AN4323
Application note

Getting started with STemWin Library

Introduction

A partnership with Segger Microcontroller GmbH & Co. KG enables STMicroelectronics to provide STemWin Library, a product based on Segger's emWin graphic library.

The STemWin Library is a professional graphical stack library enabling the building up of graphical user interfaces (GUIs) with any STM32, LCD/TFT display and LCD/TFT controller, taking advantage of STM32 hardware acceleration whenever possible.

The STemWin Library is a comprehensive solution with rich features, such as JPG, GIF and PNG decoding, many widgets (checkboxes, buttons…), and a VNC server. It allows a local display to be displayed remotely, and also professional tools (such as GUIBuilder) to create dialog boxes by a drag and drop font converter.

This graphic library is fully integrated inside the STM32Cube firmware packages (such as STM32CubeF2, STM32CubeF3 and STM32CubeF4). It can be downloaded free from the STMicroelectronics web site (http://www.st.com/stm32cube)

Table 1. Applicable software

Type	Part numbers
MCUs Embedded Software	STemWin, STM32CubeF0, STM32CubeF1, STM32CubeF2, STM32CubeF3, STM32CubeF4, STM32CubeF7, STM32CubeL1, STM32CubeL4 and STM32CubeH7

Contents

List of tables

List of figures

1 General information

The STemWin supports Arm®[a]-based devices.

arm

2 Library and package presentation

The STemWin Library package includes a set of firmware libraries and software tools used to build advanced and professional GUI-based applications.

2.1 Licensing information

- STemWin Library GUI files are provided in object format and licensed under MCD-ST Image Software License Agreement V2 (the “License”); you may not use this package except in compliance with the License. You may obtain a copy of the License at: www.st.com.
- STemWin Library configuration and header files are provided in source format and licensed under MCD-ST Liberty Software License Agreement V2 (the “License”); you may not use this package except in compliance with the License. You may obtain a copy of the License at: www.st.com.

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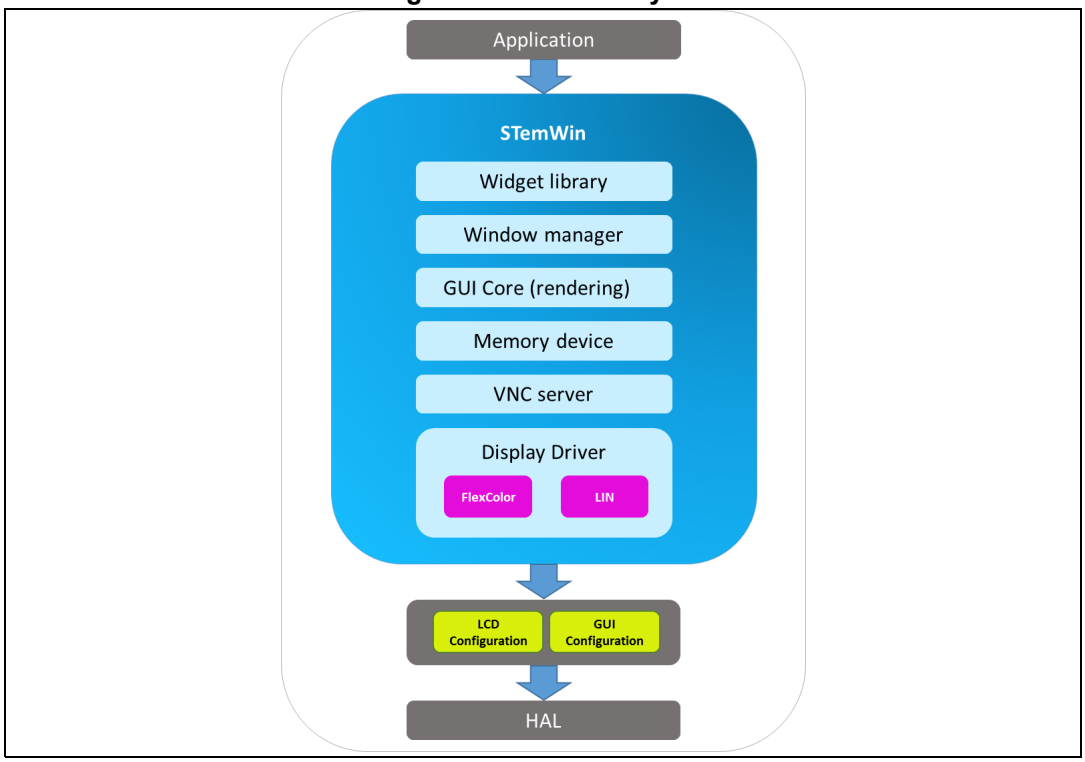
2.2 Library description

Figure 1 shows how STemWin is structured internally and how it can be implemented in a complete project.

a. Arm is a registered trademark of Arm Limited (or its subsidiaries) in the US and/or elsewhere.

Figure 1. STemWin layers



1. The CRC module (in RCC peripheral clock enable register) should be enabled before using the library.

STemWin Library includes two optimized drivers:

- Direct linear access (LIN) driver. This kind of driver is used for example on STM32F429, STM32F769, STM32H743 and any STM32 based on the LCD TFT Display Controller (LTDC) or LTDC/DSI (Display Serial Interface) hardware.
- FlexColor (indirect access) driver for serial and parallel bus external LCD controllers.

Refer to *Table 2* for a list of all supported display controllers.

Note: It is still possible to support any other LCD type just by implementing its own "custom" driver.

In addition to the main application, the user has to set and customize two essential interface files:

- LCD configuration file (LCDConf.c)
  - LCD Display initialization and configuration
  - LCD Display driver link and customizing
  - Additional hardware capability management
- GUI configuration file (GUIConf.c)
  - GUI management

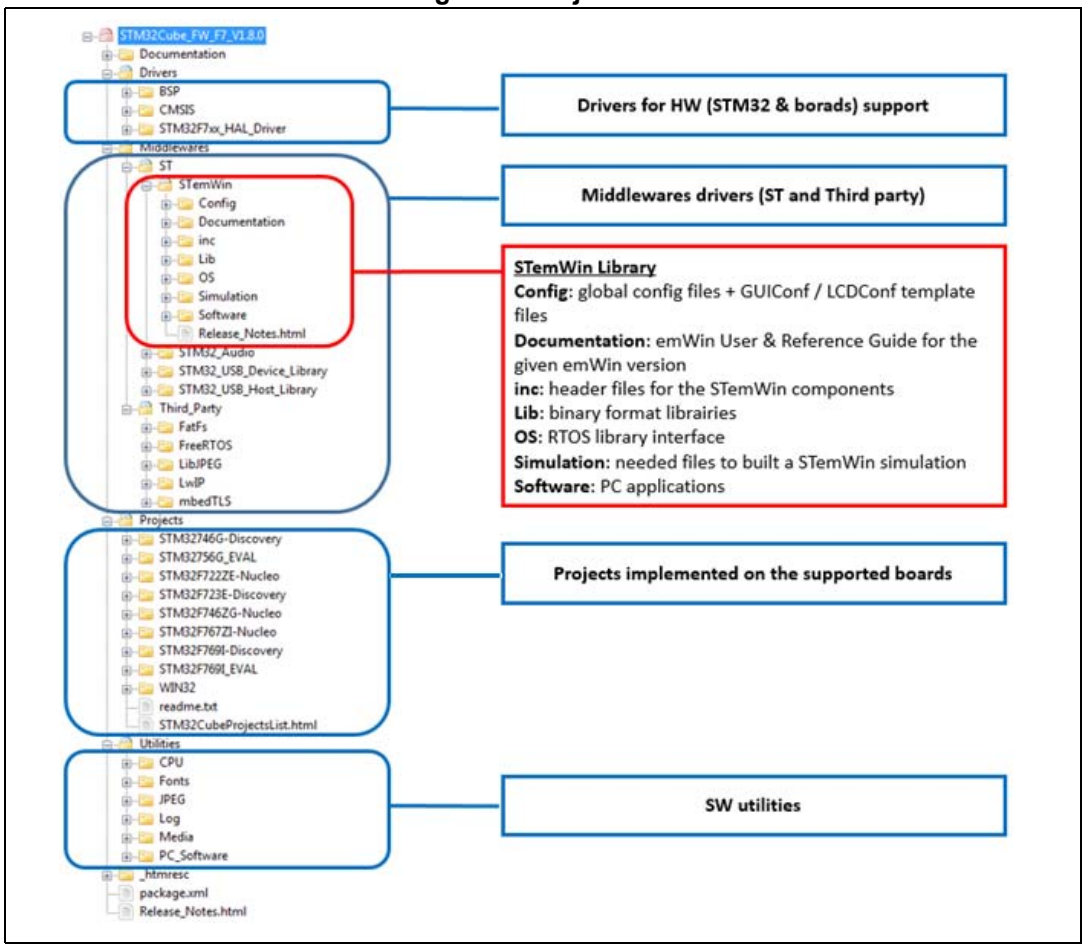
Table 2. Supported LCD controllers

Driver	Supported LCD controllers	Supported bits/pixels
GUIDRV_Lin	This driver supports every display controller with linear addressable video memory with a direct (full bus) interface. This means that the video RAM is directly addressable by the address lines of the CPU. The driver contains no controller-specific code. So it can also be used for solutions without display controller which require a driver which only manages the video RAM.	1, 2, 4, 8, 16, 24, 32
GUIDRV_FlexColor	**Epson** S1D19122 **FocalTech** FT1509 **Himax** HX8353, HX8325A, HX8357, HX8340, HX8347, HX8352A, HX8352B, HX8301 **Hitachi** HD66772 **Ilitek** ILI9320, ILI9325, ILI9328, ILI9335, ILI9338, ILI9340, ILI9341, ILI9342, ILI9163, ILI9481, ILI9486, ILI9488, ILI9220, ILI9221 **LG Electronics** LGDP4531, LGDP4551, GDP4525 **Novatek** NT39122 **OriseTech** SPFD5408, SPFD54124C, SPFD5414D **Raio** RA8870, RA8875 **Renesas** R61505, R61516, R61526, R61580 **Samsung** S6E63D6, S6D0117 **Sitronix** ST7628, ST7637, ST7687, ST7735, ST7712 **Solomon** SSD1284, SSD1289, SSD1298, SSD1355, SSD2119, SSD1963, SSD1961, SSD1351 **Syncoam** SEPS525	16, 18

2.3 Package organization

Figure 2 shows the project tree.

Figure 2. Project tree



2.4 Delivered binaries

STemWin Library is distributed by ST as an object code library locked to STM32 products.

The library is compiled for CM0 and CM3 cores:

- With and without OS support.
- With Size optimization
- Using ABGR and ARGB format

The library is compiled for CM4 and CM7 cores:

- With and without OS support.
- With size and time optimization
- Using ABGR and ARGB format
- The FPU is enabled.

Note: The library is compiler-dependent (IAR, Arm, GCC).

The library is also compiled for WIN32 simulation

- Using ABGR and ARGB format

Note: In the STM32CubeFW relative to a given core, only binary files generated for this core and simulation one are included in the package.

