EMU: reconfigurable graphical user interfaces for Micro-Manager

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Abstract

Background: Advanced light microscopy methods are key to many biological studies. Their ease of use depends, besides experimental aspects, on intuitive graphical user interfaces (GUI). The open-source software Micro-Manager offers a universal GUI for microscope control but requires implementing plugins to further tailor it to specific systems. However, GUIs are often tailored to a single system. Since even similar devices can have different Micro-Manager device properties, such as power percentage versus absolute power, directly transferring a GUI to another instrument usually requires changing the source-code.

Results: We developed Easier Micro-Manager User interface (EMU), a Micro-Manager plugin, to simplify building flexible and reconfigurable GUIs. EMU can be seamlessly used with the Java Swing library to create device-independent GUIs for Micro-Manager. Such GUIs are easily transferred to another microscope thanks to an intuitive configuration menu that includes mapping of the device properties to the GUI functionalities and customization of the graphical elements. We also provide resources such as user and programming guides, a tutorial and code examples.

Conclusions: Micro-Manager users now have a powerful tool to improve the user experience on their instruments. EMU GUIs can be easily configured for new microscopes and shared with other research groups. In the future, newly developed GUIs will be added to EMU to benefit the whole community.

Keywords: Microscopy, User interface, GUI, Micro-Manager

Background

Light microscopy is an ever-growing field with countless applications in biosciences. A substantial portion of technology developments and cutting-edge research are carried out on custom microscopes because of their high flexibility. Beyond the mechanical and optical requirements of such microscopes, researchers face the challenges of controlling the hardware and presenting the users with an intuitive graphical user interface (GUI). While control software are often developed for a specific instrument, a number of more general...
platforms are available. These software can be commercially available, such as Meta-Morph (Molecular Devices), SlideBook (3i), SciScan (Scientifica) or ScanImage (Vidrio) [1], or shared online by their authors. They span a variety of programming languages, allowing users to work with their preferred tools and facilitating post-processing and analysis. Examples of such microscope control software are found for LabView (National Instruments) [2], Matlab (MathWorks) [3] or Python [4–7]. Another well-established alternative is Micro-Manager (μManager) [8], an open-source software written in C++ and Java, and based on ImageJ [9].

μManager is a ready-to-use platform compatible with a wide range of hardware devices. The support for new devices is community driven and constantly expanding. In addition, μManager features the possibility to run scripts or plugins to perform custom experiments. μManager offers a universal GUI and some customization tools that are easy to set-up and use. However, because they are aimed at covering general needs, they cannot rival with a tailored GUI in terms of user experience. The preferred way to implement a GUI in μManager is by writing a plugin in Java, which is automatically detected at start-up and can be loaded from the main menu. Several dedicated Java libraries exist in order to build a GUI, among which the widely used Swing toolkit [10]. In order to simplify the programming task, most major Java integrated development environments provide graphical tools based on Swing. With only a basic understanding of Swing, developers can assemble complex GUIs by placing (“drag-and-drop”) components on a panel or a frame. In order to control a microscope, the Swing GUIs should be made compatible with μManager plugin system and call its application programming interface (API) to modify the devices’ states whenever users interact with the graphical components.

Yet, similar devices might have different properties, such as absolute laser power versus laser power percentage; as well as different property state values, such as “On” versus “1”. These differences originate from the absence of industry standards for device communication API or simply from distinct inherent working principles. Additionally, device properties are defined in μManager device adapters, which are implemented by the manufacturers or individual researchers, and lack device property standardization as well. Therefore, in order to benefit the community, μManager GUIs should be flexible enough to accommodate these discrepancies without requiring modifying the source code.

Several GUIs have been developed to control complex microscopes with μManager, such as for the Olympus IX83 [11], OpenSPIM [12], OpenSpin [13] and diSPIM [14] microscopes. Because these GUIs perform specialised acquisitions and hardware control, they are meant to work with very specific hardware devices. As a result, any departure from the original devices requires modifying the source-code to achieve compatibility. Regrettably, this is a common trait of GUIs, which are generally bound to a single system and never benefit other users.

