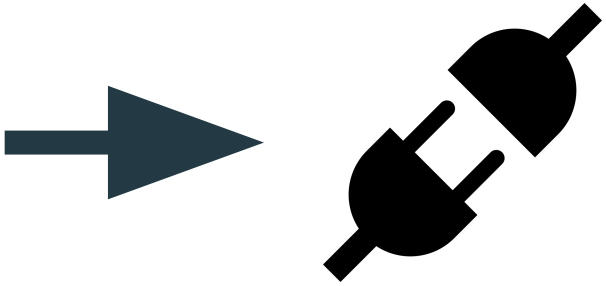
Icy



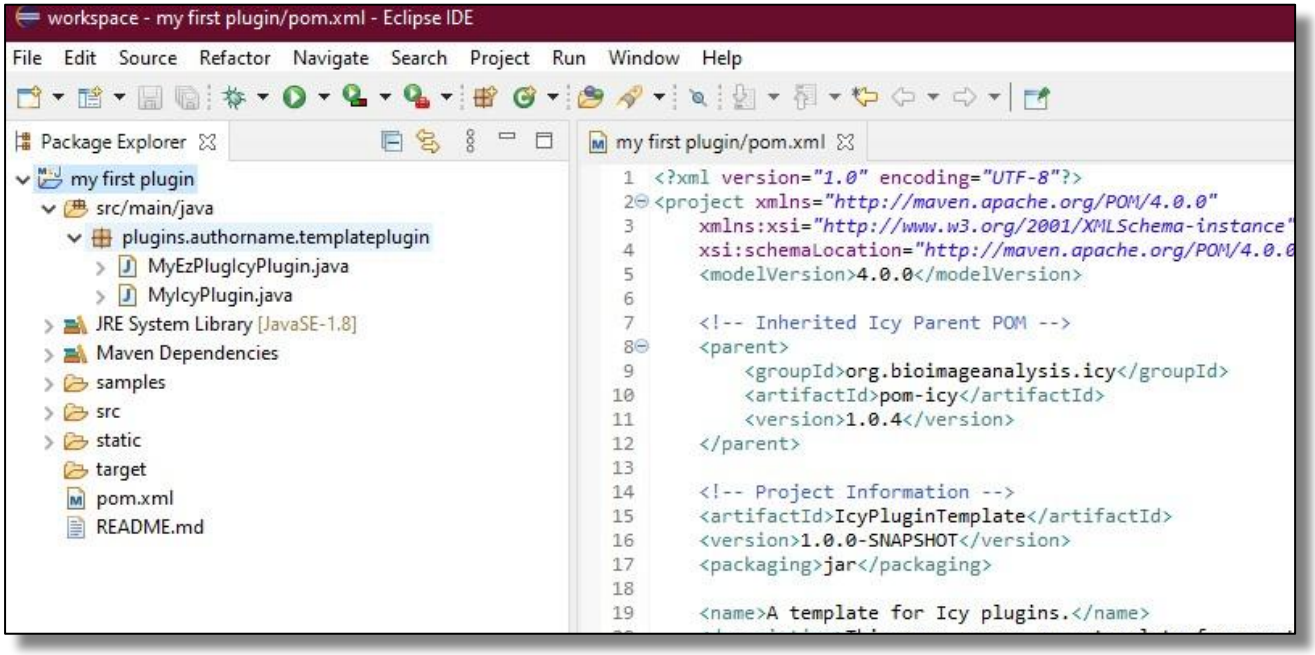
Icy Plugin Development

Training - Level 3

http://icy.bioimageanalysis.org

Icy Development Environment

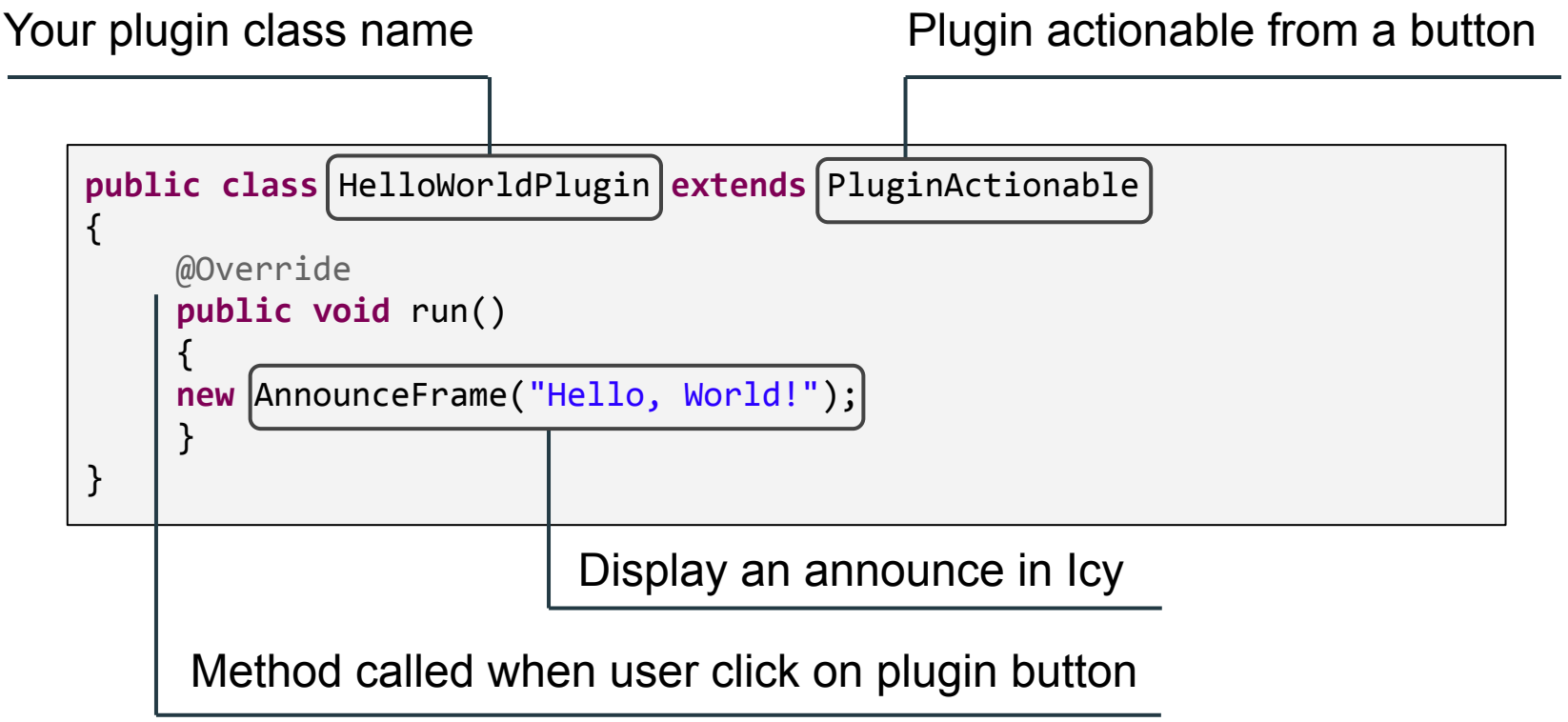
Follow the **Quick Start** tutorial to set up your development environment and get the basics:
http://icy.bioimageanalysis.org/developer/create-a-new-icy-plugin/



Get image samples for testing from http://icy.bioimageanalysis.org/doc/images.zip

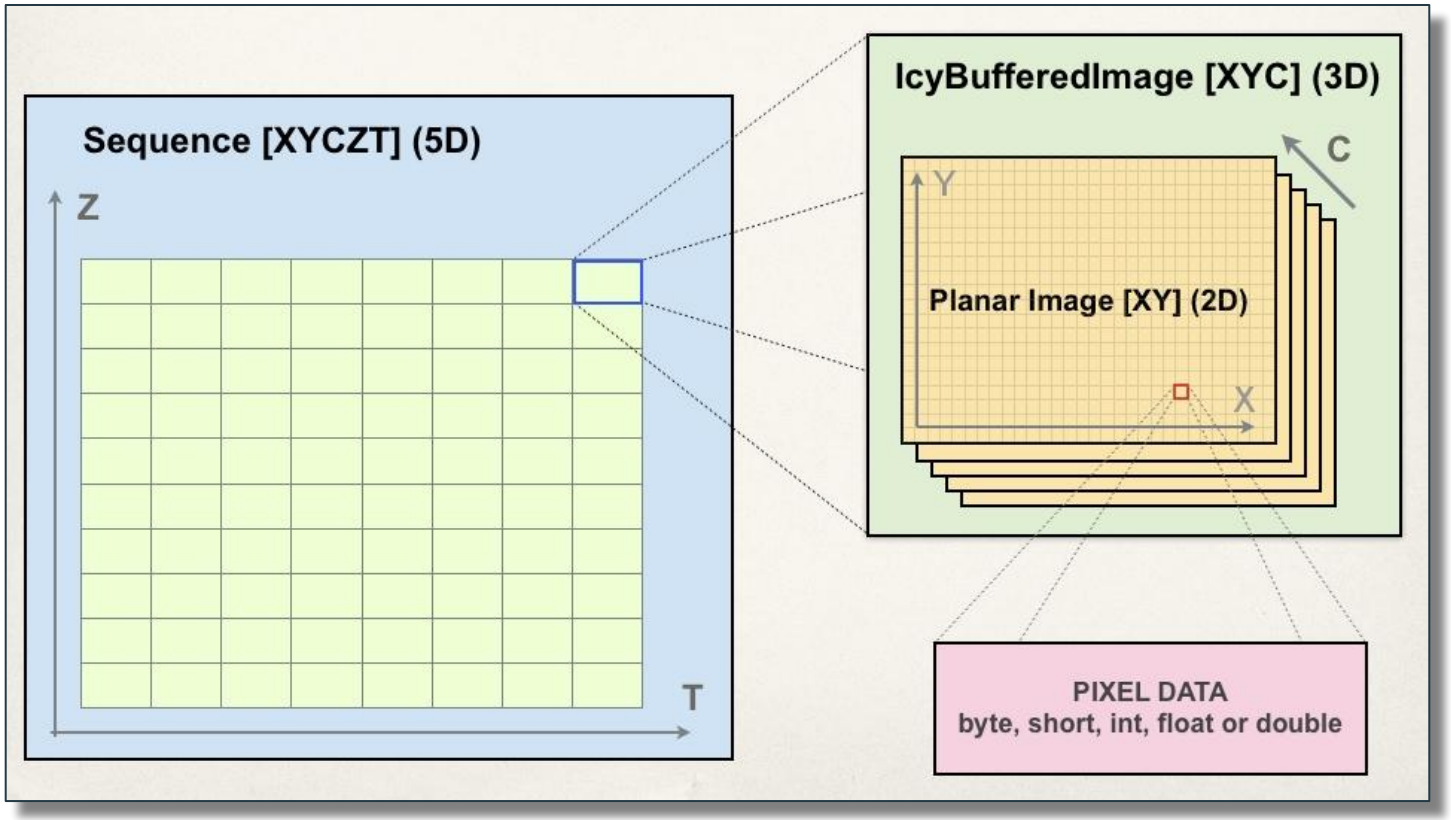
Hello World ! (in Icy)

Something as simple as...



