The OpenGL Utility Toolkit (GLUT) Programming Interface

API Version 3

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1 Introduction

The OpenGL Utility Toolkit (GLUT) is a programming interface with ANSI C and FORTRAN bindings for writing window system independent OpenGL programs. The toolkit supports the following functionality:

- Multiple windows for OpenGL rendering.
- Callback driven event processing.
- Sophisticated input devices.
- An “idle” routine and timers.
- A simple, cascading pop-up menu facility.
- Utility routines to generate various solid and wire frame objects.
- Support for bitmap and stroke fonts.
- Miscellaneous window management functions, including managing overlays.

An ANSI C implementation of GLUT for the X Window System [13] has been implemented by the author. Windows NT and OS/2 versions of GLUT are also available.

This documentation serves as both a specification and a programming guide. If you are interested in a brief introduction to programming with GLUT, look for the introductory OpenGL column [8] published in *The X Journal*.

The remainder of this section describes GLUT’s design philosophy and usage model. The following sections specify the GLUT routines, grouped by functionality. The final sections discuss usage advice, the FORTRAN binding, and implementation issues. Appendix A enumerates and annotates the logical programmer visible state maintained by GLUT. Appendix B presents the ANSI C GLUT API via its header file. Appendix C presents the FORTRAN GLUT API via its header file.

1.1 Background

One of the major accomplishments in the specification of OpenGL [14, 10] was the isolation of window system dependencies from OpenGL’s rendering model. The result is that OpenGL is window system independent.

Window system operations such as the creation of a rendering window and the handling of window system events are left to the native window system to define. Necessary interactions between OpenGL and the window system such as creating and binding an OpenGL context to a window are described separately from the OpenGL specification in a window system dependent specification. For example, the GLX specification [3] describes the standard by which OpenGL interacts with the X Window System.

The predecessor to OpenGL is IRIS GL [15, 16]. Unlike OpenGL, IRIS GL does specify how rendering windows are created and manipulated. IRIS GL’s windowing interface is reasonably popular largely because it is simple to use. IRIS GL programmers can worry about graphics programming without needing to be an expert in programming the native window system. Experience also demonstrated that IRIS GL’s windowing interface was high-level enough that it could be retargeted to different window systems. Silicon Graphics migrated from NeWS to the X Window System without any major changes to IRIS GL’s basic windowing interface.

Removing window system operations from OpenGL is a sound decision because it allows the OpenGL graphics system to be retargeted to various systems including powerful but expensive graphics workstations as well as mass-production graphics systems like video games, set-top boxes for interactive television, and PCs.

Unfortunately, the lack of a window system interface for OpenGL is a gap in OpenGL’s utility. Learning native window system APIs such as the X Window System’s Xlib [6] or Motif [7] can be daunting. Even those familiar with native window system APIs need to understand the interface that binds OpenGL to the native window system. And when an OpenGL program is written using the native window system interface, despite the portability of the program’s OpenGL rendering code, the program itself will be window system dependent.

Testing and documenting OpenGL’s functionality lead to the development of the tk and aux toolkits. The aux toolkit is used in the examples found in the *OpenGL Programming Guide* [9]. Unfortunately, aux has
numerous limitations and its utility is largely limited to toy programs. The \texttt{tk} library has more functionality than \texttt{aux} but was developed in an \textit{ad hoc} fashion and still lacks much important functionality that IRIS GL programmers expect, like pop-up menus and overlays.

GLUT is designed to fill the need for a window system independent programming interface for OpenGL programs. The interface is designed to be simple yet still meet the needs of useful OpenGL programs. Features from the IRIS GL, \texttt{aux}, and \texttt{tk} interfaces are included to make it easy for programmers used to these interfaces to develop programs for GLUT.

1.2 Design Philosophy

GLUT simplifies the implementation of programs using OpenGL rendering. The GLUT application programming interface (API) requires very few routines to display a graphics scene rendered using OpenGL. The GLUT API (like the OpenGL API) is stateful. Most initial GLUT state is defined and the initial state is reasonable for simple programs.

The GLUT routines also take relatively few parameters. No pointers are returned. The only pointers passed into GLUT are pointers to character strings (all strings passed to GLUT are copied, not referenced) and opaque font handles.

The GLUT API is (as much as reasonable) window system independent. For this reason, GLUT does not return any native window system handles, pointers, or other data structures. More subtle window system dependencies such as reliance on window system dependent fonts are avoided by GLUT; instead, GLUT supplies its own (limited) set of fonts.

For programming ease, GLUT provides a simple menu sub-API. While the menuing support is designed to be implemented as pop-up menus, GLUT gives window system leeway to support the menu functionality in another manner (pull-down menus for example).

Two of the most important pieces of GLUT state are the current window and current menu. Most window and menu routines affect the current window or menu respectively. Most callbacks implicitly set the current window and menu to the appropriate window or menu responsible for the callback. GLUT is designed so that a program with only a single window and/or menu will not need to keep track of any window or menu identifiers. This greatly simplifies very simple GLUT programs.

GLUT is designed for simple to moderately complex programs focused on OpenGL rendering. GLUT implements its own event loop. For this reason, mixing GLUT with other APIs that demand their own event handling structure may be difficult. The advantage of a builtin event dispatch loop is simplicity.

GLUT contains routines for rendering fonts and geometric objects, however GLUT makes no claims on the OpenGL display list name space. For this reason, none of the GLUT rendering routines use OpenGL display lists. It is up to the GLUT programmer to compile the output from GLUT rendering routines into display lists if this is desired.

GLUT routines are logically organized into several sub-APIs according to their functionality. The sub-APIs are:

\textit{Initialization.} Command line processing, window system initialization, and initial window creation state are controlled by these routines.

\textit{Beginning Event Processing.} This routine enters GLUT's event processing loop. This routine never returns, and it continuously calls GLUT callbacks as necessary.

\textit{Window Management.} These routines create and control windows.

\textit{Overlay Management.} These routines establish and manage overlays for windows.

\textit{Menu Management.} These routines create and control pop-up menus.

\textit{Callback Registration.} These routines register callbacks to be called by the GLUT event processing loop.

\textit{Color Index Colormap Management.} These routines allow the manipulation of color index colormaps for windows.

\textit{State Retrieval.} These routines allow programs to retrieve state from GLUT.
1.3 API Version 2

Font Rendering. These routines allow rendering of stroke and bitmap fonts.

Geometric Shape Rendering. These routines allow the rendering of 3D geometric objects including spheres, cones, icosahedrons, and teapots.

1.3 API Version 2

In response to feedback from the original version of GLUT, GLUT API version 2 was developed. Additions to the original GLUT API version 1 are:

- Support for requesting stereo and multisample windows.
- New routines to query support for and provide callbacks for sophisticated input devices: the Spaceball, tablet, and dial & button box.
- New routine to register a callback for keyboard function and directional keys. In version 1, only ASCII characters could be generated.
- New queries for stereo, multisampling, and elapsed time.
- New routine to ease querying for OpenGL extension support.

GLUT API version 2 is completely compatible with version 1 of the API.

1.4 API Version 3

Further feedback lead to the development of GLUT API version 3. Additions to the GLUT API version 2 are:

- The glutMenuStateFunc has been deprecated in favor of the glutMenuStatusFunc.
- glutFullScreen requests full screen top-level windows.
- Three additional Helvetica bitmap fonts.
- Implementations should enforce not allowing any modifications to menus while menus are in use.
- glutBitmapWidth and glutStrokeBitmap return the widths of individual characters.
- glutGetModifiers called during a keyboard, mouse, or special callback returns the modifiers (Shift, Ctrl, Alt) held down when the mouse or keyboard event was generated.
- Access to per-window transparent overlays when overlay hardware is supported. The routines added are glutEstablishOverlay, glutRemoveOverlay, glutShowOverlay, glutHideOverlay, glutUseOverlay, glutLayerGet, and glutPostOverlayRedisplay.
- A new display mode called GLUT_LUMINANCE using OpenGL's RGBA color model, but that has no green or blue components. The red component is converted to an index and looked up in a writable colormap to determine displayed colors. See glutInitDisplayMode.

GLUT API version 3 should be largely compatible with version 2. Be aware that programs that used to (through some degree of fortuitous timing) modify menus while menus are in use will encounter fatal errors when doing so in version 3.

Another change in GLUT 3.0 that may require source code modification to pre-3.0 GLUT programs. GLUT 3.0 no longer lets a window be shown without a display callback registered. This change makes sure windows are not displayed on the screen without the GLUT application providing a way for them to be rendered. In conjunction with this change, glutDisplayFunc no longer allows NULL to deregister a display callback. While there is no longer a way to deregister a display callback, you can still change the change the display callback routine with subsequent calls to glutDisplayFunc.

The display mode mask parameter for glutInitDisplayMode and the milliseconds parameter for glutTimerFunc are now of type unsigned int (previously unsigned long).
1.5 Conventions

GLUT window and screen coordinates are expressed in pixels. The upper left hand corner of the screen or a window is (0,0). X coordinates increase in a rightward direction; Y coordinates increase in a downward direction. Note: This is inconsistent with OpenGL’s coordinate scheme that generally considers the lower left hand coordinate of a window to be at (0,0) but is consistent with most popular window systems.

Integer identifiers in GLUT begin with one, not zero. So window identifiers, menu identifiers, and menu item indexes are based from one, not zero.

In GLUT’s ANSI C binding, for most routines, basic types (int, char*) are used as parameters. In routines where the parameters are directly passed to OpenGL routines, OpenGL types (GLfloat) are used.

The header files for GLUT should be included in GLUT programs with the following include directive:

```c
#include <GL/glut.h>
```

Because a very large window system software vendor (who will remain nameless) has an apparent inability to appreciate that OpenGL’s API is independent of their window system API, portable ANSI C GLUT programs should not directly include `<GL/gl.h>` or `<GL/glu.h>`. Instead, ANSI C GLUT programs should rely on `<GL/glut.h>` to include the necessary OpenGL and GLU related header files.

The ANSI C GLUT library archive is typically named `libglut.a` on Unix systems. GLUT programs need to link with the system’s OpenGL and GLUT libraries (and any libraries these libraries potentially depend on). A set of window system dependent libraries may also be necessary for linking GLUT programs. For example, programs using the X11 GLUT implementation typically need to link with Xlib, the X extension library, possibly the X Input extension library, the X miscellaneous utilities library, and the math library. An example X11/Unix compile line would look like:

```bash
cc -o foo foo.c -lglut -lGLU -lGL -lXmu -lXi -lXext -lX11 -lm
```

1.6 Terminology

A number of terms are used in a GLUT-specific manner throughout this document. The GLUT meaning of these terms is independent of the window system GLUT is used with. Here are GLUT-specific meanings for the following GLUT-specific terms:

**Callback** A programmer specified routine that can be registered with GLUT to be called in response to a specific type of event. Also used to refer to a specific callback routine being called.

**Colormap** A mapping of pixel values to RGB color values. Use by color index windows.

**Dials and button box** A sophisticated input device consisting of a pad of buttons and an array of rotating dials, often used by computer-aided design programs.

**Display mode** A set of OpenGL frame buffer capabilities that can be attributed to a window.

**Idle** A state when no window system events are received for processing as callbacks and the idle callback, if one is registered, is called.

**Layer in use** Either the normal plane or overlay. This per-window state determines what frame buffer layer OpenGL commands affect.

**Menu entry** A menu item that the user can select to trigger the menu callback for the menu entry’s value.

**Menu item** Either a menu entry or a sub-menu trigger.

**Modifiers** The Shift, Ctrl, and Alt keys that can be held down simultaneously with a key or mouse button being pressed or released.

**Multisampling** A technique for hardware antialiasing generally available only on expensive 3D graphics hardware [1]. Each pixel is composed of a number of samples (each containing color and depth information). The samples are averaged to determine the displayed pixel color value. Multisampling is supported as an extension to OpenGL.
Normal plane  The default frame buffer layer where GLUT window state resides; as opposed to the overlay.

Overlay  A frame buffer layer that can be displayed preferentially to the normal plane and supports transparency to display through to the normal plane. Overlays are useful for rubber-banding effects, text annotation, and other operations, to avoid damaging the normal plane frame buffer state. Overlays require hardware support not present on all systems.

Pop  The act of forcing a window to the top of the stacking order for sibling windows.

Pop-up menu  A menu that can be set to appear when a specified mouse button is pressed in a window. A pop-menu consists of multiple menu items.

Push  The act of forcing a window to the bottom of the stacking order for sibling windows.

Reshape  The act of changing the size or shape of the window.

Spaceball  A sophisticated 3D input device that provides six degrees of freedom, three axes of rotation and three axes of translation. It also supports a number of buttons. The device is a hand-sized ball attached to a base. By cupping the ball with one’s hand and applying torsional or directional force on the ball, rotations and translations are generated.

Stereo  A frame buffer capability providing left and right color buffers for creating stereoscopic renderings. Typically, the user wears LCD shuttered goggles synchronized with the alternating display on the screen of the left and right color buffers.

Sub-menu  A menu cascaded from some sub-menu trigger.

Sub-menu trigger  A menu item that the user can enter to cascade another pop-up menu.

Subwindow  A type of window that is the child window of a top-level window or other subwindow. The drawing and visible region of a subwindow is limited by its parent window.

Tablet  A precise 2D input device. Like a mouse, 2D coordinates are returned. The absolute position of the tablet “puck” on the tablet is returned. Tablets also support a number of buttons.

Timer  A callback that can be scheduled to be called in a specified interval of time.

Top-level window  A window that can be placed, moved, resized, etc. independently from other top-level windows by the user. Subwindows may reside within a top-level window.

Window  A rectangular area for OpenGL rendering.

Window display state  One of shown, hidden, or iconified. A shown window is potentially visible on the screen (it may be obscured by other windows and not actually visible). A hidden window will never be visible. An iconified window is not visible but could be made visible in response to some user action like clicking on the window’s corresponding icon.

Window system  A broad notion that refers to both the mechanism and policy of the window system. For example, in the X Window System both the window manager and the X server are integral to what GLUT considers the window system.

2 Initialization

Routines beginning with the glutInit- prefix are used to initialize GLUT state. The primary initialization routine is glutInit that should only be called exactly once in a GLUT program. No non-glutInit- prefixed GLUT or OpenGL routines should be called before glutInit.

The other glutInit- routines may be called before glutInit. The reason is these routines can be used to set default window initialization state that might be modified by the command processing done in glutInit. For example, glutInitWindowSize(400, 400) can be called before glutInit to indicate 400 by 400 is the program’s default window size. Setting the initial window size or position before glutInit allows the GLUT program user to specify the initial size or position using command line arguments.
2. INITIALIZATION

2.1 glutInit

glutInit is used to initialize the GLUT library.

Usage

void glutInit(int *argcp, char **argv);

argcp A pointer to the program’s unmodified argc variable from main. Upon return, the value pointed to by argcp will be updated, because glutInit extracts any command line options intended for the GLUT library.

argv The program’s unmodified argv variable from main. Like argcp, the data for argv will be updated because glutInit extracts any command line options understood by the GLUT library.

Description

glutInit will initialize the GLUT library and negotiate a session with the window system. During this process, glutInit may cause the termination of the GLUT program with an error message to the user if GLUT cannot be properly initialized. Examples of this situation include the failure to connect to the window system, the lack of window system support for OpenGL, and invalid command line options.

glutInit also processes command line options, but the specific options parse are window system dependent.

X Implementation Notes

The X Window System specific options parsed by glutInit are as follows:

- -display DISPLAY Specify the X server to connect to. If not specified, the value of the DISPLAY environment variable is used.

- -geometry WxH+X+Y Determines where window’s should be created on the screen. The parameter following -geometry should be formatted as a standard X geometry specification. The effect of using this option is to change the GLUT initial size and initial position the same as if glutInitWindowSize or glutInitWindowPosition were called directly.

- -iconic Requests all top-level windows be created in an iconic state.

- -indirect Force the use of indirect OpenGL rendering contexts.

- -direct Force the use of direct OpenGL rendering contexts (not all GLX implementations support direct rendering contexts). A fatal error is generated if direct rendering is not supported by the OpenGL implementation.

  If neither -indirect or -direct are used to force a particular behavior, GLUT will attempt to use direct rendering if possible and otherwise fallback to indirect rendering.

- -gldebug After processing callbacks and/or events, check if there are any OpenGL errors by calling glGetError. If an error is reported, print out a warning by looking up the error code with gluErrorString. Using this option is helpful in detecting OpenGL run-time errors.

- -sync Enable synchronous X protocol transactions. This option makes it easier to track down potential X protocol errors.

2.2 glutInitWindowPosition, glutInitWindowSize

glutInitWindowPosition and glutInitWindowSize set the initial window position and size respectively.
2.3 glutInitDisplayMode

Usage

```c
void glutInitWindowSize(int width, int height);
void glutInitWindowPosition(int x, int y);
```

- `width` Width in pixels.
- `height` Height in pixels.
- `x` Window X location in pixels.
- `y` Window Y location in pixels.

Description

Windows created by `glutCreateWindow` will be requested to be created with the current `initial window position` and `size`.

The initial value of the `initial window position` GLUT state is -1 and -1. If either the X or Y component to the `initial window position` is negative, the actual window position is left to the window system to determine. The initial value of the `initial window size` GLUT state is 300 by 300. The `initial window size` components must be greater than zero.

The intent of the `initial window position` and `size` values is to provide a suggestion to the window system for a window’s initial size and position. The window system is not obligated to use this information. Therefore, GLUT programs should not assume the window was created at the specified size or position. A GLUT program should use the window’s reshape callback to determine the true size of the window.

2.3 glutInitDisplayMode

`glutInitDisplayMode` sets the `initial display mode`.

Usage

```c
void glutInitDisplayMode(unsigned int mode);
```

- `mode` Display mode, normally the bitwise OR-ing of GLUT display mode bit masks. See values below:

  - `GLUT_RGBA` Bit mask to select an RGBA mode window. This is the default if neither `GLUT_RGBA` nor `GLUT_INDEX` are specified.
  - `GLUT_RGB` An alias for `GLUT_RGBA`.
  - `GLUT_INDEX` Bit mask to select a color index mode window. This overrides `GLUT_RGBA` if it is also specified.
  - `GLUT_SINGLE` Bit mask to select a single buffered window. This is the default if neither `GLUT_DOUBLE` or `GLUT_SINGLE` are specified.
  - `GLUT_DOUBLE` Bit mask to select a double buffered window. This overrides `GLUT_SINGLE` if it is also specified.
  - `GLUT_ACCUM` Bit mask to select a window with an accumulation buffer.
  - `GLUT_ALPHA` Bit mask to select a window with an alpha component to the color buffer(s).
  - `GLUT_DEPTH` Bit mask to select a window with a depth buffer.
  - `GLUT_STENCIL` Bit mask to select a window with a stencil buffer.
  - `GLUT_MULTISAMPLE` Bit mask to select a window with multisampling support. If multisampling is not available, a non-multisampling window will automatically be chosen. Note: both the OpenGL client-side and server-side implementations must support the `GLX_SAMPLE_SGIS` extension for multisampling to be available.
  - `GLUT_STEREO` Bit mask to select a stereo window.
GLUT_LUMINANCE Bit mask to select a window with a “luminance” color model. This model provides the functionality of OpenGL’s RGBA color model, but the green and blue components are not maintained in the frame buffer. Instead each pixel’s red component is converted to an index between zero and glutGet(GLUT_WINDOW_COLORMAP_SIZE)−1 and looked up in a per-window color map to determine the color of pixels within the window. The initial colormap of GLUT_LUMINANCE windows is initialized to be a linear gray ramp, but can be modified with GLUT’s colormap routines.

