

# ArduinoWidgets library

## Version 1.0

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## 1 Versions

Version	Date	Comment
0.1	October 15, 2017	Initial version
0.2	October 18, 2017	Description of an example of Arduino sketch
0.3	October 21, 2017	Description of the first half of the Views
0.4	November 5, 2017	Section 5 completed
0.8	November 10, 2017	Section 6 completed
0.9	November 11, 2017	document completed

## 2 Introduction

This document describes the *ArduinoWidgets* library, an Arduino library that allow Arduino programmers to perform highly complex graphic operations on a wide variety of touchscreens, such as building graphical interfaces and allowing interactivity. It handles a collection of widgets of user interfaces (UI) such as:

- Views and regions;
- Labels, text and lists;
- Points, Lines and Rectangles;
- PushButtons (rectangle and arrows);
- Tabs and Controls;
- Sliders, Switches;
- Keys and Keyboard;
- More to come later.

The *ArduinoWidgets* library is built above the `UTFT` library which take care of the physical interface between various Arduino hardware (ARM, AVR, Teensy, etc..) and a variety of LCD displays. In addition to `UTFT`, *ArduinoWidgets* include a physical interface with the Touch technology of the screen.

No other library is necessary to work with *ArduinoWidgets*.

In the next section, an example of usage of the *ArduinoWidgets* library is described.

### 3 An example

The example is fully contained in the following Arduino sketch "**AW\_doc\_example**":

This sketch is contained in the "**Examples**" folder of the *ArduinoWidgets* library. It can be easily found in the Arduino IDE : clic on the "Examples" item of the File menu and scroll to the "ArduinoWidgets" line. A submenu show some examples. Choose "**AW\_doc\_example**".

It displays a collection of graphic objects, some of them are "ready to use" in the library, and some others are custom objects which are created from the library. In addition, a label is displayed with the name each object :

- The line is a 5 pixel width black line.
- The roundRect is a green rectangle with round corners.
- The half circle is a red circle with has been clipped by an invisible rectangle to let visible only a half circle.
- The button include a numeric label inside. When clicking the button the number in the button is incremented and the built-in led is switched on or off
- The slider control the backlight of the screen (via a PWM pin of the micro-controller).

The last 2 objects are interactive objects : they allow actions from the user, which can control either output pins of the micro-controller (backlight, led) or specific properties of another object (a label value for instance).

Here is the complete listing :

```

1 //--- Project : ArduinoWidgets library
2 //--- Authors : Pierre Molinaro & Jean-Luc Bechenec
3 //--- Description : ArduinoWidgets library multiple views example
4
5 #include <ArduinoWidgets.h>
6 #include <UTFT.h>
7
8 //--- This part is hardware dependent :
9 //--- Teensy 3.6 + LCD 7" with Touch, SSD1963 controler,
    resolution 800x480
10 //--- LCD type (see /Applications/Arduino.app/Contents/Java/
    hardware/teensy/avr/libraries/UTFT/UTFT.h)
11
12 static const byte RS      = 23 ;
13 static const byte WR      = 22 ;
14 static const byte CS      = 15 ;
15 static const byte RESET   = 33 ;
16
17 //--- Warning D33 of Teensy 3.1:

```

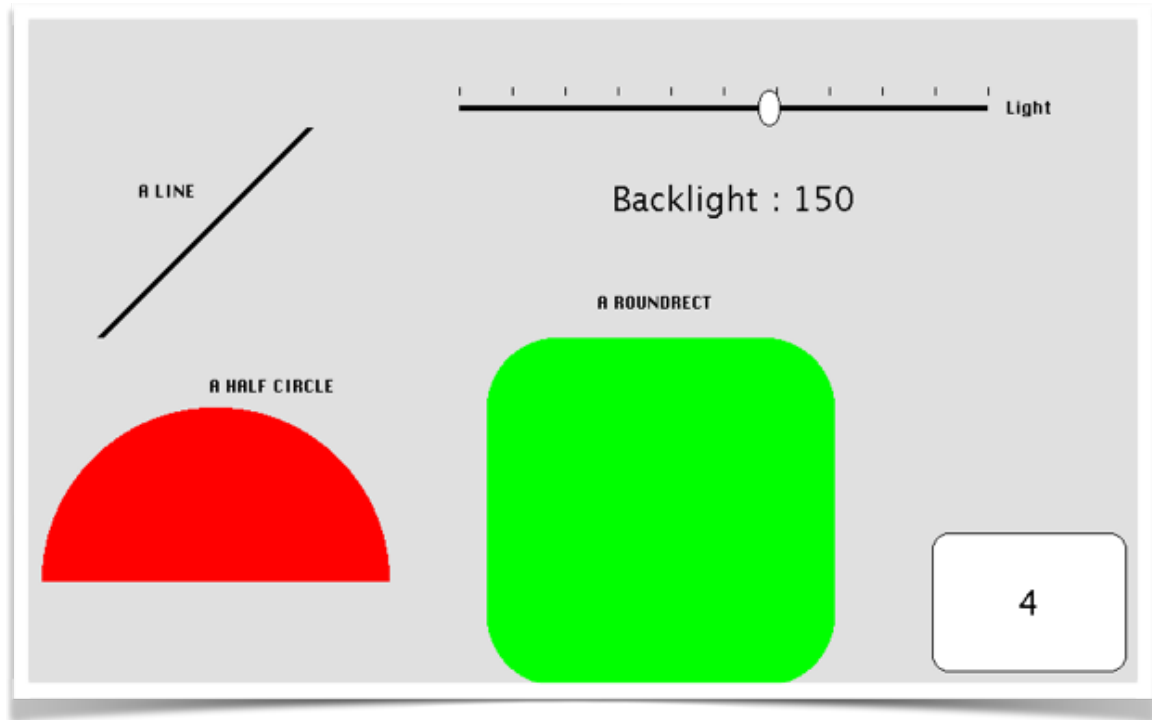


Figure 1: The AW\_doc\_example

```

18 //--- https://forum.pjrc.com/threads/24823-Teensy-3-1-Tying-Pin
   -33-(pta4)-low-freezes-teensy
19
20 //--- Do not change 'myGLCD' name; it is declared as extern in
   AWContext.cpp
21
22 UTFT myGLCD (SSD1963_800ALT, RS, WR, CS, RESET) ;
23
24 static const byte T_CLK  = 11 ;
25 static const byte T_CS   = 12 ;
26 static const byte T_DIN  = 25 ;
27 static const byte T_DOUT = 24 ;
28 static const byte T_IRQ  = 28 ;
29
30 static const byte BACKLIGHT = 9 ;
31
32 //--- Do not change 'myTouch' name; it is declared as extern in
   AWContext.cpp
33 AWTouch myTouch (T_CLK, T_CS, T_DIN, T_DOUT, T_IRQ) ;
34
35 //--- end of hardware dependent part
36
37 //////////////////////////////////////
38 //--- Definitions of behaviours of existing Views in the library

```

```

39 ///////////////////////////////////////////////////
40
41 /////////////////////////////////////////////////// BUTTON ///////////////////////////////////////////////////
42
43 //--- button related global variable
44 int buttonValue = 0 ;
45
46 //--- button action
47 void bigButtonAction (AWView * inSender)
48 {
49     AWPushButton * sendingButton = (AWPushButton *) inSender ;
50     buttonValue ++ ;
51     sendingButton->setTitle (String(buttonValue)) ;
52     digitalWrite (LED_BUILTIN, !digitalRead(LED_BUILTIN));
53 }
54
55 /////////////////////////////////////////////////// SLIDER ///////////////////////////////////////////////////
56
57 //--- Slider global variables
58 AWSlider *backlightSlider;
59 AWLabel * label1;    // constant label
60 AWLabel * label2;    // variable label
61 //--- Slider action
62 void sliderAction (AWView * inSender)
63 {
64     AWSlider * sendingSlider = (AWSlider *) inSender ;
65     AWInt pos = sendingSlider->knobPosition ();
66     if (sendingSlider == backlightSlider) {
67         analogWrite (BACKLIGHT, pos);
68         label2->setTitle(pos);
69     }
70 }
71
72 ///////////////////////////////////////////////////
73 //--- Definitions of new View classes
74 ///////////////////////////////////////////////////
75
76 /////////////////////////////////////////////////// ROUND CORNERS RECTANGLE ///////////////////////////////////////////////////
77
78 class CustomView1 : public AWView
79 {
80     CustomView1 (const AWRect & inViewFrame);
81     virtual void drawInRegion (const AWRegion & inRegion) const;
82 };
83 CustomView1::CustomView1 (const AWRect & inViewFrame) :
84 AWView(inViewFrame,
85     AWCColor ()), // let the corners opaque,
86     outside the drawing region

```

```

86   Color2 (AWColor::green ())
87   { }
88   void CustomView1::drawInRegion (const ARegion & inRegion) const
89   {
90       ARect viewFrame = absoluteFrame () ;
91       AContext::setColor (Color2) ;
92       viewFrame.fillRoundRectInRegion (AInt (50), inRegion) ; //
           radius of corners is 50
93   }
94   //--- Global variable ROUNDRECT
95   CustomView1 * roundRectView ;
96
97   //////////// CLIPPING VIEW : A HALF CIRCLE ////////////
98
99   class ClippingView : public AView
100  {
101      ClippingView (const ARect & inViewFrame);
102      virtual void drawInRegion (const ARegion & inRegion) const;
103  };
104  ClippingView::ClippingView (const ARect & inViewFrame) :
105  AView(inViewFrame,
106      AColor ())          // outside the drawing region is opaque
107      { }
108  void ClippingView::drawInRegion (const ARegion & inRegion) const
109  {
110      ARegion drawingRegion = inRegion ;
111      ARect viewFrame = absoluteFrame () ;
112      ARect clipRectangle = viewFrame ;
113      clipRectangle.size.width /= 1 ;
114      clipRectangle.size.height /= 2 ;    // the clip rectangle hide
           the low half of the circle
115      drawingRegion -= clipRectangle ;
116      AContext::setColor (AWColor::red ());
117      viewFrame.fillOvalInRegion (drawingRegion) ;
118  }
119  //--- Global variable CLIPPING VIEW
120  ClippingView * crossView ;
121
122
123  //////////// SETUP ////////////
124
125  void setup() {
126      //--- This part is hardware dependent
127      //--- set up the backlight
128      analogWrite (BACKLIGHT, 150);
129      pinMode (LED_BUILTIN, OUTPUT);
130      digitalWrite (LED_BUILTIN, HIGH);
131

```



```

132  AWContext::begin (kOrientationLandscape,
133                    800,          // Screen width
134                    480,          // Screen height
135                    true,         // true : X is flipped
136                    false) ;     // false : Y is not flipped
137
138  //--- end of hardware dependent part
139
140  //--- create a button on screen
141  AWPushButton * bigButton = new AWPushButton(AWRect (600, 100,
142          140, 100), String (buttonValue), AWFont (ChicagoDigit36)) ;
142  bigButton->setAction (bigButtonAction) ;
143  addView (new AWLabel (AWPoint (625, 220), 100,
144          kAWAlignmentCenter, "A_BUTTON")) ;
145
146  //--- create 2 labels, one constant and one that can be changed
147          by the slider
147  label1 = new AWLabel(AWPoint ( 300, 340), AInt (250),
148          AWAignment (kAWAlignmentRight), String ("Backlight:_"),
149          AWFont (Lucida_Grande24)) ;
148  addView (label1) ;
149  label2 = new AWLabel(AWPoint ( 550, 340), AInt (100),
150          AWAignment (kAWAlignmentLeft), String ("150"), AWFont (
151          Lucida_Grande24)) ;
150  addView (label2) ;
151
152  //--- create the slider with its label
153  backlightSlider = new AWSlider (AWPoint (300,400), 400,
154          kHorizontal, true) ;
154  backlightSlider->setMaxKnobPosition (255);
155  backlightSlider->setKnobPosition (150);
156  backlightSlider->setAction (sliderAction);
157  addView (new AWLabel (AWPoint (690, 410), 100,
158          kAWAlignmentCenter, "A_SLIDER")) ;
158  addView (backlightSlider) ;
159
160  //--- create a black line of 5 pixel of thickness
161  AWPoint lineOrigin ;
162  lineOrigin.x = 50 ;
163  lineOrigin.y = 250 ;
164  AWPoint lineEnd;
165  lineEnd.x = 200 ;
166  lineEnd.y = 400 ;
167  for (int i=0 ; i < 5 ; i++) {
168      addView (new AWLine (lineOrigin, lineEnd)) ;
169      lineOrigin.x++;
170      lineEnd.x++;

```

```

171     }
172     addView (new AWLabel (AWPoint (50, 350), 100,
173         kAWAlignmentCenter, "A_LINE")) ;
174 //--- create the roundRect
175     roundRectView = new CustomView1(AWRect (350, 50, 200, 200)) ;
176     addView (roundRectView) ;
177     addView (new AWLabel (AWPoint (400, 270), 100,
178         kAWAlignmentCenter, "A_ROUNDRECT")) ;
179 //--- create the clipping view (half-circle)
180     crossView = new ClippingView(AWRect (50, -50, 250, 250)) ;
181     addView (crossView) ;
182     addView (new AWLabel (AWPoint (100, 210), 150,
183         kAWAlignmentCenter, "A_HALF_CIRCLE")) ;
184 }
185
186 ////////////////////////////////////////////////// LOOP ///////////////////////////////////
187
188 void loop() {
189     AWContext::handleTouchAndDisplay () ;
190 }

```

To run this program, it is recommended to open the sketch in the example folder of the *ArduinoWidgets* library, because a small file must be present in the same folder as the sketch. Its name must be "touch-calibration-values.h" and it must contain :

```

#include "touch-calibration-values.h"

const float xA = 310.0 ; // 571.0 ;
const float yA = 116.0 ; // 963.0 ;

const float xB = 3811.0 ; // 488.0 ;
const float yB = 113.0 ; // 3001.0 ;

const float xC = 3814.0 ; // 3526.0 ;
const float yC = 3936.0 ; // 3349.0 ;

const float xD = 362.0 ; // 3519.0 ;
const float yD = 3938.0 ; // 698.0 ;

```

This .cpp file contain the values of the calibration of your screen. If this file is not present in the sketch folder, a compilation error will occur

```

.../AWContext.cpp:617: undefined reference to `yA'
.../AWContext.cpp:642: _undefined_reference_to_ `xA'
.../AWContext.cpp:643: undefined reference to `yB'

```

```
.../AWContext.cpp:643:_undefined_reference_to_`yC'  
.../AWContext.cpp:643: undefined reference to `xB'  
.../AWContext.cpp:643:_undefined_reference_to_`yD'  
.../AWContext.cpp:643: undefined reference to `xC'  
.../AWContext.cpp:634:_undefined_reference_to_`xD'
```

Go to the section "Calibration" to know how to calibrate your touch screen.

## 4 A quick overview of the AW\_doc\_example

This section is not an in depth description on how to use each object of the library but just a global introduction to how to build a program which use the *ArduinoWidgets* library. A detailed description of the library is given in the next sections of this document.

The program is divided in five parts :

- The first part is to include the necessary libraries.
- The second part is the necessary adaptation to your hardware.
- The third part is the declaration of new graphic objets, the specific behaviors of existing objects of the library and the declarations of constants and variables.
- The fourth part is the setup() function in which there also a part for your specific hardware
- The fifth part is the loop() function.

The first step is to import the two necessary libraries *ArduinoWidgets* and *UTFT* .

```
#include <ArduinoWidgets.h>
#include <UTFT.h>
```

Before using your specific Touch LCD display, please read the following documents which are located inside the UTFT/documentation folder :

- "UTFT\_Requirements.pdf" for describing the pins which are used to connect your micro-controller to your LCD
- "UTFT\_Supported\_display\_modules\_&\_controllers.pdf" for finding the right declaration of the controller which is used in your screen

Then adapt the hardware dependent part 1 in the listing to your specific hardware :

```
/*--- This part is hardware dependent, such as here :
/*--- Teensy 3.6 + LCD 7" with Touch,
/*--- SSD1963 controler, resolution 800x480

static const byte RS      = 23 ;
static const byte WR      = 22 ;
static const byte CS      = 15 ;
static const byte RESET = 33 ;

/*--- Do not change 'myGLCD' name;
/*--- it is declared as extern in AWContext.cpp

UTFT myGLCD (SSD1963_800ALT, RS, WR, CS, RESET) ;
```

```
static const byte T_CLK  = 11 ;
static const byte T_CS   = 12 ;
static const byte T_DIN  = 25 ;
static const byte T_DOUT = 24 ;
static const byte T_IRQ  = 28 ;

static const byte BACKLIGHT = 9 ;

//--- Do not change 'myTouch' name;
//--- it is declared as extern in AWContext.cpp

AWTouch myTouch (T_CLK, T_CS, T_DIN, T_DOUT, T_IRQ) ;

//--- end of hardware dependent part
```

At this stage, don't forget to add the file "touch-calibration-values.h" which must be present in the same folder as the sketch (see the end of section 3).

Then add the specific customizations and creations of the objects to display on the screen, with the desired interactivity :

- a value to display inside a button and an action when clicking in the button, which increment the button's value;
- some variables and an action to be attached to a slider which control the brightness of the backlight of the screen;
- a new `AWView` object to display a rectangle with round corners;
- a new `AWView` object to display a half circle which is the combination of a full circle with a clipping rectangle.

Then the `setup()` function initialize the backlight of the LCD to the value 150 (the maximum is 255). Then it initialize the LCD with the proper parameters (orientation, size, X and Y directions). Please note that the origine (0,0) of the screen is in the lower-left corner, exactly as in a Cartesian coordinate system.

