Error Handling

This chapter describes the way that GSL functions report and handle errors. By examining the status information returned by every function you can determine whether it succeeded or failed, and if it failed you can find out what the precise cause of failure was. You can also define your own error handling functions to modify the default behavior of the library.

The functions described in this section are declared in the header file `gsl_errno.h'.

Error Reporting

The library follows the thread-safe error reporting conventions of the POSIX Threads library. Functions return a non-zero error code to indicate an error and `0` to indicate success.

```
int status = gsl_function (...)

if (status) { /* an error occurred */
  .....
  /* status value specifies the type of error */
}
```

The routines report an error whenever they cannot perform the task requested of them. For example, a root-finding function would return a non-zero error code if could not converge to the requested accuracy, or exceeded a limit on the number of iterations. Situations like this are a normal occurrence when using any mathematical library and you should check the return status of the functions that you call.

Whenever a routine reports an error the return value specifies the type of error. The return value is analogous to the value of the variable `errno` in the C library. The caller can examine the return code and decide what action to take, including ignoring the error if it is not considered serious.

In addition to reporting errors by return codes the library also has an error handler function `gsl_error`. This function is called by other library functions when they report an error, just before they return to the caller. The default behavior of the error handler is to print a message and abort the program,

```
gsl: file.c:67: ERROR: invalid argument supplied by user
Default GSL error handler invoked.
Aborted
```

The purpose of the `gsl_error` handler is to provide a function where a breakpoint can be set that will catch library errors when running under the debugger. It is not intended for use in production programs, which should handle any errors using the return codes.

Error Codes

The error code numbers returned by library functions are defined in the file `gsl_errno.h'. They all have the prefix `GSL_` and expand to non-zero constant integer values. Many of the error codes use the same base name as a corresponding error code in C library. Here are some of the most common error codes,

Macro: int **GSL_EDOM**

Domain error; used by mathematical functions when an argument value does not fall into the domain over which the function is defined (like EDOM in the C library)

Macro: int **GSL_ERANGE**

Range error; used by mathematical functions when the result value is not representable because of overflow or underflow (like ERANGE in the C library)

Macro: int **GSL_ENOMEM**

No memory available. The system cannot allocate more virtual memory because its capacity is full (like ENOMEM in the C library). This error is reported when a GSL routine encounters problems when trying to allocate memory with `malloc`.

Macro: int **GSL_EINVAL**

Invalid argument. This is used to indicate various kinds of problems with passing the wrong argument to a library function (like EINVAL in the C library).

The error codes can be converted into an error message using the function `gsl_strerror`.

Function: const char * **gsl_strerror** *(const int gsl_errno)*

This function returns a pointer to a string describing the error code *gsl_errno*. For example,

```
printf ("error: %s\n", gsl_strerror (status));
```

would print an error message like `error: output range error` for a status value of `GSL_ERANGE`.

Error Handlers

The default behavior of the GSL error handler is to print a short message and call `abort()`. When this default is in use programs will stop with a core-dump whenever a library routine reports an error. This is intended as a fail-safe default for programs which do not check the return status of library routines (we don't encourage you to write programs this way).

If you turn off the default error handler it is your responsibility to check the return values of routines and handle them yourself. You can also customize the error behavior by providing a new error handler. For example, an alternative error handler could log all errors to a file, ignore certain error conditions (such as underflows), or start the debugger and attach it to the current process when an error occurs.