**Description**
The *initial display mode* is used when creating top-level windows, subwindows, and overlays to determine the OpenGL display mode for the to-be-created window or overlay.

Note that GLUT_RGBA selects the RGBA color model, but it does not request any bits of alpha (sometimes called an *alpha buffer* or *destination alpha*) be allocated. To request alpha, specify GLUT ALPHA. The same applies to GLUT_LUMINANCE.

**GLUT_LUMINANCE Implementation Notes**
GLUT_LUMINANCE is not supported on most OpenGL platforms.

### 3 Beginning Event Processing

After a GLUT program has done initial setup such as creating windows and menus, GLUT programs enter the GLUT event processing loop by calling `glutMainLoop`.

#### 3.1 glutMainLoop

`glutMainLoop` enters the GLUT event processing loop.

**Usage**

```c
void glutMainLoop(void);
```

**Description**

`glutMainLoop` enters the GLUT event processing loop. This routine should be called at most once in a GLUT program. Once called, this routine will never return. It will call as necessary any callbacks that have been registered.

### 4 Window Management

GLUT supports two types of windows: top-level windows and subwindows. Both types support OpenGL rendering and GLUT callbacks. There is a single identifier space for both types of windows.

#### 4.1 glutCreateWindow

`glutCreateWindow` creates a top-level window.

**Usage**

```c
int glutCreateWindow(char *name);
```

name ASCII character string for use as window name.
4.2 glutCreateSubWindow

Description

`glutCreateWindow` creates a top-level window. The name will be provided to the window system as the window’s name. The intent is that the window system will label the window with the name.

Implicitly, the current window is set to the newly created window.

Each created window has a unique associated OpenGL context. State changes to a window’s associated OpenGL context can be done immediately after the window is created.

The display state of a window is initially for the window to be shown. But the window’s display state is not actually acted upon until `glutMainLoop` is entered. This means until `glutMainLoop` is called, rendering to a created window is ineffective because the window can not yet be displayed.

The value returned is a unique small integer identifier for the window. The range of allocated identifiers starts at one. This window identifier can be used when calling `glutSetWindow`.

X Implementation Notes

The proper X Inter-Client Communication Conventions Manual (ICCCM) top-level properties are established. The `WM_COMMAND` property that lists the command line used to invoke the GLUT program is only established for the first window created.

4.2 glutCreateSubWindow

`glutCreateSubWindow` creates a subwindow.

Usage

```c
int glutCreateSubWindow(int win,
                           int x, int y, int width, int height);
```

**win** Identifier of the subwindow’s parent window.

**x** Window X location in pixels relative to parent window’s origin.

**y** Window Y location in pixels relative to parent window’s origin.

**width** Width in pixels.

**height** Height in pixels.

Description

`glutCreateSubWindow` creates a subwindow of the window identified by `win` of size `width` and `height` at location `x` and `y` within the current window. Implicitly, the current window is set to the newly created subwindow.

Each created window has a unique associated OpenGL context. State changes to a window’s associated OpenGL context can be done immediately after the window is created.

The display state of a window is initially for the window to be shown. But the window’s display state is not actually acted upon until `glutMainLoop` is entered. This means until `glutMainLoop` is called, rendering to a created window is ineffective. Subwindows can not be iconified.

Subwindows can be nested arbitrarily deep.

The value returned is a unique small integer identifier for the window. The range of allocated identifiers starts at one.

4.3 glutSetWindow, glutGetWindow

`glutSetWindow` sets the current window; `glutGetWindow` returns the identifier of the current window.
4. WINDOW MANAGEMENT

Usage

void glutSetWindow(int win);
int glutGetWindow(void);

win Identifier of GLUT window to make the current window.

Description

glutSetWindow sets the current window; glutGetWindow returns the identifier of the current window. If no windows exist or the previously current window was destroyed, glutGetWindow returns zero. glutSetWindow does not change the layer in use for the window; this is done using glutUseLayer.

4.4 glutDestroyWindow

glutDestroyWindow destroys the specified window.

Usage

void glutDestroyWindow(int win);

win Identifier of GLUT window to destroy.

Description

glutDestroyWindow destroys the window specified by win and the window’s associated OpenGL context, logical colormap (if the window is color index), and overlay and related state (if an overlay has been established). Any subwindows of destroyed windows are also destroyed by glutDestroyWindow. If win was the current window, the current window becomes invalid (glutGetWindow will return zero).

4.5 glutPostRedisplay

glutPostRedisplay marks the current window as needing to be redisplayed.

Usage

void glutPostRedisplay(void);

Description

Mark the normal plane of current window as needing to be redisplayed. The next iteration through glutMainLoop, the window’s display callback will be called to redisplay the window’s normal plane. Multiple calls to glutPostRedisplay before the next display callback opportunity generates only a single redisplay callback. glutPostRedisplay may be called within a window’s display or overlay display callback to re-mark that window for redisplay.

Logically, normal plane damage notification for a window is treated as a glutPostRedisplay on the damaged window. Unlike damage reported by the window system, glutPostRedisplay will not set to true the normal plane’s damaged status (returned by glutLayerGet (GLUT_NORMAL_DAMAGED)).

Also, see glutPostOverlayRedisplay.

4.6 glutSwapBuffers

glutSwapBuffers swaps the buffers of the current window if double buffered.

Usage

void glutSwapBuffers(void);
4.7 glutPositionWindow

Description
Performs a buffer swap on the layer in use for the current window. Specifically, glutSwapBuffers promotes the contents of the back buffer of the layer in use of the current window to become the contents of the front buffer. The contents of the back buffer then become undefined. The update typically takes place during the vertical retrace of the monitor, rather than immediately after glutSwapBuffers is called.

An implicit glFlush is done by glutSwapBuffers before it returns. Subsequent OpenGL commands can be issued immediately after calling glutSwapBuffers, but are not executed until the buffer exchange is completed.

If the layer in use is not double buffered, glutSwapBuffers has no effect.

4.7 glutPositionWindow

glutPositionWindow requests a change to the position of the current window.

Usage
void glutPositionWindow(int x, int y);

x New X location of window in pixels.
y New Y location of window in pixels.

Description

glutPositionWindow requests a change in the position of the current window. For top-level windows, the x and y parameters are pixel offsets from the screen origin. For subwindows, the x and y parameters are pixel offsets from the window’s parent window origin.

The requests by glutPositionWindow are not processed immediately. The request is executed after returning to the main event loop. This allows multiple glutPositionWindow, glutReshapeWindow, and glutFullScreen requests to the same window to be coalesced.

In the case of top-level windows, a glutPositionWindow call is considered only a request for positioning the window. The window system is free to apply its own policies to top-level window placement. The intent is that top-level windows should be repositioned according glutPositionWindow’s parameters.

glutPositionWindow disables the full screen status of a window if previously enabled.

4.8 glutReshapeWindow

glutReshapeWindow requests a change to the size of the current window.

Usage
void glutReshapeWindow(int width, int height);

width New width of window in pixels.
height New height of window in pixels.

Description

glutReshapeWindow requests a change in the size of the current window. The width and height parameters are size extents in pixels. The width and height must be positive values.

The requests by glutReshapeWindow are not processed immediately. The request is executed after returning to the main event loop. This allows multiple glutReshapeWindow, glutPositionWindow, and glutFullScreen requests to the same window to be coalesced.

In the case of top-level windows, a glutReshapeWindow call is considered only a request for sizing the window. The window system is free to apply its own policies to top-level window sizing. The intent is that
top-level windows should be reshaped according to glutReshapeWindow’s parameters. Whether a reshape actually takes effect and, if so, the reshaped dimensions are reported to the program by a reshape callback.

4.9 glutFullScreen

glutFullScreen requests that the current window be made full screen.

Usage

```c
void glutFullScreen(void);
```

Description

glutFullScreen requests that the current window be made full screen. The exact semantics of what full screen means may vary by window system. The intent is to make the window as large as possible and disable any window decorations or borders added by the window system. The window width and height are not guaranteed to be the same as the screen width and height, but that is the intent of making a window full screen.

- glutFullScreen is defined to work only on top-level windows.
- The glutFullScreen requests are not processed immediately. The request is executed after returning to the main event loop. This allows multiple glutReshapeWindow, glutPositionWindow, and glutFullScreen requests to the same window to be coalesced.
- Subsequent glutReshapeWindow and glutPositionWindow requests on the window will disable the full screen status of the window.

X Implementation Notes

In the X implementation of GLUT, full screen is implemented by sizing and positioning the window to cover the entire screen and posting the _WM_HINTS property on the window requesting absolutely no decorations. Non-Motif window managers may not respond to _WM_HINTS.

4.10 glutPopWindow, glutPushWindow

glutPopWindow and glutPushWindow change the stacking order of the current window relative to its siblings.

Usage

```c
void glutPopWindow(void);
void glutPushWindow(void);
```

Description

glutPopWindow and glutPushWindow work on both top-level windows and subwindows. The effect of pushing and popping windows does not take place immediately. Instead the push or pop is saved for execution upon return to the GLUT event loop. Subsequent push or pop requests on a window replace the previously saved request for that window. The effect of pushing and popping top-level windows is subject to the window system’s policy for restacking windows.

4.11 glutShowWindow, glutHideWindow, glutIconifyWindow

glutShowWindow, glutHideWindow, and glutIconifyWindow change the display status of the current window.
4.12 glutSetWindowTitle, glutSetIconTitle

Usage

void glutShowWindow(void);
void glutHideWindow(void);
void glutIconifyWindow(void);

Description

glutShowWindow will show the current window (though it may still not be visible if obscured by other shown windows). glutHideWindow will hide the current window. glutIconifyWindow will iconify a top-level window, but GLUT prohibits iconification of a subwindow. The effect of showing, hiding, and iconifying windows does not take place immediately. Instead the requests are saved for execution upon return to the GLUT event loop. Subsequent show, hide, or iconification requests on a window replace the previously saved request for that window. The effect of hiding, showing, or iconifying top-level windows is subject to the window system’s policy for displaying windows.

4.12 glutSetWindowTitle, glutSetIconTitle

glutSetWindowTitle and glutSetIconTitle change the window or icon title respectively of the current top-level window.

Usage

void glutSetWindowTitle(char *name);
void glutSetIconTitle(char *name);

name ASCII character string for the window or icon name to be set for the window.

Description

These routines should be called only when the current window is a top-level window. Upon creation of a top-level window, the window and icon names are determined by the name parameter to glutCreateWindow. Once created, glutSetWindowTitle and glutSetIconTitle can change the window and icon names respectively of top-level windows. Each call requests the window system change the title appropriately. Requests are not buffered or coalesced. The policy by which the window and icon name are displayed is window system dependent.

4.13 glutSetCursor

glutSetCursor changes the cursor image of the current window.

Usage

void glutSetCursor(int cursor);

cursor Name of cursor image to change to.

GLUT_CURSOR_RIGHT_ARROW Arrow pointing up and to the right.
GLUT_CURSOR_LEFT_ARROW Arrow pointing up and to the left.
GLUT_CURSOR_INFO Pointing hand.
GLUT_CURSOR_DESTROY Skull & cross bones.
GLUT_CURSOR_HELP Question mark.
GLUT_CURSOR_CYCLE Arrows rotating in a circle.
GLUT_CURSOR_SPRAY Spray can.
GLUT_CURSOR_WAIT  Wrist watch.
GLUT_CURSOR_TEXT  Insertion point cursor for text.
GLUT_CURSOR_CROSSHAIR Simple cross-hair.
GLUT_CURSOR_UP_DOWN Bi-directional pointing up & down.
GLUT_CURSOR_LEFT_RIGHT Bi-directional pointing left & right.
GLUT_CURSOR_TOP_SIDE Arrow pointing to top side.
GLUT_CURSOR_BOTTOM_SIDE Arrow pointing to bottom side.
GLUT_CURSOR_LEFT_SIDE Arrow pointing to left side.
GLUT_CURSOR_RIGHT_SIDE Arrow pointing to right side.
GLUT_CURSOR_TOP_LEFT_CORNER Arrow pointing to top-left corner.
GLUT_CURSOR_TOP_RIGHT_CORNER Arrow pointing to top-right corner.
GLUT_CURSOR_BOTTOM_RIGHT_CORNER Arrow pointing to bottom-right corner.
GLUT_CURSOR_BOTTOM_LEFT_CORNER Arrow pointing to bottom-left corner.
GLUT_CURSOR_FULL_CROSSHAIR Full-screen cross-hair cursor (if possible, otherwise GLUT_CURSOR_CROSSHAIR).
GLUT_CURSOR_NONE Invisible cursor.
GLUT_CURSOR_INHERIT Use parent’s cursor.

Description

glutSetCursor changes the cursor image of the current window. Each call requests the window system change the cursor appropriately. The cursor image when a window is created is GLUT_CURSOR_INHERIT. The exact cursor images used are implementation dependent. The intent is for the image to convey the meaning of the cursor name. For a top-level window, GLUT_CURSOR_INHERIT uses the default window system cursor.

X Implementation Notes

GLUT for X uses SGI’s _SGI_CROSSHAIR_CURSOR convention [4] to access a full-screen cross-hair cursor if possible.

5 Overlay Management

When overlay hardware is available, GLUT provides a set of routine for establishing, using, and removing an overlay for GLUT windows. When an overlay is established, a separate OpenGL context is also established. A window’s overlay OpenGL state is kept distinct from the normal planes OpenGL state.

5.1 glutEstablishOverlay

glutEstablishOverlay establishes an overlay (if possible) for the current window.

Usage

void glutEstablishOverlay(void);
5.2 GLUT UseLayer

Description

glutEstablishOverlay establishes an overlay (if possible) for the current window. The requested display mode for the overlay is determined by the initial display mode. glutLayerGet (GLUT_OVERLAY_POSSIBLE) can be called to determine if an overlay is possible for the current window with the current initial display mode. Do not attempt to establish an overlay when one is not possible; GLUT will terminate the program.

If glutEstablishOverlay is called when an overlay already exists, the existing overlay is first removed, and then a new overlay is established. The state of the old overlay’s OpenGL context is discarded.

The initial display state of an overlay is shown, however the overlay is only actually shown if the overlay’s window is shown.

Implicitly, the window’s layer in use changes to the overlay immediately after the overlay is established.

X Implementation Notes

GLUT for X uses the SERVER_OVERLAY_VISUALS convention [5] is used to determine if overlay visuals are available. While the convention allows for opaque overlays (no transparency) and overlays with the transparency specified as a bitmask, GLUT overlay management only provides access to transparent pixel overlays.

Until RGBA overlays are better understood, GLUT only supports color index overlays.

5.2 GLUT UseLayer

glutUseLayer changes the layer in use for the current window.

Usage

void glutUseLayer (GLenum layer);

layer Either GLUT_NORMAL or GLUT_OVERLAY, selecting the normal plane or overlay respectively.

Description

glutUseLayer changes the per-window layer in use for the current window, selecting either the normal plane or overlay. The overlay should only be specified if an overlay exists, however windows without an overlay may still call glutUseLayer (GLUT_NORMAL). OpenGL commands for the window are directed to the current layer in use.

To query the layer in use for a window, call glutLayerGet (GLUT_LAYER_IN_USE).

5.3 GLUT RemoveOverlay

glutRemoveOverlay removes the overlay (if one exists) from the current window.

Usage

void glutRemoveOverlay (void);

Description

glutRemoveOverlay removes the overlay (if one exists). It is safe to call glutRemoveOverlay even if no overlay is currently established–it does nothing in this case. Implicitly, the window’s layer in use changes to the normal plane immediately once the overlay is removed.

If the program intends to re-establish the overlay later, it is typically faster and less resource intensive to use glutHideOverlay and glutShowOverlay to simply change the display status of the overlay.
5.4  glutPostOverlayRedisplay

glutPostOverlayRedisplay marks the overlay of the current window as needing to be redisplayed.

Usage

void glutPostOverlayRedisplay(void);

Description

Mark the overlay of current window as needing to be redisplayed. The next iteration through glutMainLoop, the window’s overlay display callback (or simply the display callback if no overlay display callback is registered) will be called to redisplay the window’s overlay plane. Multiple calls to glutPostOverlayRedisplay before the next display callback opportunity (or overlay display callback opportunity if one is registered) generate only a single redisplay. glutPostOverlayRedisplay may be called within a window’s display or overlay display callback to re-mark that window for redisplay.

Logically, overlay damage notification for a window is treated as a glutPostOverlayRedisplay on the damaged window. Unlike damage reported by the window system, glutPostOverlayRedisplay will not set to true the overlay’s damaged status (returned by glutLayerGet(GLUT_OVERLAY_DAMAGED)).

Also, see glutPostRedisplay.

5.5  glutShowOverlay, glutHideOverlay

glutShowOverlay shows the overlay of the current window; glutHideOverlay hides the overlay.

Usage

void glutShowOverlay(void);
void glutHideOverlay(void);

Description

glutShowOverlay shows the overlay of the current window; glutHideOverlay hides the overlay. The effect of showing or hiding an overlay takes place immediately. Note that glutShowOverlay will not actually display the overlay unless the window is also shown (and even a shown window may be obscured by other windows, thereby obscuring the overlay). It is typically faster and less resource intensive to use these routines to control the display status of an overlay as opposed to removing and re-establishing the overlay.

6  Menu Management

GLUT supports simple cascading pop-up menus. They are designed to let a user select various modes within a program. The functionality is simple and minimalistic and is meant to be that way. Do not mistake GLUT’s pop-up menu facility with an attempt to create a full-featured user interface.

It is illegal to create or destroy menus, or change, add, or remove menu items while a menu (and any cascaded sub-menus) are in use (that is, popped up).

6.1  glutCreateMenu

glutCreateMenu creates a new pop-up menu.

Usage

int glutCreateMenu(void (*func)(int value));

func The callback function for the menu that is called when a menu entry from the menu is selected. The value passed to the callback is determined by the value for the selected menu entry.
6.2 glutSetMenu, glutGetMenu

**Description**

glutCreateMenu creates a new pop-up menu and returns a unique small integer identifier. The range of allocated identifiers starts at one. The menu identifier range is separate from the window identifier range. Implicitly, the *current menu* is set to the newly created menu. This menu identifier can be used when calling glutSetMenu.

When the menu callback is called because a menu entry is selected for the menu, the *current menu* will be implicitly set to the menu with the selected entry before the callback is made.

