MView Manual

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https://nmgit.github.io/MView/

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What is MView?

At the highest level, MView is a framework that can be used to interface with virtually any external data source. In short, MView takes care of the overhead involved with running a GUI and device communication so that the end user can concentrate on their data.

MView also provides a very good base on which to build new projects. This prevents the use of fragmented code.

MView is built to support plugins and custom tiles so that each MView GUI can be customized to a very high degree without having to write too much new code.

Using MView, a variety of control and display elements can be easily configured. These include:

- Buttons
- Numerical/Textual Readouts
- Plots

Some backend features include:

- Datalogging using Datachest
- Email/Text notifications
- Flow Based Programming

MView accomplishes this by wrapping low-level communication and overhead into a **device driver** that abstracts all sources of data (**devices**) into an **MDevice** object. All MDevice objects implement a common software interface. This allows even the most complex devices to be handled in a simple manner.

With this system in place, MView implements a range of error-checking, graphing, and logging functionality which the end user can use with ease.

While not nearly as powerful as LabVIEW, MView is easy to set up and it works. This makes it ideal for simple monitoring tasks where the massive overhead of LabView is not needed. Additionally MView is also accessible by anyone who knows even the smallest amount of python without the need to learn labview.

Please see https://nmgit.github.io/MView/ for the full API.

How to Read This Document

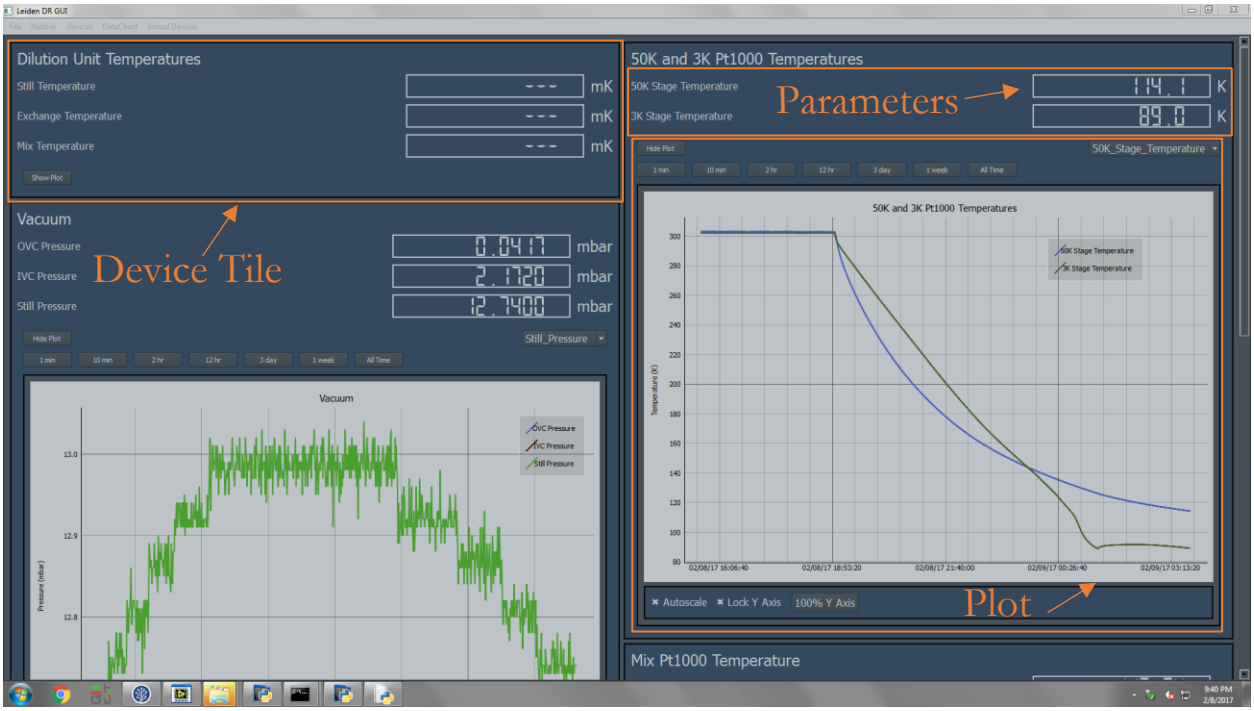
This manual is written so that it can be read as a tutorial from start to finish. That being said, any section can be accessed directly for reference without reading the rest of the document. It is like the show 'The Office' – you *can* watch each episode out of order, but it is much better if you watch it straight through.

Everyone who uses or plans to use MView should read this document all the way through at least once.

There are many places where I put an entire python program into the document. I did this for the sake of clarity and completeness, not every line must be read but the general idea should be understood.

One more thing: there is a lot of code formatted with a dark background, so don't print this out unless you enjoy buying toner.

The MView Interface



MView for Our Purposes

Setting up a simple GUI for LabRad Devices

Setting up a new MView GUI is generally very easy. In this section, we will configure a simple MView project that monitors data from a LabRad device.

In order to create a GUI using MView, we must set up a program that configures our devices and tells MView how to behave.

Installing MView

Clone the Servers repository from the McDermott github. Don't forget to add `~path~\mcDermott \Servers\GUI\mView` as well as `~path~\mcDermott\Servers\dataChest` to the `PYTHONPATH` environment variable.

MView also uses the pyqtgraph package. This is installed most easily with pip:

```
>>pip install pyqtgraph
```

Before You start:

- ***Please refer to the DataChest manual for DataChest setup.***
- ***Please refer to the comments in telecomm.py for telecomm server setup.***

Step 1: Imports

The first thing that must be done is to import the necessary MView libraries.

```
import MGui # Handles all GUI operations. Independent of LabRAD.
from MDevices.Device import Device # This is the device driver that represents a LabRad
server
```

MGui: Handles the overhead of initializing MView
MDevices.Device: All device drivers are stored in the MDevices folder. Device is the device driver that talks to LabRad servers.

Step 2: Initialization

Next, we need to write the class that initializes MView as well as all Devices.

```
class MyGuiClass:
  my_gui = self.gui = MGui.MGui()
```

my_gui: Holds a reference to the MVeiw Gui.

Step 3: Create a LabRad and Telecomm Server Connection

A connection to LabRad is created so that it can be passed to devices.

```
try:
 # Attempt to establish a labrad connection.
 cxn = labrad.connect()
except:
 # If no connection can be made, abort with an error message.
 print("Please start the LabRAD manager")
 time.sleep(2)
 sys.exit(0)
try:
 # As of writing, there is one class in MView itself that is dependent
 # on LabRad, and it requires the telecomm server to be running.
 # This is subject to change.
 tele = cxn.telecomm_server
except:
 # If no connection can be made, abort with an error message.
 print("Please start the telecomm server")
 time.sleep(2)
 sys.exit(1)
```

NOTE: The code in steps 1-3 is the same for all MView GUIs.

Step 4: Initializing Devices

A) Instantiating a new device

We must now initialize the LabRad Devices. Let's create a device that represents a CP2800 compressor.

First, we instantiate a new Device:

```
Compressor = Device("Compressor")
```

There are optional keyword arguments which can also be specified:

- `lock_logging_settings = False`
  Prevent the user from editing the datalogging settings on the GUI. Note that MView still has full control over locked settings.
- `default_log_location = None`
  The default datalogging location, must be inside DataChest root. This will override the normal restoring of previous log locations when MView is opened and closed. i.e. MView will automatically switch its log location here upon opening.

This creates a device called "Compressor." Not much else happens until we tell it how to communicate.

Second, we pass it a reference to our connection:

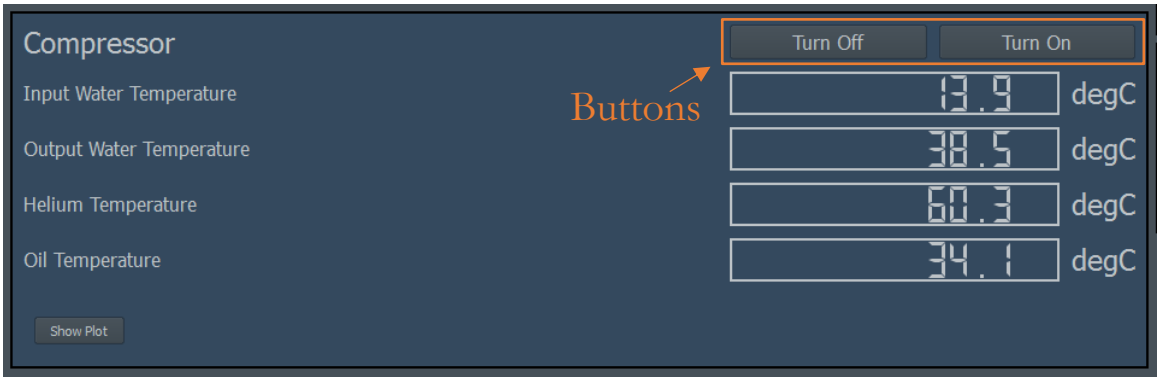
```
Compressor.connection(cxn)
```

Third, we tell it what the name of the server is. The name of the server for the CP2800 is "cp2800_compressor."

```
Compressor.setServerName("cp2800 compressor")
```

Now we have a basic MDevice. We next need to define buttons (if we want them), and parameters.

B) Adding Buttons



Next, let's add a button that turns off the compressor when we click it. This is done using the MDevice.addButton(label, message, setting, setting arguments) method.

```
MDevice.addButton(label, message, setting, setting arguments)
```

Here is how it should look in the context of this example:

```
Compressor.addButton("Turn Off",
   "You are about to turn the compressor off.",
   "stop", None)
Compressor.addButton("Turn On",
   "You are about to turn the compressor on.",
   "start", None)
```

The first argument sets the button's text. The second argument is the text to be displayed in a warning popup, if no warning is to be displayed, then the second argument should be None. The third argument is the LabRad server setting that is triggered when the button is pushed, and the fourth argument is an array of arguments for the LabRad setting, None if no arguments.

C) Adding Parameters

It is now time to add parameters to the device's tile. This is done with the MDevice.addParameter() method.

```
MDevice.addParameter(Label, LabRad Setting, Labrad Setting Arguments)
```

Optional Keyword arguments include:

- `show = True`
  Display the parameter on the GUI.
- `units = None`
  The recommended units, used to override current unit. Default LabRad server units are used if this is not specified, as well as if the specified units are incompatible with the measurement.
- `Precision = 2`
  The precision of the measurement **on the display**. Full precision is used by MView internally.
- `Index = None`
  If the reading is part of an array, this is the index.
- `Log = True`
  Log this parameter.

Here is how it should look in the context of this example:

```
Compressor.addParameter("Input Water Temperature",
   "current_temperatures_only", None, index=0)
Compressor.addParameter("Output Water Temperature",
   "current_temperatures_only", None, index=1)
Compressor.addParameter("Helium Temperature",
   "current_temperatures_only", None, index=2)
Compressor.addParameter("Oil Temperature",
   "current_temperatures_only", None, index=3)
```

Step 5: Selecting the Device

Just as with any LabRad device, we must call the 'select_device' command. This is done in the following way:

```
Compressor.selectDeviceCommand("select device", 0)
```

This selects device 0.