The objects are then created :

- the button and its label;
- two labels, one of which is associated to the action of the slider;
- the slider;
- a black line;
- the `roundRect`;

- the half circle;

```
void setup() {
//--- This part is hardware dependent
//--- set up the backlight
    analogWrite (BACKLIGHT, 150);
    pinMode (LED_BUILTIN, OUTPUT);
    digitalWrite (LED_BUILTIN, HIGH);

    AWContext::begin (kOrientationLandscape,
                      800,          // Screen width
                      480,          // Screen height
                      true,         // true : X is flipped
                      false) ;     // false : Y is not flipped

//--- end of hardware dependent part

//--- create a button on screen
    AWPushButton * bigButton = new AWPushButton(AWRect (600, 100,
        140, 100), String (buttonValue), AWFFont (ChicagoDigit36)) ;
    bigButton->setAction (bigButtonAction) ;
    addView (new AWLabel (AWPoint (625, 220), 100,
        kAWAlignmentCenter, "A_BUTTON")) ;
    addView (bigButton) ;

//--- create 2 labels, one constant and one that can be changed
    by the slider
    label1 = new AWLabel(AWPoint ( 300, 340), AWWInt (250),
        AWWAlignment (kAWAlignmentRight), String ("Backlight:_:_"),
        AWWFont (Lucida_Grande24)) ;
    addView (label1) ;
    label2 = new AWLabel(AWPoint ( 550, 340), AWWInt (100),
        AWWAlignment (kAWAlignmentLeft), String ("150"), AWWFont (
        Lucida_Grande24)) ;
    addView (label2) ;

//--- create the slider with its label
    backlightSlider = new AWWSlider (AWPoint (300,400), 400,
        kHorizontal, true) ;
    backlightSlider->setMaxKnobPosition (255);
    backlightSlider->setKnobPosition (150);
    backlightSlider->setAction (sliderAction);
    addView (new AWLabel (AWPoint (690, 410), 100,
        kAWAlignmentCenter, "A_SLIDER")) ;
    addView (backlightSlider) ;

//--- create a black line of 5 pixel of thickness
    AWPoint lineOrigin ;
```

```
lineOrigin.x = 50 ;
lineOrigin.y = 250 ;
AWPoint lineEnd;
lineEnd.x = 200 ;
lineEnd.y = 400 ;
for (int i=0 ; i < 5 ; i++) {
    addView (new AWLine (lineOrigin, lineEnd)) ;
    lineOrigin.x++;
    lineEnd.x++;
}
addView (new AWLabel (AWPoint (50, 350), 100,
    kAWAlignmentCenter, "A_LINE")) ;

//--- create the roundRect
roundRectView = new CustomView1(AWRect (350, 50, 200, 200)) ;
addView (roundRectView) ;
addView (new AWLabel (AWPoint (400, 270), 100,
    kAWAlignmentCenter, "A_ROUNDRECT")) ;

//--- create the clipping view (half-circle)
crossView = new ClippingView(AWRect (50, -50, 250, 250)) ;
addView (crossView) ;
addView (new AWLabel (AWPoint (100, 210), 150,
    kAWAlignmentCenter, "A_HALF_CIRCLE")) ;

}
```

The `loop()` function of the sketch is very simple since it contain only one instruction which do everything: get events and call actions: `handleTouchAndDisplay()`

```
void loop() {
    AWContext::handleTouchAndDisplay () ;
}
```

## 4.1 How to use the code lines of the following sections of *ArduinoWidgets*

In the following sections of this document, there is three pieces of Arduino code that will not be repeated.

The first one is :

```
#include <ArduinoWidgets.h>
#include <UTFT.h>
//--- This part is hardware dependent, such as here :
//--- Teensy 3.6 + LCD 7" with Touch,
//--- SSD1963 controler, resolution 800x480

static const byte RS      = 23 ;
static const byte WR      = 22 ;
static const byte CS      = 15 ;
static const byte RESET = 33 ;

//--- Do not change 'myGLCD' name;
//--- it is declared as extern in AWContext.cpp

UTFT myGLCD (SSD1963_800ALT, RS, WR, CS, RESET) ;

static const byte T_CLK  = 11 ;
static const byte T_CS   = 12 ;
static const byte T_DIN  = 25 ;
static const byte T_DOUT = 24 ;
static const byte T_IRQ  = 28 ;

static const byte BACKLIGHT = 9 ;

//--- Do not change 'myTouch' name;
//--- it is declared as extern in AWContext.cpp

AWTouch myTouch (T_CLK, T_CS, T_DIN, T_DOUT, T_IRQ) ;

//--- end of hardware dependent part

//--- add here you constants, classes, functions, variables, ...
```

The second one is the `setup()` :

```
void setup() {
//--- This part is hardware dependent
//--- set up the backlight
  analogWrite (BACKLIGHT, 150);
  pinMode (LED_BUILTIN, OUTPUT);
  digitalWrite (LED_BUILTIN, HIGH);
}
```



#### 4.1 How to use the code lines of the following sections of Arduino IDE

```
AWContext::begin (kOrientationLandscape,
                  800,          // Screen width
                  480,          // Screen height
                  true,         // true : X is flipped
                  false) ;     // false : Y is not flipped

//--- end of hardware dependent part

//--- add here your lines of code for setup

} //--- end of setup
```

The third part is the `loop()` function of the sketch.

```
void loop() {
    AWContext::handleTouchAndDisplay ();
}
```

You can create an Arduino sketch by inserting first the 3 parts above, then the lines of code found in the various examples below.

If you want to test the examples which are described in this document, the best way is to use the "example" menu of the Arduino's IDE. But you can also assemble the lines of code of each subsection with the above parts to be adapted first to your specific hardware.

## 5 The fondation of *ArduinoWidgets*

The *ArduinoWidgets* library is objet oriented (C++). It is made of a collection of classes the instances of which are objects. The collection of classes can be expanded later in future versions and you can create your own classes with inheritance.

The consequence is the naming and the syntax to use in your Arduino program :

- Objects are instances of class.
- Each class embed its own variables which are hidden to your sketch and class variables which are independent of objects
- Each class also embed functions which concern one objects and are public for use by your code, and also class functions which are independent of objects.

For example, drawing a line consists to create an instance of a *AWLine* class :

```
AWLine * myLine;  
myLine = new AWLine (AWPoint (100,100), AWPoint (300,300));  
addView (myLine) ;
```

The object `myLine` (a pointer) is an instance of the *AWLine* class, which is a line to draw between 2 points of coordinate (100,100) and (300, 300) with the constructor `new AWLine`.

The class function `addView` just add the drawing of the line to the list of drawings. The effective drawing will be made by the class function `handleTouchAndDisplay` which is called once for all drawings, in the loop.

Another example is the display of a text label :

```
label = new AWLabel(AWPoint ( 300, 340), AWInt (150),  
    AWAlignment (kAWAlignmentCenter), String ("My_Label:_"),  
    AWFont (Lucida_Grande24)) ;  
addView (label) ;
```

The object `label` is created with the constructor of the class *AWLabel*, with the parameters which define the coordinate and size of the text field, the default string in it and the font. The class function `addView` just add the drawing of the line to the list of drawings as explained above.

## 5.1 Context

The *Context* is the entire Screen you are using. You must know about *Context* before seeing something on your screen and touch it.

To create a context, just call the `begin` function of class `AWContext`. This must be done only once in your sketch.

For example :

```
AWContext::begin (kOrientationLandscape,
                  800,          // Screen width
                  480,          // Screen height
                  true,         // true : X is flipped
                  false) ;     // false : Y is not flipped
```

This describe the specific display which is in use : landscape orientation, dimensions : 800x600, horizontal axis is flipped, not the vertical axis.

The orientation can be either `kOrientationLandscape`, `kOrientationPortrait`.

There is a method in the `loop` for dealing with all events and actions of the touch screen and the draw and redraw on the screen according to the events. This is the unique instruction in the `loop` which work as a background task in the examples.

```
static void handleTouchAndDisplay (void) ;
```

`handleTouchAndDisplay` handle the touch events, especially the press detection (`touchDown`), press move (`touchMove`), press release (`touchUp`), and the drawing of all views (see View section) on the screen. Generally, a touch event generate an action which is sent to a specific object in a view.

The *Context* have also a variety of properties and methods, such as :

- A screen rectangle : you can get the size on the screen rectangle

```
//--- Screen rect
static AWRect screenRect (void) ;
```

- A color (background color) : you can set or get the color of the screen and its opacity

```
//--- Color
static void setColor (const AWColor & inColor) ;
static AWColor color (void) ;
static bool colorIsOpaque (void) ;
```

- A calibration method with the drawing of a calibration rectangle and specific points to touch:

```
static void calibrateTouch (void) ;
```

## 5.2 The Views

Every pieces of drawing on the screen are "Views".

A view is a rectangular section of the screen. It is responsible for handling all drawing and user-initiated events within its frame.

*ArduinoWidgets* provides the `View` class as an abstract view implementation that subclasses use as the basis for implementing custom display and user interaction. They are the most pervasive type of object in the *ArduinoWidgets* library; nearly every object you see on the screen is a view. Views are in the front line of both drawing and event handling, and hence are one of the more important types of objects to understand.

In a very real sense, a view draws itself. It also provides a surface that can be responsive to input from a touch event.

In addition to drawing content and responding to user events, `View` instances act as containers for other views. By nesting views within other views, an application creates a hierarchy of views. This view hierarchy provides a clearly defined structure for how views draw relative to each other and pass messages from one view to another, up to the enclosing window, and on to the application for processing.

*ArduinoWidgets* provides several type of views for containing graphics, texts and controls, with color attributes, which can send messages to its own view or to other views. A view can be opaque or transparent. In this last case, if the view is not validated, the drawing of views behind it is allowed.

The root `View` is the screen.

Each `View` is placed in a parent `View`, the `superView`, in which it is a frame. This frame can be moved and resized in the `superView` and the view's content moves with it.

The view is specified when a view instance is created programmatically using :

```
//--- Constructor
AWView (const AWRect & inRelativeFrame,
        const AIColor & inBackColor) ;
```

When it is necessary to know the frame rectangle of a view, the `absoluteFrame` method can return this frame rectangle.

To translate a frame you can use the method `translateBy`. To change the frame size you can use `setSize`.

To specify or to get the bgcolor of a view, you can use the methods `BackColor` or `setBackColor`.

```
//----- Frame
inline AWRect absoluteFrame (void) const { return
    mAbsoluteFrame ; }

//----- Frame change
void translateBy (const AWRInt inDx, const AWRInt inDy) ;
void setSize (const AWRSize & inNewSize) ;
```

```
//----- Background color
inline AWCOLOR backgroundColor (void) const { return mBackColor ; }
void setBackgroundColor (const AWCOLOR & inBackColor) ;
```

To add a new View on the screen, just call `addView` or `addCenteredView`:

```
void addView (class AWCOLOR * inView) ;
void addCenteredView (class AWCOLOR * inView) ;
```

### *What is a View Hierarchy?*

In addition to being responsible for drawing and handling user events, a view instance can act as a container, enclosing other view instances. Those views are linked together creating a view hierarchy. Unlike a class hierarchy, which defines the lineage of a class, the view hierarchy defines the layout of views relative to other views.

It permits a complex view to be constructed out of other views. For example, a graphical keypad might be a container view with a separate subview for each key.

The `context` instance maintains a reference to a single top-level view instance. `addView` and `addCenteredView` without argument just add a subview to the root view.

The view instances enclosed within a view are called `subViews`. The parent view that encloses a view is referred to as its `superView`. Each view has another view as its `superView` and may be the `superView` for any number of `subViews`. While a view instance can have multiple `subViews`, it can have only one `superView`. In order for a view and its subviews to be visible to the user, the view must be inserted into a view hierarchy.

A view is added to a parent view via the method `addSubview` or `addCenteredSubview`, in a hierarchical order :

```
//----- Managing view hierarchy
void addSubview (AWCOLOR * inView) ; // if inView is non
NULL, view is added in front of other subviews
void addCenteredSubview (AWCOLOR * inView) ; // if inView is non
NULL, view is added in front of other subviews
```

To locate the `superView` use the method `superView`. You can also remove a `subView` from a `superView` with `removeFromSuperView`.

```
//----- Managing view hierarchy
void addSubview (AWCOLOR * inView) ; // if inView is non
NULL, view is added in front of other subviews
void addCenteredSubview (AWCOLOR * inView) ; // if inView is non
NULL, view is added in front of other subviews
void removeFromSuperView (void) ; // Does nothing if has no
super view
```

```
inline AView * superView (void) { return mSuperView ; } //
Returns NULL if has no super view
```

An example of a View containing subViews will be given in subsection "PushButton".

### View Tags

The View class defines methods that allow you to tag individual view objects with integer tags.

The View method `tag` always returns `-1`. Subclasses can override this method to return a different value. It is common for a subclass to implement a `setTag` method that stores the tag value in an instance variable, allowing the tag to be set on an individual view basis.

```
//----- Tag
inline void setTag (const int inTag) { mTag = inTag ; }
inline int tag (void) const { return mTag ; }
```

### User interactivity : sending and receiving Actions

A view or subview can be sensitive to touch actions of the user. In order to be responsive to a touch event, each view must redefine `touchDown`, `touchMove` and `touchUp`. The method `sendAction` call the function which is attached to the view by using `setAction` :

```
//----- Action
void sendAction (void) ;
inline AAction action (void) const { return mAction ; }
inline void setAction (AAction inAction) { mAction = inAction ; }

//----- Touch
virtual void touchDown (const AWPPoint & inPoint) ;
virtual void touchMove (const AWPPoint & inPoint) ;
virtual void touchUp (const AWPPoint & inPoint) ;
```

### Drawing and display views

These methods force a display of the screen by the function `handleTouchAndDisplay`, although the later method iterates only through the list of invalidated views. The display method causes each view in the screen's view hierarchy to redraw itself.

These methods mark views or regions of views for redrawing :

```
//----- Display view
void setNeedsDisplay (void) ;
void setNeedsDisplayInRect (const AWPRect & inRect) ;
```

The method `drawInRegion` may be redefined in each view : It is responsible of the drawing of the view.

```
//--- Draw method (to be overridden)
virtual void drawInRegion (const ARegion & inDrawRegion) const
;
```

A view can be opaque (visible) or transparent (invalid or invisible). An important aspect of the drawing of views is view opacity. A view does not have to draw every bit of its surface, but if it does it should declare itself to be opaque (by implementing `isOpaque` to return YES).

```
//--- Tell the view is opaque
virtual bool isOpaque (void) const ;

//----- Visibility
inline bool isVisible (void) const { return mIsVisible ; }
void setVisibility (const bool inIsVisible) ;

//----- Handle "on screen" state
inline bool isOnScreen (void) const { return mIsOnScreen ; }
```

`AWView` is a class that defines the basic drawing and event-handling. `AWView` itself does not draw content or respond to user events, so you typically don't interact with a direct instance of `AWView`. Instead you use an instance of a custom `AWView` subclass. A custom view class inherits from `AWView` and overrides many of its methods, which are invoked automatically by the *ArduinoWidgets* library.

There is a collection of ready to use subclass Views in the *ArduinoWidgets* library, which are :

- `AWLine` : display a line
- `AWLabel` : display of text on a line.
- `AWPushButton` : display a button
- `AWRectView` : display a rectangle with or without round corners
- `AWSegmentedControl` : display a radio button in a tab form
- `AWSlider` : display a linear potentiometer with one cursor
- `AWDynamicSlider` : display a linear potentiometer with one cursor
- `AWTabview` : display tabs which are usefull for switching from one View to another.
- `AWSwitch` : display a check box.
- `AWArrowPushButton` : display a button with an arrow shape.
- `AWKeyButton` : display a key of keyboard
- `AWKeyboardBackView` : display an entire keyboard.

You also will be able to create and add your custom View !

### 5.3 The action

The action is the interactive part of the *ArduinoWidgets* library, which rely on the touch capabilities of the screen. An action is the message a control sends to the target or, from the perspective of the target, the method it implements to respond to the action.

The standard way to pass information between objects is message passing—one object invokes the method of another object. However, message passing requires that the object sending the message know who the receiver is and what messages it responds to. This is the reason why the action routines are located in the declaration part of the Arduino sketch, before the `setup`.

A control is a view object which implement touch capabilities. For exemple, `myControl` (a Push-Button or a Key or a Tab, for exemple) is a control. In the `setup`, inside the initialization code of `myControl`, we add the following line :

```
myControl->setAction (myControlAction) ;
```

`myControlAction` is a routine which is declared before the `setup`. We suppose here that this control is, for example, a PushButton :

```
//--- myControl action
void myControlAction (AWView * inSender)
{
    AWPushButton * sendingButton = (AWPushButton *) inSender ;
    // Your Action code here
}
```

Your action code can display a label's title, control any Arduino's output pin (a led, a PWM signal, the backlight of the screen, etc..).

You will find several example of how an action is implemented in the description of the following *ArduinoWidgets* views.



## 5.4 The coordinate plane

A view is responsible for the drawing and event handling in a rectangular area of a window. In order to specify that rectangle of responsibility, you define its location as an origin point and size using a coordinate system.

This section describes the coordinate system used by views, how a view's location and size is specified, and how the size of a view interacts with its content.

All information about location is given to *ArduinoWidgets* in terms of coordinates on a plane. The coordinate plane is a two-dimensional grid, as illustrated in Figure 2.

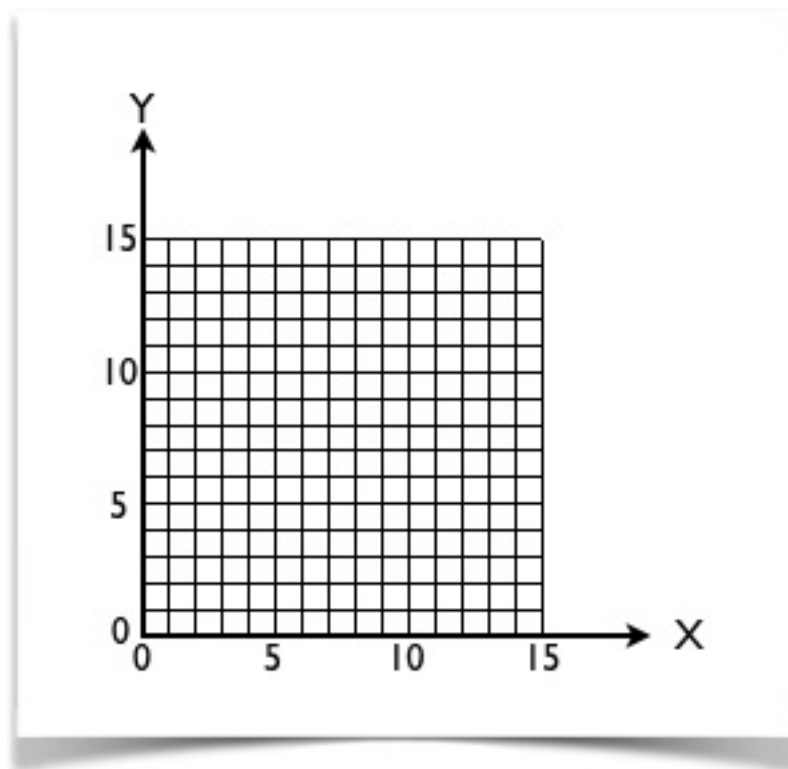


Figure 2: The coordinate plane

All grid coordinates are `AWInt` (in the range -32767 to 32767).

```
typedef int16_t AWInt ;
```

The origine of all coordinates is (0,0) and is located at the bottom left corner of the screen.