Data structure

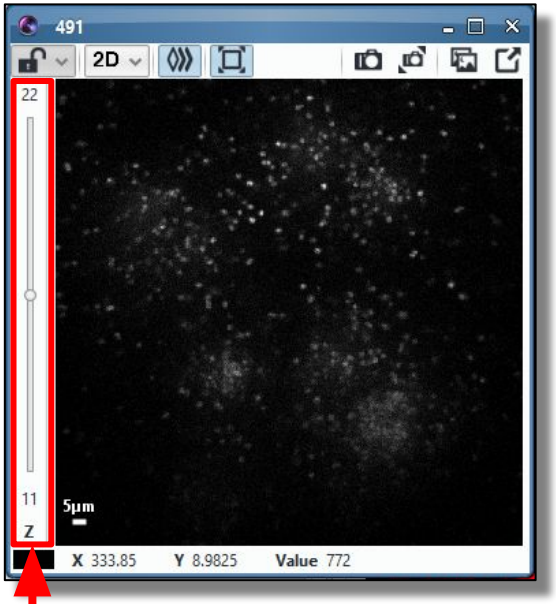
5D image data organized by channel



Any data type !

Data structure - view

3D image
Z stack - single channel



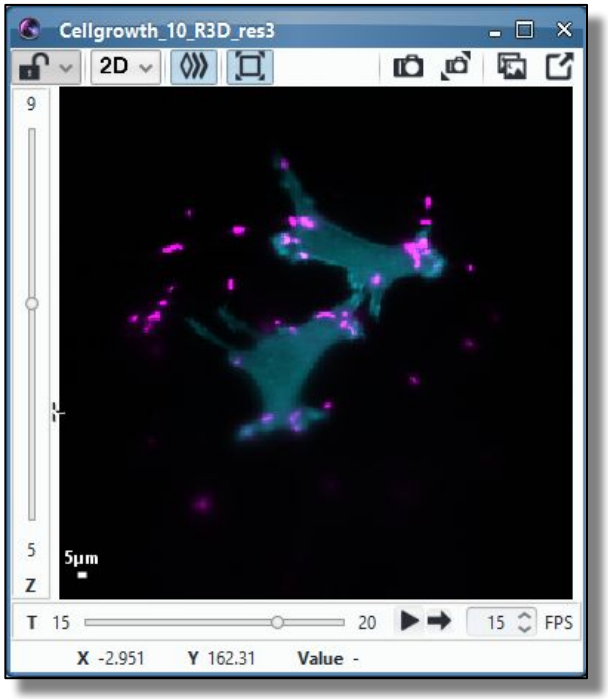
Z slider to navigate through Z slices

4D image
timelapse of Z stack - single channel

T slider to navigate through frames

Play / pause, loop, frame rate control

5D image
timelapse of Z stack - multi channel



Working with image

The basics…

Get the current active image

```
IcyBufferedImage image = getActiveImage();

// check if an image is opened
if (image == null)
{
     MessageDialog.showDialog("This plugin needs an opened image.");
     return;
}
```

Display a message if no image is opened

Get image samples for testing from http://icy.bioimageanalysis.org/doc/images.zip

Retrieve image information

```
int w = image.getSizeX();
```
Get the image width

```
int h = image.getSizeY();
```
Get the image height

```
int numChannel = image.getSizeC();
```
Get the number of channel

```
DataType type = image.getDataType_();
```
Get the image data type

```
double pixel = image.getData(0, 0, 0);
```
Get the pixel value at specified X, Y, C position

Modify an image

Goal: Divide intensity by 2 in a single image

Naive way…

```
for (int x = 0; x < w; x++)
{
    for (int y = 0; y < h; y++)
    {
        image.setData(x, y, 0, image.getData(x, y, 0) / 2);
    }
}
```

Get pixel value at position X, Y, C

Set pixel value at position X, Y, C

Iterate through all pixels of the image

Modify an image

Goal: Divide intensity by 2 in a single image

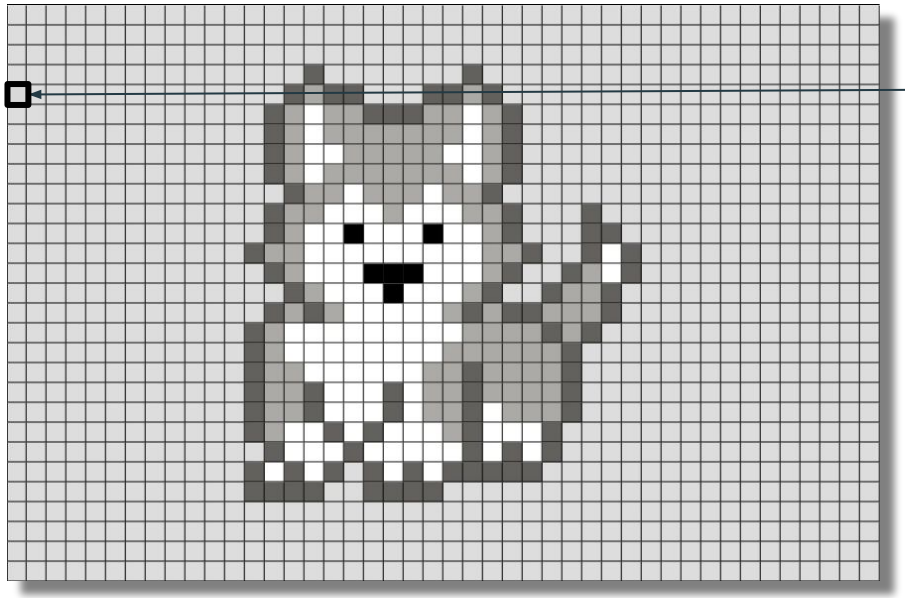
```
for (int x = 0; x < w; x++)
{
    for (int y = 0; y < h; y++)
    {
        image.setData(x, y, 0, image.getData(x, y, 0) / 2);
    }
}
```

Slow! Because image.setData(..) causes image refresh events and other recalculations.

http://icy.bioimageanalysis.org/doc/icy-dev-plugin/ModifyImagePluginSlow.java

Modify an image

Using cursors



IcyBufferedImageCursor

```
cursor
x  y  c
0  4  0
```

```
double get(x, y, c)
void set(x, y, c, value)
```

- Handles pixel data type for you. You only use double values
- Readable way of accessing pixel data
- Handles internal temporal variables
- Access pixels in any order
- Avoids constant calls for internal image updates when changing pixel intensities: Using `commitChanges()`

Modify an image

Goal: Divide intensity by 2 in a single image

A simpler way… Using cursors

Create cursor

```
IcyBufferedImageCursor cursor = new IcyBufferedImageCursor(image);
try {
    for (int y = 0; y < h; y++) {
        for (int x = 0; x < w; x++) {
            cursor.set(x, y, 0, cursor.get(x, y, 0) / 2);
        }
    }
}
finally {
    cursor.commitChanges();
}
```

Use `set` and `get` to read/modify pixels

End image modification → image refresh and recalculations

Modify an image

Goal: Divide intensity by 2 in a single image

Create an *image cursor* for **image** using **IcyBufferedImageCursor**

```
IcyBufferedImageCursor cursor = new IcyBufferedImageCursor(image);
try {
    for (int y = 0; y < h; y++) {
        for (int x = 0; x < w; x++) {
            cursor.set(x, y, 0, cursor.get(x, y, 0) / 2);
        }
    }
}
finally {
    cursor.commitChanges();
}
```

Modify an image

Goal: Divide intensity by 2 in a single image

Read pixels using **`get(x, y, c)`**. Returned value is a double.
Update pixels using **`set(x, y, c, val)`**. **`val`** is a double.
Use **`setSafe`** to handle data type value bounds.

```
IcyBufferedImageCursor cursor = new IcyBufferedImageCursor(image);
try {
    for (int y = 0; y < h; y++) {
        for (int x = 0; x < w; x++) {
            cursor.set(x, y, 0, cursor.get(x, y, 0) / 2);
        }
    }
}
finally {
    cursor.commitChanges();
}
```

Modify an image

Goal: Divide intensity by 2 in a single image

When all changes have been made, use **`commitChanges()`** to make sure all changes are applied to the image.

```
IcyBufferedImageCursor cursor = new IcyBufferedImageCursor(image);
try {
    for (int y = 0; y < h; y++) {
        for (int x = 0; x < w; x++) {
            cursor.set(x, y, 0, cursor.get(x, y, 0) / 2);
        }
    }
}
finally {
    cursor.commitChanges();
}
```

Modify an image

Complete code with cursors …

```
IcyBufferedImage image = getActiveImage();

if (image == null)
{
     MessageDialog.showDialog("This plugin needs an opened image.");
     return;
}

int w = image.getSizeX(), h = image.getSizeY();
IcyBufferedImageCursor cursor = new IcyBufferedImageCursor(image);
try {
    for (int y = 0; y < h; y++) {
        for (int x = 0; x < w; x++) {
            cursor.set(x, y, 0, cursor.get(x, y, 0) / 2);
        }
    }
}
finally {
    cursor.commitChanges();
}
```

http://icy.bioimageanalysis.org/doc/icy-dev-plugin/ModifyImagePluginCursor.java

Modify an image

Goal: Divide intensity by 2 in a single image

Another way… Using update flags

Start image modification

```
image.beginUpdate();
try {
    for (int x = 0; x < w; x++) {
        for (int x = 0; x < w; x++) {
            image.setData(x, y, 0, image.getData(x, y, 0) / 2);
        }
    }
}
finally {
    image.endUpdate();
}
```

