000 0100x
02382     { 26 « 1,    0}, { 27 « 1,    0},  //  21: 0000 0101x
02383     { 28 « 1,    0}, { 29 « 1,    0},  //  22: 0000 0011 0x
02384     { 30 « 1,    0}, { 31 « 1,    0},  //  23: 0000 0011 1x
02385     { 32 « 1,    0}, { 33 « 1,    0},  //  24: 0000 0100 0x
02386     {       0,  10}, {       0,  -10},  //  25: 0000 0100 1x
02387     {       0,   9}, {       0,   -9},  //  26: 0000 0101 0x
02388     {       0,   8}, {       0,   -8},  //  27: 0000 0101 1x
02389     {       0,  16}, {       0,  -16},  //  28: 0000 0011 00x
02390     {       0,  15}, {       0,  -15},  //  29: 0000 0011 01x
02391     {       0,  14}, {       0,  -14},  //  30: 0000 0011 10x
02392     {       0,  13}, {       0,  -13},  //  31: 0000 0011 11x
02393     {       0,  12}, {       0,  -12},  //  32: 0000 0100 00x
02394     {       0,  11}, {       0,  -11},  //  33: 0000 0100 01x
02395 };
02396
02397 static const plm_vlc_t PLM_VIDEO_DCT_SIZE_LUMINANCE[] = {
02398     {  1 « 1,    0}, {  2 « 1,    0},  //   0: x
02399     {       0,   1}, {       0,   2},  //   1: 0x
02400     {  3 « 1,    0}, {  4 « 1,    0},  //   2: 1x
02401     {       0,   0}, {       0,   3},  //   3: 10x
02402     {       0,   4}, {  5 « 1,    0},  //   4: 11x
02403     {       0,   5}, {  6 « 1,    0},  //   5: 111x
02404     {       0,   6}, {  7 « 1,    0},  //   6: 1111x
02405     {       0,   7}, {  8 « 1,    0},  //   7: 1111 1x
02406     {       0,   8}, {      -1,   0},  //   8: 1111 11x
02407 };
02408
02409 static const plm_vlc_t PLM_VIDEO_DCT_SIZE_CHROMINANCE[] = {
02410     {  1 « 1,    0}, {  2 « 1,    0},  //   0: x
02411     {       0,   0}, {       0,   1},  //   1: 0x
02412     {       0,   2}, {  3 « 1,    0},  //   2: 1x
02413     {       0,   3}, {  4 « 1,    0},  //   3: 11x
02414     {       0,   4}, {  5 « 1,    0},  //   4: 111x
02415     {       0,   5}, {  6 « 1,    0},  //   5: 1111x
02416     {       0,   6}, {  7 « 1,    0},  //   6: 1111 1x
02417     {       0,   7}, {  8 « 1,    0},  //   7: 1111 11x
02418     {       0,   8}, {      -1,   0},  //   8: 1111 111x
02419 };
02420
02421 static const plm_vlc_t *PLM_VIDEO_DCT_SIZE[] = {
02422     PLM_VIDEO_DCT_SIZE_LUMINANCE,
02423     PLM_VIDEO_DCT_SIZE_CHROMINANCE,
02424     PLM_VIDEO_DCT_SIZE_CHROMINANCE
02425 };
02426
02427
02428 //  dct_coeff bitmap:
02429 //    0xff00  run
02430 //    0x00ff  level
02431
02432 //  Decoded values are unsigned. Sign bit follows in the stream.
02433
02434 static const plm_vlc_uint_t PLM_VIDEO_DCT_COEFF[] = {
02435     {  1 « 1,        0}, {       0,   0x0001},  //   0: x
02436     {  2 « 1,        0}, {  3 « 1,        0},  //   1: 0x
02437     {  4 « 1,        0}, {  5 « 1,        0},  //   2: 00x
02438     {  6 « 1,        0}, {       0,   0x0101},  //   3: 01x
02439     {  7 « 1,        0}, {  8 « 1,        0},  //   4: 000x
02440     {  9 « 1,        0}, { 10 « 1,        0},  //   5: 001x
02441     {       0,   0x0002}, {       0,   0x0201},  //   6: 010x
02442     { 11 « 1,        0}, { 12 « 1,        0},  //   7: 0000x
02443     { 13 « 1,        0}, { 14 « 1,        0},  //   8: 0001x
```