Note that the `begin` function of class `AWContext` have 2 boolean parameters to flip or not the X and Y coordinates if necessary.

Horizontal coordinates increase as you move from left to right, and vertical coordinates increase as you move from bottom to top.

Each view use the same coordinate system as its mother view.

## 5.5 Points and Pixels

Each point is at the intersection of a horizontal grid line and a vertical grid line. The coordinate origin (0,0) is in the lower-left corner of the screen.

You can store the coordinates of a point into an object `AWPoint` which contain 2 variables of type `AWInt`:

```
// AWPoint :  
AWInt x ;  
AWInt y ;
```

Figure 3 shows the relationship between points, grid lines, and pixels, the physical dots on the screen. A pixel is centered around a point. In other words, a point is at the center of a pixel.

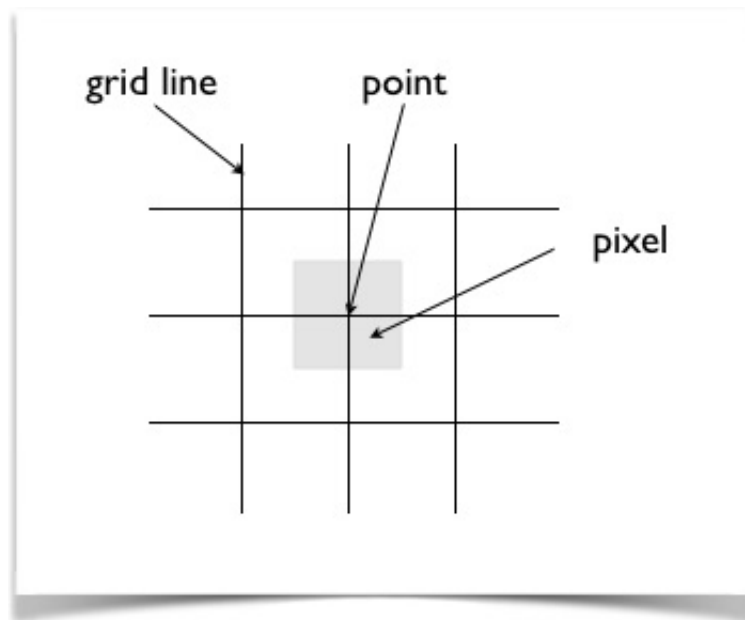


Figure 3: Points and Pixels

To create a `AWPoint` at coordinates `X` and `Y`, you call :

```
AWPoint myPoint ;  
myPoint.x = X;  
myPoint.y = Y;
```

The Point is not a View. The above `myPoint` is not drawn at this stage.

To compare two Points there is two special operators :

```
//--- Equatable  
inline bool operator == (const AWPoint & inP) const { return (x  
    == inP.x) && (y == inP.y) ; }
```

```
inline bool operator != (const AWPPoint & inP) const { return
    !(*this == inP) ; }
```

The Point class has the following methods : (?? Why and how to use it ??)

```
//--- Translation
void translateBy (const AWInt inDx, const AWInt inDy) { x +=
    inDx ; y += inDy ; }
void translateBy (AWPoint & inTranslation) { x += inTranslation
    .x ; y += inTranslation.y ; }

//--- Stroke line
void strokeLineInRegion (const AWPPoint & inPoint, const
    AWRegion & inDrawRegion) const ;

static void strokeLineInRegion (const AWInt inP1X,
                                const AWInt inP1Y,
                                const AWInt inP2X,
                                const AWInt inP2Y,
                                const AWRegion &
                                    inDrawRegion) ;

//--- Draw Point
void drawInRegion (const AWRegion & inDrawRegion) const ;
static void drawPointInRegion (const AWInt inX, const AWInt inY
    , const AWRegion & inDrawRegion) ;
```

And a special drawing of circle (?? Why and how to use it ??)

```
//--- Frame circle
void frameCircleInRegion (const AWInt inRadius,
    const AWRegion & inDrawRegion) const ;

static void frameCircleInRegion (const AWInt inCenterX,
    const AWInt inCenterY,
    const AWInt inRadius,
    const AWRegion & inDrawRegion) ;

//--- Fill circle
void fillCircleInRegion (const AWInt inRadius,
    const AWRegion & inDrawRegion) const ;

static void fillCircleInRegion (const AWInt inCenterX,
    const AWInt inCenterY,
    const AWInt inRadius,
    const AWRegion & inDrawRegion) ;
```

## 5.6 Rectangle

A rectangle is not a View but a rectangle is the foundation of each `AWView`.

A Rectangle is defined by an origine `AWPoint` and an `AWSize`. The origine Point is the bottom-left corner :

```
//--- Properties
    AWPoint origin ;
    AWSize size ;

// AWsize :
AWInt width ;
AWInt height ;

// AWRect :
myRect = new AWRect (AWPoint, AWSize);
myRect = new AWRect (X, Y, width, height);
```

The coordinates of the bottom left corner are X = left, Y = bottom.

For example, you can create a new rectangle `myRect` of left-bottom corner X=350, Y=50, width W=200 and height H=200 like this :

```
myRect = new AWRect (350, 50, 200, 200);
```

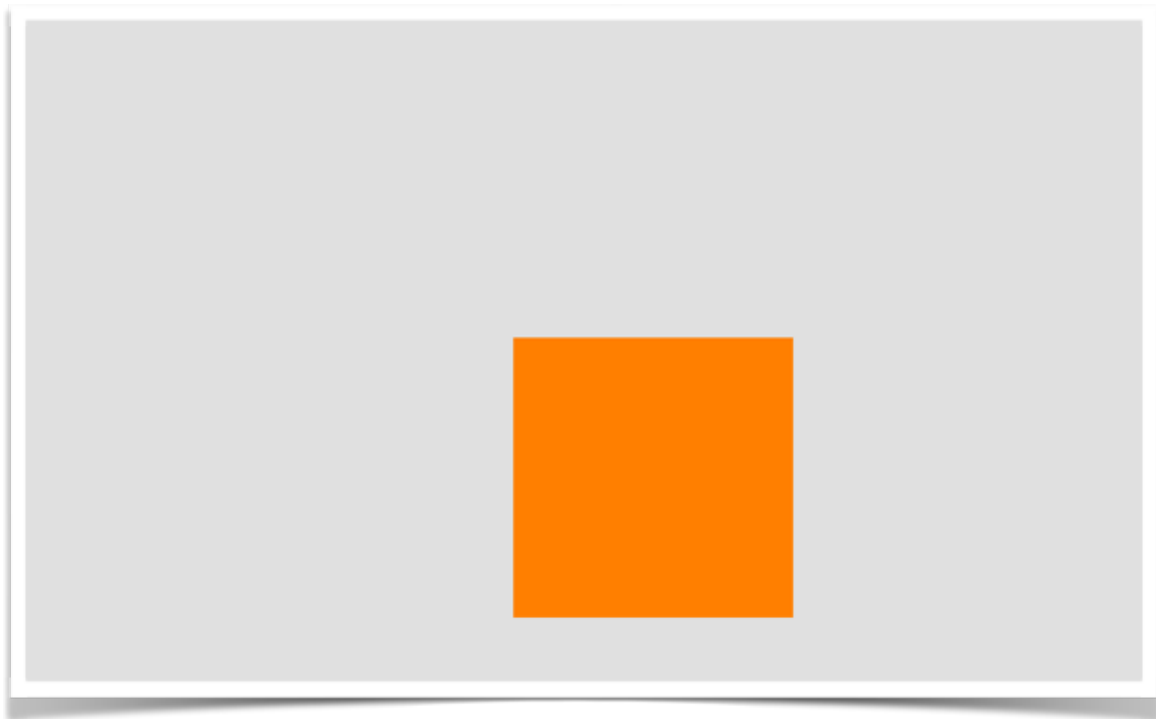


Figure 4: A Rectangle

This rectangle have a bottom left corner origin of coordinates (350, 50).

The width (200) and height (200) are the number in pixels in the horizontal and vertical directions.

Consequently, the coordinate of the top right corner of this rectangle is (549, 249) :

- left = X = 350
- bottom = Y = 50
- right = X + W -1 = 350 + 200 -1 = 549
- top = Y + H -1 = 50 + 200 -1 = 249

You can create rectangle from various combinations of AWInt, AWPoint and ASize, according to the 3 constructors.

You will see farther all the operations and transformations that you can do on ARect such as :

- to be visible or invisible or empty (if W <=0 or H <=0)
- a pixel is a rectangle with W = H =1
- a horizontal line is a rectangle with W =1
- a vertical line is a rectangle with H = 1
- a 800x600 screen is a rectangle (0, 0, 800, 600)
- find corners points
- make intersection, inclusion or union of rectangles
- find differences (the opposite of intersection) of rectangles
- inset en translate rectangles
- draw and fill rectangles, round-rectangles, and ovals

The following example show how to display two rectangles : one without round corners and one with round corners :

First declare custom Views based on respective rectangles. The new classes are RectangleView and RoundRectangleView. Then create an instance of each class :

```
////////// RECTANGLE //////////
class RectangleView : public AView
{
    RectangleView (const ARect & inViewFrame);
    virtual void drawInRegion (const ARegion & inRegion) const;
};
```

```

RectangleView::RectangleView (const AWRect & inViewFrame) : //
    constructor
    AView(inViewFrame,
        AColor ()),
        RectColor (AColor::orange ())
    { }
void RectangleView::drawInRegion (const ARegion & inRegion)
    const
{
    AWRect viewFrame = absoluteFrame () ;
    AContext::setColor (RectColor) ;
    viewFrame.fillRectInRegion (inRegion) ;
}
//--- Global variable RectView
RectangleView * RectView ;

////////// ROUND CORNERS RECTANGLE //////////
class RoundRectangleView : public AView
{
    RoundRectangleView (const AWRect & inViewFrame);
    virtual void drawInRegion (const ARegion & inRegion) const;
};
RoundRectangleView::RoundRectangleView (const AWRect &
    inViewFrame) : // constructor
    AView(inViewFrame,
        AColor ()),
        RectColor (AColor::green ())
    { }
void RoundRectangleView::drawInRegion (const ARegion & inRegion)
    const
{
    AWRect viewFrame = absoluteFrame () ;
    AContext::setColor (RectColor) ;
    viewFrame.fillRoundRectInRegion (AInt (50), inRegion) ;
}
//--- Global variable RoundRectView
RoundRectangleView * RoundRectView ;

```

Then draw the rectangles in the setup() :

```

//--- draw the Rectangle
RectView = new RectangleView (AWRect (350, 50, 200, 300)) ;
addView (RectView) ;

//--- draw the RoundRectangle
RoundRectView = new RoundRectangleView (AWRect (80, 200, 250,
    200)) ;
addView (RoundRectView) ;

```

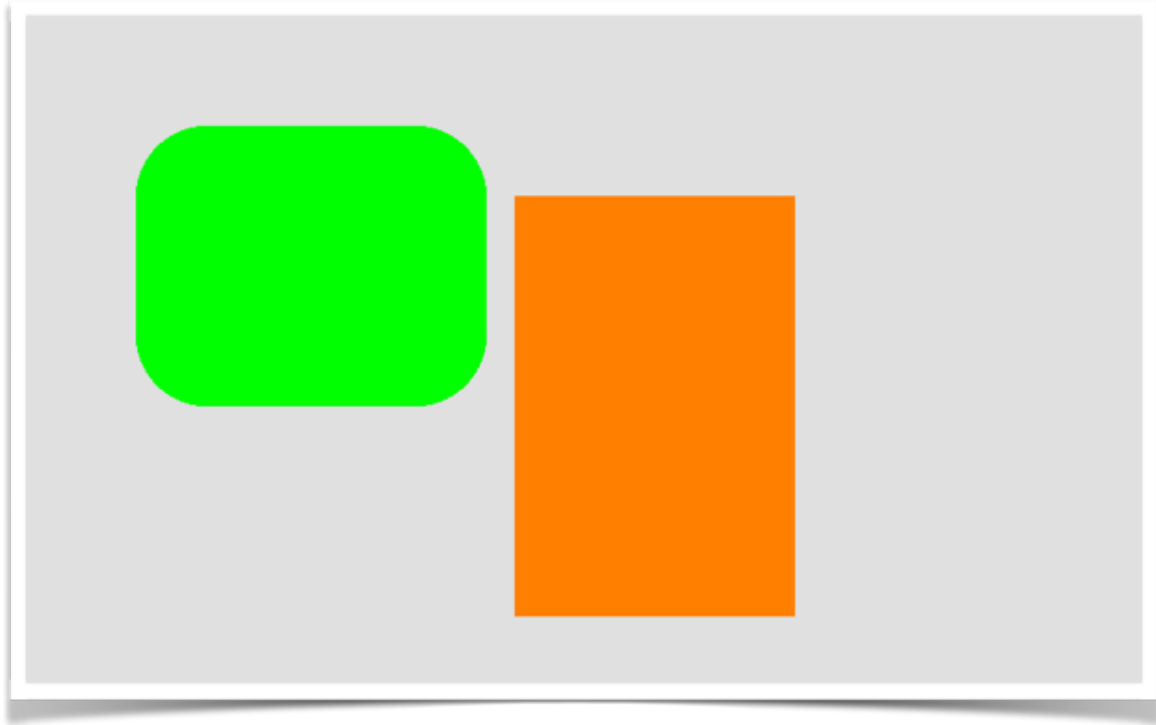


Figure 5: Two Rectangles

Figure 5 show these 2 rectangles.

There is a collection of operations on rectangles that are useful to know for drawing :

1. First, the class `AWRect` have a variety of constructors :

```
inline AWRect (const AWPoint inOrigin, const ASize inSize)
    : origin (inOrigin), size (inSize) {}

inline AWRect (const AWPoint inOrigin) : origin (inOrigin),
    size (ASize (1, 1)) {}

inline AWRect (const AWInt inX, const AWInt inY, const
    AWInt inWidth, const AWInt inHeight) :
    origin (AWPoint (inX, inY)),
    size (ASize (inWidth, inHeight)) {}

AWRect (const AWPoint & inP1, const AWPoint & inP2) ;

static AWRect horizontalLine (const AWInt inX, const AWInt
    inY, const AWInt inWidth) ;
```

```
static AWRect verticalLine (const AWInt inX, const AWInt
    inY, const AWInt inHeight) ;
```

2. Second, you can access the Point and Size values of a rectangle :

```
inline bool isEmpty (void) const { return (size.width <= 0)
    || (size.height <= 0) ; }
bool containsPoint (const AWPPoint & inPoint) const ;
AWPoint topRight (void) const ;
AWPoint bottomRight (void) const ;
AWPoint topLeft (void) const ;
inline AWPPoint bottomLeft (void) const { return origin ; }
inline AWInt minX (void) const { return origin.x ; }
inline AWInt maxX (void) const { return origin.x + size.
    width - 1 ; }
inline AWInt minY (void) const { return origin.y ; }
inline AWInt maxY (void) const { return origin.y + size.
    height - 1 ; }
```

3. You can determine the intersection between 2 rectangles, which is a rectangle :

```
AWRect operator & (const AWRect & inOtherRect) const ;
bool intersects (const AWRect & inOtherRect) const ;
```

4. You can determine the inclusion of 2 rectangles, which is a rectangle drawn around the included rectangles :

```
bool includesRect (const AWRect & inOtherRect) const ;
```

5. You can determine the union of 2 rectangles, which returns the smallest rectangle that completely encloses both receiver rect and inOtherRect :

```
AWRect operator + (const AWRect & inOtherRect) const ;
void operator += (const AWRect inOtherRect) ;
```

6. You can determine the difference between 2 rectangles, which returns 4 rectangles, possibly empty :

```
void differenceFrom (const AWRect & inRect,
    AWRect & outR1,
    AWRect & outR2,
    AWRect & outR3,
    AWRect & outR4) const ;
```

7. You can transform a rectangle, by reducing its size or translating its coordinates :

```
void inset (const AWInt inDx, const AWInt inDy) ;
void translateBy (const AWInt inDx, const AWInt inDy) ;
```

8. You can test the equality of 2 rectangles :



```
//--- Equatable
bool operator == (const AWRect & inRect) const { return (
    origin == inRect.origin) && (size == inRect.size) ; }
inline bool operator != (const AWRect & inRect) const {
    return ! (*this == inRect) ; }
```

9. You have a series of drawing a rectangle in regions which are explained below :

```
void fillRectInRegion (const AWRRegion & inDrawRegion) const ;
void frameRectInRegion (const AWRRegion & inDrawRegion) const ;
void fillRoundRectInRegion (const AWInt inRadius, const
    AWRRegion & inDrawRegion) const ;
void frameRoundRectInRegion (const AWInt inRadius, const
    AWRRegion & inDrawRegion) const ;
void fillOvalInRegion (const AWRRegion & inDrawRegion) const ;
void frameOvalInRegion (const AWRRegion & inDrawRegion) const ;
```

## 5.7 Region

The minimum Region is a Rectangle or can be empty.

A Region is made of a combination of one or more separate and non-empty rectangles.