Here, we present a framework, called Easier Micro-Manager User interfaces (EMU), allowing developers to build μManager GUIs without explicit references to the devices or their properties. While EMU GUIs are, as previously, assembled using Swing, they additionally declare settings, properties and parameters. These are automatically aggregated upon starting EMU and can be configured through an intuitive graphical interface. The EMU configuration specifies the mapping between device and GUI properties, as well as the settings’ and parameters’ values. Thus, each EMU GUI is independent from the devices and can be rapidly configured to suit a microscope or accommodate device
EMU plugin example. SimpleUI is a GUI available by default in EMU. It can control four lasers and an optional filterwheel. The solid box delimits the ConfigurableMainFrame instance while the dashed boxes are the two base ConfigurablePanel objects of the GUI. All titles and colors are GUI parameters, while the GUI properties are, for each laser, the power percentage and on/off, and the filter wheel position. Additional GUI parameters allow disabling the on/off buttons. Finally, a plugin setting hides or shows the filter wheel panel exchanges. Finally, EMU aims at offering a repository of already existing GUIs for the community to use.

**Implementation**

EMU is a μManager 2.0.0-gamma plugin. It is written in Java and includes its own plugin system. EMU can be started from the plugin menu of μManager. When starting EMU for the first time, users can choose a GUI among the list of available EMU plugins, before configuring it using the EMU configuration menu. The configuration file is saved locally and is loaded automatically at the next start. In the next sections, we showcase how to implement an EMU plugin with code examples and how to configure the plugin in μManager.

**Implementing an EMU plugin**

The EMU framework is based on the Java Swing toolkit [10]. EMU plugins consist of multiple ConfigurablePanel objects arranged within a single ConfigurableMainFrame

| Class                  | Note                              | in EMU configuration menu          |
|------------------------|-----------------------------------|------------------------------------|
| UIProperty             | General GUI property              | device and property drop-down lists|
| SingleStateUIProperty  | Accepts a single-state            | + field for the state value        |
| TwoStateUIProperty     | Accepts an On and an Off state    | + fields for the On and Off values |
| MultiStateUIProperty   | Accepts a fixed number of states  | + field for each state value       |
| RescaledUIProperty     | Rescales value to slope*v+ offset | + fields for the slope/offset values|
instance, as illustrated in Fig. 1. ConfigurablePanel and ConfigurableMainFrame are subclasses of the Swing classes JPanel and JFrame, respectively.

A ConfigurablePanel is a unit of device control. In the following code snippet, we create a subclass of ConfigurablePanel similar to the laser panel of Fig. 1, with a slider to set the laser power and a toggle button to turn it on or off. We also create a border, with title, around the graphical components. Since ConfigurablePanel is a subclass of JPanel, the laying out of components is performed using Swing:

```java
public class LaserPanel extends ConfigurablePanel {
    private JSlider slider;
    private JToggleButton button;
    // the constructor only uses Swing
    public LaserPanel(String title) {
        super(title);
        // border
        this.setBorder(new TitledBorder(null, "Laser", TitledBorder.LEFT, TitledBorder.TOP, null, null));
        // slider
        slider = new JSlider();
        slider.setMajorTickSpacing(20);
        slider.setPaintTicks(true);
        slider.setPaintLabels(true);
        slider.setOrientation(SwingConstants.VERTICAL);
        this.add(slider);
        // toggle button
        button = new JToggleButton("On/Off");
        this.add(button);
    }
}
```

Several abstract methods from ConfigurablePanel must additionally be implemented (see Additional file 1). Three of these methods concern the GUI properties: initializeProperties, addComponentListeners and propertyHasChanged.

In initializeProperties, we need to declare the GUI properties. Since we want to control two device properties, laser power and laser on/off, we have to declare two GUI properties. Different UIProperty subclasses exist (see Table 1 and Additional file 2), and the choice of the class depends mainly on the graphical components to which it is linked. For instance, the slider allows setting a value between 0 and 100 by default. As we do not know whether the device property ultimately linked to the slider will be a power percentage or an absolute power, we should declare a RescaledUIProperty. In the EMU configuration menu, this type of property allows users to set scaling factors mapping the slider value to a suitable range with respects to the device property (see Fig. 2). Likewise, the laser operation is controlled by a toggle button. Therefore we choose a property with only two states (TwoStateUIProperty). The on and off states are set in the EMU configuration menu as well. Declaration of the GUI properties is done as follows:

```java
private final String PERCENTAGE = "power percentage";
private final String OPERATION = "on/off";

@Override
protected void initializeProperties() {
    // Descriptions are shown in the EMU configuration help window
    String desc1 = "Description percentage";
    String desc2 = "Description operation";
    this.addProperty(new RescaledUIProperty(this, label(PERCENTAGE), desc1));
    this.addProperty(new TwoStateUIProperty(this, label(OPERATION), desc2));
}
```