```
02444     { 15 « 1,        0}, {       0,   0x0003},  //   9: 0010x
02445     {       0,   0x0401}, {       0,   0x0301},  //  10: 0011x
02446     { 16 « 1,        0}, {       0,   0xffff},  //  11: 0000 0x
02447     { 17 « 1,        0}, { 18 « 1,        0},  //  12: 0000 1x
02448     {       0,   0x0701}, {       0,   0x0601},  //  13: 0001 0x
02449     {       0,   0x0102}, {       0,   0x0501},  //  14: 0001 1x
02450     { 19 « 1,        0}, { 20 « 1,        0},  //  15: 0010 0x
02451     { 21 « 1,        0}, { 22 « 1,        0},  //  16: 0000 00x
02452     {       0,   0x0202}, {       0,   0x0901},  //  17: 0000 10x
02453     {       0,   0x0004}, {       0,   0x0801},  //  18: 0000 11x
02454     { 23 « 1,        0}, { 24 « 1,        0},  //  19: 0010 00x
02455     { 25 « 1,        0}, { 26 « 1,        0},  //  20: 0010 01x
02456     { 27 « 1,        0}, { 28 « 1,        0},  //  21: 0000 000x
02457     { 29 « 1,        0}, { 30 « 1,        0},  //  22: 0000 001x
02458     {       0,   0x0d01}, {       0,   0x0006},  //  23: 0010 000x
02459     {       0,   0x0c01}, {       0,   0x0b01},  //  24: 0010 001x
02460     {       0,   0x0302}, {       0,   0x0103},  //  25: 0010 010x
02461     {       0,   0x0005}, {       0,   0x0a01},  //  26: 0010 011x
02462     { 31 « 1,        0}, { 32 « 1,        0},  //  27: 0000 0000x
02463     { 33 « 1,        0}, { 34 « 1,        0},  //  28: 0000 0001x
02464     { 35 « 1,        0}, { 36 « 1,        0},  //  29: 0000 0010x
02465     { 37 « 1,        0}, { 38 « 1,        0},  //  30: 0000 0011x
02466     { 39 « 1,        0}, { 40 « 1,        0},  //  31: 0000 0000 0x
02467     { 41 « 1,        0}, { 42 « 1,        0},  //  32: 0000 0000 1x
02468     { 43 « 1,        0}, { 44 « 1,        0},  //  33: 0000 0001 0x
02469     { 45 « 1,        0}, { 46 « 1,        0},  //  34: 0000 0001 1x
02470     {       0,   0x1001}, {       0,   0x0502},  //  35: 0000 0010 0x
02471     {       0,   0x0007}, {       0,   0x0203},  //  36: 0000 0010 1x
02472     {       0,   0x0104}, {       0,   0x0f01},  //  37: 0000 0011 0x
02473     {       0,   0x0e01}, {       0,   0x0402},  //  38: 0000 0011 1x
02474     { 47 « 1,        0}, { 48 « 1,        0},  //  39: 0000 0000 00x
02475     { 49 « 1,        0}, { 50 « 1,        0},  //  40: 0000 0000 01x
02476     { 51 « 1,        0}, { 52 « 1,        0},  //  41: 0000 0000 10x
02477     { 53 « 1,        0}, { 54 « 1,        0},  //  42: 0000 0000 11x
02478     { 55 « 1,        0}, { 56 « 1,        0},  //  43: 0000 0001 00x
02479     { 57 « 1,        0}, { 58 « 1,        0},  //  44: 0000 0001 01x
02480     { 59 « 1,        0}, { 60 « 1,        0},  //  45: 0000 0001 10x
02481     { 61 « 1,        0}, { 62 « 1,        0},  //  46: 0000 0001 11x
02482     {      -1,        0}, { 63 « 1,        0},  //  47: 0000 0000 000x
02483     { 64 « 1,        0}, { 65 « 1,        0},  //  48: 0000 0000 001x
02484     { 66 « 1,        0}, { 67 « 1,        0},  //  49: 0000 0000 010x
02485     { 68 « 1,        0}, { 69 « 1,        0},  //  50: 0000 0000 011x
02486     { 70 « 1,        0}, { 71 « 1,        0},  //  51: 0000 0000 100x
02487     { 72 « 1,        0}, { 73 « 1,        0},  //  52: 0000 0000 101x
02488     { 74 « 1,        0}, { 75 « 1,        0},  //  53: 0000 0000 110x
02489     { 76 « 1,        0}, { 77 « 1,        0},  //  54: 0000 0000 111x
02490     {       0,   0x000b}, {       0,   0x0802},  //  55: 0000 0001 000x
02491     {       0,   0x0403}, {       0,   0x000a},  //  56: 0000 0001 001x
02492     {       0,   0x0204}, {       0,   0x0702},  //  57: 0000 0001 010x
02493     {       0,   0x1501}, {       0,   0x1401},  //  58: 0000 0001 011x
02494     {       0,   0x0009}, {       0,   0x1301},  //  59: 0000 0001 100x
02495     {       0,   0x1201}, {       0,   0x0105},  //  60: 0000 0001 101x
02496     {       0,   0x0303}, {       0,   0x0008},  //  61: 0000 0001 110x
02497     {       0,   0x0602}, {       0,   0x1101},  //  62: 0000 0001 111x
02498     { 78 « 1,        0}, { 79 « 1,        0},  //  63: 0000 0000 0001x
02499     { 80 « 1,        0}, { 81 « 1,        0},  //  64: 0000 0000 0010x
02500     { 82 « 1,        0}, { 83 « 1,        0},  //  65: 0000 0000 0011x
02501     { 84 « 1,        0}, { 85 « 1,        0},  //  66: 0000 0000 0100x
02502     { 86 « 1,        0}, { 87 « 1,        0},  //  67: 0000 0000 0101x
02503     { 88 « 1,        0}, { 89 « 1,        0},  //  68: 0000 0000 0110x
02504     { 90 « 1,        0}, { 91 « 1,        0},  //  69: 0000 0000 0111x
02505     {       0,   0x0a02}, {       0,   0x0902},  //  70: 0000 0000 1000x
02506     {       0,   0x0503}, {       0,   0x0304},  //  71: 0000 0000 1001x
02507     {       0,   0x0205}, {       0,   0x0107},  //  72: 0000 0000 1010x
02508     {       0,   0x0106}, {       0,   0x000f},  //  73: 0000 0000 1011x
02509     {       0,   0x000e}, {       0,   0x000d},  //  74: 0000 0000 1100x
02510     {       0,   0x000c}, {       0,   0x1a01},  //  75: 0000 0000 1101x
02511     {       0,   0x1901}, {       0,   0x1801},  //  76: 0000 0000 1110x
02512     {       0,   0x1701}, {       0,   0x1601},  //  77: 0000 0000 1111x
02513     { 92 « 1,        0}, { 93 « 1,        0},  //  78: 0000 0000 0001 0x
02514     { 94 « 1,        0}, { 95 « 1,        0},  //  79: 0000 0000 0001 1x
02515     { 96 « 1,        0}, { 97 « 1,        0},  //  80: 0000 0000 0010 0x
02516     { 98 « 1,        0}, { 99 « 1,        0},  //  81: 0000 0000 0010 1x
02517     {100 « 1,        0}, {101 « 1,        0},  //  82: 0000 0000 0011 0x
02518     {102 « 1,        0}, {103 « 1,        0},  //  83: 0000 0000 0011 1x
02519     {       0,   0x001f}, {       0,   0x001e},  //  84: 0000 0000 0100 0x
02520     {       0,   0x001d}, {       0,   0x001c},  //  85: 0000 0000 0100 1x
02521     {       0,   0x001b}, {       0,   0x001a},  //  86: 0000 0000 0101 0x
02522     {       0,   0x0019}, {       0,   0x0018},  //  87: 0000 0000 0101 1x
02523     {       0,   0x0017}, {       0,   0x0016},  //  88: 0000 0000 0110 0x
02524     {       0,   0x0015}, {       0,   0x0014},  //  89: 0000 0000 0110 1x
02525     {       0,   0x0013}, {       0,   0x0012},  //  90: 0000 0000 0111 0x
02526     {       0,   0x0011}, {       0,   0x0010},  //  91: 0000 0000 0111 1x
02527     {104 « 1,        0}, {105 « 1,        0},  //  92: 0000 0000 0001 00x
02528     {106 « 1,        0}, {107 « 1,        0},  //  93: 0000 0000 0001 01x
02529     {108 « 1,        0}, {109 « 1,        0},  //  94: 0000 0000 0001 10x
02530     {110 « 1,        0}, {111 « 1,        0},  //  95: 0000 0000 0001 11x
```

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02531     {       0,   0x0028}, {       0,   0x0027},  //  96: 0000 0000 0010 00x
02532     {       0,   0x0026}, {       0,   0x0025},  //  97: 0000 0000 0010 01x
02533     {       0,   0x0024}, {       0,   0x0023},  //  98: 0000 0000 0010 10x
02534     {       0,   0x0022}, {       0,   0x0021},  //  99: 0000 0000 0010 11x
02535     {       0,   0x0020}, {       0,   0x010e},  // 100: 0000 0000 0011 00x
02536     {       0,   0x010d}, {       0,   0x010c},  // 101: 0000 0000 0011 01x
02537     {       0,   0x010b}, {       0,   0x010a},  // 102: 0000 0000 0011 10x
02538     {       0,   0x0109}, {       0,   0x0108},  // 103: 0000 0000 0011 11x
02539     {       0,   0x0112}, {       0,   0x0111},  // 104: 0000 0000 0001 000x
02540     {       0,   0x0110}, {       0,   0x010f},  // 105: 0000 0000 0001 001x
02541     {       0,   0x0603}, {       0,   0x1002},  // 106: 0000 0000 0001 010x
02542     {       0,   0x0f02}, {       0,   0x0e02},  // 107: 0000 0000 0001 011x
02543     {       0,   0x0d02}, {       0,   0x0c02},  // 108: 0000 0000 0001 100x
02544     {       0,   0x0b02}, {       0,   0x1f01},  // 109: 0000 0000 0001 101x
02545     {       0,   0x1e01}, {       0,   0x1d01},  // 110: 0000 0000 0001 110x
02546     {       0,   0x1c01}, {       0,   0x1b01},  // 111: 0000 0000 0001 111x
02547 };
02548
02549 typedef struct {
02550     int full_px;
02551     int is_set;
02552     int r_size;
02553     int h;
02554     int v;
02555 } plm_video_motion_t;
02556
02557 struct plm_video_t {
02558     double framerate;
02559     double time;
02560     int frames_decoded;
02561     int width;
02562     int height;
02563     int mb_width;
02564     int mb_height;
02565     int mb_size;
02566
02567     int luma_width;
02568     int luma_height;
02569
02570     int chroma_width;
02571     int chroma_height;
02572
02573     int start_code;
02574     int picture_type;
02575
02576     plm_video_motion_t motion_forward;
02577     plm_video_motion_t motion_backward;
02578
02579     int has_sequence_header;
02580
02581     int quantizer_scale;
02582     int slice_begin;
02583     int macroblock_address;
02584
02585     int mb_row;
02586     int mb_col;
02587
02588     int macroblock_type;
02589     int macroblock_intra;
02590
02591     int dc_predictor[3];
02592
02593     plm_buffer_t *buffer;
02594     int destroy_buffer_when_done;
02595
02596     plm_frame_t frame_current;
02597     plm_frame_t frame_forward;
02598     plm_frame_t frame_backward;
02599
02600     uint8_t *frames_data;
02601
02602     int block_data[64];
02603     uint8_t intra_quant_matrix[64];
02604     uint8_t non_intra_quant_matrix[64];
02605
02606     int has_reference_frame;
02607     int assume_no_b_frames;
02608 };
02609
02610 static inline uint8_t plm_clamp(int n) {
02611     if (n > 255) {
02612         n = 255;
02613     }
02614     else if (n < 0) {
02615         n = 0;
02616     }
02617     return n;
```

```
02618 }
02619
02620 int plm_video_decode_sequence_header(plm_video_t *self);
02621 void plm_video_init_frame(plm_video_t *self, plm_frame_t *frame, uint8_t *base);
02622 void plm_video_decode_picture(plm_video_t *self);
02623 void plm_video_decode_slice(plm_video_t *self, int slice);
02624 void plm_video_decode_macroblock(plm_video_t *self);
02625 void plm_video_decode_motion_vectors(plm_video_t *self);
02626 int plm_video_decode_motion_vector(plm_video_t *self, int r_size, int motion);
02627 void plm_video_predict_macroblock(plm_video_t *self);
02628 void plm_video_copy_macroblock(plm_video_t *self, plm_frame_t *s, int motion_h, int motion_v);
02629 void plm_video_interpolate_macroblock(plm_video_t *self, plm_frame_t *s, int motion_h, int motion_v);
02630 void plm_video_process_macroblock(plm_video_t *self, uint8_t *s, uint8_t *d, int mh, int mb, int bs,
      int interp);
02631 void plm_video_decode_block(plm_video_t *self, int block);
02632 void plm_video_idct(int *block);
02633
02634 plm_video_t * plm_video_create_with_buffer(plm_buffer_t *buffer, int destroy_when_done) {
02635     plm_video_t *self = (plm_video_t *)PLM_MALLOC(sizeof(plm_video_t));
02636     memset(self, 0, sizeof(plm_video_t));
02637
02638     self->buffer = buffer;
02639     self->destroy_buffer_when_done = destroy_when_done;
02640
02641     // Attempt to decode the sequence header
02642     self->start_code = plm_buffer_find_start_code(self->buffer, PLM_START_SEQUENCE);
02643     if (self->start_code != -1) {
02644         plm_video_decode_sequence_header(self);
02645     }
02646     return self;
02647 }
02648
02649 void plm_video_destroy(plm_video_t *self) {
02650     if (self->destroy_buffer_when_done) {
02651         plm_buffer_destroy(self->buffer);
02652     }
02653
02654     if (self->has_sequence_header) {
02655         PLM_FREE(self->frames_data);
02656     }
02657
02658     PLM_FREE(self);
02659 }
02660
02661 double plm_video_get_framerate(plm_video_t *self) {
02662     return plm_video_has_header(self)
02663         ? self->framerate
02664         : 0;
02665 }
02666
02667 int plm_video_get_width(plm_video_t *self) {
02668     return plm_video_has_header(self)
02669         ? self->width
02670         : 0;
02671 }
02672
02673 int plm_video_get_height(plm_video_t *self) {
02674     return plm_video_has_header(self)
02675         ? self->height
02676         : 0;
02677 }
02678
02679 void plm_video_set_no_delay(plm_video_t *self, int no_delay) {
02680     self->assume_no_b_frames = no_delay;
02681 }
02682
02683 double plm_video_get_time(plm_video_t *self) {
02684     return self->time;
02685 }
02686
02687 void plm_video_set_time(plm_video_t *self, double time) {
02688     self->frames_decoded = self->framerate * time;
02689     self->time = time;
02690 }
02691
02692 void plm_video_rewind(plm_video_t *self) {
02693     plm_buffer_rewind(self->buffer);
02694     self->time = 0;
02695     self->frames_decoded = 0;
02696     self->has_reference_frame = FALSE;
02697     self->start_code = -1;
02698 }
02699
02700 int plm_video_has_ended(plm_video_t *self) {
02701     return plm_buffer_has_ended(self->buffer);
02702 }
02703
```

```
02704 plm_frame_t *plm_video_decode(plm_video_t *self) {
02705     if (!plm_video_has_header(self)) {
02706         return NULL;
02707     }
02708
02709     plm_frame_t *frame = NULL;
02710     do {
02711         if (self->start_code != PLM_START_PICTURE) {
02712             self->start_code = plm_buffer_find_start_code(self->buffer, PLM_START_PICTURE);
02713
02714             if (self->start_code == -1) {
02715                 // If we reached the end of the file and the previously decoded
02716                 // frame was a reference frame, we still have to return it.
02717                 if (
02718                     self->has_reference_frame &&
02719                     !self->assume_no_b_frames &&
02720                     plm_buffer_has_ended(self->buffer) && (
02721                         self->picture_type == PLM_VIDEO_PICTURE_TYPE_INTRA ||
02722                         self->picture_type == PLM_VIDEO_PICTURE_TYPE_PREDICTIVE
02723                     )
02724                 ) {
02725                     self->has_reference_frame = FALSE;
02726                     frame = &self->frame_backward;
02727                     break;
02728                 }
02729
02730                 return NULL;
02731             }
02732         }
02733
02734         // Make sure we have a full picture in the buffer before attempting to
02735         // decode it. Sadly, this can only be done by seeking for the start code
02736         // of the next picture. Also, if we didn't find the start code for the
02737         // next picture, but the source has ended, we assume that this last
02738         // picture is in the buffer.
02739         if (
02740             plm_buffer_has_start_code(self->buffer, PLM_START_PICTURE) == -1 &&
02741             !plm_buffer_has_ended(self->buffer)
02742         ) {
02743             return NULL;
02744         }
02745         plm_buffer_discard_read_bytes(self->buffer);
02746
02747         plm_video_decode_picture(self);
02748
02749         if (self->assume_no_b_frames) {
02750             frame = &self->frame_backward;
02751         }
02752         else if (self->picture_type == PLM_VIDEO_PICTURE_TYPE_B) {
02753             frame = &self->frame_current;
02754         }
02755         else if (self->has_reference_frame) {
02756             frame = &self->frame_forward;
02757         }
02758         else {
02759             self->has_reference_frame = TRUE;
02760         }
02761     } while (!frame);
02762
02763     frame->time = self->time;
02764     self->frames_decoded++;
02765     self->time = (double)self->frames_decoded / self->framerate;
02766
02767     return frame;
02768 }
02769
02770 int plm_video_has_header(plm_video_t *self) {
02771     if (self->has_sequence_header) {
02772         return TRUE;
02773     }
02774
02775     if (self->start_code != PLM_START_SEQUENCE) {
02776         self->start_code = plm_buffer_find_start_code(self->buffer, PLM_START_SEQUENCE);
02777     }
02778     if (self->start_code == -1) {
02779         return FALSE;
02780     }
02781
02782     if (!plm_video_decode_sequence_header(self)) {
02783         return FALSE;
02784     }
02785
02786     return TRUE;
02787 }
02788
02789 int plm_video_decode_sequence_header(plm_video_t *self) {
02790     int max_header_size = 64 + 2 * 64 * 8; // 64 bit header + 2x 64 byte matrix
```

```