To summarize, 74 binary files are generated and split as follow:

For a CMx (CM0 and CM3) core there are 12 binaries:

- STemWinXY_CMx_GCC.a
- STemWinXY_CMx_GCC_ARGB.a
- STemWinXY_CMx_IAR.a
- STemWinXY_CMx_IAR_ARGB.a
- STemWinXY_CMx_Keil.lib
- STemWinXY_CMx_Keil_ARGB.lib
- STemWinXY_CMx_OS_GCC.a
- STemWinXY_CMx_OS_GCC_ARGB.a
- STemWinXY_CMx_OS_IAR.a
- STemWinXY_CMx_OS_IAR_ARGB.a
- STemWinXY_CMx_OS_Keil.lib
- STemWinXY_CMx_OS_Keil_ARGB.lib

For a CMx (CM4 and CM7) core there are 24 binaries:

- STemWinXY_CMx_GCC.a
- STemWinXY_CMx_GCC_ARGB.a
- STemWinXY_CMx_GCC_ot.a
- STemWinXY_CMx_GCC_ot_ARGB.a
- STemWinXY_CMx_IAR.a
- STemWinXY_CMx_IAR_ARGB.a
- STemWinXY_CMx_IAR_ot.a
- STemWinXY_CMx_IAR_ot_ARGB.a
- STemWinXY_CMx_Keil.lib
- STemWinXY_CMx_Keil_ARGB.lib
- STemWinXY_CMx_Keil_ot.lib
- STemWinXY_CMx_Keil_ot_ARGB.lib
- STemWinXY_CMx_OS_GCC.a
- STemWinXY_CMx_OS_GCC_ARGB.a
- STemWinXY_CMx_OS_GCC_ot.a
- STemWinXY_CMx_OS_GCC_ot_ARGB.a
- STemWinXY_CMx_OS_IAR.a
- STemWinXY_CMx_OS_IAR_ARGB.a
- STemWinXY_CMx_OS_IAR_ot.a
- STemWinXY_CMx_OS_IAR_ot_ARGB.a
- STemWinXY_CMx_OS_Keil.lib
- STemWinXY_CMx_OS_Keil_ARGB.lib
- STemWinXY_CMx_OS_Keil_ot.lib
- STemWinXY_CMx_OS_Keil_ot_ARGB.lib

Then user add the simulation binaries:

- STemWinXY_WIN32.lib
- STemWinXY_WIN32_ARGB.lib

3 Supported boards and examples

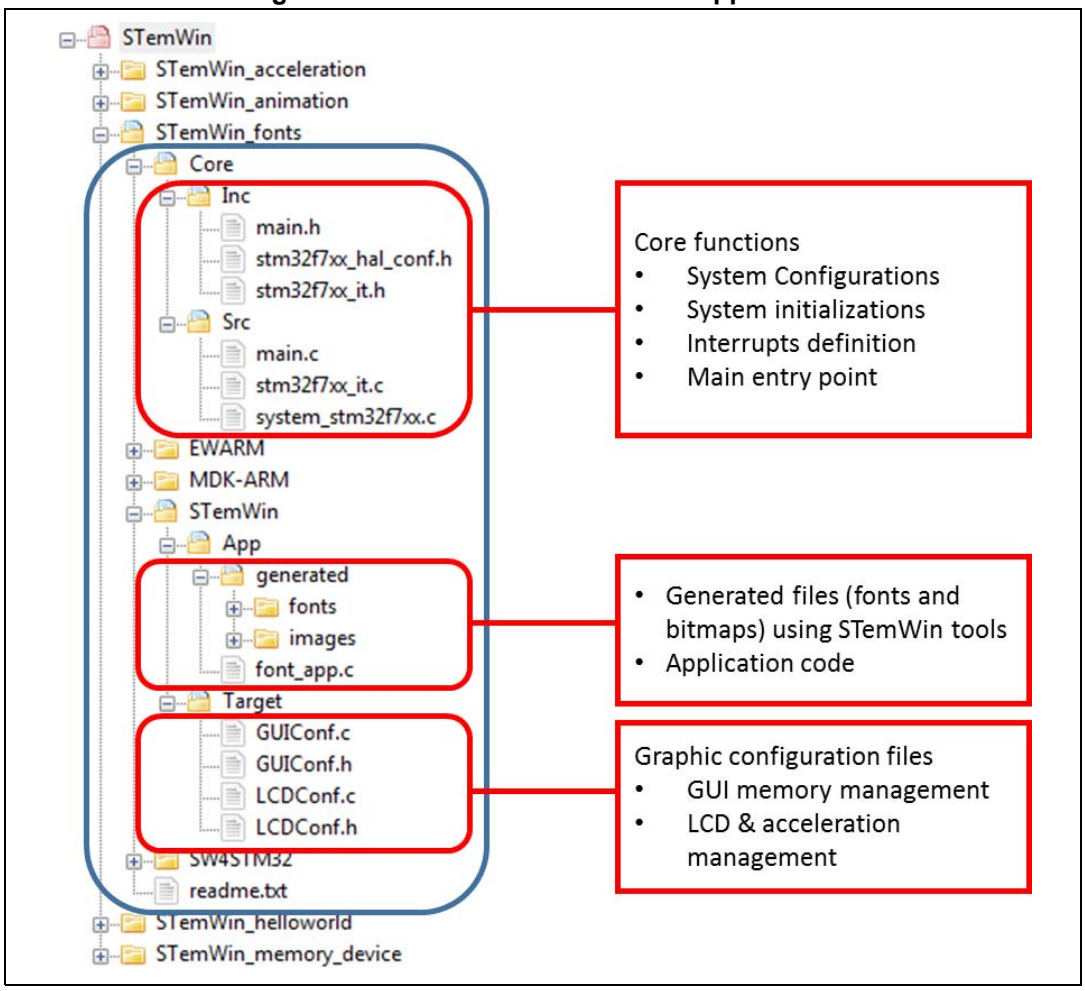
Table 3 lists the supported boards and examples.

Table 3. Supported boards and examples

STM32 Series/board		LCD interface	LCD driver
STM32F0	STM32091C-EVAL	SPI	FlexColor
STM32F1	STM3210C-EVAL	SPI	FlexColor
	STM3210E-EVAL	FSMC	
STM32F2	STM322xG-EVAL	FSMC	FlexColor
STM32F3	STM32303C-EVAL	SPI	FlexColor
	STM32303E-EVAL	SPI	
	STM32373C-EVAL	SPI	
STM32F4	STM32F412G-DISCO	FMC	FlexColor
	STM32F413G-DISCO	FMC	FlexColor
	STM32F429I-DISCO	LTDC	Lin
	STM32F4x9I-EVAL	LTDC	Lin
	STM32F4xG-EVAL	FSMC	FlexColor
	STM32F446E-EVAL	FMC	FlexColor
	STM32F469I-EVAL	LTDC/DSI	Lin
	STM32F469I-DISCO	LTDC/DSI	Lin
STM32F7	STM32F723E-DISCO	FMC	FlexColor
	STM32F769I-EVAL	LTDC/DSI	Lin
	STM32F769I-DISCO	LTDC/DSI	Lin
	STM32F746G-DISCO	LTDC	Lin
	STM32F756G-EVAL	LTDC	Lin
STM32H7	STM32H743I-EVAL	LTDC	Lin
STM32L1	STM32L152D-EVAL	FSMC	FlexColor
STM32L4	STM32L49I-EVAL-MB1314	GFXMMU/LTDC/DSI	Lin
	STM32L49I-EVAL-MB1315	LTDC	Lin
	STM32L49I-DISCO	GFXMMU/LTDC/DSI	Lin
	STM32L476G-EVAL	FMC	FlexColor
	STM32L496G-DISCO	FMC	FlexColor

Figure 3 shows the architecture of a given STemWin application.

Figure 3. Structure of the STemWin application



The “Target” folder contains the two interface files described in *Section 2.2*:

- GUIConf.c/.h
- LCDConf.c/.h

A STemWin application can be built using or not an OS. On the application architecture presented above it’s a non OS case.

4 How to use STemWin Library step by step

This section provides an overview of the main features of STemWin Library, as well as the main settings and configuration steps. For further details, refer to the Segger's emWin User Manual.

4.1 Configuration

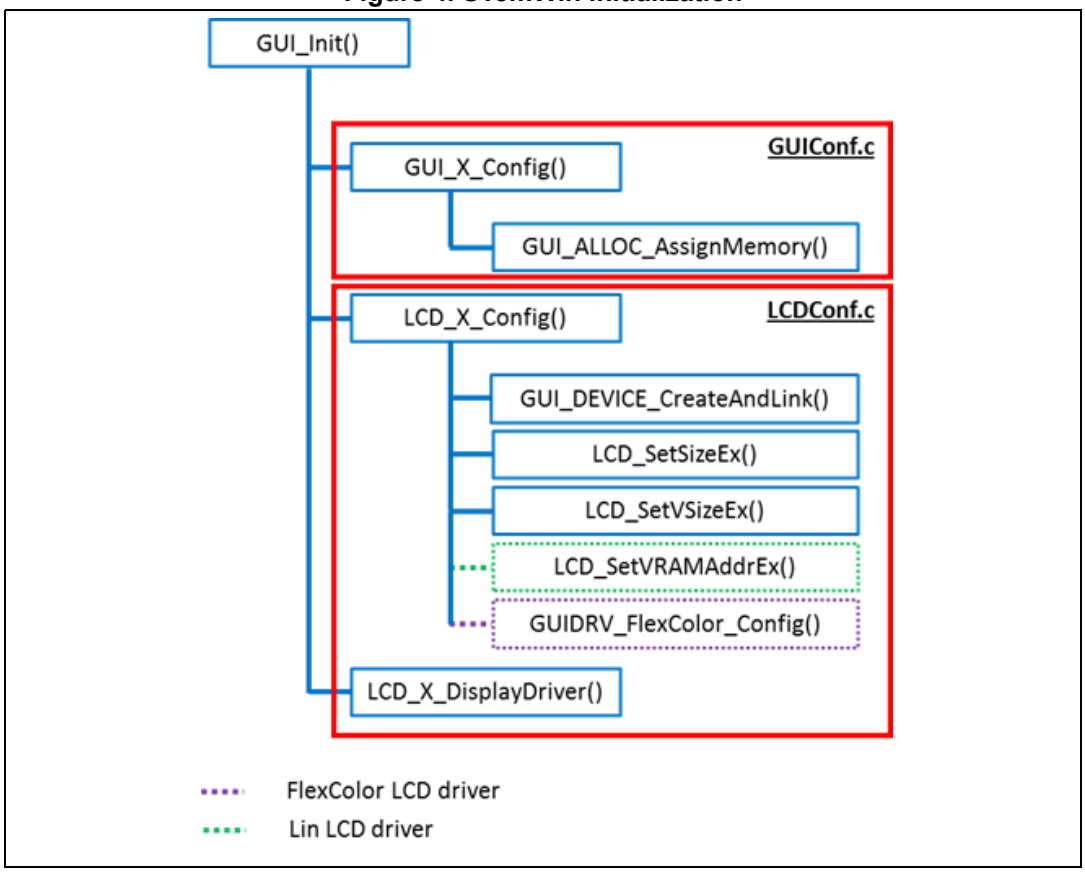
The configuration is basically divided into two parts: GUI configuration and LCD configuration.

- The GUI configuration covers the configuration of default colors and fonts and of available memory.
- The LCD configuration is more hardware-dependent and enables the user to define the different graphical parameters, the display driver, the color conversion routines to be used and the drawing accelerated function if the STM32 support Chrom-ART.

When a new LCD controller needs to be supported, two essential files must be created/modified: GUIConf.c and LCDConf.c.

The stack initialization done by calling "GUI_Init()" function is based on these 2 files as shown in *Figure 4*.

Figure 4. STemWin initialization



4.1.1 GUIConf.c

In this file, the user should implement the GUI_X_Config() function which is the very first routine called during the initialization process. Its main task is to set up the available memory for the GUI and to then assign it to the dynamic memory management system.

This operation is done via the GUI_ALLOC_AssignMemory() function: it passes a pointer to a memory block and its size (in bytes) to the memory manager.

Note: The memory must be accessible and must be 8-, 16- and 32-bit wide. Memory access is checked during initialization.

4.1.2 LCDConf.c

The main function here is LCD_X_Config(), called immediately after GUI_X_Config() has been executed. LCD_X_Config() allows creating and configuring a display driver for each layer by calling:

- GUI_DEVICE_CreateAndLink(), which creates the driver device and links it to the device chain;
- LCD_SetSizeEx() and LCD_SetVSizeEx(), to set the display size configuration;
- Other driver-specific configuration routines such as:
  - GUIDRV_FlexColor_Config(), in association with the usage of the FlexColor driver;
  - LCD_SetVRAMAddrEx(), required in case of linear addressable memory.

As mentioned in *Section 2.2*, STemWin Library comes with two optimized drivers, GUIDRV_Lin and GUIDRV_FlexColor, which cover all the LCDs embedded in ST EVAL-boards.

For more details about usage of these drivers, please visit Segger's website:

http://www.segger.com

In general, when a new LCD type needs to be supported, the user should check if the same LCD controller is already supported, then he just has to update the already existing LCDConf.c.

Another function, LCD_X_DisplayDriver(), is called by the display driver for several purposes, for example when using advanced features like multiple buffers, smooth scrolling or virtual pages. To support the corresponding task, the routine needs to be adapted to the display controller.

If the used display controller is not supported, user can easily create his own driver just by adapting the GUIDRV_Template.c file located under the CubeFW on this path "Middlewares\ST\STemWin\Config".