**X Implementation Notes**

If available, GLUT for X will take advantage of overlay planes for implementing pop-up menus. The use of overlay planes can eliminate display callbacks when pop-up menus are deactivated. The SERVER_OVERLAY_VISUALS convention [5] is used to determine if overlay visuals are available.

### 6.2 glutSetMenu, glutGetMenu

**glutSetMenu** sets the *current menu*; **glutGetMenu** returns the identifier of the *current menu*.

**Usage**

```c
void glutSetMenu(int menu);
int glutGetMenu(void);
```

**menu** The identifier of the menu to make the *current menu*.

**Description**

**glutSetMenu** sets the *current menu*; **glutGetMenu** returns the identifier of the *current menu*. If no menus exist or the previous *current menu* was destroyed, **glutGetMenu** returns zero.

### 6.3 glutDestroyMenu

**glutDestroyMenu** destroys the specified menu.

**Usage**

```c
void glutDestroyMenu(int menu);
```

**menu** The identifier of the menu to destroy.

**Description**

**glutDestroyMenu** destroys the specified menu by **menu**. If **menu** was the *current menu*, the *current menu* becomes invalid and **glutGetMenu** will return zero.

### 6.4 glutAddMenuEntry

**glutAddMenuEntry** adds a menu entry to the bottom of the *current menu*.

**Usage**

```c
void glutAddMenuEntry(char *name, int value);
```

**name** ASCII character string to display in the menu entry.

**value** Value to return to the menu’s callback function if the menu entry is selected.
6. MENU MANAGEMENT

Description

glutAddMenuEntry adds a menu entry to the bottom of the current menu. The string name will be displayed for the newly added menu entry. If the menu entry is selected by the user, the menu’s callback will be called passing value as the callback’s parameter.

6.5 glutAddSubMenu

glutAddSubMenu adds a sub-menu trigger to the bottom of the current menu.

Usage

void glutAddSubMenu(char *name, int menu);

name ASCII character string to display in the menu item from which to cascade the sub-menu.

menu Identifier of the menu to cascade from this sub-menu menu item.

Description

glutAddSubMenu adds a sub-menu trigger to the bottom of the current menu. The string name will be displayed for the newly added sub-menu trigger. If the sub-menu trigger is entered, the sub-menu numbered menu will be cascaded, allowing sub-menu menu items to be selected.

6.6 glutChangeToMenuEntry

glutChangeToMenuEntry changes the specified menu item in the current menu into a menu entry.

Usage

void glutChangeToMenuEntry(int entry, char *name, int value);

entry Index into the menu items of the current menu (1 is the topmost menu item).

name ASCII character string to display in the menu entry.

value Value to return to the menu’s callback function if the menu entry is selected.

Description

glutChangeToMenuEntry changes the specified menu entry in the current menu into a menu entry. The entry parameter determines which menu item should be changed, with one being the topmost item. entry must be between 1 and glutGet(GLUT_MENU_NUM_ITEMS) inclusive. The menu item to change does not have to be a menu entry already. The string name will be displayed for the newly changed menu entry. The value will be returned to the menu’s callback if this menu entry is selected.

6.7 glutChangeToSubMenu

glutChangeToSubMenu changes the specified menu item in the current menu into a sub-menu trigger.

Usage

void glutChangeToSubMenu(int entry, char *name, int menu);

entry Index into the menu items of the current menu (1 is the topmost menu item).

name ASCII character string to display in the menu item to cascade the sub-menu from.

menu Identifier of the menu to cascade from this sub-menu menu item.
6.8 glutRemoveMenuItem

**Description**

`glutChangeToSubMenu` changes the specified menu item in the *current menu* into a sub-menu trigger. The `entry` parameter determines which menu item should be changed, with one being the topmost item. `entry` must be between 1 and `glutGet(GLUT_MENU_NUM_ITEMS)` inclusive. The menu item to change does not have to be a sub-menu trigger already. The string `name` will be displayed for the newly changed sub-menu trigger. The `menu` identifier names the sub-menu to cascade from the newly added sub-menu trigger.

6.8 glutRemoveMenuItem

`glutRemoveMenuItem` remove the specified menu item.

**Usage**

```c
void glutRemoveMenuItem(int entry);
```

`entry` Index into the menu items of the *current menu* (1 is the topmost menu item).

**Description**

`glutRemoveMenuItem` remove the `entry` menu item regardless of whether it is a menu entry or sub-menu trigger. `entry` must be between 1 and `glutGet(GLUT_MENU_NUM_ITEMS)` inclusive. Menu items below the removed menu item are renumbered.

6.9 glutAttachMenu, glutDetachMenu

`glutAttachMenu` attaches a mouse button for the *current window* to the identifier of the *current menu*; `glutDetachMenu` detaches an attached mouse button from the *current window*.

**Usage**

```c
void glutAttachMenu(int button);
void glutDetachMenu(int button);
```

`button` The button to attach a menu or detach a menu.

**Description**

`glutAttachMenu` attaches a mouse button for the *current window* to the identifier of the *current menu*; `glutDetachMenu` detaches an attached mouse button from the *current window*. By attaching a menu identifier to a button, the named menu will be popped up when the user presses the specified button. `button` should be one of `GLUT_LEFT_BUTTON`, `GLUT_MIDDLE_BUTTON`, and `GLUT_RIGHT_BUTTON`. Note that the menu is attached to the button by identifier, not by reference.

7 Callback Registration

GLUT supports a number of callbacks to respond to events. There are three types of callbacks: window, menu, and global. Window callbacks indicate when to redisplay or reshape a window, when the visibility of the window changes, and when input is available for the window. The menu callback is set by the `glutCreateMenu` call described already. The global callbacks manage the passing of time and menu usage. The calling order of callbacks between different windows is undefined.

Callbacks for input events should be delivered to the window the event occurs in. Events should not propagate to parent windows.
X Implementation Notes

The X GLUT implementation uses the X Input extension [11, 12] to support sophisticated input devices: Spaceball, dial & button box, and digitizing tablet. Because the X Input extension does not mandate how particular types of devices are advertised through the extension, it is possible GLUT for X may not correctly support input devices that would otherwise be of the correct type. The X GLUT implementation will support the Silicon Graphics Spaceball, dial & button box, and digitizing tablet as advertised through the X Input extension.

7.1 glutDisplayFunc

GlutDisplayFunc sets the display callback for the current window.

Usage

```c
void glutDisplayFunc(void (*func)(void));
```

**func** The new display callback function.

Description

GlutDisplayFunc sets the display callback for the current window. When GLUT determines that the normal plane for the window needs to be redisplayed, the display callback for the window is called. Before the callback, the current window is set to the window needing to be redisplayed and (if no overlay display callback is registered) the layer in use is set to the normal plane. The display callback is called with no parameters. The entire normal plane region should be redisplayed in response to the callback (this includes ancillary buffers if your program depends on their state).

GLUT determines when the display callback should be triggered based on the window’s redisplay state. The redisplay state for a window can be either set explicitly by calling glutPostRedisplay or implicitly as the result of window damage reported by the window system. Multiple posted redisesplays for a window are coalesced by GLUT to minimize the number of display callbacks called.

When an overlay is established for a window, but there is no overlay display callback registered, the display callback is used for redisplaying both the overlay and normal plane (that is, it will be called if either the redisplay state or overlay redisplay state is set). In this case, the layer in use is not implicitly changed on entry to the display callback.

See glutOverlayDisplayFunc to understand how distinct callbacks for the overlay and normal plane of a window may be established.

When a window is created, no display callback exists for the window. It is the responsibility of the programmer to install a display callback for the window before the window is shown. A display callback must be registered for any window that is shown. If a window becomes displayed without a display callback being registered, a fatal error occurs. Passing NULL to glutDisplayFunc is illegal as of GLUT 3.0; there is no way to “deregister” a display callback (though another callback routine can always be registered).

Upon return from the display callback, the normal damaged state of the window (returned by calling glutLayerGet (GLUT_NORMAL_DAMAGED) is cleared. If there is no overlay display callback registered the overlay damaged state of the window (returned by calling glutLayerGet (GLUT_OVERLAY_DAMAGED) is also cleared.

7.2 glutOverlayDisplayFunc

GlutOverlayDisplayFunc sets the overlay display callback for the current window.

Usage

```c
void glutOverlayDisplayFunc(void (*func)(void));
```

**func** The new overlay display callback function.
7.3 glutReshapeFunc

Description

glutReshapeFunc sets the reshape callback for the current window. The reshape callback is triggered when a window is reshaped. A reshape callback is also triggered immediately before a window’s first display callback after a window is created or whenever an overlay for the window is established. The width and height parameters of the callback specify the new window size in pixels. Before the callback, the current window is set to the window that has been reshaped.

If a reshape callback is not registered for a window or NULL is passed to glutReshapeFunc (to deregister a previously registered callback), the default reshape callback is used. This default callback will simply call glViewport(0, 0, width, height) on the normal plane (and on the overlay if one exists).

If an overlay is established for the window, a single reshape callback is generated. It is the callback’s responsibility to update both the normal plane and overlay for the window (changing the layer in use as necessary).

When a top-level window is reshaped, subwindows are not reshaped. It is up to the GLUT program to manage the size and positions of subwindows within a top-level window. Still, reshape callbacks will be triggered for subwindows when their size is changed using glutReshapeWindow.

7.4 glutKeyboardFunc

glutKeyboardFunc sets the keyboard callback for the current window.

Usage

void glutKeyboardFunc(void (*func)(unsigned char key, int x, int y));

func The new keyboard callback function.

Description

glutKeyboardFunc sets the keyboard callback for the current window. The keyboard callback is called when a key is pressed or released. The callback is triggered whenever a key is pressed or released, before and after a display callback, and after a reshape callback. Before the callback, the current window is set to the window that has the input.

When an overlay is established, the keyboard callback is called for the overlay plane (if one exists). If an overlay is not established, the keyboard callback is called for the normal plane. If a display callback is not registered for the window or NULL is passed to glutDisplayFunc (to deregister a previously registered callback), the default display callback is used. This default callback will simply call glutPostOverlayRedisplay or implicitly as the result of window damage reported by the window system. Multiple posted overlay redisplay events for a window are coalesced by GLUT to minimize the number of overlay display callbacks called.

Upon return from the overlay display callback, the overlay damaged state of the window (returned by calling glutLayerGet(GLUT_OVERLAY_DAMAGED)) is cleared.

The overlay display callback can be deregistered by passing NULL to glutOverlayDisplayFunc. The overlay display callback is initially NULL when an overlay is established. See glutDisplayFunc to understand how the display callback alone is used if an overlay display callback is not registered.
func The new keyboard callback function.

Description

glutKeyboardFunc sets the keyboard callback for the current window. When a user types into the window, each key press generating an ASCII character will generate a keyboard callback. The key callback parameter is the generated ASCII character. The state of modifier keys such as Shift cannot be determined directly; their only effect will be on the returned ASCII data. The x and y callback parameters indicate the mouse location in window relative coordinates when the key was pressed. When a new window is created, no keyboard callback is initially registered, and ASCII key strokes in the window are ignored. Passing NULL to glutKeyboardFunc disables the generation of keyboard callbacks.

During a keyboard callback, glutGetModifiers may be called to determine the state of modifier keys when the keystroke generating the callback occurred.

Also, see glutSpecialFunc for a means to detect non-ASCII key strokes.

7.5 glutMouseFunc

glutMouseFunc sets the mouse callback for the current window.

Usage

void glutMouseFunc(void (*func)(int button, int state,
                        int x, int y));

func The new mouse callback function.

Description

glutMouseFunc sets the mouse callback for the current window. When a user presses and releases mouse buttons in the window, each press and each release generates a mouse callback. The button parameter is one of GLUT_LEFT_BUTTON, GLUT_MIDDLE_BUTTON, or GLUT_RIGHT_BUTTON. For systems with only two mouse buttons, it may not be possible to generate GLUT_MIDDLE_BUTTON callback. For systems with a single mouse button, it may be possible to generate only a GLUT_LEFT_BUTTON callback. The state parameter is either GLUT_UP or GLUT_DOWN indicating whether the callback was due to a release or press respectively. The x and y callback parameters indicate the window relative coordinates when the mouse button state changed. If a GLUT_DOWN callback for a specific button is triggered, the program can assume a GLUT_UP callback for the same button will be generated (assuming the window still has a mouse callback registered) when the mouse button is released even if the mouse has moved outside the window.

If a menu is attached to a button for a window, mouse callbacks will not be generated for that button.

During a mouse callback, glutGetModifiers may be called to determine the state of modifier keys when the mouse event generating the callback occurred.

Passing NULL to glutMouseFunc disables the generation of mouse callbacks.

7.6 glutMotionFunc, glutPassiveMotionFunc

glutMotionFunc and glutPassiveMotionFunc set the motion and passive motion callbacks respectively for the current window.

Usage

void glutMotionFunc(void (*func)(int x, int y));
void glutPassiveMotionFunc(void (*func)(int x, int y));

func The new motion or passive motion callback function.
7.7 glutVisibilityFunc

Description

glutMotionFunc and glutPassiveMotionFunc set the motion and passive motion callback respectively for the current window. The motion callback for a window is called when the mouse moves within the window while one or more mouse buttons are pressed. The passive motion callback for a window is called when the mouse moves within the window while no mouse buttons are pressed.

The x and y callback parameters indicate the mouse location in window relative coordinates.

Passing NULL to glutMotionFunc or glutPassiveMotionFunc disables the generation of the mouse or passive motion callback respectively.

7.7 glutVisibilityFunc

glutVisibilityFunc sets the visibility callback for the current window.

Usage

void glutVisibilityFunc(void (*func)(int state));

func The new visibility callback function.

Description

glutVisibilityFunc sets the visibility callback for the current window. The visibility callback for a window is called when the visibility of a window changes. The state callback parameter is either GLUT_NOT_VISIBLE or GLUT_VISIBLE depending on the current visibility of the window. GLUT_VISIBLE does not distinguish a window being totally versus partially visible. GLUT_NOT_VISIBLE means no part of the window is visible, i.e., until the window’s visibility changes, all further rendering to the window is discarded.

GLUT considers a window visible if any pixel of the window is visible or any pixel of any descendant window is visible on the screen.

Passing NULL to glutVisibilityFunc disables the generation of the visibility callback.

If the visibility callback for a window is disabled and later re-enabled, the visibility status of the window is undefined; any change in window visibility will be reported, that is if you disable a visibility callback and re-enable the callback, you are guaranteed the next visibility change will be reported.

7.8 glutEntryFunc

glutEntryFunc sets the mouse enter/leave callback for the current window.

Usage

void glutEntryFunc(void (*func)(int state));

func The new entry callback function.

Description

glutEntryFunc sets the mouse enter/leave callback for the current window. The state callback parameter is either GLUT_LEFT or GLUT_ENTERED depending on if the mouse pointer has last left or entered the window.

Passing NULL to glutEntryFunc disables the generation of the mouse enter/leave callback.

Some window systems may not generate accurate enter/leave callbacks.

X Implementation Notes

An X implementation of GLUT should generate accurate enter/leave callbacks.
7.9 \texttt{glutSpecialFunc}

\texttt{glutSpecialFunc} sets the special keyboard callback for the current window.

Usage

\begin{verbatim}
void glutSpecialFunc(void (*func)(int key, int x, int y));
\end{verbatim}

\texttt{func} The new entry callback function.

Description

\texttt{glutSpecialFunc} sets the special keyboard callback for the current window. The special keyboard callback is triggered when keyboard function or directional keys are pressed. The \texttt{key} callback parameter is a \texttt{GLUT\_KEY\_*} constant for the special key pressed. The \texttt{x} and \texttt{y} callback parameters indicate the mouse in window relative coordinates when the key was pressed. When a new window is created, no special callback is initially registered and special key strokes in the window are ignored. Passing \texttt{NULL} to \texttt{glutSpecialFunc} disables the generation of special callbacks.

During a special callback, \texttt{glutGetModifiers} may be called to determine the state of modifier keys when the keystroke generating the callback occurred.

An implementation should do its best to provide ways to generate all the \texttt{GLUT\_KEY\_*} special keys. The available \texttt{GLUT\_KEY\_*} values are:

- \texttt{GLUT\_KEY\_F1} F1 function key.
- \texttt{GLUT\_KEY\_F2} F2 function key.
- \texttt{GLUT\_KEY\_F3} F3 function key.
- \texttt{GLUT\_KEY\_F4} F4 function key.
- \texttt{GLUT\_KEY\_F5} F5 function key.
- \texttt{GLUT\_KEY\_F6} F6 function key.
- \texttt{GLUT\_KEY\_F7} F7 function key.
- \texttt{GLUT\_KEY\_F8} F8 function key.
- \texttt{GLUT\_KEY\_F9} F9 function key.
- \texttt{GLUT\_KEY\_F10} F10 function key.
- \texttt{GLUT\_KEY\_F11} F11 function key.
- \texttt{GLUT\_KEY\_F12} F12 function key.
- \texttt{GLUT\_KEY\_LEFT} Left directional key.
- \texttt{GLUT\_KEY\_UP} Up directional key.
- \texttt{GLUT\_KEY\_RIGHT} Right directional key.
- \texttt{GLUT\_KEY\_DOWN} Down directional key.
- \texttt{GLUT\_KEY\_PAGE\_UP} Page up directional key.
- \texttt{GLUT\_KEY\_PAGE\_DOWN} Page down directional key.
- \texttt{GLUT\_KEY\_HOME} Home directional key.
- \texttt{GLUT\_KEY\_END} End directional key.
- \texttt{GLUT\_KEY\_INSERT} Inset directional key.

Note that the escape, backspace, and delete keys are generated as an ASCII character.

7.10 \texttt{glutSpaceballMotionFunc}

\texttt{glutSpaceballMotionFunc} sets the Spaceball motion callback for the current window.
7.1 glutSpaceballRotateFunc

Usage

void glutSpaceballRotateFunc(void (*func)(int x, int y, int z));

func The new entry callback function.

Description

glutSpaceballRotateFunc sets the Spaceball rotation callback for the current window. The Spaceball rotate callback for a window is called when the window has Spaceball input focus (normally, when the mouse is in the window) and the user generates Spaceball rotations. The x, y, and z callback parameters indicate the rotation along the X, Y, and Z axes. The callback parameters are normalized to be within the range of -1800 to 1800 inclusive.

Registering a Spaceball rotate callback when a Spaceball device is not available is ineffectual and not an error. In this case, no Spaceball rotate callbacks will be generated. Passing NULL to glutSpaceballRotateFunc disables the generation of Spaceball rotate callbacks. When a new window is created, no Spaceball rotate callback is initially registered.

7.11 glutSpaceballButtonFunc

Usage

void glutSpaceballButtonFunc(void (*func)(int button, int state));

func The new entry callback function.