02791     if (!plm_buffer_has(self->buffer, max_header_size)) {
02792         return FALSE;
02793     }
02794
02795     self->width = plm_buffer_read(self->buffer, 12);
02796     self->height = plm_buffer_read(self->buffer, 12);
02797
02798     if (self->width <= 0 || self->height <= 0) {
02799         return FALSE;
02800     }
02801
02802     // Skip pixel aspect ratio
02803     plm_buffer_skip(self->buffer, 4);
02804
02805     self->framerate = PLM_VIDEO_PICTURE_RATE[plm_buffer_read(self->buffer, 4)];
02806
02807     // Skip bit_rate, marker, buffer_size and constrained bit
02808     plm_buffer_skip(self->buffer, 18 + 1 + 10 + 1);
02809
02810     // Load custom intra quant matrix?
02811     if (plm_buffer_read(self->buffer, 1)) {
02812         for (int i = 0; i < 64; i++) {
02813             int idx = PLM_VIDEO_ZIG_ZAG[i];
02814             self->intra_quant_matrix[idx] = plm_buffer_read(self->buffer, 8);
02815         }
02816     }
02817     else {
02818         memcpy(self->intra_quant_matrix, PLM_VIDEO_INTRA_QUANT_MATRIX, 64);
02819     }
02820
02821     // Load custom non intra quant matrix?
02822     if (plm_buffer_read(self->buffer, 1)) {
02823         for (int i = 0; i < 64; i++) {
02824             int idx = PLM_VIDEO_ZIG_ZAG[i];
02825             self->non_intra_quant_matrix[idx] = plm_buffer_read(self->buffer, 8);
02826         }
02827     }
02828     else {
02829         memcpy(self->non_intra_quant_matrix, PLM_VIDEO_NON_INTRA_QUANT_MATRIX, 64);
02830     }
02831
02832     self->mb_width = (self->width + 15) » 4;
02833     self->mb_height = (self->height + 15) » 4;
02834     self->mb_size = self->mb_width * self->mb_height;
02835
02836     self->luma_width = self->mb_width « 4;
02837     self->luma_height = self->mb_height « 4;
02838
02839     self->chroma_width = self->mb_width « 3;
02840     self->chroma_height = self->mb_height « 3;
02841
02842
02843     // Allocate one big chunk of data for all 3 frames = 9 planes
02844     size_t luma_plane_size = self->luma_width * self->luma_height;
02845     size_t chroma_plane_size = self->chroma_width * self->chroma_height;
02846     size_t frame_data_size = (luma_plane_size + 2 * chroma_plane_size);
02847
02848     self->frames_data = (uint8_t*)PLM_MALLOC(frame_data_size * 3);
02849     plm_video_init_frame(self, &self->frame_current, self->frames_data + frame_data_size * 0);
02850     plm_video_init_frame(self, &self->frame_forward, self->frames_data + frame_data_size * 1);
02851     plm_video_init_frame(self, &self->frame_backward, self->frames_data + frame_data_size * 2);
02852
02853     self->has_sequence_header = TRUE;
02854     return TRUE;
02855 }
02856
02857 void plm_video_init_frame(plm_video_t *self, plm_frame_t *frame, uint8_t *base) {
02858     size_t luma_plane_size = self->luma_width * self->luma_height;
02859     size_t chroma_plane_size = self->chroma_width * self->chroma_height;
02860
02861     frame->width = self->width;
02862     frame->height = self->height;
02863     frame->y.width = self->luma_width;
02864     frame->y.height = self->luma_height;
02865     frame->y.data = base;
02866
02867     frame->cr.width = self->chroma_width;
02868     frame->cr.height = self->chroma_height;
02869     frame->cr.data = base + luma_plane_size;
02870
02871     frame->cb.width = self->chroma_width;
02872     frame->cb.height = self->chroma_height;
02873     frame->cb.data = base + luma_plane_size + chroma_plane_size;
02874 }
02875
02876 void plm_video_decode_picture(plm_video_t *self) {
02877     plm_buffer_skip(self->buffer, 10); // skip temporalReference
```

```
02878     self->picture_type = plm_buffer_read(self->buffer, 3);
02879     plm_buffer_skip(self->buffer, 16); // skip vbv_delay
02880
02881     // D frames or unknown coding type
02882     if (self->picture_type <= 0 || self->picture_type > PLM_VIDEO_PICTURE_TYPE_B) {
02883         return;
02884     }
02885
02886     // Forward full_px, f_code
02887     if (
02888         self->picture_type == PLM_VIDEO_PICTURE_TYPE_PREDICTIVE ||
02889         self->picture_type == PLM_VIDEO_PICTURE_TYPE_B
02890     ) {
02891         self->motion_forward.full_px = plm_buffer_read(self->buffer, 1);
02892         int f_code = plm_buffer_read(self->buffer, 3);
02893         if (f_code == 0) {
02894             // Ignore picture with zero f_code
02895             return;
02896         }
02897         self->motion_forward.r_size = f_code - 1;
02898     }
02899
02900     // Backward full_px, f_code
02901     if (self->picture_type == PLM_VIDEO_PICTURE_TYPE_B) {
02902         self->motion_backward.full_px = plm_buffer_read(self->buffer, 1);
02903         int f_code = plm_buffer_read(self->buffer, 3);
02904         if (f_code == 0) {
02905             // Ignore picture with zero f_code
02906             return;
02907         }
02908         self->motion_backward.r_size = f_code - 1;
02909     }
02910
02911     plm_frame_t frame_temp = self->frame_forward;
02912     if (
02913         self->picture_type == PLM_VIDEO_PICTURE_TYPE_INTRA ||
02914         self->picture_type == PLM_VIDEO_PICTURE_TYPE_PREDICTIVE
02915     ) {
02916         self->frame_forward = self->frame_backward;
02917     }
02918
02919
02920     // Find first slice start code; skip extension and user data
02921     do {
02922         self->start_code = plm_buffer_next_start_code(self->buffer);
02923     } while (
02924         self->start_code == PLM_START_EXTENSION ||
02925         self->start_code == PLM_START_USER_DATA
02926     );
02927
02928     // Decode all slices
02929     while (PLM_START_IS_SLICE(self->start_code)) {
02930         plm_video_decode_slice(self, self->start_code & 0x000000FF);
02931         if (self->macroblock_address >= self->mb_size - 2) {
02932             break;
02933         }
02934         self->start_code = plm_buffer_next_start_code(self->buffer);
02935     }
02936
02937     // If this is a reference picture rotate the prediction pointers
02938     if (
02939         self->picture_type == PLM_VIDEO_PICTURE_TYPE_INTRA ||
02940         self->picture_type == PLM_VIDEO_PICTURE_TYPE_PREDICTIVE
02941     ) {
02942         self->frame_backward = self->frame_current;
02943         self->frame_current = frame_temp;
02944     }
02945 }
02946
02947 void plm_video_decode_slice(plm_video_t *self, int slice) {
02948     self->slice_begin = TRUE;
02949     self->macroblock_address = (slice - 1) * self->mb_width - 1;
02950
02951     // Reset motion vectors and DC predictors
02952     self->motion_backward.h = self->motion_forward.h = 0;
02953     self->motion_backward.v = self->motion_forward.v = 0;
02954     self->dc_predictor[0] = 128;
02955     self->dc_predictor[1] = 128;
02956     self->dc_predictor[2] = 128;
02957
02958     self->quantizer_scale = plm_buffer_read(self->buffer, 5);
02959
02960     // Skip extra
02961     while (plm_buffer_read(self->buffer, 1)) {
02962         plm_buffer_skip(self->buffer, 8);
02963     }
02964
```

```
02965     do {
02966         plm_video_decode_macroblock(self);
02967     } while (
02968         self->macroblock_address < self->mb_size - 1 &&
02969         plm_buffer_peek_non_zero(self->buffer, 23)
02970     );
02971 }
02972
02973 void plm_video_decode_macroblock(plm_video_t *self) {
02974     // Decode increment
02975     int increment = 0;
02976     int t = plm_buffer_read_vlc(self->buffer, PLM_VIDEO_MACROBLOCK_ADDRESS_INCREMENT);
02977
02978     while (t == 34) {
02979         // macroblock_stuffing
02980         t = plm_buffer_read_vlc(self->buffer, PLM_VIDEO_MACROBLOCK_ADDRESS_INCREMENT);
02981     }
02982     while (t == 35) {
02983         // macroblock_escape
02984         increment += 33;
02985         t = plm_buffer_read_vlc(self->buffer, PLM_VIDEO_MACROBLOCK_ADDRESS_INCREMENT);
02986     }
02987     increment += t;
02988
02989     // Process any skipped macroblocks
02990     if (self->slice_begin) {
02991         // The first increment of each slice is relative to beginning of the
02992         // previous row, not the previous macroblock
02993         self->slice_begin = FALSE;
02994         self->macroblock_address += increment;
02995     }
02996     else {
02997         if (self->macroblock_address + increment >= self->mb_size) {
02998             return; // invalid
02999         }
03000         if (increment > 1) {
03001             // Skipped macroblocks reset DC predictors
03002             self->dc_predictor[0] = 128;
03003             self->dc_predictor[1] = 128;
03004             self->dc_predictor[2] = 128;
03005
03006             // Skipped macroblocks in P-pictures reset motion vectors
03007             if (self->picture_type == PLM_VIDEO_PICTURE_TYPE_PREDICTIVE) {
03008                 self->motion_forward.h = 0;
03009                 self->motion_forward.v = 0;
03010             }
03011         }
03012
03013         // Predict skipped macroblocks
03014         while (increment > 1) {
03015             self->macroblock_address++;
03016             self->mb_row = self->macroblock_address / self->mb_width;
03017             self->mb_col = self->macroblock_address % self->mb_width;
03018
03019             plm_video_predict_macroblock(self);
03020             increment--;
03021         }
03022         self->macroblock_address++;
03023     }
03024
03025     self->mb_row = self->macroblock_address / self->mb_width;
03026     self->mb_col = self->macroblock_address % self->mb_width;
03027
03028     if (self->mb_col >= self->mb_width || self->mb_row >= self->mb_height) {
03029         return; // corrupt stream;
03030     }
03031
03032     // Process the current macroblock
03033     const plm_vlc_t *table = PLM_VIDEO_MACROBLOCK_TYPE[self->picture_type];
03034     self->macroblock_type = plm_buffer_read_vlc(self->buffer, table);
03035
03036     self->macroblock_intra = (self->macroblock_type & 0x01);
03037     self->motion_forward.is_set = (self->macroblock_type & 0x08);
03038     self->motion_backward.is_set = (self->macroblock_type & 0x04);
03039
03040     // Quantizer scale
03041     if ((self->macroblock_type & 0x10) != 0) {
03042         self->quantizer_scale = plm_buffer_read(self->buffer, 5);
03043     }
03044
03045     if (self->macroblock_intra) {
03046         // Intra-coded macroblocks reset motion vectors
03047         self->motion_backward.h = self->motion_forward.h = 0;
03048         self->motion_backward.v = self->motion_forward.v = 0;
03049     }
03050     else {
03051         // Non-intra macroblocks reset DC predictors
```

```
03052         self->dc_predictor[0] = 128;
03053         self->dc_predictor[1] = 128;
03054         self->dc_predictor[2] = 128;
03055 
03056         plm_video_decode_motion_vectors(self);
03057         plm_video_predict_macroblock(self);
03058     }
03059 
03060     // Decode blocks
03061     int cbp = ((self->macroblock_type & 0x02) != 0)
03062         ? plm_buffer_read_vlc(self->buffer, PLM_VIDEO_CODE_BLOCK_PATTERN)
03063         : (self->macroblock_intra ? 0x3f : 0);
03064 
03065     for (int block = 0, mask = 0x20; block < 6; block++) {
03066         if ((cbp & mask) != 0) {
03067             plm_video_decode_block(self, block);
03068         }
03069         mask »= 1;
03070     }
03071 }
03072 
03073 void plm_video_decode_motion_vectors(plm_video_t *self) {
03074 
03075     // Forward
03076     if (self->motion_forward.is_set) {
03077         int r_size = self->motion_forward.r_size;
03078         self->motion_forward.h = plm_video_decode_motion_vector(self, r_size, self->motion_forward.h);
03079         self->motion_forward.v = plm_video_decode_motion_vector(self, r_size, self->motion_forward.v);
03080     }
03081     else if (self->picture_type == PLM_VIDEO_PICTURE_TYPE_PREDICTIVE) {
03082         // No motion information in P-picture, reset vectors
03083         self->motion_forward.h = 0;
03084         self->motion_forward.v = 0;
03085     }
03086 
03087     if (self->motion_backward.is_set) {
03088         int r_size = self->motion_backward.r_size;
03089         self->motion_backward.h = plm_video_decode_motion_vector(self, r_size,
      self->motion_backward.h);
03090         self->motion_backward.v = plm_video_decode_motion_vector(self, r_size,
      self->motion_backward.v);
03091     }
03092 }
03093 
03094 int plm_video_decode_motion_vector(plm_video_t *self, int r_size, int motion) {
03095     int fscale = 1 « r_size;
03096     int m_code = plm_buffer_read_vlc(self->buffer, PLM_VIDEO_MOTION);
03097     int r = 0;
03098     int d;
03099 
03100     if ((m_code != 0) && (fscale != 1)) {
03101         r = plm_buffer_read(self->buffer, r_size);
03102         d = ((abs(m_code) - 1) « r_size) + r + 1;
03103         if (m_code < 0) {
03104             d = -d;
03105         }
03106     }
03107     else {
03108         d = m_code;
03109     }
03110 
03111     motion += d;
03112     if (motion > (fscale « 4) - 1) {
03113         motion -= fscale « 5;
03114     }
03115     else if (motion < ((-fscale) « 4)) {
03116         motion += fscale « 5;
03117     }
03118 
03119     return motion;
03120 }
03121 
03122 void plm_video_predict_macroblock(plm_video_t *self) {
03123     int fw_h = self->motion_forward.h;
03124     int fw_v = self->motion_forward.v;
03125 
03126     if (self->motion_forward.full_px) {
03127         fw_h «= 1;
03128         fw_v «= 1;
03129     }
03130 
03131     if (self->picture_type == PLM_VIDEO_PICTURE_TYPE_B) {
03132         int bw_h = self->motion_backward.h;
03133         int bw_v = self->motion_backward.v;
03134 
03135         if (self->motion_backward.full_px) {
03136             bw_h «= 1;
```

```
03137             bw_v <<= 1;
03138         }
03139
03140         if (self->motion_forward.is_set) {
03141             plm_video_copy_macroblock(self, &self->frame_forward, fw_h, fw_v);
03142             if (self->motion_backward.is_set) {
03143                 plm_video_interpolate_macroblock(self, &self->frame_backward, bw_h, bw_v);
03144             }
03145         }
03146         else {
03147             plm_video_copy_macroblock(self, &self->frame_backward, bw_h, bw_v);
03148         }
03149     }
03150     else {
03151         plm_video_copy_macroblock(self, &self->frame_forward, fw_h, fw_v);
03152     }
03153 }
03154
03155 void plm_video_copy_macroblock(plm_video_t *self, plm_frame_t *s, int motion_h, int motion_v) {
03156     plm_frame_t *d = &self->frame_current;
03157     plm_video_process_macroblock(self, s->y.data, d->y.data, motion_h, motion_v, 16, FALSE);
03158     plm_video_process_macroblock(self, s->cr.data, d->cr.data, motion_h / 2, motion_v / 2, 8, FALSE);
03159     plm_video_process_macroblock(self, s->cb.data, d->cb.data, motion_h / 2, motion_v / 2, 8, FALSE);
03160 }
03161
03162 void plm_video_interpolate_macroblock(plm_video_t *self, plm_frame_t *s, int motion_h, int motion_v) {
03163     plm_frame_t *d = &self->frame_current;
03164     plm_video_process_macroblock(self, s->y.data, d->y.data, motion_h, motion_v, 16, TRUE);
03165     plm_video_process_macroblock(self, s->cr.data, d->cr.data, motion_h / 2, motion_v / 2, 8, TRUE);
03166     plm_video_process_macroblock(self, s->cb.data, d->cb.data, motion_h / 2, motion_v / 2, 8, TRUE);
03167 }
03168
03169 #define PLM_BLOCK_SET(DEST, DEST_INDEX, DEST_WIDTH, SOURCE_INDEX, SOURCE_WIDTH, BLOCK_SIZE, OP) do { \
03170     int dest_scan = DEST_WIDTH - BLOCK_SIZE; \
03171     int source_scan = SOURCE_WIDTH - BLOCK_SIZE; \
03172     for (int y = 0; y < BLOCK_SIZE; y++) { \
03173         for (int x = 0; x < BLOCK_SIZE; x++) { \
03174             DEST[DEST_INDEX] = OP; \
03175             SOURCE_INDEX++; DEST_INDEX++; \
03176         } \
03177         SOURCE_INDEX += source_scan; \
03178         DEST_INDEX += dest_scan; \
03179     }} while(FALSE)
03180
03181 void plm_video_process_macroblock(
03182     plm_video_t *self, uint8_t *s, uint8_t *d,
03183     int motion_h, int motion_v, int block_size, int interpolate
03184 ) {
03185     int dw = self->mb_width * block_size;
03186
03187     int hp = motion_h >> 1;
03188     int vp = motion_v >> 1;
03189     int odd_h = (motion_h & 1) == 1;
03190     int odd_v = (motion_v & 1) == 1;
03191
03192     unsigned int si = ((self->mb_row * block_size) + vp) * dw + (self->mb_col * block_size) + hp;