End image modification → image refresh and recalculations

http://icy.bioimageanalysis.org/doc/icy-dev-plugin/ModifyImagePluginSimple.java

Modify an image

Goal: Divide intensity by 2 in a single image

An optimized solution… Similar performance as cursors but less readable

```
Object dataArray = image.getDataXY(0);

double[] doubleDataArray = Array1DUtil.arrayToDoubleArray(dataArray,
image.isSignedDataType());

MathUtil.divide(doubleDataArray, 2d);

Array1DUtil.doubleArrayToSafeArray(doubleDataArray, image.getDataXY(0),
image.isSignedDataType());

image.dataChanged();
```

http://icy.bioimageanalysis.org/doc/icy-dev-plugin/ModifyImagePluginFast.java

Modify an image

Complete code: optimized version

```
IcyBufferedImage image = getActiveImage();

if (image == null)
{
     MessageDialog.showDialog("This plugin needs an opened image.");
     return;
}

Object dataArray = image.getDataXY(0);

double[] doubleDataArray = Array1DUtil.arrayToDoubleArray(dataArray,
image.isSignedDataType());

MathUtil.divide(doubleDataArray, 2d);

Array1DUtil.doubleArrayToSafeArray(doubleDataArray, image.getDataXY(0),
image.isSignedDataType());

image.dataChanged();
```

http://icy.bioimageanalysis.org/doc/icy-dev-plugin/ModifyImagePluginFast.java

Image utilities…

IcyBufferedImageUtil class

```
// Add a channel to the image
image = IcyBufferedImageUtil.addChannel(image);

// Change the image data type
image = IcyBufferedImageUtil.convertToType(image, DataType.DOUBLE, true);

// Extract a channel
image = IcyBufferedImageUtil.extractChannel(image, 1);

// Get a region of the image
image = IcyBufferedImageUtil.getSubImage(
          image, new Rectangle(10, 10, 50, 50), 0, 1);

// Resize the image
image = IcyBufferedImageUtil.scale(image, 500, 500);
```

Sequence processing & creation

Goal: Compute the maximum intensity projection over the Z dimension

Get the current active sequence

```
Sequence sequence = getActiveSequence();

// check if a sequence is opened
if (sequence == null)
{
     MessageDialog.showDialog("This plugin needs an opened sequence.");
     return;
}
```

Display a message if no sequence is opened

Sequence processing & creation

Goal: Compute the maximum intensity projection over the Z dimension

The idea...

```
private Sequence sequence;

@Override
public void run()
{
    sequence = getActiveSequence();

    if (sequence == null) // check if a sequence is opened
    {
        MessageDialog.showDialog("This plugin needs an opened sequence.");
        return;
    }

    createResultSequence(); // Create a sequence with black frames
    computeMaxZProjection();
    showResultSequence();
}
```

Sequence processing & creation

Note **sequence** is accessible from other methods in the plugin (1, 2, 3)

```
private Sequence sequence;

@Override
public void run()
{
    sequence = getActiveSequence();

    if (sequence == null) // check if a sequence is opened
    {
        MessageDialog.showDialog("This plugin needs an opened sequence.");
        return;
    }

 1  createResultSequence(); // Create a sequence with black frames
 2  computeMaxZProjection();
 3  showResultSequence();
}
```

Sequence processing & creation

1. Create a new sequence with black frames and using the original name

Note **resultSequence** is accessible from other methods in the plugin

```
private Sequence resultSequence;

private void createResultSequence()
{
    resultSequence = new Sequence(sequence.getName() + " - Z projection");
    resultSequence.beginUpdate();
    for (int t = 0; t < sequence.getSizeT(); t++) {
        resultSequence.addImage(t,
            new IcyBufferedImage(sequence.getSizeX(), sequence.getSizeY(),
                sequence.getSizeC(), sequence.getDataType_()));
    }
    resultSequence.endUpdate();
}
```

Add an planar image at each frame

Sequence processing & creation

2. Compute max projection on sequence

sequenceCursor and **resultCursor** are accessible from other methods.

```
private SequenceCursor sequenceCursor;
private SequenceCursor resultCursor;

private void computeMaxZProjection() {
    sequenceCursor = new SequenceCursor(sequence);
    resultCursor = new SequenceCursor(resultSequence);
    try {
        for (int t = 0; t < sequence.getSizeT(); t++) {
            computeFrame(t);
        }
    }
    finally {
        resultCursor.commitChanges();
    }
    resultSequence.dataChanged();
}
```

Instantiate cursors

Compute projection for each frame

Commit changes on **resultSequence**

Sequence processing & creation

2.1. Compute max projection on each frame

```
private void computeFrame(int t) {
    for (int c = 0; c < sequence.getSizeC(); c++) {
        for (int z = 0; z < sequence.getSizeZ(); z++) {
            projectMax(t, c, z);
        }
    }
}
```

1 projection on each channel

Compute projection on the volume

```
private void projectMax(int t, int c, int z) {
    for (int y = 0; y < sequence.getHeight(); y++) {
        for (int x = 0; x < sequence.getWidth(); x++) {
            resultCursor.set(x, y, 0, t, c,
                    Math.max(
                            resultCursor.get(x, y, 0, t, c),
                            sequenceCursor.get(x, y, z, t, c)));
        }
    }
}
```

at each pixel of the slice z

Keep the maximum value

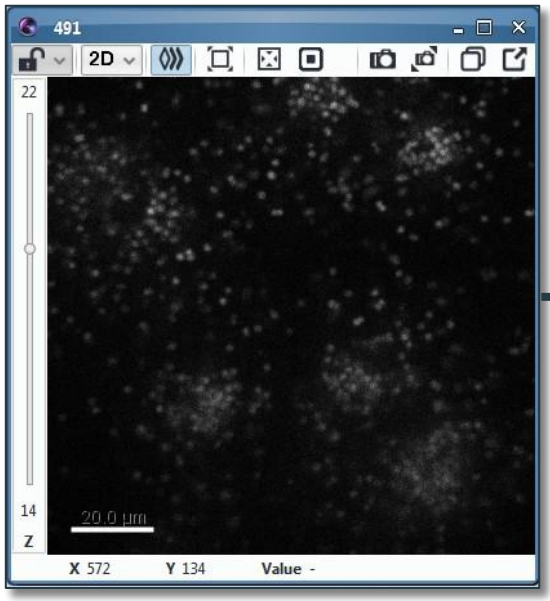
http://icy.bioimageanalysis.org/doc/icy-dev-plugin/MaximumZProjectionPlugin.java

Sequence processing & creation

3. Show result

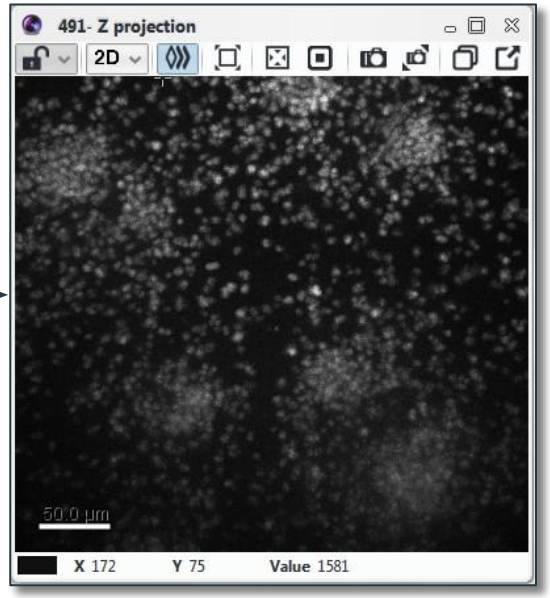
```
private void showResultSequence()
{
    addSequence(resultSequence);
}
```

Before



Z max projection

After



http://icy.bioimageanalysis.org/doc/icy-dev-plugin/MaximumZProjectionPlugin.java

Sequence processing & creation exercice

Try computing a projection like the maximum Z-projection, but on the time axis (maximum T-projection)

Sequence processing & creation exercice - solution

Basically the idea is to exchange the Z and T dimension in the algorithm.

computeMaxZProjection ⟶ computeMaxTProjection

computeFrame ⟶ computeSlice

```
private void computeMaxTProjection() {
    ...
    try {
        for (int z = 0; z < sequence.getSizeZ(); z++)
            computeSlice(z);
    }
    ...
}

private void computeSlice(int z) {
    for (int c = 0; c < sequence.getSizeC(); c++) {
        for (int t = 0; t < sequence.getSizeT(); t++) {
            projectMax(t, c, z);
        }
    }
}
```

http://icy.bioimageanalysis.org/doc/icy-dev-plugin/MaximumTProjectionPlugin.java

Sequence utilities…

SequenceUtil class

```
// Get a copy of specified sequence
result = SequenceUtil.getCopy(sequence);

// Add one Z slice at position 5
SequenceUtil.addZ(sequence, 5, 1);

// Convert the specified sequence (Z-stack format) to timelapse
SequenceUtil.convertToTime(sequence);

// Remove the frame 12
SequenceUtil.removeTAndShift(sequence, 12);

// Get a sub-region of the sequence
result = SequenceUtil.getSubSequence(sequence,
            new Rectangle5D.Integer(
                  //x   y   z  t  c
                    50, 50, 0, 0, 0,
                  //sx   sy   sz                    st                   sc
                    100, 100, sequence.getSizeZ(), sequence.getSizeT(), 1));
```

Thread & good practices

The **run** method of the plugin is always called on the ***Event Dispatch Thread*** (graphic thread) as you need it to create your graphical interface.
But if you do a long process in this thread the application won't respond for sometime.

```
public class BadPlugin extends PluginActionable
{
    @Override
    public void run()
    {
        // We are in the Event Dispatch Thread

        // this is a really bad idea! It blocks the UI
        ThreadUtil.sleep(10000);
    }
}
```

