Robo-ELF Software

Jonathan Kriss

JHU CiiS Lab

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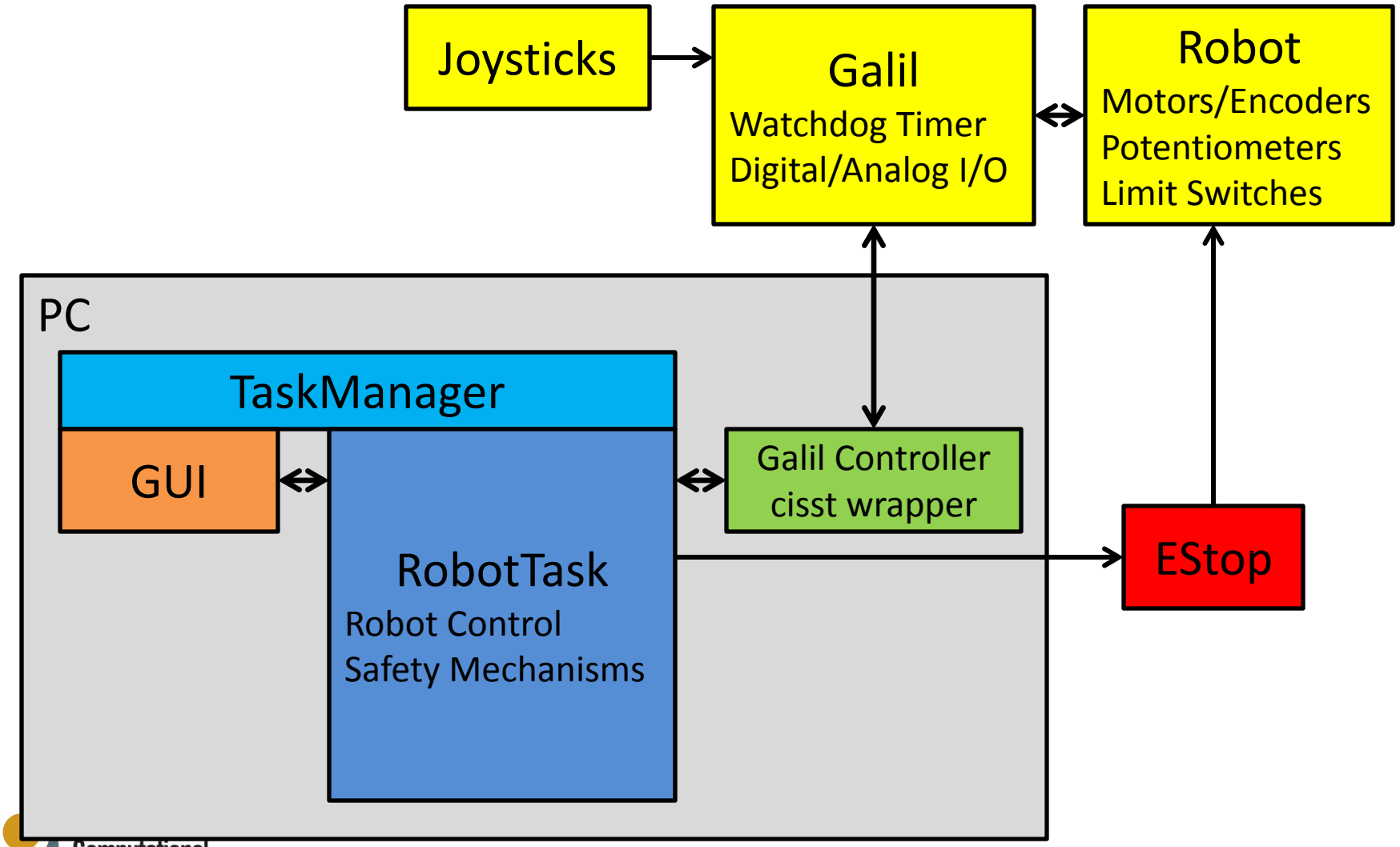
System Overview