03193     unsigned int di = (self->mb_row * dw + self->mb_col) * block_size;
03194
03195     unsigned int max_address = (dw * (self->mb_height * block_size - block_size + 1) - block_size);
03196     if (si > max_address || di > max_address) {
03197         return; // corrupt video
03198     }
03199
03200     #define PLM_MB_CASE(INTERPOLATE, ODD_H, ODD_V, OP) \
03201         case ((INTERPOLATE << 2) | (ODD_H << 1) | (ODD_V)): \
03202             PLM_BLOCK_SET(d, di, dw, si, dw, block_size, OP); \
03203             break
03204
03205     switch ((interpolate << 2) | (odd_h << 1) | (odd_v)) {
03206         PLM_MB_CASE(0, 0, 0, (s[si]));
03207         PLM_MB_CASE(0, 0, 1, (s[si] + s[si + dw] + 1) >> 1);
03208         PLM_MB_CASE(0, 1, 0, (s[si] + s[si + 1] + 1) >> 1);
03209         PLM_MB_CASE(0, 1, 1, (s[si] + s[si + 1] + s[si + dw] + s[si + dw + 1] + 2) >> 2);
03210
03211         PLM_MB_CASE(1, 0, 0, (d[di] + (s[si]) + 1) >> 1);
03212         PLM_MB_CASE(1, 0, 1, (d[di] + ((s[si] + s[si + dw] + 1) >> 1) + 1) >> 1);
03213         PLM_MB_CASE(1, 1, 0, (d[di] + ((s[si] + s[si + 1] + 1) >> 1) + 1) >> 1);
03214         PLM_MB_CASE(1, 1, 1, (d[di] + ((s[si] + s[si + 1] + s[si + dw] + s[si + dw + 1] + 2) >> 2) + 1)
      >> 1);
03215     }
03216
03217     #undef PLM_MB_CASE
03218 }
03219
03220 void plm_video_decode_block(plm_video_t *self, int block) {
03221
03222     int n = 0;
```

```
03223     uint8_t *quant_matrix;
03224
03225     // Decode DC coefficient of intra-coded blocks
03226     if (self->macroblock_intra) {
03227         int predictor;
03228         int dct_size;
03229
03230         // DC prediction
03231         int plane_index = block > 3 ? block - 3 : 0;
03232         predictor = self->dc_predictor[plane_index];
03233         dct_size = plm_buffer_read_vlc(self->buffer, PLM_VIDEO_DCT_SIZE[plane_index]);
03234
03235         // Read DC coeff
03236         if (dct_size > 0) {
03237             int differential = plm_buffer_read(self->buffer, dct_size);
03238             if ((differential & (1 << (dct_size - 1))) != 0) {
03239                 self->block_data[0] = predictor + differential;
03240             }
03241             else {
03242                 self->block_data[0] = predictor + (-(1 << dct_size) | (differential + 1));
03243             }
03244         }
03245         else {
03246             self->block_data[0] = predictor;
03247         }
03248
03249         // Save predictor value
03250         self->dc_predictor[plane_index] = self->block_data[0];
03251
03252         // Dequantize + premultiply
03253         self->block_data[0] <<= (3 + 5);
03254
03255         quant_matrix = self->intra_quant_matrix;
03256         n = 1;
03257     }
03258     else {
03259         quant_matrix = self->non_intra_quant_matrix;
03260     }
03261
03262     // Decode AC coefficients (+DC for non-intra)
03263     int level = 0;
03264     while (TRUE) {
03265         int run = 0;
03266         uint16_t coeff = plm_buffer_read_vlc_uint(self->buffer, PLM_VIDEO_DCT_COEFF);
03267
03268         if ((coeff == 0x0001) && (n > 0) && (plm_buffer_read(self->buffer, 1) == 0)) {
03269             // end_of_block
03270             break;
03271         }
03272         if (coeff == 0xffff) {
03273             // escape
03274             run = plm_buffer_read(self->buffer, 6);
03275             level = plm_buffer_read(self->buffer, 8);
03276             if (level == 0) {
03277                 level = plm_buffer_read(self->buffer, 8);
03278             }
03279             else if (level == 128) {
03280                 level = plm_buffer_read(self->buffer, 8) - 256;
03281             }
03282             else if (level > 128) {
03283                 level = level - 256;
03284             }
03285         }
03286         else {
03287             run = coeff >> 8;
03288             level = coeff & 0xff;
03289             if (plm_buffer_read(self->buffer, 1)) {
03290                 level = -level;
03291             }
03292         }
03293
03294         n += run;
03295         if (n < 0 || n >= 64) {
03296             return; // invalid
03297         }
03298
03299         int de_zig_zagged = PLM_VIDEO_ZIG_ZAG[n];
03300         n++;
03301
03302         // Dequantize, oddify, clip
03303         level <<= 1;
03304         if (!self->macroblock_intra) {
03305             level += (level < 0 ? -1 : 1);
03306         }
03307         level = (level * self->quantizer_scale * quant_matrix[de_zig_zagged]) >> 4;
03308         if ((level & 1) == 0) {
03309             level -= level > 0 ? 1 : -1;
```

```
03310         }
03311         if (level > 2047) {
03312             level = 2047;
03313         }
03314         else if (level < -2048) {
03315             level = -2048;
03316         }
03317
03318         // Save premultiplied coefficient
03319         self->block_data[de_zig_zagged] = level * PLM_VIDEO_PREMULTIPLIER_MATRIX[de_zig_zagged];
03320     }
03321
03322     // Move block to its place
03323     uint8_t *d;
03324     int dw;
03325     int di;
03326
03327     if (block < 4) {
03328         d = self->frame_current.y.data;
03329         dw = self->luma_width;
03330         di = (self->mb_row * self->luma_width + self->mb_col) << 4;
03331         if ((block & 1) != 0) {
03332             di += 8;
03333         }
03334         if ((block & 2) != 0) {
03335             di += self->luma_width << 3;
03336         }
03337     }
03338     else {
03339         d = (block == 4) ? self->frame_current.cb.data : self->frame_current.cr.data;
03340         dw = self->chroma_width;
03341         di = ((self->mb_row * self->luma_width) << 2) + (self->mb_col << 3);
03342     }
03343
03344     int *s = self->block_data;
03345     int si = 0;
03346     if (self->macroblock_intra) {
03347         // Overwrite (no prediction)
03348         if (n == 1) {
03349             int clamped = plm_clamp((s[0] + 128) >> 8);
03350             PLM_BLOCK_SET(d, di, dw, si, 8, 8, clamped);
03351             s[0] = 0;
03352         }
03353         else {
03354             plm_video_idct(s);
03355             PLM_BLOCK_SET(d, di, dw, si, 8, 8, plm_clamp(s[si]));
03356             memset(self->block_data, 0, sizeof(self->block_data));
03357         }
03358     }
03359     else {
03360         // Add data to the predicted macroblock
03361         if (n == 1) {
03362             int value = (s[0] + 128) >> 8;
03363             PLM_BLOCK_SET(d, di, dw, si, 8, 8, plm_clamp(d[di] + value));
03364             s[0] = 0;
03365         }
03366         else {
03367             plm_video_idct(s);
03368             PLM_BLOCK_SET(d, di, dw, si, 8, 8, plm_clamp(d[di] + s[si]));
03369             memset(self->block_data, 0, sizeof(self->block_data));
03370         }
03371     }
03372 }
03373
03374 void plm_video_idct(int *block) {
03375     int
03376         b1, b3, b4, b6, b7, tmp1, tmp2, m0,
03377         x0, x1, x2, x3, x4, y3, y4, y5, y6, y7;
03378
03379     // Transform columns
03380     for (int i = 0; i < 8; ++i) {
03381         b1 = block[4 * 8 + i];
03382         b3 = block[2 * 8 + i] + block[6 * 8 + i];
03383         b4 = block[5 * 8 + i] - block[3 * 8 + i];
03384         tmp1 = block[1 * 8 + i] + block[7 * 8 + i];
03385         tmp2 = block[3 * 8 + i] + block[5 * 8 + i];
03386         b6 = block[1 * 8 + i] - block[7 * 8 + i];
03387         b7 = tmp1 + tmp2;
03388         m0 = block[0 * 8 + i];
03389         x4 = ((b6 * 473 - b4 * 196 + 128) >> 8) - b7;
03390         x0 = x4 - (((tmp1 - tmp2) * 362 + 128) >> 8);
03391         x1 = m0 - b1;
03392         x2 = (((block[2 * 8 + i] - block[6 * 8 + i]) * 362 + 128) >> 8) - b3;
03393         x3 = m0 + b1;
03394         y3 = x1 + x2;
03395         y4 = x3 + b3;
03396         y5 = x1 - x2;
```

```
03397         y6 = x3 - b3;
03398         y7 = -x0 - ((b4 * 473 + b6 * 196 + 128) >> 8);
03399         block[0 * 8 + i] = b7 + y4;
03400         block[1 * 8 + i] = x4 + y3;
03401         block[2 * 8 + i] = y5 - x0;
03402         block[3 * 8 + i] = y6 - y7;
03403         block[4 * 8 + i] = y6 + y7;
03404         block[5 * 8 + i] = x0 + y5;
03405         block[6 * 8 + i] = y3 - x4;
03406         block[7 * 8 + i] = y4 - b7;
03407     }
03408
03409     // Transform rows
03410     for (int i = 0; i < 64; i += 8) {
03411         b1 = block[4 + i];
03412         b3 = block[2 + i] + block[6 + i];
03413         b4 = block[5 + i] - block[3 + i];
03414         tmp1 = block[1 + i] + block[7 + i];
03415         tmp2 = block[3 + i] + block[5 + i];
03416         b6 = block[1 + i] - block[7 + i];
03417         b7 = tmp1 + tmp2;
03418         m0 = block[0 + i];
03419         x4 = ((b6 * 473 - b4 * 196 + 128) >> 8) - b7;
03420         x0 = x4 - (((tmp1 - tmp2) * 362 + 128) >> 8);
03421         x1 = m0 - b1;
03422         x2 = (((block[2 + i] - block[6 + i]) * 362 + 128) >> 8) - b3;
03423         x3 = m0 + b1;
03424         y3 = x1 + x2;
03425         y4 = x3 + b3;
03426         y5 = x1 - x2;
03427         y6 = x3 - b3;
03428         y7 = -x0 - ((b4 * 473 + b6 * 196 + 128) >> 8);
03429         block[0 + i] = (b7 + y4 + 128) >> 8;
03430         block[1 + i] = (x4 + y3 + 128) >> 8;
03431         block[2 + i] = (y5 - x0 + 128) >> 8;
03432         block[3 + i] = (y6 - y7 + 128) >> 8;
03433         block[4 + i] = (y6 + y7 + 128) >> 8;
03434         block[5 + i] = (x0 + y5 + 128) >> 8;
03435         block[6 + i] = (y3 - x4 + 128) >> 8;
03436         block[7 + i] = (y4 - b7 + 128) >> 8;
03437     }
03438 }
03439
03440 // YCbCr conversion following the BT.601 standard:
03441 // https://infogalactic.com/info/YCbCr#ITU-R_BT.601_conversion
03442
03443 #define PLM_PUT_PIXEL(RI, GI, BI, Y_OFFSET, DEST_OFFSET) \
03444     y = ((frame->y.data[y_index + Y_OFFSET]-16) * 76309) >> 16; \
03445     dest[d_index + DEST_OFFSET + RI] = plm_clamp(y + r); \
03446     dest[d_index + DEST_OFFSET + GI] = plm_clamp(y - g); \
03447     dest[d_index + DEST_OFFSET + BI] = plm_clamp(y + b);
03448
03449 #define PLM_DEFINE_FRAME_CONVERT_FUNCTION(NAME, BYTES_PER_PIXEL, RI, GI, BI) \
03450     void NAME(plm_frame_t *frame, uint8_t *dest, int stride) { \
03451         int cols = frame->width >> 1; \
03452         int rows = frame->height >> 1; \
03453         int yw = frame->y.width; \
03454         int cw = frame->cb.width; \
03455         for (int row = 0; row < rows; row++) { \
03456             int c_index = row * cw; \
03457             int y_index = row * 2 * yw; \
03458             int d_index = row * 2 * stride; \
03459             for (int col = 0; col < cols; col++) { \
03460                 int y; \
03461                 int cr = frame->cr.data[c_index] - 128; \
03462                 int cb = frame->cb.data[c_index] - 128; \
03463                 int r = (cr * 104597) >> 16; \
03464                 int g = (cb * 25674 + cr * 53278) >> 16; \
03465                 int b = (cb * 132201) >> 16; \
03466                 PLM_PUT_PIXEL(RI, GI, BI, 0,      0); \
03467                 PLM_PUT_PIXEL(RI, GI, BI, 1,      BYTES_PER_PIXEL); \
03468                 PLM_PUT_PIXEL(RI, GI, BI, yw,     stride); \
03469                 PLM_PUT_PIXEL(RI, GI, BI, yw + 1, stride + BYTES_PER_PIXEL); \
03470                 c_index += 1; \
03471                 y_index += 2; \
03472                 d_index += 2 * BYTES_PER_PIXEL; \
03473             } \
03474         } \
03475     }
03476
03477 PLM_DEFINE_FRAME_CONVERT_FUNCTION(plm_frame_to_rgb,  3, 0, 1, 2)
03478 PLM_DEFINE_FRAME_CONVERT_FUNCTION(plm_frame_to_bgr,  3, 2, 1, 0)
03479 PLM_DEFINE_FRAME_CONVERT_FUNCTION(plm_frame_to_rgba, 4, 0, 1, 2)
03480 PLM_DEFINE_FRAME_CONVERT_FUNCTION(plm_frame_to_bgra, 4, 2, 1, 0)
03481 PLM_DEFINE_FRAME_CONVERT_FUNCTION(plm_frame_to_argb, 4, 1, 2, 3)
03482 PLM_DEFINE_FRAME_CONVERT_FUNCTION(plm_frame_to_abgr, 4, 3, 2, 1)
03483
```

```
03484
03485 #undef PLM_PUT_PIXEL
03486 #undef PLM_DEFINE_FRAME_CONVERT_FUNCTION
03487
03488
03489
03490 // -----------------------------------------------------------------------------
03491 // plm_audio implementation
03492
03493 // Based on kjmp2 by Martin J. Fiedler
03494 // http://keyj.emphy.de/kjmp2/
03495
03496 static const int PLM_AUDIO_FRAME_SYNC = 0x7ff;
03497
03498 static const int PLM_AUDIO_MPEG_2_5 = 0x0;
03499 static const int PLM_AUDIO_MPEG_2 = 0x2;
03500 static const int PLM_AUDIO_MPEG_1 = 0x3;
03501
03502 static const int PLM_AUDIO_LAYER_III = 0x1;
03503 static const int PLM_AUDIO_LAYER_II = 0x2;
03504 static const int PLM_AUDIO_LAYER_I = 0x3;
03505
03506 static const int PLM_AUDIO_MODE_STEREO = 0x0;
03507 static const int PLM_AUDIO_MODE_JOINT_STEREO = 0x1;
03508 static const int PLM_AUDIO_MODE_DUAL_CHANNEL = 0x2;
03509 static const int PLM_AUDIO_MODE_MONO = 0x3;
03510
03511 static const unsigned short PLM_AUDIO_SAMPLE_RATE[] = {
03512     44100, 48000, 32000, 0, // MPEG-1
03513     22050, 24000, 16000, 0  // MPEG-2
03514 };
03515
03516 static const short PLM_AUDIO_BIT_RATE[] = {
03517     32, 48, 56, 64, 80, 96, 112, 128, 160, 192, 224, 256, 320, 384, // MPEG-1
03518      8, 16, 24, 32, 40, 48,  56,  64,  80,  96, 112, 128, 144, 160  // MPEG-2
03519 };
03520
03521 static const int PLM_AUDIO_SCALEFACTOR_BASE[] = {
03522     0x02000000, 0x01965FEA, 0x01428A30
03523 };
03524
03525 static const float PLM_AUDIO_SYNTHESIS_WINDOW[] = {
03526          0.0,     -0.5,     -0.5,     -0.5,     -0.5,     -0.5,
03527         -0.5,     -1.0,     -1.0,     -1.0,     -1.0,     -1.5,
03528         -1.5,     -2.0,     -2.0,     -2.5,     -2.5,     -3.0,
03529         -3.5,     -3.5,     -4.0,     -4.5,     -5.0,     -5.5,
03530         -6.5,     -7.0,     -8.0,     -8.5,     -9.5,    -10.5,
03531        -12.0,    -13.0,    -14.5,    -15.5,    -17.5,    -19.0,
03532        -20.5,    -22.5,    -24.5,    -26.5,    -29.0,    -31.5,
03533        -34.0,    -36.5,    -39.5,    -42.5,    -45.5,    -48.5,
03534        -52.0,    -55.5,    -58.5,    -62.5,    -66.0,    -69.5,
03535        -73.5,    -77.0,    -80.5,    -84.5,    -88.0,    -91.5,
03536        -95.0,    -98.0,   -101.0,   -104.0,    106.5,    109.0,
03537        111.0,    112.5,    113.5,    114.0,    114.0,    113.5,
03538        112.0,    110.5,    107.5,    104.0,    100.0,     94.5,
03539         88.5,     81.5,     73.0,     63.5,     53.0,     41.5,
03540         28.5,     14.5,     -1.0,    -18.0,    -36.0,    -55.5,
03541        -76.5,    -98.5,   -122.0,   -147.0,   -173.5,   -200.5,
03542       -229.5,   -259.5,   -290.5,   -322.5,   -355.5,   -389.5,
03543       -424.0,   -459.5,   -495.5,   -532.0,   -568.5,   -605.0,
03544       -641.5,   -678.0,   -714.0,   -749.0,   -783.5,   -817.0,
03545       -849.0,   -879.5,   -908.5,   -935.0,   -959.5,   -981.0,
03546      -1000.5,  -1016.0,  -1028.5,  -1037.5,  -1042.5,  -1043.5,
03547      -1040.0,  -1031.5,   1018.5,   1000.0,    976.0,    946.5,
03548        911.0,    869.5,    822.0,    767.5,    707.0,    640.0,
03549        565.5,    485.0,    397.0,    302.5,    201.0,     92.5,
03550        -22.5,   -144.0,   -272.5,   -407.0,   -547.5,   -694.0,
03551       -846.0,  -1003.0,  -1165.0,  -1331.5,  -1502.0,  -1675.5,
03552      -1852.5,  -2031.5,  -2212.5,  -2394.0,  -2576.5,  -2758.5,
03553      -2939.5,  -3118.5,  -3294.5,  -3467.5,  -3635.5,  -3798.5,
03554      -3955.0,  -4104.5,  -4245.5,  -4377.5,  -4499.0,  -4609.5,
03555      -4708.0,  -4792.5,  -4863.5,  -4919.0,  -4958.0,  -4979.5,
03556      -4983.0,  -4967.5,  -4931.5,  -4875.0,  -4796.0,  -4694.5,
03557      -4569.5,  -4420.0,  -4246.0,  -4046.0,  -3820.0,  -3567.0,
03558       3287.0,   2979.5,   2644.0,   2280.5,   1888.0,   1467.5,
03559       1018.5,    541.0,     35.0,   -499.0,  -1061.0,  -1650.0,
03560      -2266.5,  -2909.0,  -3577.0,  -4270.0,  -4987.5,  -5727.5,
03561      -6490.0,  -7274.0,  -8077.5,  -8899.5,  -9739.0, -10594.5,
03562     -11464.5, -12347.0, -13241.0, -14144.5, -15056.0, -15973.5,
03563     -16895.5, -17820.0, -18744.5, -19668.0, -20588.0, -21503.0,
03564     -22410.5, -23308.5, -24195.0, -25068.5, -25926.5, -26767.0,
03565     -27589.0, -28389.0, -29166.5, -29919.0, -30644.5, -31342.0,
03566     -32009.5, -32645.0, -33247.0, -33814.5, -34346.0, -34839.5,