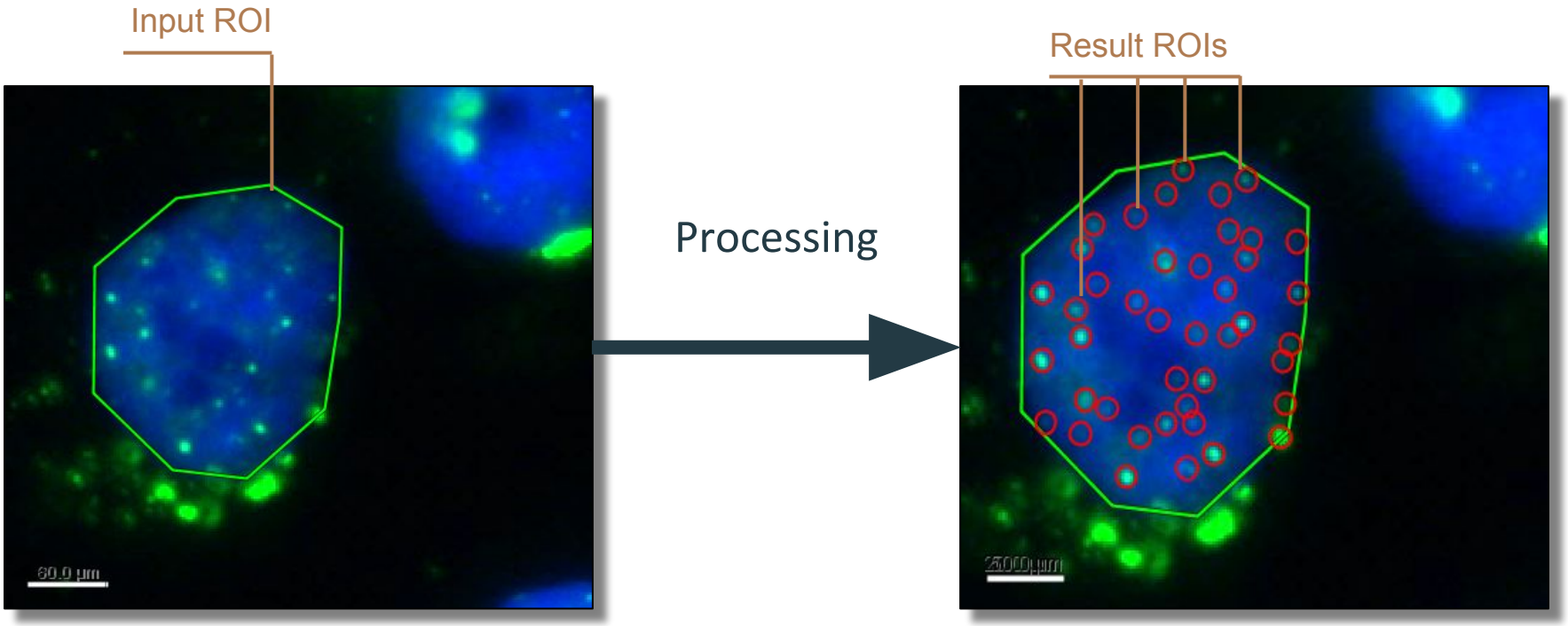
Thread & good practices

ThreadUtil class

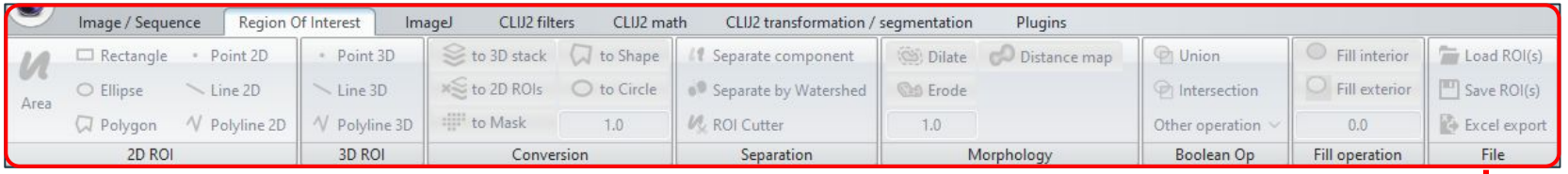
```
public class GoodPlugin extends PluginActionable
{
    @Override
    public void run()
    {
        // WE ARE IN THE EVENT DISPATCH THREAD (GRAPHICS THREAD)

        // request the following Runnable to execute in background thread
        ThreadUtil.bgRun(new Runnable()
        {
            @Override
            public void run()
            {
                // WE ARE NOT ANYMORE IN THE EVENT DISPATCH THREAD
                ThreadUtil.sleep(10000);
            }
        });
    }
}
```

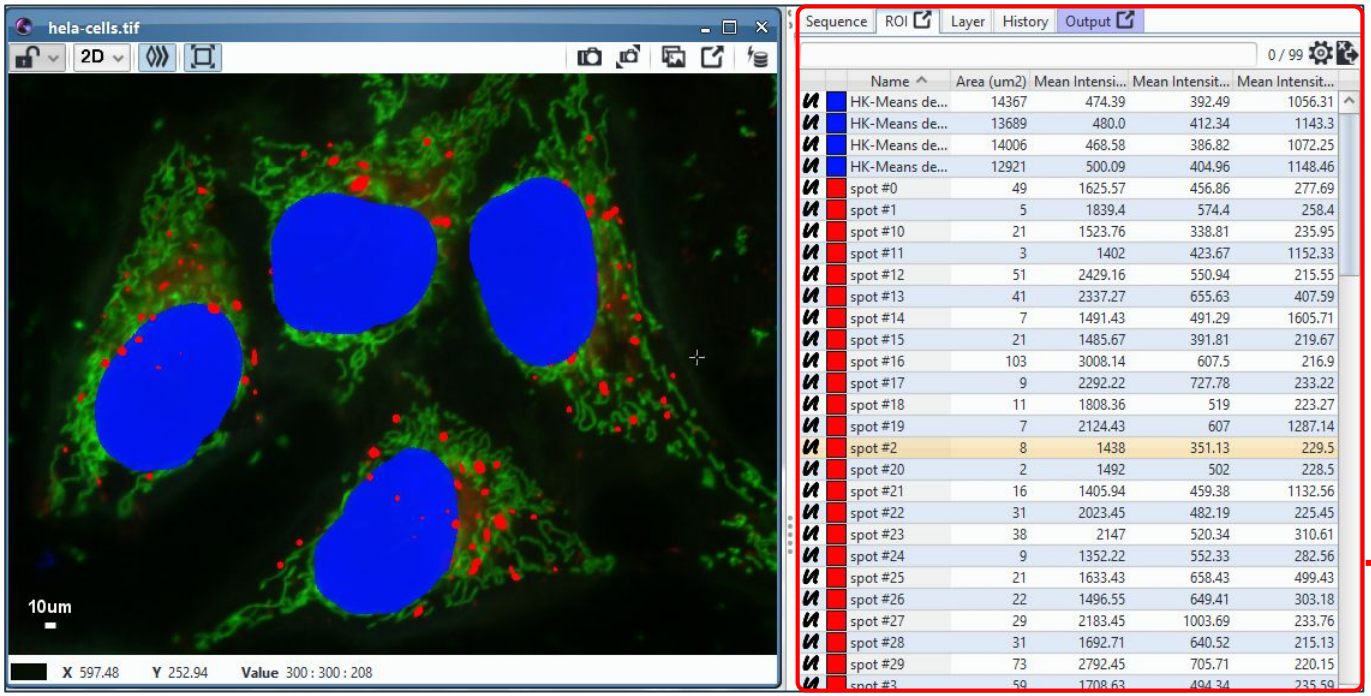
ROI (Region Of Interest)

ROI are very important in Icy. They can both be used as input information (to know where to apply a process for instance) but they are also the way to provide results. Almost all plugins generate ROIs as results from which you can easily extract quantitative information.



ROI in Icy

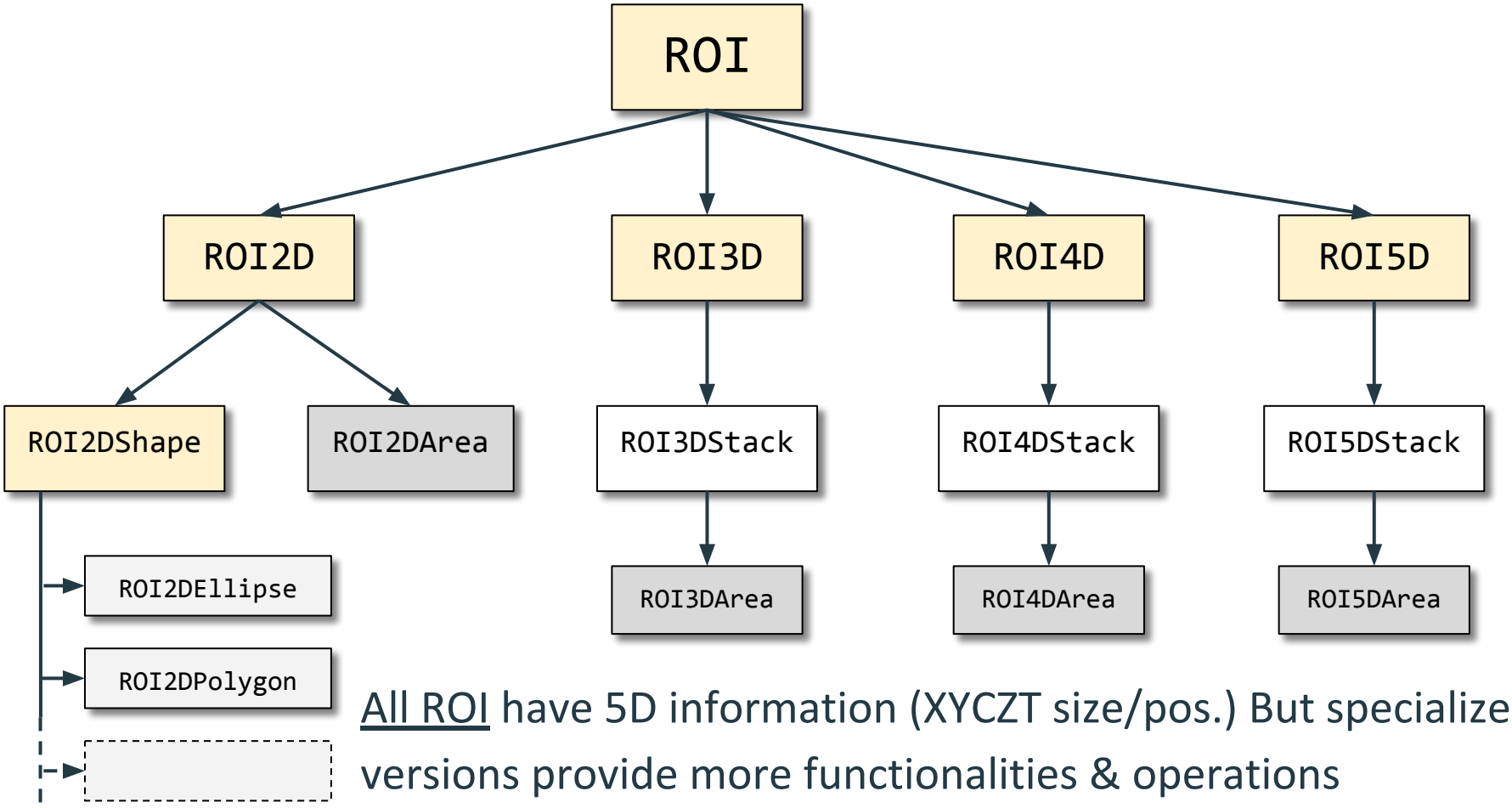




ROI manipulation tools

Quantitative information extracted from ROIs

ROI - class hierarchy



All ROI have 5D information (XYCZT size/pos.) But specialized versions provide more functionalities & operations