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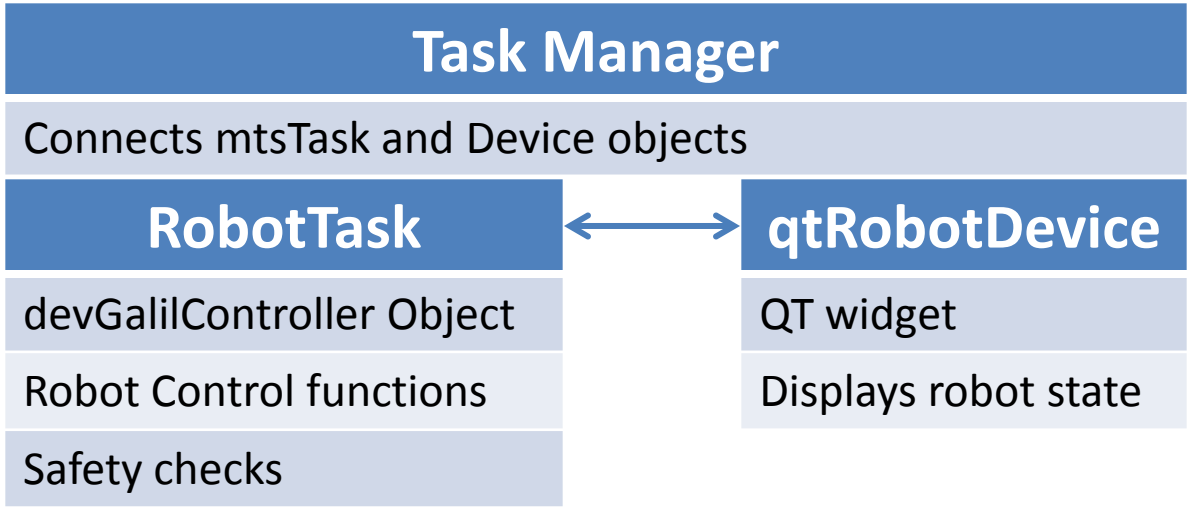
Task-level Diagram



RobotTask Functional Description

- GalilController object
- ProvidesThroatRobot Interface
- Safety checks
  - Estop Connection
  - PC Watchdog Timer
  - Encoder/Pot checking
  - Joystick valid input check
- Control Functions