03567     -35295.0, -35710.0, -36084.5, -36417.5, -36707.5, -36954.0,
03568     -37156.5, -37315.0, -37428.0, -37496.0,  37519.0,  37496.0,
03569      37428.0,  37315.0,  37156.5,  36954.0,  36707.5,  36417.5,
03570      36084.5,  35710.0,  35295.0,  34839.5,  34346.0,  33814.5,
```

```
03571       33247.0,  32645.0,  32009.5,  31342.0,  30644.5,  29919.0,
03572       29166.5,  28389.0,  27589.0,  26767.0,  25926.5,  25068.5,
03573       24195.0,  23308.5,  22410.5,  21503.0,  20588.0,  19668.0,
03574       18744.5,  17820.0,  16895.5,  15973.5,  15056.0,  14144.5,
03575       13241.0,  12347.0,  11464.5,  10594.5,   9739.0,   8899.5,
03576        8077.5,   7274.0,   6490.0,   5727.5,   4987.5,   4270.0,
03577        3577.0,   2909.0,   2266.5,   1650.0,   1061.0,    499.0,
03578         -35.0,   -541.0,  -1018.5,  -1467.5,  -1888.0,  -2280.5,
03579       -2644.0,  -2979.5,   3287.0,   3567.0,   3820.0,   4046.0,
03580        4246.0,   4420.0,   4569.5,   4694.5,   4796.0,   4875.0,
03581        4931.5,   4967.5,   4983.0,   4979.5,   4958.0,   4919.0,
03582        4863.5,   4792.5,   4708.0,   4609.5,   4499.0,   4377.5,
03583        4245.5,   4104.5,   3955.0,   3798.5,   3635.5,   3467.5,
03584        3294.5,   3118.5,   2939.5,   2758.5,   2576.5,   2394.0,
03585        2212.5,   2031.5,   1852.5,   1675.5,   1502.0,   1331.5,
03586        1165.0,   1003.0,    846.0,    694.0,    547.5,    407.0,
03587         272.5,    144.0,     22.5,    -92.5,   -201.0,   -302.5,
03588        -397.0,   -485.0,   -565.5,   -640.0,   -707.0,   -767.5,
03589        -822.0,   -869.5,   -911.0,   -946.5,   -976.0,  -1000.0,
03590        1018.5,   1031.5,   1040.0,   1043.5,   1042.5,   1037.5,
03591        1028.5,   1016.0,   1000.5,    981.0,    959.5,    935.0,
03592         908.5,    879.5,    849.0,    817.0,    783.5,    749.0,
03593         714.0,    678.0,    641.5,    605.0,    568.5,    532.0,
03594         495.5,    459.5,    424.0,    389.5,    355.5,    322.5,
03595         290.5,    259.5,    229.5,    200.5,    173.5,    147.0,
03596         122.0,     98.5,     76.5,     55.5,     36.0,     18.0,
03597           1.0,    -14.5,    -28.5,    -41.5,    -53.0,    -63.5,
03598         -73.0,    -81.5,    -88.5,    -94.5,   -100.0,   -104.0,
03599        -107.5,   -110.5,   -112.0,   -113.5,   -114.0,   -114.0,
03600        -113.5,   -112.5,   -111.0,   -109.0,    106.5,    104.0,
03601         101.0,     98.0,     95.0,     91.5,     88.0,     84.5,
03602          80.5,     77.0,     73.5,     69.5,     66.0,     62.5,
03603          58.5,     55.5,     52.0,     48.5,     45.5,     42.5,
03604          39.5,     36.5,     34.0,     31.5,     29.0,     26.5,
03605          24.5,     22.5,     20.5,     19.0,     17.5,     15.5,
03606          14.5,     13.0,     12.0,     10.5,      9.5,      8.5,
03607           8.0,      7.0,      6.5,      5.5,      5.0,      4.5,
03608           4.0,      3.5,      3.5,      3.0,      2.5,      2.5,
03609           2.0,      2.0,      1.5,      1.5,      1.0,      1.0,
03610           1.0,      1.0,      0.5,      0.5,      0.5,      0.5,
03611           0.5,      0.5
03612 };
03613
03614 // Quantizer lookup, step 1: bitrate classes
03615 static const uint8_t PLM_AUDIO_QUANT_LUT_STEP_1[2][16] = {
03616     // 32, 48, 56, 64, 80, 96,112,128,160,192,224,256,320,384 <- bitrate
03617     { 0,  0,  1,  1,  1,  2,  2,  2,  2,  2,  2,  2,  2,  2 }, // mono
03618     // 16, 24, 28, 32, 40, 48, 56, 64, 80, 96,112,128,160,192 <- bitrate / chan
03619     { 0,  0,  0,  0,  0,  0,  1,  1,  1,  2,  2,  2,  2,  2 } // stereo
03620 };
03621
03622 // Quantizer lookup, step 2: bitrate class, sample rate -> B2 table idx, sblimit
03623 #define PLM_AUDIO_QUANT_TAB_A (27 | 64)   // Table 3-B.2a: high-rate, sblimit = 27
03624 #define PLM_AUDIO_QUANT_TAB_B (30 | 64)   // Table 3-B.2b: high-rate, sblimit = 30
03625 #define PLM_AUDIO_QUANT_TAB_C 8           // Table 3-B.2c:  low-rate, sblimit =  8
03626 #define PLM_AUDIO_QUANT_TAB_D 12          // Table 3-B.2d:  low-rate, sblimit = 12
03627
03628 static const uint8_t QUANT_LUT_STEP_2[3][3] = {
03629     //44.1 kHz,              48 kHz,              32 kHz
03630     { PLM_AUDIO_QUANT_TAB_C, PLM_AUDIO_QUANT_TAB_C, PLM_AUDIO_QUANT_TAB_D }, // 32 - 48 kbit/sec/ch
03631     { PLM_AUDIO_QUANT_TAB_A, PLM_AUDIO_QUANT_TAB_A, PLM_AUDIO_QUANT_TAB_A }, // 56 - 80 kbit/sec/ch
03632     { PLM_AUDIO_QUANT_TAB_B, PLM_AUDIO_QUANT_TAB_A, PLM_AUDIO_QUANT_TAB_B }  // 96+  kbit/sec/ch
03633 };
03634
03635 // Quantizer lookup, step 3: B2 table, subband -> nbal, row index
03636 // (upper 4 bits: nbal, lower 4 bits: row index)
03637 static const uint8_t PLM_AUDIO_QUANT_LUT_STEP_3[3][32] = {
03638     // Low-rate table (3-B.2c and 3-B.2d)
03639     {
03640         0x44,0x44,
03641         0x34,0x34,0x34,0x34,0x34,0x34,0x34,0x34,0x34,0x34
03642     },
03643     // High-rate table (3-B.2a and 3-B.2b)
03644     {
03645         0x43,0x43,0x43,
03646         0x42,0x42,0x42,0x42,0x42,0x42,0x42,0x42,
03647         0x31,0x31,0x31,0x31,0x31,0x31,0x31,0x31,0x31,0x31,0x31,0x31,
03648         0x20,0x20,0x20,0x20,0x20,0x20,0x20
03649     },
03650     // MPEG-2 LSR table (B.2 in ISO 13818-3)
03651     {
03652         0x45,0x45,0x45,0x45,
03653         0x34,0x34,0x34,0x34,0x34,0x34,0x34,
03654         0x24,0x24,0x24,0x24,0x24,0x24,0x24,0x24,0x24,0x24,
03655         0x24,0x24,0x24,0x24,0x24,0x24,0x24,0x24,0x24
03656     }
03657 };
```

```
03658
03659 // Quantizer lookup, step 4: table row, allocation[] value -> quant table index
03660 static const uint8_t PLM_AUDIO_QUANT_LUT_STEP_4[6][16] = {
03661     { 0, 1, 2, 17 },
03662     { 0, 1, 2,  3, 4, 5, 6, 17 },
03663     { 0, 1, 2,  3, 4, 5, 6,  7,  8,  9, 10, 11, 12, 13, 14, 17 },
03664     { 0, 1, 3,  5, 6, 7, 8,  9, 10, 11, 12, 13, 14, 15, 16, 17 },
03665     { 0, 1, 2,  4, 5, 6, 7,  8,  9, 10, 11, 12, 13, 14, 15, 17 },
03666     { 0, 1, 2,  3, 4, 5, 6,  7,  8,  9, 10, 11, 12, 13, 14, 15 }
03667 };
03668
03669 typedef struct plm_quantizer_spec_t {
03670     unsigned short levels;
03671     unsigned char group;
03672     unsigned char bits;
03673 } plm_quantizer_spec_t;
03674
03675 static const plm_quantizer_spec_t PLM_AUDIO_QUANT_TAB[] = {
03676     {     3, 1,  5 },  //  1
03677     {     5, 1,  7 },  //  2
03678     {     7, 0,  3 },  //  3
03679     {     9, 1, 10 },  //  4
03680     {    15, 0,  4 },  //  5
03681     {    31, 0,  5 },  //  6
03682     {    63, 0,  6 },  //  7
03683     {   127, 0,  7 },  //  8
03684     {   255, 0,  8 },  //  9
03685     {   511, 0,  9 },  // 10
03686     {  1023, 0, 10 },  // 11
03687     {  2047, 0, 11 },  // 12
03688     {  4095, 0, 12 },  // 13
03689     {  8191, 0, 13 },  // 14
03690     { 16383, 0, 14 },  // 15
03691     { 32767, 0, 15 },  // 16
03692     { 65535, 0, 16 }   // 17
03693 };
03694
03695 struct plm_audio_t {
03696     double time;
03697     int samples_decoded;
03698     int samplerate_index;
03699     int bitrate_index;
03700     int version;
03701     int layer;
03702     int mode;
03703     int bound;
03704     int v_pos;
03705     int next_frame_data_size;
03706     int has_header;
03707
03708     plm_buffer_t *buffer;
03709     int destroy_buffer_when_done;
03710
03711     const plm_quantizer_spec_t *allocation[2][32];
03712     uint8_t scale_factor_info[2][32];
03713     int scale_factor[2][32][3];
03714     int sample[2][32][3];
03715
03716     plm_samples_t samples;
03717     float D[1024];
03718     float V[2][1024];
03719     float U[32];
03720 };
03721
03722 int plm_audio_find_frame_sync(plm_audio_t *self);
03723 int plm_audio_decode_header(plm_audio_t *self);
03724 void plm_audio_decode_frame(plm_audio_t *self);
03725 const plm_quantizer_spec_t *plm_audio_read_allocation(plm_audio_t *self, int sb, int tab3);
03726 void plm_audio_read_samples(plm_audio_t *self, int ch, int sb, int part);
03727 void plm_audio_idct36(int s[32][3], int ss, float *d, int dp);
03728
03729 plm_audio_t *plm_audio_create_with_buffer(plm_buffer_t *buffer, int destroy_when_done) {
03730     plm_audio_t *self = (plm_audio_t *)PLM_MALLOC(sizeof(plm_audio_t));
03731     memset(self, 0, sizeof(plm_audio_t));
03732
03733     self->samples.count = PLM_AUDIO_SAMPLES_PER_FRAME;
03734     self->buffer = buffer;
03735     self->destroy_buffer_when_done = destroy_when_done;
03736     self->samplerate_index = 3; // Indicates 0
03737
03738     memcpy(self->D, PLM_AUDIO_SYNTHESIS_WINDOW, 512 * sizeof(float));
03739     memcpy(self->D + 512, PLM_AUDIO_SYNTHESIS_WINDOW, 512 * sizeof(float));
03740
03741     // Attempt to decode first header
03742     self->next_frame_data_size = plm_audio_decode_header(self);
03743
03744     return self;
```

```
03745 }
03746
03747 void plm_audio_destroy(plm_audio_t *self) {
03748     if (self->destroy_buffer_when_done) {
03749         plm_buffer_destroy(self->buffer);
03750     }
03751     PLM_FREE(self);
03752 }
03753
03754 int plm_audio_has_header(plm_audio_t *self) {
03755     if (self->has_header) {
03756         return TRUE;
03757     }
03758
03759     self->next_frame_data_size = plm_audio_decode_header(self);
03760     return self->has_header;
03761 }
03762
03763 int plm_audio_get_samplerate(plm_audio_t *self) {
03764     return plm_audio_has_header(self)
03765         ? PLM_AUDIO_SAMPLE_RATE[self->samplerate_index]
03766         : 0;
03767 }
03768
03769 double plm_audio_get_time(plm_audio_t *self) {
03770     return self->time;
03771 }
03772
03773 void plm_audio_set_time(plm_audio_t *self, double time) {
03774     self->samples_decoded = time *
03775         (double)PLM_AUDIO_SAMPLE_RATE[self->samplerate_index];
03776     self->time = time;
03777 }
03778
03779 void plm_audio_rewind(plm_audio_t *self) {
03780     plm_buffer_rewind(self->buffer);
03781     self->time = 0;
03782     self->samples_decoded = 0;
03783     self->next_frame_data_size = 0;
03784 }
03785
03786 int plm_audio_has_ended(plm_audio_t *self) {
03787     return plm_buffer_has_ended(self->buffer);
03788 }
03789
03790 plm_samples_t *plm_audio_decode(plm_audio_t *self) {
03791     // Do we have at least enough information to decode the frame header?
03792     if (!self->next_frame_data_size) {
03793         if (!plm_buffer_has(self->buffer, 48)) {
03794             return NULL;
03795         }
03796         self->next_frame_data_size = plm_audio_decode_header(self);
03797     }
03798
03799     if (
03800         self->next_frame_data_size == 0 ||
03801         !plm_buffer_has(self->buffer, self->next_frame_data_size « 3)
03802     ) {
03803         return NULL;
03804     }
03805
03806     plm_audio_decode_frame(self);
03807     self->next_frame_data_size = 0;
03808
03809     self->samples.time = self->time;
03810
03811     self->samples_decoded += PLM_AUDIO_SAMPLES_PER_FRAME;
03812     self->time = (double)self->samples_decoded /
03813         (double)PLM_AUDIO_SAMPLE_RATE[self->samplerate_index];
03814
03815     return &self->samples;
03816 }
03817
03818 int plm_audio_find_frame_sync(plm_audio_t *self) {
03819     size_t i;
03820     for (i = self->buffer->bit_index » 3; i < self->buffer->length-1; i++) {
03821         if (
03822             self->buffer->bytes[i] == 0xFF &&
03823             (self->buffer->bytes[i+1] & 0xFE) == 0xFC
03824         ) {
03825             self->buffer->bit_index = ((i+1) « 3) + 3;
03826             return TRUE;
03827         }
03828     }
03829     self->buffer->bit_index = (i + 1) « 3;
03830     return FALSE;
03831 }
```

```
03832
03833 int plm_audio_decode_header(plm_audio_t *self) {
03834     if (!plm_buffer_has(self->buffer, 48)) {
03835         return 0;
03836     }
03837
03838     plm_buffer_skip_bytes(self->buffer, 0x00);
03839     int sync = plm_buffer_read(self->buffer, 11);
03840
03841
03842     // Attempt to resync if no syncword was found. This sucks balls. The MP2
03843     // stream contains a syncword just before every frame (11 bits set to 1).
03844     // However, this syncword is not guaranteed to not occur elsewhere in the
03845     // stream. So, if we have to resync, we also have to check if the header
03846     // (samplerate, bitrate) differs from the one we had before. This all
03847     // may still lead to garbage data being decoded :/
03848
03849     if (sync != PLM_AUDIO_FRAME_SYNC && !plm_audio_find_frame_sync(self)) {
03850         return 0;
03851     }
03852
03853     self->version = plm_buffer_read(self->buffer, 2);
03854     self->layer = plm_buffer_read(self->buffer, 2);
03855     int hasCRC = !plm_buffer_read(self->buffer, 1);
03856
03857     if (
03858         self->version != PLM_AUDIO_MPEG_1 ||
03859         self->layer != PLM_AUDIO_LAYER_II
03860     ) {
03861         return 0;
03862     }
03863
03864     int bitrate_index = plm_buffer_read(self->buffer, 4) - 1;
03865     if (bitrate_index > 13) {
03866         return 0;
03867     }
03868
03869     int samplerate_index = plm_buffer_read(self->buffer, 2);
03870     if (samplerate_index == 3) {
03871         return 0;
03872     }
03873
03874     int padding = plm_buffer_read(self->buffer, 1);
03875     plm_buffer_skip(self->buffer, 1); // f_private
03876     int mode = plm_buffer_read(self->buffer, 2);
03877
03878     // If we already have a header, make sure the samplerate, bitrate and mode
03879     // are still the same, otherwise we might have missed sync.
03880     if (
03881         self->has_header && (
03882             self->bitrate_index != bitrate_index ||
03883             self->samplerate_index != samplerate_index ||
03884             self->mode != mode
03885         )
03886     ) {
03887         return 0;
03888     }
03889
03890     self->bitrate_index = bitrate_index;
03891     self->samplerate_index = samplerate_index;
03892     self->mode = mode;
03893     self->has_header = TRUE;
03894
03895     // Parse the mode_extension, set up the stereo bound
03896     if (mode == PLM_AUDIO_MODE_JOINT_STEREO) {
03897         self->bound = (plm_buffer_read(self->buffer, 2) + 1) << 2;
03898     }
03899     else {
03900         plm_buffer_skip(self->buffer, 2);
03901         self->bound = (mode == PLM_AUDIO_MODE_MONO) ? 0 : 32;
03902     }
03903
03904     // Discard the last 4 bits of the header and the CRC value, if present
03905     plm_buffer_skip(self->buffer, 4); // copyright(1), original(1), emphasis(2)
03906     if (hasCRC) {
03907         plm_buffer_skip(self->buffer, 16);
03908     }
03909
03910     // Compute frame size, check if we have enough data to decode the whole
03911     // frame.
03912     int bitrate = PLM_AUDIO_BIT_RATE[self->bitrate_index];
03913     int samplerate = PLM_AUDIO_SAMPLE_RATE[self->samplerate_index];
03914     int frame_size = (144000 * bitrate / samplerate) + padding;
03915     return frame_size - (hasCRC ? 6 : 4);
03916 }
03917
03918 void plm_audio_decode_frame(plm_audio_t *self) {
```

```
03919     // Prepare the quantizer table lookups
03920     int tab3 = 0;
03921     int sblimit = 0;
03922
03923     int tab1 = (self->mode == PLM_AUDIO_MODE_MONO) ? 0 : 1;
03924     int tab2 = PLM_AUDIO_QUANT_LUT_STEP_1[tab1][self->bitrate_index];
03925     tab3 = QUANT_LUT_STEP_2[tab2][self->samplerate_index];
03926     sblimit = tab3 & 63;
03927     tab3 >>= 6;
03928
03929     if (self->bound > sblimit) {
03930         self->bound = sblimit;
03931     }
03932
03933     // Read the allocation information
03934     for (int sb = 0; sb < self->bound; sb++) {
03935         self->allocation[0][sb] = plm_audio_read_allocation(self, sb, tab3);
03936         self->allocation[1][sb] = plm_audio_read_allocation(self, sb, tab3);
03937     }
03938
03939     for (int sb = self->bound; sb < sblimit; sb++) {
03940         self->allocation[0][sb] =
03941             self->allocation[1][sb] =
03942             plm_audio_read_allocation(self, sb, tab3);
03943     }
03944
03945     // Read scale factor selector information
03946     int channels = (self->mode == PLM_AUDIO_MODE_MONO) ? 1 : 2;
03947     for (int sb = 0; sb < sblimit; sb++) {
03948         for (int ch = 0; ch < channels; ch++) {
03949             if (self->allocation[ch][sb]) {
03950                 self->scale_factor_info[ch][sb] = plm_buffer_read(self->buffer, 2);