// method to avoid property name collisions between panels
private String label(String property){
    return this.getProperty() + " " + property;
}
When the user interacts with a graphical component, the state of the corresponding device property should change. In Swing, you can register a listener with a component, the former being called when the component's state is modified. In a listener implementation, the ConfigurablePanel should call setPropertyValue(String, String) (see Additional file 1) to update the GUI property given the component’s new state. In turn, the UIProperty will change the state of the device property. The listeners can be registered with the components in the constructor or in the addComponentListeners method. Alternatively, the EMU SwingUIListeners class provides a number of static methods that cover common cases. For instance, here, a convenient way to have the slider and toggle button modify their respective properties is:

```java
@override
protected void addComponentListeners() {
    // SwingUIListeners is an EMU class
    SwingUIListeners.addActionListenerOnChangeValue(this, label(OPERATION), button);
    try {
        SwingUIListeners.addActionListenerOnTwoState(this, label(OPERATION), button);
    } catch (IncorrectUIPropertyTypeException e) {
        e.printStackTrace();
    }
}
```

Whenever the state of the graphical components needs to be updated, the ConfigurablePanel instances are notified, which triggers the propertyHasChanged method. In

![Fig. 2 Configuring GUI properties. In the “Properties” tab of the EMU configuration menu, users can map device properties to GUI properties using drop-down lists. Additionally, some GUI properties have state values than need to be specified. Here shown for SimpleUI](image)
this method, we need to update the state of the graphical components to reflect the device properties’ values. Here, this means setting the slider value to the (rescaled) laser power, or switching the toggle button to the state of the laser operation. This is done in the following way:

```java
@Override
protected void propertyHasChanged(String propertyName, String newValue) {
    if (label(PERCENTAGE).equals(propertyName)) {
        if (EnvUtils.isNumeric(newValue)) {
            // RescaledUIProperty values can represent a float or an int
            int val = (int) Float.parseFloat(newValue);
            slider.setValue(val); // Swing call
        } else if (label(OPERATION).equals(propertyName)) {
            try {
                UIPROPERTY prop = this.getUIPROPERTY(label(OPERATION));
                // we check if newValue corresponds to the TwoStateUIPROPERTY ON state
                boolean onValue = ((TwoStateUIPROPERTY) prop).isOnState(newValue);
                button.setSelected(onValue); // Swing call
            } catch (UnknownUIPropertyException e) {
                e.printStackTrace();
            }
        }
    }
}
```

Note that here, we made use of a `TwoStateUIPROPERTY` class method (see Additional file 2).

With these three methods implemented, any numerical device property can be linked to the slider, while any device property can be switched between two states by the toggle button.

Another aspect of EMU panels are the GUI parameters, which are meant to add additional levels of customization to the panel, such as title, colors or button texts. Similarly to the properties, they are declared in `initializeParameters`. Parameters are not modified by the panel and their value only changes at start-up when the configuration is loaded, or when a new configuration is saved, which triggers a call to the `parameterHasChanged` method. Various types of parameters are available in EMU (see Table 2 and Additional file 3).

Since we added a titled border to the panel, we can use a `StringUIParameter` to let users choose the border title:

```java
private final String TITLE = "title";

@Override
protected void initializeParameters() {
    String desc = "Description"; // shown in the EMU configuration help window
    String def = "Default title"; // default value in the EMU configuration
    this.addUIParameter(new StringUIParameter(this, TITLE, desc, def));
}

@Override
protected void parameterHasChanged(String parameterName) {
    if (TITLE.equals(parameterName)) {
        try {
            String newTitle = this.getStringUIParameterValue(TITLE);
            (TitledBorder) this.getBorder().setTitle(newTitle); // Swing call
        } catch (UnknownUIParameterException e) {
            e.printStackTrace();
        }
    }
}
```