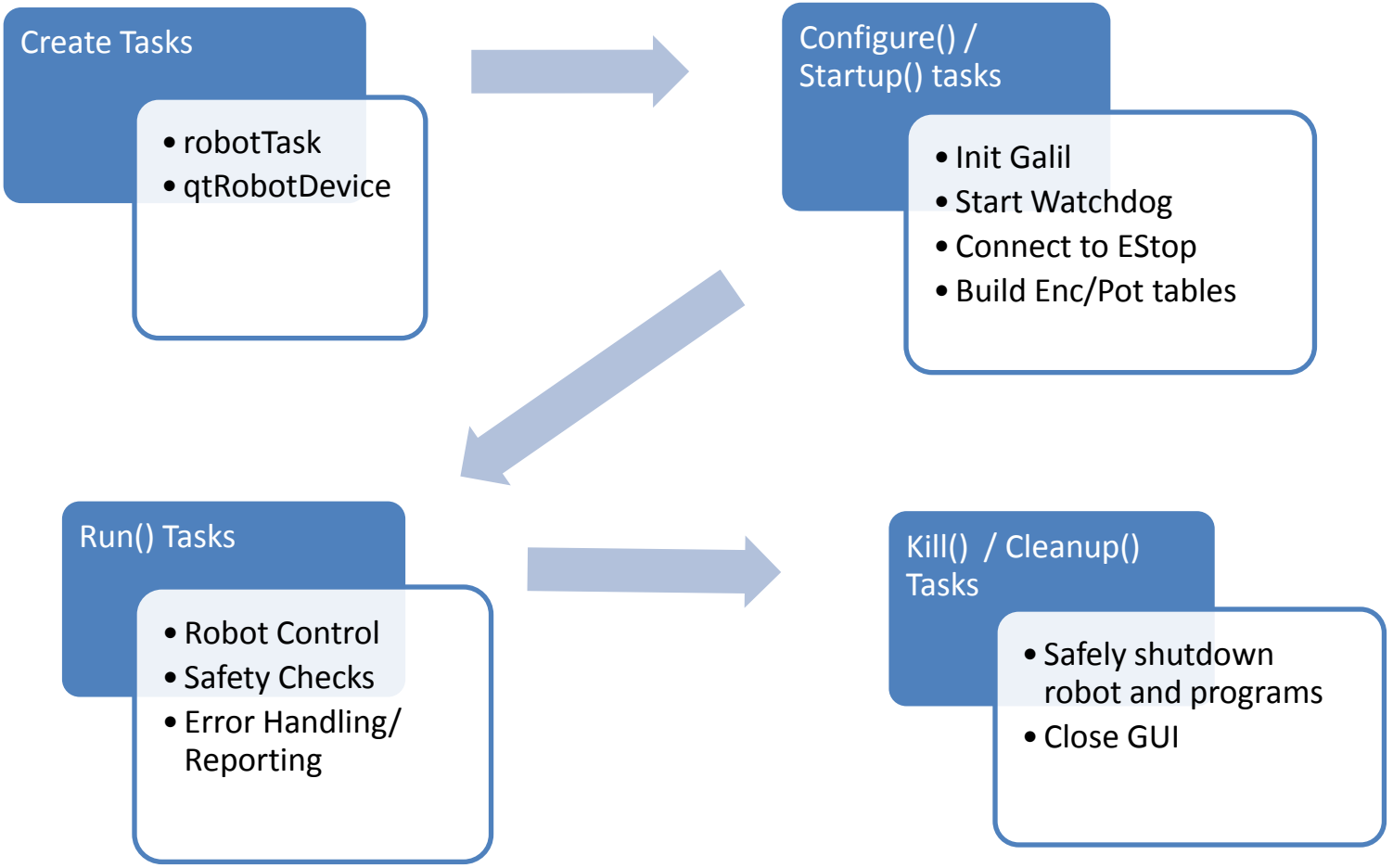
qtRobotDevice Functional Description

- RequiresThroatRobot Interface
- Gets state information from robotTask
- Displays position and switch state on GUI