Step 6: The Plot

To add a plot to our graph, the MDevice.addPlot() method can be called.

```
Compressor.addPlot()
```

To set the y-axis label, the following command is used:

```
MDevice.setYLabel(y-axis label, custom units = None)
```

The first argument is the label displayed on the y-axis, and the second is an optional override of the default units. For example, it is a good idea to use this override when the server does give units. In our case, this takes the form of

```
Compressor.setYLabel("Temperature")
```

Step 7: Begin()

The next thing we must do is to tell the device to start. This is done with the MDevice.begin() method.

```
    Compressor.begin()
```

Step 8: Add Device to Gui

We can now add our device to the MView gui.

```
    self.gui.addDevice(Compressor)
```

Step 8: Starting MView

We start MView using the MGui.startGui() method.

```
  startGui(self, title, tele, autostart = True):
```

- **title:** The title on the gui.
- **tele:** Reference to the telecom server.
- **autostart:** Allows gui to run when startGui() is called. The purpose of this option will be discussed in a later section.

```
    self.gui.startGui('Leiden DR GUI',tele)
```

Step 9: Calling __init__()

As with any python class, we must call our init method **outside** of the main class.

```
class myGuiClass
...
viewer = myGuiClass()
viewer.  init  ()
```

Step 10: Putting it All Together

Here is how our new piece of code should look.

```
# Copyright (C) 2016 Noah Meltzer
#
# This program is free software: you can redistribute it and/or modify
# it under the terms of the GNU General Public License as published by
# the Free Software Foundation, either version 2 of the License, or
# (at your option) any later version.
#
# This program is distributed in the hope that it will be useful,
# but WITHOUT ANY WARRANTY; without even the implied warranty of
# MERCHANTABILITY or FITNESS FOR A PARTICULAR PURPOSE. See the
# GNU General Public License for more details.
#
# You should have received a copy of the GNU General Public License
# along with this program. If not, see <http://www.gnu.org/licenses/>.

import sys
import time
from tendo import singleton

import labrad

from dataChestWrapper import *
```

```
import MGui # Handles all GUI operations. Independent of LabRAD.
from MDevices.Device import Device
from MDevices.Mhdf5Device import Mhdf5Device

class nViewer:
  gui = None
  devices = []
  def __init__(self, parent = None):
    # Establish a connection to LabRAD.
    try:
      # Thiss will sys.exit(-1) if other instance is running.
      me = singleton.SingleInstance()
    except:
      print("Multiple instances cannot be running")
      time.sleep(2)
      sys.exit(1)
    try:
      cxn = labrad.connect() # Attempt to establish a labrad connection.
    except:
      # If no connection can be made, abort with an error message.
      print("Please start the LabRAD manager")
      time.sleep(2)
      sys.exit(0)
    try:
      # As of writing, there is one class in MView itself that is dependent
      # on LabRad, and it requires the telecomm server to be running.
      # This is subject to change.
      tele = cxn.telecomm_server
    except:
      # If no connection can be made, abort with an error message.
      print("Please start the telecomm server")
      time.sleep(2)
      sys.exit(1)
    self.gui = MGui.MGui()


    Compressor = Device("Compressor")
    Compressor.connection(cxn)
    Compressor.setServerName("cp2800_compressor")
    Compressor.addButton("Turn Off",
       "You are about to turn the compressor off.",
       "stop", None)
    Compressor.addButton("Turn On",
       "You are about to turn the compressor on.",
       "start", None)
    Compressor.addButton("Elapsed Time",
       None,
       "elapsed_time", None)
    Compressor.addParameter("Input Water Temperature",
       "current_temperatures_only", None, index =0)
    Compressor.addParameter("Output Water Temperature",
       "current_temperatures_only", None, index =1)
    Compressor.addParameter("Helium Temperature",
       "current_temperatures_only", None, index =2)
    Compressor.addParameter("Oil Temperature",
       "current_temperatures_only", None, index =3)
    Compressor.selectDeviceCommand("select_device", 0)
    Compressor.setYLabel("Temperature")
    Compressor.addPlot()
    Compressor.begin()
    self.gui.addDevice(Compressor)
    # Create the gui.

    self.gui.startGui('Leiden DR GUI',tele)


# In Python, the main class's __init__() IS NOT automatically called.
viewer = nViewer()
viewer.__init__()
```

Devices in MView

MView Device Structure

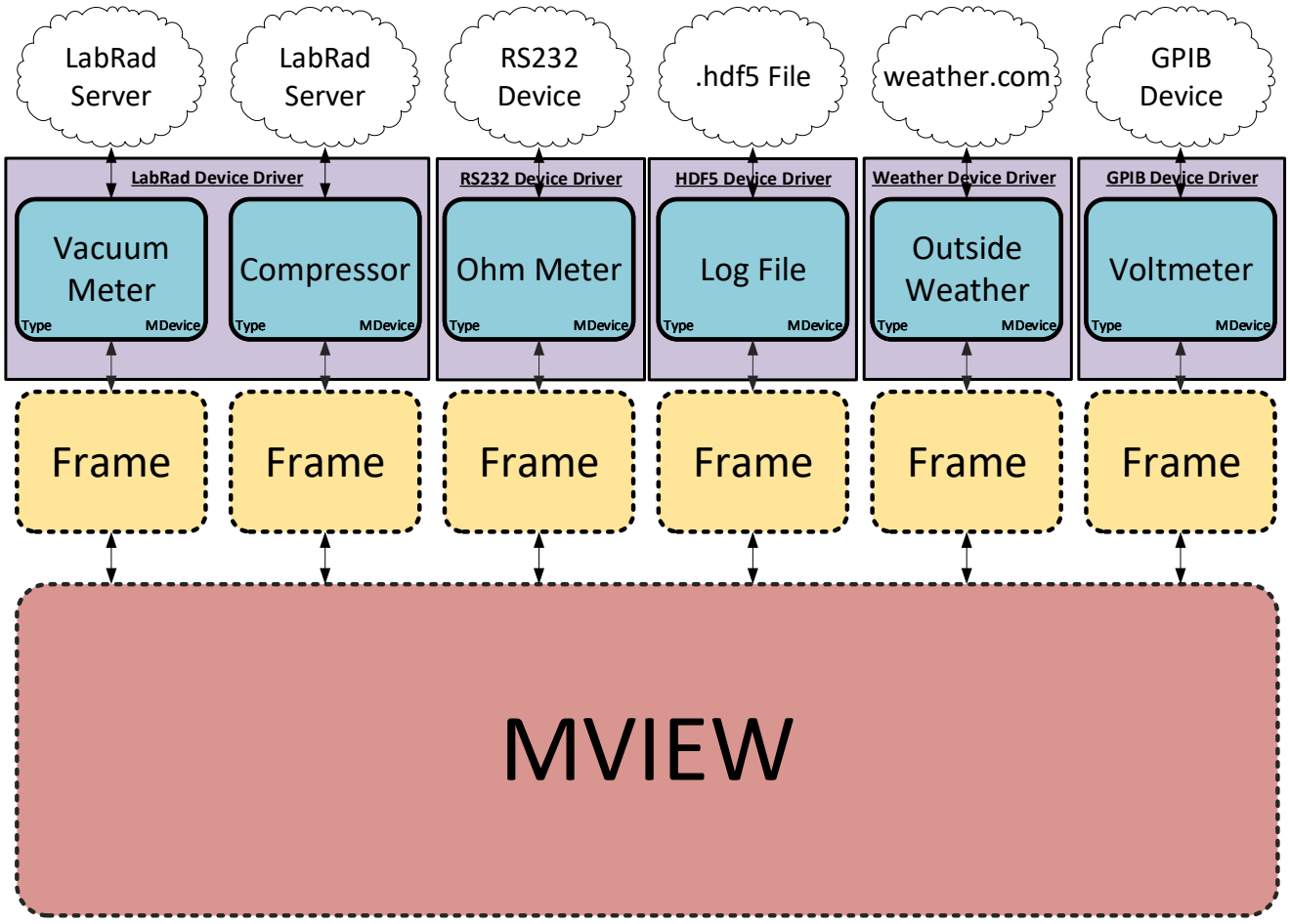


Figure 1: The structure of devices in MView

The MDevice Class

https://nmgit.github.io/MView/mView.MDevice.html

MView uses the MDevice class to give all sources of data a common interface with which to interact in the context of MView. These sources of data can be anything including but not limited to LabRad servers, RS232 devices, GPIB Devices, they can even represent the contents of .hdf5 files.

Devices in MView are created by instantiating their device drivers. For example, if there are two RS232 devices, we create two instances of the RS232 device driver. This means that only one generic device driver needs to be created for each interface (RS232, LabRad Servers, HDF5 files, etc.) and it can then be applied to all devices that use the same interface.

Special fuctions

There are a few special functions that are made available to use when the parent class is MDevice.

- **`MDevice.onLoad()`**

  Called at the end of MGui.startGui(), when the main MView GUI has finished loading. This allows the MDevice to configure pieces of MView only available once the program has fully loaded.

- **`MDevice.onBegin()`**

  Called at the end of MDevice.begin(). This is called before MView starts. This allows us to configure settings that MView might use while starting. This might include datalog locations or device-specific information.

- **`MDevice.onAddParameter(*args)`**

  Called when when a new parameter is added. It is passed whatever MDevice.addParameter() is passed. (Note: MDevice.onAddParameter() and MDevice.addParameter() are different).

  Warning: Never override the MDevice.addParameter() method. The MDevice.onAddParameter() method is meant to be overridden. All arguments and keyword arguments passed to MDevice.addParameter() are also passed to MDevice.onAddParameter().

- **`MDevice.query()`**

  Automatically called periodically, determined by MDevice.Mframe.getRefreshRate(). There is also a MDevice.Mframe.setRefreshRate() function with which the refresh rate can be configured. This is where any MDevice Query's its hardware.

- **`MDevice.prompt(button)`**

  Called when a device's button is pushed. Button is an array which is associated with the button. The array is constructed in the device driver code, and the PyQT button is then appended to the end by MView. The array associated with the button is passed to prompt()

in the device driver. The device driver then determines what to do based on the button pushed.

The MFrame Class

https://nmgit.github.io/MView/mView.MFrame.html

Each device has a something called a 'frame,' which is an instance of the MFrame class. The frame serves a few purposes:

- Note the 'Frame' between MView and MDevice shown in figure 1. Because the all MDevices run on their own thread, they cannot update the GUI directly. The MFrame class provides a thread-safe way for MView to interact with MDevices by forcing all information about a device into exclusively thread-safe data structures which can be accessed either by MView or and MDevice at any time.
- The MFrame holds all information about an MDevice. This includes everything from current readings to a reference to the MDeviceContainer that represents the device on the GUI to all of the logged data and more. Think of an MDevice as representing student taking notes in class, the MFrame represents that student's notebook. The notebook holds all information beyond what it makes sense for the student to hold in their memory. While it can be argued that the MFrame and MDevice classes should be combined, the two classes were separated for the sake of semantics.