Other mechanisms make EMU panels flexible but are beyond the scope of this section, for instance: internal properties (see Additional file 4), which are values shared between panels; the possibility to map multiple GUI properties to the same device property; or the mapping of a GUI property to a bundle of device properties, known as “configuration group preset” in μManager.
Table 2  UIParameter child classes. Each UIParameter child class holds a member variable represented by the type indicated in the second column. In the EMU configuration menu, the GUI parameters appear as specified in the third column.

| Class            | Parameter type          | in EMU configuration menu   |
|------------------|-------------------------|-----------------------------|
| BoolUIParameter  | Boolean                 | checkbox                    |
| ColorUIParameter | java.awt.Color          | drop-down list of colors    |
| ComboUIParameter | String                  | drop-down list of Strings   |
| DoubleUIParameter| Double                  | field                       |
| IntegerUIParameter| Integer                 | field                       |
| StringUIParameter| String                  | field                       |
| UIPropertyParameter| String                  | drop-down list of UIProperty labels |

Finally, the ConfigurablePanel subclasses are assembled within a single ConfigurableMainFrame subclass. The latter declares its own parameters, called settings (see Table 3 and Additional file 5), which are instantiated in getDefaultPluginSettings. In the same vein as GUI properties and parameters, their values are defined in the EMU configuration. ConfigurablePanel subclass instances should be created in the initComponents methods, in order to be able to retrieve the settings’ values at runtime. In the following example, the ConfigurableMainFrame subclass uses an IntSetting to let users choose the number of lasers in the GUI.

```java
public class Frame extends ConfigurableMainFrame {
    // setting label
    private final String NM_LASERS = "Number of lasers";

    public Frame(String title, SystemController controller, 
                  TreeMap<String, String> settings) {
        super(title, controller, settings);
    }

    @Override
    protected void initComponents() {
        // retrieves the setting value
        Setting setting = this.getCurrentPluginSettings().get(NM_LASERS);
        int num_lasers = ((IntSetting) setting).getValue();

        // uses Swing to layout the panels
        JPanel panel = new JPanel();
        panel.setLayout(new GridLayout(1, num_lasers));
        for (int i = 0; i < num_lasers; i++) {
            // unique label to each laser panel to avoid property collisions
            LaserPanel laserPanel = new LaserPanel("Laser-" + i);
            panel.add(laserPanel);
        }
        this.setContentPane(panel);
        this.pack();
    }

    @Override
    public HashMap<String, Setting> getDefaultPluginSettings() {
        HashMap<String, Setting> settings = new HashMap<String, Setting>();

        // adds the integer setting with a default value of 4
        settings.put(NM_LASERS, new IntSetting(NM_LASERS, "Description", 4));
        return settings;
    }

    @Override
    protected String getPluginInfo() {
        return "Plugin description";
    }
}
```

In order to be detected by EMU, one additional class is required (UIPlugin) before packaging the GUI into a .jar file. The detailed steps can be found in the EMU guide [15],
Table 3 Setting child classes. Each class holds a member variable represented by the type indicated in the second column. All Setting child classes appear in the EMU configuration menu as a field, except for the BoolSetting settings, which appear as checkboxes.

| Class       | Setting type | in EMU configuration menu |
|-------------|--------------|---------------------------|
| BoolSetting | Boolean      | checkbox                  |
| DoubleSetting | Double      | field                     |
| IntSetting  | Integer      | field                     |
| StringSetting | String      | field                     |

including the source code for the plugin of Fig. 1. In the next section, we will look at a the configuration of the latter.

**Configuring an EMU plugin**

The EMU configuration menu is shown each time a plugin without known calibration is started. Later, it can be accessed by clicking on the menu bar “Configuration” (see Fig. 1), then “Modify configuration”. The EMU configuration menu consists of four tabs: “Plugin Settings”, “Properties”, “Parameters” and “Global Settings”.

In the “Properties” tab (see Fig. 2 for SimpleUI), users can map μManager device properties to GUI properties by first selecting the device in the drop-down list of the second column, then the relevant device property in the third column. Some GUI properties have additional states that need to be configured as well (see Table 1). In particular, this is the case for the GUI properties used in the previous section. States are related to the actual device property values and can be easily inferred from the “device property browser”. The latter is accessible from the “Devices” menu in μManager main window.