Description

glutSpaceballButtonFunc sets the Spaceball button callback for the current window. The Spaceball button callback for a window is called when the window has Spaceball input focus (normally, when the mouse is in the window) and the user generates Spaceball button presses. The button parameter will be the button number (starting at one). The number of available Spaceball buttons can be determined with
glutDeviceGet (GLUT_NUM_SPACEBALL_BUTTONS). The state is either GLUT_UP or GLUT_DOWN indicating whether the callback was due to a release or press respectively.

Registering a Spaceball button callback when a Spaceball device is not available is ineffectual and not an error. In this case, no Spaceball button callbacks will be generated.

Passing NULL to glutSpaceballButtonFunc disables the generation of Spaceball button callbacks. When a new window is created, no Spaceball button callback is initially registered.

7.13 glutButtonBoxFunc

glutButtonBoxFunc sets the dial & button box button callback for the current window.

Usage

void glutButtonBoxFunc(void (*func)(int button, int state));

func The new entry callback function.

Description

glutButtonBoxFunc sets the dial & button box button callback for the current window. The dial & button box button callback for a window is called when the window has dial & button box input focus (normally, when the mouse is in the window) and the user generates dial & button box button presses. The button parameter will be the button number (starting at one). The number of available dial & button box buttons can be determined with glutDeviceGet (GLUT_NUM_BUTTON_BOX_BUTTONS). The state is either GLUT_UP or GLUT_DOWN indicating whether the callback was due to a release or press respectively.

Registering a dial & button box button callback when a dial & button box device is not available is ineffectual and not an error. In this case, no dial & button box button callbacks will be generated.

Passing NULL to glutButtonBoxFunc disables the generation of dial & button box button callbacks. When a new window is created, no dial & button box button callback is initially registered.

7.14 glutDialsFunc

glutDialsFunc sets the dial & button box dials callback for the current window.

Usage

void glutDialsFunc(void (*func)(int dial, int value));

func The new entry callback function.

Description

glutDialsFunc sets the dial & button box dials callback for the current window. The dial & button box dials callback for a window is called when the window has dial & button box input focus (normally, when the mouse is in the window) and the user generates dial & button box dial changes. The dial parameter will be the dial number (starting at one). The number of available dial & button box dials can be determined with glutDeviceGet (GLUT_NUM_DIALS). The value measures the absolute rotation in degrees. Dial values do not “roll over” with each complete rotation but continue to accumulate degrees (until the int dial value overflows).

Registering a dial & button box dials callback when a dial & button box device is not available is ineffectual and not an error. In this case, no dial & button box dials callbacks will be generated.

Passing NULL to glutDialsFunc disables the generation of dial & button box dials callbacks. When a new window is created, no dial & button box dials callback is initially registered.
7.15 glutTabletMotionFunc

glutTabletMotionFunc sets the special keyboard callback for the current window.

Usage

void glutTabletMotionFunc(void (*func)(int x, int y));

func The new entry callback function.

Description

glutTabletMotionFunc sets the tablet motion callback for the current window. The tablet motion callback for a window is called when the window has tablet input focus (normally, when the mouse is in the window) and the user generates tablet motion. The x and y callback parameters indicate the absolute position of the tablet “puck” on the tablet. The callback parameters are normalized to be within the range of 0 to 2000 inclusive.

Registering a tablet motion callback when a tablet device is not available is ineffectual and not an error. In this case, no tablet motion callbacks will be generated.

Passing NULL to glutTabletMotionFunc disables the generation of tablet motion callbacks. When a new window is created, no tablet motion callback is initially registered.

7.16 glutTabletButtonFunc

glutTabletButtonFunc sets the special keyboard callback for the current window.

Usage

void glutTabletButtonFunc(void (*func)(int button, int state, int x, int y));

func The new entry callback function.

Description

glutTabletButtonFunc sets the tablet button callback for the current window. The tablet button callback for a window is called when the window has tablet input focus (normally, when the mouse is in the window) and the user generates tablet button presses. The button parameter will be the button number (starting at one). The number of available tablet buttons can be determined with glutDeviceGet(GLUT_NUM_TABLET_BUTTONS). The state is either GLUT_UP or GLUT_DOWN indicating whether the callback was due to a release or press respectively. The x and y callback parameters indicate the window relative coordinates when the tablet button state changed.

Registering a tablet button callback when a tablet device is not available is ineffectual and not an error. In this case, no tablet button callbacks will be generated.

Passing NULL to glutTabletButtonFunc disables the generation of tablet button callbacks. When a new window is created, no tablet button callback is initially registered.

7.17 glutMenuStatusFunc

glutMenuStatusFunc sets the global menu status callback.

Usage

void glutMenuStatusFunc(void (*func)(int status, int x, int y));
void glutMenuStateFunc(void (*func)(int status));
Description

glutMenuStatusFunc sets the global menu status callback so a GLUT program can determine when a menu is in use or not. When a menu status callback is registered, it will be called with the value GLUT_MENU_IN_USE for its value parameter when pop-up menus are in use by the user; and the callback will be called with the value GLUT_MENU_NOT_IN_USE for its status parameter when pop-up menus are no longer in use. The \( x \) and \( y \) parameters indicate the location in window coordinates of the button press that caused the menu to go into use, or the location where the menu was released (may be outside the window). The \( \text{func} \) parameter names the callback function. Other callbacks continue to operate (except mouse motion callbacks) when pop-up menus are in use so the menu status callback allows a program to suspend animation or other tasks when menus are in use. The cascading and unmapping of sub-menus from an initial pop-up menu does not generate menu status callbacks. There is a single menu status callback for GLUT.

When the menu status callback is called, the current menu will be set to the initial pop-up menu in both the GLUT_MENU_IN_USE and GLUT_MENU_NOT_IN_USE cases. The current window will be set to the window from which the initial menu was popped up from, also in both cases.

Passing NULL to glutMenuStatusFunc disables the generation of the menu status callback. glutMenuStateFunc is a deprecated version of the glutMenuStatusFunc routine. The only difference is glutMenuStateFunc callback prototype does not deliver the two additional \( x \) and \( y \) coordinates.

7.18 glutIdleFunc

glutIdleFunc sets the global idle callback.

Usage

```c
void glutIdleFunc(void (*func)(void));
```

Description

glutIdleFunc sets the global idle callback to be \( \text{func} \) so a GLUT program can perform background processing tasks or continuous animation when window system events are not being received. If enabled, the idle callback is continuously called when events are not being received. The callback routine has no parameters. The current window and current menu will not be changed before the idle callback. Programs with multiple windows and/or menus should explicitly set the current window and/or current menu and not rely on its current setting.

The amount of computation and rendering done in an idle callback should be minimized to avoid affecting the program’s interactive response. In general, not more than a single frame of rendering should be done in an idle callback.

Passing NULL to glutIdleFunc disables the generation of the idle callback.

7.19 glutTimerFunc

glutTimerFunc registers a timer callback to be triggered in a specified number of milliseconds.

Usage

```c
void glutTimerFunc(unsigned int msecs, 
                  void (*func)(int value), value);
```

Description

glutTimerFunc registers the timer callback \( \text{func} \) to be triggered in at least \( \text{msecs} \) milliseconds. The value parameter to the timer callback will be the value of the value parameter to glutTimerFunc. Multiple timer callbacks at same or differing times may be registered simultaneously.

The number of milliseconds is a lower bound on the time before the callback is generated. GLUT attempts to deliver the timer callback as soon as possible after the expiration of the callback’s time interval.
There is no support for canceling a registered callback. Instead, ignore a callback based on its value parameter when it is triggered.

8 Color Index Colormap Management

OpenGL supports both RGBA and color index rendering. The RGBA mode is generally preferable to color index because more OpenGL rendering capabilities are available and color index mode requires the loading of colormap entries.

The GLUT color index routines are used to write and read entries in a window’s color index colormap. Every GLUT color index window has its own logical color index colormap. The size of a window’s colormap can be determined by calling `glutGet(GLUT_WINDOW_COLORMAP_SIZE)`.

GLUT color index windows within a program can attempt to share colormap resources by copying a single color index colormap to multiple windows using `glutCopyColormap`. If possible GLUT will attempt to share the actual colormap. While copying colormaps using `glutCopyColormap` can potentially allow sharing of physical colormap resources, logically each window has its own colormap. So changing a copied colormap of a window will force the duplication of the colormap. For this reason, color index programs should generally load a single color index colormap, copy it to all color index windows within the program, and then not modify any colormap cells.

Use of multiple colormaps is likely to result in colormap installation problems where some windows are displayed with an incorrect colormap due to limitations on colormap resources.

8.1 glutSetColor

`glutSetColor` sets the color of a colormap entry in the layer of use for the current window.

Usage

```c
void glutSetColor(int cell, GLfloat red, GLfloat green, GLfloat blue);
```

- `cell` Color cell index (starting at zero).
- `red` Red intensity (clamped between 0.0 and 1.0 inclusive).
- `green` Green intensity (clamped between 0.0 and 1.0 inclusive).
- `blue` Blue intensity (clamped between 0.0 and 1.0 inclusive).

Description

Sets the cell color index colormap entry of the current window’s logical colormap for the layer in use with the color specified by `red`, `green`, and `blue`. The layer in use of the current window should be a color index window. cell should be zero or greater and less than the total number of colormap entries for the window. If the layer in use’s colormap was copied by reference, a `glutSetColor` call will force the duplication of the colormap. Do not attempt to set the color of an overlay’s transparent index.

8.2 glutGetColor

`glutGetColor` retrieves a red, green, or blue component for a given color index colormap entry for the layer in use’s logical colormap for the current window.

Usage

```c
GLfloat glutGetColor(int cell, int component);
```

- `cell` Color cell index (starting at zero).
- `component` One of GLUT_RED, GLUT_GREEN, or GLUT_BLUE.
Description

glutGetColor retrieves a red, green, or blue component for a given color index colormap entry for the current window’s logical colormap. The current window should be a color index window. cell should be zero or greater and less than the total number of colormap entries for the window. For valid color indices, the value returned is a floating point value between 0.0 and 1.0 inclusive. glutGetColor will return -1.0 if the color index specified is an overlay’s transparent index, less than zero, or greater or equal to the value returned by glutGet (GLUT_WINDOW_COLORMAP_SIZE), that is if the color index is transparent or outside the valid range of color indices.

8.3 glutCopyColormap

glutCopyColormap copies the logical colormap for the layer in use from a specified window to the current window.

Usage

void glutCopyColormap(int win);

win The identifier of the window to copy the logical colormap from.

Description

glutCopyColormap copies (lazily if possible to promote sharing) the logical colormap from a specified window to the current window’s layer in use. The copy will be from the normal plane to the normal plane; or from the overlay to the overlay (never across different layers). Once a colormap has been copied, avoid setting cells in the colormap with glutSetColor since that will force an actual copy of the colormap if it was previously copied by reference. glutCopyColormap should only be called when both the current window and the win window are color index windows.

9 State Retrieval

GLUT maintains a considerable amount of programmer visible state. Some (but not all) of this state may be directly retrieved.

9.1 glutGet

glutGet retrieves simple GLUT state represented by integers.

Usage

int glutGet(GLenum state);

state Name of state to retrieve.

GLUT_WINDOW_X X location in pixels (relative to the screen origin) of the current window.

GLUT_WINDOW_Y Y location in pixels (relative to the screen origin) of the current window.

GLUT_WINDOW_WIDTH Width in pixels of the current window.

GLUT_WINDOW_HEIGHT Height in pixels of the current window.

GLUT_WINDOW_BUFFER_SIZE Total number of bits for current window’s color buffer. For an RGBA window, this is the sum of GLUT_WINDOW_RED_SIZE, GLUT_WINDOW_GREEN_SIZE, GLUT_WINDOW_BLUE_SIZE, and GLUT_WINDOW_ALPHA_SIZE. For color index windows, this is the size of the color indexes.

GLUT_WINDOW_STENCIL_SIZE Number of bits in the current window’s stencil buffer.
9.1 glutGet

GLUT_WINDOW_DEPTH_SIZE Number of bits in the current window’s depth buffer.

GLUT_WINDOW_RED_SIZE Number of bits of red stored the current window’s color buffer. Zero if the window is color index.

GLUT_WINDOW_GREEN_SIZE Number of bits of green stored the current window’s color buffer. Zero if the window is color index.

GLUT_WINDOW_BLUE_SIZE Number of bits of blue stored the current window’s color buffer. Zero if the window is color index.

GLUT_WINDOW_ALPHA_SIZE Number of bits of alpha stored the current window’s color buffer. Zero if the window is color index.

GLUT_WINDOW_ACCUM_RED_SIZE Number of bits of red stored in the current window’s accumulation buffer. Zero if the window is color index.

GLUT_WINDOW_ACCUM_GREEN_SIZE Number of bits of green stored in the current window’s accumulation buffer. Zero if the window is color index.

GLUT_WINDOW_ACCUM_BLUE_SIZE Number of bits of blue stored in the current window’s accumulation buffer. Zero if the window is color index.

GLUT_WINDOW_ACCUM_ALPHA_SIZE Number of bits of alpha stored in the current window’s accumulation buffer. Zero if the window is color index.

GLUT_WINDOW_DOUBLEBUFFER One if the current window is double buffered, zero otherwise.

GLUT_WINDOW_RGBA One if the current window is RGBA mode, zero otherwise (i.e., color index).

GLUT_WINDOW_PARENT The window number of the current window’s parent; zero if the window is a top-level window.

GLUT_WINDOW_NUM_CHILDREN The number of subwindows the current window has (not counting children of children).

GLUT_WINDOW_COLORMAP_SIZE Size of current window’s color index colormap; zero for RGBA color model windows.

GLUT_WINDOW_NUM_SAMPLES Number of samples for multisampling for the current window.

GLUT_WINDOW_STEREO One if the current window is stereo, zero otherwise.

GLUT_WINDOW_CURSOR Current cursor for the current window.

GLUT_SCREEN_WIDTH Width of the screen in pixels. Zero indicates the width is unknown or not available.

GLUT_SCREEN_HEIGHT Height of the screen in pixels. Zero indicates the height is unknown or not available.

GLUT_SCREEN_WIDTH_MM Width of the screen in millimeters. Zero indicates the width is unknown or not available.

GLUT_SCREEN_HEIGHT_MM Height of the screen in millimeters. Zero indicates the height is unknown or not available.

GLUT_MENU_NUM_ITEMS Number of menu items in the current menu.

GLUT_DISPLAY_MODE_POSSIBLE Whether the current display mode is supported or not.

GLUT_INIT_DISPLAY_MODE The initial display mode bit mask.

GLUT_INIT_WINDOW_X The X value of the initial window position.

GLUT_INIT_WINDOW_Y The Y value of the initial window position.

GLUT_INIT_WINDOW_WIDTH The width value of the initial window size.

GLUT_INIT_WINDOW_HEIGHT The height value of the initial window size.

GLUT_ELAPSED_TIME Number of milliseconds since glutInit called (or first call to glutGet (GLUT_ELAPSED_TIME)).
Description

glutGet retrieves simple GLUT state represented by integers. The state parameter determines what type of state to return. Window capability state is returned for the layer in use. GLUT state names beginning with GLUT_WINDOW return state for the current window. GLUT state names beginning with GLUT_MENU return state for the current menu. Other GLUT state names return global state. Requesting state for an invalid GLUT state name returns negative one.

9.2 glutLayerGet

glutLayerGet retrieves GLUT state pertaining to the layers of the current window.

Usage

int glutLayerGet(GLenum info);

info Name of device information to retrieve.

GLUT_OVERLAY_POSSIBLE Whether an overlay could be established for the current window given the current initial display mode. If false, glutEstablishOverlay will fail with a fatal error if called.

GLUT_LAYER_IN_USE Either GLUT_NORMAL or GLUT_OVERLAY depending on whether the normal plane or overlay is the layer in use.

GLUT_HAS_OVERLAY If the current window has an overlay established.

GLUT_TRANSPARENT_INDEX The transparent color index of the overlay of the current window; negative one is returned if no overlay is in use.

GLUT_NORMAL_DAMAGED True if the normal plane of the current window has damaged (by window system activity) since the last display callback was triggered. Calling glutPostRedisplay will not set this true.

GLUT_OVERLAY_DAMAGED True if the overlay plane of the current window has damaged (by window system activity) since the last display callback was triggered. Calling glutPostRedisplay or glutPostOverlayRedisplay will not set this true. Negative one is returned if no overlay is in use.

Description

glutLayerGet retrieves GLUT layer information for the current window represented by integers. The info parameter determines what type of layer information to return.

9.3 glutDeviceGet

glutDeviceGet retrieves GLUT device information represented by integers.

Usage

int glutDeviceGet(GLenum info);

info Name of device information to retrieve.

GLUT_HAS_KEYBOARD Non-zero if a keyboard is available; zero if not available. For most GLUT implementations, a keyboard can be assumed.

GLUT_HAS_MOUSE Non-zero if a mouse is available; zero if not available. For most GLUT implementations, a keyboard can be assumed.

GLUT_HAS_SPACEBALL Non-zero if a Spaceball is available; zero if not available.

GLUT_HAS_DIAL_AND_BUTTON_BOX Non-zero if a dial & button box is available; zero if not available.
9.4 glutGetModifiers

glutGetModifiers returns the modifier key state when certain callbacks were generated.

**Usage**

```c
int glutGetModifiers(void);
```

- **GLUT_ACTIVE_SHIFT** Set if the Shift modifier or Caps Lock is active.
- **GLUT_ACTIVE_CTRL** Set if the Ctrl modifier is active.
- **GLUT_ACTIVE_ALT** Set if the Alt modifier is active.

**Description**

glutGetModifiers returns the modifier key state at the time the input event for a keyboard, special, or mouse callback is generated. This routine may only be called while a keyboard, special, or mouse callback is being handled. The window system is permitted to intercept window system defined modifier key strokes or mouse buttons, in which case, no GLUT callback will be generated. This interception will be independent of use of glutGetModifiers.

9.5 glutExtensionSupported

glutExtensionSupported helps to easily determine whether a given OpenGL extension is supported.

**Usage**

```c
int glutExtensionSupported(char *extension);
```

- **extension** Name of OpenGL extension.
10. **FONT RENDERING**

**Description**

`glutExtensionSupported` helps to easily determine whether a given OpenGL extension is supported or not. The `extension` parameter names the extension to query. The supported extensions can also be determined with `glGetString(GL_EXTENSIONS)`, but `glutExtensionSupported` does the correct parsing of the returned string.

`glutExtensionSupported` returns non-zero if the extension is supported, zero if not supported.

There must be a valid current window to call `glutExtensionSupported`. `glutExtensionSupported` only returns information about OpenGL extensions only. This means window system dependent extensions (for example, GLX extensions) are not reported by `glutExtensionSupported`.

10 **Font Rendering**

GLUT supports two types of font rendering: stroke fonts, meaning each character is rendered as a set of line segments; and bitmap fonts, where each character is a bitmap generated with `glBitmap`. Stroke fonts have the advantage that because they are geometry, they can be arbitrarily scaled and rendered. Bitmap fonts are less flexible since they are rendered as bitmaps but are usually faster than stroke fonts.