Warning: Although this is a more advanced topic that the end user probably won't need to worry about, it is worth mentioning that MDevice is a child of QThread. This means that all devices run on a thread separate from one another and from the main MView GUI. These threads are known as worker threads as opposed to the main thread which runs the GUI. This is important because functions in the main thread *absolutely should not* be called by worker threads, doing so causes undefined behavior. More simply, never try to update the GUI directly from a device driver, always use the frame.

MDevice API

Please see https://nmgit.github.io/MView/mView.MDevice.html

Writing a Device Driver

We will now write a device driver that communicates with RS232 devices.

Things you should know

MView was written to be expandable by the user. In order to make this work, creation of new device drivers is easy and do-able without extensive knowledge of python or MView itself.

All device drivers are children of the MDevice class, which handles much of the overhead when interacting with MView and handling threading.

All devices device drivers should go in the mView/MDevices/ folder.

What it should do

Let's think about what this device driver must be able to do. In order to communicate with a serial device, we need to do the following:

1. Connect the device's respective COM port.
2. Send the device a serial command.
3. Receive a serial response.

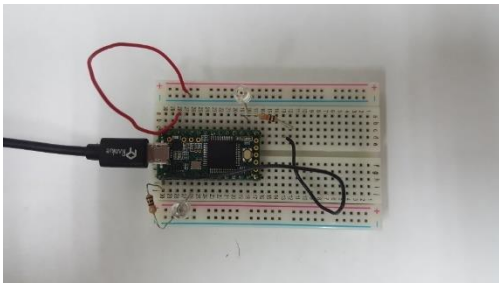
How we will do it

PySerial is a good tool for serial communication in python, so it is what we will use for the device driver.

The Device

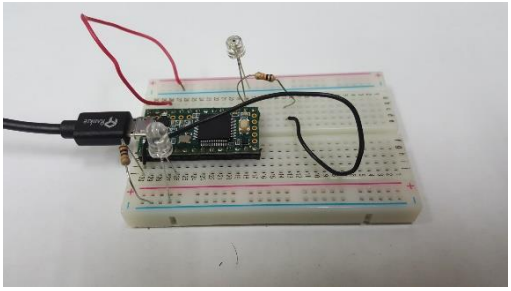
We will use a simple serial device to test our new device driver. Let's call this device the Light Meter 3000, it has a light sensor, as well as an led.. Note that this device is just to test our driver; however, our driver should be generic and work with all serial devices. To read from the light sensor, the character 's' is sent to the device, and a value terminated by '\r\n' is returned.

```
>>> import serial
>>> device = serial.Serial("COM7", timeout=1)
>>> device.write('s')
1L
>>> lightlevel = device.readline()
>>> lightlevel
'17\r\n'
>>> int(lightlevel.strip())
17
```

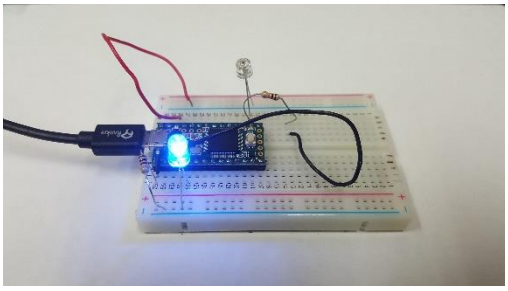


The led can be lit to 10 different brightness's by sending the character 'b' immediately followed by a number 0-9.

```
>>> device.write('b0')
2L
```



```
>>> device.write('b9')
2L
```



Writing The Code

NOTE: This device driver is a simple example, for the sake of simplicity, this tutorial will not include error-checking or recovery from errors.

Before we write the actual class, lets insert a code header and import statements.

```
# Copyright (C) 2016 Noah Meltzer
#
# This program is free software: you can redistribute it and/or modify
# it under the terms of the GNU General Public License as published by
# the Free Software Foundation, either version 2 of the License, or
# (at your option) any later version.
#
# This program is distributed in the hope that it will be useful,
# but WITHOUT ANY WARRANTY; without even the implied warranty of
# MERCHANTABILITY or FITNESS FOR A PARTICULAR PURPOSE. See the
# GNU General Public License for more details.
#
# You should have received a copy of the GNU General Public License
# along with this program. If not, see <http://www.gnu.org/licenses/>.

  author   = "Noah Meltzer"
__copyright__ = "Copyright 2016, Noah Meltzer, McDermott Group"
  license   = "GPL"
__version__ = "0.0.1"
__maintainer__ = "Noah Meltzer"
__status__ = "Beta"

# Import the parent class
from MDevice import MDevice
# We will use the pyserial class to interface with COM ports.
import serial
import time
# Traceback is good for printing errors and debugging.
import traceback
# Import necessary Qt libraries
from PyQt4 import QtGui
```

Next, let's create the class. Notice that MDevice is the parent class

```
class RS232Device(MDevice):
```

Initializing Variables

The __init__ function is called when the device is instantiated. We will use it to initialize some variables.

```
def __init__(self, *args, **kwargs):
  '''Initialize variables. Most of the device parameters cannot yet be initialized.'''
  super(RS232Device, self).__init__(*args, **kwargs)
  # The name of the device is passed as the first argument.
  self.name = args[0]
  # The name of the port (i.e. COMx) is given as the second argument.
  self.portname = args[1]
  # This dictionary will hold basic information about different parameters.
  # This dictionary will just be used by us.
  self.paramInfo = {}
  # This will hold a reference to the pySerial instance that
  # is used to communicate with the device.
  self.port = None
  # Is the device connected?
  self.connected = False
  # The serial timeout, default 10ms.
  self.timeout = kwargs.get("timeout",10)
  # Default baud rate is 9600.
  self.baud = kwargs.get("baud", 9600)
```

Implementing onAddParameter()

Time to handle a new parameter being added. We will override the MDevice.onAddParameter() function for this one. Remember, **never override MDevice.addParameter().**

```
def onAddParameter(self, paramName, command, *args, **kwargs):
  # Look for keyword arguments
  precision = kwargs.get("precision", None)
  units = kwargs.get("units", None)
  # Add a key to our dictionary that holds another dictionary.
  self.paramInfo[str(paramName)] = {}
  thisParam = self.paramInfo[str(paramName)]
  # Add some more keys to our dictionary.
  thisParam["name"] = paramName
  thisParam["command"] = command
  thisParam["precision"] = precision
  thisParam["units"] = units
```

Implementing Buttons

Now it is time to allow for buttons to be added. To do this, we implement the addButton() method which creates a button. A button is a list whose contents are defined by the user. There is no strict requirement for buttons other than that they are of type list. The list holds any commands or warning messages to be used by our prompt() function later.

```
def addButton(self, text, command, **kwargs):
  # Look for a message keyword argument
  message = kwargs.get("message", None)
  # Build the list.  The QPush button object will be appended to the end of this list.
  button = []
  # We will make the first element of the list hold
  # the text that is displayed on the button.
  button.append(text)
  # The second element will be the command sent to the device
  # if the button is clicked.
  button.append(command)
  # We can include a warning message too.
  button.append(message)
  # Add the button to the gui
  self.addButtonToGui(button)
```

The MDevice.prompt() function is called whenever a button is pressed, the button we created in the addButton() function is also passed to prompt. This means we have access to all messages, commands, and even the PyQt pushbutton which means that we can do things like change the color of the button based on state. Here is the implementation:

```
def prompt(self, button):
  # We stored the warning message in the 3rd element of the button array.
  # If it is None, do not display a warning message, if it is not, display about
  # warning using the QMessageBox class.
  if button[2] is not None:
    # Create a QMessageBox
    msg = QtGui.QMessageBox()
    # Set the icon to an exclamation point.
    msg.setIcon(QtGui.QMessageBox.Warning)
    # Our warning message text is in the 3rd element of our array.
    msg.setText(button[2])
    # Add ok and cancel buttons.
    msg.setStandardButtons(QtGui.QMessageBox.Ok | QtGui.QMessageBox.Cancel)
    # The window title.
    msg.setWindowTitle("Warning")
    # Execute the class and retrieve the value clicked.
    retval = msg.exec_()
    # If ok was clicked then send the command to the serial device.
    if retval == QtGui.QMessageBox.Ok:
      # The command was put into the 2nd element of the array.
      self.port.write(button[1])
  # If no warning message was given, then just go ahead and send the command.
  else:
    # The command was put into the 2nd element of the array.
    self.port.write(button[1])
```

Implementing setPort and setYLabel

The setPort and setYLabel methods are implemented as follows:

```
def setPort(self, portname, timeout = 10):
  '''Set the name of the port. i.e. COMx. Keyword args: timeout = 10.'''
  self.portname = portname
  self.timeout = timeout

def setYLabel(self, yLbl, units=''):
  '''Set the label to be displayed on the independent variable axis.'''
  self.frame.setYLabel(yLbl, units)
```

Implementing initialization

We will now implement the MDevice.onBegin() function that is called when the MDevice.begin() function is called. This happens once the device is set up, and it should initiate a the last steps that need to be completed in order to have a working device. This includes connecting to the device.

```
def onBegin(self):
  '''Begin the device.'''
  self.connect()
```

Connecting

Now, we implement the connect function. This should open a port.

```
def connect(self):
  '''Open the serial port and try to connect to it.'''
  try:
   self.port = serial.Serial(self.portname,
                             int(self.baud),
                             timeout=self.timeout,
                             write_timeout = 10)
   self.connected = True
   return self.port
  except:
   traceback.print_exc()
   self.connected = False
   print "ERROR: port:", self.port, "will try again."
   return None
```

Querying the device

The query function is called with a period defined by MDevice.frame.getRefreshRate(). At the end it should set the readings by calling self.frame.setReadings([readings]). Where [readings] is an array of readings.

```
  def query(self):
```

```
  '''The query function is called with a period defined
       by MDevice.frame.getRefreshRate().  At the end it
       should set the readings by calling self.frame.setReadings([readings]).
       Where [readings] is an array of readings.
   '''
  try:
    readings = []
    if not self.connected:
      # if not connected, connect.
      self.connect()
    # If self.port is not None.
    if self.port is not None:
      # For each parameter, get readings
      for param in self.getParameters():
        print "param:",param
        # Flush anything that might on the port.
        self.port.flush()
        # Write the command to the port.
        command = self.paramInfo[param]['command']
        if command != None:
          self.port.write(self.paramInfo[param]['command'])
          # Wait while there is nothing on the port.
          while(not self.port.in_waiting > 0):
            time.sleep(0.01)
          # While there is stuff on the port, read it.
          reading = self.port.readline()
          # Strip whitespace and newline characters off the received value.
          reading = int(reading.strip())
        # Tell the device what the readings were.
          self.setReading(param, reading)
  except:
    try:
      self.port.close()
    except:
      pass
    traceback.print_exc()
    self.connected = False
```

Closing the Port

The MDevice.close() method is called when MView is closed. In that function we tidy up after ourselves, in this case we should close the port we opened.

```
def close(self):
  '''Stop the device. This includes closing the port.'''
  try:
    self.port.close()
  except:
    print "Could not close port."
```