The role of a Region is to manage more or less complex geometric entities which are not limited to a Rectangle.

A Region is not a View and do not allow any drawing by itself, but it allow several operations.

```
//--- Region from a rectangle (empty if rectangle is empty)
AWRegion (const AWRect & inRect) ;
AWRegion(); // build an empty region
```

The purpose of regions is to limit drawing within the region.

For example, if you want to draw a half circle on the screen, you can set the region to half the square that enclose the whole circle, and then draw the whole circle. Only the half within the region will actually be drawn.

This is how is implemented this example :

First declare a custom View with a new class named ClippingView which derive from the class AView:

```
////////// CLIPPING VIEW : A HALF CIRCLE //////////
class ClippingView : public AView
{
    ClippingView (const AWRect & inViewFrame);
    virtual void drawInRegion (const AWRegion & inRegion) const;
};
ClippingView::ClippingView (const AWRect & inViewFrame) :
    AView(inViewFrame,
        AColor ()) // outside the drawing region is opaque
    { }
void ClippingView::drawInRegion (const AWRegion & inRegion) const
{
    AWRegion drawingRegion = inRegion ;
    AWRect viewFrame = absoluteFrame () ;
    AWRect clipRectangle = viewFrame ;
    clipRectangle.size.width /= 1 ;
    clipRectangle.size.height /= 2 ; // the clip rectangle hide
    the low half of the circle
    drawingRegion -= clipRectangle ;
    AContext::setColor (AColor::red ());
    viewFrame.fillOvalInRegion (drawingRegion) ;
}
//--- Global variable CLIPPING VIEW
ClippingView * crossView ;
```

This `ClippingView` class inherit from the `AWView` class (variables and methods) and declare its constructor and the `drawInRegion` function.

This `drawInRegion` function determine the region which match the rectangle given in the constructor and build a clip rectangle (the half bottom of the region here) which is used to reduce the drawing region with the function `drawingRegion -= clipRectangle ;`.

Then a circle is drawn in the drawing region. The result will be a half circle !

The custom View is created in the `setup` and displayed by the `handleTouchAndDisplay` function in the loop:

```
//--- create the clipping view (half-circle
crossView = new ClippingView(AWRect (300, 100, 250, 250)) ;
addView (crossView) ;
```

The region is defined by a rectangle which extends from the bottom left corner (300, 100) with size (250, 250). The circle is centered in this rectangle.

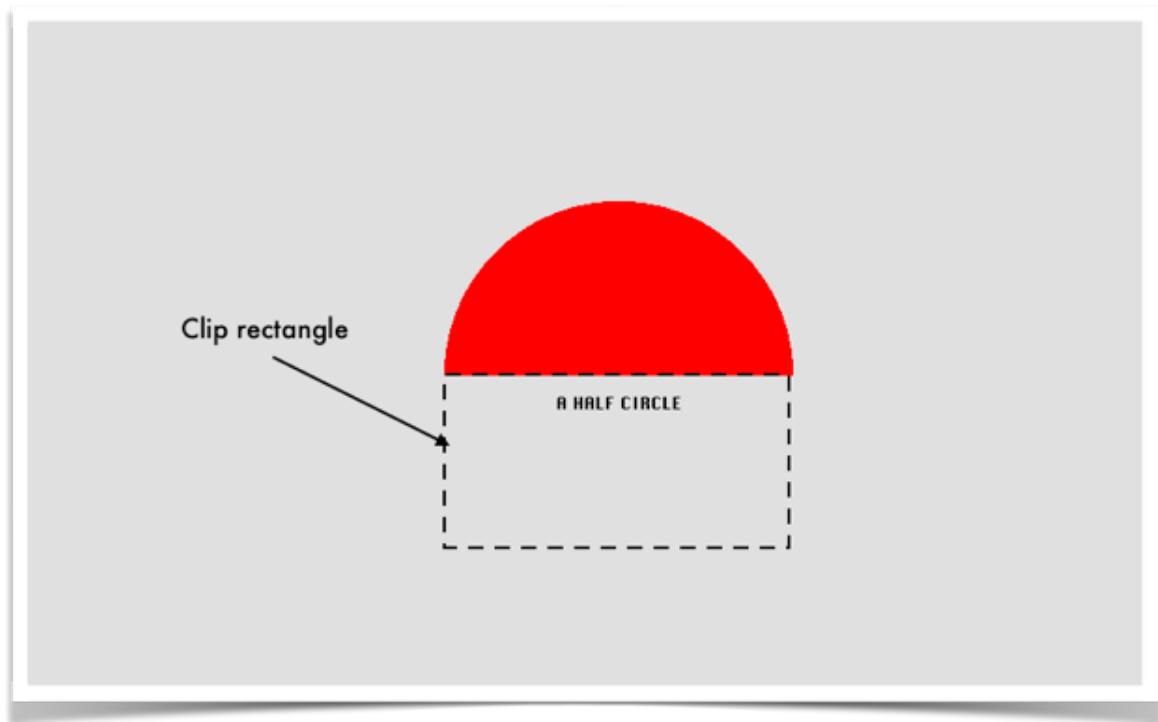


Figure 6: Region with clipping rectangle

There is various operations on regions, which are defined in the methods of the class `AWRegion`, for example :

1. Release a region which become empty.

```
//--- release region, becomes empty
void release (void) ;
```

2. Get characteristics of the region.

```
inline bool isEmpty (void) const { return NULL == mPtr ; }
AWInt rectCount (void) const ;
AWRect rectAtIndex (const AWInt inIndex) const ;
```

3. Do operations such as addition or subtraction of a rectangle to/from the region.

```
//--- Difference from a rectangle
void operator -= (const AWRect & inRect) ;

//--- Adding a rectangle
void operator += (const AWRect & inRect) ;
```

4. Intersection with a rectangle.

```
AWRegion operator & (const AWRect & inRect) const ;
bool intersects (const AWRect & inOtherRect) const ;
```

5. Intersection of regions.

```
AWRegion operator & (const AWRegion & inRect) const ;
```

6. Enclosing rectangle.

```
AWRect enclosingRect (void) const ;
```

7. Testing if a point is inside a region.

```
bool containsPoint (const AWPt & inPoint) const ;
bool containsPoint (const AWInt inX, const AWInt inY) const ;
```

8. Handle a copy.

```
AWRegion (const AWRegion & inRegion) ;
AWRegion & operator = (const AWRegion & inRegion) ;
```

## 5.8 Colors

The AWColor class is not derived from an AView class.

A color is defined by 3 bytes (uint\_8) and a boolean. The 3 bytes define respectively the red, green and blue component and the boolean "IsOpaque" define if the color is opaque or transparent.

```
class AWColor {
//--- Default constructor (clear color)
    inline AWColor (void) : mRed (0), mGreen (0), mBlue (0),
        mIsOpaque (false) {}

//--- Constructor (custom color)
    inline AWColor (const uint8_t inRed,
                    const uint8_t inGreen,
                    const uint8_t inBlue) :

    mRed (inRed),
    mGreen (inGreen),
    mBlue (inBlue),
    mIsOpaque (true) {
    }
}
```

A set of 17 colors is predefined to simplify your programming.

```
inline static AWColor black (void) {
    return AWColor (0, 0, 0) ;
}
inline static AWColor gray (void) {
    return AWColor (128, 128, 128) ;
}
inline static AWColor darkGray (void) {
    return AWColor (64, 64, 64) ;
}
inline static AWColor lightGray (void) {
    return AWColor (192, 192, 192) ;
}
inline static AWColor veryLightGray (void) {
    return AWColor (224, 224, 224) ;
}
inline static AWColor red (void) {
    return AWColor (255, 0, 0) ;
}
inline static AWColor green (void) {
    return AWColor (0, 255, 0) ;
}
inline static AWColor blue (void) {
    return AWColor (0, 0, 255) ;
}
}
```

```

inline static AWCOLOR white (void) {
    return AWCOLOR (255, 255, 255) ;
}
inline static AWCOLOR yellow (void) {
    return AWCOLOR (255, 255, 0) ;
}
inline static AWCOLOR orange (void) {
    return AWCOLOR (255, 127, 0) ;
}
inline static AWCOLOR brown (void) {
    return AWCOLOR (153, 102, 51) ;
}
inline static AWCOLOR cyan (void) {
    return AWCOLOR (0, 255, 255) ;
}
inline static AWCOLOR magenta (void) {
    return AWCOLOR (255, 0, 255) ;
}
inline static AWCOLOR purple (void) {
    return AWCOLOR (127, 0, 127) ;
}
inline static AWCOLOR deepSkyBlue (void) {
    return AWCOLOR (0, 0xBF, 255) ;
}
inline static AWCOLOR lightSkyBlue (void) {
    return AWCOLOR (0x87, 0xCE, 0xFA) ;
}

```

You can set colors, test colors or get colors.

```

bool operator == (const AWCOLOR & inOtherColor) const ;
inline bool operator != (const AWCOLOR & inOtherColor) const {
    return !(*this == inOtherColor) ;
}
inline uint8_t redComponent (void) const { return mRed ; }
inline uint8_t greenComponent (void) const { return mGreen ; }
inline uint8_t blueComponent (void) const { return mBlue ; }
inline bool isOpaque (void) const { return mIsOpaque ; }
} ;

```

In the previous example, the red color of the half circle is set by the instruction line :

```

AWContext::setColor (AWCOLOR::red ()) ;

```

And generally, you will find a function to set the color in every classes of the *ArduinoWidgets* library.

## 5.9 Fonts

The AWFont class is not derived from an AView class.

A font is not a View.

The class AWFont contain font description and fonctions.

```
class AWFont {
//--- Default constructor: empty font
    AWFont (void) : mFont () {}

//--- Constructor from a font description
    AWFont (const AWFontInternalDefinition & definition) ;

    void drawStringInRegion (const AWInt inX,
                             const AWInt inY,
                             const char * inCString,
                             const AWRegion & inDrawRegion
                             ) const ;

    void drawStringInRegion (const AWInt inX,
                             const AWInt inY,
                             const String & inString,
                             const AWRegion & inDrawRegion
                             ) const ;

    AWInt ascent (void) const ;
    AWInt descent (void) const ;
    AWInt lineHeight (void) const ;

    AWInt advancement (const uint32_t inCodePoint) const ;

    AWRect stringRect (const AWInt inX,
                       const AWInt inY,
                       const char * inCString) const ;

    AWInt stringLength (const char * inCString) const ;
    AWInt stringLength (const String & inString) const ;

//--- Equatable
    inline bool operator == (const AWFont & inFont) const { return
        mFont == inFont.mFont ; }
    inline bool operator != (const AWFont & inFont) const { return
        !(*this == inFont) ; }
} ;
```

The definition of type `AWFontInternalDefinition` refer to one of these fonts which are already implemented in the *ArduinoWidgets* library :

```
AWFont-ChicagoDigit-36.h
extern const AWFontInternalDefinition ChicagoDigit36 ;

AWFont-ChicagoFLF12.h
extern const AWFontInternalDefinition ChicagoFLF12 ;

AWFont-ChicagoFLF24.h
extern const AWFontInternalDefinition ChicagoFLF24 ;

AWFont-Geneva10.h
extern const AWFontInternalDefinition Geneva10 ;

AWFont-Geneva12.h
extern const AWFontInternalDefinition Geneva12 ;

AWFont-Geneva9.h
extern const AWFontInternalDefinition Geneva9 ;

AWFont-Lucida_Grande18.h
extern const AWFontInternalDefinition Lucida_Grande18 ;

AWFont-Lucida_Grande24.h
extern const AWFontInternalDefinition Lucida_Grande24 ;
```

These are examples of all fonts :



Figure 7: Fonts



## 6 The existing Views of *ArduinoWidgets*

This section describe the View subclasses which are already present in the *ArduinoWidgets* library, that you can use very simply.

For each View, the class declaration, which is in the .h file of the library, is reproduced without the private properties and methods.

As explained before, the `drawInRegion` method is "virtual" and must be defined in the instance of the view in your program.

### 6.1 Lines

A `AWLine` class inherit from a `AWView` class. Its constructor is :

```
AWLine (const AWPoint & inRelativePoint1,
        const AWPoint & inRelativePoint2) ;
```

The `AWLine` class contain the following methods which can be used in your program :

```
//--- Draw
virtual void drawInRegion (const AWRegion & inDrawRegion) const
    ;

//--- Tell the view is opaque
virtual bool isOpaque (void) const { return false ; }
```

A line is defined by 2 `AWPoints`.

To create and draw a new line "myLine" from Point1 (50,50) and Point2 (400,400):

```
//--- Constructor
AWLine (const AWPoint & inRelativePoint1,
        const AWPoint & inRelativePoint2) ;
```

This example display a line from 100,100 to 300,300

```
AWLine * myLine;
myLine = new AWLine (AWPoint(100,100), AWPoint(300,300));
addView (myLine) ;
```

Note that, in this case, you cannot use the origin and destination points for further operations because they are only arguments of the constructor of `myLine`.

This example display a line from `AWPoint lineOrigin(50,50)` to `AWPoint lineEnd(400,400)`.

```
//--- create a black line
AWPoint lineOrigin ;
lineOrigin.x = 50 ;
```

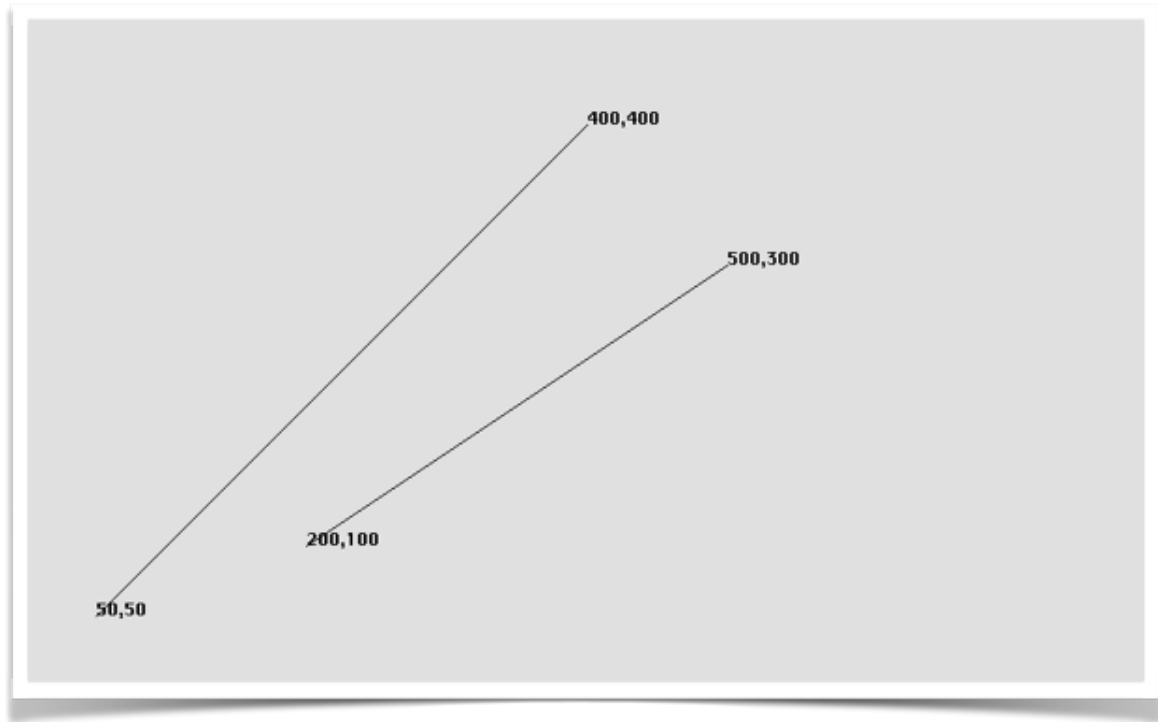


Figure 8: Points and Pixels

```
lineOrigin.y = 50 ;  
AWPoint lineEnd;  
lineEnd.x = 400 ;  
lineEnd.y = 400 ;  
AWLine * myLine1;  
myLine1 = new AWLine (lineOrigin, lineEnd);  
addView (myLine1) ;
```

Note that in this case you can use the lineOrigin and lineEnd points for further operations because they are declared outside the constructor of myLine1.

Note also that AWLine arguments are references (pointers) to AWPoints.

Note also that pixels are centered on points and, consequently, lines are centered on a grid line.

Figure 9 show that the dimensions of a line is one pixel more than the width or height used in the drawing method, as it is explained in subsection 5.6.

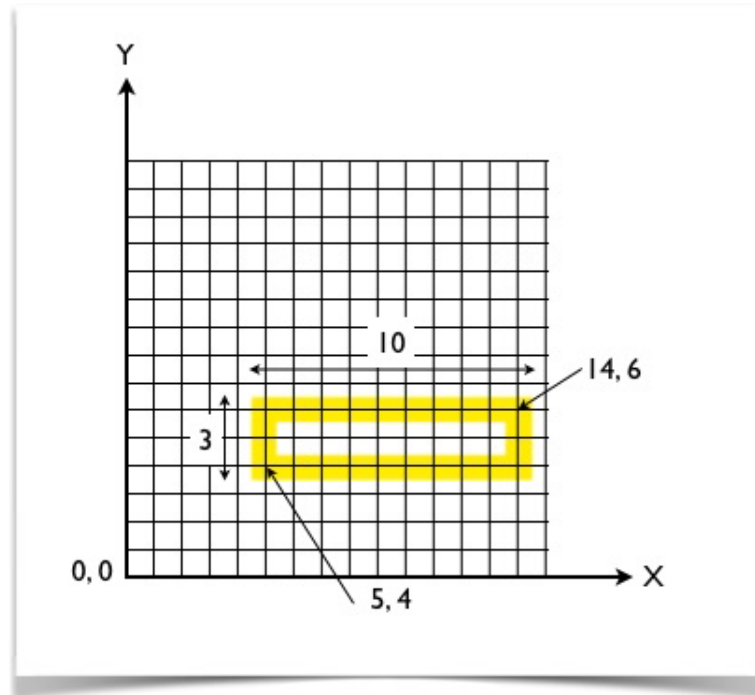


Figure 9: Lines and Pixels

## 6.2 Label and AutoLabel

A `Label` is a string of text, "Title", that can be displayed anywhere on the screen (Context) or on a View or subView, or Region

You can choose a Point and a width to define where the `Label` is displayed (if the size of the `Label` is greater than the size, the `Label` will be clipped. You can choose the alignment of the text with this enum :

```
typedef enum {
    kAWAlignmentLeft,
    kAWAlignmentCenter,
    kAWAlignmentRight
} AWAlignment ;
```

You can choose the style : the Font and size, the Color  
The Font and size is chosen from this list :

- ChicagoDigit36
- ChicagoFLF12
- ChicagoFLF24
- Geneva10
- Geneva12

- Geneva9
- LucidaGrande18
- LucidaGrande24

You can choose the color from this list: black, gray, darkGray, lightGray, veryLightGray, red, green, blue, white, yellow, orange, brown, cyan, magenta, purple, deepSkyBlue, lightSkyBlue.

or any other color according to the "Color" section 6.