10.1 **glutBitmapCharacter**

`glutBitmapCharacter` renders a bitmap character using OpenGL.

**Usage**

```c
void glutBitmapCharacter(void *font, int character);
```

*font*  Bitmap font to use.

*character* Character to render (not confined to 8 bits).

**Description**

Without using any display lists, `glutBitmapCharacter` renders the character in the named bitmap font. The available fonts are:

- **GLUT_BITMAP_8_BY_13** A fixed width font with every character fitting in an 8 by 13 pixel rectangle. The exact bitmaps to be used is defined by the standard X glyph bitmaps for the X font named:
  `-misc-fixed-medium-r-normal--13-120-75-75-C-80-iso8859-1`

- **GLUT_BITMAP_9_BY_15** A fixed width font with every character fitting in an 9 by 15 pixel rectangle. The exact bitmaps to be used is defined by the standard X glyph bitmaps for the X font named:
  `-misc-fixed-medium-r-normal--15-140-75-75-C-90-iso8859-1`

- **GLUT_BITMAP_TIMES_ROMAN_10** A 10-point proportional spaced Times Roman font. The exact bitmaps to be used is defined by the standard X glyph bitmaps for the X font named:
  `-adobe-times-medium-r-normal--10-100-75-75-p-54-iso8859-1`

- **GLUT_BITMAP_TIMES_ROMAN_24** A 24-point proportional spaced Times Roman font. The exact bitmaps to be used is defined by the standard X glyph bitmaps for the X font named:
  `-adobe-times-medium-r-normal--24-240-75-75-p-124-iso8859-1`

- **GLUT_BITMAP HELVETICA_10** A 10-point proportional spaced Helvetica font. The exact bitmaps to be used is defined by the standard X glyph bitmaps for the X font named:
  `-adobe-helvetica-medium-r-normal--10-100-75-75-p-56-iso8859-1`
10.2 glutBitmapWidth

GLUT_BITMAP_HELVETICA_12 A 12-point proportional spaced Helvetica font. The exact bitmaps to be used is defined by the standard X glyph bitmaps for the X font named:
- adobe-helvetica-medium-r-normal--12-120-75-75-p-67-iso8859-1

GLUT_BITMAP_HELVETICA_18 A 18-point proportional spaced Helvetica font. The exact bitmaps to be used is defined by the standard X glyph bitmaps for the X font named:
- adobe-helvetica-medium-r-normal--18-180-75-75-p-98-iso8859-1

Rendering a nonexistent character has no effect. glutBitmapCharacter automatically sets the OpenGL unpack pixel storage modes it needs appropriately and saves and restores the previous modes before returning. The generated call to glBitmap will adjust the current raster position based on the width of the character.

10.2 glutBitmapWidth

glutBitmapWidth returns the width of a bitmap character.

Usage

int glutBitmapWidth(GLUTbitmapFont font, int character)

font Bitmap font to use.
character Character to return width of (not confined to 8 bits).

Description

glutBitmapWidth returns the width in pixels of a bitmap character in a supported bitmap font. While the width of characters in a font may vary (though fixed width fonts do not vary), the maximum height characteristics of a particular font are fixed.

10.3 glutStrokeCharacter

glutStrokeCharacter renders a stroke character using OpenGL.

Usage

void glutStrokeCharacter(void *font, int character);

font Stroke font to use.
character Character to render (not confined to 8 bits).

Description

Without using any display lists, glutStrokeCharacter renders the character in the named stroke font. The available fonts are:

GLUT_STROKE_ROMAN A proportionally spaced Roman Simplex font for ASCII characters 32 through 127. The maximum top character in the font is 119.05 units; the bottom descends 33.33 units.

GLUT_STROKE_MONO_ROMAN A mono-spaced spaced Roman Simplex font (same characters as GLUT_STROKE_ROMAN) for ASCII characters 32 through 127. The maximum top character in the font is 119.05 units; the bottom descends 33.33 units. Each character is 104.76 units wide.

Rendering a nonexistent character has no effect. A glTranslatef is used to translate the current model view matrix to advance the width of the character.
10.4 glutStrokeWidth

glutStrokeWidth returns the width of a stroke character.

Usage

```c
int glutStrokeWidth(GLUTstrokeFont font, int character)
```

- `font`: Stroke font to use.
- `character`: Character to return width of (not confined to 8 bits).

Description

glutStrokeWidth returns the width in pixels of a stroke character in a supported stroke font. While the width of characters in a font may vary (though fixed width fonts do not vary), the maximum height characteristics of a particular font are fixed.

11 Geometric Object Rendering

GLUT includes a number of routines for generating easily recognizable 3D geometric objects. These routines reflect functionality available in the aux toolkit described in the OpenGL Programmer’s Guide and are included in GLUT to allow the construction of simple GLUT programs that render recognizable objects. These routines can be implemented as pure OpenGL rendering routines. The routines do not generate display lists for the objects they create.

The routines generate normals appropriate for lighting but do not generate texture coordinates (except for the teapot).

11.1 glutSolidSphere, glutWireSphere

`glutSolidSphere` and `glutWireSphere` render a solid or wireframe sphere respectively.

Usage

```c
void glutSolidSphere(GLdouble radius,
                     GLint slices, GLint stacks);
void glutWireSphere(GLdouble radius,
                    GLint slices, GLint stacks);
```

- `radius`: The radius of the sphere.
- `slices`: The number of subdivisions around the Z axis (similar to lines of longitude).
- `stacks`: The number of subdivisions along the Z axis (similar to lines of latitude).

Description

Renders a sphere centered at the modeling coordinates origin of the specified `radius`. The sphere is subdivided around the Z axis into slices and along the Z axis into stacks.

11.2 glutSolidCube, glutWireCube

`glutSolidCube` and `glutWireCube` render a solid or wireframe cube respectively.

Usage

```c
void glutSolidCube(GLdouble size);
void glutWireCube(GLdouble size);
```
11.3  **glutSolidCone, glutWireCone**

**Description**

`glutSolidCube` and `glutWireCube` render a solid or wireframe cube respectively. The cube is centered at the modeling coordinates origin with sides of length `size`.

**11.3 glutSolidCone, glutWireCone**

`glutSolidCone` and `glutWireCone` render a solid or wireframe cone respectively.

**Usage**

```c
void glutSolidCone(GLdouble base, GLdouble height,
                   GLint slices, GLint stacks);

void glutWireCone(GLdouble base, GLdouble height,
                   GLint slices, GLint stacks);
```

*base*  The radius of the base of the cone.

*height*  The height of the cone.

*slices*  The number of subdivisions around the Z axis.

*stacks*  The number of subdivisions along the Z axis.

**Description**

`glutSolidCone` and `glutWireCone` render a solid or wireframe cone respectively oriented along the Z axis. The base of the cone is placed at Z = 0, and the top at Z = height. The cone is subdivided around the Z axis into slices, and along the Z axis into stacks.

11.4  **glutSolidTorus, glutWireTorus**

`glutSolidTorus` and `glutWireTorus` render a solid or wireframe torus (doughnut) respectively.

**Usage**

```c
void glutSolidTorus(GLdouble innerRadius,
                    GLdouble outerRadius,
                    GLint nsides, GLint rings);

void glutWireTorus(GLdouble innerRadius,
                    GLdouble outerRadius,
                    GLint nsides, GLint rings);
```

*innerRadius*  Inner radius of the torus.

*outerRadius*  Outer radius of the torus.

*nsides*  Number of sides for each radial section.

*rings*  Number of radial divisions for the torus.

**Description**

`glutSolidTorus` and `glutWireTorus` render a solid or wireframe torus (doughnut) respectively centered at the modeling coordinates origin whose axis is aligned with the Z axis.

11.5  **glutSolidDodecahedron, glutWireDodecahedron**

`glutSolidDodecahedron` and `glutWireDodecahedron` render a solid or wireframe dodecahedron (12-sided regular solid) respectively.
11. GEOMETRIC OBJECT RENDERING

Usage

void glutSolidDodecahedron(void);
void glutWireDodecahedron(void);

Description

`glutSolidDodecahedron` and `glutWireDodecahedron` render a solid or wireframe dodecahedron respectively centered at the modeling coordinates origin with a radius of $\sqrt{3}$.

11.6  glutSolidOctahedron, glutWireOctahedron

`glutSolidOctahedron` and `glutWireOctahedron` render a solid or wireframe octahedron (8-sided regular solid) respectively.

Usage

void glutSolidOctahedron(void);
void glutWireOctahedron(void);

Description

`glutSolidOctahedron` and `glutWireOctahedron` render a solid or wireframe octahedron respectively centered at the modeling coordinates origin with a radius of 1.0.

11.7  glutSolidTetrahedron, glutWireTetrahedron

`glutSolidTetrahedron` and `glutWireTetrahedron` render a solid or wireframe tetrahedron (4-sided regular solid) respectively.

Usage

void glutSolidTetrahedron(void);
void glutWireTetrahedron(void);

Description

`glutSolidTetrahedron` and `glutWireTetrahedron` render a solid or wireframe tetrahedron respectively centered at the modeling coordinates origin with a radius of $\sqrt{3}$.

11.8  glutSolidIcosahedron, glutWireIcosahedron

`glutSolidIcosahedron` and `glutWireIcosahedron` render a solid or wireframe icosahedron (20-sided regular solid) respectively.

Usage

void glutSolidIcosahedron(void);
void glutWireIcosahedron(void);

Description

`glutSolidIcosahedron` and `glutWireIcosahedron` render a solid or wireframe icosahedron respectively. The icosahedron is centered at the modeling coordinates origin and has a radius of 1.0.
11.9  `glutSolidTeapot`, `glutWireTeapot`

`glutSolidTeapot` and `glutWireTeapot` render a solid or wireframe teapot\(^1\) respectively.

**Usage**

```c
void glutSolidTeapot(GLdouble size);
void glutWireTeapot(GLdouble size);
```

- **`size`** Relative size of the teapot.

**Description**

`glutSolidTeapot` and `glutWireTeapot` render a solid or wireframe teapot respectively. Both surface normals and texture coordinates for the teapot are generated. The teapot is generated with OpenGL evaluators.

### 12 Usage Advice

There are a number of points to keep in mind when writing GLUT programs. Some of these are strong recommendations, others simply hints and tips.

- Do not change state that will affect the way a window will be drawn in a window’s display callback. Your display callbacks should be idempotent.
- If you need to redisplay a window, instead of rendering in whatever callback you happen to be in, call `glutPostRedisplay` (or `glutPostRedisplay` for overlays). As a general rule, the only code that renders directly to the screen should be in called from display callbacks; other types of callbacks should not be rendering to the screen.
- If you use an idle callback to control your animation, use the visibility callbacks to determine when the window is fully obscured or iconified to determine when not to waste processor time rendering.
- Neither GLUT nor the window system automatically reshape sub-windows. If subwindows should be resheloped to reflect a reshaping of the top-level window, the GLUT program is responsible for doing this.
- Avoid using color index mode if possible. The RGBA color model is more functional, and it is less likely to cause colormap swapping effects.
- Do not call any GLUT routine that affects the *current window* or *current menu* if there is no *current window* or *current menu* defined. This can be the case at initialization time (before any windows or menus have been created) or if your destroy the *current window* or *current menu*. GLUT implementations are not obliged to generate a warning because doing so would slow down the operation of every such routine to first make sure there was a *current window* or *current menu*.
- For most callbacks, the *current window* and/or *current menu* is set appropriately at the time of the callback. Timer and idle callbacks are exceptions. If your application uses multiple windows or menus, make sure you explicitly set the *current window* or *menu* appropriately using `glutSetWindow` or `glutSetMenu` in the idle and timer callbacks.
- If you register a single function as a callback routine for multiple windows, you can call `glutGetWindow` within the callback to determine what window generated the callback. Likewise, `glutGetMenu` can be called to determine what menu.
- By default, timer and idle callbacks may be called while a pop-up menu is active. On slow machines, slow rendering in an idle callback may compromise menu performance. Also, it may be desirable for motion to stop immediately when a menu is triggered. In this case, use the menu entry/exit callback set with `glutMenuStateFunc` to track the usage of pop-up menus.

\(^1\) Yes, the *classic* computer graphics teapot modeled by Martin Newell in 1975 [2].
Do not select for more input callbacks than you actually need. For example, if you do not need motion or passive motion callbacks, disable them by passing NULL to their callback register functions. Disabling input callbacks allows the GLUT implementation to limit the window system input events that must be processed.

Not every OpenGL implementation supports the same range of frame buffer capabilities, though minimum requirements for frame buffer capabilities do exist. If glutCreateWindow or glutCreateSubWindow are called with an initial display mode not supported by the OpenGL implementation, a fatal error will be generated with an explanatory message. To avoid this, glutGet(GLUT_DISPLAY_MODE_POSSIBLE) should be called to determine if the initial display mode is supported by the OpenGL implementation.

The Backspace, Delete, and Escape keys generate ASCII characters, so detect these key presses with the glutKeyboardFunc callback, not with the glutSpecialFunc callback.

Keep in mind that when a window is damaged, you should assume all of the ancillary buffers are damaged and redraw them all.

Keep in mind that after a glutSwapBuffers, you should assume the state of the back buffer becomes undefined.

If not using glutSwapBuffers for double buffered animation, remember to use glFlush to make sure rendering requests are dispatched to the frame buffer. While many OpenGL implementations will automatically flush pending commands, this is specifically not mandated.

Remember that it is illegal to create or destroy menus or change, add, or remove menu items while a menu (and any cascaded sub-menus) are in use (that is, “popped up”). Use the menu status callback to know when to avoid menu manipulation.

It is more efficient to use glutHideOverlay and glutShowOverlay to control the display state of a window’s overlay instead of removing and re-establishing an overlay every time an overlay is needed.

Few workstations have support for multiple simultaneously installed overlay colormaps. For this reason, if an overlay is cleared or otherwise not be used, it is best to hide it using glutHideOverlay to avoid other windows with active overlays from being displayed with the wrong colormap. If your application uses multiple overlays, use glutCopyColormap to promote colormap sharing.

If you are encountering GLUT warnings or fatal errors in your programs, try setting a debugger breakpoint in glutWarning or glutFatalError (though these names are potentially implementation dependent) to determine where within your program the error occurred.

GLUT has no special routine for exiting the program. GLUT programs should use ANSI C’s exit routine. If a program needs to perform special operations before quitting the program, use the ANSI C onexit routine to register exit callbacks. GLUT will exit the program unilaterally when fatal errors occur or when the window system requests the program to terminate. For this reason, avoid calling any GLUT routines within an exit callback.

Definitely, definitely, use the -gde bug option to look for OpenGL errors when OpenGL rendering does not appear to be operating properly. OpenGL errors are only reported if you explicitly look for them!

13 FORTRAN Binding

All GLUT functionality is available through the GLUT FORTRAN API. The GLUT FORTRAN binding is intended to be used in conjunction with the OpenGL and GLU FORTRAN APIs.

A FORTRAN routine using GLUT routines should include the GLUT FORTRAN header file. While this is potentially system dependent, on Unix systems this is normally done by including after the SUBROUTINE, FUNCTION, or PROGRAM line:
#include "GL/fglut.h"

Though the FORTRAN 77 specification differentiates identifiers by their first six characters only, the GLUT FORTRAN binding (and the OpenGL and GLU FORTRAN bindings) assume identifiers are not limited to 6 characters.

The FORTRAN GLUT binding library archive is typically named libfglut.a on Unix systems. FORTRAN GLUT programs need to link with the system’s OpenGL and GLUT libraries and the respective Fortran binding libraries (and any libraries these libraries potentially depend on). A set of window system dependent libraries may also be necessary for linking GLUT programs. For example, programs using the X11 GLUT implementation typically need to link with Xlib, the X extension library, possibly the X Input extension library, the X miscellaneous utilities library, and the math library. An example X11/Unix compile line for a GLUT FORTRAN program would look like:

```
f77 -o foo foo.c -lfglut -lglut -lfGLU -lGLU -lfGL -lGL 
   -lXmu -lXi -lXext -lX11 -lm
```

### 13.1 Names for the FORTRAN GLUT Binding

Allowing for FORTRAN’s case-insensitivity, the GLUT FORTRAN binding constant and routine names are the same as the C binding’s names.

The OpenGL Architectural Review Board (ARB) official OpenGL FORTRAN API prefixes every routine and constant with the letter F. The justification was to avoid name space collisions with the C names in anachronistic compilers. Nearly all modern FORTRAN compilers avoid these name space clashes via other means (underbar suffixing of FORTRAN routines is used by most Unix FORTRAN compilers).

The GLUT FORTRAN API does not use such prefixing conventions because of the documentation and coding confusion introduced by such prefixes. The confusion is heightened by FORTRAN’s default implicit variable initialization so programmers may realize the lack of a constant prefix as a result of a run-time error. The confusion introduced to support the prefixes was not deemed worthwhile simply to support anachronistic compilers.

The OpenGL ARB’s official FORTRAN binding for the GLU and OpenGL APIs that chose to prefix the letter F before every OpenGL and GLU constant and routine name.

### 13.2 Font Naming Caveat

Because GLUT fonts are compiled directly into GLUT programs as data, and programs should only have the fonts compiled into them that they use, GLUT font names like GLUT_BITMAP_TIMES_ROMAN_24 are really symbols so the linker should only pull in used fonts.

Unfortunately, because some supposedly modern FORTRAN compilers link declared but unused data EXTERNALs, “GL/fglut.h” does not explicitly declare EXTERNAL the GLUT font symbols. Declaring the GLUT font symbols as EXTERNAL risks forcing every GLUT FORTRAN program to contain the data for every GLUT font. GLUT FORTRAN programmers should explicitly declare EXTERNAL the GLUT fonts they use. Example:

```fortran
SUBROUTINE PRINTA
   INCLUDE "GL/fglut.h"
   EXTERNAL GLUT_BITMAP_TIMES_ROMAN_24
   CALL glutBitmapCharacter(GLUT_BITMAP_TIMES_ROMAN_24, 65)
END
```

### 13.3 NULL Callback

FORTRAN does not support passing NULL as a callback parameter the way ANSI C does. For this reason, GLUTNULL is used in place of NULL in GLUT FORTRAN programs to indicate a NULL callback.
14 Implementation Issues

While this specification is primarily intended to describe the GLUT API and not its implementation, the section describes implementation issues that are likely to help both GLUT implementors properly implement GLUT and provide GLUT programmers with information to better utilize GLUT.

14.1 Name Space Conventions

The GLUT implementation should have a well-defined name space for both exported symbols and visible, but not purposefully exported symbols. All exported functions are prefixed by `glut`. All exported macro definitions are prefixed by `GLUT`. No data symbols are exported. All internal symbols that might be user-visible but not intended to be exported should be prefixed by `__glut`. Users of the GLUT API should not use any `__glut` prefixed symbols.