Putting it all together

Here is what our device driver should look like when we are finished.

```
# Copyright (C) 2016 Noah Meltzer
#
# This program is free software: you can redistribute it and/or modify
# it under the terms of the GNU General Public License as published by
# the Free Software Foundation, either version 2 of the License, or
# (at your option) any later version.
#
# This program is distributed in the hope that it will be useful,
# but WITHOUT ANY WARRANTY; without even the implied warranty of
# MERCHANTABILITY or FITNESS FOR A PARTICULAR PURPOSE. See the
# GNU General Public License for more details.
#
# You should have received a copy of the GNU General Public License
# along with this program. If not, see <http://www.gnu.org/licenses/>.

__author__ = "Noah Meltzer"
__copyright__ = "Copyright 2016, Noah Meltzer, McDermott Group"
  license   = "GPL"
  version   = "0.0.1"
__maintainer__ = "Noah Meltzer"
__status__ = "Beta"

# Import the parent class
from MDevice import MDevice
# We will use the pyserial class to interface with COM ports.
import serial
import time
# Traceback is good for printing errors and debugging.
import traceback
# Import necessary Qt libraries
from PyQt4 import QtGui

class RS232Device(MDevice):
  def __init__(self, *args, **kwargs):
    '''Initialize variables. Most of the device parameters cannot yet be initialized.'''
    super(RS232Device, self).__init__(*args, **kwargs)
    # The name of the device is passed as the first argument.
    self.name = args[0]
    # The name of the port (i.e. COMx) is given as the second argument.
    self.portname = args[1]
    # This dictionary will hold basic information about different parameters.
    # This dictionary will just be used by us.
    self.paramInfo = {}
    # This will hold a reference to the pySerial instance that
    # is used to communicate with the device.
    self.port = None
    # Is the device connected?
    self.connected = False
    # The serial timeout, default 10ms.
    self.timeout = kwargs.get("timeout",10)
    # Default baud rate is 9600.
    self.baud = kwargs.get("baud", 9600)

  def onAddParameter(self, paramName, command, *args, **kwargs):
    # Look for keyword arguments
    precision = kwargs.get("precision", None)
    units = kwargs.get("units", None)
    # Add a key to our dictionary that holds another dictionary.
    self.paramInfo[str(paramName)] = {}
    thisParam = self.paramInfo[str(paramName)]
    # Add some more keys to our dictionary.
    thisParam["name"] = paramName
    thisParam["command"] = command
    thisParam["precision"] = precision
    thisParam["units"] = units
```

```
  def addButton(self, text, command, **kwargs):
    # Look for a message keyword argument
    message = kwargs.get("message", None)
    # Build the list.  The QPush button object will be appended to the end of this list.
    button = []
    # We will make the first element of the list hold
    # the text that is displayed on the button.
    button.append(text)
    # The second element will be the command sent to the device
    # if the button is clicked.
    button.append(command)
    # We can include a warning message too.
    button.append(message)
    # Add the button to the gui
    self.addButtonToGui(button)
  def prompt(self, button):
    # We stored the warning message in the 3rd element of the button array.
    # If it is None, do not display a warning message, if it is not, display about
    # warning using the QMessageBox class.
    if button[2] is not None:
      # Create a QMessageBox
      msg = QtGui.QMessageBox()
      # Set the icon to an exclamation point.
      msg.setIcon(QtGui.QMessageBox.Warning)
      # Our warning message text is in the 3rd element of our array.
      msg.setText(button[2])
      # Add ok and cancel buttons.
      msg.setStandardButtons(QtGui.QMessageBox.Ok | QtGui.QMessageBox.Cancel)
      # The window title.
      msg.setWindowTitle("Warning")
      # Execute the class and retrieve the value clicked.
      retval = msg.exec_()
      # If ok was clicked then send the command to the serial device.
      if retval == QtGui.QMessageBox.Ok:
        # The command was put into the 2nd element of the array.
        self.port.write(button[1])
    # If no warning message was given, then just go ahead and send the command.
    else:
      # The command was put into the 2nd element of the array.
      self.port.write(button[1])

  def setPort(self, portname, timeout = 10):
    '''Set the name of the port. i.e. COMx. Keyword args: timeout = 10.'''
    self.portname = portname
    self.timeout = timeout

  def setYLabel(self, yLbl, units=''):
    '''Set the label to be displayed on the independent variable axis.'''
    self.frame.setYLabel(yLbl, units)

  def onBegin(self):
    '''Begin the device.'''
    self.connect()

  def connect(self):
    '''Open the serial port and try to connect to it.'''
    try:
      self.port = serial.Serial(self.portname, int(self.baud), timeout=self.timeout, write_timeout =
10)
      self.connected = True
      return self.port
    except:
      traceback.print_exc()
      self.connected = False
      print "ERROR: port:", self.port, "will try again."
      return None

  def query(self):
    '''The query function is called with a period defined
```

```
        by MDevice.frame.getRefreshRate().  At the end it
        should set the readings by calling self.frame.setReadings([readings]).
        Where [readings] is an array of readings.
    '''
    try:
      readings = []
      if not self.connected:
        # if not connected, connect.
        self.connect()
      # If self.port is not None.
      if self.port is not None:
        # For each parameter, get readings
        for param in self.getParameters():
          print "param:",param
          # Flush anything that might on the port.
          self.port.flush()
          # Write the command to the port.
          command = self.paramInfo[param]['command']
          if command != None:
            self.port.write(self.paramInfo[param]['command'])
            # Wait while there is nothing on the port.
            while(not self.port.in_waiting > 0):
              time.sleep(0.01)
            # While there is stuff on the port, read it.
            reading = self.port.readline()
            # Strip whitespace and newline characters off the received value.
            reading = int(reading.strip())
          # Tell the device what the readings were.
            self.setReading(param, reading)
    except:
      try:
        self.port.close()
      except:
        pass
      traceback.print_exc()
      self.connected = False
      pass
  def close(self):
    '''Stop the device. This includes closing the port.'''
    try:
      self.port.close()
    except:
      print "Could not close port."
```

The Associated GUI

Here is the python program that will initialize the light meter 3000's MView GUI.

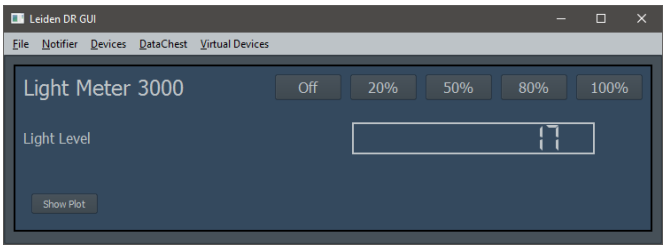
```
# Copyright (C) 2016 Noah Meltzer
#
# This program is free software: you can redistribute it and/or modify
# it under the terms of the GNU General Public License as published by
# the Free Software Foundation, either version 2 of the License, or
# (at your option) any later version.
#
# This program is distributed in the hope that it will be useful,
# but WITHOUT ANY WARRANTY; without even the implied warranty of
# MERCHANTABILITY or FITNESS FOR A PARTICULAR PURPOSE. See the
# GNU General Public License for more details.
#
# You should have received a copy of the GNU General Public License
# along with this program. If not, see <http://www.gnu.org/licenses/>.


"""
version = 1.1.1
description = Demonstration
```

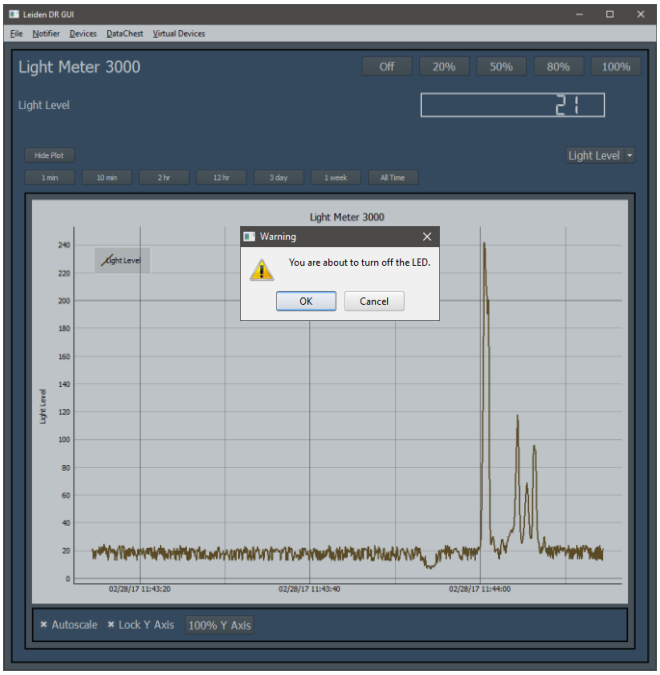
```
"""

import sys
sys.dont_write_bytecode = True
import MGui  # Handles all GUI operations. Independent of  LabRAD.

from MDevices.RS232Device import RS232Device

from MNodeEditor import MNodeTree
from MNodeEditor.MNodes import MDeviceNode
from MNodeEditor.MNodes import runningAverage

import labrad
import time

from tendo import singleton

class mViewer:
  gui = None
  devices = []

  def __init__(self, parent = None):
    # Establish a connection to LabRAD.
    try:
      me = singleton.SingleInstance() # will sys.exit(-1) if other instance is running
    except:
      print("Multiple instances cannot be running")
      time.sleep(2)
      sys.exit(1)
    try:
      cxn = labrad.connect()
    except:
      print("Please start the LabRAD manager")
      time.sleep(2)
      sys.exit(0)
    try:
      tele = cxn.telecomm server
    except:
      print("Please start the telecomm server")
      time.sleep(2)
      sys.exit(1)

    self.gui = MGui.MGui()
    lm3000 = RS232Device("Light Meter 3000", "COM7", baud = 115200)
    lm3000.addButton("Off", 'b0', message = "You are about to turn off the LED.")
    lm3000.addButton("20%", 'b2')
    lm3000.addButton("50%", 'b5')
    lm3000.addButton("80%", 'b8')
    lm3000.addButton("100%", 'b9')
    lm3000.addParameter("Light Level", "s")
    lm3000.setYLabel("Light Level")
    lm3000.addPlot()
    lm3000.begin()
    self.gui.addDevice(lm3000)

    self.nodeTree = MNodeTree.NodeTree()

    lightMeterNode = MDeviceNode.MDeviceNode(lm3000)
    self.nodeTree.addNode(lightMeterNode)
    rawLightOutput = lightMeterNode.getAnchorByName("Light Level")
    avgLight = lightMeterNode.addAnchor(name = "Average Light Level", type = "input", terminate = True)

    avg = runningAverage.runningAverage()
    avg.setWindowWidth(100)
    avgInput = avg.getAnchorByName("data")
    avgOutput = avg.getAnchorByName("running avg")

    self.nodeTree.connect(rawLightOutput, avgInput)
    self.nodeTree.connect(avgOutput, avgLight)
    # self.nodeTree.connect(output, virtAvgInput)
```

```
    # Create the gui.

    self.gui.startGui('Leiden DR GUI',tele)


# In Python, the main class's   init  () IS NOT automatically called.
viewer=mViewer()
viewer.__init__()
```