All GSL error handlers have the type `gsl_error_handler_t`, which is defined in ``gsl_errno.h'`,

Data Type: **gsl_error_handler_t**

This is the type of GSL error handler functions. An error handler will be passed four arguments which specify the reason for the error (a string), the name of the source file in which it occurred (also a string), the line number in that file (an integer) and the error number (an integer). The source file and line number are set at compile time using the `__FILE__` and `__LINE__` directives in the preprocessor. An error handler function returns type `void`. Error handler functions should be defined like this,

```
void handler (const char * reason,
              const char * file,
              int line,
                  int gsl_errno)
```

To request the use of your own error handler you need to call the function `gsl_set_error_handler` which is also declared in `` `gsl_errno.h' ``,

Function: gsl_error_handler_t * **gsl_set_error_handler** *(gsl_error_handler_t new_handler)*

> This function sets a new error handler, *new_handler*, for the GSL library routines. The previous handler is returned (so that you can restore it later). Note that the pointer to a user defined error handler function is stored in a static variable, so there can be only one error handler per program. This function should be not be used in multi-threaded programs except to set up a program-wide error handler from a master thread. The following example shows how to set and restore a new error handler,

```
/* save original handler, install new handler */
old_handler = gsl_set_error_handler (&my_handler);

/* code uses new handler */
.....

/* restore original handler */
gsl_set_error_handler (old_handler);
```

> To use the default behavior (`abort` on error) set the error handler to `NULL`,

```
old_handler = gsl_set_error_handler (NULL);
```

Function: gsl_error_handler_t * **gsl_set_error_handler_off** *()*

> This function turns off the error handler by defining an error handler which does nothing. This will cause the program to continue after any error, so the return values from any library routines must be checked. This is the recommended behavior for production programs. The previous handler is returned (so that you can restore it later).

The error behavior can be changed for specific applications by recompiling the library with a customized definition of the `GSL_ERROR` macro in the file `` `gsl_errno.h' ``.

Using GSL error reporting in your own functions

If you are writing numerical functions in a program which also uses GSL code you may find it convenient to adopt the same error reporting conventions as in the library.

To report an error you need to call the function `gsl_error` with a string describing the error and then return an appropriate error code from `gsl_errno.h`, or a special value, such as `NaN`. For convenience the file `` `gsl_errno.h' `` defines two macros which carry out these steps:

Macro: **GSL_ERROR** *(reason, gsl_errno)*

> This macro reports an error using the GSL conventions and returns a status value of `gsl_errno`. It expands to the following code fragment,

```
gsl_error (reason, __FILE__, __LINE__, gsl_errno);
return gsl_errno;
```

The macro definition in `gsl_errno.h' actually wraps the code in a `do { ... } while (0)` block to prevent possible parsing problems.

Here is an example of how the macro could be used to report that a routine did not achieve a requested tolerance. To report the error the routine needs to return the error code `GSL_ETOL`.

```
if (residual > tolerance)
  {
    GSL_ERROR("residual exceeds tolerance", GSL_ETOL);
  }
```

Macro: **GSL_ERROR_VAL** *(reason, gsl_errno, value)*

This macro is the same as `GSL_ERROR` but returns a user-defined value of *value* instead of an error code. It can be used for mathematical functions that return a floating point value.

The following example shows how to return a `NaN` at a mathematical singularity using the `GSL_ERROR_VAL` macro,

```
if (x == 0)
  {
    GSL_ERROR_VAL("argument lies on singularity",
                  GSL_ERANGE, GSL_NAN);
  }
```

Examples

Here is an example of some code which checks the return value of a function where an error might be reported,

```
#include <stdio.h>
#include <gsl/gsl_errno.h>
#include <gsl/gsl_fft_complex.h>

...
  int status;
  size_t n = 37;

  gsl_set_error_handler_off();

  status = gsl_fft_complex_radix2_forward (data, n);

  if (status) {
    if (status == GSL_EINVAL) {
       fprintf (stderr, "invalid argument, n=%d\n", n);
    } else {
       fprintf (stderr, "failed, gsl_errno=%d\n",
                        status);
    }
    exit (-1);
  }
...
```

The function `gsl_fft_complex_radix2` only accepts integer lengths which are a power of two. If the variable `n` is not a power of two then the call to the library function will return `GSL_EINVAL`, indicating that the length argument is invalid. The function call to `gsl_set_error_handler_off()` stops the default error handler from aborting the program. The `else` clause catches any other possible errors.

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