14.2 Modular Implementation

It is often the case that windowing libraries tend to result in large, bulky programs because a large measure of “dynamically dead” code is linked into the programs because it can not be determined at link time that the program will never require (that is, execute) the code. A consideration (not a primary one though) in GLUT’s API design is make the API modular enough that programs using a limited subset of GLUT’s API can minimize the portion of the GLUT library implementation required. This does assume the implementation of GLUT is structured to take advantage of the API’s modularity.

A good implementation can be structured so significant chunks of code for color index colormap management, non-standard device support (Spaceball, dial & button box, and tablet), overlay management, pop-up menus, miscellaneous window management routines (pop, push, show, hide, full-screen, iconify), geometric shape rendering, and font rendering only need to be pulled into GLUT programs when the interface to this functionality is explicitly used by the GLUT program.

14.3 Error Checking and Reporting

How errors and warnings about improper GLUT usage are reported to GLUT programs is implementation dependent. The recommended behavior in the case of an error is to output a message and exit. In the case of a warning, the recommended behavior is to output a message and continue. All improper uses of the GLUT interface do not need to be caught or reported. What conditions are caught or reported should be based on how expensive the condition is to check for. For example, an implementation may not check every `glutSetWindow` call to determine if the window identifier is valid.

The run-time overhead of error checking for a very common operation may outweigh the benefit of clean error reporting. This trade-off is left for the implementor to make. The implementor should also consider the difficulty of diagnosing the improper usage without a message being output. For example, if a GLUT program attempts to create a menu while a menu is in use (improper usage!), this warrants a message because this improper usage may often be benign, allowing the bug to easily go unnoticed.

14.4 Avoid Unspecified GLUT Usage Restrictions

GLUT implementations should be careful to not limit the conditions under which GLUT routines may be called. GLUT implementations are expected to be resilient when GLUT programs call GLUT routines with defined behavior at “unexpected” times. For example, a program should be permitted to destroy the current window from within a display callback (assuming the user does not then call GLUT routines requiring a current window). This means after dispatching callbacks, a GLUT implementation should be “defensive” about how the program might have used manipulated GLUT state during the callback.
A GLUT State

This appendix specifies precisely what programmer visible state GLUT maintains. There are three categories of programmer visible state that GLUT maintains: global, window, and menu. The window and menu state categories are maintained for each created window or menu. Additional overlay-related window state is maintained when an overlay is established for a window for the lifetime of the overlay.

The tables below name each element of state, define its type, specify what GLUT API entry points set or change the state (if possible), specify what GLUT API entry point or glutGet, glutDeviceGet, or glutLayerGet state constant is used to get the state (if possible), and how the state is initially set. For details of how any API entry point operates on the specified state, see the routine’s official description. Footnotes for each category of state indicate additional caveats to the element of state.

A.1 Types of State

These types are used to specify GLUT’s programmer visible state:

**Bitmask** A group of boolean bits.

**Boolean** True or false.

**Callback** A handle to a user-supplied routine invoked when the given callback is triggered (or NULL which is the default callback).

**ColorCell** Red, green, and blue color component triple, an array of which makes a colormap.

**Cursor** A GLUT cursor name.

**Integer** An integer value.

**Layer** Either normal plane or overlay.

**MenuItem** Either a menu entry or a submenu trigger. Both subtypes contain of a String name. A menu entry has an Integer value. A submenu cascade has an Integer menu name naming its associated submenu.

**MenuState** Either in use or not in use.

**Stacking** An ordering for top-level windows and sub-windows having the same parent. Higher windows obscure lower windows.

**State** One of shown, hidden, or iconified.

**String** A string of ASCII characters.

**Timer** A triple of a timer Callback, an Integer callback parameter, and a time in milliseconds (that expires in real time).

A.2 Global State

There are two types of global state: program controlled state which can be modified directly or indirectly by the program, and fixed system dependent state.
A.2.1 Program Controlled State

<table>
<thead>
<tr>
<th>Name</th>
<th>Type</th>
<th>Set/Change</th>
<th>Get</th>
<th>Initial</th>
</tr>
</thead>
<tbody>
<tr>
<td>currentWindow</td>
<td>Integer</td>
<td>glutSetWindow (1)</td>
<td>glutGetWindow</td>
<td>0</td>
</tr>
<tr>
<td>currentMenu</td>
<td>Integer</td>
<td>glutSetMenu (2)</td>
<td>glutGetMenu</td>
<td>0</td>
</tr>
<tr>
<td>initWindowX</td>
<td>Integer</td>
<td>glutInitWindowPosition</td>
<td>GLUT_INIT_WINDOW_X</td>
<td>-1</td>
</tr>
<tr>
<td>initWindowY</td>
<td>Integer</td>
<td>glutInitWindowPosition</td>
<td>GLUT_INIT_WINDOW_Y</td>
<td>-1</td>
</tr>
<tr>
<td>initWindowWidth</td>
<td>Integer</td>
<td>glutInitWindowSize</td>
<td>GLUT_INIT_WINDOW_WIDTH</td>
<td>300</td>
</tr>
<tr>
<td>initWindowHeight</td>
<td>Integer</td>
<td>glutInitWindowSize</td>
<td>GLUT_INIT_WINDOW_HEIGHT</td>
<td>300</td>
</tr>
<tr>
<td>initDisplayMode</td>
<td>Bitmask</td>
<td>glutInitDisplayMode</td>
<td>GLUT_INIT_DISPLAY_MODE</td>
<td>GLUT_RGB,</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>GLUT_SINGLE,</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>GLUT_DEPTH</td>
</tr>
<tr>
<td>idleCallback</td>
<td>Callback</td>
<td>glutIdleFunc</td>
<td></td>
<td>NULL</td>
</tr>
<tr>
<td>menuState</td>
<td>MenuState</td>
<td></td>
<td></td>
<td>NotInUse</td>
</tr>
<tr>
<td>menuStateCallback</td>
<td>Callback</td>
<td>glutMenuEntryFunc</td>
<td></td>
<td>NULL</td>
</tr>
<tr>
<td>timerList</td>
<td>list of Timer</td>
<td>glutTimerFunc</td>
<td></td>
<td>none</td>
</tr>
</tbody>
</table>

(1) The currentWindow is also changed implicitly by every window or menu callback (to the window triggering the callback) and the creation of a window (to the window being created).

(2) The currentMenu is also changed implicitly by every menu callback (to the menu triggering the callback) and the creation of a menu (to the menu being created).

(3) The menu state callback is triggered when the menuState changes.

A.2.2 Fixed System Dependent State

<table>
<thead>
<tr>
<th>Name</th>
<th>Type</th>
<th>Get</th>
</tr>
</thead>
<tbody>
<tr>
<td>screenWidth</td>
<td>Integer</td>
<td>GLUT_SCREEN_WIDTH</td>
</tr>
<tr>
<td>screenHeight</td>
<td>Integer</td>
<td>GLUT_SCREEN_HEIGHT</td>
</tr>
<tr>
<td>screenWidthMM</td>
<td>Integer</td>
<td>GLUT_SCREEN_WIDTH_MM</td>
</tr>
<tr>
<td>screenHeightMM</td>
<td>Integer</td>
<td>GLUT_SCREEN_HEIGHT_MM</td>
</tr>
<tr>
<td>hasKeyboard</td>
<td>Boolean</td>
<td>GLUT_HAS_KEYBOARD</td>
</tr>
<tr>
<td>hasMouse</td>
<td>Boolean</td>
<td>GLUT_HAS_MOUSE</td>
</tr>
<tr>
<td>hasSpaceball</td>
<td>Boolean</td>
<td>GLUT_HAS_SPACEBALL</td>
</tr>
<tr>
<td>hasDialAndButtonBox</td>
<td>Boolean</td>
<td>GLUT_HAS_DIAL_AND_BUTTON_BOX</td>
</tr>
<tr>
<td>hasTablet</td>
<td>Boolean</td>
<td>GLUT_HAS_TABLET</td>
</tr>
<tr>
<td>numMouseButtons</td>
<td>Integer</td>
<td>GLUT_NUM_MOUSE_BUTTONS</td>
</tr>
<tr>
<td>numSpaceballButtons</td>
<td>Integer</td>
<td>GLUT_NUM_SPACEBALL_BUTTONS</td>
</tr>
<tr>
<td>numButtonBoxButtons</td>
<td>Integer</td>
<td>GLUT_NUM_BUTTON_BOX_BUTTONS</td>
</tr>
<tr>
<td>numDials</td>
<td>Integer</td>
<td>GLUT_NUM_DIALS</td>
</tr>
<tr>
<td>numTabletButtons</td>
<td>Integer</td>
<td>GLUT_NUM_TABLET_BUTTONS</td>
</tr>
</tbody>
</table>

A.3 Window State

For the purposes of listing the window state elements, window state is classified into three types: base state, frame buffer capability state, and layer state. The tags *top-level, sub-win, and cindex* indicate the table entry applies only to top-level windows, subwindows, or color index windows respectively.
### A.3.1 Basic State

<table>
<thead>
<tr>
<th>Name</th>
<th>Type</th>
<th>Set/Change</th>
<th>Get</th>
<th>Initial</th>
</tr>
</thead>
<tbody>
<tr>
<td>number</td>
<td>Integer</td>
<td>-</td>
<td>glutGetWindow</td>
<td>top-level: glutCreateWindow (1) sub-win: glutCreateSubWindow (1)</td>
</tr>
<tr>
<td>x</td>
<td>Integer</td>
<td>glutPositionWindow</td>
<td>GLUT_WINDOW_X</td>
<td>top-level: initWindowX (2) sub-win: glutCreateSubWindow</td>
</tr>
<tr>
<td>y</td>
<td>Integer</td>
<td>glutPositionWindow</td>
<td>GLUT_WINDOW_Y</td>
<td>top-level: initWindowY (3) sub-win: glutCreateSubWindow</td>
</tr>
<tr>
<td>width</td>
<td>Integer</td>
<td>glutReshapeWindow</td>
<td>GLUT_WINDOW_WIDTH</td>
<td>top-level: initWindowWidth (4) sub-win: glutCreateSubWindow</td>
</tr>
<tr>
<td>height</td>
<td>Integer</td>
<td>glutReshapeWindow</td>
<td>GLUT_WINDOW_HEIGHT</td>
<td>top-level: initWindowHeight (5) sub-win: glutCreateSubWindow</td>
</tr>
<tr>
<td>top-level: fullScreen</td>
<td>Boolean</td>
<td>glutFullScreen</td>
<td></td>
<td>False</td>
</tr>
<tr>
<td>cursor</td>
<td>Cursor</td>
<td>glutSetCursor</td>
<td>GLUT_WINDOW_CURSOR</td>
<td>GLUT_CURSOR_INHERIT top</td>
</tr>
<tr>
<td>displayState</td>
<td>State (7)</td>
<td>glutShowWindow (8)</td>
<td>-</td>
<td>shown</td>
</tr>
<tr>
<td>visibility</td>
<td>Visibility</td>
<td></td>
<td></td>
<td>undefined</td>
</tr>
<tr>
<td>redisplay</td>
<td>Boolean</td>
<td>glutPostRedisplay (11)</td>
<td>-</td>
<td>False</td>
</tr>
<tr>
<td>top-level: windowTitle</td>
<td>String</td>
<td>glutWindowTitle</td>
<td>-</td>
<td>glutCreateWindow</td>
</tr>
<tr>
<td>top-level: iconTitle</td>
<td>String</td>
<td>glutIconTitle</td>
<td>-</td>
<td>glutCreateWindow</td>
</tr>
<tr>
<td>displayCallback</td>
<td>Callback</td>
<td>glutDisplayFunc</td>
<td>-</td>
<td>NULL (12)</td>
</tr>
<tr>
<td>reshapeCallback</td>
<td>Callback</td>
<td>glutReshapeFunc</td>
<td>-</td>
<td>NULL (13)</td>
</tr>
<tr>
<td>keyboardCallback</td>
<td>Callback</td>
<td>glutKeyboardFunc</td>
<td>-</td>
<td>NULL</td>
</tr>
<tr>
<td>mouseCallback</td>
<td>Callback</td>
<td>glutMouseFunc</td>
<td>-</td>
<td>NULL</td>
</tr>
<tr>
<td>motionCallback</td>
<td>Callback</td>
<td>glutMotionFunc</td>
<td>-</td>
<td>NULL</td>
</tr>
<tr>
<td>passiveMotionCallback</td>
<td>Callback</td>
<td>glutPassiveMotionFunc</td>
<td>-</td>
<td>NULL</td>
</tr>
<tr>
<td>specialCallback</td>
<td>Callback</td>
<td>glutSpecialFunc</td>
<td>-</td>
<td>NULL</td>
</tr>
<tr>
<td>spacebarMotionCallback</td>
<td>Callback</td>
<td>glutSpaceballMotionFunc</td>
<td>-</td>
<td>NULL</td>
</tr>
<tr>
<td>spacebarRotateCallback</td>
<td>Callback</td>
<td>glutSpaceballRotateFunc</td>
<td>-</td>
<td>NULL</td>
</tr>
<tr>
<td>spacebarButtonCallback</td>
<td>Callback</td>
<td>glutSpaceballButtonFunc</td>
<td>-</td>
<td>NULL</td>
</tr>
<tr>
<td>buttonBoxCallback</td>
<td>Callback</td>
<td>glutButtonBoxFunc</td>
<td>-</td>
<td>NULL</td>
</tr>
<tr>
<td>dialsCallback</td>
<td>Callback</td>
<td>glutDialsFunc</td>
<td>-</td>
<td>NULL</td>
</tr>
<tr>
<td>tabletMotionCallback</td>
<td>Callback</td>
<td>glutTableMotionFunc</td>
<td>-</td>
<td>NULL</td>
</tr>
<tr>
<td>tabletButtonCallback</td>
<td>Callback</td>
<td>glutTableButtonFunc</td>
<td>-</td>
<td>NULL</td>
</tr>
<tr>
<td>visibilityCallback</td>
<td>Callback</td>
<td>glutVisibilityFunc</td>
<td>-</td>
<td>NULL</td>
</tr>
<tr>
<td>entryCallback</td>
<td>Callback</td>
<td>glutEntryFunc</td>
<td>-</td>
<td>NULL</td>
</tr>
<tr>
<td>cindex: colormap</td>
<td>array of ColorCell</td>
<td>glutSetColor</td>
<td>-</td>
<td>undefined</td>
</tr>
<tr>
<td>windowParent</td>
<td>Integer</td>
<td>-</td>
<td>GLUT_WINDOW_PARENT</td>
<td>top-level: 0 sub-win: (14)</td>
</tr>
<tr>
<td>numChildren</td>
<td>Integer</td>
<td>glutCreateSubWindow</td>
<td>GLU_NUM_CHILDREN</td>
<td>0</td>
</tr>
<tr>
<td>leftMenu</td>
<td>Integer</td>
<td>glutAttachMenu</td>
<td>-</td>
<td>0</td>
</tr>
<tr>
<td>middleMenu</td>
<td>Integer</td>
<td>glutAttachMenu</td>
<td>-</td>
<td>0</td>
</tr>
<tr>
<td>rightMenu</td>
<td>Integer</td>
<td>glutAttachMenu</td>
<td>-</td>
<td>0</td>
</tr>
</tbody>
</table>

1. Assigned dynamically from unassigned window numbers greater than zero.
2. If `initWindowX` is greater or equal to zero and `initWindowY` is greater or equal to zero then `initWindowX`, else window location left to window system to decide.
3. If `initWindowY` is greater or equal to zero and `initWindowX` is greater or equal to zero then `initWindowY`, else window location left to window system to decide.
4. If `initWindowWidth` is greater than zero and `initWindowHeight` is greater than zero the `initWindowWidth`, else window size left to window system to decide.
5. If `initWindowHeight` is greater than zero and `initWindowWidth` is greater than zero then `initWindowHeight`, else window size left to window system to decide.
6. glutFullScreen sets to true; glutPositionWindow and glutReshapeWindow set to false.
7. Subwindows cannot be iconified.
(8) Window system events can also change the displayState.

(9) Visibility of a window can change for window system dependent reason, for example, a new window may occlude the window. glutPopWindow and glutPushWindow can affect window visibility as a side effect.

(10) The visibility callback set by glutVisibilityFunc allows the visibility state to be tracked.

(11) The redisplay state can be explicitly enabled by glutRedisplayFunc or implicitly in response to normal plane redisplay events from the window system.

(12) A window’s displayCallback must be registered before the first display callback would be triggered (or the program is terminated).

(13) Instead of being a no-op as most NULL callbacks are, a NULL reshapeCallback sets the OpenGL viewport to render into the complete window, i.e., glViewport(0, 0, width, height).

(14) Determined by currentWindow at glutCreateSubWindow time.

### A.3.2 Frame Buffer Capability State

<table>
<thead>
<tr>
<th>Name</th>
<th>Type</th>
<th>Get</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total number of bits in color buffer</td>
<td>Integer</td>
<td>GLUT_WINDOW_BUFFER_SIZE</td>
</tr>
<tr>
<td>Number of bits in stencil buffer</td>
<td>Integer</td>
<td>GLUT_WINDOW_STENCIL_SIZE</td>
</tr>
<tr>
<td>Number of bits in depth buffer</td>
<td>Integer</td>
<td>GLUT_WINDOW_DEPTH_SIZE</td>
</tr>
<tr>
<td>Number of bits of red stored in color buffer</td>
<td>Integer</td>
<td>GLUT_WINDOW_RED_SIZE</td>
</tr>
<tr>
<td>Number of bits of green stored in color buffer</td>
<td>Integer</td>
<td>GLUT_WINDOW_GREEN_SIZE</td>
</tr>
<tr>
<td>Number of bits of blue stored in color buffer</td>
<td>Integer</td>
<td>GLUT_WINDOW_BLUE_SIZE</td>
</tr>
<tr>
<td>Number of bits of alpha stored in color buffer</td>
<td>Integer</td>
<td>GLUT_WINDOW_ALPHA_SIZE</td>
</tr>
<tr>
<td>Number of bits of red stored in accumulation buffer</td>
<td>Integer</td>
<td>GLUT_WINDOW_ACCUM_RED_SIZE</td>
</tr>
<tr>
<td>Number of bits of green stored in accumulation buffer</td>
<td>Integer</td>
<td>GLUT_WINDOW_ACCUM_GREEN_SIZE</td>
</tr>
<tr>
<td>Number of bits of blue stored in accumulation buffer</td>
<td>Integer</td>
<td>GLUT_WINDOW_ACCUM_BLUE_SIZE</td>
</tr>
<tr>
<td>Number of bits of alpha stored in accumulation buffer</td>
<td>Integer</td>
<td>GLUT_WINDOW_ACCUM_ALPHA_SIZE</td>
</tr>
<tr>
<td>Color index colormap size</td>
<td>Integer</td>
<td>GLUT_WINDOW_COLORMAP_SIZE</td>
</tr>
<tr>
<td>If double buffered</td>
<td>Boolean</td>
<td>GLUT_WINDOW_DOUBLEBUFFER</td>
</tr>
<tr>
<td>If RGBA color model</td>
<td>Boolean</td>
<td>GLUT_WINDOW_RGBA</td>
</tr>
<tr>
<td>If stereo</td>
<td>Boolean</td>
<td>GLUT_WINDOW_STEREO</td>
</tr>
<tr>
<td>Number of samples for multisampling</td>
<td>Integer</td>
<td>GLUT_WINDOW_MULTISAMPLE</td>
</tr>
</tbody>
</table>

A window’s (normal plane) frame buffer capability state is derived from the global initDisplayMode state at the window’s creation. A window’s frame buffer capabilities can not be changed.

