Test Plan for the Library of Linear Algebraic Equation Solver

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1 Revision History

Date	Version	Notes
December 18, 2017	1.0	Initial draft

2 Symbols, Abbreviations and Acronyms

symbol	description
T	Test
O	Output
CA	Commonality Analysis
IM	Instance Module
ϵ	Difference

Contents

List of Tables

3 General Information

The following section gives an overview of the Verification and Validation (V & V) plan for the Library of Linear Algebraic Equation Solver. This section also explains the purpose, scope and overview of the document. The full documentation can be found at the mentioned link below:

https://github.com/deviprasad135/CAS741

3.1 Purpose

The purpose of this document is to plan the Verification and Validation process for the Library of Linear Algebraic Equation Solver. The main purpose of this document is to check whether the Library of Linear Algebraic Equation Solver meets the specifications and fulfill its intended purpose. This document will be used as the reference and guidance for testing the Library of Linear Algebraic Equation Solver.

3.2 Scope

The scope of testing is limited to Library of Linear Algebraic Equation Solver. The library includes two linear algebraic solving functions. The scope is limited to these two solving functions. The programming language used is R.

See SRS Documentation at: https://github.com/deviprasad135/CAS741/blob/master/Doc/SRS/CA.pdf

3.3 Overview of Document

The following sections provides in depth information about the V & V of Library of Linear Algebraic Equation Solver. The following sections also provides information about automated testing approach, testing tools. Test cases for system testing and unit testing are provided.

4 Plan

4.1 Software Description

Software which is tested is Library of Linear Algebraic Equation Solver. The library contains two linear algebraic equation solving algorithms. Given the initial values of algebraic equation A and B, the program calculates the final value x by using numerical methods.

4.2 Test Team

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4.3 Automated Testing Approach

Automated unit testing will be done for the Library of Linear Algebraic Equation Solver. Unit Testing Framework and R's Test Class will be used in a combination for automated testing. Syntax checking will be done automatically by the compiler. The aim of testing is 100% code coverage .

4.4 Verification Tools

The verification tools which will be used are as follows :

1. The programming language used is R. Comparison is done between the RStusio's optR library functional programs with the Library of Linear Algebraic Equation Solver by the Unit Testing Framework designed in RStudio. The following equation is used for comparison.

$$\epsilon_{\text{rel}} = \text{norm} = \frac{||x_{\text{R}} - x_{\text{LAES}}||}{||x_{\text{R}}||}$$

2. The framework for automated system testing is provided by using RStudio's Test Class .

3. For program debugging and for checking syntax errors the Rstudio's IDE will be used as a Static Analyzer tool .

4. covr which is an RStudio's library is used for code coverage.

5. RStudio's unit test library will be used for performing unit tests on the code.

4.5 Non-Testing Based Verification

Not Applicable

5 System Test Description

System Test is done to verify whether the goals mentioned in Commonality Analysis are achieved. Input and Output analysis is used to test the system as a whole by black box testing approach.

5.1 Tests for Functional Requirements

5.1.1 Calculation Tests

Gaussian Elimination Method

1. **T-1: Simple Linear system involving two equations and two variables**

   Type: Functional, Automated, System.

   Initial State: Not applicable

   Input: $A = \begin{bmatrix} 2 & 3 \\ 4 & 9 \end{bmatrix}$, $b = \begin{bmatrix} 6 \\ 15 \end{bmatrix}$

   Output:4 $x = \begin{bmatrix} 3/2 \\ 1 \end{bmatrix}$, Success = true

   How test will be performed: Automated system test

2. **T-2: Linear system involving three equations and three variables**

   Type: Functional, Automated, System.

   Initial State: Not applicable

   Input: $A = \begin{bmatrix} 1 & 3 & -2 \\ 3 & 5 & 6 \\ 2 & 4 & 3 \end{bmatrix}$, $b = \begin{bmatrix} 5 \\ 7 \\ 8 \end{bmatrix}$

Output: $x = \begin{bmatrix} -15 \\ 8 \\ 2 \end{bmatrix}$, Success = true

How test will be performed: Automated system test

3. **T-3: Linear system involving six equations and six variables**

   Type: Functional, Automated, System.

   Initial State: Not applicable

   Input: $A = \begin{bmatrix} 1 & 1 & -2 & 1 & 3 & -1 \\ 2 & -1 & 1 & 2 & 2 & -3 \\ 1 & 3 & -3 & -1 & 2 & 1 \\ 5 & 2 & -1 & -1 & 2 & 1 \\ -3 & -1 & 2 & 3 & 1 & 3 \\ 4 & 3 & 1 & -6 & -3 & -2 \end{bmatrix}$, $b = \begin{bmatrix} 4 \\ 20 \\ -15 \\ -3 \\ 16 \\ -27 \end{bmatrix}$

   Output: $x = \begin{bmatrix} 1/3 \\ -430/99 \\ 313/99 \\ 104/99 \\ 142/33 \\ -37/99 \end{bmatrix}$, Success = true

   How test will be performed: Automated system test

4. **T-4: Linear system of equations which are singular**

   Type: Functional, Automated, System.

