Module Guide: Curve Fitting Software

Malavika Srinivasan

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1 Revision History

Date	Version	Notes
Oct 27, 2018	1.0	First draft by Malavika
Oct 30, 2018	1.1	Second draft by Malavika
Oct 27, 2018	1.2	Third draft by Malavika
Nov 5, 2018	1.3	Fourth draft by Malavika
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2 Introduction

Decomposing a system into modules is a commonly accepted approach to developing software. A module is a work assignment for a programmer or programming team (Parnas et al., 1984). We advocate a decomposition based on the principle of information hiding (Parnas, 1972). This principle supports design for change, because the "secrets" that each module hides represent likely future changes. Design for change is valuable in SC, where modifications are frequent, especially during initial development as the solution space is explored.

Our design follows the rules layed out by Parnas et al. (1984), as follows:

- System details that are likely to change independently should be the secrets of separate modules.
- Each data structure is used in only one module.
- Any other program that requires information stored in a module's data structures must obtain it by calling access programs belonging to that module.

After completing the first stage of the design, the Software Requirements Specification (SRS), the Module Guide (MG) is developed (Parnas et al., 1984). The MG specifies the modular structure of the system and is intended to allow both designers and maintainers to easily identify the parts of the software. The potential readers of this document are as follows:

- New project members: This document can be a guide for a new project member to easily understand the overall structure and quickly find the relevant modules they are searching for.
- Maintainers: The hierarchical structure of the module guide improves the maintainers' understanding when they need to make changes to the system. It is important for a maintainer to update the relevant sections of the document after changes have been made.
- Designers: Once the module guide has been written, it can be used to check for consistency, feasibility and flexibility. Designers can verify the system in various ways, such as consistency among modules, feasibility of the decomposition, and flexibility of the design.

The rest of the document is organized as follows. Section 3 lists the anticipated and unlikely changes of the software requirements. Section 4 summarizes the module decomposition that was constructed according to the likely changes. Section 5 specifies the connections between the software requirements and the modules. Section 6 gives a detailed description of the modules. Section 7 includes two traceability matrices. One checks the completeness of the design against the requirements provided in the SRS. The other shows the relation between anticipated changes and the modules. Section 8 describes the use relation between modules.

3 Anticipated and Unlikely Changes

This section lists possible changes to the system. According to the likeliness of the change, the possible changes are classified into two categories. Anticipated changes are listed in Section 3.1, and unlikely changes are listed in Section 3.2.

3.1 Anticipated Changes

Anticipated changes are the source of the information that is to be hidden inside the modules. Ideally, changing one of the anticipated changes will only require changing the one module that hides the associated decision. The approach adapted here is called design for change.

AC1: The specific hardware on which the software is running.

AC2: The format of output data. Instead of best fit coefficients and plot, they may want to obtain the value of 'y' at a particular 't' or a series of 't' values where (t_i, y_i) is the input data at $i = 0, 1, 2, ...n$.

AC3: The user may not want to input the degree of the polynomial for regression and my want it to be computed by CFS.

3.2 Unlikely Changes

The module design should be as general as possible. However, a general system is more complex. Sometimes this complexity is not necessary. Fixing some design decisions at the system architecture stage can simplify the software design. If these decision should later need to be changed, then many parts of the design will potentially need to be modified. Hence, it is not intended that these decisions will be changed.

UC1: Input/Output devices (Input: File and/or Keyboard, Output: File, Memory, and/or Screen).

UC2: If CFS is used with non linear systems, then the results from the software are no longer valid.

4 Module Hierarchy

This section provides an overview of the module design. Modules are summarized in a hierarchy decomposed by secrets in Table 1. The modules listed below, which are leaves in the hierarchy tree, are the modules that will actually be implemented.

M1: Hardware-Hiding Module

M2: Behaviour-Hiding Module

M3: User-program Module

M4: Input Module

M5: Output Module

M6: Software Decision Module

M7: Sequence Services Module

M8: Interpolation Module

M9: Regression Module

M10: Plot Module

Note that M1 is a commonly used module and is already implemented by the operating system. It will not be reimplemented. Similarly, M7 and M10 are already available in Python and will not be reimplemented.

Level 1	**Level 2**
Hardware-Hiding Module	
Behaviour-Hiding Module	Input Output
Software Decision Module	Sequence Services Interpolation Regression Plot

Table 1: Module Hierarchy

5 Connection Between Requirements and Design

The design of the system is intended to satisfy the requirements developed in the SRS. In this stage, the system is decomposed into modules. The connection between requirements and modules is listed in Table 2.

6 Module Decomposition

Modules are decomposed according to the principle of "information hiding" proposed by Parnas et al. (1984). The *Secrets* field in a module decomposition is a brief statement of the design decision hidden by the module. The *Services* field specifies *what* the module will

do without documenting *how* to do it. For each module, a suggestion for the implementing software is given under the *Implemented By* title. If the entry is *OS*, this means that the module is provided by the operating system or by standard programming language libraries. Also indicate if the module will be implemented specifically for the software.

Only the leaf modules in the hierarchy have to be implemented. If a dash (–) is shown, this means that the module is not a leaf and will not have to be implemented. Whether or not this module is implemented depends on the programming language selected.

6.1 Hardware Hiding Modules (M1)

Secrets: The data structure and algorithm used to implement the virtual hardware.