03951             }
03952         }
03953         if (self->mode == PLM_AUDIO_MODE_MONO) {
03954             self->scale_factor_info[1][sb] = self->scale_factor_info[0][sb];
03955         }
03956     }
03957
03958     // Read scale factors
03959     for (int sb = 0; sb < sblimit; sb++) {
03960         for (int ch = 0; ch < channels; ch++) {
03961             if (self->allocation[ch][sb]) {
03962                 int *sf = self->scale_factor[ch][sb];
03963                 switch (self->scale_factor_info[ch][sb]) {
03964                     case 0:
03965                         sf[0] = plm_buffer_read(self->buffer, 6);
03966                         sf[1] = plm_buffer_read(self->buffer, 6);
03967                         sf[2] = plm_buffer_read(self->buffer, 6);
03968                         break;
03969                     case 1:
03970                         sf[0] =
03971                         sf[1] = plm_buffer_read(self->buffer, 6);
03972                         sf[2] = plm_buffer_read(self->buffer, 6);
03973                         break;
03974                     case 2:
03975                         sf[0] =
03976                         sf[1] =
03977                         sf[2] = plm_buffer_read(self->buffer, 6);
03978                         break;
03979                     case 3:
03980                         sf[0] = plm_buffer_read(self->buffer, 6);
03981                         sf[1] =
03982                         sf[2] = plm_buffer_read(self->buffer, 6);
03983                         break;
03984                 }
03985             }
03986         }
03987         if (self->mode == PLM_AUDIO_MODE_MONO) {
03988             self->scale_factor[1][sb][0] = self->scale_factor[0][sb][0];
03989             self->scale_factor[1][sb][1] = self->scale_factor[0][sb][1];
03990             self->scale_factor[1][sb][2] = self->scale_factor[0][sb][2];
03991         }
03992     }
03993
03994     // Coefficient input and reconstruction
03995     int out_pos = 0;
03996     for (int part = 0; part < 3; part++) {
03997         for (int granule = 0; granule < 4; granule++) {
03998
03999             // Read the samples
04000             for (int sb = 0; sb < self->bound; sb++) {
04001                 plm_audio_read_samples(self, 0, sb, part);
04002                 plm_audio_read_samples(self, 1, sb, part);
04003             }
04004             for (int sb = self->bound; sb < sblimit; sb++) {
04005                 plm_audio_read_samples(self, 0, sb, part);
```

```
04006                 self->sample[1][sb][0] = self->sample[0][sb][0];
04007                 self->sample[1][sb][1] = self->sample[0][sb][1];
04008                 self->sample[1][sb][2] = self->sample[0][sb][2];
04009             }
04010             for (int sb = sblimit; sb < 32; sb++) {
04011                 self->sample[0][sb][0] = 0;
04012                 self->sample[0][sb][1] = 0;
04013                 self->sample[0][sb][2] = 0;
04014                 self->sample[1][sb][0] = 0;
04015                 self->sample[1][sb][1] = 0;
04016                 self->sample[1][sb][2] = 0;
04017             }
04018
04019             // Synthesis loop
04020             for (int p = 0; p < 3; p++) {
04021                 // Shifting step
04022                 self->v_pos = (self->v_pos - 64) & 1023;
04023
04024                 for (int ch = 0; ch < 2; ch++) {
04025                     plm_audio_idct36(self->sample[ch], p, self->V[ch], self->v_pos);
04026
04027                     // Build U, windowing, calculate output
04028                     memset(self->U, 0, sizeof(self->U));
04029
04030                     int d_index = 512 - (self->v_pos >> 1);
04031                     int v_index = (self->v_pos % 128) >> 1;
04032                     while (v_index < 1024) {
04033                         for (int i = 0; i < 32; ++i) {
04034                             self->U[i] += self->D[d_index++] * self->V[ch][v_index++];
04035                         }
04036
04037                         v_index += 128 - 32;
04038                         d_index += 64 - 32;
04039                     }
04040
04041                     d_index -= (512 - 32);
04042                     v_index = (128 - 32 + 1024) - v_index;
04043                     while (v_index < 1024) {
04044                         for (int i = 0; i < 32; ++i) {
04045                             self->U[i] += self->D[d_index++] * self->V[ch][v_index++];
04046                         }
04047
04048                         v_index += 128 - 32;
04049                         d_index += 64 - 32;
04050                     }
04051
04052                     // Output samples
04053                     #ifdef PLM_AUDIO_SEPARATE_CHANNELS
04054                         float *out_channel = ch == 0
04055                             ? self->samples.left
04056                             : self->samples.right;
04057                         for (int j = 0; j < 32; j++) {
04058                             out_channel[out_pos + j] = self->U[j] / 2147418112.0f;
04059                         }
04060                     #else
04061                         for (int j = 0; j < 32; j++) {
04062                             self->samples.interleaved[((out_pos + j) << 1) + ch] =
04063                                 self->U[j] / 2147418112.0f;
04064                         }
04065                     #endif
04066                 } // End of synthesis channel loop
04067                 out_pos += 32;
04068             } // End of synthesis sub-block loop
04069
04070         } // Decoding of the granule finished
04071     }
04072
04073     plm_buffer_align(self->buffer);
04074 }
04075
04076 const plm_quantizer_spec_t *plm_audio_read_allocation(plm_audio_t *self, int sb, int tab3) {
04077     int tab4 = PLM_AUDIO_QUANT_LUT_STEP_3[tab3][sb];
04078     int qtab = PLM_AUDIO_QUANT_LUT_STEP_4[tab4 & 15][plm_buffer_read(self->buffer, tab4 >> 4)];
04079     return qtab ? (&PLM_AUDIO_QUANT_TAB[qtab - 1]) : 0;
04080 }
04081
04082 void plm_audio_read_samples(plm_audio_t *self, int ch, int sb, int part) {
04083     const plm_quantizer_spec_t *q = self->allocation[ch][sb];
04084     int sf = self->scale_factor[ch][sb][part];
04085     int *sample = self->sample[ch][sb];
04086     int val = 0;
04087
04088     if (!q) {
04089         // No bits allocated for this subband
04090         sample[0] = sample[1] = sample[2] = 0;
04091         return;
04092     }
```

```
04093
04094     // Resolve scalefactor
04095     if (sf == 63) {
04096         sf = 0;
04097     }
04098     else {
04099         int shift = (sf / 3) | 0;
04100         sf = (PLM_AUDIO_SCALEFACTOR_BASE[sf % 3] + ((1 << shift) >> 1)) >> shift;
04101     }
04102
04103     // Decode samples
04104     int adj = q->levels;
04105     if (q->group) {
04106         // Decode grouped samples
04107         val = plm_buffer_read(self->buffer, q->bits);
04108         sample[0] = val % adj;
04109         val /= adj;
04110         sample[1] = val % adj;
04111         sample[2] = val / adj;
04112     }
04113     else {
04114         // Decode direct samples
04115         sample[0] = plm_buffer_read(self->buffer, q->bits);
04116         sample[1] = plm_buffer_read(self->buffer, q->bits);
04117         sample[2] = plm_buffer_read(self->buffer, q->bits);
04118     }
04119
04120     // Postmultiply samples
04121     int scale = 65536 / (adj + 1);
04122     adj = ((adj + 1) >> 1) - 1;
04123
04124     val = (adj - sample[0]) * scale;
04125     sample[0] = (val * (sf >> 12) + ((val * (sf & 4095) + 2048) >> 12)) >> 12;
04126
04127     val = (adj - sample[1]) * scale;
04128     sample[1] = (val * (sf >> 12) + ((val * (sf & 4095) + 2048) >> 12)) >> 12;
04129
04130     val = (adj - sample[2]) * scale;
04131     sample[2] = (val * (sf >> 12) + ((val * (sf & 4095) + 2048) >> 12)) >> 12;
04132 }
04133
04134 void plm_audio_idct36(int s[32][3], int ss, float *d, int dp) {
04135     float t01, t02, t03, t04, t05, t06, t07, t08, t09, t10, t11, t12,
04136         t13, t14, t15, t16, t17, t18, t19, t20, t21, t22, t23, t24,
04137         t25, t26, t27, t28, t29, t30, t31, t32, t33;
04138
04139     t01 = (float)(s[0][ss] + s[31][ss]); t02 = (float)(s[0][ss] - s[31][ss]) * 0.500602998235f;
04140     t03 = (float)(s[1][ss] + s[30][ss]); t04 = (float)(s[1][ss] - s[30][ss]) * 0.505470959898f;
04141     t05 = (float)(s[2][ss] + s[29][ss]); t06 = (float)(s[2][ss] - s[29][ss]) * 0.515447309923f;
04142     t07 = (float)(s[3][ss] + s[28][ss]); t08 = (float)(s[3][ss] - s[28][ss]) * 0.53104259109f;
04143     t09 = (float)(s[4][ss] + s[27][ss]); t10 = (float)(s[4][ss] - s[27][ss]) * 0.553103896034f;
04144     t11 = (float)(s[5][ss] + s[26][ss]); t12 = (float)(s[5][ss] - s[26][ss]) * 0.582934968206f;
04145     t13 = (float)(s[6][ss] + s[25][ss]); t14 = (float)(s[6][ss] - s[25][ss]) * 0.622504123036f;
04146     t15 = (float)(s[7][ss] + s[24][ss]); t16 = (float)(s[7][ss] - s[24][ss]) * 0.674808341455f;
04147     t17 = (float)(s[8][ss] + s[23][ss]); t18 = (float)(s[8][ss] - s[23][ss]) * 0.744536271002f;
04148     t19 = (float)(s[9][ss] + s[22][ss]); t20 = (float)(s[9][ss] - s[22][ss]) * 0.839349645416f;
04149     t21 = (float)(s[10][ss] + s[21][ss]); t22 = (float)(s[10][ss] - s[21][ss]) * 0.972568237862f;
04150     t23 = (float)(s[11][ss] + s[20][ss]); t24 = (float)(s[11][ss] - s[20][ss]) * 1.16943993343f;
04151     t25 = (float)(s[12][ss] + s[19][ss]); t26 = (float)(s[12][ss] - s[19][ss]) * 1.48416461631f;
04152     t27 = (float)(s[13][ss] + s[18][ss]); t28 = (float)(s[13][ss] - s[18][ss]) * 2.05778100995f;
04153     t29 = (float)(s[14][ss] + s[17][ss]); t30 = (float)(s[14][ss] - s[17][ss]) * 3.40760841847f;
04154     t31 = (float)(s[15][ss] + s[16][ss]); t32 = (float)(s[15][ss] - s[16][ss]) * 10.1900081235f;
04155
04156     t33 = t01 + t31; t31 = (t01 - t31) * 0.502419286188f;
04157     t01 = t03 + t29; t29 = (t03 - t29) * 0.52249861494f;
04158     t03 = t05 + t27; t27 = (t05 - t27) * 0.566944034816f;
04159     t05 = t07 + t25; t25 = (t07 - t25) * 0.64682178336f;
04160     t07 = t09 + t23; t23 = (t09 - t23) * 0.788154623451f;
04161     t09 = t11 + t21; t21 = (t11 - t21) * 1.06067768599f;
04162     t11 = t13 + t19; t19 = (t13 - t19) * 1.72244709824f;
04163     t13 = t15 + t17; t17 = (t15 - t17) * 5.10114861869f;
04164     t15 = t33 + t13; t13 = (t33 - t13) * 0.509795579104f;
04165     t33 = t01 + t11; t01 = (t01 - t11) * 0.601344886935f;
04166     t11 = t03 + t09; t09 = (t03 - t09) * 0.899976223136f;
04167     t03 = t05 + t07; t07 = (t05 - t07) * 2.56291544774f;
04168     t05 = t15 + t03; t15 = (t15 - t03) * 0.541196100146f;
04169     t03 = t33 + t11; t11 = (t33 - t11) * 1.30656296488f;
04170     t33 = t05 + t03; t05 = (t05 - t03) * 0.707106781187f;
04171     t03 = t15 + t11; t15 = (t15 - t11) * 0.707106781187f;
04172     t03 += t15;
04173     t11 = t13 + t07; t13 = (t13 - t07) * 0.541196100146f;
04174     t07 = t01 + t09; t09 = (t01 - t09) * 1.30656296488f;
04175     t01 = t11 + t07; t07 = (t11 - t07) * 0.707106781187f;
04176     t11 = t13 + t09; t13 = (t13 - t09) * 0.707106781187f;
04177     t11 += t13; t01 += t11;
04178     t11 += t07; t07 += t13;
04179     t09 = t31 + t17; t31 = (t31 - t17) * 0.509795579104f;
```

```
04180     t17 = t29 + t19; t29 = (t29 - t19) * 0.601344886935f;
04181     t19 = t27 + t21; t21 = (t27 - t21) * 0.899976223136f;
04182     t27 = t25 + t23; t23 = (t25 - t23) * 2.56291544774f;
04183     t25 = t09 + t27; t09 = (t09 - t27) * 0.541196100146f;
04184     t27 = t17 + t19; t19 = (t17 - t19) * 1.30656296488f;
04185     t17 = t25 + t27; t27 = (t25 - t27) * 0.707106781187f;
04186     t25 = t09 + t19; t19 = (t09 - t19) * 0.707106781187f;
04187     t25 += t19;
04188     t09 = t31 + t23; t31 = (t31 - t23) * 0.541196100146f;
04189     t23 = t29 + t21; t21 = (t29 - t21) * 1.30656296488f;
04190     t29 = t09 + t23; t23 = (t09 - t23) * 0.707106781187f;
04191     t09 = t31 + t21; t31 = (t31 - t21) * 0.707106781187f;
04192     t09 += t31; t29 += t09; t09 += t23; t23 += t31;
04193     t17 += t29; t29 += t25; t25 += t09; t09 += t27;
04194     t27 += t23; t23 += t19; t19 += t31;
04195     t21 = t02 + t32; t02 = (t02 - t32) * 0.502419286188f;
04196     t32 = t04 + t30; t04 = (t04 - t30) * 0.52249861494f;
04197     t30 = t06 + t28; t28 = (t06 - t28) * 0.566944034816f;
04198     t06 = t08 + t26; t08 = (t08 - t26) * 0.64682178336f;
04199     t26 = t10 + t24; t10 = (t10 - t24) * 0.788154623451f;
04200     t24 = t12 + t22; t22 = (t12 - t22) * 1.06067768599f;
04201     t12 = t14 + t20; t20 = (t14 - t20) * 1.72244709824f;
04202     t14 = t16 + t18; t16 = (t16 - t18) * 5.10114861869f;
04203     t18 = t21 + t14; t14 = (t21 - t14) * 0.509795579104f;
04204     t21 = t32 + t12; t32 = (t32 - t12) * 0.601344886935f;
04205     t12 = t30 + t24; t24 = (t30 - t24) * 0.899976223136f;
04206     t30 = t06 + t26; t26 = (t06 - t26) * 2.56291544774f;
04207     t06 = t18 + t30; t18 = (t18 - t30) * 0.541196100146f;
04208     t30 = t21 + t12; t12 = (t21 - t12) * 1.30656296488f;
04209     t21 = t06 + t30; t30 = (t06 - t30) * 0.707106781187f;
04210     t06 = t18 + t12; t12 = (t18 - t12) * 0.707106781187f;
04211     t06 += t12;
04212     t18 = t14 + t26; t26 = (t14 - t26) * 0.541196100146f;
04213     t14 = t32 + t24; t24 = (t32 - t24) * 1.30656296488f;
04214     t32 = t18 + t14; t14 = (t18 - t14) * 0.707106781187f;
04215     t18 = t26 + t24; t24 = (t26 - t24) * 0.707106781187f;
04216     t18 += t24; t32 += t18;
04217     t18 += t14; t26 = t14 + t24;
04218     t14 = t02 + t16; t02 = (t02 - t16) * 0.509795579104f;
04219     t16 = t04 + t20; t04 = (t04 - t20) * 0.601344886935f;
04220     t20 = t28 + t22; t22 = (t28 - t22) * 0.899976223136f;
04221     t28 = t08 + t10; t10 = (t08 - t10) * 2.56291544774f;
04222     t08 = t14 + t28; t14 = (t14 - t28) * 0.541196100146f;
04223     t28 = t16 + t20; t20 = (t16 - t20) * 1.30656296488f;
04224     t16 = t08 + t28; t28 = (t08 - t28) * 0.707106781187f;
04225     t08 = t14 + t20; t20 = (t14 - t20) * 0.707106781187f;
04226     t08 += t20;
04227     t14 = t02 + t10; t02 = (t02 - t10) * 0.541196100146f;
04228     t10 = t04 + t22; t22 = (t04 - t22) * 1.30656296488f;
04229     t04 = t14 + t10; t10 = (t14 - t10) * 0.707106781187f;
04230     t14 = t02 + t22; t02 = (t02 - t22) * 0.707106781187f;
04231     t14 += t02; t04 += t14; t14 += t10; t10 += t02;
04232     t16 += t04; t04 += t08; t08 += t14; t14 += t28;
04233     t28 += t10; t10 += t20; t20 += t02; t21 += t16;
04234     t16 += t32; t32 += t04; t04 += t06; t06 += t08;
04235     t08 += t18; t18 += t14; t14 += t30; t30 += t28;
04236     t28 += t26; t26 += t10; t10 += t12; t12 += t20;
04237     t20 += t24; t24 += t02;
04238
04239     d[dp + 48] = -t33;
04240     d[dp + 49] = d[dp + 47] = -t21;
04241     d[dp + 50] = d[dp + 46] = -t17;
04242     d[dp + 51] = d[dp + 45] = -t16;
04243     d[dp + 52] = d[dp + 44] = -t01;
04244     d[dp + 53] = d[dp + 43] = -t32;
04245     d[dp + 54] = d[dp + 42] = -t29;
04246     d[dp + 55] = d[dp + 41] = -t04;
04247     d[dp + 56] = d[dp + 40] = -t03;
04248     d[dp + 57] = d[dp + 39] = -t06;
04249     d[dp + 58] = d[dp + 38] = -t25;
04250     d[dp + 59] = d[dp + 37] = -t08;
04251     d[dp + 60] = d[dp + 36] = -t11;
04252     d[dp + 61] = d[dp + 35] = -t18;
04253     d[dp + 62] = d[dp + 34] = -t09;
04254     d[dp + 63] = d[dp + 33] = -t14;
04255     d[dp + 32] = -t05;
04256     d[dp + 0] = t05; d[dp + 31] = -t30;
04257     d[dp + 1] = t30; d[dp + 30] = -t27;
04258     d[dp + 2] = t27; d[dp + 29] = -t28;
04259     d[dp + 3] = t28; d[dp + 28] = -t07;
04260     d[dp + 4] = t07; d[dp + 27] = -t26;
04261     d[dp + 5] = t26; d[dp + 26] = -t23;
04262     d[dp + 6] = t23; d[dp + 25] = -t10;
04263     d[dp + 7] = t10; d[dp + 24] = -t15;
04264     d[dp + 8] = t15; d[dp + 23] = -t12;
04265     d[dp + 9] = t12; d[dp + 22] = -t19;
04266     d[dp + 10] = t19; d[dp + 21] = -t20;
```

```
04267     d[dp + 11] = t20; d[dp + 20] = -t13;
04268     d[dp + 12] = t13; d[dp + 19] = -t24;
04269     d[dp + 13] = t24; d[dp + 18] = -t31;
04270     d[dp + 14] = t31; d[dp + 17] = -t02;
04271     d[dp + 15] = t02; d[dp + 16] = 0.0;
04272 }
04273
04274
04275 #endif // PL_MPEG_IMPLEMENTATION
```