### A.3.3 Layer State

<table>
<thead>
<tr>
<th>Name</th>
<th>Type</th>
<th>Set/Change</th>
<th>Get</th>
<th>Initial</th>
</tr>
</thead>
<tbody>
<tr>
<td>hasOverlay</td>
<td>Boolean</td>
<td>glutEstablishOverlay</td>
<td>GLUT_HAS_OVERLAY</td>
<td>False</td>
</tr>
<tr>
<td>overlayPossible</td>
<td>Boolean</td>
<td>glutEstablishOverlay</td>
<td>GLUT_OVERLAY_POSSIBLE</td>
<td>False</td>
</tr>
<tr>
<td>layerInUse</td>
<td>Layer</td>
<td>(1)</td>
<td>GLUT_LAYER_INUSE</td>
<td>NULL</td>
</tr>
<tr>
<td>index: transparentIndex</td>
<td>Integer</td>
<td>-</td>
<td>GLUT_TRANSPARENT_INDEX</td>
<td>(3)</td>
</tr>
<tr>
<td>overlayRedisplay</td>
<td>Boolean</td>
<td>glutPostOverlayRedisplay(4)</td>
<td>-</td>
<td>False</td>
</tr>
<tr>
<td>overlayRedisplayCallback</td>
<td>Boolean</td>
<td>-</td>
<td>-</td>
<td>NULL</td>
</tr>
<tr>
<td>overlayDisplayCallback</td>
<td>State</td>
<td>glutShowOverlay</td>
<td>GLUT_NORMAL-dangerous</td>
<td>False</td>
</tr>
<tr>
<td>normalDamaged</td>
<td>Boolean</td>
<td>(5)</td>
<td>GLUT_NORMAL_DAMAGED</td>
<td>False</td>
</tr>
<tr>
<td>overlayDamaged</td>
<td>Boolean</td>
<td>(6)</td>
<td>GLUT_NORMAL_DAMAGED</td>
<td>False</td>
</tr>
</tbody>
</table>

(1) Whether an overlay is possible is based on the initDisplayMode state and the frame buffer capability state of the window.

(2) The layerInUse is implicitly set to overlay after glutEstablishOverlay; likewise, glutRemoveOverlay resets the state to normal plane.

(3) The transparentIndex is set when a color index overlay is established. It cannot be set; it may change if the overlay is re-established.

(4) When no overlay is in use or if the overlay is not color index, the transparentIndex is -1.

(5) The overlayRedisplay state can be explicitly enabled by glutPostOverlayRedisplay or implicitly in response to overlay redisplay events from the window system.

(6) Set when the window system reports a region of the window’s normal plane is undefined (for example, damaged by another window moving or being initially shown). The specifics of when damage occurs are left to the window system to determine. The damage may occur independent from damage to the window’s normal plane. The window’s redisplay state is always set true when damage occurs. normalDamaged is cleared whenever the window’s display callback returns.

When an overlay is established, overlay frame buffer capability state is maintained as described in Section A.3.2. The layerInUse determines whether glutGet returns normal plane or overlay state when an overlay is established.
## A.4 Menu State

<table>
<thead>
<tr>
<th>Name</th>
<th>Type</th>
<th>Set/Change</th>
<th>Get</th>
<th>Initial</th>
</tr>
</thead>
<tbody>
<tr>
<td>number</td>
<td>Integer</td>
<td>-</td>
<td>glutSetMenu</td>
<td><em>top-level:</em> glutCreateMenu (1)</td>
</tr>
<tr>
<td>select</td>
<td>Callback</td>
<td>-</td>
<td>-</td>
<td>glutCreateMenu</td>
</tr>
<tr>
<td>items</td>
<td>list of MenuItem</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>numItems</td>
<td>Integer</td>
<td>-</td>
<td>GLUT_MENU_NUM_ITEMS</td>
<td>0</td>
</tr>
</tbody>
</table>

(1) Assigned dynamically from unassigned window numbers greater than zero.
B  glut.h ANSI C Header File

1  ifndef __glut_h__
2  define __glut_h__
3
4  /* Copyright (c) Mark J. Kilgard, 1994, 1995, 1996. */
5
6  /* This program is freely distributable without licensing fees and is
7 provided without guarantee or warrantee expressed or implied. This
8 program is -not- in the public domain. */
9
10  #include <GL/gl.h>
11  #include <GL/glu.h>
12
13  #ifdef __cplusplus
14     extern "C" {
15  #endif
16
17  /*
18   * GLUT API revision history:
19   *
20   * GLUT_API_VERSION is updated to reflect incompatible GLUT
21   * API changes (interface changes, semantic changes, deletions,
22   * or additions).
23   *
24   * GLUT_API_VERSION=1 First public release of GLUT. 11/29/94
25   *
26   * GLUT_API_VERSION=2 Added support for OpenGL/GLX multisampling,
27   * extension. Supports new input devices like tablet, dial and button
28   * box, and Spaceball. Easy to query OpenGL extensions.
29   *
30   * GLUT_API_VERSION=3 glutMenuStatus added.
31   *
32   */
33  ifndef GLUT_API_VERSION /* allow this to be overridden */
34     define GLUT_API_VERSION 3
35  #endif
36
37  /*
38   * GLUT implementation revision history:
39   *
40   * GLUT_XLIB_IMPLEMENTATION is updated to reflect both GLUT
41   * API revisions and implementation revisions (ie, bug fixes).
42   *
43   * GLUT_XLIB_IMPLEMENTATION=1 mjk’s first public release of
44   * GLUT Xlib-based implementation. 11/29/94
45   *
46   * GLUT_XLIB_IMPLEMENTATION=2 mjk’s second public release of
47   * GLUT Xlib-based implementation providing GLUT version 2
48   * interfaces.
49   *
50   * GLUT_XLIB_IMPLEMENTATION=3 mjk’s GLUT 2.2 images. 4/17/95
51   *
52   * GLUT_XLIB_IMPLEMENTATION=4 mjk’s GLUT 2.3 images. 6/??/95
53   *
54   * GLUT_XLIB_IMPLEMENTATION=5 mjk’s GLUT 3.0 images. 10/??/95
55   *
56   */
57  ifndef GLUT_XLIB_IMPLEMENTATION /* allow this to be overridden */
58     define GLUT_XLIB_IMPLEMENTATION 5
59  #endif
60
61  /* display mode bit masks */
62     define GLUT_RGB 0
63     define GLUT_RGBA GLUT_RGB
64     define GLUT_INDEX 1
65     define GLUT_SINGLE 0
66     define GLUT_DOUBLE 2
#define GLUT_ACCUM 4
#define GLUT_ALPHA 8
#define GLUT_DEPTH 16
#define GLUT_STENCIL 32
#if (GLUT_API_VERSION >= 2)
#define GLUT_MULTISAMPLE 128
#define GLUT_STEREO 256
#endif
#if (GLUT_API_VERSION >= 3)
#define GLUT_LUMINANCE 512
#endif
/* mouse buttons */
define GLUT_LEFT_BUTTON 0
define GLUT_MIDDLE_BUTTON 1
define GLUT_RIGHT_BUTTON 2
/* mouse button callback state */
define GLUT_DOWN 0
define GLUT_UP 1
#if (GLUT_API_VERSION >= 2)
/* function keys */
define GLUT_KEY_F1 1
define GLUT_KEY_F2 2
define GLUT_KEY_F3 3
define GLUT_KEY_F4 4
define GLUT_KEY_F5 5
define GLUT_KEY_F6 6
define GLUT_KEY_F7 7
define GLUT_KEY_F8 8
define GLUT_KEY_F9 9
define GLUT_KEY_F10 10
define GLUT_KEY_F11 11
define GLUT_KEY_F12 12
/* directional keys */
define GLUT_LEFT 100
#define GLUT_KEY_UP 101
#define GLUT_KEY_RIGHT 102
#define GLUT_KEY_DOWN 103
#define GLUT_KEY_PAGE_UP 104
#define GLUT_KEY_PAGE_DOWN 105
#define GLUT_KEY_HOME 106
#define GLUT_KEY_END 107
#define GLUT_KEY_INSERT 108
#endif
/* entry/exit callback state */
define GLUT_LEFT 0
define GLUT_ENTERED 1
/* menu usage callback state */
define GLUT_MENU_NOT_IN_USE 0
define GLUT_MENU_IN_USE 1
/* visibility callback state */
define GLUT_NOT_VISIBLE 0
define GLUT_VISIBLE 1
/* color index component selection values */
define GLUT_RED 0
#define GLUT_GREEN 1
#define GLUT_BLUE 2
/* layers for use */
define GLUT_NORMAL 0
define GLUT_OVERLAY 1
*/ stroke font opaque addresses (use constants instead in source code) */
extern void *glutStrokeRoman;
extern void *glutStrokeMonoRoman;

*/ stroke font constants (use these in GLUT program) */
#define GLUT_STROKE_ROMAN (&glutStrokeRoman)
#define GLUT_STROKE_MONO_ROMAN (&glutStrokeMonoRoman)

*/ bitmap font opaque addresses (use constants instead in source code) */
extern void *glutBitmap9By15;
extern void *glutBitmap8By13;
extern void *glutBitmapTimesRoman10;
extern void *glutBitmapTimesRoman24;
extern void *glutBitmapHelvetica10;
extern void *glutBitmapHelvetica12;
extern void *glutBitmapHelvetica18;

*/ bitmap font constants (use these in GLUT program) */
define GLUT_BITMAP_9_BY_15 (&glutBitmap9By15)
define GLUT_BITMAP_8_BY_13 (&glutBitmap8By13)
define GLUT_BITMAP_TIMES_ROMAN_10 (&glutBitmapTimesRoman10)
define GLUT_BITMAP_TIMES_ROMAN_24 (&glutBitmapTimesRoman24)
#if (GLUT_API_VERSION >= 3)
define GLUT_BITMAP_HELVETICA_10 (&glutBitmapHelvetica10)
define GLUT_BITMAP_HELVETICA_12 (&glutBitmapHelvetica12)
define GLUT_BITMAP_HELVETICA_18 (&glutBitmapHelvetica18)
#endif

*/ glutGet parameters */
define GLUT_WINDOW_X 100
define GLUT_WINDOW_Y 101
define GLUT_WINDOW_WIDTH 102
define GLUT_WINDOW_HEIGHT 103
define GLUT_WINDOW_BUFFER_SIZE 104
define GLUT_WINDOW_STENCIL_SIZE 105
define GLUT_WINDOW_DEPTH_SIZE 106
define GLUT_WINDOW_RED_SIZE 107
define GLUT_WINDOW_GREEN_SIZE 108
define GLUT_WINDOW_BLUE_SIZE 109
define GLUT_WINDOW_ALPHA_SIZE 110
define GLUT_WINDOW_ACCUM_RED_SIZE 111
define GLUT_WINDOW_ACCUM_GREEN_SIZE 112
define GLUT_WINDOW_ACCUM_BLUE_SIZE 113
define GLUT_WINDOW_ACCUM_ALPHA_SIZE 114
define GLUT_WINDOW_DOUBLEBUFFER 115
define GLUT_WINDOW_RGBA 116
define GLUT_WINDOW_PARENT 117
define GLUT_WINDOW_NUM_CHILDREN 118
define GLUT_WINDOW_COLORMAP_SIZE 119
#if (GLUT_API_VERSION >= 2)
define GLUT_WINDOW_NUM_SAMPLES 120
define GLUT_WINDOW_STEREO 121
#endif
#if (GLUT_API_VERSION >= 3)
define GLUT_WINDOW_CURSOR 122
#endif
#define GLUT_SCREEN_WIDTH 200
#define GLUT_SCREEN_HEIGHT 201
#define GLUT_SCREEN_WIDTH_MM 202
#define GLUT_SCREEN_HEIGHT_MM 203
#define GLUT_MENU_NUM_ITEMS 300
#define GLUT_DISPLAY_MODE_POSSIBLE 400
#define GLUT_INIT_WINDOW_X 500
#define GLUT_INIT_WINDOW_Y 501
#define GLUT_INIT_WINDOW_WIDTH 502
#define GLUT_INIT_WINDOW_HEIGHT 503
#define GLUT_INIT_DISPLAY_MODE 504
#if (GLUT_API_VERSION >= 2)
#define GLUT_ELAPSED_TIME 700
#endif

#if (GLUT_API_VERSION >= 2)
/* glutDeviceGet parameters */
#define GLUT_HAS_KEYBOARD 600
#define GLUT_HAS_MOUSE 601
#define GLUT_HAS_SPACEBALL 602
#define GLUT_HAS_DIAL_AND_BUTTON_BOX 603
#define GLUT_HAS_TABLET 604
#define GLUT_NUM_MOUSE_BUTTONS 605
#define GLUT_NUM_SPACEBALL_BUTTONS 606
#define GLUT_NUM_BUTTON_BOX_BUTTONS 607
#define GLUT_NUM_DIALS 608
#define GLUT_NUM_TABLET_BUTTONS 609
#endif

#if (GLUT_API_VERSION >= 3)
/* glutLayerGet parameters */
#define GLUT_OVERLAY_POSSIBLE 800
#define GLUT_LAYER_IN_USE 801
#define GLUT_HAS_OVERLAY 802
#define GLUT_TRANSPARENT_INDEX 803
#define GLUT_NORMAL_DAMAGED 804
#define GLUT_OVERLAY_DAMAGED 805
/* glutUseLayer parameters */
#define GLUT_NORMAL 0
#define GLUT_OVERLAY 1
/* glutGetModifiers return mask */
#define GLUT_ACTIVE_SHIFT 1
#define GLUT_ACTIVE_CTRL 2
#define GLUT_ACTIVE_ALT 4
/* glutSetCursor parameters */
/* Basic arrows */
#define GLUT_CURSOR_RIGHT_ARROW 0
#define GLUT_CURSOR_LEFT_ARROW 1
/* Symbolic cursor shapes */
#define GLUT_CURSOR_INFO 2
#define GLUT_CURSOR_DESTROY 3
#define GLUT_CURSOR_HELP 4
#define GLUT_CURSOR_CYCLE 5
#define GLUT_CURSOR_SPRAY 6
#define GLUT_CURSOR_WAIT 7
#define GLUT_CURSOR_TEXT 8
#define GLUT_CURSOR_CROSSHAIR 9
/* Directional cursors */
#define GLUT_CURSOR_UP_DOWN 10
#define GLUT_CURSOR_LEFT_RIGHT 11
/* Sizing cursors */
#define GLUT_CURSOR_TOP_SIDE 12
#define GLUT_CURSOR_BOTTOM_SIDE 13
#define GLUT_CURSOR_LEFT_SIDE 14
#define GLUT_CURSOR_RIGHT_SIDE 15
#define GLUT_CURSOR_TOP_LEFT_CORNER 16
#define GLUT_CURSOR_TOP_RIGHT_CORNER 17
#define GLUT_CURSOR_BOTTOM_RIGHT_CORNER 18
#define GLUT_CURSOR_BOTTOM_LEFT_CORNER 19
/* Inherit from parent window */
#define GLUT_CURSOR_INHERIT 100
/* Blank cursor */
#define GLUT_CURSOR_NONE 101
/* Fullscreen crosshair (if available) */
#define GLUT_CURSOR_FULL_CROSSHAIR 102
#endif
/* GLUT initialization sub-API */
extern void glutInit(int *argcp, char **argv);
extern void glutInitDisplayMode(unsigned int mode);
extern void glutInitWindowPosition(int x, int y);
extern void glutInitWindowSize(int width, int height);
extern void glutMainLoop(void);

/* GLUT window sub-api */
extern int glutCreateWindow(char *title);
extern int glutCreateSubWindow(int win, int x, int y, int width, int height);
extern void glutDestroyWindow(int win);
extern void glutPostRedisplay(void);
extern void glutSwapBuffers(void);
extern int glutGetWindow(void);
extern void glutSetWindow(int win);
extern void glutSetWindowTitle(char *title);
extern void glutPositionWindow(int x, int y);
extern void glutReshapeWindow(int width, int height);
extern void glutPopWindow(void);
extern void glutPushWindow(void);
extern void glutIconifyWindow(void);
extern void glutShowWindow(void);
extern void glutHideWindow(void);
#if (GLUT_API_VERSION >= 3)
extern void glutFullScreen(void);
extern void glutSetCursor(int cursor);
#endif

/* GLUT overlay sub-API */
extern void glutEstablishOverlay(void);
extern void glutRemoveOverlay(void);
extern void glutUseLayer(GLenum layer);
extern void glutPostOverlayRedisplay(void);
extern void glutShowOverlay(void);
extern void glutHideOverlay(void);
#endif

/* GLUT menu sub-API */
extern int glutCreateMenu(void (*)(int));
extern void glutDestroyMenu(int menu);
extern int glutGetMenu(void);
extern void glutSetMenu(int menu);
extern void glutAddMenuEntry(char *label, int value);
extern void glutAddSubMenu(char *label, int submenu);
extern void glutChangeToMenuEntry(int item, char *label, int value);
extern void glutChangeToSubMenu(int item, char *label, int submenu);
extern void glutRemoveMenuItem(int item);
extern void glutAttachMenu(int button);
extern void glutDetachMenu(int button);

/* GLUT callback sub-api */
extern void glutDisplayFunc(void (*)(void));
extern void glutReshapeFunc(void (*)(int width, int height));
extern void glutKeyboardFunc(void (*)(unsigned char key, int x, int y));
extern void glutMouseFunc(void (*)(int button, int state, int x, int y));
extern void glutMotionFunc(void (*)(int x, int y));
extern void glutPassiveMotionFunc(void (*)(int x, int y));
extern void glutEntryFunc(void (*)(int state));
extern void glutVisibilityFunc(void (*)(int state));
extern void glutIdleFunc(void (*)(void));
extern void glutTimerFunc(unsigned int millis, void (*)(int value), int value);
extern void glutMenuStateFunc(void (*)(int state));
#if (GLUT_API_VERSION >= 2)
extern void glutSpecialFunc(void (*)(int key, int x, int y));
extern void glutSpaceballMotionFunc(void (*)(int x, int y, int z));
extern void glutSpaceballRotateFunc(void (*)(int x, int y, int z));
extern void glutSpaceballButtonFunc(void (*)(int button, int state));
#endif
extern void glutButtonBoxFunc(void (*)(int button, int state));
extern void glutDialsFunc(void (*)(int dial, int value));
extern void glutTabletMotionFunc(void (*)(int x, int y));
extern void glutTabletButtonFunc(void (*)(int button, int state, int x, int y));
#if (GLUT_API_VERSION >= 3)
extern void glutMenuStatusFunc(void (*)(int status, int x, int y));
extern void glutOverlayDisplayFunc(void (*)(void));
#endif
#endif