Actually this template file contains the complete functionality needed for a display driver. The main routines that need to be adapted are _SetPixelIndex() and _GetPixelIndex(). If the display is not readable, a display data cache should be implemented instead of using the _GetPixelIndex() function.

4.1.3 Hardware acceleration

In order to decrease the CPU load and speed up many drawing operations, ST had included a Hardware acceleration IP known as the Chrom-ART in many STM32 products.

EmWin on the other side provide a list of API functions that can be accelerated.

The table below shows currently implemented HW acceleration API functions on the “LCDConf.c”.

Table 4. Hardware acceleration API list

Function	Description
GUICC_M1555I_SetCustColorConv()	Function to set color conversion routines for the according fixed palette modes
GUICC_M565_SetCustColorConv()	
GUICC_M4444I_SetCustColorConv()	
GUICC_M888_SetCustColorConv()	
GUICC_M8888I_SetCustColorConv()	
LCD_DEVFUNC_COPYBUFFER	Id function to set a custom defined routine for copying buffers
LCD_DEVFUNC_FILLRECT	Id function to set a custom defined routine for filling rectangles
LCD_DEVFUNC_COPYRECT	Id function to set a custom defined routine for copying rectangular areas
LCD_DEVFUNC_DRAWBMP_8BPP	Id function to set a custom routine for drawing 8bpp bitmaps
LCD_DEVFUNC_DRAWBMP_16BPP	Id function to set a custom routine for drawing 16bpp bitmaps
LCD_DEVFUNC_DRAWBMP_32BPP	Id function to set a custom routine for drawing 32bpp bitmaps
GUI_SetFuncAlphaBlending()	Function to set up a custom defined function for doing alpha blending operations
GUI_SetFuncGetpPalConvTable()	Function to set up palette conversion of a bitmap into index values
GUI_SetFuncMixColorsBulk()	Function to set up bulk blending operations
GUI_AA_SetpfDrawCharAA4()	Function to set up drawing 4bpp alpha characters
GUI_MEMDEV_SetDrawMemdev16bppFunc()	Function to set up drawing 16bpp bitmaps into 16bpp memory devices.
GUI_SetFuncDrawAlpha()	Function to set up 2 accelerations, first for drawing memory devices with alpha value into another memory device and the second for drawing bitmaps with alpha value.

Remarks:

- Note that not all STM32 products supports HW acceleration.
- On the currently delivered “LCDConf.c” some acceleration API are not yet implemented.

4.1.4 GUI_X.c or GUI_X_OS.c

- GUI_X.c for single task execution:

"Single task" means that the project uses STemWin only from within one single task. The main purpose is to supply STemWin with a timing base. OS_TimeMS needs to be incremented each ms.

- GUI_X_OS.c for multitask execution:

If STemWin is used in a multitasking system, this file contains additional routines required for synchronizing tasks.

All the functions of this file are using the CMSIS-RTOS API which is a generic RTOS interface for Arm® Cortex®-M processor-based devices, which provides a standardized API for software components that require RTOS functionality.

4.2 GUI initialization

To initialize the STemWin internal data structures and variables, GUI_Init() should be used.

Note that before initializing the GUI, the CRC module (in RCC peripheral clock enable register) should be enabled

A simple "Hello world" program illustrates this initialization, as shown below.

"Hello world" example:

```
void Main(void) {
  int xPos, yPos;

   __HAL_RCC_CRC_CLK_ENABLE();
  GUI_Init();

  xPos = LCD_GetXSize() / 2;
  yPos = LCD_GetYSize() / 3;
  GUI_SetFont(GUI_FONT_COMIC24B_ASCII);
  GUI_DispStringHCenterAt("Hello world!", xPos, yPos);
  while(1);
}
```

4.3 Core functions

4.3.1 Image file display

STemWin currently supports the BMP, JPEG, GIF and PNG file formats. The library includes rich APIs for each one of these image formats (fully documented in the STemWin User Manual). An approximation of the memory resources needed for each image type is given in *Section 5: Performance and footprint*.

4.3.2 Bidirectional text

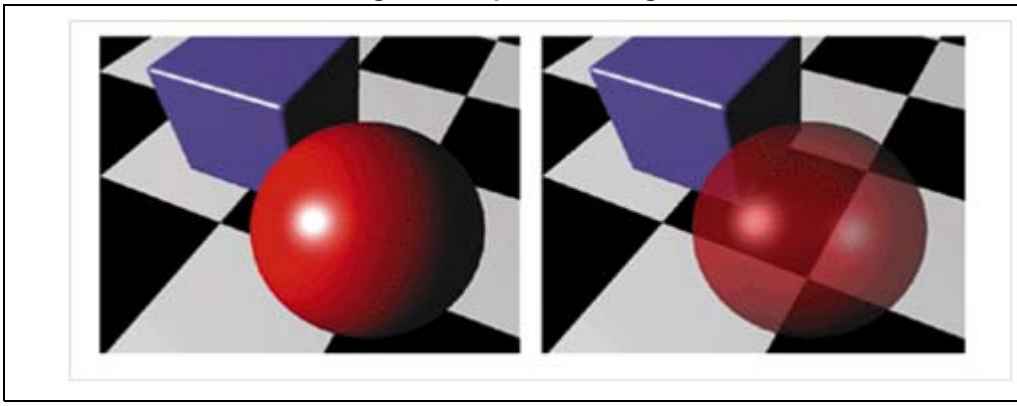
Drawing Arabic or Hebrew text with STemWin is quite easy and is supported automatically in each text-based function. It only needs to be enabled once by using the following command:

```
GUI_UC_EnableBIDI()
```

4.3.3 Alpha blending

Alpha blending is a method combining the alpha channel with other layers in an image in order to create the appearance of semi-transparency (see *Figure 5*).

Figure 5. Alpha blending effect



The user can enable automatic alpha blending using the following command:

```
GUI_EnableAlpha()
```

He can also give an alpha value to determine how much of a pixel should be visible and how much of the background should show through:

```
GUI_SetUserAlpha()
```

4.3.4 Sprites and cursors

A sprite is an image which can be shown above all other graphics on the screen.

A sprite preserves the screen area it covers. It can be moved or removed at any time, fully restoring the screen content. Animation by use of multiple images is also possible.

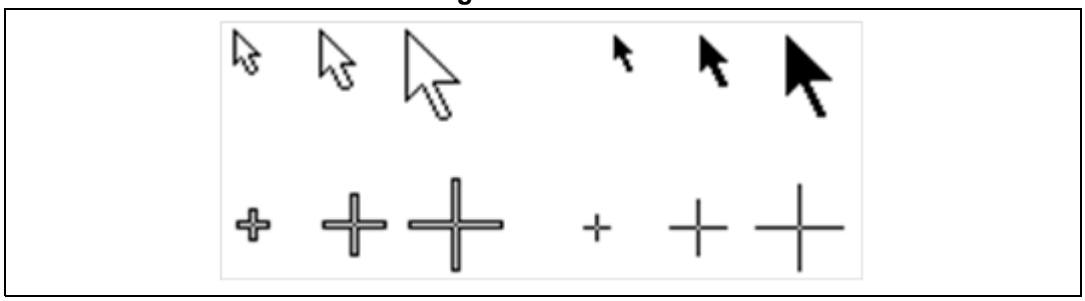
Figure 6. Animated sprites

Sprites can be animated (*Figure 6*) by calling `GUI_SPRITE_CreateAnim()`.

Note that sprites manage the background automatically.

STemWin also includes a system-wide cursor (*Figure 7*), which can also be animated by using `GUI_CURSOR_SetAnim()`. Cursors are actually based on sprites.

Figure 7. Cursors



Although the cursor always exists, it is hidden by default. It is not visible until a call is made to show it (`GUI_CURSOR_Show()`), and may be hidden again at any point (`GUI_CURSOR_Hide()`).

4.4 Memory devices

A memory device is a hardware-independent destination device for drawing operations.

If a memory device is created (by calling `GUI_MEMDEV_Create()`) then validated (by calling `GUI_MEMDEV_Select()`), all drawing operations are executed in memory. The final result is displayed on the screen only when all operations have been finished. This action is done by calling `GUI_MEMDEV_CopyToLCD()`.

Memory devices can be used:

- to prevent flickering effect (due to direct drawing on the display),
- as containers for decompressed images,
- for rotating (`GUI_MEMDEV_Rotate()`) and scaling operations (*Figure 8*),
- for fading operations,
- for window animations,
- for transparency effects.

Figure 8. Scaling and rotation effect using memdev

Since memory devices need a considerable amount of memory (see component “Memory Device” in *Table 8*), it is advised to use an external memory if available.

4.5 Antialiasing

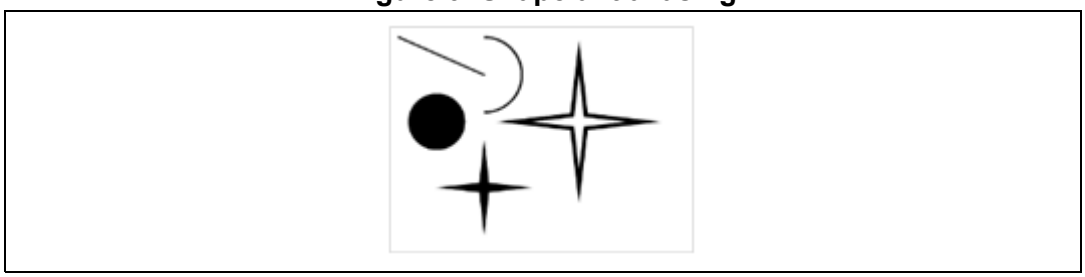
Antialiasing smoothes curves and diagonal lines by “blending” the background color with the foreground one. This is done by adding intermediate colors between object and background.

Shape antialiasing

STemWin supports antialiased drawing of:

- Text (Font Converter is required to create AA fonts)
- Arcs (`GUI_AA_DrawArc()`)
- Circles (`GUI_AA_FillCircle()`)
- Lines (`GUI_AA_DrawLine()`)
- Polygons (`GUI_AA_DrawPolyOutline()` and `GUI_AA_FillPolygon()`)

Figure 9. Shape antialiasing



4.6 Window Manager

Window Manager can be described as:

- A management system for a hierarchic window structure:
  - Each layer has its own desktop window. Each desktop window can have its own hierarchic tree of child windows.
- A callback mechanism-based system:
  - Communication is based on an event-driven callback mechanism. All drawing operations should be done within the WM_PAINT event.
- The foundation of the widget library:
  - All widgets are based on the functions of the Window Manager.

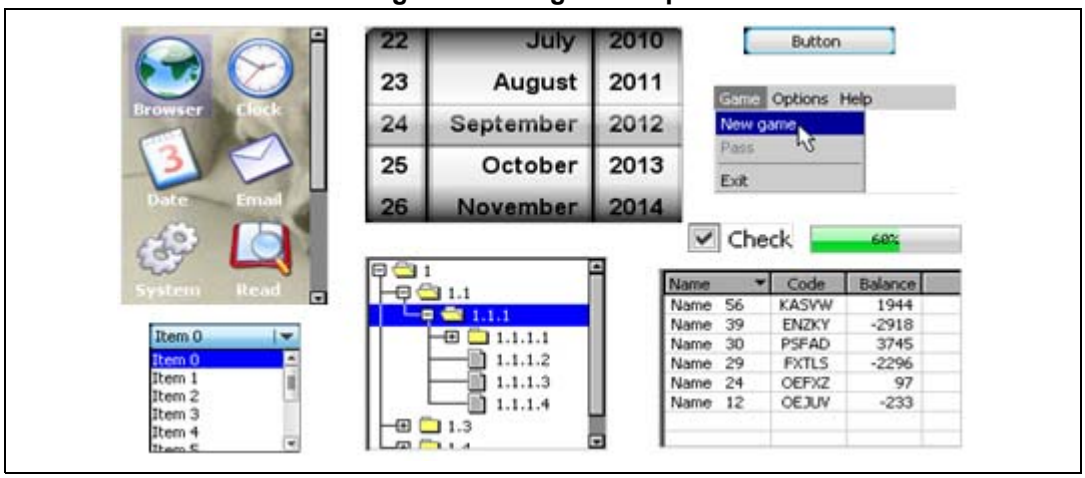
4.7 Widget library

Widgets (**Wi**ndow + Ga**dge**t) are windows with object-type properties. They require the Window Manager.