Figure 10 show how it is simple to display a Label with these 2 lines of code in the setup():

```
addView (new AWLabel(AWPoint ( 300, 250), AWInt (250),
    AWAlignment (kAWAlignmentCenter), String ("ChicagoFLF24"),
    AWFont (ChicagoFLF24))) ;
```

or:

```
myLabel = new AWLabel(AWPoint ( 300, 340), AWInt (150),
    AWAlignment (kAWAlignmentCenter), String ("My_Label:_"),
    AWFont (Lucida_Grande24)) ;
addView (myLabel) ;
```

or:

```
static AWLabel *gLabel1;
//--- then in setuo()
gLabel1 = new AWLabel(AWPoint ( 300, 340), AWInt (150),
    AWAlignment (kAWAlignmentCenter), String ("My_Label:_"),
    AWFont (Lucida_Grande24)) ;
gLabel1->setBackColor (AWColor::gray() );
gLabel1->setTextColor (AWColor::red() );
addView (gLabel1) ;
```

The constructor of AWLabel is:

```
AWLabel (const AWPoint & inRelativeOrigin,
    const AWInt inWidth,
    const AWAlignment inAlignment,
    const String & inTitle,
    const AWFont & inFont = awkDefaultFont) ;
```

The AWLabel class contain the following methods which can be used in your program :

```
//----- Draw
virtual void drawInRegion (const AWRegion & inDrawRegion) const
;
```

```

//----- Title
void setTitle (const String & inTitle) ;
String title (void) const { return mTitle; }

//----- Text color
void setTextColor (const AWColor & inColor) ;

//----- Font
inline AWFont font (void) const { return mFont ; }

//----- Alignment
inline AWAignment alignment (void) const { return mAlignment ;
}
void setAlignment (const AWAignment inAlignment) ;

```



Figure 10: Labels and AutoLabel

An `AutoLabel` is a simplified version of `Label`, without alignment and width, which are calculated to match automatically the string's size :

```

class AWAutoLabel : public AWView {
//--- Constructor
AWAutoLabel (const AWPoint & inRelativeOrigin,
              const String & inTitle,
              const AWFont & inFont = awkDefaultFont) ;

```

```

//--- Draw
virtual void drawInRegion (const ARegion & inDrawRegion) const
    ;

//----- Title
void setTitle (const String & inTitle) ;

//----- Text color
void setTextColor (const AColor & inColor) ;

//----- Font
inline AFont font (void) const { return mTextFont ; }
} ;

```

The code in the setup() for the Figure 10 is :

```

addView (new ALabel(APoint ( 300, 50), AInt (250),
    AAlignment (kAAlignmentCenter), String ("Lucida_Grande24"),
    AFont (Lucida_Grande24))) ;
addView (new ALabel(APoint ( 300, 100), AInt (250),
    AAlignment (kAAlignmentCenter), String ("Lucida_Grande18"),
    AFont (Lucida_Grande18))) ;
addView (new ALabel(APoint ( 300, 150), AInt (250),
    AAlignment (kAAlignmentCenter), String ("Geneva12"),
    AFont (Geneva12))) ;
addView (new ALabel(APoint ( 300, 200), AInt (250),
    AAlignment (kAAlignmentCenter), String ("Geneva10"),
    AFont (Geneva10))) ;
addView (new ALabel(APoint ( 300, 250), AInt (250),
    AAlignment (kAAlignmentCenter), String ("ChicagoFLF24"),
    AFont (ChicagoFLF24))) ;
addView (new ALabel(APoint ( 300, 300), AInt (250),
    AAlignment (kAAlignmentCenter), String ("ChicagoFLF12"),
    AFont (ChicagoFLF12))) ;
addView (new ALabel(APoint ( 300, 350), AInt (300),
    AAlignment (kAAlignmentCenter), String ("0123456789"),
    AFont (ChicagoDigit36))) ;
addView (new ALabel(APoint ( 300, 400), AInt (250),
    AAlignment (kAAlignmentCenter), String ("Geneva9"), AFont
    (Geneva9))) ;
addView (new AAutoLabel(APoint ( 50, 200), String ("AutoLabel
    "), AFont (ChicagoFLF24))) ;

```

A Label or AutoLabel can be a stand alone view as explained above, or it can be a subview of another view.

You can change the Title of a Label or AutoLabel as in this exemple to display the freeRam in myLabel

:

```
const size_t gFreeRam = freeRAM () ;  
myLabel->setTitle ("Free_Ram:_" + String (gFreeRam)) ;
```

You can display or hide a Label or AutoLabel by changing its visibility :

```
myLabel->setVisibility (true) ; // or false
```

### 6.3 PushButton

A `PushButton` class inherit from a `AWView` class with an Action. The View is a `roundRectangle` with a title inside.

When the user click inside the Button, an action is sent to a receiver.

The `PushButton` class contain the following constructors :

```
AWPushButton (const AWPPoint & inRelativeBaselineOrigin,
              const AWInt inWidth,
              const String & inTitle,
              const AWFFont & inFont = awkDefaultFont)
              ;

AWPushButton (const AWRect & inFrame,
              const String & inTitle,
              const AWFFont & inFont = awkDefaultFont)
              ;
```

The example below show a unique `PushButton` centered in the screen with a number inside. Each time you click in the button, the number inside the button is incremented.

The code of this example include a declaration before the `setup()` :

```
//--- Current button value
int buttonValue = 0 ;

//--- button action
void bigButtonAction (AWView * inSender)
{
    AWPPushButton * sendingButton = (AWPushButton *) inSender ;
    buttonValue ++ ;
    sendingButton->setTitle (String (buttonValue)) ;
}
```

and an initialization of the button in the `setup()` :

```
// create a big button centered on screen
AWPushButton * bigButton = new AWPPushButton(AWRect (0, 0, 300,
    100), String (buttonValue), AWFFont (ChicagoDigit36)) ;
bigButton->setAction (bigButtonAction) ;
addCenteredView (bigButton) ;
```

The receiver of the `PushButton` is the Title of the button itself, but, in general, it can be any receiver inside any other object View.

The `bigButtonAction` function is activated each time there is a click in this button. It execute what you want to do.



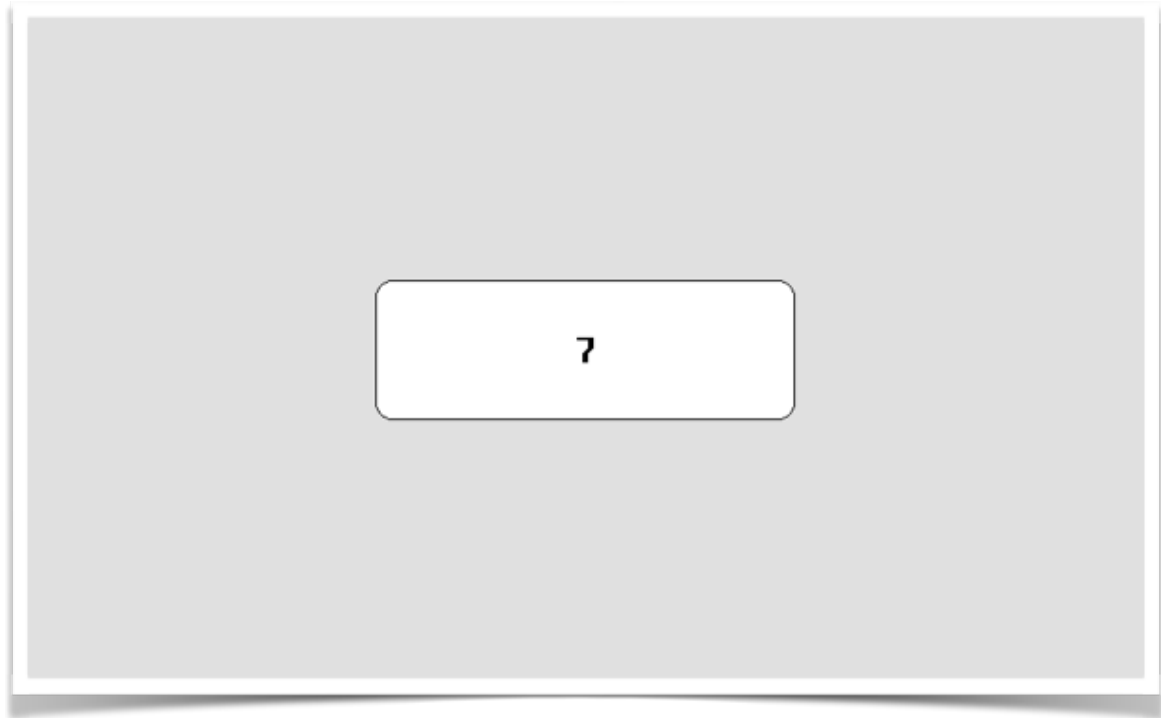


Figure 11: A PushButton

The PushButton class contain the following methods which can be used in your program :

```
//----- Title
protected : String mTitle ;
void setTitle (const String & inTitle) ;
//----- Font
inline AWFont font (void) const { return mFont ; }
//--- Draw
virtual void drawInRegion (const AWRegion & inDrawRegion) const
;
//--- Properties
inline AWColor textColor (void) const { return mTextColor ; }
void setTextColor (const AWColor inTextColor) { mTextColor =
    inTextColor ; }
protected : AWInt mStringDisplayLength ;
inline AWInt verticalMargin (void) const { return
    mVerticalMargin ; }
//--- Enabled state
inline bool isEnabled (void) const { return mIsEnabled ; }
void setEnabled (const bool inState) ;
//--- Hilite state
inline bool isHilited (void) const { return mHiliteState ; }
//--- Tell the view is opaque or not
virtual bool isOpaque (void) const ;
```

```
//--- Touch
virtual void touchDown (const AWPPoint & inPoint) ;
virtual void touchMove (const AWPPoint & inPoint) ;
virtual void touchUp (const AWPPoint & inPoint) ;
} ;
```

This example show a View with 4 PushButtons as subViews. It implements also the actions which are done when clicking in a button.

In the declaration part, we create a base View which will contain the PushButtons and the actions on this View :

```
static AWPView * gBaseView ;
// This base View will move 20 pixels when clicking in a button
// We declare the respective actions which will apply : a
  translation
static void leftButtonAction (AWPView * inSender) {
  gBaseView->translateBy (-20, 0) ;
}
static void rightButtonAction (AWPView * inSender) {
  gBaseView->translateBy (20, 0) ;
}
static void upButtonAction (AWPView * inSender) {
  gBaseView->translateBy (0, 20) ;
}
static void downButtonAction (AWPView * inSender) {
  gBaseView->translateBy (0, -20) ;
}
```

In the setup(), we put everything in place :

```
gBaseView = new AWPView (AWRect (550, 150, 140, 95),
  awkBackColor) ;
addView (gBaseView) ;
view = new AWPPushButton (AWPoint (5, 40), 60, "Left") ;
view->setAction (leftButtonAction) ;
gBaseView->addSubview (view) ;
view = new AWPPushButton (AWPoint (75, 40), 60, "Right") ;
view->setAction (rightButtonAction) ;
gBaseView->addSubview (view) ;
view = new AWPPushButton (AWPoint (40, 15), 60, "Down") ;
view->setAction (downButtonAction) ;
gBaseView->addSubview (view) ;
view = new AWPPushButton (AWPoint (40, 70), 60, "Up") ;
view->setAction (upButtonAction) ;
gBaseView->addSubview (view) ;
```

Everything is done by `AWContext::handleTouchAndDisplay ()` in the loop.

This figure show the 4 PushButtons. Left, the base View is not visible (awkBackColor) and right, the base View is visible (gray).

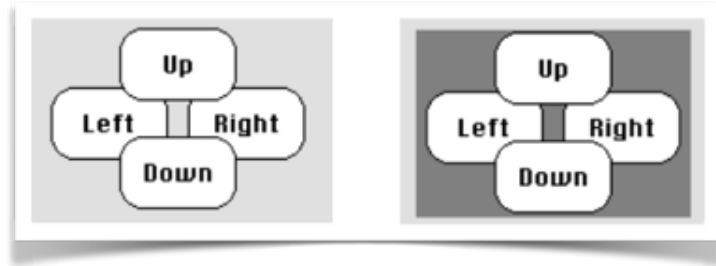


Figure 12: A view with 4 PushButton subviews

There will be further examples of PushButton together with examples of other views.

## 6.4 SegmentedControl

A `SegmentedControl` class inherit from a `AWView` class, with an Action.  
For example, this series of 3 tabs which divide a `SegmentedControl` view in 3 actions

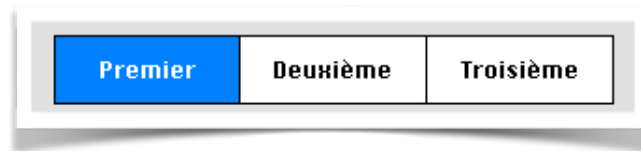


Figure 13: SegmentedControl

The `SegmentedControl` class contain the following constructor :

```
AWSegmentedControl (const AWPoint & inRelativeBaselineOrigin,
                    const AWInt inWidth,
                    const AWFont & inFont =
                        awkDefaultFont) ;
```

The `SegmentedControl` class contain the following methods which can be used in your program :

```
//--- Draw
virtual void drawInRegion (const AWRegion & inDrawRegion) const
    ;

//--- Adding a Tab
void addTab (const String & inTitle) ;

//--- Utilities
AWRect tabTitleRectForIndex (const AWInt inIndex) const ;

//----- Font
inline AWFont font (void) const { return mFont ; }

//--- Properties
inline AWInt selectedTabIndex (void) const { return
    mSelectedTabIndex ; }
void selectTabAtIndex (const AWInt inIndex) ;

//----- Segmented control action
typedef void (* AWSegmentedControlAction) (AWSegmentedControl *
    inSender, const AWInt inHilitedTabIndex) ;
```

```
// If segmented control action is NULL (by default), touch up
// changes selection and send action (defined in AWView)
// If not NULL, touch up does not change selection, and sends
// segmented control action
inline AWSegmentedControlAction segmentedControlAction (void)
    const { return mSegmentedControlAction ; }
inline void setSegmentedControlAction (const
    AWSegmentedControlAction inAction) {
    mSegmentedControlAction = inAction ;
}

//----- Touch
virtual void touchDown (const AWPPoint & inPoint) ;
virtual void touchMove (const AWPPoint & inPoint) ;
virtual void touchUp (const AWPPoint & inPoint) ;

//----- Enabled state
inline bool isEnabled (void) const { return mIsEnabled ; }
void setEnabled (const bool inState) ;
} ;
```

The example of Figure 13 have, in the declaration part :

```
static AWSegmentedControl * gSegmentedControl ;

static void segmentedControlAction (AWSegmentedControl *
    inSender, const AWInt inHighlightedTabIndex) {
    beep () ;
    digitalWrite(LED_BUILTIN, !digitalRead(LED_BUILTIN));
}
```

Then in the setup part :

```
gSegmentedControl = new AWSegmentedControl (AWPoint (440, 100),
    300) ;
gSegmentedControl->addTab ("Premier") ;
gSegmentedControl->addTab ("Deuxieme") ;
gSegmentedControl->addTab ("Troisieme") ;
// gSegmentedControl->setEnabled (false) ;
gSegmentedControl->setSegmentedControlAction (
    segmentedControlAction) ;
addView (gSegmentedControl) ;
```

This example sound a beep and turn the built-in led on or off when clicking in any of the tabs.

## 6.5 Slider

A `Slider` class inherit from a `AWView` class with an `Action`.

A `Slider` is a complex `View` class which can control any entity by simply moving a cursor along a linear potentiometer.

When the slider is moved (translated) an action is sent to a receiver with the value of the slider.

The `Slider` class contain the following constructor :

```
const bool kHorizontal = false;
const bool kVertical = true;

AWSlider (const AWPPoint & inOrigin,
          const AWInt inSize,
          const bool inOrientation,
          const bool inHasRuler = true) ;
```

In this example, one slider control the brightness of the backlight of the screen, and the 3 other sliders control the color of a `colorView` (a simple rectangle).