ROI - basics

Generic 5D contains method

```
boolean contained = roi.contains(x,  y, z, t, c);

if (roi instanceof ROI2D)
{
    contained = ((ROI2D) roi).contains(x,  y);
}
```

2D specific test

2D specialized contains method

Get all 2D roi from this sequence

Get all selected roi from this sequence

```
List<ROI2D> roi2ds = sequence.getROI2Ds();

List<ROI> rois = sequence.getSelectedROIs();

ROI roi = sequence.getSelectedROI();
```

Get first selected ROI from this sequence

ROI - mean intensity

Simple method using `roi.contains(...)`:

```
// consider first image only here
IcyBufferedImage image = sequence.getFirstImage();
double mean = 0;
double sample = 0;

for (int x = 0; x < sequence.getSizeX(); x++)
{
    for (int y = 0; y < sequence.getSizeY(); y++)
    {
        if (roi.contains(x, y))
        {
            mean += image.getData(x, y, 0);
            sample++;
        }
    }
}

System.out.println("mean intensity over ROI: " + (mean / sample));
```

Roi 'contains' test (can be slow)

http://icy.bioimageanalysis.org/doc/icy-dev-plugin/MeanIntensityPluginROI.java

ROI - mean intensity

Problem:

The roi `contains()` method can be slow depending the ROI implementation.

→ slow processing on large images

Solution:

Use `BooleanMask2D` object for fast `contains()` method.

ROI - mean intensity

Faster method using `BooleanMask2D`:

```
BooleanMask2D mask = roi.getBooleanMask(true);
// consider first image only here
IcyBufferedImage image = sequence.getFirstImage();
double mean = 0;
double sample = 0;

for (int x = 0; x < sequence.getSizeX(); x++)
{
    for (int y = 0; y < sequence.getSizeY(); y++)
    {
        if (mask.contains(x, y))
        {
            mean += image.getData(x, y, 0);
            sample++;
        }
    }
}
```

Mask ‘contains’ test (fast)

http://icy.bioimageanalysis.org/doc/icy-dev-plugin/MeanIntensityPluginBooleanMask.java

ROI - mean intensity

Alternative method using DataIterator:

Create a new Sequence data iterator that iterates through all pixels contained in a ROI

```
SequenceDataIterator iterator = new SequenceDataIterator(sequence, roi);
double mean = 0;
double sample = 0;

while (!iterator.done())
{
    mean += iterator.get();
    iterator.next();
    sample++;
}
```

Get the current pixel value

Move to the next pixel

While we still have pixels to process

http://icy.bioimageanalysis.org/doc/icy-dev-plugin/MeanIntensityPluginIterator.java

ROI - Threshold result

The idea : Create a ROI which contains all pixel value >= threshold value

→ many different ways to do that !

Let’s see some of them…

ROI - Threshold result - 1

Naive way..

Create a new empty ROI (type: mask)

```
ROI2DArea roi = new ROI2DArea();
// consider first image only here
IcyBufferedImage image = sequence.getFirstImage();

for (int x = 0; x < sequence.getSizeX(); x++)
{
    for (int y = 0; y < sequence.getSizeY(); y++)
    {
        if (image.getData(x, y, 0) >= threshold)
        {
            roi.addPoint(x, y);
        }
    }
}

sequence.addROI(roi);
```

Add the accepted point to the ROI

Attach the result ROI to the sequence (make it visible)

http://icy.bioimageanalysis.org/doc/icy-dev-plugin/ThresholdPluginSimple.java

ROI - Threshold result - 2

Faster method...

Get sequence data in double array format

```
// consider first image and first channel only here
double[] doubleArray = Array1DUtil.arrayToDoubleArray(
    sequence.getDataXY(0, 0, 0), sequence.isSignedDataType());
boolean[] mask = new boolean[doubleArray.length];
```

Create a boolean array with same size as the data array

Set mask to true where pixels are accepted

```
for (int i = 0; i < doubleArray.length; i++)
    mask[i] = (doubleArray[i] >= threshold);

BooleanMask2D mask2d = new BooleanMask2D(sequence.getBounds2D(), mask);
ROI2DArea roi = new ROI2DArea(mask2d);
```

Create a BooleanMask2D object and then a ROI from this mask

http://icy.bioimageanalysis.org/doc/icy-dev-plugin/ThresholdPluginFast.java

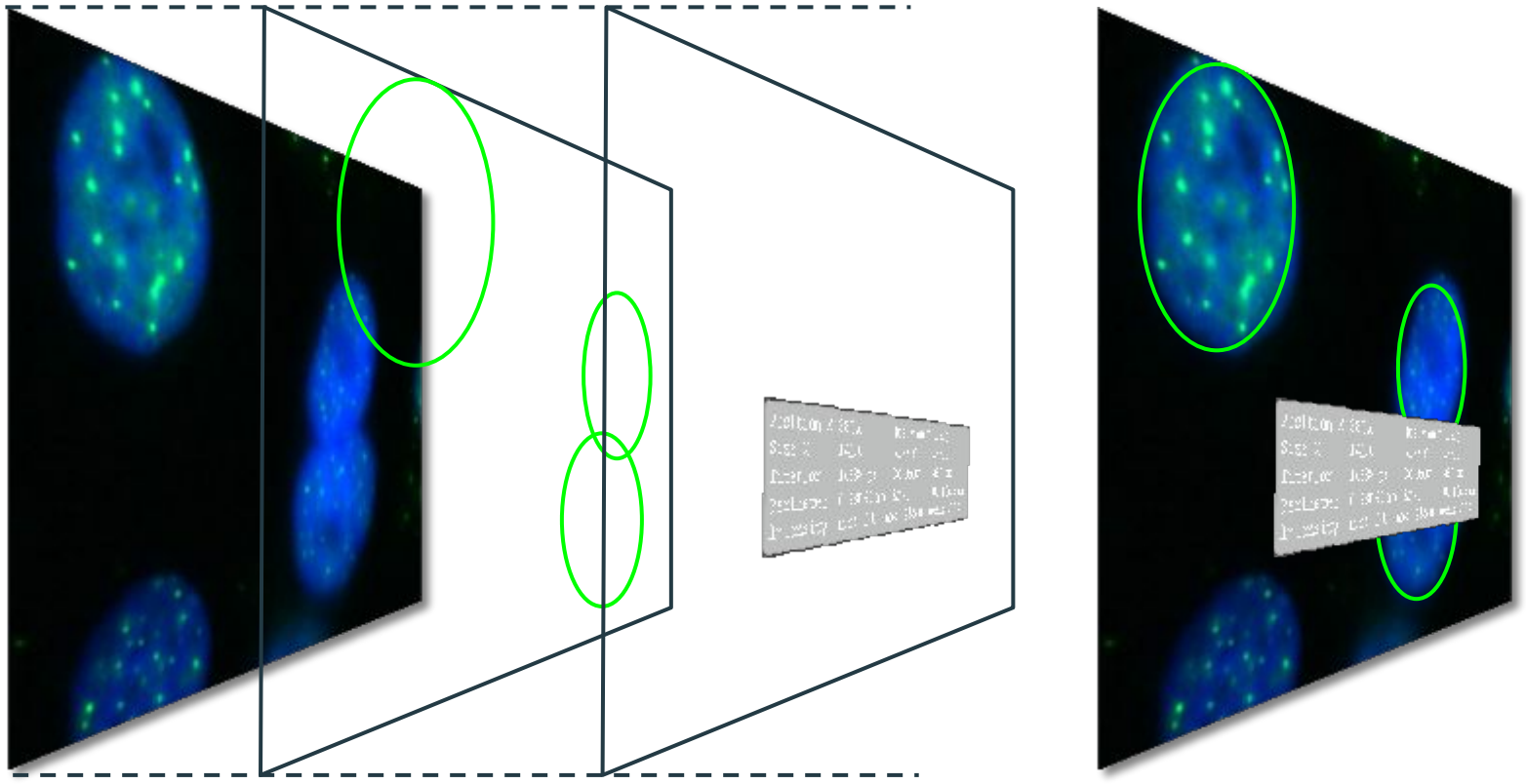
ROI utilities…

ROIUtil class

```
// Get the area of the specified roi and return result with correct units.
double area = ROIAreaDescriptor.computeArea(roi, sequence);

// Return the mean intensity of sequence pixels contained in the ROI.
double meanIntensity = ROIMeanIntensityDescriptor.computeMeanIntensity(
                            roi, sequence);

// Process the union of specified rois
ROI unionRoi = ROIUtil.getUnion(rois);

// Process the subtraction of roi2 to roi1
roi = ROIUtil.subtract(roi1, roi2);
```

