Octave-GTK: A GTK binding for GNU Octave

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Abstract: This paper discusses the problems faced with interoperability between two programming languages, with respect to GNU Octave, and GTK API written in C, to provide the GTK API on Octave. Octave-GTK is the fusion of two different API's: one exported by GNU Octave [scientific computing tool] and the other GTK [GUI toolkit]; this enables one to use GTK primitives within GNU Octave, to build graphical front ends, at the same time using octave engine for number crunching power. This paper illustrates our implementation of binding logic, and shows results extended to various other libraries using the same base code generator. Also shown, are methods of code generation, binding automation, and the niche we plan to fill in the absence of GUI in Octave. Canonical discussion of advantages, feasibility and problems faced in the process are elucidated.

Keywords: Free Software, Language binding, Interoperability, Octave-GTK, code-generator

1 INTRODUCTION

Language binding, is a favorite solution for programming language interoperability problems, that helps extend the reuse of libraries, and saves developer’s time, and provides new functionality to the host language.

Octave GTK project adds GTK bindings to Octave by extending it, thereby providing access to a GUI toolkit from GNU Octave for the first time. It is also possible to build a GUI for Octave around these features of GTK. The Octave GTK team has produced in addition to the GTK bindings for Octave, the libGlade, libGD bindings, and also customized the Glade GUI[1] editor and code generator for GNU Octave. This is a significant step in creating a complete GUI ecosystem for GNU Octave.

The aims of Octave GTK project, are two fold.

1. Generating the GTK binding
2. Create an GUI based ecosystem around GNU Octave.

2 Overview of technology

The target API, GTK is written in C, whereas the host language GNU Octave, is interpreted. This complicates things further, as we will see [sec 4]. We show all our results on a GNU/Linux system running Linux kernel 2.4, on an x86 processor.

To understand the relevance of Octave-GTK, and the problem it solves, it is essential that the reader be familiar with GNU Octave, and GTK technologies, and the space that Octave-GTK is to fill.

2.1 GNU Octave

GNU Octave is a high-level language, primarily intended for numerical computations. GNU Octave[2] users describe it as a convenient command line interface for solving linear and nonlinear problems numerically.

GNU Octave is a large project, with about 146,875 lines of C++ code, few FORTRAN programs borrowed from standard numeric libraries like LAPACK, BLAS, FFTLIB, RANLIB, and ODESSA, a lexical analyzer and parser written in flex and Bison, an Octave interpreter for the Octave language.
GNU Octave also supports an interpreted language called Octave, which has access to the whole lot of Octave libraries for number crunching. In fact much of the Octave’s functionality itself is written in octave.

GNU Octave has capacity to solve Ordinary Differential Equations (ODE), perform symbolic computing, plot 2D and 3D graphs. It is a high level computational tool for the scientist and engineer. Also, special packages for Image, Signal, Audio processing exist in Octave Forge.

Octave accommodates extensions, by using shared libraries, dynamic loaded files that provide extra functionality. This is similar to the plug in concept. Octave can take a shared library and load all the symbols(functions and variables) present in it, to extend its[Octave’s] functionality to the user. Thus GNU Octave package gives us the power to extend Octave interpreter, and utilize the inbuilt computational routines, for other needs; say like GUI for scientific programs, where we cannot expect every GUI programmer to write his/her own Matrix routines. Plotting functions et-al. This is where Octave-GTK plays a vital role; by bridging this gap.

### 2.2 GTK

GTK [Gimp Toolkit] is a cross platform object oriented (OO) GUI toolkit, written in C, as a collection of several libraries glib, gdk,gdk-pixbuf, and gtk itself, altogether about 358,998 lines of code.

One of the design goals for writing GTK in C, was that it would be easy for others to write language bindings for scripting languages. Given the fact that many scripting languages themselves are implemented in C this is considered feasible, if not easy.

### 2.3 Other GTK Bindings

Proof of the design is seen in the number of language bindings for GTK, from the languages like LISP, GUILE, Ada,SLang, C++, C, Python, and Perl.