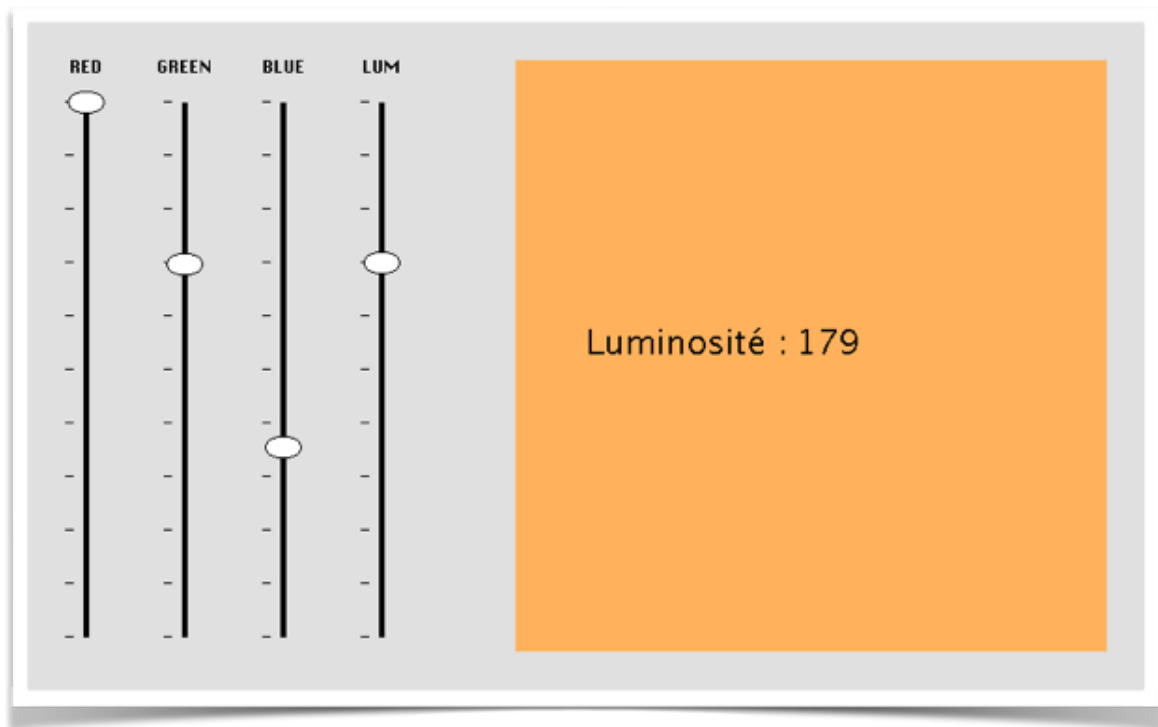


Figure 14: Four Sliders to control the brightness and the color of a Rectangle

This exemple include a declaration part before the `setup()` :

```
//--- Label
AWLabel * label1;
```

```

AWidget * label2;

//--- Current color value
AWColor displayedColor = AWColor::white () ;

AWSlider *redSlider;
AWSlider *greenSlider;
AWSlider *blueSlider;
AWSlider *backlightSlider;
AWidget *colorView;

//--- Slider action
void sliderAction (AWidget * inSender)
{
    AWSlider * sendingSlider = (AWSlider *) inSender ;
    AWInt pos = sendingSlider->knobPosition ();
    if (sendingSlider == backlightSlider) {
        analogWrite (BACKLIGHT, pos);
        label2->setTitle(pos);
    }
    else {
        AWColor newColor(redSlider->knobPosition (), greenSlider->
            knobPosition (), blueSlider->knobPosition ());
        colorView->setBackColor (newColor) ;
    }
}

```

and an initialization of the sliders and receivers in the setup() :

```

redSlider = new AWSlider (AWidget (30,30), 400, kVertical, true)
;
redSlider->setMaxKnobPosition (255);
redSlider->setKnobPosition (255);
redSlider->setAction (sliderAction);
addView (redSlider) ;
addView (new AWidget (AWidget (25, 440), 40, kAWAlignmentCenter
, "RED")) ;

greenSlider = new AWSlider (AWidget (100,30), 400, kVertical,
true) ;
greenSlider->setMaxKnobPosition (255);
greenSlider->setKnobPosition (255);
greenSlider->setAction (sliderAction);
addView (new AWidget (AWidget (95, 440), 40, kAWAlignmentCenter
, "GREEN")) ;

blueSlider = new AWSlider (AWidget (170,30), 400, kVertical,
true) ;
blueSlider->setMaxKnobPosition (255);

```

```

blueSlider->setKnobPosition (255);
blueSlider->setAction (sliderAction);
addView (new AWLabel (AWPoint (165, 440), 40,
    kAWAlignmentCenter, "BLUE")) ;

backlightSlider = new AWSlider (AWPoint (240,30), 400,
    kVertical, true) ;
backlightSlider->setMaxKnobPosition (255);
backlightSlider->setKnobPosition (200);
backlightSlider->setAction (sliderAction);
addView (new AWLabel (AWPoint (235, 440), 40,
    kAWAlignmentCenter, "LUM")) ;

addView (greenSlider) ;
addView (blueSlider) ;
addView (backlightSlider) ;
colorView = new AWView (AWRect (350, 30, 420, 420), AWColor::
    white());
addView (colorView) ;

label1 = new AWLabel(AWPoint ( 400, 240), AInt (150),
    AAlignment (kAWAlignmentLeft), String ("Brightness:_:"),
    AFont (Lucida\_Grande24)) ;
addView (label1) ;
label2 = new AWLabel(AWPoint ( 550, 240), AInt (100),
    AAlignment (kAWAlignmentLeft), String ("200"), AFont (
    Lucida_Grande24)) ;
addView (label2) ;

```

The Slider class contain the following methods which can be used in your program :

```

//--- Draw
virtual void drawInRegion ( const ARegion & inDrawRegion )
    const ;

//--- Orientation
bool orientation() const { return mOrientation ; }

//--- Knob color
protected : AWColor mKnobColor ;

//--- Ruler display
protected : void drawRulerInRegion ( const ARegion &
    inDrawRegion ) const ;
bool hasRuler() const { return mHasRuler ; }
//--- Set the number of scales on the slider. Any value < 1
    sets mHasRuler
//--- to false so that no ruler is displayed

```



```

void setHowManyScales ( const AWInt inHowManyScales ) ;

//--- Position
inline AWInt knobPosition (void) const { return mKnobPosition ;
    }
void setKnobPosition ( AWInt inKnobPosition, const bool
    inRefresh = false ) ;
inline AWInt maxKnobPosition (void) const { return
    mMaxKnobPosition ; }
void setMaxKnobPosition ( AWInt inMaxKnobPosition ) ;
protected : AWRect knobRect() const ;

//--- Enabled state
inline bool isEnabled (void) const { return mIsEnabled ; }
// void setEnabled (const bool inState) ;

//--- Tell the view is opaque or not
virtual bool isOpaque (void) const ;

//--- Touch
virtual void touchDown (const AWPPoint & inPoint) ;
virtual void touchMove (const AWPPoint & inPoint) ;
virtual void touchUp (const AWPPoint & inPoint) ;

```

This example show one horizontal slider and one vertical slider, both having division scales. Both sliders are combined with a respective AutoLabel to display their position.

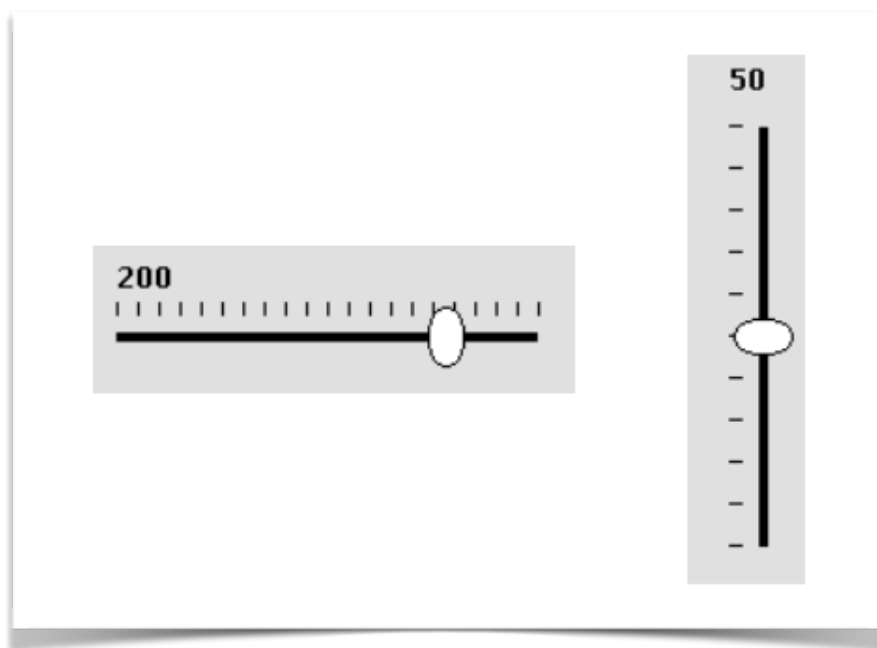


Figure 15: Sliders with scales lines

The declarations are :

```
static AWSlider * gSliderH;
static AWSlider * gSliderV;
static AWAutoLabel * gSliderHLabel;
static AWAutoLabel * gSliderVLabel;
```

The actions are :

```
static void updateHSliderLabelAction (AWView * inSender)
{
    AWSlider * sendingSlider = (AWSlider *) inSender ;
    AWInt pos = sendingSlider->knobPosition ();
    if (sendingSlider == gSliderH) {
        gSliderHLabel->setTitle(pos);
    }
}
static void updateVSliderLabelAction (AWView * inSender)
{
    gSliderVLabel->setTitle(String(((AWSlider *) inSender)->
        knobPosition()));
}
```

The setup, with `setHowManyScales` and combined labels is :

```
gSliderH = new AWSlider(AWPoint(300,200),200,kHorizontal) ;
gSliderH->setHowManyScales( 20 ) ;
gSliderH->setMaxKnobPosition (255);
gSliderH->setKnobPosition (200);
addView(gSliderH) ;
gSliderHLabel = new AWAutoLabel ( AWPoint( 310, 235), "200" ) ;
gSliderH->setAction(updateHSliderLabelAction) ;
addView(gSliderHLabel);

gSliderV = new AWSlider(AWPoint(725,140),200,kVertical) ;
addView(gSliderV) ;
gSliderVLabel = new AWAutoLabel ( AWPoint( 725, 345 ), "50" ) ;
gSliderV->setAction(updateVSliderLabelAction) ;
addView(gSliderVLabel) ;
```

## 6.6 DynamicSlider

A `DynamicSlider` class inherit from a `AWView` class.

A `DynamicSlider` is a `Slider` with 2 knobs. One elliptic *main* knob exactly the same as in a `Slider`, and one smaller and circular *target* knob which can be hidden when its position is the same as the main knob's position.

The main knob is movable with the touch control as usual and the dynamic knob can follow the main knob but slowly and smoothly. Both knobs have respective positions, so the dynamic knob can be used to create a smooth evolution of a parameter, such as the sound level in a mixing table or a smooth acceleration of a locomotive.

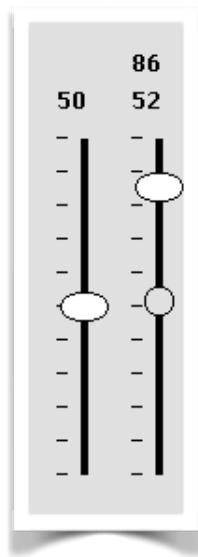


Figure 16: A Slider (left) and a dynamic Slider (right)

The `DynamicSlider` class contain the following constructor and methods

```
class AWDynamicSlider : public AWSlider
{
    AWDynamicSlider ( const AWPoint & inOrigin,
                     const AWInt inSize,
                     const bool inOrientation,
                     const bool inHasRuler = true ) ;

    //--- Draw
    virtual void drawInRegion ( const AWRegion & inDrawRegion )
        const ;

    //--- Position
```

```
inline AWInt dynamicKnobPosition (void) const { return
    mDynKnobPosition ; }
void setDynamicKnobPosition ( AWInt inKnobPosition ) ;
};
```

The example of figure 16 show a vertical dynamic slider, combined with two AutoLabel to display the respective positions of the main and target knobs (right slider only).

The declarations are :

```
static AWDynamicSlider * gDynSliderV;
```

The actions are :

```
static void updateDynamicVSliderLabelAction (AWView * inSender)
{
    gDynamicSliderVLabelTarget->setTitle(String((AWDynamicSlider
        *)inSender)->knobPosition()));
    gDynamicSliderVLabelCurrent->setTitle(String((AWDynamicSlider
        *)inSender)->dynamicKnobPosition()));
}
```

The setup, with combined main and target labels is :

```
gDynSliderV = new AWDynamicSlider(AWPoint(765,140),200,
    kVertical) ;
addView(gDynSliderV) ;
gDynamicSliderVLabelCurrent = new AWAutoLabel ( AWPoint( 765,
    345), "50") ;
gDynamicSliderVLabelTarget = new AWAutoLabel ( AWPoint( 765,
    365), "50") ;
gDynSliderV->setAction(updateDynamicVSliderLabelAction) ;
addView(gDynamicSliderVLabelCurrent) ;
addView(gDynamicSliderVLabelTarget) ;
```

Finally, in order to move automatically the target knob in order to join slowly the main knob, the following code is added in the loop, with a global static unsigned gDynamicDeadLine which store the system time :

```
if (gDynamicDeadLine <= millis()) {
    gDynamicDeadLine += 100;
    AWInt targetPos = gDynSliderV->knobPosition();
    AWInt currentPos = gDynSliderV->dynamicKnobPosition();
    if (currentPos < targetPos) {
        gDynSliderV->setDynamicKnobPosition(currentPos + 1);
    }
    else if (currentPos > targetPos) {
```

```
        gDynSliderV->setDynamicKnobPosition(currentPos - 1);  
    }  
}
```

## 6.7 TabView

A `TabView` class inherit from a `AWView` class

A `TabView` is a navigation interface. It is a view looking like a tab bar controller to organize your app into one or more distinct modes of operation. The view hierarchy of a tab bar controller is self contained. It is composed of views that the tab bar controller manages directly and views that are managed by content views you provide. Each content view manages a distinct view hierarchy, and the `TabView` coordinates the navigation between the view hierarchies.

The key component of a `TabView` interface is the presence of a tab bar view along the bottom of the screen (for example). This view is used to initiate the navigation between your app's different modes and can also convey information about the state of each mode.

The `TabView` creates and manages its own view and also manages the views that provide the content view for each mode.

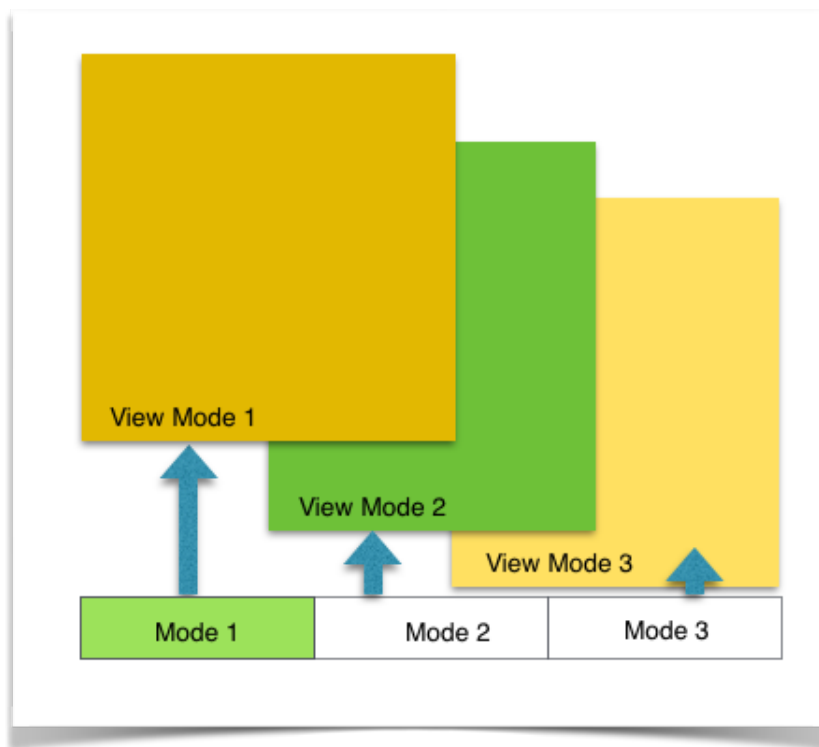


Figure 17: a TavView controlling views

The `TabView` class contain the following constructor and methods

```
class AWTabView : public AWView {
//--- Constructor
    AWTabView (const AWRect & inRelativeFrame,
               const AWFont & inFont = awkDefaultFont) ;

//--- Destructor
```

```

    virtual ~ AWTabView (void) ;

//--- Draw
    virtual void drawInRegion (const AWRRegion & inDrawRegion) const
        ;

//--- Adding a Tab
    void addTab (const String & inTitle, AView * inView) ;

//----- Font
    inline AFont font (void) const { return mFont ; }

//--- Utilities
    AInt titleHeight (void) const ;
    ARect horizontalSeparator (void) const ;
    ARect contentRectFromFrame (const ARect & inFrame) const ;
    ARect titleRect (void) const ;
    ARect tabTitleRectForIndex (const AInt inIndex) const ;

//--- Properties
    inline AInt selectedTabIndex (void) const { return
        mSelectedTabIndex ; }
    void selectTabAtIndex (const AInt inIndex) ;

//----- Badge
    void setBadgeAtIndex (const AInt inIndex, const bool
        inDisplayBadge) ; // Does nothing if index if out of mList
        bounds
    bool hasBadgeAtIndex (const AInt inIndex) const ; // return
        false if index if out of mList bounds
    ARect badgeRect (const AInt inItemIndex) const ;

//----- Touch
    virtual void touchDown (const APoint & inPoint) ;
    virtual void touchMove (const APoint & inPoint) ;
    virtual void touchUp (const APoint & inPoint) ;
} ;

```

An example of TabView is given in the following code :

First declare a AWTabView : gTabView

```
static AWTabView * gTabView ;
```

Then, in the setup, create the gTabView and 4 views which are here simple rectangles. Each view is associated with a tab by addTab which define the label in the tab and the associated view. Doing that 4 times create a 4 tab TabView

```
gTabView = new AWTabView (ARect (10, 10, 550, 500)) ;
```

```
AWView * view ;  
view = new AWView (AWRect (0, 0, 250, 300), AWColor::brown ())  
;  
gTabView->addTab ("First", view) ;  
view = new AWView (AWRect (100, 0, 250, 300), AWColor::yellow  
()) ;  
gTabView->addTab ("Second", view) ;  
view = new AWView (AWRect (200, 0, 250, 300), AWColor::cyan ())  
;  
gTabView->addTab ("Third", view) ;  
view = new AWView (AWRect (300, 0, 250, 300), AWColor::purple  
()) ;  
gTabView->addTab ("Fourth", view) ;  
addView (gTabView) ;
```

And its all !