In the “Parameters” tab (see Fig. 3), each GUI parameter appears as a field, a drop-down list or a checkbox, depending of their type (see Table 2). Finally, the other tabs are the frame settings (“Plugin Settings”) or EMU options (“Global Settings”).

After saving the EMU configuration, a human-readable file is automatically created in a subfolder of the μManager installation folder. Multiple configurations can coexist and be saved in the EMU configuration file. The EMU menu (see the menu bar in Fig. 1) allows users to switch between GUIs or between configurations in a single click. Finally, at each start of EMU, the configuration file is loaded and the last known plugin configured.

**Example cases**

To illustrate the flexibility of EMU plugins, we can consider a simple example such as SimpleUI (see Fig. 1). The plugin controls four lasers, allowing users to turn their emission on and off and change their power percentage. Laser names and colors can be set in the EMU configuration menu (see Fig. 3). Several cases can be encountered when working with lasers in μManager: (i) lasers have an operation (on/off) and a power percentage device property, (ii) some lasers have an absolute power instead of a power percentage device property and (iii) some lasers do not have a laser emission device property [16]. In (i), the GUI properties can be mapped to the devices and their relevant device properties. Since the GUI property representing the laser percentage is an instance of RescaledUIProperty (see Table 1), users can leave the slope and offset values (see Fig. 2) equal to the default 1 and 0, respectively. For the lasers in (ii), the laser percentage GUI property is mapped to an absolute power device property. There, the slope parameter should be set to \( \text{max}/100 \) (with \( \text{max} \) being the maximum laser power), effectively rescaling the power
percentage to the range \([0, \text{max}]\) of the device property. Finally, for lasers in the case (iii), no laser operation device property exists. The laser operation GUI properties should remain unconfigured. Using the GUI parameters, the on/off buttons can be disabled. In all three cases, the GUI can be configured to reflect an accurate picture of the microscope lasers in spite of their differences.

The previous example plugin is simple. However there is no limit on how complex an EMU plugin can be. We routinely use htSMLM [17] (see Additional file 6), an EMU plugin aimed at controlling a wide-field microscope for localization microscopy [18–20]. htSMLM features four generic lasers, two optional lasers compatible with the iBeamSMART series from Toptica, an axial focusing panel, up to four filter wheels and multiple toggle buttons. It also includes tools to automate activation in localization microscopy and to perform acquisition series (localization microscopy, multi-slice localization, snapshot, time series, z-stack) that take into account the device properties linked to the GUI. htSMLM has been used by scientists with a wide variety of backgrounds and projects, ranging from biology to optics [21–24].

**Discussion**

μManager GUIs are too often tailored to a specific system and are not usable for instruments with similar, yet different, devices. Therefore, such GUIs are only shared when the
system has the potential to be broadly replicated. Users without programming skills are limited to the μManager main GUI window for device control. While the main GUI covers general need and is thus applicable to most instruments, user experience can be largely improved by using more specialized GUIs in conjunction with the main window. EMU fills this gap by providing device-independent and easily configurable GUIs for μManager.

Since microscopes are composed of a wide variety of devices, the diversity and redundancy of devices prevent automated allocation of the device properties to graphical components without using stringent constraints. In order to give a high degree of flexibility to developers, EMU consists of a set of classes that can be seamlessly inserted in a Swing GUI. The two main components, frames and panels, declare parameters matching the constraints of the graphical components rather than those of the intended devices. Hence, assumptions are limited to whether a certain type of device can be controlled by a specific graphical component. For instance, laser power is a device property that is undoubtedly determined by a number within a range and can therefore be represented graphically by a slider linked to a `RescaledUIProperty`. Similarly, a filter wheel has fixed positions, regardless of whether the actual device positioning is continuous or discrete, and can be paired with a set of buttons linked to a `MultiStateUIProperty`.

The implementation and graphical layout of an EMU GUI is left to developers. Because EMU provides an advanced configuration system and the mechanism of interaction with the device properties, they can focus solely on the GUI design and the choice of properties and parameters fitting the GUI desired functionalities. EMU automatically aggregates the GUI properties and parameters in its configuration menu, which makes the framework particularly beneficial for complex GUIs. Moreover, EMU is compatible with “drag-and-drop” software found in most integrated development environment. Since EMU’s API is designed to be simple and involves only a few additional lines of code, plugins can be built and put to use rapidly.