### 2.4 Octave-GTK

One can see that Octave-GTK is a technically feasible problem, trying to export the GTK API to be accessible from the GNU Octave runtime. As with the likes of other GTK bindings, [see 2.2] one can be convinced that GTK binding code, can be written from the compiled languages [C++], interpreted languages [LISP], or both [Python]. Octave-GTK design and architecture will be presented in the following sections.

### 3 Problem definition

**Problem Definition:** To create a language binding for GTK from Octave, to access GTK function from Octave language and interpreter. The steps involved are

1. Translate Octave types to C, for access from within GTK API.
2. Translate GTK C objects into Octave Objects for access from Octave.
3. Make GTK API functions, accessible/callable from octave language
4. Make Octave functions, both built-in & custom, be callable from C, for use as callbacks.

### 4 Architecture

The specifications derived in [sec 3], dictate the architecture used to solve the problem. We have to make a glue layer implemented for Octave interpreter as the octave-gtk shared library. As shown in the [figure 9], this octave-gtk library does all the work mentioned in [sec 3]. This is our mechanism.

### 5 Prototype

We have made a proof -of-concept implementation of the octave-gtk glue layer proposed. The image [figure 9], shows our first implementation. The section of Octave code given below, produces the output in this [figure 9].

```bash
#!/usr/bin/octave -q

xml=0;
choice=0 %0->AM 1->AM DSBSC 2->AM SSB

function on_radiobutton1_clicked(radio)
  global choice
  if(gtk_toggle_button_get_active(radio))
    choice=0;
  end
end
```
function on_radiobutton2_clicked(radio)
global choice
  if(gtk_toggle_button_get_active(radio)>0)
    choice=1;
  end
end

function on_radiobutton3_clicked(radio)
global choice
  if(gtk_toggle_button_get_active(radio)>0)
    choice=2;
  end
end

function on_button1_clicked(btn)
global xml
global choice
  modf=glade_xml_get_widget(xml,"entry1");
  carf=glade_xml_get_widget(xml,"entry2");
  timed=glade_xml_get_widget(xml,"entry3");

  wm=2*pi*modf;
  wc=2*pi*carf;
  t=0:0.001:timed;

  switch(choice)
    case 0:
      am=2*(1+0.5*cos(wm.*t)).*cos(wc.*t);
      plot(t,am);
    case 1:
      dsbsc=2*cos(wm.*t).*cos(wc.*t);
      plot(t,dsbsc);
    case 2:
      ssbsc=cos((wc+wm).*t);
      plot(t,ssbsc);
    end
end

% Beginning of Callbacks %

function main()
global xml;
gtk();
glade();
gtk_init();
xml=glade_xml_new(
  "modulation.glade","window","");
window = glade_xml_get_widget(xml,"window")
  %starts the whole script
main0;

%octave-gtk demonstration.
The glue code is loaded all at once by calling gtk(), from the Octave runtime. This loads Octave interpreter’s symbol table with all our glue functions. Within the glue functions themselves we have a pattern of calling the target GTK functions.

5.1 Glue logic

1. Check, of arguments are valid
   i.e donot take integer when object expected, et al.

2. Translate Arguments
   Convert Objects to pointers, string to char *

3. Call the GTK function.

4. Return Arguments to Octave
   Generally reverse step 2, and free objects if necessary, close open file handles and similar ‘cleanup’ tasks. Convert pointers to Octave Objects.

    /***************************************************************************/
    C Prototype
    GtkWidget *gtk_button_new(const char *name);
    */
    DEFUN_DLD(gtk_button_new,args,,
      "creates a Button")
    {
      string ss;
      long int x;
      GtkWidget *w;

      if(args.length() < 1)
      {
        std::cout << "eg: gtkbuttonnew (title)" << std::endl;
        return octave_value(1);
      }

      ss=args(0).string_value();
w = gtk_button_new_with_label (ss.c_str());
x = (long int )w;
cout<<"Button created Created"<<endl;
return octave_value((double)x);
}

First the character string name for the button is obtained from the octave interpreter. Then within the glue code, a check to see if the data supplied by the interpreter is a character string is performed. Next the algorithm proceeds to the next level to create the button using the C function. Finally the pointer to the button is returned to the interpreter as octave_value.