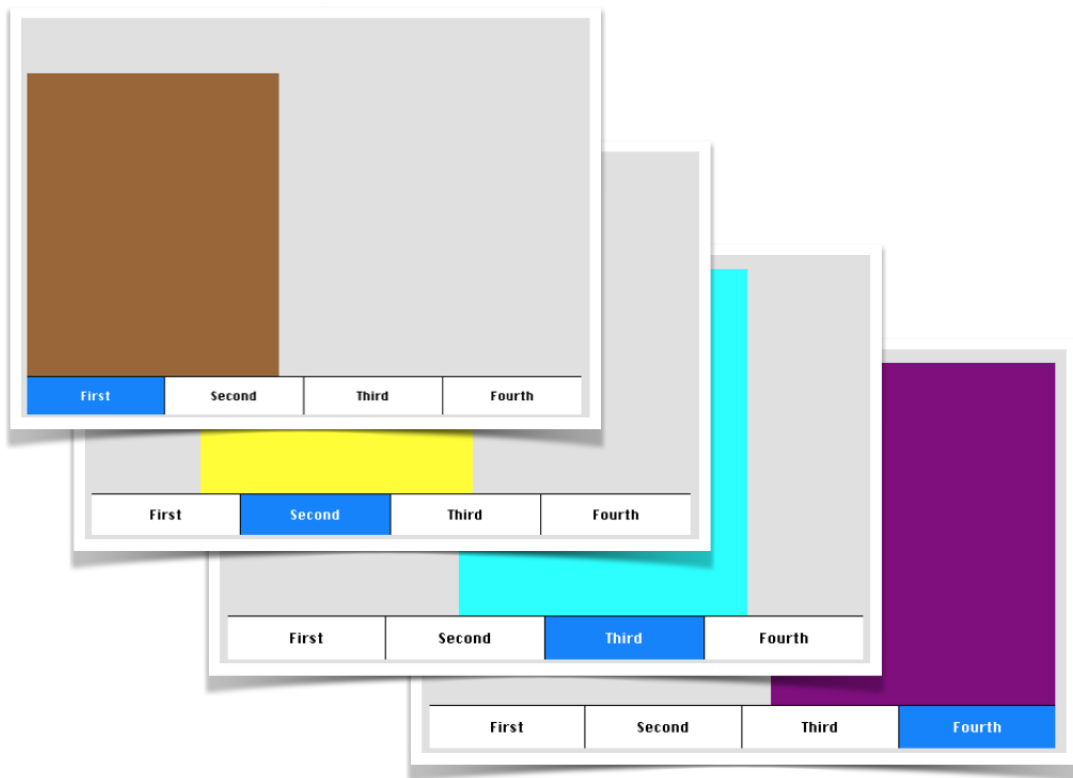


Figure 18: A 4 tabs TabView controlling 4 views



## 6.8 Switch

A `Switch` class inherit from a `AWView` class

A `Switch` is like a checkbox which can be toggled between true or false when clicking on it. Switches are commonly used to indicate whether a feature is enabled or disabled. You set the initial value of the switch in your program, but you can modify that value at runtime using the methods of this class.

A `Switch` is defined by a `Point` and a string `Title` (and a `Font` if you except the default font).

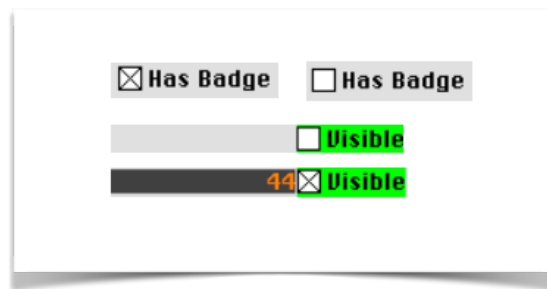


Figure 19: Some Switches

The `Switch` class contain the following constructor and methods

```
class AWSwitch : public AWView {
//--- Constructor
    AWSwitch (const AWPPoint & inBaseLineRelativeOrigin,
              const String & inTitle,
              const AWFFont & inFont = awkDefaultFont) ;

//--- Draw
    virtual void drawInRegion (const AWRegion & inDrawRegion) const
        ;

//---
    void setTitle (const String & inTitle) ;
    AWRRect boxRect (void) const ;

//----- Font
    inline AWFFont font (void) const { return mFont ; }

//----- State
    inline bool checked (void) const { return mChecked ; }
    void setChecked (const bool inChecked) ;

//----- Hilite state
    protected : bool mHiliteState ; // false (by default): not
```

```

        hilitated

//--- Enabled state
    inline bool isEnabled (void) const { return mIsEnabled ; }
    void setEnabled (const bool inState) ;

//----- Touch
    virtual void touchDown (const AWPPoint & inPoint) ;
    virtual void touchMove (const AWPPoint & inPoint) ;
    virtual void touchUp (const AWPPoint & inPoint) ;
} ;

```

To create the example of the above figure, you declare a gSwitch :

```
static AWPSwitch * gSwitch ;
```

And an action depending of the state of the gSwitch : In this example the action is to change the visibility of a label.

```

static void switchAction (AWPView * inSender) {
    gLabel2->setVisibility (gSwitch->checked ()) ;
}

```

Then, in the setup, create the gSwitch view with the title "Visible" and its associated action. Each time you click in the gSwitch the action will be executed.

```

gSwitch = new AWPSwitch (AWPPoint (102, 95), "Visible") ;
gSwitch->setBackColor (AWPColor::green ()) ;
gSwitch->setAction (switchAction) ;
addView (gSwitch) ;
gSwitch->sendAction () ;

```

## 6.9 ArrowPushButton

A `ArrowPushButton` class inherit from a `AWView` class

An `ArrowPushButton` is a `PushButton` with an arrow picture inside and no title.

It is used exactly as a `PushButton`, but you can choose the direction and color of the arrow.



Figure 20: An `ArrowPushButton`

The `ArrowPushButton` class contain the following constructor and methods

```
enum { kUpArrow, kDownArrow, kRightArrow, kLeftArrow } ;

class ARArrowPushButton : public AWView
{
public: ARArrowPushButton(const ARect & inRelativeFrame,
                        const uint32_t inArrowDirection,
                        const AColor & inArrowColor) ;

    //-- Arrow color
private: uint32_t mArrowDirection ;
    //-- Arrow color
private: AColor mArrowColor ;
public: AColor arrowColor() const { return mArrowColor; } ;
public: void setArrowColor(AColor & inArrowColor) {
    mArrowColor = inArrowColor; } ;

    //-- Enabled state
inline bool isEnabled (void) const { return mIsEnabled ; }
void setEnabled (const bool inState) ;

    //-- On Off state management
inline bool isOn() const { return mIsOn ; }
inline void setIsOn (const bool inIsOn) { mIsOn = inIsOn ; }

inline bool onOffState() const { return mOnOffState ; }
inline void setOnOffState(const bool inOnOffState) {
    mOnOffState = inOnOffState ; }

    //-- Draw
```

```
virtual void drawInRegion (const ARegion & inDrawRegion) const
    ;

//--- Tell the view is opaque or not
virtual bool isOpaque (void) const ;

//--- Touch
virtual void touchDown (const APoint & inPoint) ;
virtual void touchMove (const APoint & inPoint) ;
virtual void touchUp (const APoint & inPoint) ;
};
```

The following code show how to use an ArrowPushButton in the setup. First, button is created with arguments for its coordinates, its direction its color.

```
AWArrowPushButton * button = new AWArrowPushButton( ARect
    (750,0,50,80), kUpArrow, AColor::blue() ) ;
button->setAction (showKeyboard) ;
addView (button) ;
```

Then we set the attached action which is showing a keyboard as described in the next sections. Then there is the traditional `addview`.

## 6.10 AWKeyButton

A `AWKeyButton` class inherit from a `AWView` class

A `AWKeyButton` is a unique key button which is a part of a keyboard. The `AWKeyboard` class is described hereafter.



Figure 21: A series of `AWKeyButtons`

The `AWKeyButton` class contain the following constructor and methods

```
class AWKeyButton : public AWView
{
    AWKeyButton (const AWRect & inFrame,
                 const AWColor & inBackColor) ;

    virtual void setShifted (const bool inShifted,
                             const AWView * const inSender
                             ) ;

    //----- Hilite state
    inline bool isHilited (void) const { return mHiliteState; }

    //----- Drawing
    protected : void drawFrameAndBackgroundInRegion (const AWRRegion
        & inDrawRegion) const ;
    virtual bool isOpaque (void) const ;

    //--- Touch
    virtual void touchDown (const AWPPoint & inPoint) ;
    virtual void touchMove (const AWPPoint & inPoint) ;
    virtual void touchUp (const AWPPoint & inPoint) ;
};
```

The `AWKeyButton` class have the following derived classes which differ to build a complete set of keybuttons of a full keyboard.

The `AWNNormalKeyButton` class contain the following constructor and methods

```
class AWNNormalKeyButton : public AWKeyButton
```

```

{
    AWRNormalKeyButton (const AWRect & inFrame,
                        const char inText,
                        const char inShiftText) ;

    virtual void setShifted (const bool inShifted,
                            const AView * const inSender
                            ) ;

    char keyChar () const { return mCurrentKey ; }

    //--- Draw
    virtual void drawInRegion (const ARegion & inDrawRegion) const
        ;
};

```

The AWReturnKeyButton class contain the following constructor and methods

```

class AWReturnKeyButton : public AWKeyButton
{
    AWReturnKeyButton (const AWRect & inFrame) ;

    //--- Draw
    virtual void drawInRegion (const ARegion & inDrawRegion) const
        ;
};

```

The ABackspaceKeyButton class contain the following constructor and methods

```

class ABackspaceKeyButton : public AWKeyButton
{
    ABackspaceKeyButton (const AWRect & inFrame) ;

    //--- Draw
    virtual void drawInRegion (const ARegion & inDrawRegion) const
        ;
};

```

The AShiftKeyButton class contain the following constructor and methods

```

class AShiftKeyButton : public AWKeyButton
{
    AShiftKeyButton (const AWRect & inFrame, const bool
                    inRightAlign) ;

    //---- Alignment of the arrow in the key
    virtual void setShifted (const bool inShifted,
                            const AView * const inSender
                            ) ;
};

```

```
//--- Draw
virtual void drawInRegion (const AWRegion & inDrawRegion) const
    ;
};
```

The *AWLeftArrowKeyButton* class contain the following constructor and methods

```
class AWLeftArrowKeyButton : public AWKeyButton
{
    AWLeftArrowKeyButton (const AWRect & inFrame) ;

    //--- Draw
    virtual void drawInRegion (const AWRegion & inDrawRegion) const
        ;
};
```

The *AWRightArrowKeyButton* class contain the following constructor and methods

```
class AWRightArrowKeyButton : public AWKeyButton
{
    AWRightArrowKeyButton (const AWRect & inFrame) ;

    //--- Draw
    virtual void drawInRegion (const AWRegion & inDrawRegion) const
        ;
};
```

All these *KeyButtons* are combined to create a *Keyboard* which is described hereafter. the combination of keys can, of course, be adapted to the applications (language, specific keys, etc..).

## 6.11 Keyboard

A `Keyboard` class inherit from a `AWView` class

The Keyboard show in this section is a french keyboard.



Figure 22: The keyboard view

The Keyboard class contain the following constructor and methods

```
typedef void (*AWKeyboardCallback) (const String &inText, const
    int inTag);

void launchKeyboard (const String &inText,
    const AWInt inMaxLength,
    AWKeyboardCallback inCallback,
    const int inTag = -1) ;
```

This example show how to use this keyboard. We need a Label to display the string which will be the result of the use of the keyboard. Then we need an Action which will display this result in the Label when the "return" key of the keyboard will be down. Then we need an Action to displau the keyboard when the user click on a PushButton.

```
AWLabel *keyboardResult ;
```



```
// Action to validate a keyboard entry
void keyboardValidateEntryAction(const String &inText, const int
    tag)
{
    keyboardResult->setTitle (inText) ;
}

// Action to display the keyboard
void displayKeyboardAction(AWView *sender)
{
    launchKeyboard (keyboardResult->title (), 40,
        keyboardValidateEntryAction, 0) ;
}
```

Then, in the setup, we create the Label for the result and the PushButton to display the keyboard

```
keyboardResult = new AWLabel (AWPoint (0, 0), 500,
    kAWAlignmentCenter, "") ;
addCenteredView (keyboardResult) ;

// Push button to display the Keyboard
AWPushButton *launchKeyboardButton = new AWPushButton (AWRect
    (20, 20, 150, 40), "Show_keyboard");
launchKeyboardButton->setAction (displayKeyboardAction) ;
addView (launchKeyboardButton) ;
```

As usual, everything is handled by the loop function :

```
AWContext::handleTouchAndDisplay () ;
```

## 7 Custom View Examples

There is plenty of new Arduino Widgets classes that can be built from the `AWView` class and from the above existing classes.

This section describes a few examples which will give you more details on the above existing views and their interactions via the action mechanisms.

You will find :

- An Ellipse View
- A Target View with an arrow
- A List View that you can fill with the Keyboard View
- A List View with Badge

## 7.1 The Ellipse custom view

This custom view is composed of an Oval which is drawn in a Rectangle. It is defined by a rectangle, a background color and an ellipse color.

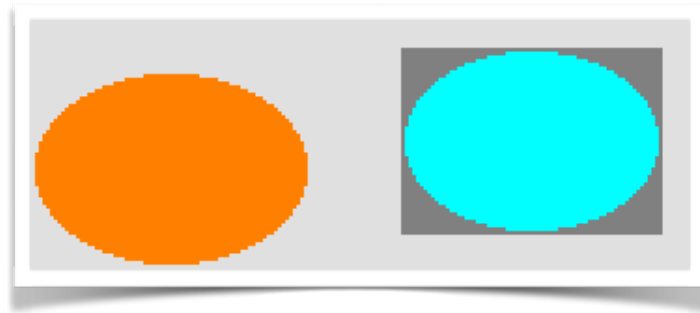


Figure 23: "An Ellipse" custom view

The declaration of the EllipseView class is :

```
class EllipseView : public AView {
//--- Constructor
public : EllipseView (const ARect & inRelativeFrame,
                    const AColor & inBackColor,
                    const AColor & inEllipseColor) :
    AView (inRelativeFrame, inBackColor),
    mEllipseColor (inEllipseColor) {
}

//--- Draw
public : virtual void drawInRegion (const ARegion &
    inDrawRegion) const {
    //--- Draw background
    super::drawInRegion (inDrawRegion) ;
    //--- Draw ellipse
    ARect r = absoluteFrame () ;
    r.inset (1, 1) ;
    AContext::setColor (mEllipseColor) ;
    r.fillOvalInRegion (inDrawRegion) ;
}

//--- Private member
private : AColor mEllipseColor ;

//--- For calling super class instance methods
private : typedef AView super ;
} ;
```

Note that the ellipse is drawn 1 pixel far from the sides of the rectangle.

In the setup, we create one orange ellipse with no bgcolor (we use the argument `awkBackColor`), and one cyan ellipse with a gray bgcolor.

```
view = new EllipseView (CGRect (1, 1, 75, 53), awkBackColor ,
    AWColor::orange ()) ;
addView (view) ;
view = new EllipseView (CGRect (100, 10, 70, 50), AWColor::gray
    (), AWColor::cyan ()) ;
addView (view) ;
```

## 7.2 The Target custom view

This example is composed of :

- 3 concentric circles with different colors
- An arrow which have reached the center of this target
- A PushButton to rotate the colors of the target

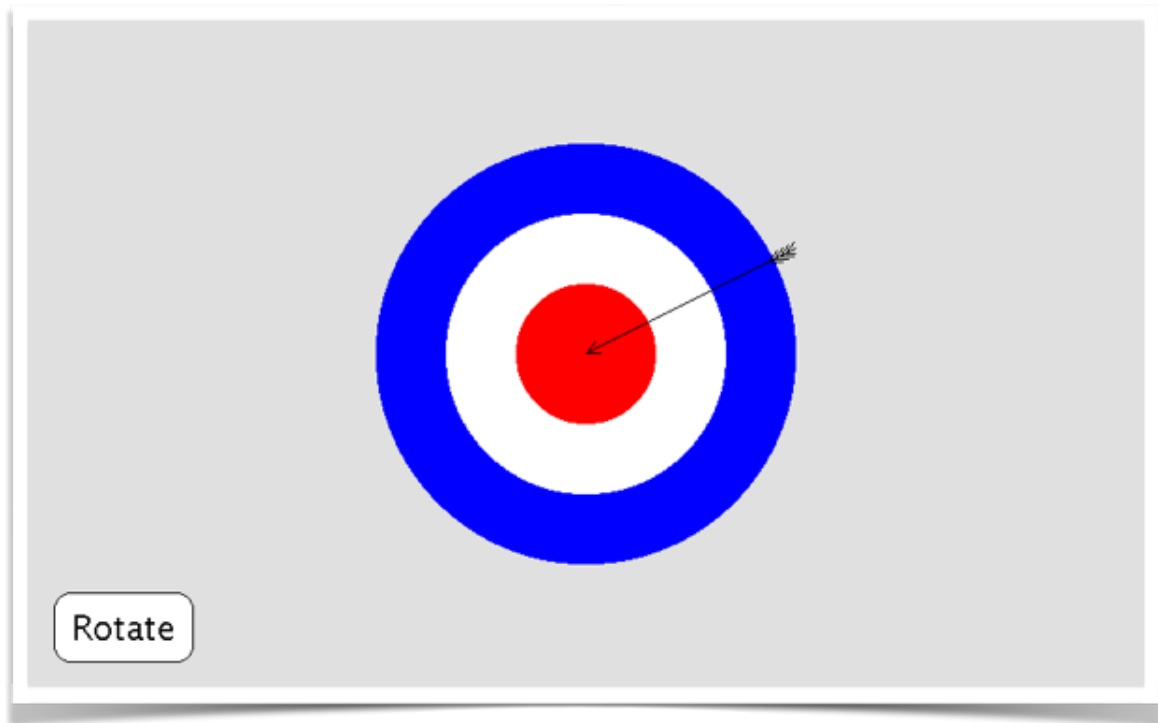


Figure 24: "A Target" custom view

First declare the new CustomView class and its functions

```
// the CustomView class
class CustomView : public AView
{
    public : CustomView (const ARect & inViewFrame);
    public : virtual void drawInRegion (const ARegion & inRegion)
        const;
    public : void rotateColors ();
}
```

```

private : AColor centerColor;
private : AColor mediumColor;
private : AColor externalColor;
};

// The CustomView constructor
CustomView::CustomView (const ARect & inViewFrame) :
AView(inViewFrame, AColor::darkGray ()),
centerColor (AColor::red ()),
mediumColor (AColor::white ()),
externalColor (AColor::blue ())
{
}

// The arrow
void drawLines (const ARegion & inRegion, const APoint &
inOrigin)
{
    APoint p = inOrigin ;
    p.translateBy ( 10, 0 ) ;
    inOrigin.strokeLineInRegion (p, inRegion) ;
    p.translateBy ( -4, 8 ) ;
    inOrigin.strokeLineInRegion (p, inRegion) ;
}

// The drawing of the CustomView class
void CustomView::drawInRegion (const ARegion & inRegion) const
{
    ARect viewFrame = absoluteFrame () ;
    AContext::setColor (externalColor) ;
    viewFrame.fillOvalInRegion (inRegion) ;
    AInt insetX = viewFrame.size.width / 6 ;
    AInt insetY = viewFrame.size.height / 6 ;
    AContext::setColor (mediumColor) ;
    viewFrame.inset (insetX, insetY) ;
    viewFrame.fillOvalInRegion (inRegion) ;
    AContext::setColor (centerColor) ;
    viewFrame.inset (insetX, insetY) ;
    viewFrame.fillOvalInRegion (inRegion) ;

    viewFrame = absoluteFrame () ;
    APoint center ;
    center.x = viewFrame.origin.x + viewFrame.size.width / 2 ;
    center.y = viewFrame.origin.y + viewFrame.size.height / 2 ;
    APoint tail ;
    tail.x = center.x + viewFrame.size.width / 2 ;
    tail.y = center.y + viewFrame.size.height / 4 ;
    AContext::setColor (AColor::black ()) ;