The Interface

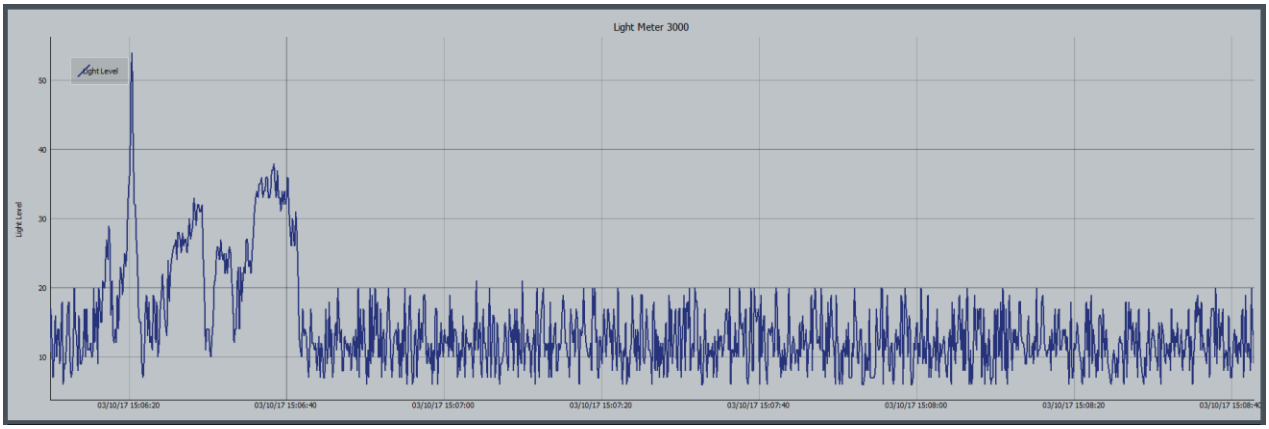
Here is what we have created!





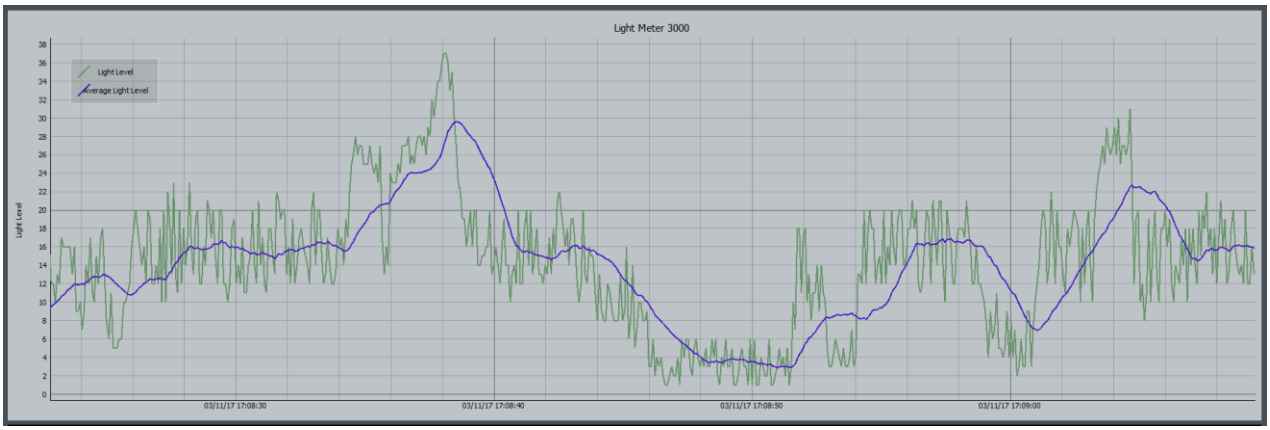
A Segway to the Cool Stuff

Lets take a closer look at the data we get from out light meter.



Notice the amount of noise in the signal. Up until this point in the guide, this noise would either have had to be ignored or dealt with manually outside of MView. There is; however, a better way and it is provided by something called the node tree.

In the following section, we will look at how to obtain the following plot automatically.



The Node Tree

What is the node tree?

MView's node tree is without a doubt MView's most useful and coolest feature. It takes MView from being just a dashboard to a tool that can perform application-specific tasks.

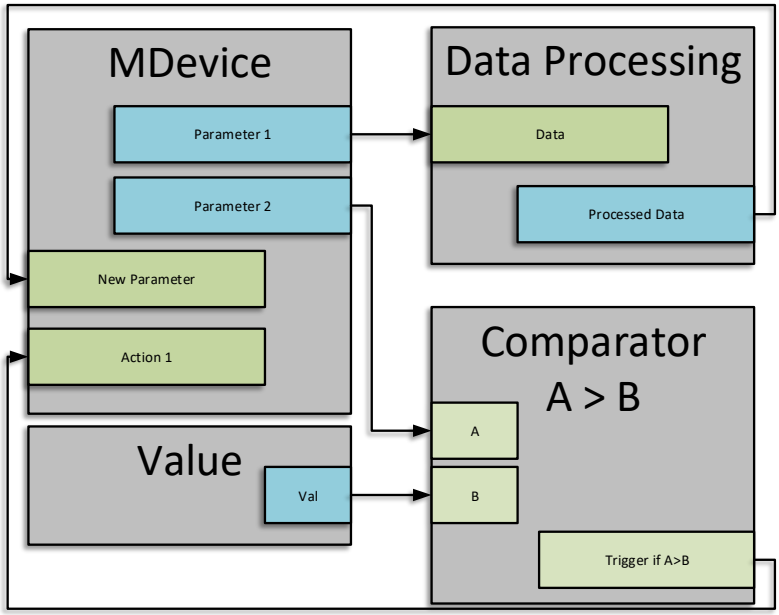
MView accomplishes this through a nodal logic editor, based on a programming paradigm called **flow-based programming (FPB)**. A quick Google search should provide a much more in depth explanation of the idea, but here is the tl;dr:

Elements in MView such as plots, devices, etc. can be represented as black boxes which are related through a network of connections. These connections communicate data between black boxes, allowing elements of MView to communicate.

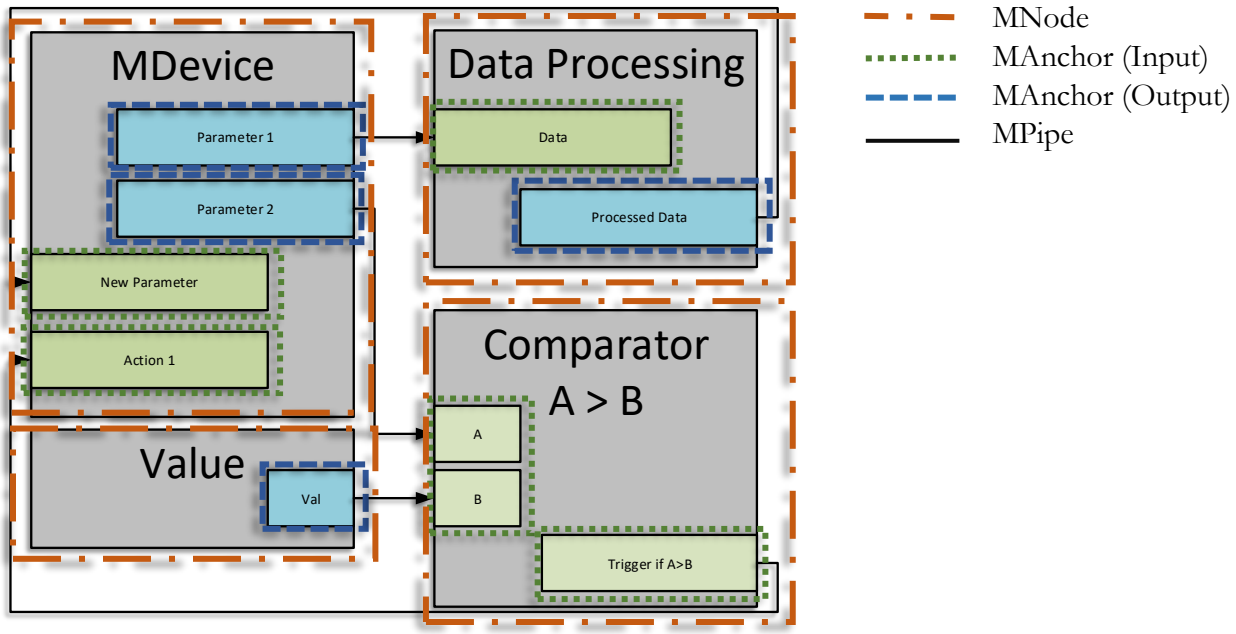
Possible applications of MView's FBP include but are not limited to, data processing, feedback loops, device control. The FBP allows equipment to be controlled and monitored in much the same way as LabView, the difference being reduced complexity along with the familiarity of python.

This is enough information for now, the idea is simple and as we use it more and more, and you will get a better understanding of what it can be used for. A description of how MView's FPB engine was written will be at the end of the document.

Please see https://nmgit.github.io/MView/mView.MNodeEditor.html for full API.

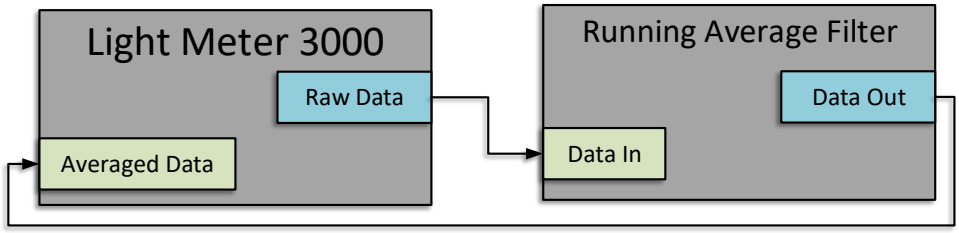


Elements of MView's Node Tree



Getting Rid of the Light Meter's Noise

We will now use the node editor to put a running average of the light meter readings on the plot. We will do this using the following map:



Note: It is always good to draw out the node tree maps before trying to implement them.

Build The Node Tree

The MView node tree can be built programmatically. This is good for creating logic that cannot be interfered with while MView is running. Additionally, multiple node trees can be created in order to allow for better logic organization.

We will put the following code at the bottom of the GUI we created in the previous section (except for the imports).