A list of all widgets available in STemWin Library can be found at: http://www.segger.com

Once a widget is created, it is treated just like any other window. The Window Manager ensures that it is properly displayed (and redrawn) whenever necessary.

Figure 10. Widget examples



Widget creation

Creating a widget can be done with one line of code.

There are basically two ways of creating a widget:

- Direct creation:

Creation functions exist for each widget:

  - `<WIDGET>_CreateEx()`: creation without user data.
  - `<WIDGET>_CreateUser()`: creation with user data.

- Indirect creation:

"Indirect" means here using a dialog box creation function and a GUI_WIDGET_CREATE_INFO structure which contains a pointer to the indirect creation routine:

  - `<WIDGET>_CreateIndirect()`: creation by dialog box creation function.

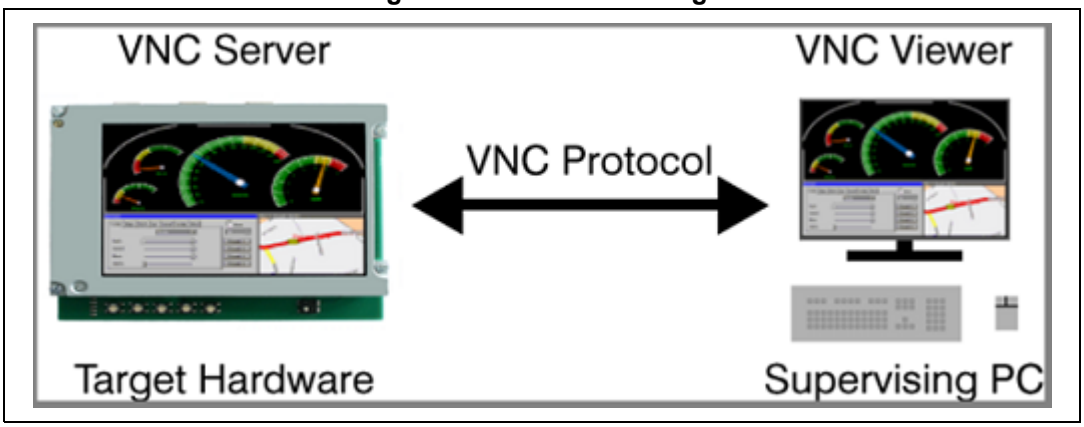
4.8 VNC server

VNC stands for "Virtual Network Computing". The VNC server is used to connect the embedded target to a network PC via TCP/IP, which allows to:

- view the LCD content on the distant PC monitor, and to
- control the embedded environment using the mouse.

In other words, the display contents of the embedded device are visible on the screen of the machine running the client (for example, a network PC); the mouse and keyboard can then be used to control the target.

Figure 11. VNC server usage



4.8.1 Requirements

- An STM32 device with embedded Ethernet IP, such as STM32F107xx, STM32F2x7xx or STM32F4x7xx.
- A TCP/IP stack should be present in the target. In the delivered demo, LwIP is used.
- The VNC server should run as a separate thread. Therefore, a multitasking system is required to use the emWin VNC server. In our case, the demo package runs with FreeRTOS.
- A VNC viewer (such as RealVNC, TightVNC, UltraVNC…) should be present in the supervising PC.

4.8.2 Process description

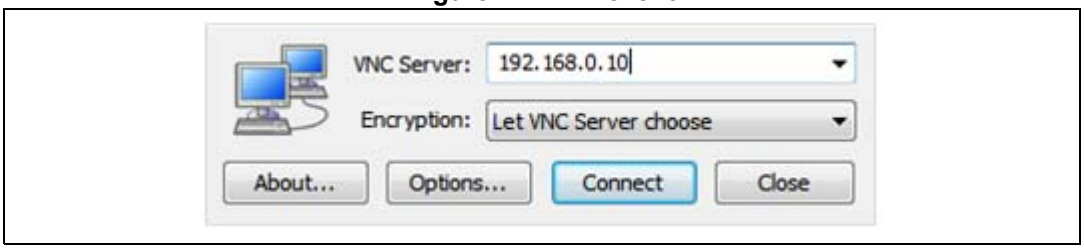
- Connect the target hardware to the network (or to the PC, if a local connection is needed) via an Ethernet cable.
- Run the demo.
  - The VNC_Server_task is a sub-task of the Background_Task.
  - After hardware (LEDs, Touch Screen, SRAM…) and GUI initialization, the TCP/IP (LwIP) stack is also initialized.
  - Then GUI_VNC_X_StartServer() is called to:

  a) initialize the VNC context and attach it to a layer,

  b) create a task for the VNC server, which listens on port 5900 until an incoming connection is detected and then runs the actual server (by calling `GUI_VNC_Process()`).
- If DHCP is enabled ("`#define USE_DHCP`" in main.h):
  - Wait for the IP address to be assigned by the DHCP server; it will be displayed in the "VNC Server" page (just after the "Intro" page).
  - If it is impossible to retrieve any IP address (DHCP timeout), a predefined static IP address is assigned and displayed.
- If DHCP is disabled (or in case of DHCP timeout):
  - Wait for a static IP address to be displayed.
  - Configure the IP address and the subnet mask of the PC with the same class address as used in the target hardware.
- Start the VNC viewer.
  - Connect to the IP address of the target hardware (see *Figure 12*).
  - The demo is then displayed on the PC.
- Using the VNC viewer, the user can:
  - Watch the running demo on the PC monitor (live streaming);
  - Control the target hardware from the PC (using the mouse);
  - Take screenshots of the demo (if needed for a manual, for example).

Note: Breaking the viewer's connection to the server and then reconnecting does not result in any loss of data.

Figure 12. VNC client



4.9 Fonts

The most common fonts are included in STemWin Library as a standard font package. All of them contain the ASCII character set and most of them also the ISO 8859-1 characters.

A complete list of the embedded fonts is shown below (taken from GUI.h).

Note: The STemWin Library default font is GUI_Font6x8.

4.9.1 Fonts included in STemWin library

```
//
// Proportional fonts
//
#define GUI_FONT_8_ASCII         &GUI_Font8_ASCII
#define GUI_FONT_8_1             &GUI_Font8_1
#define GUI_FONT_10S_ASCII       &GUI_Font10S_ASCII
#define GUI_FONT_10S_1           &GUI_Font10S_1
#define GUI_FONT_10_ASCII        &GUI_Font10_ASCII
#define GUI_FONT_10_1            &GUI_Font10_1
#define GUI_FONT_13_ASCII        &GUI_Font13_ASCII
#define GUI_FONT_13_1            &GUI_Font13_1
#define GUI_FONT_13B_ASCII       &GUI_Font13B_ASCII
#define GUI_FONT_13B_1           &GUI_Font13B_1
#define GUI_FONT_13H_ASCII       &GUI_Font13H_ASCII
#define GUI_FONT_13H_1           &GUI_Font13H_1
#define GUI_FONT_13HB_ASCII      &GUI_Font13HB_ASCII
#define GUI_FONT_13HB_1          &GUI_Font13HB_1
#define GUI_FONT_16_ASCII        &GUI_Font16_ASCII
#define GUI_FONT_16_1            &GUI_Font16_1
#define GUI_FONT_16_HK           &GUI_Font16_HK
#define GUI_FONT_16_1HK          &GUI_Font16_1HK
#define GUI_FONT_16B_ASCII       &GUI_Font16B_ASCII
#define GUI_FONT_16B_1           &GUI_Font16B_1
#define GUI_FONT_20_ASCII        &GUI_Font20_ASCII
#define GUI_FONT_20_1            &GUI_Font20_1
#define GUI_FONT_20B_ASCII       &GUI_Font20B_ASCII
#define GUI_FONT_20B_1           &GUI_Font20B_1
#define GUI_FONT_24_ASCII        &GUI_Font24_ASCII
#define GUI_FONT_24_1            &GUI_Font24_1
#define GUI_FONT_24B_ASCII       &GUI_Font24B_ASCII
#define GUI_FONT_24B_1           &GUI_Font24B_1
#define GUI_FONT_32_ASCII        &GUI_Font32_ASCII
#define GUI_FONT_32_1            &GUI_Font32_1
#define GUI_FONT_32B_ASCII       &GUI_Font32B_ASCII
#define GUI_FONT_32B_1           &GUI_Font32B_1
```

```
//
// Proportional fonts, framed
//
#define GUI_FONT_20F_ASCII      &GUI_Font20F_ASCII

//
// Monospaced
//
#define GUI_FONT_4X6            &GUI_Font4x6
#define GUI_FONT_6X8            &GUI_Font6x8
#define GUI_FONT_6X8_ASCII      &GUI_Font6x8_ASCII
#define GUI_FONT_6X8_1          &GUI_Font6x8_1
#define GUI_FONT_6X9            &GUI_Font6x9
#define GUI_FONT_8X8            &GUI_Font8x8
#define GUI_FONT_8X8_ASCII      &GUI_Font8x8_ASCII
#define GUI_FONT_8X8_1          &GUI_Font8x8_1
#define GUI_FONT_8X9            &GUI_Font8x9
#define GUI_FONT_8X10_ASCII     &GUI_Font8x10_ASCII
#define GUI_FONT_8X12_ASCII     &GUI_Font8x12_ASCII
#define GUI_FONT_8X13_ASCII     &GUI_Font8x13_ASCII
#define GUI_FONT_8X13_1         &GUI_Font8x13_1
#define GUI_FONT_8X15B_ASCII    &GUI_Font8x15B_ASCII
#define GUI_FONT_8X15B_1        &GUI_Font8x15B_1
#define GUI_FONT_8X16           &GUI_Font8x16
#define GUI_FONT_8X17           &GUI_Font8x17
#define GUI_FONT_8X18           &GUI_Font8x18
#define GUI_FONT_8X16X1X2       &GUI_Font8x16x1x2
#define GUI_FONT_8X16X2X2       &GUI_Font8x16x2x2
#define GUI_FONT_8X16X3X3       &GUI_Font8x16x3x3
#define GUI_FONT_8X16_ASCII     &GUI_Font8x16_ASCII
#define GUI_FONT_8X16_1         &GUI_Font8x16_1

//
// Digits
//
#define GUI_FONT_D24X32         &GUI_FontD24x32
#define GUI_FONT_D32            &GUI_FontD32
#define GUI_FONT_D36X48         &GUI_FontD36x48
#define GUI_FONT_D48            &GUI_FontD48
#define GUI_FONT_D48X64         &GUI_FontD48x64
#define GUI_FONT_D64            &GUI_FontD64
#define GUI_FONT_D60X80         &GUI_FontD60x80
#define GUI_FONT_D80            &GUI_FontD80

//
```

```
// Comic fonts
//
#define GUI_FONT_COMIC18B_ASCII &GUI_FontComic18B_ASCII
#define GUI_FONT_COMIC18B_1     &GUI_FontComic18B_1
#define GUI_FONT_COMIC24B_ASCII &GUI_FontComic24B_ASCII
#define GUI_FONT_COMIC24B_1     &GUI_FontComic24B_1
```

In most cases, those fonts are found sufficient. However, if needed, STemWin also supports several external font formats:

- System Independent Font (SIF) format
- External Bitmap Font (XBF) format
- TrueType Font (TTF) format

For those, STemWin Library includes a rich font API. See *Table 5*.

Table 5. Font API

Routine	Description
C file related font functions	
GUI_SetDefaultFont()	Sets the default font.
GUI_SetFont()	Sets the current font.
'SIF' file related font functions	
GUI_SIF_CreateFont()	Creates and selects a font by passing a pointer to system-independent font data.
GUI_SIF_DeleteFont()	Deletes a font previously created by GUI_SIF_CreateFont().
'TTF' file related font functions	
GUI_TTF_CreateFont()	Creates a GUI font from a TTF font file.
GUI_TTF_DestroyCache()	Destroys the cache of the TTF engine.
GUI_TTF_Done()	Frees all dynamically allocated memory of the TTF engine.
GUI_TTF_GetFamilyName()	Returns the family name of the font.
GUI_TTF_GetStyleName()	Returns the style name of the font.
GUI_TTF_SetCacheSize()	Can be used to set the default size of the TTF cache.
'XBF' file related font functions	
GUI_XBF_CreateFont()	Creates and selects a font by passing a pointer to a callback function, which then extracts data from the XBF font file.
GUI_XBF_DeleteFont()	Deletes a font previously created by GUI_XBF_CreateFont().
Common font-related functions	
GUI_GetCharDistX()	Returns the width in pixels (X-size) of a specified character in the current font.
GUI_GetFont()	Returns a pointer to the currently selected font.
GUI_GetFontDistY()	Returns the Y-spacing of the current font.
GUI_GetFontInfo()	Returns a structure containing font information.