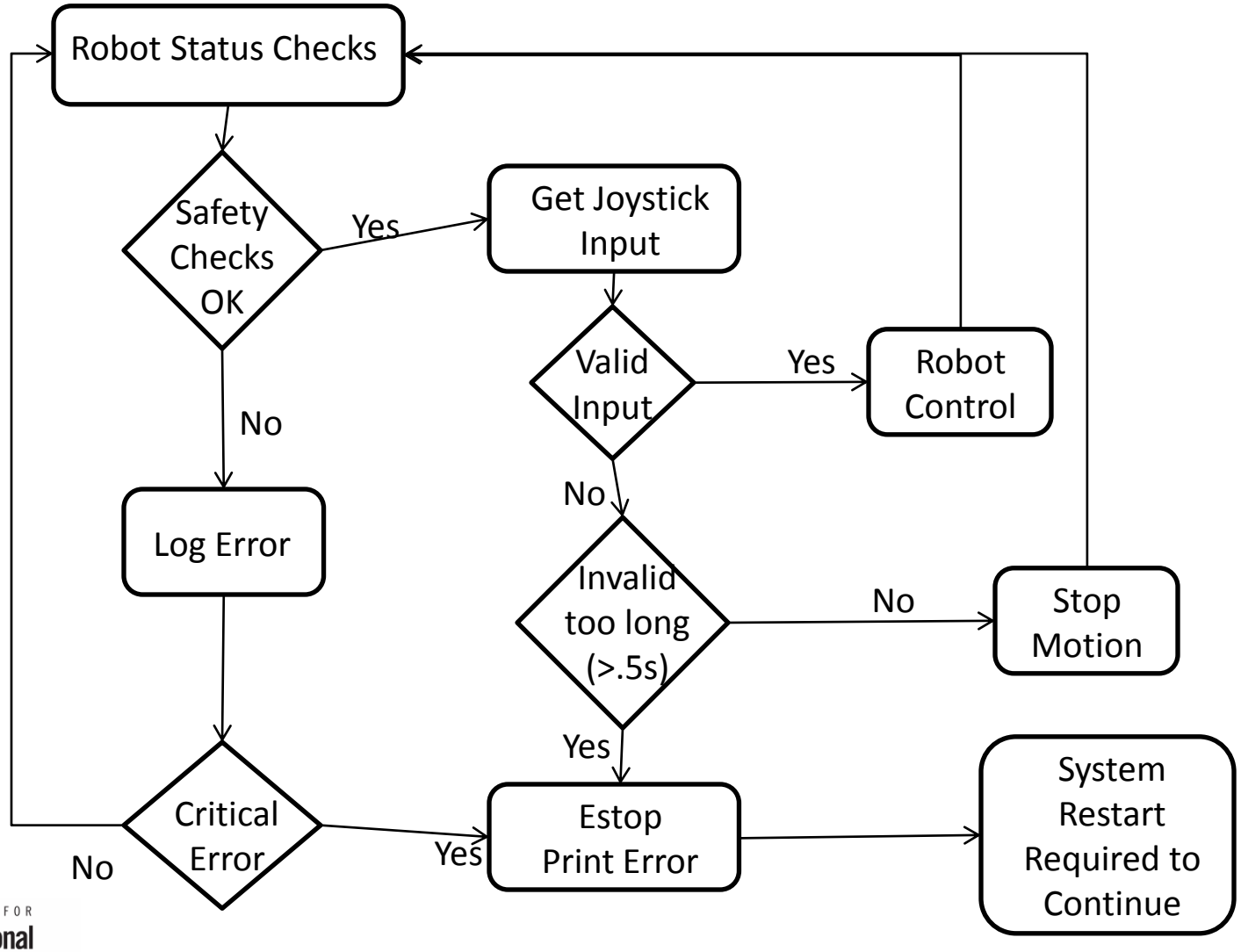
devGalilController Functional Description

- Cisst GenericObject
- cisst wrapper for Galil C++ API
- Receives input from:
  - Potentiometers(analog)
  - Encoders(digital)
  - Joystick controls(digital)
  - Limit switches(digital)

System Startup/Run/Shutdown



RobotTask Run Loop



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Safety Checks

- Estop
  - Cuts power to motors
  - Activated by robotTask, Stop button
- Watchdog Timer
  - Ensures good connection between Galil and PC
  - 50ms interval, 75ms non-critical timeout, 125ms critical timeout
- Encoder/Potentiometer checking
  - Compares values to detect encoder failure
- Software limits
  - Prevents commanded movement outside of those limits
  - Implemented with Galil's built-in software limits
- Joystick Input Check
  - Two switches per axis on joystick input to check consistency

Safety Errors

Critical Errors

- Errors that could present a danger to the patient
- Immediate stop of robot through Estop
- Some errors can be fixed with a restart and recalibration

Non-Critical Errors

- Errors that do not pose a danger to the patient or cause the system to stop working

Safety Errors

Critical Errors

- Communication failure
  - PC <-> Galil
  - PC <- > Estop
- Encoder/ Pot Error
- Galil System Error
  - Power error, Motion Error
- Invalid Joystick input
  - Over error threshold time

Non-Critical Errors

- Galil Command errors
  - Limit switch hit, ect.
- Non-critical watchdog timeout
- Invalid Joystick input
  - Under error threshold time

Emergency Stop

- Relay controllable by serial interface
- Each run loop, check connection
- EmergencyStop() function opens relays and cuts power to motors
- Can also be activated manually with button