Instantiating A Node Tree

We need to import the MNode tree libraries:

```
from MNodeEditor import MNodeTree
```

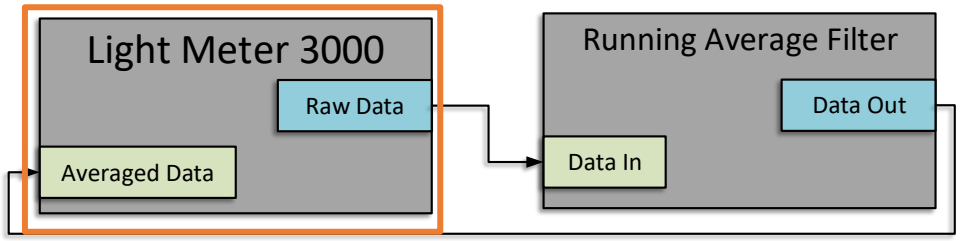
Now at the bottom of the GUI code, lets instantiate a new node tree:

```
self.nodeTree = MNodeTree.NodeTree()
```

Creating an MDeviceNode

We need to create an MNode that represents the light meter 3000 MDevice. Luckily, this MNode is provided. It is called MDeviceNode and we instantaneity it by passing in our MDevice.

```
lightMeterNode = MDeviceNode.MDeviceNode(lm3000)
```



We now need to add this node to the node tree.

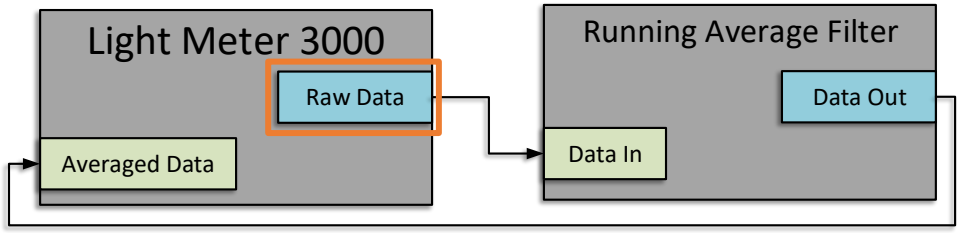
```
self.nodeTree.addNode(lightMeterNode)
```

Next, we grab the MNode anchor which gives the raw light output. We do this using the MNode.getAnchorByName:

```
getAnchorByName(self, name):
```

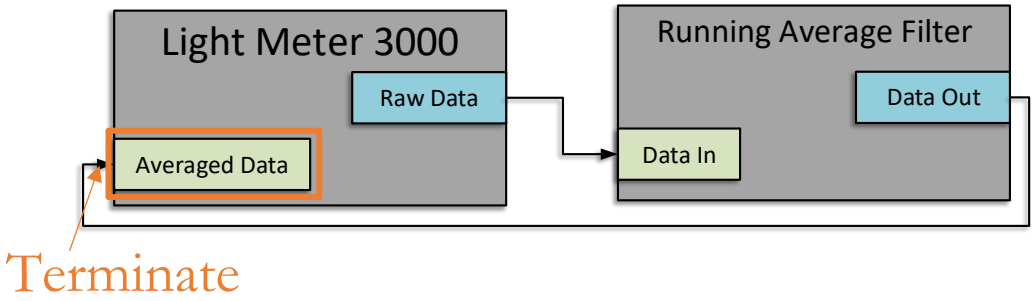
The 'name' field can be the name of any MDevice parameter for an MDeviceNode.

```
rawLightOutput = lightMeterNode.getAnchorByName("Light Level")
```



We will also create the avgLight input on the MDevice using the MNode.addAnchor() function. This adds a parameter to our light meter 3000 MDevice.

```
avgLight = lightMeterNode.addAnchor(name = "Average Light Level", type = "input", terminate = True)
```



Warning: Notice that our tree is circular. i.e. the light meter 3000 connects to the running average filter which connects back to the light meter and the arrows create a circle. If we are not careful, this will create an infinite loop condition. This is because output anchors refresh the nodes they are connected to. So when the light meter refreshes, the running average filter refreshes which then refreshes the light meter and on and on.
We need to add a termination point where the refresh stops propagating. We do this at the averaged data input anchor of the light meter node. We use the 'terminate' keyword when creating the anchor to tell the MView FBP engine not to propagate refreshes.

Creating a Running Average Node

The running average node is conveniently already written (but don't worry, you will learn how to write your own nodes!). We will first create a running average node:

```
avg = runningAverage.runningAverage()
```

We will then use the RunningAverage.setWindowWidth() function to define the window width of the running average.

```
avg.setWindowWidth(100)
```

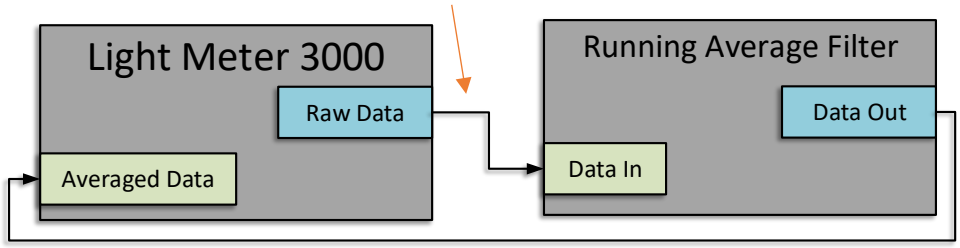
The running average node comes with two achors: 'data' and 'running avg,' which we will connect to our MDeviceNode. Let's get references to the inputs and outputs:

```
avgInput = avg.getAnchorByName("data")
avgOutput = avg.getAnchorByName("running avg")
```

Connecting Everything

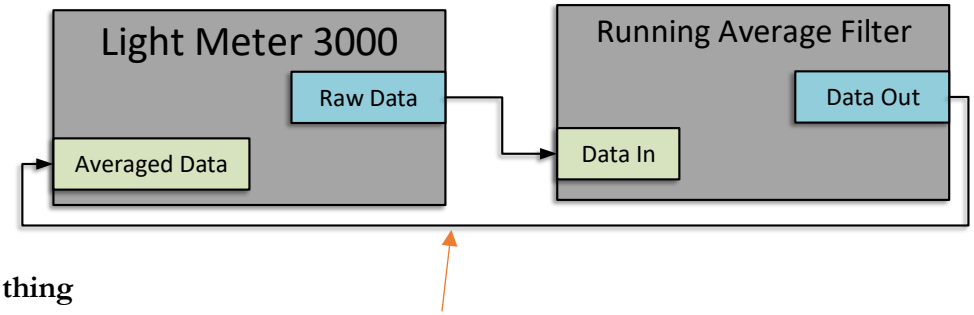
We now need to make all the connections between the nodes. First let's connect the raw light ouput to the average inpute.

```
self.nodeTree.connect(rawLightOutput, avgInput)
```



Next, we connect the average output of running average to the average light input of our light meter.

```
self.nodeTree.connect(avgOutput, avgLight)
```



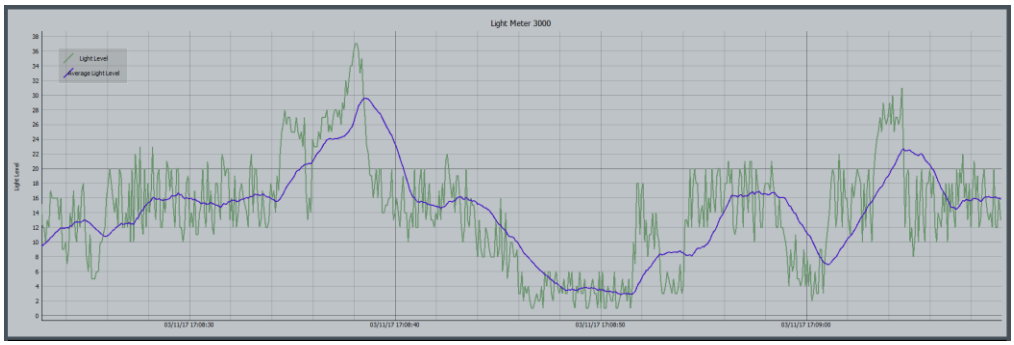
The whole thing

Here is what we should now have:

```
self.nodeTree = MNodeTree.NodeTree()

lightMeterNode = MDeviceNode.MDeviceNode(lm3000)
self.nodeTree.addNode(lightMeterNode)
rawLightOutput = lightMeterNode.getAnchorByName("Light Level")
avgLight = lightMeterNode.addAnchor(name = "Average Light Level", type = "input", terminate = True)

avg = runningAverage.runningAverage()
avg.setWindowWidth(100)
avgInput = avg.getAnchorByName("data")
avgOutput = avg.getAnchorByName("running avg")

self.nodeTree.connect(rawLightOutput, avgInput)
self.nodeTree.connect(avgOutput, avgLight)
```

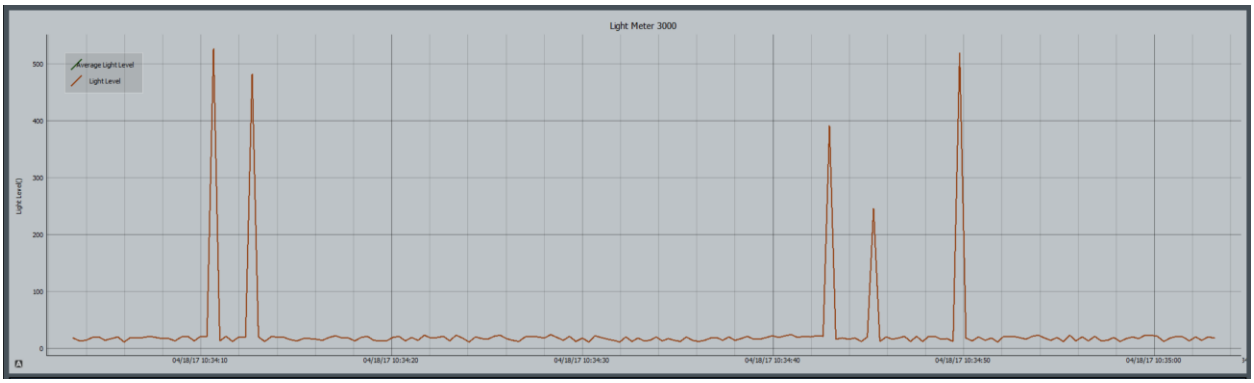
We are now good to call the self.gui.startGui() method.

We should end up with something that looks like this:



Writing Tree Nodes

Let's say that we got our light meter 3000 off aliexpress.com so it wasn't top-shelf to begin with and now it is starting to behave in weird ways. The readings have started to spike for no apparent reason, but you don't want to buy another light meter. Luckily you are using MView and filtering out spikes like these is easy.



We will write a filter node that finds the difference between the current measurement and the previous measurement, ignoring measurements for which the difference is too large.

The MNode Class

All MNodes are children of the MNode base class, which provides a few useful event-triggered functions that can be overridden.

- **`MNode.onBegin()`**

  Called when the node is added to a node tree.

- **`MNode.onRefreshData()`**

  Called by the MDevice when it is refreshing its data.

- **`MNode.onLoad()`**

  Called when startGui() finishes. Called before MDevice.onLoad().

- **`MNode.pipeDisconnected()`**

  Called when a pipe is disconnected from a node.

- **`MNode.pipeConnected(anchor, pipe)`**

  Called when a pipe is connected to a node. The references to the anchor the pipe was connected to as well as a reference to the pipe itself is passed to the function.