6.5 video.h

```
00001 #include "../core/include/subsystems/screen.h"
00002 #include "pl_mpeg.h"
00003 #include <string>
00004
00006 void set_video(const std::string &filename);
00008 void video_restart();
00009 // plays the video set by set_video()
00010 // because of memory constraints we're limited to one video at a time
00011 class VideoPlayer : public screen::Page {
00012   public:
00013     VideoPlayer();
00014     void update(bool was_pressed, int x, int y) override;
00015
00016     void draw(vex::brain::lcd &screen, bool first_draw,
00017               unsigned int frame_number) override;
00018 };
```

6.6 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
```

6.7 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 };
```

6.8 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 };
```

6.9 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 };
```

6.10 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 };
```

6.11 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 };
```

6.12 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     void goto_page(size_t page);
00193
00195     void stop_screen();
00196
00198     using update_func_t = std::function<void(bool, int, int)>;
00199
00201     using draw_func_t = std::function<void(vex::brain::lcd &screen, bool, unsigned int)>;
00202
00204     class StatsPage : public Page
00205     {
00206     public:
00209         StatsPage(std::map<std::string, vex::motor &> motors);
00211         void update(bool was_pressed, int x, int y) override;
00213         void draw(vex::brain::lcd &, bool first_draw, unsigned int frame_number) override;
00214
00215     private:
00216         void draw_motor_stats(const std::string &name, vex::motor &mot, unsigned int frame, int x, int
      y, vex::brain::lcd &scr);
00217
00218         std::map<std::string, vex::motor &> motors;
00219         static const int y_start = 0;
00220         static const int per_column = 4;
00221         static const int row_height = 20;
00222         static const int row_width = 200;
00223     };
00224
00228     class OdometryPage : public Page
00229     {
```