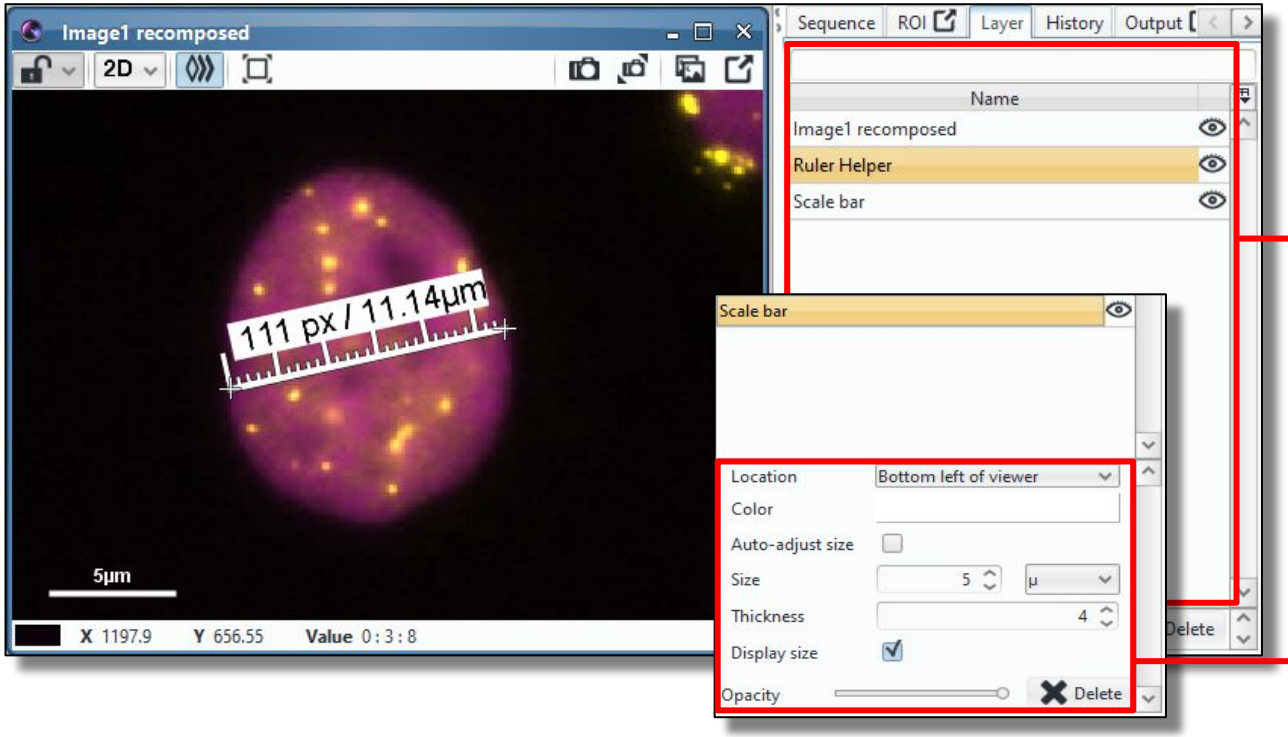
Overlay - concept

Image + ROI + Tooltip = **View**



Overlay in Icy

Overlay allow to enrich image display with various informations.



Layer panel displaying all layers visible on this image

Some layers can display extra settings when you select them

Overlay - description

So plugins can use Overlays to display rich information over images...

...but it also allows user interaction by receiving directly mouse and key events.

Overlay - display

Create a new Overlay class

```
public class SimpleCrossOverlay extends Overlay
{
    public SimpleCrossOverlay()
    {
        super("Simple cross");
    }

    @Override
    public void paint(Graphics2D g, Sequence sequence, IcyCanvas canvas)
    {
        if (g != null)
        {
            // paint a yellow cross all over the image
            g.setColor(Color.YELLOW);
            g.setStroke(new BasicStroke(5));
            g.drawLine(0, 0, sequence.getWidth(), sequence.getHeight());
            g.drawLine(0, sequence.getHeight(), sequence.getWidth(), 0);
        }
    }
}
```

Name (appears in the ‘Layers’ tab)

Method called by Icy to draw the overlay

Drawing is relative to the image coordinate system

Overlay - user interaction

Mouse click event method

Mouse position in image coordinate space

```
    ...
    @Override
    public void mouseClick(MouseEvent e, Point2D point, IcyCanvas canvas)
    {
        // remove the overlay when the user clicks on the image
        remove();
    }
}
```

Remove the Overlay from sequences where it is attached

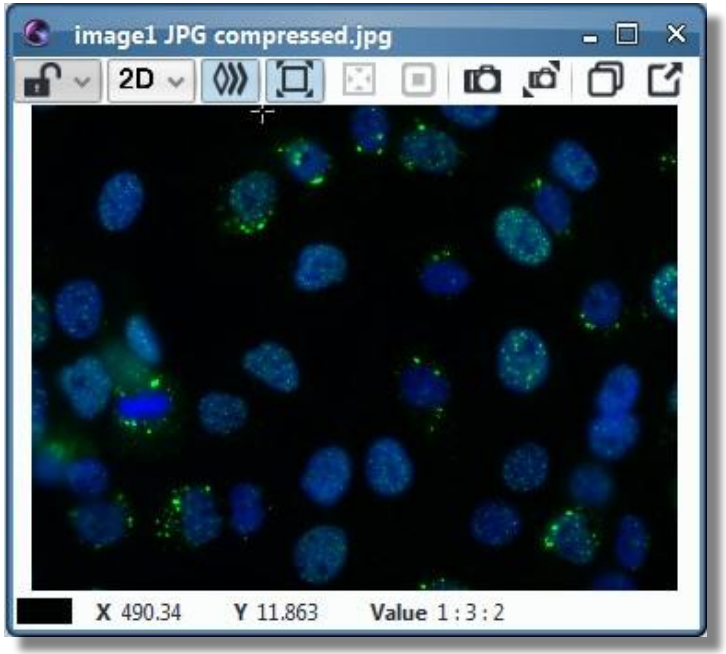
Almost done...

```
sequence.addOverlay(new SimpleCrossOverlay());
```

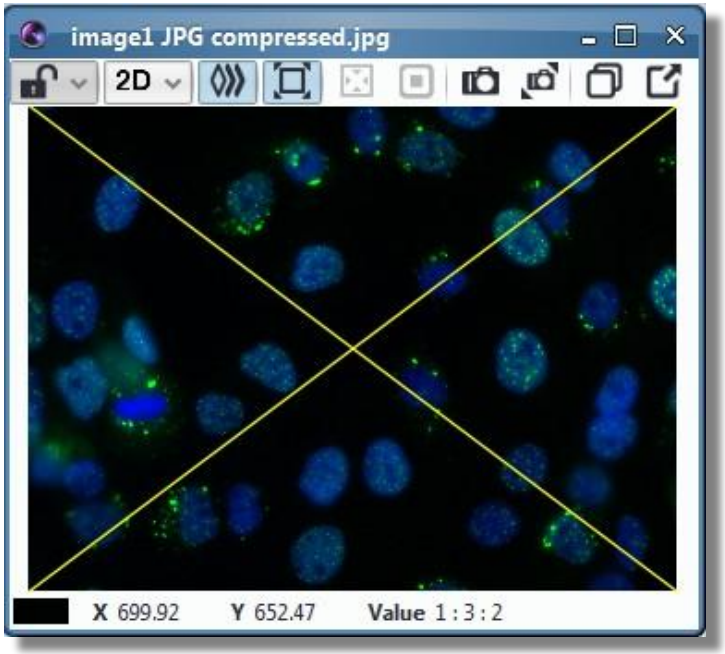
Add a new `SimpleCrossOverlay` to the sequence

Overlay

Before



After



http://icy.bioimageanalysis.org/doc/icy-dev-plugin/SimpleCrossOverlayPlugin.java

Overlay - exercise

Create an overlay displaying the overlapped ROI name at the mouse cursor position.

Overlay - exercise - solution

```
public class ROINameOverlay extends Overlay
{
    String roiName;         // stored ROI name
    Point2D mousePos;       // stored mouse position

    public ROINameOverlay()
    {
        super("ROI name display");
        // initialize vars
        roiName = null;
        mousePos = null;
    }

    @Override
    public void paint(Graphics2D g, Sequence sequence, IcyCanvas canvas)
    {
        if (g != null)
        {
            // paint ROI name in white
            g.setColor(Color.WHITE);
            if (roiName != null)
                g.drawString(roiName, (float) mousePos.getX(), (float) mousePos.getY());
        }
    }
```

Overlay - exercise - solution

```
public void mouseMove(MouseEvent e, Point2D imagePoint, IcyCanvas canvas)
{
    updateROIName(canvas.getSequence(), imagePoint);
}

public void mouseDrag(MouseEvent e, Point2D imagePoint, IcyCanvas canvas)
{
    updateROIName(canvas.getSequence(), imagePoint);
}

private void updateROIName(Sequence sequence, Point2D imagePoint)
{
    // find overlapped ROI
    ROI2D roi = getOverlappedROI(sequence, imagePoint);
    // store its name
    if (roi != null)
        roiName = roi.getName();
    else
        roiName = null;
    // store mouse position
    mousePos = (Point2D) imagePoint.clone();
    // notify that we need to be redraw
    painterChanged();
}
```

http://icy.bioimageanalysis.org/doc/icy-dev-plugin/ROINameOverlayPlugin.java

Overlay - Anchor2D & tools

Anchor2D class

Offer simple object mouse manipulation as selection and drag operation

ImageOverlay class

Simple overlay to display an image

VtkPainter interface

Easier VTK overlay implementation

GUI - foreword

Creating a user interface can be a pain (especially in Java)

But in 90% of cases they look the same:

- Parameters (name, value)
- Buttons here, labels there, etc.

Our goal: provide an API that is

- Simple (your plugin in less than 5 min.)
- Standardized (users don’t get lost)
- Powerful (bells & whistles included!)

EzPlug - basics

```
public class MyNiceLookingPlugin extends EzPlug
{
    @Override
    public void initialize()
    {
        // create the interface here
    }

    @Override
    public void execute()
    {
        // do some "real" work
    }

    @Override
    public void clean()
    {
        // clean things when closing
    }
}
```

The interface is generated automatically

No more hardcore Swing!