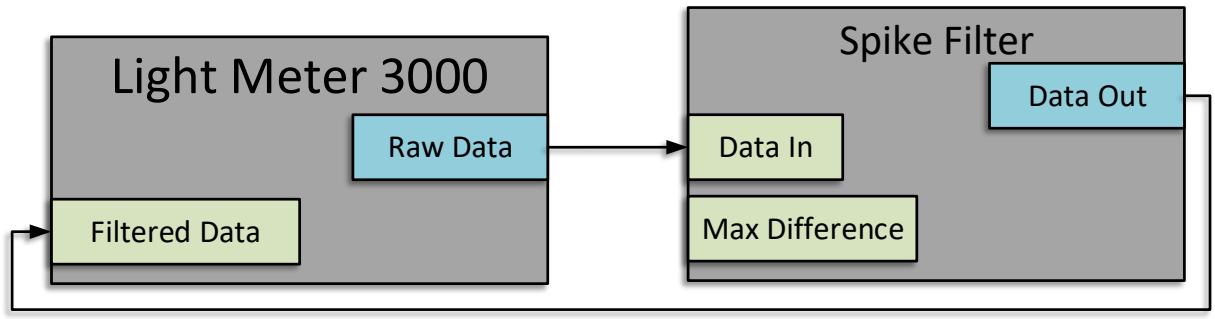
- **`MNode.anchorAdded(anchor, kwargs)`**

Called when an anchor is added to the node. A reference to the anchor as well as the keyword arguments passed to addAnchor() are passed to the function.

The Node We Want To Build

We want to write an MNode that takes in raw data as well as a value for the maximum difference and outputs the filtered data, one value at a time.

Our Node tree should look something like this:



Writing The Node

Importing the necessary libraries

The MNode and MAnchor parent classes are necessary to handle all of the overhead. We use numpy for numbers.

```
# Import MNodeEditor libraries
from MNodeEditor.MNode import MNode
from MNodeEditor.MAnchor import MAnchor
# Numpy to help with numbers
import numpy as np
```

Create Class

We now get to create our main class. Let's call it spikeFilter. It is an MNode so it must be a child of MNode. We will also write and __init__ function.

```
class spikeFilter(MNode):
  def __init__(self, *args, **kwargs):
    '''Initialize parent, and begin the parent.'''
    # Initialize parent.
    super(spikeFilter, self).  init  (*args, **kwargs)
    # Begin parent.
    self.begin()
    # Set up variables to hold current and previous
    # reading
    self.prev = np.nan
    self.curr = np.nan
```

Remember that we are provided with an onBegin function which is automatically called when the parent finishes initializing.

In this function, we will create all of the Nodes anchors so that we can communicate with it.

```
def onBegin(self, *args, **kwargs):
  '''Called when parent finished beginning.'''
  # Anchor for the raw data input
  self.dataAnchor = self.addAnchor(name = 'raw_data', type = 'input')
  # Anchor for the threshold (we dont necessarily need
  # to create an anchor for this, but we will anyway.)
  self.thresholdAnchor = self.addAnchor(name = 'threshold', type = 'input')
  # An anchor for the data output.
  # Note that this anchor has an 'ouput' type.
  self.output = self.addAnchor(name = 'filtered data', type = 'output')
  # Set the title of our node.
  self.setTitle("Spike Filter")
```

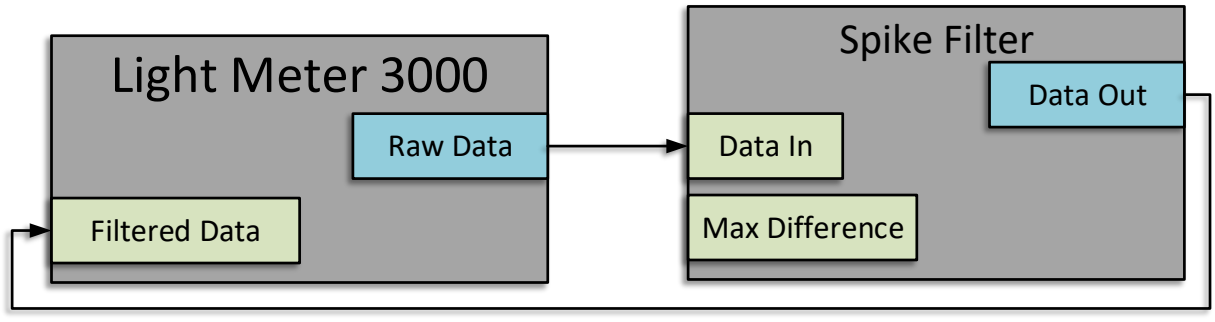
Now it is time to implement perhaps the most important part of the our spikeFilter node: the part that filters. This is done using the onRefreshData function provided to us. This function is called when the node is supposed to refresh the data on its anchors.

```
def onRefreshData(self):
  '''Refresh anchor data.'''
  # Get the current reading from the data anchor.
  self.curr = self.dataAnchor.getData()
  # Get the threshold value from the threshold anchor.
  threshold = self.thresholdAnchor.getData()
  # If the previous reading is a valid number (not
  # necessarily the case on startup) then continue.
  if self.prev != np.nan or self.prev != None:
     # If the absolute value of the difference is less than
     # the threshold...
     if abs(self.prev-self.curr) < threshold:
       # Then set the data on the output anchor to the current reading.
       self.output.setData(self.curr)
     else:
       # Otherwise, the data should be nan.
       self.output.setData(np.nan)
  # Update the previous value
  self.prev = self.curr
```

That's it! We are done with the node, let's create the tree in back in our startup program.

Creating the Tree

We want to implement the following tree:

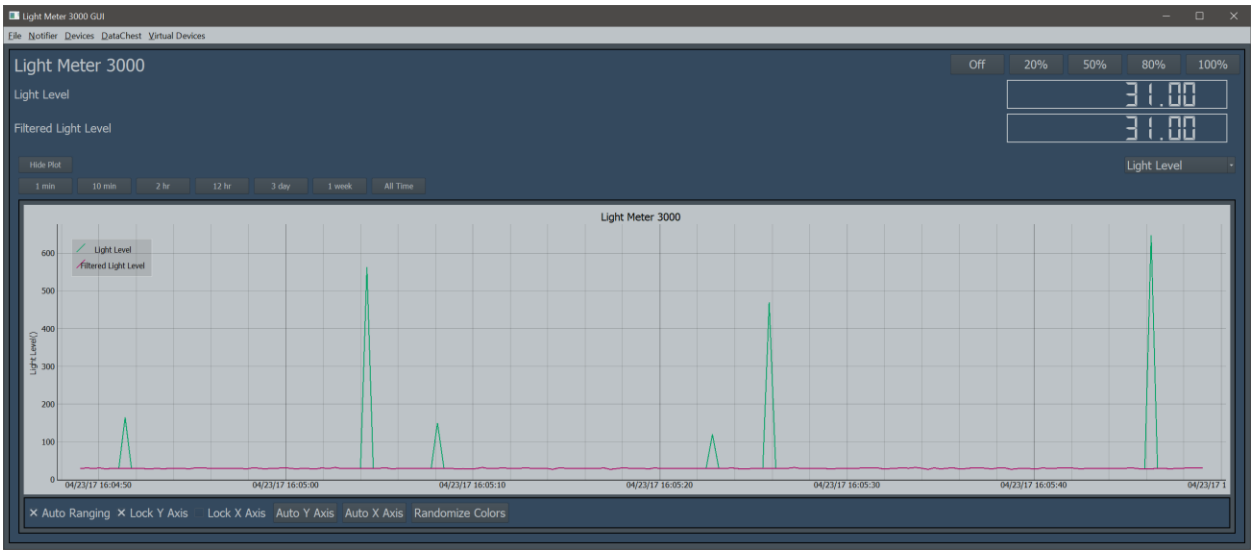


It is done like so:

```
self.nodeTree = MNodeTree.NodeTree()

lightMeterNode = MDeviceNode.MDeviceNode(lm3000)
self.nodeTree.addNode(lightMeterNode)
rawLightOutput = lightMeterNode.getAnchorByName("Light Level")
filtLight = lightMeterNode.addAnchor(name = "Filtered Light Level", type = "input", terminate =True)
spikeFilt = spikeFilter.spikeFilter()
# You can set the data of an input anchor when nothing is connected.
spikeFilt.getAnchorByName("threshold").setData(50)
rawSpikeDataInput = spikeFilt.getAnchorByName("raw data")
deSpikedData = spikeFilt.getAnchorByName("filtered_data")

self.nodeTree.connect(rawLightOutput, rawSpikeDataInput)
self.nodeTree.connect(deSpikedData, filtLight)
```

Note: addAnchor takes all keyword arguments that addParameter does.

That's it! We're done, let's take a look at the output.



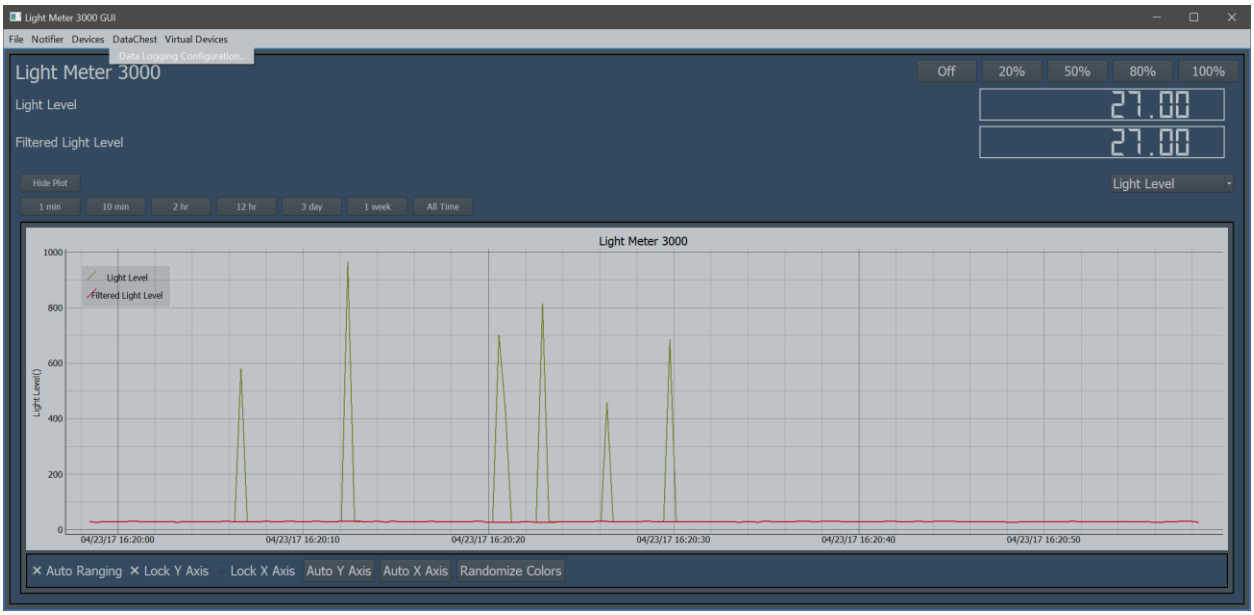
As can be seen from the legend, the green line is the raw data with spikes and the pink line is the filtered data.