5.2 Code Generation

Since all this process [sec 5.1] of glue logic is same for all the functions called, one may generalize this concept, and introduce code generators to do the job of producing the glue code. This is nothing new, as seen from various GTK bindings mentioned in [2,3]. For most functions this will work, when an apriori type-mapping between Octave types and corresponding C types is present.

Type-mapping is helpful for representation of GTK objects [sec 2.1], using custom designed Octave objects, by deriving from types like octave_base_scalar. Thus, one can store pointers within a member of the Octave object, so also its GTK attributes like widget name, type, properties can be stored. Now type-mapping should be considered solved.

Concept of type-mapping is not always applicable for all C constructs, where pointers to integers, might mean returning a single variable, array or some type-cast value. This, cannot be understood by the code generator, even with type-mapping; so in some cases one needs to provide manual overrides for the rest of the functions, that have ambiguous type-mapping.

Ideal choices for code generation for the GTK API as shown in [2] binding is Python language. For feasibility of code-generation for Octave, our team has experimentally tackled the GD [8] library and produced the GD-Octave glue for Octave, using a code-generator.

5.3 Implementation

In this prototype, we have not used custom octave objects, no type-mapping. This means, simply, we store the GTK widgets, and pointers, in long integers. Naturally this technique is non-portable (depends on computer architecture, the library was built on) and user can easily crash the Octave interpreter, by passing wrong pointer (often the case of segmentation faults). There has been no type-checking but the other steps 3,4 of the [sec 5.1] have been followed. As with the case of evolutionary software, we are in the process of implementing the refined designs, detailed earlier.

5.4 Callbacks

This presents one of the biggest challenges in the problem. Calling an Octave function, that is a callback from the GTK environment. Every widget, which needs a callback, stores within its member variables, the name of the Octave function acting as a callback for a particular event. An intermediate generic callback is registered with the GTK system. This intermediate function which is the callback from the GTK side, extracts the name of Octave callback function from the widget (we store it earlier into the GObject), and then uses Octave interpreter to evaluate that function using feval() .

Our method of implementing callbacks are heavily dependent on the introspection capabilities offered by GNU Octave, and within GObject itself. We will be using the Octave interpreter’s symbol tables, and function lists to find out the callback and functions like feval() to evaluate the function callbacks with necessary arguments.

6 Advantages

When the Octave-GTK code is complete, advantages of this language Interoperability with Octave & C are as follows.

1. Octave will have a GUI toolkit for users to work with:
   This means that newer, faster means of scientific programs can be written with Octave, similar to other scripting languages that have taken advantage of GTK. More over, people could do faster prototyping with interpreted languages, and Octave-GTK can become an Ideal RAD tool for academics, and developers alike.

2. It is possible to write a GUI for Octave with Octave itself:
This is indeed an elegant solution, but we cannot comment till the performance-time trade off matches user satisfaction, but however it is still a possibility.

3. The GNOME connection:
   GNOME technologies like Bonobo, libgnomeui could further be ported to the Octave language, making Octave powerful like some general purpose programming language. We could write components for GNOME from Octave given this set of primitives.
   
   As of this writing, Octave-GTK has components to build and convert the Glade files into Octave code, and directly manipulating the GUI. Our team has customized the Glade tool, to be a GUI builder for Octave, and ported the LibGlade library with bindings to Octave. The example in [Sec 4] shows one such program using a GUI description saved from the .glade file, and code generate automatically.

4. Library Reuse:
   An Octave library with many computational routines, could be used for scientific computing, rather than re-implement it. Similarly, it is unnecessary to rewrite a GUI toolkit for Octave, when it is possible to use GTK, which can mesh well. Thus Octave-GTK, will achieve the Library reuse, which simply means lesser code to write, maintain and transfer.

7 Contribution

As a part of this project we have contributed the following library bindings to the Octave project, using the same base code-generator.

    They are bindings to,

    • GTK GUI library,
    • Glade GUI editor and loader,
    • GD image load/save/editing library

8 Conclusion

Using Octave-Gtk it is possible to have simpler API’s for scientific computing and this significantly reduces the effort in GUI development.Moreover Octave itself will empowered to compete with proprietary alternatives. Octave-GTK introduces a powerful, and free alternative to mixing GUI and free scientific computing tool.

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