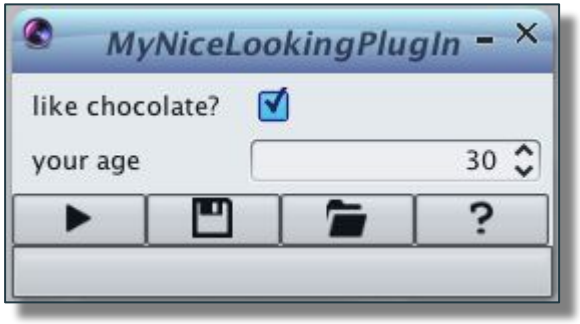
Load/save parameters

Online documentation

Progress bar

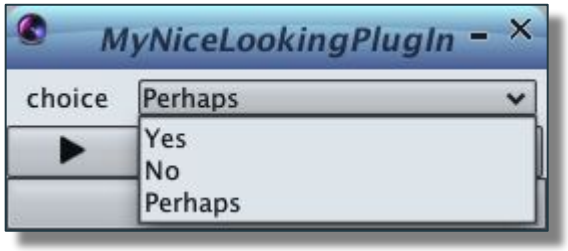
EzPlug - GUI - parameters

```
public class MyNiceLookingPlugin extends EzPlug
{
    EzVarInteger age = new EzVarInteger(
        "your age", 30, 10, 100, 1);
            Name, default, min, max, step
    EzVarBoolean isYummy = new EzVarBoolean(
        "like chocolate?", true);
            name,          default

    @Override
    public void initialize()
    {
        // add elements in order of appearance
        addEzComponent(isYummy);
        addEzComponent(age);
    }
    ...
}
```

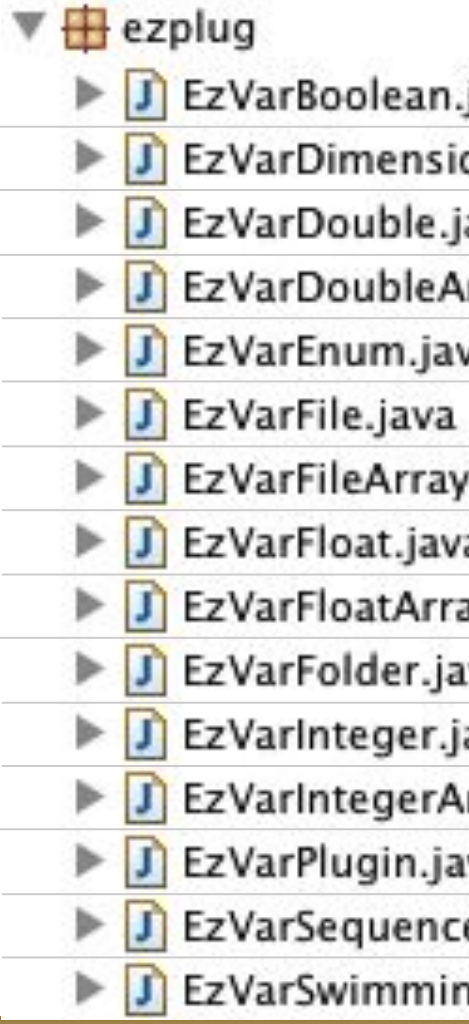


EzPlug - GUI - parameters

```
public class MyNiceLookingPlugin extends EzPlug
{
    enum Choice
    {
        Yes, No, Perhaps
    }

    EzVarEnum<Choice> choice = new EzVarEnum<Choice>(
            "choice",              name
            Choice.values(),       valid values
            Choice.Perhaps);       default

    @Override
    public void initialize()
    {
        addEzComponent(choice);
    }
    ...
}
```



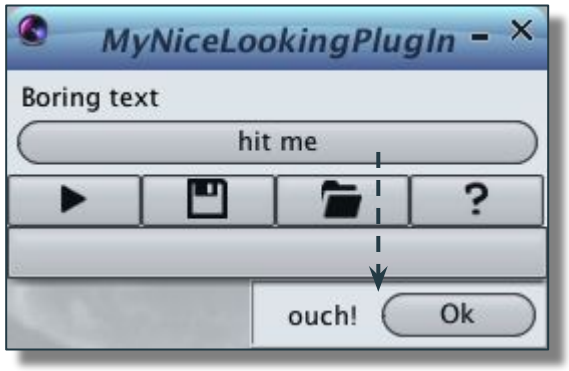
EzPlug - GUI - parameters



EzVarBoolean.java	Check box
EzVarDimensionPicker.java	Spinner
EzVarDouble.java	Spinner, Combo box
EzVarDoubleArrayNative.java	Free text (spaced values), Combo box
EzVarEnum.java	Combo box
EzVarFile.java	Button (File chooser)
EzVarFileArray.java	Button (Multi-File chooser)
EzVarFloat.java	Spinner, Combo box
EzVarFloatArrayNative.java	Free text (spaced values), Combo box
EzVarFolder.java	Button (opens a folder chooser)
EzVarInteger.java	Spinner, Combo box
EzVarIntegerArrayNative.java	Free text (spaced values), Combo box
EzVarPlugin.java	Combo box
EzVarSequence.java	Combo box
EzVarSwimmingObject.java	Combo box

EzPlug - GUI - buttons & labels

```
public class MyNiceLookingPlugin extends EzPlug
{
    ActionListener action = new ActionListener()
    {
        @Override
        public void actionPerformed(ActionEvent e)
        {
            new AnnounceFrame("ouch!");
        }
    };

    EzButton tap = new EzButton("hit me", action);

    @Override
    public void initialize()
    {
        addEzComponent(new EzLabel("Boring text"));
        addEzComponent(tap);
    }
    ...
}
```



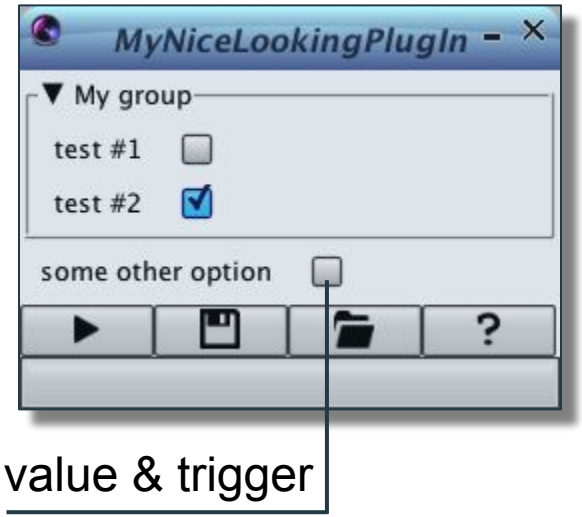
EzPlug - GUI - groups

```
public class MyNiceLookingPlugin extends EzPlug
{
    EzVarBoolean b1 = new EzVarBoolean(
            "test #1", false);

    EzVarBoolean b2 = new EzVarBoolean(
            "test #2", true);

    EzVarBoolean b3 = new EzVarBoolean(
            "some other option", false);

    EzGroup grp = new EzGroup("My group", b1, b2);

    @Override
    public void initialize()
    {
        addEzComponent(grp);
        addEzComponent(b3);
    }
    ...
}
```

EzPlug - GUI - hiding/showing

```
public class MyNiceLookingPlugin extends EzPlug
{
    EzVarBoolean b1 = new EzVarBoolean(
            "test #1", false);

    EzVarBoolean b2 = new EzVarBoolean(
            "test #2", true);

    EzVarBoolean b3 = new EzVarBoolean(
            "some other option", false);

    EzGroup grp = new EzGroup("My group", b1, b2);

    @Override
    public void initialize()
    {
        addEzComponent(grp);
        addEzComponent(b3);
        b3.addVisibilityTriggerTo(grp, false);
    }
    ...
}
```

"show {grp} only if {b3} has value {false}"



EzPlug - stop a running process

```
public class MyNiceLookingPlugin extends EzPlug
implements EzStoppable
{
    ...
    @Override
    public void execute()
    {
        // who am i?!
        Thread t = Thread.currentThread();

        for (int i = 1; i <= 100; i++)
        {
            // do stuff
            if (t.isInterrupted())
            break;
        }
    }
    ...
}
```

The easy way...

EzPlug - stop a running process

```
public class MyNiceLookingPlugin extends EzPlug
implements EzStoppable
{
    boolean stopFlag;

    @Override
    public void stopExecution()
    {
        stopFlag = true;
    }

    @Override
    public void execute()
    {
        stopFlag = false; // don't, stop me noooow!
        for (int i = 1; i <= 100; i++)
        {
            // do stuff
            if (stopFlag)
            break;
        }
    }
```

For more control...

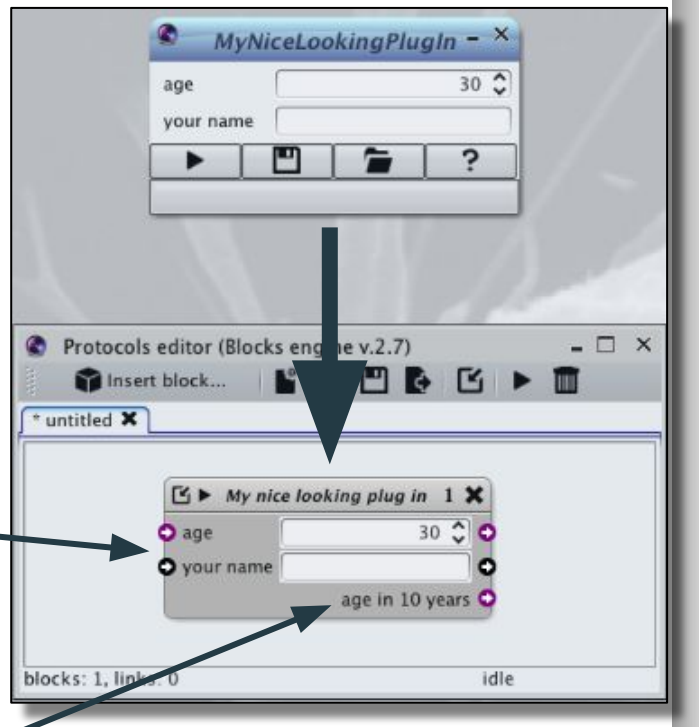
EzPlug - going further

- Progress bar / main buttons can be hidden
- Supports “regular” AWT/Swing components
- Available as modal dialogs (use EzDialog)
- Open to new parameter types (extend EzVar)

EzPlug - going beyond

Make your plugin compatible with block

```
public class MyNiceLookingPlugin extends EzPlug
implements Block
{
    EzVarInteger age = ...
    EzVarText text = ...
    ...
    // no GUI for this one
    VarInteger out = new VarInteger("out", 0);

    ... // fill the other methods

    public void declareInput(VarList inputMap)
    {
        inputMap.add(age.getVariable());
        inputMap.add(text.getVariable());
    }

    public void declareOutput(VarList outputMap)
    {
        outputMap.add(out);
    }
```



EzPlug - exercise

Create a GUI from the *ROI - Threshold* example using *EzPlug*.
It should be compatible with Block programming / Protocols.