```

```

        center.strokeLineInRegion (tail, inRegion) ;
        drawLines (inRegion, center) ;
        center.translateBy (viewFrame.size.width / 2 - 20, viewFrame.
            size.width / 4 - 10) ;
        for (int i = 0 ; i < 4 ; i++) {
            drawLines (inRegion, center) ;
            center.translateBy (4, 2) ;
        }
    }

// the color rotation function of the CustomView class
void CustomView::rotateColors ()
{
    AWCOLOR centerSave = centerColor ;
    centerColor = mediumColor ;
    mediumColor = externalColor ;
    externalColor = centerSave ;
    setNeedsDisplay () ;
}

// The targetView object pointer
CustomView * targetView ;

// The color rotation function of the targetView object
void rotate (AWView * sender)
{
    targetView->rotateColors () ;
}

```

Then create the elements in the setup

```

// create the target view centered on screen
targetView = new CustomView(AWRect (0, 0, 300, 300)) ;
addCenteredView (targetView) ;

// create the button to rotate colors
AWPushButton * pushToRotate = new AWPUSHBUTTON (AWRect (20, 20,
    100, 50), "Rotate", AWFONT (Lucida_Grande24)) ;
pushToRotate->setAction (rotate) ;
addView (pushToRotate) ;

```

### 7.3 The Keyboard and List example

This example is composed of :

- An AWList View
- An AWPushButton to add an element
- An AWPushButton to delete an element
- An AWKeyboard to compose and enter an element

The following figures show the list :

- With the keyboard to enter an element
- With the buttons to add or remove an element

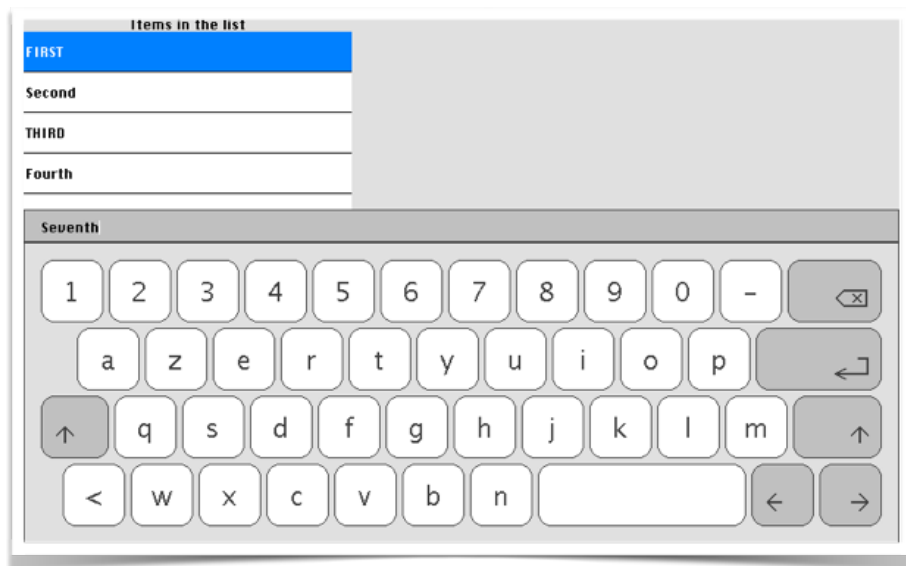


Figure 25: Keyboard and List views

To program this example, you declare the objects and actions :

```
//--- List View
AWListView * listView ;

// delete item button, enabled only if listView is not empty
AWPushButton * delButton ;

// Action to validate a keyboard entry
void keyboardValidateEntryAction(const String &inText, const int
tag)
```



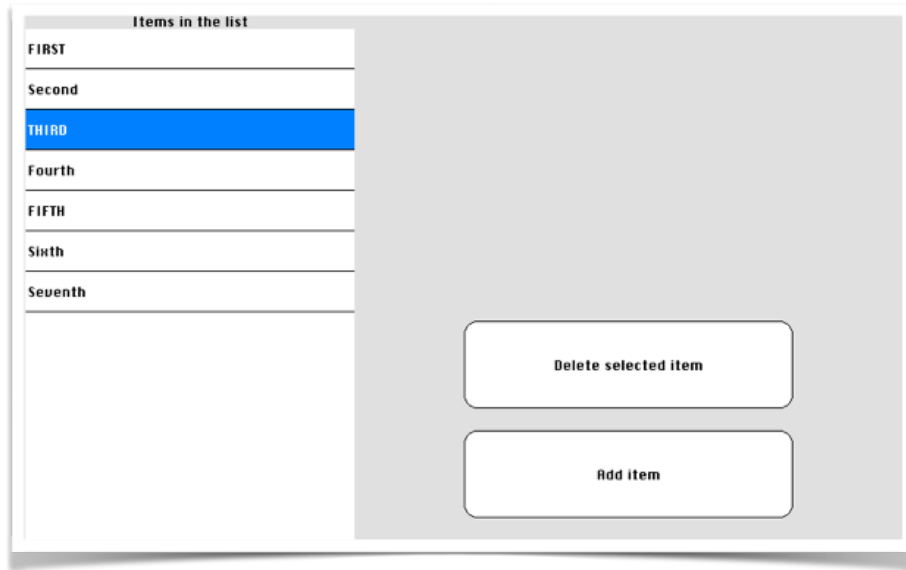


Figure 26: The List

```

{
    listView->append (inText) ;
    delButton->setEnabled (true) ;
}

//--- button to add an item to the list action
void addItemAction (AWView * inSender)
{
    launchKeyboard ("", 40, keyboardValidateEntryAction, 0) ;
}

//--- button to remove the selected item from the list action
void delItemAction (AWView * inSender)
{
    listView->removeItemAtIndex (listView->selectedIndex ()) ;
    if (listView->count () == 0) {
        delButton->setEnabled (false) ;
    }
}

```

Then you create the objects in the setup.

```

// Create the listView
listView = new AWListView ( ARect (0, 0, 300, 480), "Items_in_
    the_list") ;
addView (listView) ;
// Create the "Add item" PushButton
AWPushButton * addButton = new AWPushButton (ARect (400, 20,

```

```
        300, 80), "Add_item") ;  
addButton->setAction (addItemAction) ;  
addView (addButton) ;  
// Create the "Delete selected item" PushButton  
delButton = new AWPushButton(AWRect (400, 120, 300, 80), "  
    Delete_selected_item") ;  
delButton->setEnabled (false) ;  
delButton->setAction (delItemAction) ;  
addView (delButton) ;
```

## 8 A List View with Badge

This example is composed of :

- An AWListView named "My List"
- An AWSwitch "Has Badge"
- An AWPushButton "Remove"
- An Alert dialog

This figure show 4 states of this exemple, from left to right :

- The initial list with first element selected
- The 3rd element selected with a click on it
- After removing the "alien" element
- After selecting and clicking the switch "Has Badge" of 3 elements

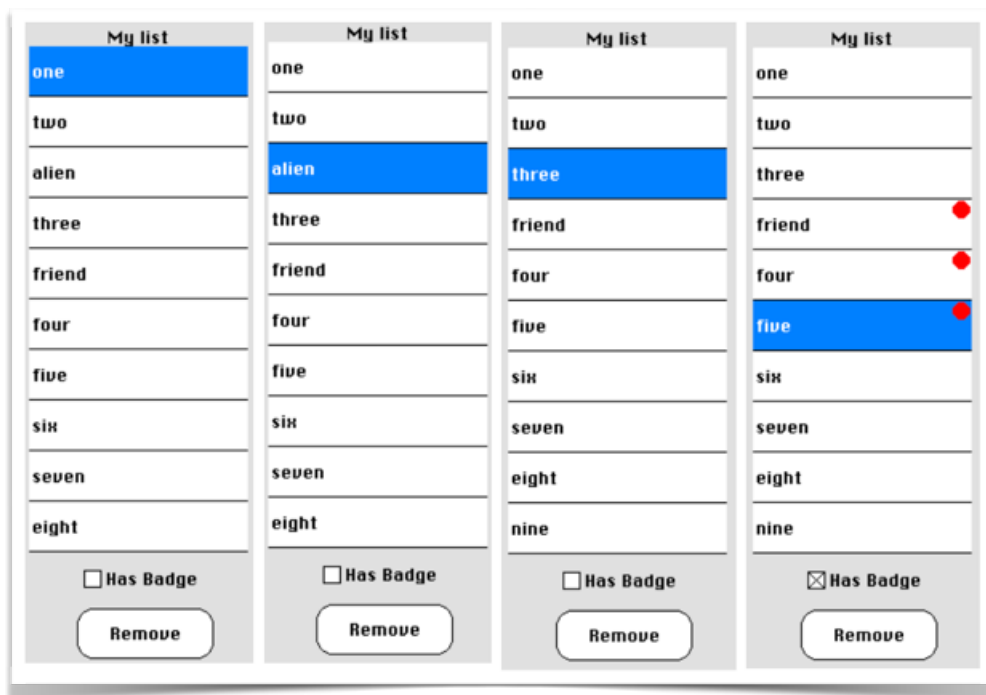


Figure 27: Managing a list with badge

And this figure show the Alert dialog when clicking the "Remove" PushButton

Before the setup, we declare the following objects :

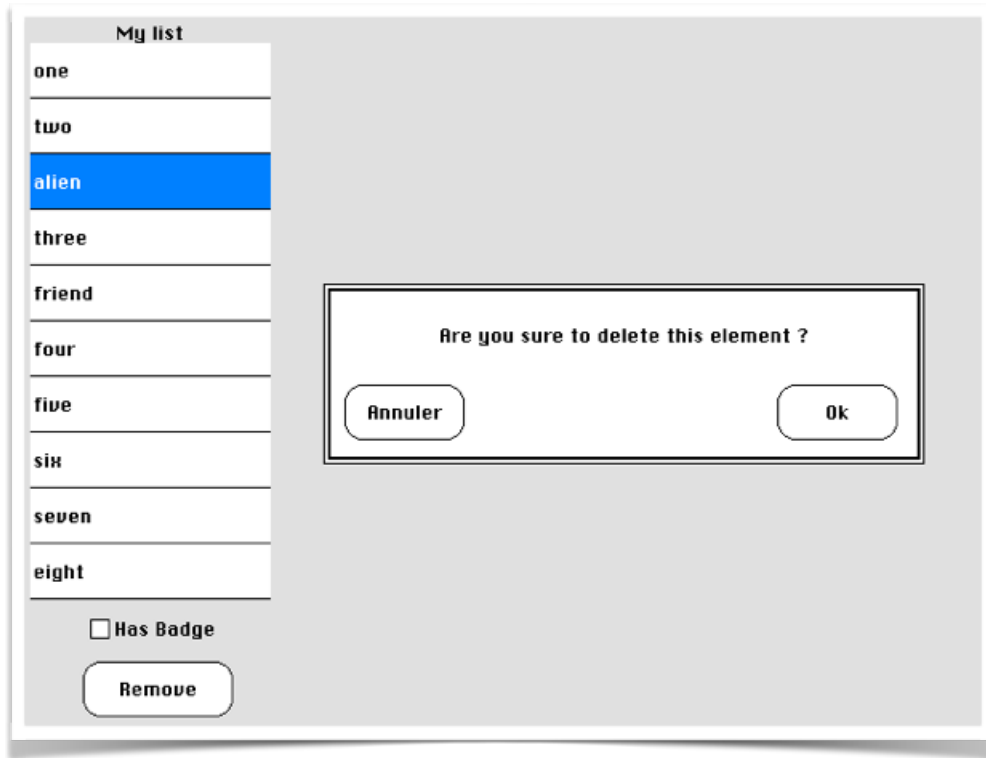


Figure 28: Alert when removing an element of the list

```
static AWListView * gListView ;
static AWPushButton * gRemoveItemLabel ;
static AWSwitch * gHasBadgeSwitch ;
```

Then we declare the following functions

```
// The action when selecting an element in the list
static void listSelectionAction (AWView * inSender) {
    const AWInt selectedItemIndex = gListView->selectedItemIndex
        () ;
    gRemoveItemLabel->setEnabled (selectedItemIndex >= 0) ;
    gHasBadgeSwitch->setEnabled (selectedItemIndex >= 0) ;
    gHasBadgeSwitch->setChecked (gListView->hasBadgeAtIndex (
        selectedItemIndex)) ;
}
// The action when removing an element
static void listRemoveAction (AWView * inSender) {
    gListView->removeItemAtIndex (gListView->selectedItemIndex ()
        ) ;
}
// The action when clicking in the "Remove" button
static void removeButtonAction (AWView * inSender) {
    presentAlert ("Are_you_sure_to_delete_this_element_?", NULL,
```

```

        listRemoveAction, -1) ;
    }
    // The action when clicking in the "Has Badge" switch
    static void hasBadgeSwitchAction (AWView * inSender) {
        const AWInt selectedIndex = gListView->selectedIndex
        () ;
        if (selectedIndex >= 0) {
            gListView->setBadgeAtIndex (selectedIndex,
                gHasBadgeSwitch->checked ()) ;
        }
    }
}

```

Then we create the objects in the setup :

```

// The "Remove" PushButton
gRemoveItemLabel = new AWPushButton (AWPoint (40, 25), 100, "
    Remove") ;
gRemoveItemLabel->setAction (removeButtonAction) ;
addView (gRemoveItemLabel) ;
// The empty list of elements in a rectangle that can limit the
    display of the list
gListView = new AWListView (AWRect (5, 90, 160, 383), "My_list"
    ) ;
addView (gListView) ;
// The elements which are appended to the liste
gListView->append ("one") ;
gListView->append ("two") ;
gListView->append ("alien") ;
gListView->append ("three") ;
gListView->append ("friend") ;
gListView->append ("four") ;
gListView->append ("five") ;
gListView->append ("six") ;
gListView->append ("seven") ;
gListView->append ("eight") ;
gListView->append ("nine") ;
gListView->append ("ten") ;
gListView->append ("eleven") ;
gListView->append ("12") ;
gListView->append ("13") ;
gListView->append ("14") ;
// The "Has Badge" Switch
gHasBadgeSwitch = new AWSwitch (AWPoint (45, 65), "Has_Badge")
    ;
gHasBadgeSwitch->setAction (hasBadgeSwitchAction) ;
addView (gHasBadgeSwitch) ;
// Start the action when selecting an element in the list
gListView->setAction (listSelectionAction) ;

```

## 9 The next steps of *ArduinoWidgets*

With this ArduinoWidgets toolbox, you can create custom views for your project and we will be pleased to add some of them in this library if that make sens.

## 10 The calibration of the Touch screen

There is a function which can be used to calibrate a new screen. It must be used only once preferably by a stand alone program, in the `setup`.

```
//----- Calibrate touch  
//  AWContext::calibrateTouch () ;
```

This program is a help to determine the following constants :

```
const float xA = 310.0 ; // 571.0 ;  
const float yA = 116.0 ; // 963.0 ;  
  
const float xB = 3811.0 ; // 488.0 ;  
const float yB = 113.0 ; // 3001.0 ;  
  
const float xC = 3814.0 ; // 3526.0 ;  
const float yC = 3936.0 ; // 3349.0 ;  
  
const float xD = 362.0 ; // 3519.0 ;  
const float yD = 3938.0 ; // 698.0 ;
```

Another help for debugging is to add the following lines in your `setup` :

```
//----- Debug touch  
// For enabling touch debug, uncomment the following line  
//  AWContext::debugTouch (AWColor::red ()) ;  
// if this line is uncommented, when a touch occurs, event is not  
//   sent to widgets, but a small square of the given  
//   color is drawn at touch location. This enables you to adjust  
//   the convertTouchPointToScreenPoint function  
// (see convertTouchPointToScreenPoint.cpp) that converts touch  
//   location to actual screen location.
```