The goal of EMU is to promote GUIs that are transferable between similar instruments. Indeed, a GUI taking advantage of EMU’s flexibility will be usable on any other microscope consisting of similar devices. Nonetheless, a few limitations can be encountered. If the GUI was designed to work with a device property specific to a single manufacturer, then the corresponding functionality will not be of interest to other users. In such a case, developers should ensure that settings or parameters can be used to simply disable this functionality. As an example, hSMLM was designed to control, among others, iBeamSmart lasers (Toptica). Since these lasers have unconventional properties, such as the so-called fine settings, the corresponding panels can be disabled using parameters. Note that unused properties do not alter the function of the rest of the GUI. Similarly, limitations stemming from the plugin design itself can occur. For instance, a maximum laser power device property expected to set the upper bound of a slider is obviously not compatible with lasers that do not have such a property. Using a parameter to set the maximum value is an easy work-around for developers. Alternatively, the slider could represent a percentage, rather than an absolute value, and be linked to a `RescaledUIProperty`. Finally, unconventional device property implementations can potentially be found in μManager, such as numerical device properties implemented with a string type. These would prevent allocating it to `RescaledUIProperty` GUI properties, which can only be paired with float or integer device properties. Other GUI properties (see Table 1), on the other hand, are compatible with any device property.
EMU includes an intuitive configuration menu allowing users to map their instrument device properties to the GUI properties, as well as setting the various parameters to improve the GUI friendliness and further tailor it to the microscope. Configuring an EMU plugin for an instrument only takes a couple of minutes. In the same way, exchanging devices on the instrument is equally convenient, as users only need to start the EMU configuration menu and change the relevant lines to reflect the presence of the new device. It is worth noting that the EMU configuration is different from the μManager configuration. The latter describes which devices are loaded in μManager and how communication is performed, while the former defines the EMU GUI look and which device properties are linked to the GUI functionalities. EMU plugins are therefore complementary to the μManager main window and an obvious consequence is that only devices compatible with μManager can be used with EMU.

In order to help developers use EMU, we provide online a variety of resources [15], including a user and a programming guide, a step-by-step tutorial on how to create an EMU plugin, as well as multiple code examples exploring all aspects of EMU’s API. EMU is included in the latest μManager distribution and comprises two example plugins.

**Conclusion**

μManager is a successful open-source software and is widely used to control custom microscopes. However, its universal interface does not provide a user experience comparable to tailored GUIs. Moreover, most GUIs are developed for a specific system and are never used elsewhere. Here, we presented EMU, a framework that allows developers to build device-independent GUIs that can easily be transferred to another microscope, as well as to other research groups. It also includes an intuitive graphical configuration menu, enabling users to rapidly tailor a GUI to their instrument. We hope that in the future developers will contribute their own GUI to EMU in order to benefit the whole community. The source code can be found on Github following the link in reference [25].

**Availability and requirements**

**Project name:** emu  
**Project homepage:** https://jdeschamps.github.io/EMU-guide  
**Operating system(s):** Platform independent  
**Programming language:** Java  
**Other requirements:** Micro-Manager 2.0.0-gamma  
**License:** LGPL-2.1  
**Any restrictions to use by non-academics:** None

**Supplementary information**

Supplementary information accompanies this paper at https://doi.org/10.1186/s12859-020-03727-8.

**Additional file 1:** UML diagram: ConfigurableMainFrame and ConfigurablePanel. Unified Modeling Language (UML) diagram of the ConfigurableMainFrame and ConfigurablePanel classes. The two abstract classes inherit from the Swing classes JFrame and JPanel, respectively. Additionally, ConfigurableMainFrame implements the ConfigurableFrame interface. As both classes are abstract, their abstract methods must be implemented by developers when creating the ConfigurableMainFrame subclass and ConfigurablePanel subclasses. Each class is represented by a box with three compartments: class name, class variables and class methods. Abstract class and interface names are written in italic. Inheritance relationship between two classes is shown as a solid line with an arrow pointing towards the superclass, while implementation of an interface is shown as a dashed line with an arrowhead pointing to the interface class. Aggregation, or class instances being owned by another class, is shown as a solid line with diamond head. The
The diagram shows all private member variables as well as all non-private member methods. Abstract methods are displayed in italic. Variable and method return types, if applicable, are indicated after a colon. The corresponding Javadoc is available in the EMU source-code [25].