Input

- Input image (Sequence)
- Threshold value (int)

Output

- ROI

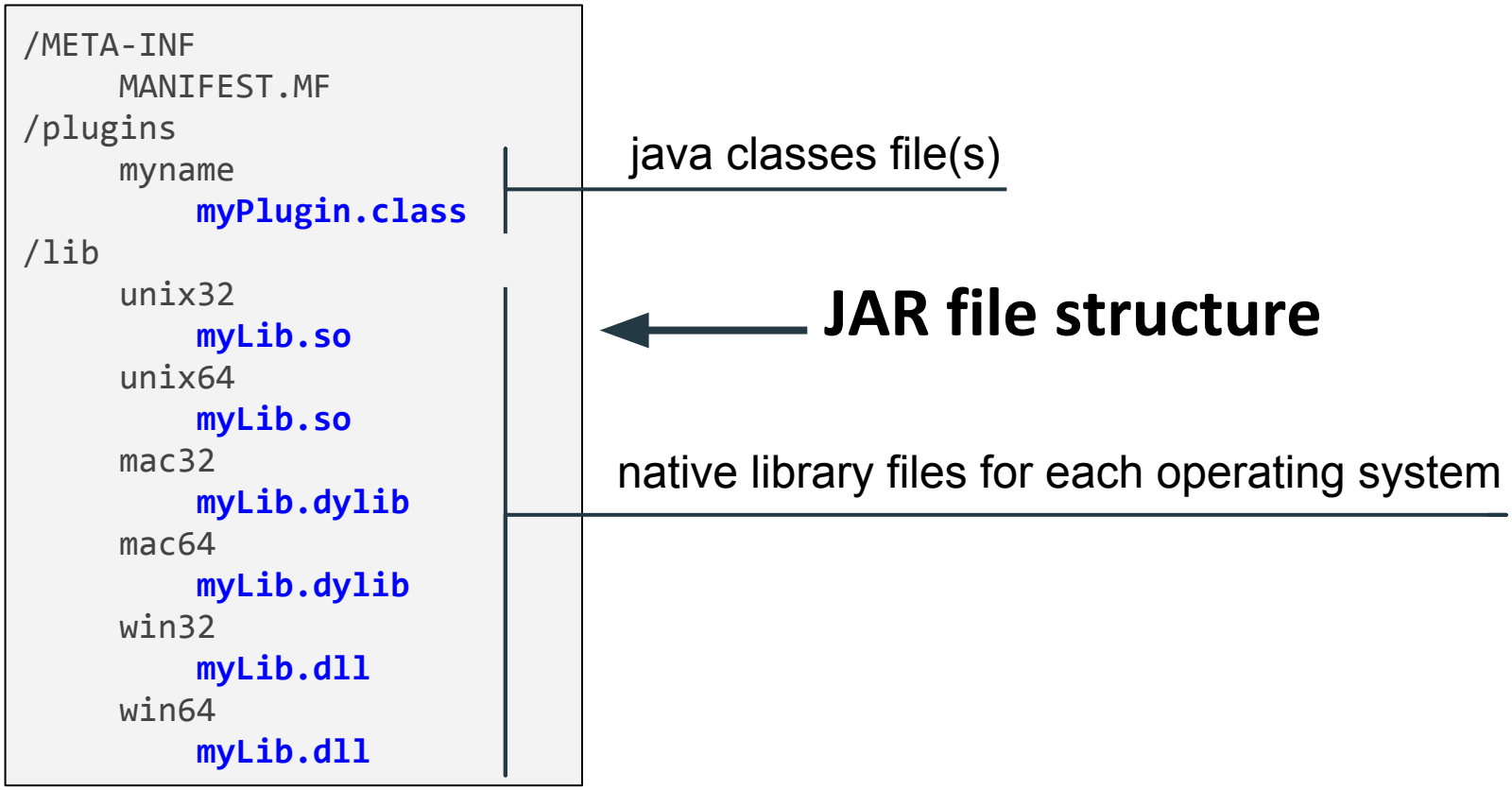
EzPlug - exercise - solution

```
public class MyThresholdPlugin extends EzPlug implements Block {
    EzVarSequence sequence = new EzVarSequence("Sequence");
    EzVarInteger threshold = new EzVarInteger("Threshold", 128, 1, 255, 1);
    VarROIArray rois = new VarROIArray("ROI");

    public void initialize() {
        addEzComponent(sequence);
        addEzComponent(threshold);
    }

    public void declareInput(VarList inputMap) {
        inputMap.add("sequence", sequence.getVariable());
        inputMap.add("threshold", threshold.getVariable());
    }

    public void declareOutput(VarList outputMap) {
        outputMap.add("rois", rois);
    }

    public void execute() {
      ROI roi = doThreshold(sequence.getValue(), threshold.getValue());
      if ((roi != null) && !isHeadLess())
            sequence.getValue().addROI(roi);
      rois.setValue(new ROI[] {roi});
    }
    ...
```

http://icy.bioimageanalysis.org/doc/icy-dev-plugin/ThresholdPluginGUI.java

Extra - Native library support

Easy integration of native library directly in the plugin jar file



Extra - Native library support

Load the native library through the plugin

```
public class NativeLibraryTestPlugin extends PluginActionable
{
    public NativeLibraryTestPlugin()
    {
        super();

        loadLibrary("myLib");
    }
    @Override
    public void run()
    {
        myLib.executeNativeMethod(..);
    }
}
```

Load the native library from the plugin JAR file

Executive the library native method

Extra - Special behavior plugin

Icy define specific plugin base classes and interfaces with special behaviours to extend freedom of plugin interactions with Icy.

- **PluginActionable**: Icy will automatically add a button in the ribbon menu allowing to execute your plugin (*EzPlug* extends it)
- **PluginDaemon**: Icy will automatically starts your plugin on application start (ideal for permanent enhancer)
- **PluginBundled**: Use it when you can to package several plugin into a single JAR file
- **PluginThreaded**: Icy will execute the plugin in a separate thread
- **PluginLibrary**: This plugin is just used a base library for other plugin

Extra - Enhancing Icy features

In the same idea, Icy also define specific plugin base classes and interfaces to extend default Icy features as visualization mode, ROI type, statistics..

- **PluginImporter**: add new importer.
  An *importer* can import/load any kind of resource (image, rois, protocols..) from any source (file, database..)
- **PluginSequenceFileImporter**: add new Sequence importer.
  This importer specifically takes a File as input and produces a Sequence (image) as result.
  For instance this is how we add MP4 file loading support.
- **PluginCanvas**: add new visualization mode (as channel montage view)
- **PluginROI**: add new ROI type
- **PluginROIDescriptor**: add new ROI descriptor(s) (statistic)

Extra - Enhancing Icy features - example

Adding a new ROI descriptor..

```
public class ROISizeDescriptor extends ROIDescriptor
{
    public static final String ID = "Size";

    public ROISizeDescriptor()
    {
        super(ID, "Size", Number.class);
    }

    public String getDescription()
    {
        return "Size (from 2D bounding box)";
    }

    public Object compute(ROI roi, Sequence sequence) throws UnsupportedOperationException
    {
        // get 2D bounds of ROI
        Rectangle2D bound2D = roi.getBounds5D().toRectangle2D();
        // return max size
        return Double.valueOf(Math.max(bound2D.getWidth(), bound2D.getHeight()));
    }
}
```

Extra - Enhancing Icy features - example

Adding a new ROI descriptor..

```
public class MySizeROIDescriptorPlugin extends Plugin implements PluginROIDescriptor
{
    public static final String ID_SIZE = ROISizeDescriptor.ID;

    // create the ROI Descriptor only once
    public static final ROISizeDescriptor sizeDescriptor = new ROISizeDescriptor();

    public List<ROIDescriptor> getDescriptors()
    {
        // return available descriptors in this plugin
        return CollectionUtil.createArrayList(sizeDescriptor);
    }

    public Map<ROIDescriptor, Object> compute(ROI roi, Sequence sequence) throws
UnsupportedOperationException
    {
        Map<ROIDescriptor, Object> result = new HashMap<>();
        // compute descriptor
        result.put(sizeDescriptor , sizeDescriptor.compute(roi, sequence));
        // return result
        return result;
    }
}
```

http://icy.bioimageanalysis.org/doc/icy-dev-plugin/ROISizeDescriptorPlugin.java

What you need next ??

When your plugin is done you may want to distribute it, for that you can check out this article:
How to publish a plugin

It’s really important to provide good documentation to your plugin. The plugin can be the best in its application, if it doesn’t have (or not enough) documentation it won’t be used...

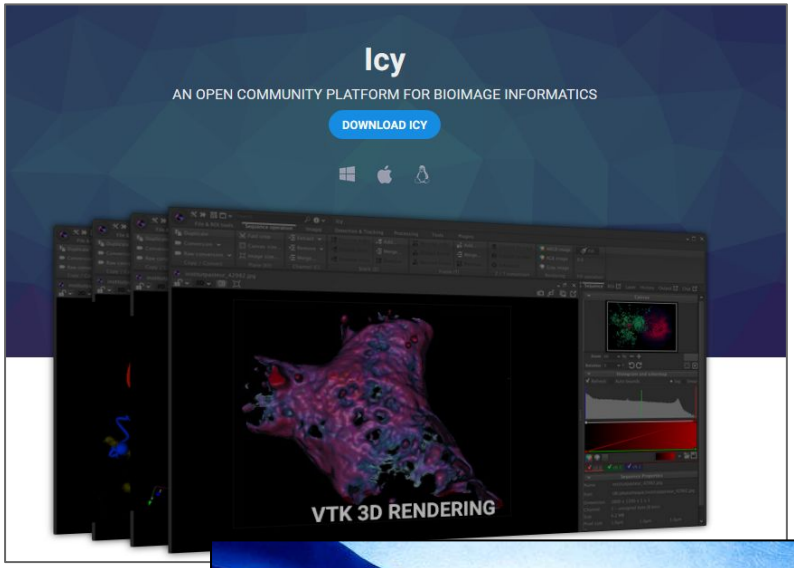
If you are stuck and need help, you can contact us through this forum:
https://forum.image.sc/tag/icy

Don’t forget to use the correct category/tags so we can quickly find it (“development” and use the “icy” tag)

Keep in touch !

Icy

http://icy.bioimageanalysis.org



Support forum

https://forum.image.sc/tag/icy

@Icy_BioImaging