Table 5. Font API (continued)

Routine	Description
GUI_GetFontSizeY()	Returns the height in pixels (Y-size) of the current font.
GUI_GetLeadingBlankCols()	Returns the number of leading blank pixel columns of the given character.
GUI_GetStringDistX()	Returns the X-size of a text using the current font.
GUI_GetTextExtend()	Evaluates the size of a text using the current font
GUI_GetTrailingBlankCols()	Returns the number of trailing blank pixel columns of the given character.
GUI_GetYDistOfFont()	Returns the Y-spacing of a particular font.
GUI_GetYSizeOfFont()	Returns the Y-size of a particular font.
GUI_IsInFont()	Evaluates whether a specified character belongs to a particular font.

4.9.2 How to add a new font

In order to be able to use any desired font when building our application, STemWin provides a tool called “Font Converter”.

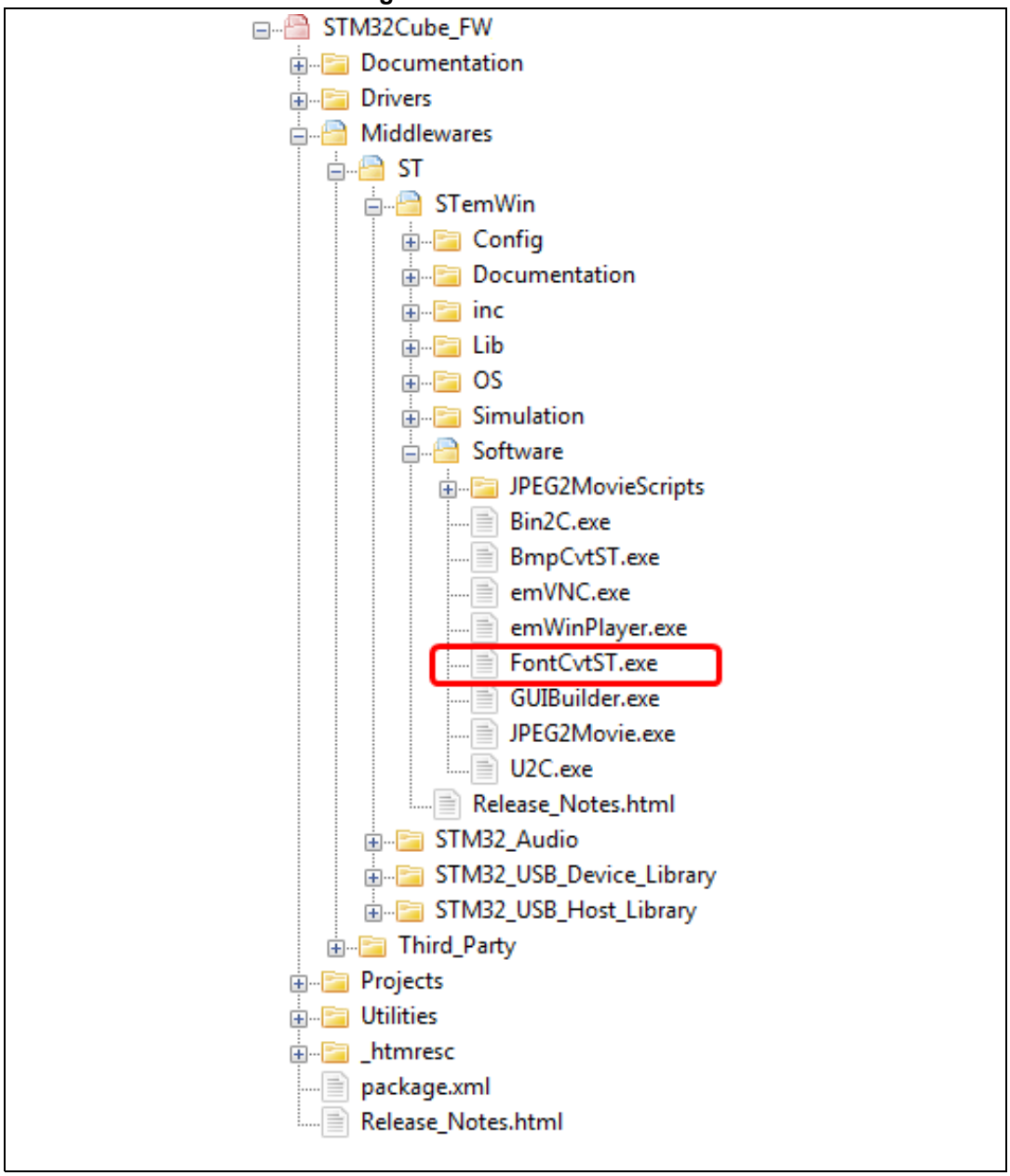
As a Windows program, it allows a convenient converting of any PC installed font into a STemWin (bitmap) font which can be easily integrated into our application.

The generated fonts will be defined either in C files or as binary files containing System Independent Fonts (SIF) or External Bitmap Font (XBF).

Only the generation of a C file from an installed font on the PC will be detailed on this part.

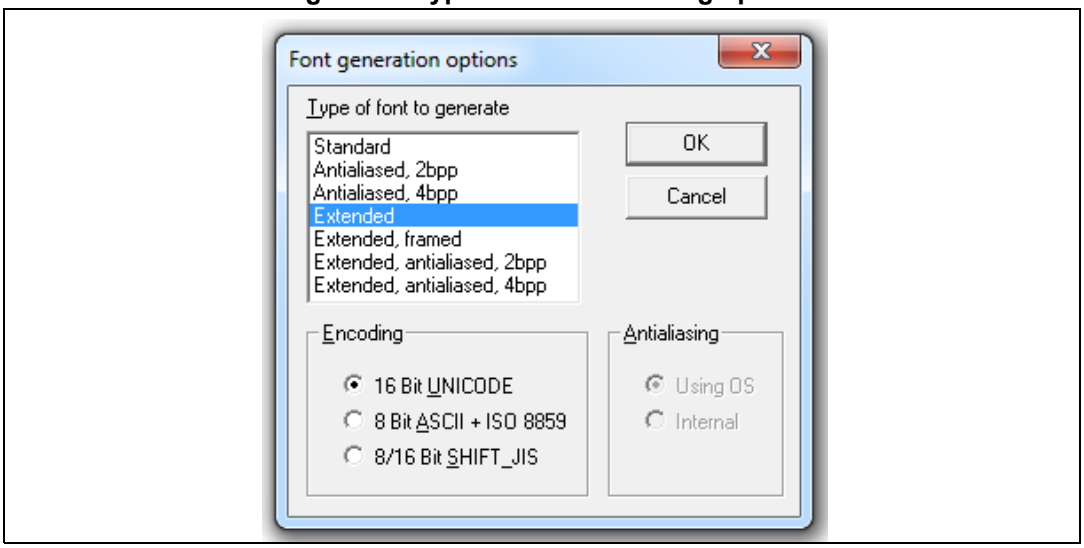
On the STM32CubeFW, go to the following path “Middlewares\ST\STemWin\Software” and execute “FontCvtST.exe”

Figure 13. Font converter



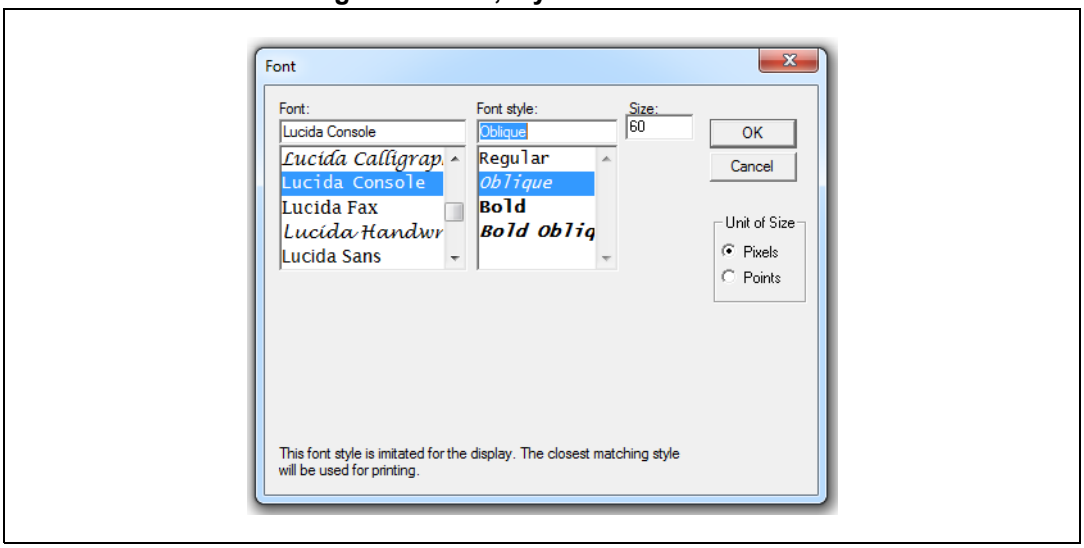
Once opened you need to choose the type of the font to generate and the encoding option.

Figure 14. Type font and encoding option



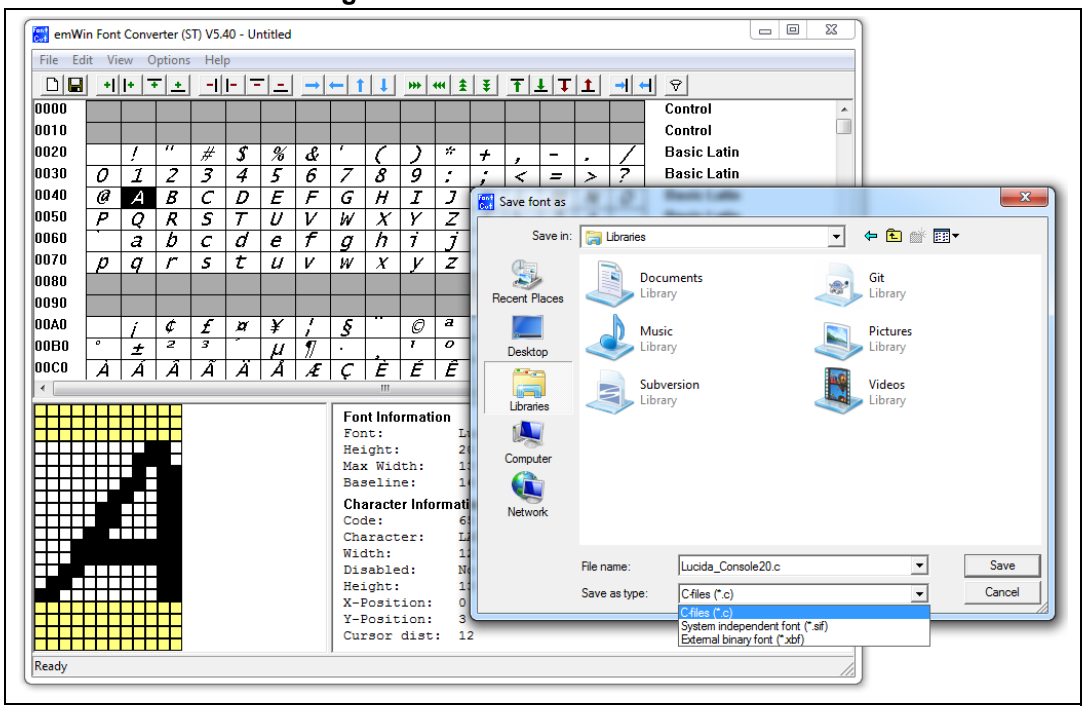
You need then to choose the desired font, its style and size.

Figure 15. font, style and size choice



You need finally to save this font to a C file with the meaningful name that gives information about the font.