Services: Serves as a virtual hardware used by the rest of the system. This module provides the interface between the hardware and the software. So, the system can use it to display outputs or to accept inputs.

Implemented By: OS

6.2 Behaviour-Hiding Module (M2)

Secrets: The contents of the required behaviours.

Services: Includes programs that provide externally visible behaviour of the system as specified in the software requirements specification (SRS) documents. This module serves as a communication layer between the hardware-hiding module and the software decision module. The programs in this module will need to change if there are changes in the SRS.

Implemented By: –

6.2.1 User-program Module (M3)

Secrets: This is the user program which uses the Interpolation, Regression and Output modules to use the appropriate service. This is not a module of CFS but is an external program which is included here for ease of understanding. [This isn't actually a module. If you want to include it, you should say this. This is an external program that uses the services provided by the other modules. —SS] [Mentioned details about UserProgram. —Malavika]

Services: NA.

Implemented By: User

6.2.2 Input Module (M4)

Secrets: The constraints of input data.

Services: Verifies the input data.

1. A 'TypeError' exception is raised if there is a type mismatch.
2. A 'LengthError' exception is raised if length of input arrays is equal to 1.
3. A 'LengthMismatchError' exception is raised if length of the two input arrays are not the same.
4. A 'valueError' exception is raised if the degree input is not a natural number.

Implemented By: CFS

6.2.3 Output Module (M5)

Secrets: The format and structure of the output data.

Services: Outputs the best fit parameters and plots the output along with input data and best fit parameters.

Implemented By: CFS

6.3 Software Decision Module (M6)

Secrets: The design decision based on mathematical theorems, physical facts, or programming considerations. The secrets of this module are *not* described in the CA document.

Services: Includes data structure and algorithms used in the system that do not provide direct interaction with the user.

Implemented By: –

6.3.1 Sequence Services Module (M7)

Secrets: The data structure for a sequence data type.

Services: Provides array manipulation, including building an array, accessing a specific entry etc.

Implemented By: Python - Numpy

6.3.2 Interpolation Module (M8)

Secrets: The algorithms used for interpolation.

Services: Provides the fit coefficients. [I removed the word best. With interpolation there is only one fit. —SS][Thank you :) —Malavika]

Implemented By: CFS

6.3.3 Linear Regression (M9)

Secrets: The algorithm used for linear regression.

Services: Provides the best fit coefficients.

Implemented By: CFS

6.3.4 Plot Module (M10)

Secrets: The data structures and algorithms for plotting data graphically.

Services: Provides a plot function.

Implemented By: Python - Matplotlib

7 Traceability Matrix

This section shows two traceability matrices: between the modules and the requirements and between the modules and the anticipated changes.

Req.	Modules
R1	M1,M2, M3, M4, M7
R2	M2, M3 M4, M7
R3	M2, M3 M4, M7
R4	M1,M2, M3
R5	M1,M2, M3
R6	M1,M2, M3
R7	M1,M2, M3
R8	M1,M2, M3
R9	M3,M6, M7, M8, M9
R10	M1,M2, M5, M7, M10

Table 2: Trace Between Requirements and Modules

AC	Modules
AC1	M1
AC2	M5
AC3	M9

Table 3: Trace Between Anticipated Changes and Modules

8 Use Hierarchy Between Modules

In this section, the uses hierarchy between modules is provided. Parnas (1978) said of two programs A and B that A *uses* B if correct execution of B may be necessary for A to complete the task described in its specification. That is, A *uses* B if there exist situations in which the correct functioning of A depends upon the availability of a correct implementation of B. Figure 1 illustrates the use relation between the modules. It can be seen that the graph is a directed acyclic graph (DAG). Each level of the hierarchy offers a testable and usable subset of the system, and modules in the higher level of the hierarchy are essentially simpler because they use modules from the lower levels.

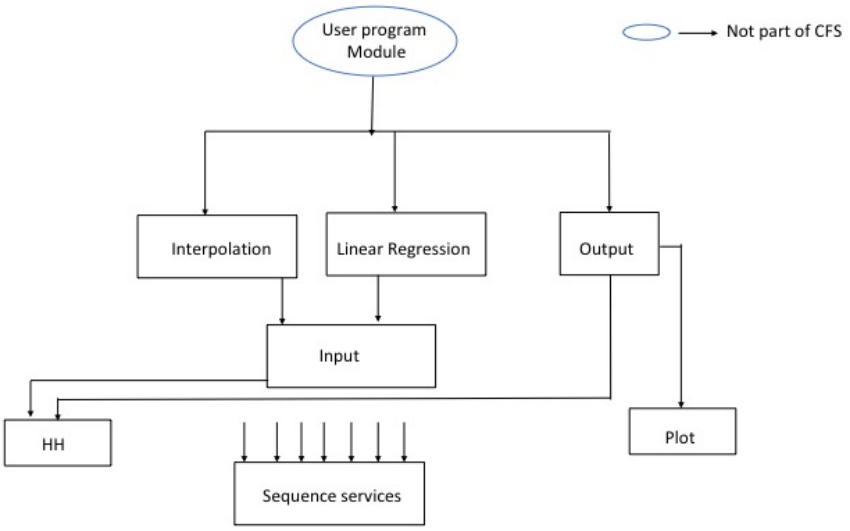

Figure 1: Use hierarchy among modules

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