**Additional file 2:** UML diagram of UIProperty and subclasses. UML diagram of the UIProperty class and its subclasses. These classes are instantiated in ConfigurablePanel subclasses and are ultimately mapped using the EMU configuration to µManager device properties. Descriptions of each class’ specificity can be found in Table 1. Each class is represented by a box with three compartments: class name, class variables, and class methods. Inheritance relationship between two classes is shown as a solid line with an arrow pointing towards the superclass. The visibility of member variables and methods is indicated by the following signs: - (private), # (protected) or + (public). The diagram shows all private member variables as well as all non-private member methods. Static methods are underlined. Variable and method return types, if applicable, are indicated after a colon. The corresponding Javadoc is available in the EMU source-code [25].

**Additional file 3:** UML diagram of UIParameter and subclasses. UML diagram of the abstract UIParameter class and its subclasses. These classes are instantiated in ConfigurablePanel subclasses and their respective member variable value_ is set to a user-defined value using the EMU configuration. Each class is represented by a box with three compartments: class name, class variables, and class methods. Abstract class names are written in italic. Parameterized class types are shown in a box on the top right corner of each class. Inheritance relationship between two classes is shown as a solid line with an arrow pointing towards the superclass. The visibility of member variables and methods is indicated by the following signs: - (private), # (protected) or + (public). The diagram shows all private member variables as well as all non-private member methods. Abstract methods are displayed in italic. Variable and method return types, if applicable, are indicated after a colon. The corresponding Javadoc is available in the EMU source-code [25].

**Additional file 4:** UML diagram of InternalProperty and subclasses. UML diagram of the abstract InternalProperty class and its subclasses. Internal properties are shared between ConfigurablePanel subclasses, provided that they are of the same type and are given the same label. Each class is represented by a box with three compartments: class name, class variables, and class methods. Abstract class names are written in italic. Parameterized class types are shown in a box on the top right corner of each class. Inheritance relationship between two classes is shown as a solid line with an arrow pointing towards the superclass. The visibility of member variables and methods is indicated by the following signs: - (private), # (protected) or + (public). The diagram shows all private member variables as well as all non-private member methods. Abstract methods are displayed in italic. Variable and method return types, if applicable, are indicated after a colon. The corresponding Javadoc is available in the EMU source-code [25].

**Additional file 5:** UML diagram of Setting and subclasses. UML diagram of the abstract Setting class and its subclasses. These classes are instantiated in ConfigurableMainFrame subclass and their respective member variable value_ is set to a user-defined value using the EMU configuration. Each class is represented by a box with three compartments: class name, class variables, and class methods. Abstract class names are written in italic. Parameterized class types are shown in a box on the top right corner of each class. Inheritance relationship between two classes is shown as a solid line with an arrow pointing towards the superclass. The visibility of member variables and methods is indicated by the following signs: - (private), # (protected) or + (public). The diagram shows all private member variables as well as all non-private member methods. Abstract methods are displayed in italic. Variable and method return types, if applicable, are indicated after a colon. The corresponding Javadoc is available in the EMU source-code [25].

**Additional file 6:** htSMLM plugin. htSMLM is a complex EMU plugin aimed at controlling a wide-field or localization microscope. Besides the controls for multiple lasers, filter wheels and focus, it features tools to perform series of sequential acquisition (e.g. localization microscopy, multi-slice localization, time series or z-stack) and automated laser activation.

**Abbreviations**
- API: Application programming interface;
- EMU: Easier Micro-Manager User interfaces;
- GUI: graphical user interface;
- µManager: Micro-Manager

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**Availability of data and materials**
EMU is distributed with Micro-Manager 2.0.0-gamma nightly-builds. The source code, guide, tutorial and examples are available at: https://github.com/jdeschamps/EMU
https://jdeschamps.github.io/EMU-guide.

**Ethics approval and consent to participate**

Not applicable.

**Consent for publication**

Not applicable.

**Competing interests**

The authors declare that they have no competing interests.

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