   Initial State: Not applicable

   Input: $A = \begin{bmatrix} 0 & 2 & -1 \\ 3 & -2 & 1 \\ 3 & 2 & -1 \end{bmatrix}$, $b = \begin{bmatrix} 5 \\ 7 \\ 8 \end{bmatrix}$

   Output: x = no solution, Success = true

   How test will be performed: Automated system test

Gauss-Jordan Method

1. **T-5: Simple Linear system involving two equations and two variables**

   Type: Functional, Automated, System.

   Initial State: Not applicable

   Input: $A = \begin{bmatrix} 2 & 3 \\ 4 & 9 \end{bmatrix}$, $b = \begin{bmatrix} 6 \\ 15 \end{bmatrix}$

   Output: $x = \begin{bmatrix} 3/2 \\ 1 \end{bmatrix}$, Success = true

   How test will be performed: Automated system test

2. **T-6: Linear system involving three equations and three variables**

   Type: Functional, Automated, System.

   Initial State: Not applicable

   Input: $A = \begin{bmatrix} 1 & 3 & -2 \\ 3 & 5 & 6 \\ 2 & 4 & 3 \end{bmatrix}$, $b = \begin{bmatrix} 5 \\ 7 \\ 8 \end{bmatrix}$

   Output: $x = \begin{bmatrix} -15 \\ 8 \\ 2 \end{bmatrix}$, Success = true

   How test will be performed: Automated system test

3. **T-7: Linear system involving six equations and six variables**

   Type: Functional, Automated, System.

   Initial State: Not applicable

Input: $A = \begin{bmatrix} 1 & 1 & -2 & 1 & 3 & -1 \\ 2 & -1 & 1 & 2 & 2 & -3 \\ 1 & 3 & -3 & -1 & 2 & 1 \\ 5 & 2 & -1 & -1 & 2 & 1 \\ -3 & -1 & 2 & 3 & 1 & 3 \\ 4 & 3 & 1 & -6 & -3 & -2 \end{bmatrix}$, $b = \begin{bmatrix} 4 \\ 20 \\ -15 \\ -3 \\ 16 \\ -27 \end{bmatrix}$

Output: $x = \begin{bmatrix} 1/3 \\ -430/99 \\ 313/99 \\ 104/99 \\ 142/33 \\ -37/99 \end{bmatrix}$, Success = true

How test will be performed: Automated system test

4. **T-8: Linear system of equations which are singular**

   Type: Functional, Automated, System.

   Initial State: Not applicable

   Input: $A = \begin{bmatrix} 0 & 2 & -1 \\ 3 & -2 & 1 \\ 3 & 2 & -1 \end{bmatrix}$, $b = \begin{bmatrix} 5 \\ 7 \\ 8 \end{bmatrix}$

   Output: x = no solution, Success = true

   How test will be performed: Automated system test

5.2 Tests for Nonfunctional Requirements

5.2.1 Performance Requirements

Accuracy

1. **T-9: Calculating the accuracy of Library of Linear Algebraic Equation Solver.**

   Type: Non-Functional, Automatic, Accuracy

   Initial State: Not Applicable

Input/Condition: $A = \begin{bmatrix} 1 & 3 & -2 \\ 3 & 5 & 6 \\ 2 & 4 & 3 \end{bmatrix}, b = \begin{bmatrix} 5 \\ 7 \\ 8 \end{bmatrix}$

Output/Result: $\epsilon_{Relative}$ will be calculated by comparing the result obtained by Library of Linear Algebraic Equation Solver and the RStudio's optR library functional programs by the following equation as norm

$$\epsilon_{\text{rel}} = \text{norm} = \frac{||x_{\text{R}} - x_{\text{LAES}}||}{||x_{\text{R}}||}$$

How test will be performed: Automatic System Test.

5.3 Traceability Between Test Cases and Requirements

The following table shows the traceability mapping for test case and the Instance Models described in Commonality Analysis since CA does not include requirements.

Table 1: Requirements Traceability Matrix

Test Number	**CA Requirements**
T1	IM1
T2	IM1
T3	IM1
T4	IM1
T5	IM2
T6	IM2
T7	IM2
T8	IM2

6 Unit Testing plan

1. **T-10: Unit Testing.**

The testing plan for Library of Linear Algebraic Equation Solver is divided into several unique steps. These sequence of steps also includes specific function unit tests. The code will be divided into several individual units of code. A unit is a smallest component of code which can be tested. These units of code are tested if they are fit to use or not.

The code will be designed in several modules like Input/Output module, Gaussian Elimination Module, Gauss-Jordan Elimination Module. The basic plan for unit testing is that I will be using RStudio's unit testing packages. The tests from the functional requirements will also be used. The unit testing is a stage where we should test for code coverage. My aim is for 100% code coverage.

7 Appendix

7.1 Symbolic Parameters

The definition of the test cases will call for SYMBOLIC_CONSTANTS. Their values are defined in this section for easy maintenance.

symbol	unit	description
ϵ	none	The measure of the difference between results obtained with Library of Linear Algebraic Equation Solver and RStudio.