Figure 16. Creation of the font C file



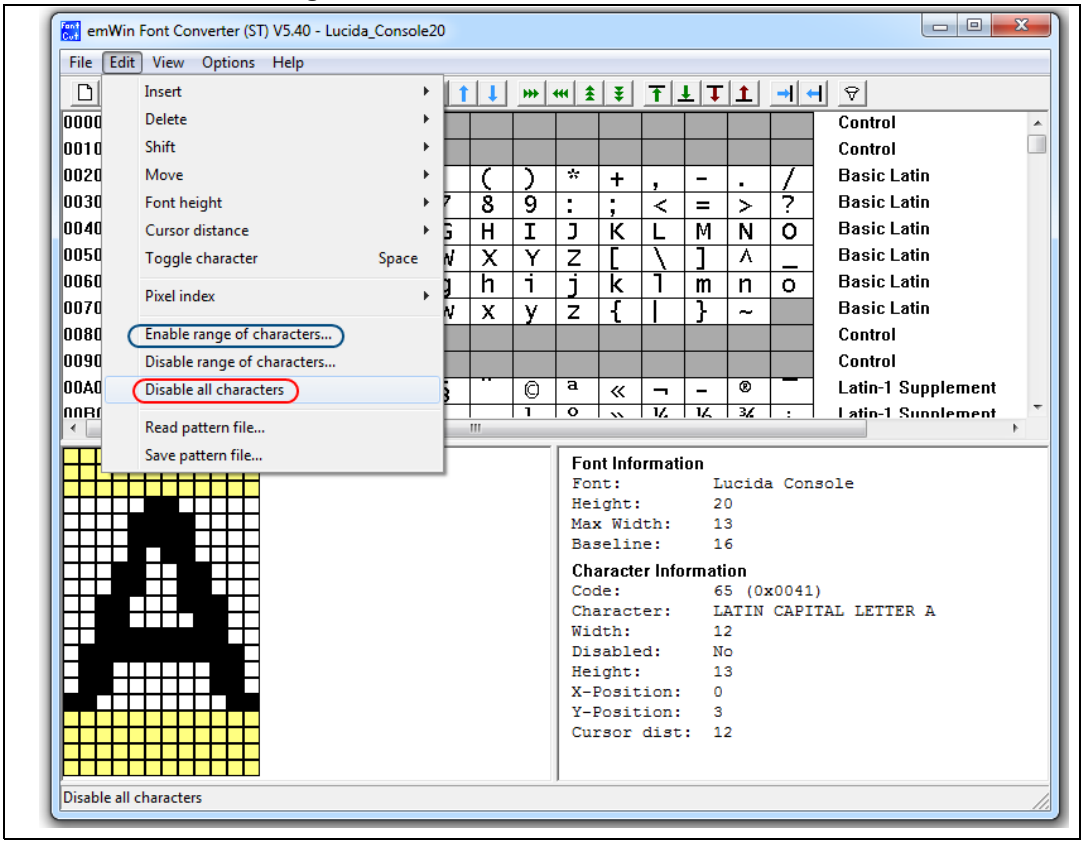
Optimization

The issue here is that the “C” file generated will contain all the characters and symbols of the font. As the “C” file will be compiled with the application so the user need enough addressable memory available for the font data.

As a solution to this issue, if some symbols and characters are not needed can disable them using the Font Converter and generate only the needed blocks from the desired font.

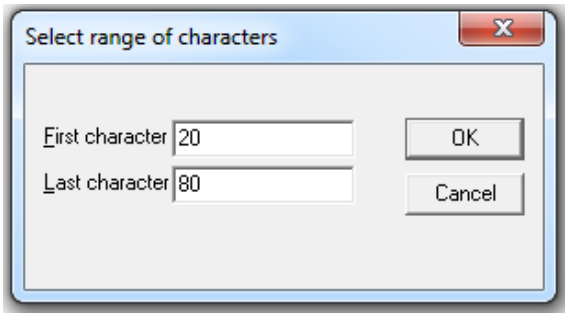
First for the opened font, the user need to disable all characters (Red selection on the following picture).

Figure 17. Disable/Enable font characters



Then enable only the blocks of characters you want to keep (Blue selection on the above picture), you need just to enter the range of you selection.

Figure 18. Characters range choice



Then you save as a “C” file.

If for example only the character ‘A’ is needed from this font, the generated font file will be the following:

```
#include "GUI.h"

#ifndef GUI_CONST_STORAGE
  #define GUI_CONST_STORAGE const
#endif
```

```
/* The following line needs to be included in any file selecting the
   font.
*/
extern GUI_CONST_STORAGE GUI_FONT GUI_FontLucida_Console20;

/* Start of unicode area <Basic Latin> */
GUI_CONST_STORAGE unsigned char acGUI_FontLucida_Console20_0041[ 26] = { /*
code 0041, LATIN CAPITAL LETTER A */
  _____XX_,________,
  ____XXXX,________,
  ____XXXX,________,
  ____X_XX,________,
  ___XX__X,X_______,
  ___XX__X,X_______,
  __XX___X,XX______,
  __XX____,XX______,
  __XXXXXX,XX______,
  _XXXXXXX,XXX_____,
  _XX_____,_XX_____,
  _XX_____,_XX_____,
  XX______,__XX____};

GUI_CONST_STORAGE GUI_CHARINFO_EXT GUI_FontLucida_Console20_CharInfo[1] = {
   {  12,  13,   0,   3,  12, acGUI_FontLucida_Console20_0041 } /* code
0041, LATIN CAPITAL LETTER A */
};

GUI_CONST_STORAGE GUI_FONT_PROP_EXT GUI_FontLucida_Console20_Prop1 = {
   0x0041 /* first character */
  ,0x0041 /* last character  */
  ,&GUI_FontLucida_Console20_CharInfo[  0] /* address of first character */
  ,(GUI_CONST_STORAGE GUI_FONT_PROP_EXT *)0 /* pointer to next
GUI_FONT_PROP_EXT */
};

GUI_CONST_STORAGE GUI_FONT GUI_FontLucida_Console20 = {
   GUI_FONTTYPE_PROP_EXT /* type of font    */
  ,20 /* height of font  */
  ,20 /* space of font y */
  ,1 /* magnification x */
  ,1 /* magnification y */
  ,{&GUI_FontLucida_Console20_Prop1}
  ,16 /* Baseline */
  ,11 /* Height of lowercase characters */
  ,13 /* Height of capital characters */
```

```
};
```

4.9.3 Language support

Text written in a language like Arabic, Hebrew, Thai or Chinese contains characters, which are normally not part of the fonts shipped with STemWin.

For such language with different read/write direction and for every meaningful character or text element of all known cultures, Unicode standard contains a unique digital code point.

To be able to decode text with Unicode characters, STemWin uses UTF-8 encoding method. (For more detail see User Manual).

The following sections explain how to support the usage of the fonts using above languages.

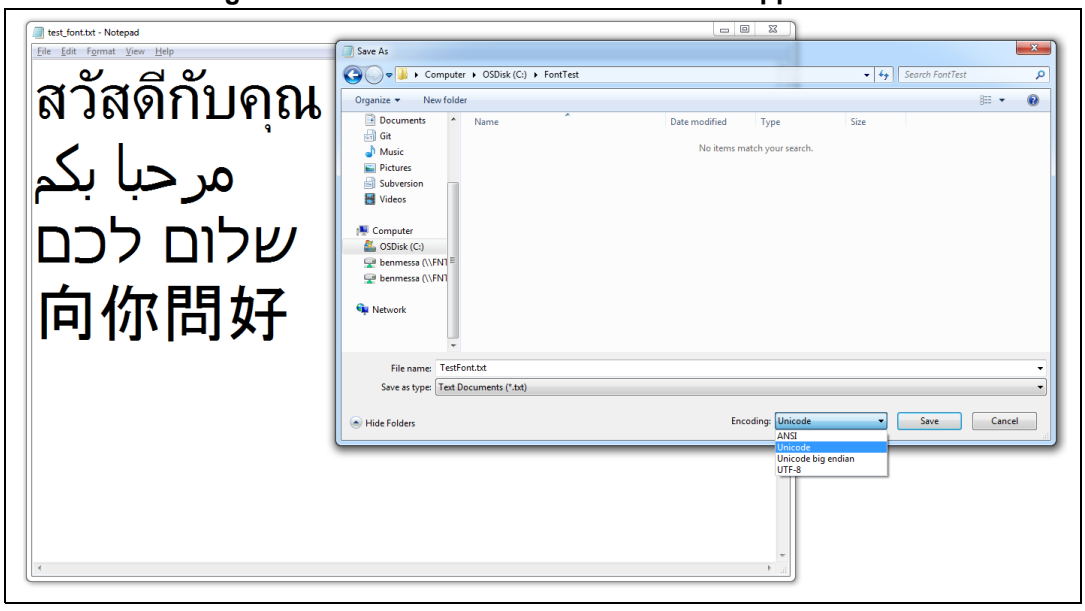
For a four given language there are two task to reach:

- Generate the font “C” file that will be used
- Add the needed SW on STemWin application to be able to display the needed characters

Let’s suppose that the user is trying to display “welcome” string translated on Thai, Arabic, Hebrew and traditional Chinese languages.

Firstly the user write the needed text using these languages, and save the text file using “Unicode” format. The user can use “Notepad.exe” for this, as showed in *Figure 19*.

Figure 19. Creation of different texts of the application



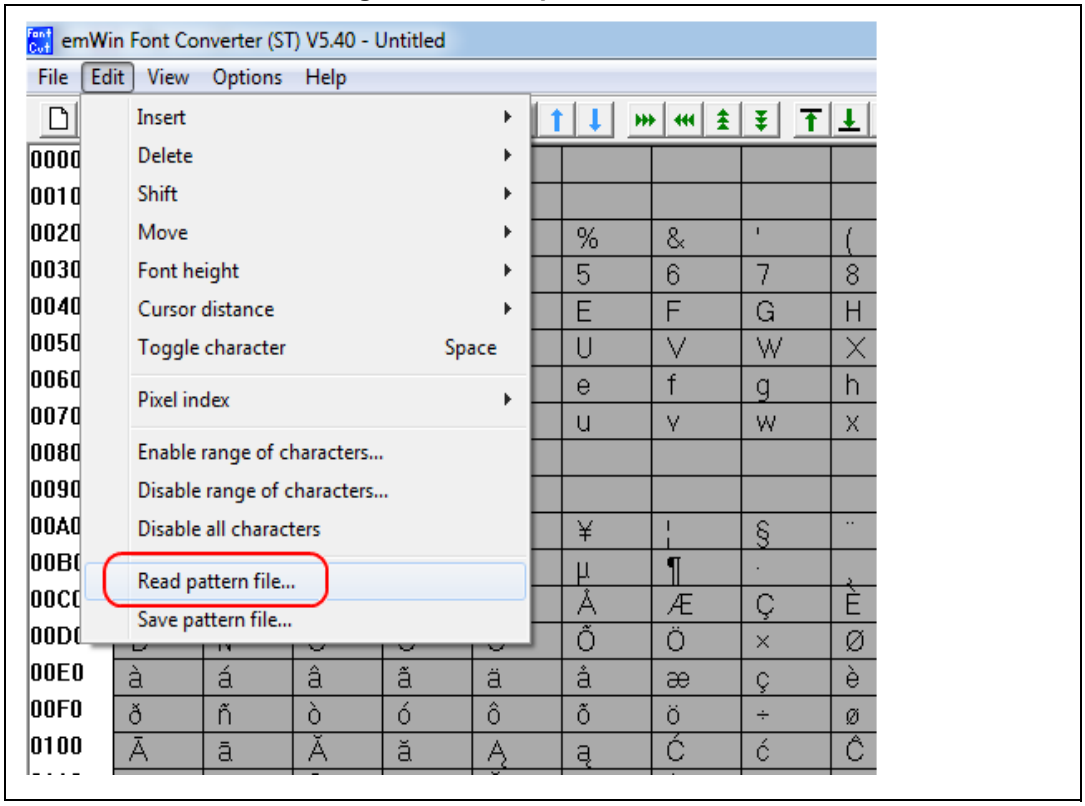
“C” file generation

Then using the “FontConverter” the user choose the font that support all these languages. On the shown case, the user generate two fonts files, the first one for the Arabic, Hebrew and Thai languages; the second for the Chinese one.

Once the font is already opened on the “FontConverter” the user need to disable all the characters as shown in *Optimization*.

Then the user read the pattern file containing the different strings.