```
00230     public:
00236         OdometryPage(OdometryBase &odom, double robot_width, double robot_height, bool do_trail);
00238         void update(bool was_pressed, int x, int y) override;
00240         void draw(vex::brain::lcd &, bool first_draw, unsigned int frame_number) override;
00241
00242     private:
00243         static const int path_len = 40;
00244         static constexpr char const *field_filename = "vex_field_240p.png";
00245
00246         OdometryBase &odom;
00247         double robot_width;
00248         double robot_height;
00249         uint8_t *buf = nullptr;
00250         int buf_size = 0;
00251         pose_t path[path_len];
00252         int path_index = 0;
00253         bool do_trail;
00254         GraphDrawer velocity_graph;
00255     };
00256
00258     class FunctionPage : public Page
00259     {
00260     public:
00264         FunctionPage(update_func_t update_f, draw_func_t draw_t);
00266         void update(bool was_pressed, int x, int y) override;
00268         void draw(vex::brain::lcd &, bool first_draw, unsigned int frame_number) override;
00269
00270     private:
00271         update_func_t update_f;
00272         draw_func_t draw_f;
00273     };
00274
00276     class PIDPage : public Page
00277     {
00278     public:
00283         PIDPage(
00284             PID &pid, std::string name, std::function<void(void)> onchange = []() {});
00285         PIDPage(
00286             PIDFF &pidff, std::string name, std::function<void(void)> onchange = []() {});
00287
00289         void update(bool was_pressed, int x, int y) override;
00291         void draw(vex::brain::lcd &, bool first_draw, unsigned int frame_number) override;
00292
00293     private:
00295         void zero_d_f() { cfg.d = 0; }
00297         void zero_i_f() { cfg.i = 0; }
00298
00299         PID::pid_config_t &cfg;
00300         PID &pid;
00301         const std::string name;
00302         std::function<void(void)> onchange;
00303
00304         SliderWidget p_slider;
00305         SliderWidget i_slider;
00306         SliderWidget d_slider;
00307         ButtonWidget zero_i;
00308         ButtonWidget zero_d;
00309
00310         GraphDrawer graph;
00311     };
00312
00313 }
```

6.13 tank_drive.h

```
00001 #pragma once
00002
00003 #ifndef PI
00004 #define PI 3.141592654
00005 #endif
00006
00007 #include "../core/include/robot_specs.h"
00008 #include "../core/include/subsystems/odometry/odometry_tank.h"
00009 #include "../core/include/utils/command_structure/auto_command.h"
00010 #include "../core/include/utils/controls/feedback_base.h"
00011 #include "../core/include/utils/controls/pid.h"
00012 #include "../core/include/utils/pure_pursuit.h"
00013 #include "vex.h"
00014 #include <vector>
00015
00016 using namespace vex;
00017
00023 class TankDrive {
```

```
00024   public:
00025     enum class BrakeType {
00026         None,
00027         ZeroVelocity,
00029         Smart,
00031     };
00041     TankDrive(motor_group &left_motors, motor_group &right_motors,
00042               robot_specs_t &config, OdometryBase *odom = NULL);
00043
00044     AutoCommand *DriveToPointCmd(point_t pt,
00045                                  vex::directionType dir = vex::forward,
00046                                  double max_speed = 1.0,
00047                                  double end_speed = 0.0);
00048     AutoCommand *DriveToPointCmd(Feedback &fb, point_t pt,
00049                                  vex::directionType dir = vex::forward,
00050                                  double max_speed = 1.0,
00051                                  double end_speed = 0.0);
00052
00053     AutoCommand *DriveForwardCmd(double dist,
00054                                  vex::directionType dir = vex::forward,
00055                                  double max_speed = 1.0,
00056                                  double end_speed = 0.0);
00057     AutoCommand *DriveForwardCmd(Feedback &fb, double dist,
00058                                  vex::directionType dir = vex::forward,
00059                                  double max_speed = 1.0,
00060                                  double end_speed = 0.0);
00061
00062     AutoCommand *TurnToHeadingCmd(double heading, double max_speed = 1.0,
00063                                   double end_speed = 0.0);
00064     AutoCommand *TurnToHeadingCmd(Feedback &fb, double heading,
00065                                   double max_speed = 1.0,
00066                                   double end_speed = 0.0);
00067
00068     AutoCommand *
00069     TurnToPointCmd(double x, double y,
00070                    vex::directionType dir = vex::directionType::fwd,
00071                    double max_speed = 1.0, double end_speed = 0.0);
00072
00073     AutoCommand *TurnDegreesCmd(double degrees, double max_speed = 1.0,
00074                                 double start_speed = 0.0);
00075     AutoCommand *TurnDegreesCmd(Feedback &fb, double degrees,
00076                                 double max_speed = 1.0, double end_speed = 0.0);
00077
00078     AutoCommand *PurePursuitCmd(PurePursuit::Path path, directionType dir,
00079                                 double max_speed = 1, double end_speed = 0);
00080     AutoCommand *PurePursuitCmd(Feedback &feedback, PurePursuit::Path path,
00081                                 directionType dir, double max_speed = 1,
00082                                 double end_speed = 0);
00083     Condition *DriveStalledCondition(double stall_time);
00084     AutoCommand *DriveTankCmd(double left, double right);
00085
00089     void stop();
00090
00101     void drive_tank(double left, double right, int power = 1,
00102                     BrakeType bt = BrakeType::None);
00108     void drive_tank_raw(double left, double right);
00109
00121     void drive_arcade(double forward_back, double left_right, int power = 1,
00122                       BrakeType bt = BrakeType::None);
00123
00139     bool drive_forward(double inches, directionType dir, Feedback &feedback,
00140                        double max_speed = 1, double end_speed = 0);
00141
00154     bool drive_forward(double inches, directionType dir, double max_speed = 1,
00155                        double end_speed = 0);
00156
00170     bool turn_degrees(double degrees, Feedback &feedback, double max_speed = 1,
00171                       double end_speed = 0);
00172
00186     bool turn_degrees(double degrees, double max_speed = 1,
00187                       double end_speed = 0);
00188
00204     bool drive_to_point(double x, double y, vex::directionType dir,
00205                         Feedback &feedback, double max_speed = 1,
00206                         double end_speed = 0);
00207
00222     bool drive_to_point(double x, double y, vex::directionType dir,
00223                         double max_speed = 1, double end_speed = 0);
00224
00237     bool turn_to_heading(double heading_deg, Feedback &feedback,
00238                          double max_speed = 1, double end_speed = 0);
00249     bool turn_to_heading(double heading_deg, double max_speed = 1,
00250                          double end_speed = 0);
00251
00255     void reset_auto();
00256
00267     static double modify_inputs(double input, int power = 2);
```

```
00268
00283     bool pure_pursuit(PurePursuit::Path path, directionType dir,
00284                       Feedback &feedback, double max_speed = 1,
00285                       double end_speed = 0);
00286
00302     bool pure_pursuit(PurePursuit::Path path, directionType dir,
00303                       double max_speed = 1, double end_speed = 0);
00304
00305   private:
00306     motor_group &left_motors;
00307     motor_group &right_motors;
00308
00309     PID correction_pid;
00311     Feedback *drive_default_feedback =
00312         NULL;
00313     Feedback *turn_default_feedback =
00314         NULL;
00315
00316     OdometryBase *odometry;
00318
00319     robot_specs_t &config;
00321
00322     bool func_initialized =
00323         false;
00326     bool is_pure_pursuit =
00327         false;
00328 };
```

6.14 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 };
```

6.15 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 };
```

6.16 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 };
```

6.17 command_controller.h

```
00001
00010 #pragma once
00011 #include "../core/include/utils/command_structure/auto_command.h"
00012 #include <queue>
00013 #include <vector>
00014
00015 class CommandController {
00016   public:
00019     [[deprecated("Empty constructor is bad. Use list constructor "
00020                  "instead.")]] CommandController()
00021         : command_queue({}) {}
00022
00026     CommandController(std::initializer_list<AutoCommand *> cmds)
00027         : command_queue(cmds) {}
00035     [[deprecated("Use list constructor instead. If you need to make a decision "
00036                  "before adding new commands, use Branch "
00037                  "(https://github.com/RIT-VEX-U/Core/wiki/"
00038                  "3-%7C-Utilites#commandcontroller)")]] void
00039     add(std::vector<AutoCommand *> cmds);
00040     void add(AutoCommand *cmd, double timeout_seconds = 10.0);
00041
```

```
00053     [[deprecated("Use list constructor instead. If you need to make a decision "
00054                  "before adding new commands, use Branch "
00055                  "(https://github.com/RIT-VEX-U/Core/wiki/"
00056                  "3-%7C-Utilites#commandcontroller)")]] void
00057     add(std::vector<AutoCommand *> cmds, double timeout_sec);
00064     void add_delay(int ms);
00065
00070     void add_cancel_func(std::function<bool(void)> true_if_cancel);
00071
00076     void run();
00077
00085     bool last_command_timed_out();
00086
00087   private:
00088     std::queue<AutoCommand *> command_queue;
00089     bool command_timed_out = false;
00090     std::function<bool()> should_cancel = []() { return false; };
00091 };
```

6.18 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 };
```

6.19 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 };
```

6.20 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 };
```

6.21 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 };
```

6.22 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 };
```

6.23 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);
```

6.24 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 };
```

6.25 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 };
```

6.26 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 };
```

6.27 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 };
```

6.28 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 };
```

6.29 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 };
```

6.30 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 };
```

6.31 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 };
```

6.32 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 };
```

6.33 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);
```

6.34 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 };
```

6.35 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 }
```

6.36 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 };
```

6.37 state_machine.h

```
00001 #pragma once
00002 #include <string>
00003 #include <type_traits>
00004 #include <utility>
00005
00034 template <typename System, typename IDType, typename Message, int32_t delay_ms,
00035           bool do_log = false>
00036 class StateMachine {
00037     static_assert(std::is_enum<Message>::value,
00038                   "Message should be an enum (it's easier that way)");
00039     static_assert(std::is_enum<IDType>::value,
00040                   "IDType should be an enum (it's easier that way)");
00041
00042   public:
00049     class MaybeMessage {
00050       public:
00054         MaybeMessage() : exists(false) {}
00059         MaybeMessage(Message msg) : exists(true), thing(msg) {}
00064         bool has_message() { return exists; }
00070         Message message() { return thing; }
00071
00072       private:
00073         bool exists;
00074         Message thing;
00075     };
00081     struct State {
00082         // run once when we enter the state
00083         virtual void entry(System &) {}
00084         // run continously while in the state
00085         virtual MaybeMessage work(System &) { return {}; }
00086         // run once when we exit the state
00087         virtual void exit(System &) {}
00088         // respond to a message when one comes in
00089         virtual State *respond(System &s, Message m) = 0;
00090         // Identify
00091         virtual IDType id() const = 0;
00092
00093         // virtual destructor cuz c++
00094         virtual ~State() {}
00095     };
00096
00097     // Data that gets passed to the runner thread. Don't worry too much about
00098     // this
00099     using thread_data = std::pair<State *, StateMachine *>;
00100
00105     StateMachine(State *initial)
00106         : runner(thread_runner, new thread_data{initial, this}) {}
00107
00113     IDType current_state() const {
00114         mut.lock();
00115         auto t = cur_type;
00116         mut.unlock();
00117         return t;
00118     }
00124     void send_message(Message msg) {
00125         mut.lock();
00126         incoming_msg = msg;
00127         mut.unlock();
00128     }
00129
00130   private:
00131     vex::task runner;
00132     mutable vex::mutex mut;
00133     MaybeMessage incoming_msg;
00134     IDType cur_type;
00135
00142     static int thread_runner(void *vptr) {
00143         thread_data *ptr = static_cast<thread_data *>(vptr);
00144         State *cur_state = ptr->first;
00145
00146         StateMachine &sys = *ptr->second;
00147         System &derived = *static_cast<System *>(&sys);
00148
00149         cur_state->entry(derived);
00150
00151         sys.cur_type = cur_state->id();
```

```
00152
00153         auto respond_to_message = [&](Message msg) {
00154             if (do_log) {
00155                 printf("responding to msg: %s\n", to_string(msg).c_str());
00156                 fflush(stdout);
00157             }
00158
00159             State *next_state = cur_state->respond(derived, msg);
00160
00161             if (cur_state != next_state) {
00162                 // switched states
00163                 sys.mut.lock();
00164
00165                 cur_state->exit(derived);
00166                 next_state->entry(derived);
00167
00168                 delete cur_state;
00169
00170                 cur_state = next_state;
00171                 sys.cur_type = cur_state->id();
00172
00173                 sys.mut.unlock();
00174             }
00175         };
00176
00177         while (true) {
00178             if (do_log) {
00179                 std::string str = to_string(cur_state->id());
00180                 std::string str2 = to_string(sys.cur_type);
00181
00182                 printf("state: %s %s\n", str.c_str(), str2.c_str());
00183             }
00184
00185             // Internal Message passed
00186             MaybeMessage internal_msg = cur_state->work(derived);
00187
00188             if (internal_msg.has_message()) {
00189                 respond_to_message(internal_msg.message());
00190             }
00191
00192             // External Message passed
00193             sys.mut.lock();
00194             MaybeMessage incoming = sys.incoming_msg;
00195             sys.incoming_msg = {};
00196             sys.mut.unlock();
00197
00198             if (incoming.has_message()) {
00199                 respond_to_message(incoming.message());
00200             }
00201
00202             vexDelay(delay_ms);
00203         }
00204         return 0;
00205     }
00206 };
```

6.38 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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