/* GLUT color index sub-api */
extern void glutSetColor(int, GLfloat red, GLfloat green, GLfloat blue);
extern GLfloat glutGetColor(int ndx, int component);
extern void glutCopyColormap(int win);
/* GLUT state retrieval sub-api */
extern int glutGet(GLenum type);
extern int glutDeviceGet(GLenum type);
#if (GLUT_API_VERSION >= 2)
/* GLUT extension support sub-API */
extern int glutExtensionSupported(char *name);
#endif
#if (GLUT_API_VERSION >= 3)
extern int glutGetModifiers(void);
extern int glutLayerGet(GLenum type);
#endif
/* GLUT font sub-API */
extern void glutBitmapCharacter(void *font, int character);
extern int glutBitmapWidth(void *font, int character);
extern void glutStrokeCharacter(void *font, int character);
extern int glutStrokeWidth(void *font, int character);
/* GLUT pre-built models sub-API */
extern void glutWireSphere(GLdouble radius, GLint slices, GLint stacks);
extern void glutSolidSphere(GLdouble radius, GLint slices, GLint stacks);
extern void glutWireCone(GLdouble base, GLdouble height, GLint slices, GLint stacks);
extern void glutSolidCone(GLdouble base, GLdouble height, GLint slices, GLint stacks);
extern void glutWireCube(GLdouble size);
extern void glutSolidCube(GLdouble size);
extern void glutWireTorus(GLdouble innerRadius, GLdouble outerRadius, GLint sides, GLint rings);
extern void glutSolidTorus(GLdouble innerRadius, GLdouble outerRadius, GLint sides, GLint rings);
extern void glutWireDodecahedron(void);
extern void glutSolidDodecahedron(void);
extern void glutWireTeapot(GLdouble size);
extern void glutSolidTeapot(GLdouble size);
extern void glutWireOctahedron(void);
extern void glutSolidOctahedron(void);
extern void glutWireTetrahedron(void);
extern void glutSolidTetrahedron(void);
extern void glutWireIcosahedron(void);
extern void glutSolidIcosahedron(void);
#ifdef __cplusplus
}
#endif
#endif /* __glut_h__ */
C GLUT Fortran header file

C display mode bit masks
   integer*4 GLUT_RGB
      parameter ( GLUT_RGB = 0 )
   integer*4 GLUT_RGBA
      parameter ( GLUT_RGBA = 0 )
   integer*4 GLUT_INDEX
      parameter ( GLUT_INDEX = 1 )
   integer*4 GLUT_SINGLE
      parameter ( GLUT_SINGLE = 0 )
   integer*4 GLUT_DOUBLE
      parameter ( GLUT_DOUBLE = 2 )
   integer*4 GLUT_ACCUM
      parameter ( GLUT_ACCUM = 4 )
   integer*4 GLUT_ALPHA
      parameter ( GLUT_ALPHA = 8 )
   integer*4 GLUT_DEPTH
      parameter ( GLUT_DEPTH = 16 )
   integer*4 GLUT_STENCIL
      parameter ( GLUT_STENCIL = 32 )
   integer*4 GLUT_MULTISAMPLE
      parameter ( GLUT_MULTISAMPLE = 128 )
   integer*4 GLUT_STEREO
      parameter ( GLUT_STEREO = 256 )

C mouse buttons
   integer*4 GLUT_LEFT_BUTTON
      parameter ( GLUT_LEFT_BUTTON = 0 )
   integer*4 GLUT_MIDDLE_BUTTON
      parameter ( GLUT_MIDDLE_BUTTON = 1 )
   integer*4 GLUT_RIGHT_BUTTON
      parameter ( GLUT_RIGHT_BUTTON = 2 )

C mouse button callback state
   integer*4 GLUT_DOWN
      parameter ( GLUT_DOWN = 0 )
   integer*4 GLUT_UP
      parameter ( GLUT_UP = 1 )

C special key callback values
   integer*4 GLUT_KEY_F1
      parameter ( GLUT_KEY_F1 = 1 )
   integer*4 GLUT_KEY_F2
      parameter ( GLUT_KEY_F2 = 2 )
   integer*4 GLUT_KEY_F3
      parameter ( GLUT_KEY_F3 = 3 )
   integer*4 GLUT_KEY_F4
      parameter ( GLUT_KEY_F4 = 4 )
   integer*4 GLUT_KEY_F5
      parameter ( GLUT_KEY_F5 = 5 )
   integer*4 GLUT_KEY_F6
      parameter ( GLUT_KEY_F6 = 6 )
   integer*4 GLUT_KEY_F7
      parameter ( GLUT_KEY_F7 = 7 )
   integer*4 GLUT_KEY_F8
      parameter ( GLUT_KEY_F8 = 8 )
   integer*4 GLUT_KEY_F9
      parameter ( GLUT_KEY_F9 = 9 )
   integer*4 GLUT_KEY_F10

parameter ( GLUT_KEY_F10 = 10 )
integer*4 GLUT_KEY_F11
parameter ( GLUT_KEY_F11 = 11 )
integer*4 GLUT_KEY_F12
parameter ( GLUT_KEY_F12 = 12 )
integer*4 GLUT_KEY_LEFT
parameter ( GLUT_KEY_LEFT = 100 )
integer*4 GLUT_KEY_UP
parameter ( GLUT_KEY_UP = 101 )
integer*4 GLUT_KEY_RIGHT
parameter ( GLUT_KEY_RIGHT = 102 )
integer*4 GLUT_KEY_DOWN
parameter ( GLUT_KEY_DOWN = 103 )
integer*4 GLUT_KEY_PAGE_UP
parameter ( GLUT_KEY_PAGE_UP = 104 )
integer*4 GLUT_KEY_PAGE_DOWN
parameter ( GLUT_KEY_PAGE_DOWN = 105 )
integer*4 GLUT_KEY_HOME
parameter ( GLUT_KEY_HOME = 106 )
integer*4 GLUT_KEY_END
parameter ( GLUT_KEY_END = 107 )
integer*4 GLUT_KEY_INSERT
parameter ( GLUT_KEY_INSERT = 108 )

C entry/exit callback state
integer*4 GLUT_LEFT
parameter ( GLUT_LEFT = 0 )
integer*4 GLUT_ENTERED
parameter ( GLUT_ENTERED = 1 )

C menu usage callback state
integer*4 GLUT_MENU_NOT_IN_USE
parameter ( GLUT_MENU_NOT_IN_USE = 0 )
integer*4 GLUT_MENU_IN_USE
parameter ( GLUT_MENU_IN_USE = 1 )

C visibility callback state
integer*4 GLUT_NOT_VISIBLE
parameter ( GLUT_NOT_VISIBLE = 0 )
integer*4 GLUT_VISIBLE
parameter ( GLUT_VISIBLE = 1 )

C color index component selection values
integer*4 GLUT_RED
parameter ( GLUT_RED = 0 )
integer*4 GLUT_GREEN
parameter ( GLUT_GREEN = 1 )
integer*4 GLUT_BLUE
parameter ( GLUT_BLUE = 2 )

XXX Unfortunately, SGI's Fortran compiler links with
EXTERNAL data even if it is not used. This defeats
the purpose of GLUT naming fonts via opaque symbols.
This means GLUT Fortran programmers should explicitly
declared EXTERNAL GLUT fonts in subroutines where
the fonts are used.

C stroke font opaque names
external GLUT_STROKE_ROMAN
external GLUT_STROKE_MONO_ROMAN

C bitmap font opaque names
external GLUT_BITMAP_9_BY_15
external GLUT_BITMAP_8_BY_13
external GLUT_BITMAP_TIMES_ROMAN_10
external GLUT_BITMAP_TIMES_ROMAN_24
external GLUT_BITMAP_HELVETICA_10
external GLUT_BITMAP_HELVETICA_12
C glutGet parameters

integer*4 GLUT_WINDOW_X
parameter ( GLUT_WINDOW_X = 100 )

integer*4 GLUT_WINDOW_Y
parameter ( GLUT_WINDOW_Y = 101 )

integer*4 GLUT_WINDOW_WIDTH
parameter ( GLUT_WINDOW_WIDTH = 102 )

integer*4 GLUT_WINDOW_HEIGHT
parameter ( GLUT_WINDOW_HEIGHT = 103 )

integer*4 GLUT_WINDOW_BUFFER_SIZE
parameter ( GLUT_WINDOW_BUFFER_SIZE = 104 )

integer*4 GLUT_WINDOW_STENCIL_SIZE
parameter ( GLUT_WINDOW_STENCIL_SIZE = 105 )

integer*4 GLUT_WINDOW_DEPTH_SIZE
parameter ( GLUT_WINDOW_DEPTH_SIZE = 106 )

integer*4 GLUT_WINDOW_RED_SIZE
parameter ( GLUT_WINDOW_RED_SIZE = 107 )

integer*4 GLUT_WINDOW_GREEN_SIZE
parameter ( GLUT_WINDOW_GREEN_SIZE = 108 )

integer*4 GLUT_WINDOW_BLUE_SIZE
parameter ( GLUT_WINDOW_BLUE_SIZE = 109 )

integer*4 GLUT_WINDOW_ALPHA_SIZE
parameter ( GLUT_WINDOW_ALPHA_SIZE = 110 )

integer*4 GLUT_WINDOW_ACCUM_RED_SIZE
parameter ( GLUT_WINDOW_ACCUM_RED_SIZE = 111 )

integer*4 GLUT_WINDOW_ACCUM_GREEN_SIZE
parameter ( GLUT_WINDOW_ACCUM_GREEN_SIZE = 112 )

integer*4 GLUT_WINDOW_ACCUM_BLUE_SIZE
parameter ( GLUT_WINDOW_ACCUM_BLUE_SIZE = 113 )

integer*4 GLUT_WINDOW_ACCUM_ALPHA_SIZE
parameter ( GLUT_WINDOW_ACCUM_ALPHA_SIZE = 114 )

integer*4 GLUT_WINDOW_DOUBLEBUFFER
parameter ( GLUT_WINDOW_DOUBLEBUFFER = 115 )

integer*4 GLUT_WINDOW_RGBA
parameter ( GLUT_WINDOW_RGBA = 116 )

integer*4 GLUT_WINDOW_PARENT
parameter ( GLUT_WINDOW_PARENT = 117 )

integer*4 GLUT_WINDOW_NUM_CHILDREN
parameter ( GLUT_WINDOW_NUM_CHILDREN = 118 )

integer*4 GLUT_WINDOW_COLORMAP_SIZE
parameter ( GLUT_WINDOW_COLORMAP_SIZE = 119 )

integer*4 GLUT_WINDOW_NUM_SAMPLES
parameter ( GLUT_WINDOW_NUM_SAMPLES = 120 )

integer*4 GLUT_WINDOW_STEREO
parameter ( GLUT_WINDOW_STEREO = 121 )

integer*4 GLUT_WINDOW_CURSOR
parameter ( GLUT_WINDOW_CURSOR = 122 )

integer*4 GLUT_SCREEN_WIDTH
parameter ( GLUT_SCREEN_WIDTH = 200 )

integer*4 GLUT_SCREEN_HEIGHT
parameter ( GLUT_SCREEN_HEIGHT = 201 )

integer*4 GLUT_SCREEN_WIDTH_MM
parameter ( GLUT_SCREEN_WIDTH_MM = 202 )

integer*4 GLUT_SCREEN_HEIGHT_MM
parameter ( GLUT_SCREEN_HEIGHT_MM = 203 )

integer*4 GLUT_MENU_NUM_ITEMS
parameter ( GLUT_MENU_NUM_ITEMS = 300 )

integer*4 GLUT_DISPLAY_MODE_POSSIBLE
parameter ( GLUT_DISPLAY_MODE_POSSIBLE = 400 )

integer*4 GLUT_INIT_WINDOW_X
parameter ( GLUT_INIT_WINDOW_X = 500 )

integer*4 GLUT_INIT_WINDOW_Y
parameter ( GLUT_INIT_WINDOW_Y = 501 )

integer*4 GLUT_INIT_WINDOW_WIDTH
parameter ( GLUT_INIT_WINDOW_WIDTH = 502 )

integer*4 GLUT_INIT_WINDOW_HEIGHT
parameter ( GLUT_INIT_WINDOW_HEIGHT = 503 )

integer*4 GLUT_INIT_DISPLAY_MODE
parameter ( GLUT_INIT_DISPLAY_MODE = 504 )

integer*4 GLUT_ELAPSED_TIME
parameter ( GLUT_ELAPSED_TIME = 700 )

c
C glutDeviceGet parameters

integer*4 GLUT_HAS_KEYBOARD
parameter ( GLUT_HAS_KEYBOARD = 600 )

integer*4 GLUT_HAS_MOUSE
parameter ( GLUT_HAS_MOUSE = 601 )

integer*4 GLUT_HAS_SPACEBALL
parameter ( GLUT_HAS_SPACEBALL = 602 )

integer*4 GLUT_HAS_DIAL_AND_BUTTON_BOX
parameter ( GLUT_HAS_DIAL_AND_BUTTON_BOX = 603 )

integer*4 GLUT_HAS_TABLET
parameter ( GLUT_HAS_TABLET = 604 )

integer*4 GLUT_NUM_MOUSE_BUTTONS
parameter ( GLUT_NUM_MOUSE_BUTTONS = 605 )

integer*4 GLUT_NUM_SPACEBALL_BUTTONS
parameter ( GLUT_NUM_SPACEBALL_BUTTONS = 606 )

integer*4 GLUT_NUM_BUTTON_BOX_BUTTONS
parameter ( GLUT_NUM_BUTTON_BOX_BUTTONS = 607 )

integer*4 GLUT_NUM_DIALS
parameter ( GLUT_NUM_DIALS = 608 )

integer*4 GLUT_NUM_TABLET_BUTTONS
parameter ( GLUT_NUM_TABLET_BUTTONS = 609 )

c
C glutLayerGet parameters

integer*4 GLUT_OVERLAY_POSSIBLE
parameter ( GLUT_OVERLAY_POSSIBLE = 800 )

integer*4 GLUT_LAYER_IN_USE
parameter ( GLUT_LAYER_IN_USE = 801 )

integer*4 GLUT_HAS_OVERLAY
parameter ( GLUT_HAS_OVERLAY = 802 )

integer*4 GLUT_TRANSPARENT_INDEX
parameter ( GLUT_TRANSPARENT_INDEX = 803 )

integer*4 GLUT_NORMAL_DAMAGED
parameter ( GLUT_NORMAL_DAMAGED = 804 )

integer*4 GLUT_OVERLAY_DAMAGED
parameter ( GLUT_OVERLAY_DAMAGED = 805 )

c
C glutUseLayer parameters

integer*4 GLUT_NORMAL
parameter ( GLUT_NORMAL = 0 )

integer*4 GLUT_OVERLAY
parameter ( GLUT_OVERLAY = 1 )

c
C glutGetModifiers return mask

integer*4 GLUT_ACTIVE_SHIFT
parameter ( GLUT_ACTIVE_SHIFT = 1 )

integer*4 GLUT_ACTIVE_CTRL
parameter ( GLUT_ACTIVE_CTRL = 2 )

integer*4 GLUT_ACTIVE_ALT
parameter ( GLUT_ACTIVE_ALT = 4 )

C glutSetCursor parameters

integer*4 GLUT_CURSOR_RIGHT_ARROW
parameter ( GLUT_CURSOR_RIGHT_ARROW = 0 )

integer*4 GLUT_CURSOR_LEFT_ARROW
parameter ( GLUT_CURSOR_LEFT_ARROW = 1 )

integer*4 GLUT_CURSOR_INFO
parameter ( GLUT_CURSOR_INFO = 2 )

integer*4 GLUT_CURSOR_DESTROY
parameter ( GLUT_CURSOR_DESTROY = 3 )

integer*4 GLUT_CURSOR_HELP
parameter ( GLUT_CURSOR_HELP = 4 )

integer*4 GLUT_CURSOR_CYCLE
parameter ( GLUT_CURSOR_CYCLE = 5 )
integer*4 GLUT_CURSOR_SPRAY
parameter ( GLUT_CURSOR_SPRAY = 6 )
integer*4 GLUT_CURSOR_WAIT
parameter ( GLUT_CURSOR_WAIT = 7 )
integer*4 GLUT_CURSOR_TEXT
parameter ( GLUT_CURSOR_TEXT = 8 )
integer*4 GLUT_CURSOR_CROSSHAIR
parameter ( GLUT_CURSOR_CROSSHAIR = 9 )
integer*4 GLUT_CURSOR_UP_DOWN
parameter ( GLUT_CURSOR_UP_DOWN = 10 )
integer*4 GLUT_CURSOR_LEFT_RIGHT
parameter ( GLUT_CURSOR_LEFT_RIGHT = 11 )
integer*4 GLUT_CURSOR_TOP_SIDE
parameter ( GLUT_CURSOR_TOP_SIDE = 12 )
integer*4 GLUT_CURSOR_BOTTOM_SIDE
parameter ( GLUT_CURSOR_BOTTOM_SIDE = 13 )
integer*4 GLUT_CURSOR_LEFT_SIDE
parameter ( GLUT_CURSOR_LEFT_SIDE = 14 )
integer*4 GLUT_CURSOR_RIGHT_SIDE
parameter ( GLUT_CURSOR_RIGHT_SIDE = 15 )
integer*4 GLUT_CURSOR_TOP_LEFT_CORNER
parameter ( GLUT_CURSOR_TOP_LEFT_CORNER = 16 )
integer*4 GLUT_CURSOR_TOP_RIGHT_CORNER
parameter ( GLUT_CURSOR_TOP_RIGHT_CORNER = 17 )
integer*4 GLUT_CURSOR_BOTTOM_RIGHT_CORNER
parameter ( GLUT_CURSOR_BOTTOM_RIGHT_CORNER = 18 )
integer*4 GLUT_CURSOR_BOTTOM_LEFT_CORNER
parameter ( GLUT_CURSOR_BOTTOM_LEFT_CORNER = 19 )
integer*4 GLUT_CURSOR_INHERIT
parameter ( GLUT_CURSOR_INHERIT = 100 )
integer*4 GLUT_CURSOR_NONE
parameter ( GLUT_CURSOR_NONE = 101 )
integer*4 GLUT_CURSOR_FULL_CROSSHAIR
parameter ( GLUT_CURSOR_FULL_CROSSHAIR = 102 )

C GLUT functions
integer*4 glutcreatwindow
integer*4 glutgetwindow
integer*4 glutcreatemenu
integer*4 glutgetmenu
real glutgetcolor
integer*4 glutget
integer*4 glutdeviceget
integer*4 glutextensionsupported

C GLUT NULL name
external glutnull
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