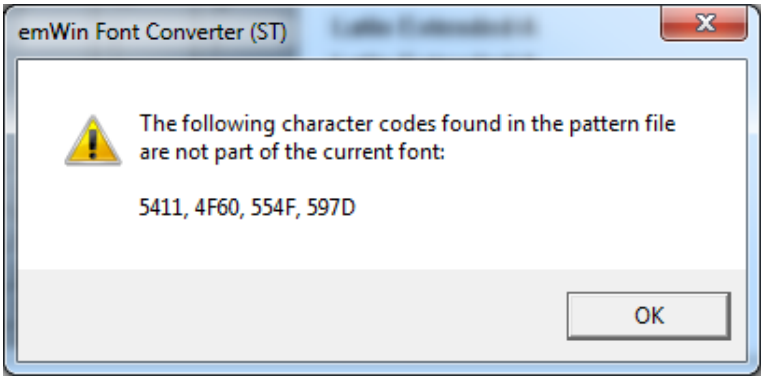
Figure 20. Read pattern file menu



Browse and load the file created. In the example, it will be “TestFont.txt”.

If any language inside the “TestFont.txt” is not supported by the font used a warning message is shown.

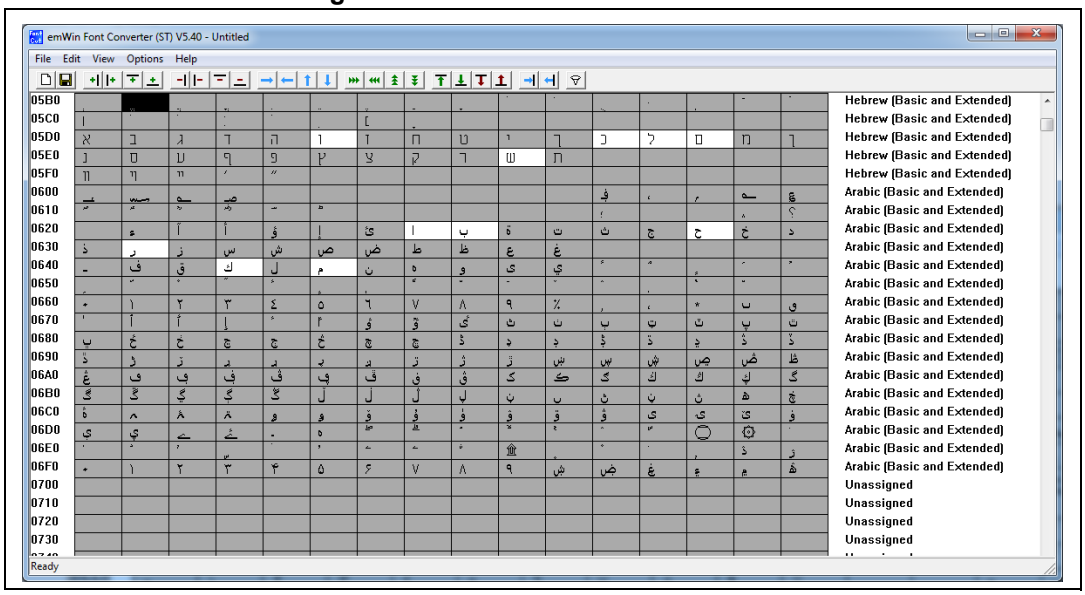
Figure 21. Missing characters codes of the used font



No problem with that, just push “OK” button.

Then the characters written on the “FontTest.txt” will be enabled.

Figure 22. Pattern characters enabled



Note:

Both Thai and Arabic language have some constraints of usage to display the exactly needed strings:

- For Arabic fonts the following range needs to be activated 0x600 to 0x6FF
- For Thai fonts
  - The font file must be created as “Extended”
  - The following range needs to be activated 0xE00-0xE7F

Once done just save to your “C” file.

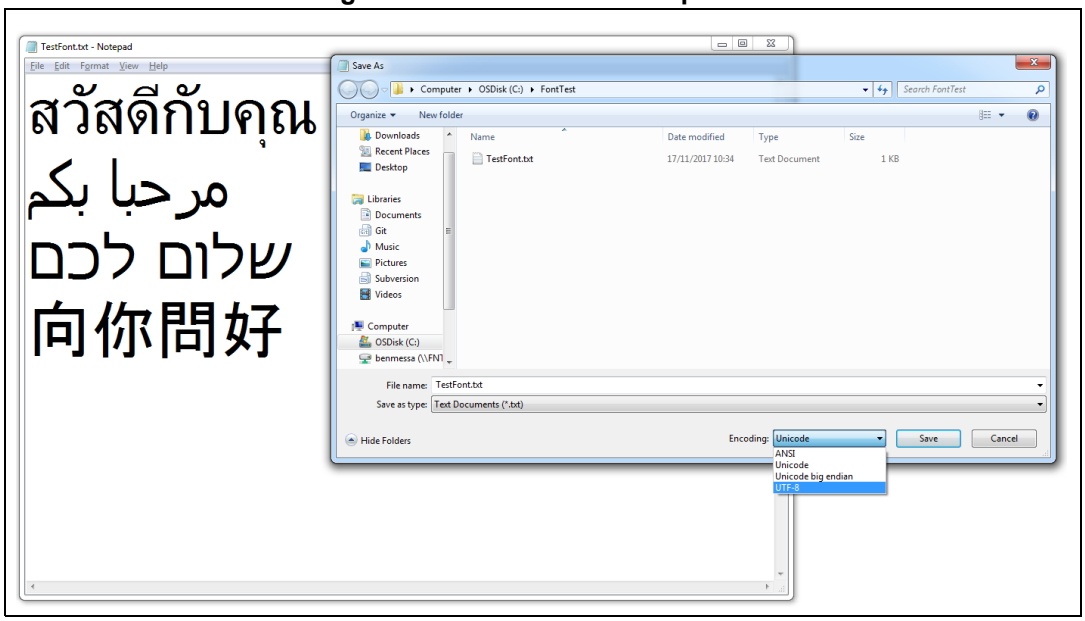
Needed SW to add

As a result of the description above, we are having the two font files that user to add to application compilation.

Now to be able to display these strings on application the user adapt the application software to decode the Unicode.

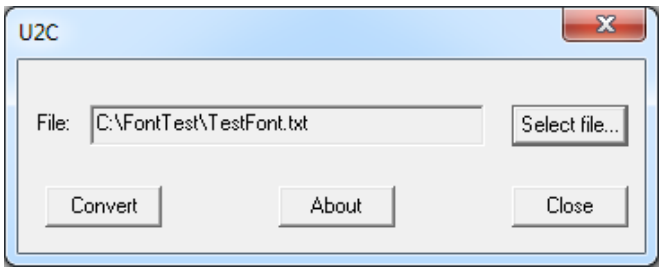
STemWin is able to decode UTF-8 encoded strings, so to display the Unicode characters added on the file “FontTest.txt”, user need firstly to save it on UTF-8 format.

Figure 23. Creation of UTF-8 pattern



To convert the UTF-8 text to a “C” code, go to the STM32CubeFW on the following path “Middlewares\ST\STemWin\Software” and execute “U2C.exe” with the file “FontTest.txt” as input.

Figure 24. Conversion of the UTF-8 pattern to "C" code



The output of the “U2C” converter will be:

```
"\xe0\xb8\xaa\xe0\xb8\xa7\xe0\xb8\xb1\xe0\xb8\xaa\xe0\xb8\x94\xe0\xb8\xb5\
xe0\xb8\x81\xe0\xb8\xb1\xe0\xb8\x9a\xe0\xb8\x84\xe0\xb8\xb8\xe0\xb8\x93"
"\xd9\x85\xd8\xb1\xd8\xad\xd8\xa8\xd8\xa7 \xd8\xa8\xd9\x83\xd9\x85"
"\xd7\xa9\xd7\x9c\xd7\x95\xd7\x9d \xd7\x9c\xd7\x9b\xd7\x9d"
"\xe5\x90\x91\xe4\xbd\xa0\xe5\x95\x8f\xe5\xa5\xbd"
```

Each line (text between “ ”) correspond to the string on the dame line on the “txt” file.

Now the user can create application using this output:

```
#include "GUI.h"
/* Font for Thai, Arabic and Hebrew languages */
#include “MicrosoftSansSerif20.c”
/* Font for Chinese language */
#include “Microsoft_YaHeiUI20.c”
```

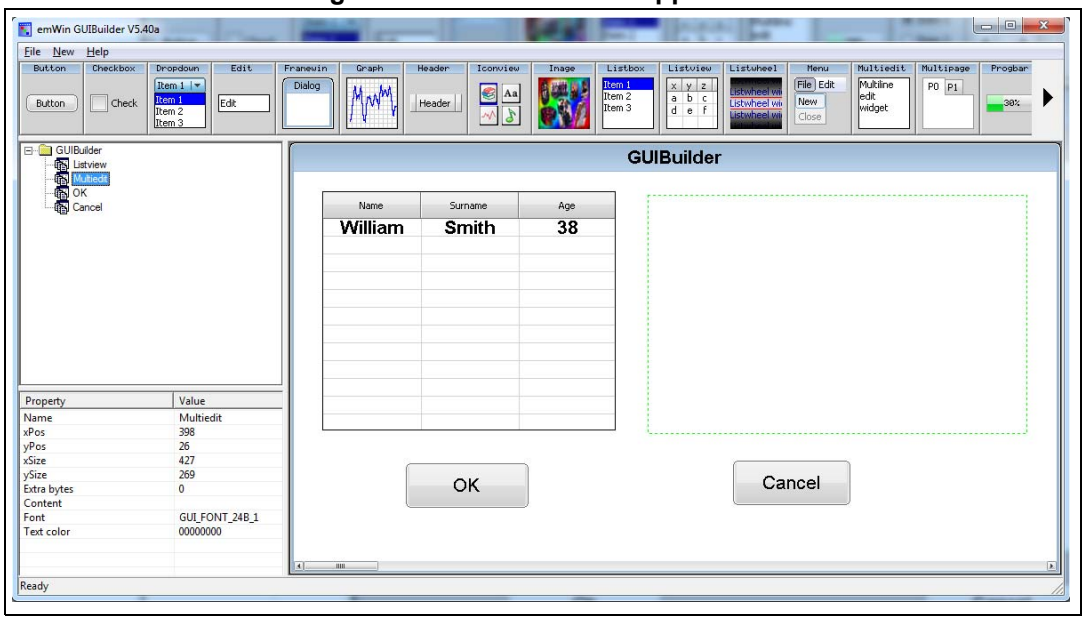
```
static const char * _apStrings[] =
{
"\xe0\xb8\xaa\xe0\xb8\xa7\xe0\xb8\xb1\xe0\xb8\xaa\xe0\xb8\x94\xe0\xb8\xb5\
xe0\xb8\x81\xe0\xb8\xb1\xe0\xb8\x9a\xe0\xb8\x84\xe0\xb8\xb8\xe0\xb8\x93",
"\xd9\x85\xd8\xb1\xd8\xad\xd8\xa8\xd8\xa7 \xd8\xa8\xd9\x83\xd9\x85",
"\xd7\xa9\xd7\x9c\xd7\x95\xd7\x9d \xd7\x9c\xd7\x9b\xd7\x9d",
"\xe5\x90\x91\xe4\xbd\xa0\xe5\x95\x8f\xe5\xa5\xbd",
};

void MainTask(void)
{
  int i;
  GUI_Init();
  GUI_SetFont(&GUI_FontMicrosoftSansSerif20);
  GUI_UC_SetEncodeUTF8();
  /* Thai string */
  GUI_DispString(_apStrings[0]);
  GUI_DispNextLine();

  /* Arabic and Hebrew strings:
     In this case we need to enable bidirectional
     (right to left) text support */
  GUI_UC_EnableBIDI(1);
  GUI_DispString(_apStrings[1]);
  GUI_DispNextLine();
  GUI_DispString(_apStrings[2]);
  GUI_DispNextLine();

  /* Chinese string, bidirectional no more needed */
  GUI_UC_EnableBIDI(0);
  GUI_DispString(_apStrings[3]);

  while(1)
  {
    GUI_Delay(500);
  }
}
```

4.10 GUIBuilder

The GUIBuilder is a tool for easily creating dialogs: instead of writing source code, the user can place and size widgets by drag and drop. Additional properties can be added via a pop-up menu. Fine tuning can be done by editing the properties of the widgets.

The GUIBuilder then generates some dialog C code that can be either customized or integrated as is in the project.