There are a few more things we can do from here, too. We don't necessarily need to log or see the noisy data, so we will turn it off.

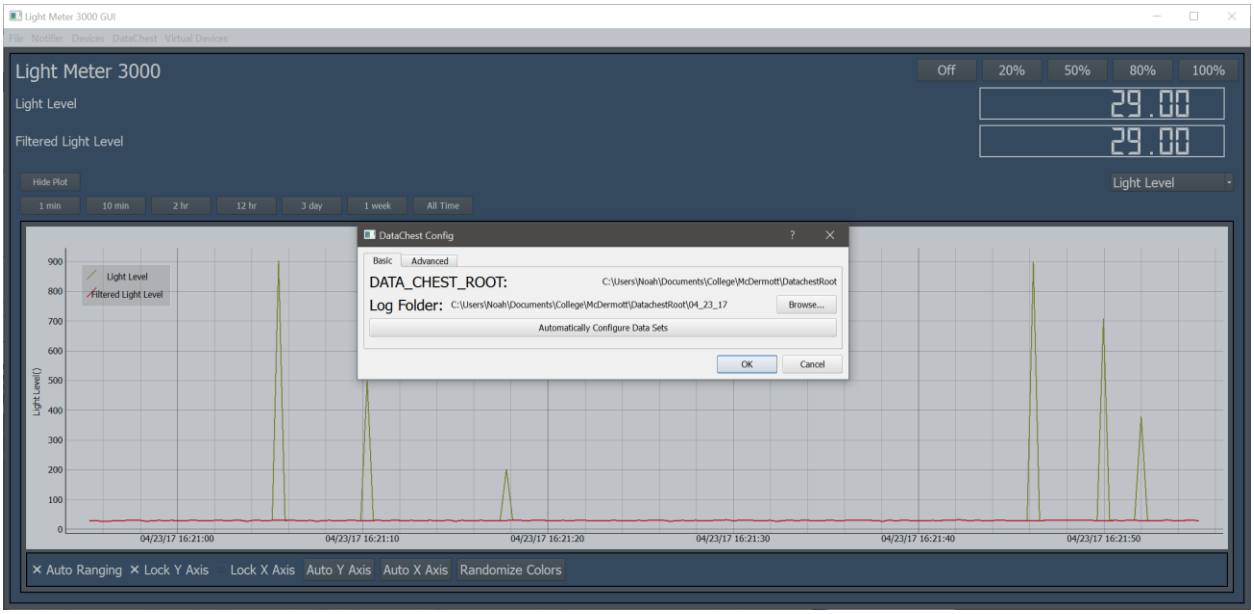
The Datalogging Settings

Using the GUI

There are a few things we can do to control the datalogging. The first uses the GUI-based menus. Let's click on the 'DataCest' tab on the menu bar.



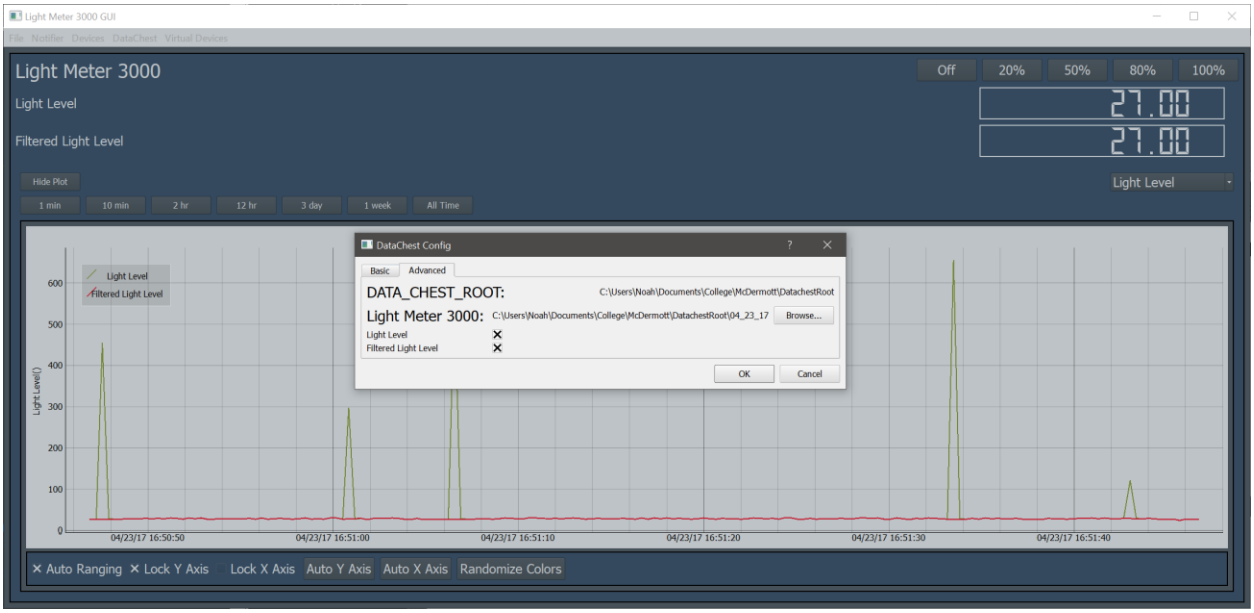
Click on the data logging configuration settings. And it will open up the dataChest config menu.



The basic settings tab shows the data_chest_root folder (environment variable) as well as a global log folder. Changing the global log folder will override current settings in the advanced tab and configure all devices to log in the selected location.

The 'Automatically Configure Data Sets' button will create a new folder inside the top level DATA_CHEST_ROOT folder named in the format MM_DD_YY, inside will be all data.

Alternatively, we can customize in the advanced tab:



All devices are listed and for each device, we can specify exactly where to store data and which parameters to log.

Click on the 'light level' fbox to stop logging the raw light data.

Programatically

There are a few more options we have when configuring datalogging programmatically in our gui startup program.

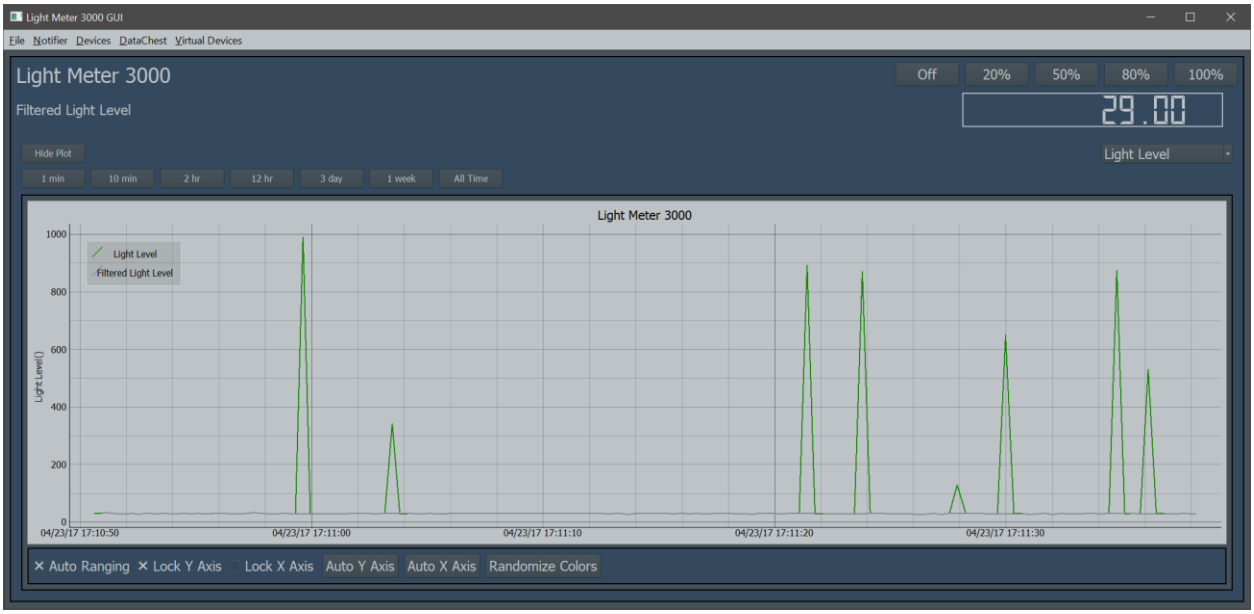
Let's disable the datalogging of certain devices by default, note: any settings changed in the gui will be persistent and override any programmatic settings.

Let's change

```
lm3000.addParameter("Light Level", "s")
```

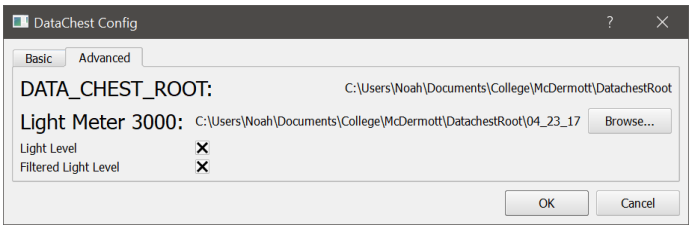
to

```
lm3000.addParameter("Light Level", "s", log=False, show=False)
```



Notice that the raw light level is no longer shown on the gui.

If we open the log settings:



Notice that the raw light level is still being logged…why is this happening? It is happening because when MView exits, it creates a file called mview.config. This file holds most of the data mview needs to start back up in the same state it was exited in. This prevents the user from having to re-enter all configuration settings. Any settings specified in the .config file will override settings entered programmatically. This means that the 'log' keyword is only good for defaults.

Let's un-check the raw light level button. From now on, MView will not log the light level both by default and because the config file will specify it.

Locking Log Settings

In order to maintain tight control, we can programmatically prevent the user from changing logging settings. This is done with the lock_log_settings keyword while instantiating a device.

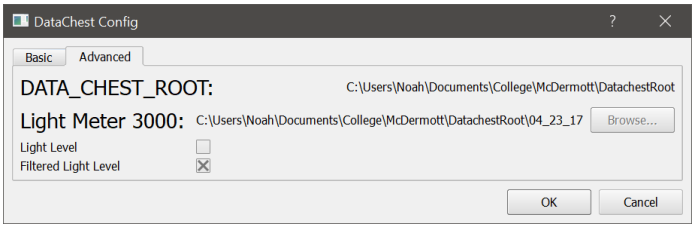
Let's change

```
lm3000 = RS232Device("Light Meter 3000", "COM7", baud = 115200)
```

to

```
lm3000 = RS232Device("Light Meter 3000", "COM7", baud = 115200, lock_logging_settings = True)
```

Now open MView and take a look at the advanced tab in the log settings dialog.



Notice that the buttons are greyed out. We can see their values but not change them. Additionally, the basic tab's 'Automatically Configure Data Sets' button will only affect non-locked devices.

Changing Default Log Location

Let's also say that we want to change the default log location. We do that using the default_log_location keyword. Again, the value is overridden by the config file, but it still provides a good way to set a default log location, which can then be locked.