Watchdog Timer

- PC and Galil send handshake signal every Run() loop
  - 50ms period
- Two timeout levels
  - 75ms non-critical
  - 125ms critical
- Non-critical timeout logs error, no Estop
- Critical timeout activates Estop
- Galil program contained in Watchdog.dmc

Maximum Effects of Timeout

- Maximum uncontrolled travel distance:
  - Axis A
    - ~.8 rot/s => .1 rot / timeout
    - ~.25 rot total range(scope tip has ~.6 rot total range)
  - Axis B
    - ~.4 rot/s => .05 rot/ timeout
    - ~ .75 rot total range
  - Axis C
    - ~4.25 in/s => .5 in/ timeout
    - ~6 in total range

Encoder/Potentiometer Checking

- Build tables of values for each on startup
  - New values should always be monotonically increasing
- During run, compare current values to values in tables using interpolation
- If error > margin of error, stop robot
  - Margin of error = step size of the table

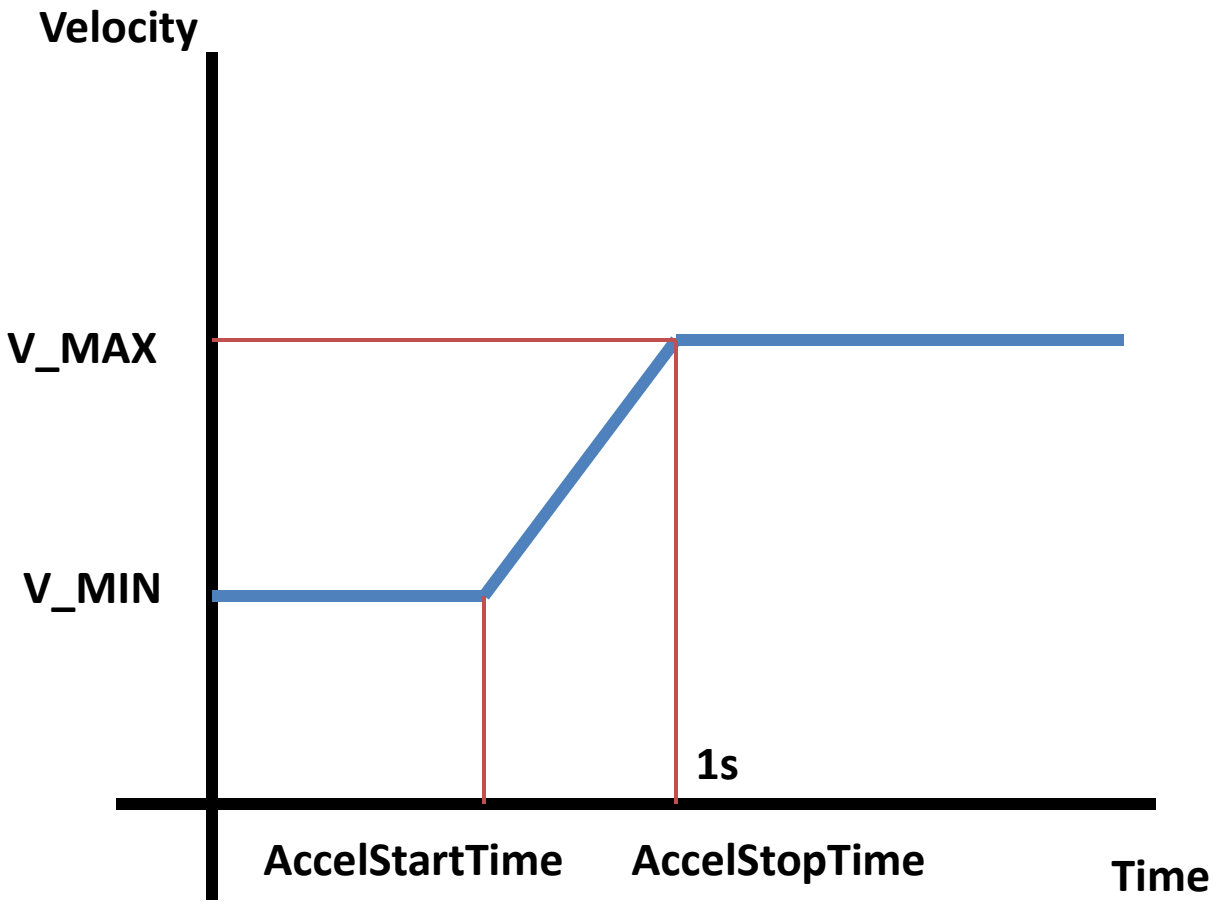
Joystick Switch Checking

- Double switches on each joystick axis provide redundant sensing
- The status of the joystick switches is constantly checked to ensure they are working properly
- If an invalid switch state lasts for more than .5s, an error is thrown and the Estop activated

Robot Control

- Velocity function based on how long joystick is held down.
- Linear acceleration from V_MIN to V_MAX
- Different min/max values for each axis

Velocity Function



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Error Handling

- Sources of errors
