Module Guide for Attitude Check

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April 3, 2024

1 Revision History

Date	Version	Notes
March 17, 2024	1.0	Initial draft
April 4, 2024	2.0	Update design

2 Reference Material

This section records information for easy reference. See SRS Documentation at https://github.com/adrian-soch/attitude_check/blob/main/docs/SRS/SRS.pdf when referenced in this document.

2.1 Abbreviations and Acronyms

symbol	description
AC	Anticipated Change
DAG	Directed Acyclic Graph
M	Module
MG	Module Guide
OS	Operating System
R	Requirement
SC	Scientific Computing
SRS	Software Requirements Specification
Attitude Check	Explanation of program name
UC	Unlikely Change

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3 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 from 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 implemented 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 4 lists the anticipated and unlikely changes of the software requirements. Section 5 summarizes the module decomposition that was constructed according to the likely changes. Section 6 specifies the connections between the software requirements and the modules. Section 7 gives a detailed description of the modules. Section 8 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 9 describes the use relation between modules.

4 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 4.1, and unlikely changes are listed in Section 4.2.

4.1 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: Detect significant linear accerlerations and ignore acceleromater data until the event is complete.

AC2: Add magnetic disturbance compensation.

4.2 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. Currently, there are no unlikely changes.

5 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.

M0: Math Module

M1: Matrix Math Module

M2: Utilities Module

M3: Quaternion Module

M4: Initializers Module

M5: Attitude Check Module

M6: Error Handling Module

Level 1	Level 2
Behaviour-Hiding Module	Attitude Check Module Initializers Module
Software Decision Module	Math Module Matrix Math Module Quaternion Module Error Handling Module Utilities Module

Table 1: Module Hierarchy

6 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.

7 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. *Attitude Check* means the module will be implemented by the Attitude Check 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.

7.1 Behaviour-Hiding Module

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: –

7.1.1 Attitude Check Module (M5)

Secrets: The algorithms for estimating attitude (orientation) using sequential sensor data.

Services: Calculates orientation estimates from sensor data.

Implemented By: Attitude Check

Type of Module: Abstract Data Type

7.1.2 Initializer Module (M4)

Secrets: The algorithm for computing a quaternion from a single set of accelerometer, gyroscope, and magnetometer measurements.

Services: Calculates an initial orientation quaternion from accelerometer, gyroscope, and magnetic data.

Implemented By: Attitude Check

Type of Module: Library

7.2 Software Decision Module

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

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

Implemented By: –

7.2.1 Math Module (M0)

Secrets: Basic mathematical formulas and expressions.

Services: Provides basic math functions.

Implemented By: Standard C++ Math Library (cmath)

7.2.2 Matrix Math Module (M1)

Secrets: Functions for matrix math including multiplication, inverses, etc.

Services: Performs matrix math.

Implemented By: Eigen (Guennebaud et al., 2010)

7.2.3 Quaternion Module (M3)

Secrets: Data structure for quaternion data.

Services: Provide a quaternion object and its associated mathematical operations, multiplication, inverses, etc.

Implemented By: Attitude Check

7.2.4 Utilities Module (M2)

Secrets: Formula for converting rotation representations to quaternion.

Services: Converts rotation representations to quaternion

Implemented By: Attitude Check

Type of Module: Library

7.2.5 Error Handling Module (M6)

Secrets: Platform dependent exception throwing or error logging.

Services: Handles logging or throwing errors depending on the platform.

Implemented By: Attitude Check

Type of Module: Library

8 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	M5
R2	M0, M1, M2, M3, M4
R3	M0, M1, M3, M5
R4	M0, M1, M3, M5
R5	M3, M5

Table 2: Trace Between Requirements and Modules

AC	Modules
AC1	M5
AC2	M5

Table 3: Trace Between Anticipated Changes and Modules

9 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.

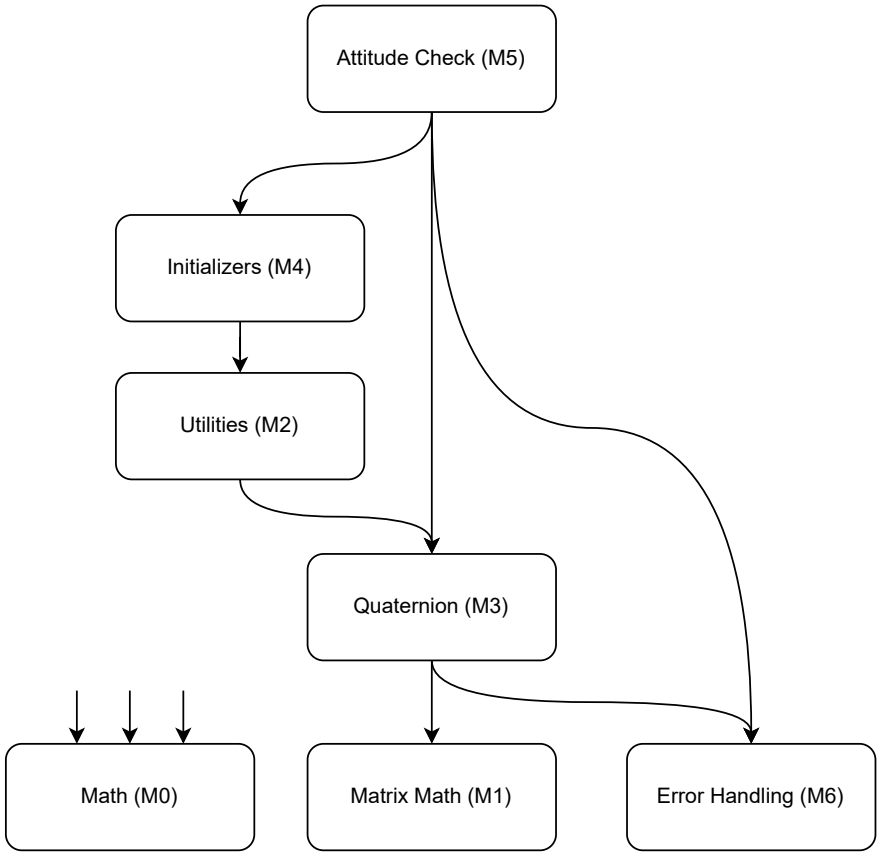

Figure 1: Use hierarchy among modules

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