Figure 25. The GUIBuilder application



4.10.1 Basic usage of the GUIBuilder

- Start with the FRAMEWIN or WINDOW widget: only those widgets are able to serve as parent windows for a dialog.
- Place the widgets within the parent window: the widgets can be placed and sized by moving them with the mouse and/or by editing the properties in the property window.
- Configure the widgets: the pop-up menu shows the available options.
- Save the dialog: each dialog is saved in a separate file. The filenames are generated automatically, based on the name of the parent window.

4.10.2 Creation routine

The file generated using GUIBuilder contains a creation routine for the dialog. The routine name includes the name of the parent window: `WM_HWIN Create<WindowName>(void);`

Simply call the following routine to create the dialog:

```
hWin = CreateFramewin();
```

4.10.3 User-defined code

The generated code contains a couple of comments to add user code between them. To be able to read back the file with the GUIBuilder, the code must be between these comments.

Note: Adding code outside the user code comments makes the file unreadable for the GUIBuilder.

4.10.4 Callback routine

The main part of the generated file is the callback routine. It normally contains the following message handlers:

- WM_INIT_DIALOG

The widget initialization is done here immediately after creating all widgets of the dialog. The user code area can be used to add further initialization.

- WM_NOTIFY_PARENT

It contains (empty) message handlers to be filled with user code. For each notification of the widget, there is one message handler. Further reactions on notification messages can be added.

4.11 Porting GUI on a different resolution

The setting of the GUI resolution is completely done on the “LCDConf.c” and it’s very simple to go from one resolution to another.

The setting depend on the screen resolution attached the board that will be used. In this case a physical size of the screen is already known.

The variables “XSIZE_PHYS” and “YSIZE_PHYS” will be set on the “LCDConf.c” to mention the physical screen size.

Suppose that our screen has the resolution of (800x480), the “LCDConf.c” have the following content:

```
/* Define physical screen sizes */
#define XSIZE_PHYS 800
#define YSIZE_PHYS 480
```

These variables will be used to initialize the hardware linked to the screen (ex: the LTDC/DSI).

The GUI resolution is then set using two other variables called “XSIZE_0” and “YSIZE_0”.

“0” correspond to layer “0”, so there are also “XSIZE_1” and “YSIZE_1” if the layer “1” is used.

Of course the GUI resolution must fit on the physical one.

```
#define XSIZE_0       XSIZE_PHYS
#define YSIZE_0       YSIZE_PHYS
```

If now the screen (or the GUI resolution) have to be modified, the variables have to be modified as mentioned above.

4.12 How to add a new effect

STemWin provides the possibility to have some effects like blurring, blending and dithering using the memory devices API.

The user can also create some other effects using memory devices or any rectangular part of the used frame buffers.

Note that all effects added and data treatments will be done on ARGB8888 format.

Color conversions will be done when displaying on the LCD if needed.

The idea is to manipulate directly the data to modify. So it’s mandatory to know the base address, the width and the height of the data to be treated.

Two method are available to reach this purpose:

- Use a free memory base address
- Use the memory device, this will allocate dynamically a given memory

It will be easier and safer to use the memory devices knowing the multitude of APIs provided by STemWin.

The new effect to be added, in the software, will be defined by a filter that get as input the data pointer, its width and height and give as output the modified data to a new address.

This will consist on the following steps:

- Create a 32 Bits Per Pixel (Bpp) source memory device
- Create a 32 Bpp destination memory device with the same sizes
- Select the source memory device using “GUI_MEMDEV_Select(hSrc)”, draw on it the data that will modify by applying the new effect
- Get the pointers of the source and destination memory devices for direct manipulation
  - The API “void * GUI_MEMDEV_GetDataPtr(GUI_MEMDEV_Handle hSrc)”, will be used.
  - Note that if the bitmap is 32 Bpp, its data pointer can be used directly as the source pointer
- Using these pointers, the width and the height, apply the effect filter to the source data and write it to the destination memory device.
- Once modified the destination memory device can be displayed on the LCD screen
  - GUI_MEMDEV_Select(0);
  - GUI_MEMDEV_CopyToLCD(hDest);

4.13 How to add a new widget

On STemWin, widgets are seen as windows with enhanced functionalities.

So creating a new widget will be based on the creation of a window but with the capability to store additional data.

Which consists essentially on adding the following functions:

- “Create” function which returns a handle to the created widget and allows setting callback function.
- “Set” and “Get” functions to request and set widget specific properties.
- “Callback” function to process messages which were sent to the custom widget

For a step by step description of this please refer to this path
https://www.segger.com/downloads/emwin/AN03002

5 Performance and footprint

5.1 LCD driver performance

Table 6 lists a set of tests used to measure the speed of the display driver.

Table 6. Speed test list

Test name	Description
Test 1: Filling	Measures the speed of filling. An area of 64 * 64 pixels is filled with different colors.
Test 2: Small fonts	Measures the speed of small character output. An area of 60 * 64 pixels is filled with small-character text.
Test 3: Big fonts	Measures the speed of big character output. An area of 65 * 48 pixels is filled with big-character text.
Test 4: Bitmap 1 bpp	Measures the speed of 1 bpp bitmaps. An area of 58 * 8 pixels is filled with a 1 bpp bitmap.
Test 5: Bitmap 2 bpp	Measures the speed of 2 bpp bitmaps. An area of 32 * 11 pixels is filled with a 2 bpp bitmap.
Test 6: Bitmap 4 bpp	Measures the speed of 4 bpp bitmaps. An area of 32 * 11 pixels is filled with a 4 bpp bitmap.
Test 7: Bitmap 8 bpp	Measures the speed of 8 bpp bitmaps. An area of 32 * 11 pixels is filled with an 8 bpp bitmap.
Test 8: Bitmap 16 bpp	Measures the speed of 16 bpp bitmaps. An area of 64 * 8 pixels is filled with an 8 bpp bitmap.

The tests were done on the STM324xG-EVAL and STM324x9I-EVAL boards using respectively FlexColor and Lin drivers.

The results are shown in *Table 7*.

Table 7. Speed test for the FlexColor and Lin drivers

Test name	FlexColor	Lin
Test 1: Filling	7.48 M	73.47 M
Test 2: Small fonts	1.57 M	4.16 M
Test 3: Big fonts	2.35 M	5.96 M
Test 4: Bitmap 1bpp	3.23 M	8.81 M
Test 5: Bitmap 2bpp	2.28 M	6.29 M
Test 6: Bitmap 4bpp	2.22 M	6.13 M
Test 7: Bitmap 8bpp	1.17 M	9.71 M
Test 8: Bitmap 16bpp	5.57 M	4.55 M

M=megapixels/second

5.2 STemWin footprint

The operation area of STemWin varies widely, depending primarily on the application and features used. In the following sections, memory requirements of various modules are listed, as well as the memory requirements of example applications.

The following table shows the memory requirements of the main components of STemWin. These values depend a lot on the compiler options, the compiler version and the used CPU. Note that the listed values are the requirements of the basic functions of each module.

Table 8. Module footprint

Component	ROM	RAM	Description
Windows Manager	6.2 Kbytes	2.5 Kbytes	Additional memory requirements of basic application when using the Window Manager.
Memory Devices	4.7 Kbytes	7 Kbytes	Additional memory requirements of a basic application when using memory devices.
Antialiasing	4.5 Kbytes	2 * LCD_XSIZE	Additional memory requirements for the antialiasing software item.
Driver	2 – 8 Kbytes	20 bytes	The memory requirements of the driver depend on the configured driver and whether a data cache is used or not. With a data cache, the driver requires more RAM.
Multilayer	2 – 8 Kbytes	-	If working with a multi layer or a multi display configuration, additional memory is required for each additional layer, because each requires its own driver.
Core	5.2 Kbytes	80 bytes	Memory requirements of a typical application without using additional software items.
JPEG	12 Kbytes	38 Kbytes	Basic routines for drawing JPEG files.
GIF	3.3 Kbytes	17 Kbytes	Basic routines for drawing GIF files.
Sprites	4.7 Kbytes	16 bytes	Routines for drawing sprites and cursors.
Font	1 – 4 Kbytes	-	Depends on the font size to be used.

Table 9. Widget footprint

Component	ROM	RAM	Description
BUTTON	1 Kbyte	40 bytes	*1
CHECKBOX	1 Kbyte	52 bytes	*1
DROPDOWN	1.8 Kbytes	52 bytes	*1
EDIT	2.2 Kbytes	28 bytes	*1
FRAMEWIN	2.2 Kbytes	12 bytes	*1
GRAPH	2.9 Kbytes	48 bytes	*1
GRAPH_DATA_XY	0.7 Kbytes	-	*1
GRAPH_DATA_YT	0.6 Kbytes	-	*1
HEADER	2.8 Kbytes	32 bytes	*1
LISTBOX	3.7 Kbytes	56 bytes	*1
LISTVIEW	3.6 Kbytes	44 bytes	*1
MENU	5.7 Kbytes	52 bytes	*1
MULTIEDIT	7.1 Kbytes	16 bytes	*1
MULTIPAGE	3.9 Kbytes	32 bytes	*1
PROGBAR	1.3 Kbytes	20 bytes	*1
RADIOBUTTON	1.4 Kbytes	32 bytes	*1
SCROLLBAR	2 Kbytes	14 bytes	*1
SLIDER	1.3 Kbytes	16 bytes	*1
TEXT	1 Kbyte	16 bytes	*1
CALENDAR	0.6 Kbyte	32 bytes	*1

6 FAQs (frequently asked questions)

This section gathers some of the most frequent questions STemWin Library package users may ask, and provides some solutions and tips.

Table 10. FAQs

No.	Question	Answer/solution
1	Are all the STemWin features included in the package?	Yes. The delivered locked binaries where compiled with all the features enabled.
2	What is the STemWin Library configuration (during the binary generation)?	The content of the “GUIConf.h” file used to generate the STemWin binaries is as follows: #define GUI_DEFAULT_FONT &GUI_Font6x8 #define GUI_NUM_LAYERS 2 #define GUI_SUPPORT_TOUCH (1) #define GUI_SUPPORT_MOUSE (1) #define GUI_WINSUPPORT (1) #define GUI_SUPPORT_MEMDEV (1) #define GUI_SUPPORT_DEVICES (1) #define BUTTON_REACT_ON_LEVEL (1) #define GUI_MEMDEV_SUPPORT_CUSTOMDRAW (1) #define GUI_USE_ARGB (1)
3	Isn’t the delivered binary too large?	No. It depends on the application. The compiler considers only called parts from the external functions; thus, non-used resources are not included in the final application size.
4	How can a new LCD controller be supported?	To support any kind of LCD controller, the user should implement two configuration files: LCDConf.c/.h GUIConf.c/.h *Section 4.1* describes in detail the content of those files.
5	Is it mandatory to use the FreeRTOS operating system?	No. Any other operating system can be used. But then a corresponding GUI_X_OS.c file is needed (see *Section 4.1.4*).
6	The project is compiled without errors but, when running the application, the display does not work.	This issue may be caused by one of the following: Stack size is too low. Wrong initialization of the display controller. Wrong configuration of the display interface.

7 Revision history

Table 11. Document revision history

Date	Revision	Changes
19-Jul-2013	1	Initial release.
07-Feb-2014	2	- The use of STemWin generic version (XYZ). - The support of STM324x9I-EVAL board.
20-Mar-2014	3	- Added reference to STM32CubeF2 and STM32CubeF4
25-Jun-2014	4	Added STM32CubeF3 in the list of applicable software.
04-Apr-2018	5	Updated *Table 1: Applicable Software*, *Figure 1: STemWin layers*, *Section 2.2: Library description*, *Table 2: Supported LCD controllers*, *Figure 2: Project tree*, *Section 2.4: Delivered binaries*, *Table 3: Supported boards and examples*, *Figure 3: Structure of the STemWin application*, *Section 3: Supported boards and examples*, *Section 4.1: Configuration*, *Section 4.1.1: GUIConf.c*, *Section 4.1.2: LCDConf.c*, *Section 4.1.4: GUI_X.c or GUI_X_OS.c*, *Section 4.2: GUI initialization*, *Figure 25*, *Table 10: FAQs* Added *Figure 4: STemWin initialization*, *Section 4.1.3: Hardware acceleration*, *Section 4.9.2: How to add a new font*, *Section 4.9.3: Language support*, *Section 4.11: Porting GUI on a different resolution*, *Section 4.12: How to add a new effect*, *Section 4.13: How to add a new widget*