  - GalilController
  - Safety Checks in robotTask
- All exceptions thrown up to high-level functions
- All errors logged to cisstLog.txt
- Safety/System failures generate simple error messages to user

Galil Exception Classes

- All exceptions thrown up to robotTask functions
  - Only ExcpCommError and ExcpSystemError handled individually
- RobotException
  - Parent class for all exceptions

- ExcpCommError
  - Generated by SendCommand when Galil returns a timeout or command error
- ExcpSystemError
  - Generic System errors, non-critical
- Classes not caught by name in robotTask
  - ExcpMotionError, ExcpPowerError, ExcpMotorOff

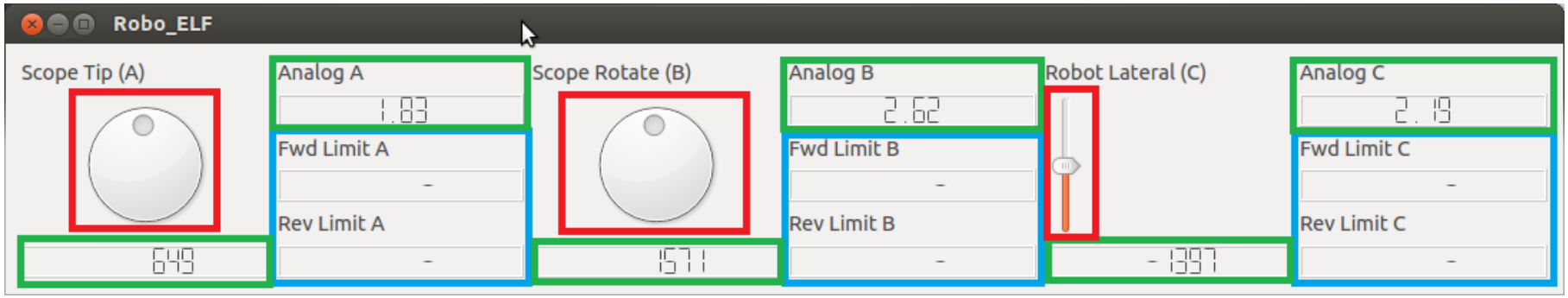
robotTask Exception Classes

- EStopException
  - Thrown by Estop functions if connection is lost
- EncoderException
  - Thrown by encoder/pot checking functions if error is detected. Also by startup calibration functions
- WatchdogException
  - Thrown by watchdog timer function if it times out
- Joystick Exception
  - Thrown by input function if readings are inconsistent

Error Logging

- robotTask set to ALLOW_ALL
- Std::cout set to allow errors only
  - Only displays error messages relevant to user
- cisstLog.txt set to “VERBOSE” allowance
  - Creates a more detailed log file

Qt GUI



- Displays information about current state
  - Current position(red/green), encoder values(green), pot values(green)
  - Limit switch state(blue)
- Reads from state table in robotTask
- No commands sent from GUI to robot