Project Title: System Verification and Validation Plan for ANN

Tanya Djavaherpour

March 4, 2024

Revision History

Date	Version	Notes
Feb. 15, 2024	1.0	Initial Draft
Mar. 04, 2024	1.1	Modification According to the Feedback 1

Contents

List of Tables

[Remove this section if it isn't needed —SS]

1 Symbols, Abbreviations, and Acronyms

symbol	description
ANN	Artificial Neural Network
IM	Instance Model
MG	Module Guide
MIS	Module Interface Specification
SRS	Software Requirements Specification
T	Test
VnV	Verification and Validation

For complete symbols used within the system, please refer the section 1 in SRS Djavaherpour (2024b) document.

This document outlines the Verification and Validation (VnV) plan for the Artificial Neural Network for Image Classification project, as detailed in the SRS Djavaherpour (2024b). The purpose of this VnV plan is to ensure that all requirements and objectives outlined in the SRS Djavaherpour (2024b) are met with accuracy and efficiency.

The organization of this document starts with the General Information about the ANN in section 2. A verification plan is provided in section 3 and section 4 describes the system tests, including tests for functional and nonfunctional requirements. Test Description is explained in section 5 (will be added).

2 General Information

2.1 Summary

The software being validated in this plan is an Artificial Neural Network designed for Image Classification, tailored specifically to work with the CIFAR-10 dataset Krizhevsky (2009). It allows users to upload images and efficiently classifies them into predefined categories. It operates within the constraints of available computational resources and is limited to handling images that fall under the CIFAR-10 dataset Krizhevsky (2009) categories, ensuring focused and optimized performance in its designated area.

2.2 Objectives

The primary objective of this VnV plan is to build confidence in the correctness and reliability of the Artificial Neural Network for Image Classification. Our goal is to demonstrate that the system can classify images with a high degree of accuracy. We aim to significantly improve upon the less than 50% accuracy achieved in previous implementation Djavaherpour (2022), acknowledging that reaching 100% accuracy is not feasible due to inherent limitations in ANN models and the variability of image data. The focus will be on achieving the highest possible accuracy within these constraints. The system's accuracy will be measured through defined quantitative methods such as the cost function in SRS Djavaherpour (2024b).

2.3   Relevant Documentation

The ANN project is supported by several crucial documents. These include a Problem Statement Djavaherpour (2024a), which introduces the initial concept, and a Software Requirements Specification Djavaherpour (2024b) that outlines the necessary system requirements, accompanied by a Verification and Validation Report Djavaherpour (2024c) to ensure the system's compliance and efficacy.

3   Plan

In this section, the VnV plan of ANN is described. It begins with an introduction to the verification and validation team (subsection 3.1) and introduces the members and thei rules. Then is followed by the SRS verification plan (subsection 3.2), design verification plan (subsection 3.3), the VnV verification plan (subsection 3.4), implementation verification plan (subsection 3.5), automated testing and verification tools (subsection 3.6), and Software validation plan (subsection 3.7).

3.1   Verification and Validation Team

The VnV team members and their roles are shown in Table 1.

3.2   SRS Verification Plan

The verification process for the Artificial Neural Network's Software Requirements Specification document will be conducted as follows:

1. An initial review will be carried out by designated team members, which include Dr. Spencer Smith, Fatemeh Norouziani, Atiyeh Sayadi, and Tanya Djavaherpour. This review will utilize a manual method, guided by an SRS Checklist Smith (2022c) developed by Dr. Smith.

2. Reviewers can give feedback and revision suggestions to the author by creating issues on GitHub.

Name	Document	Role	Description
Dr. Spencer Smith	All	Instructor/ Reviewer	Review the documents, design and documentation style.
Tanya Djavaherpour	All	Author	Create and manage all the documents, create the VnV plan, perform the VnV testing, verify the implementation.
Fatemeh Norouziani	All	Domain Expert Reviewer	Review all the documents.
Atiyeh Sayadi	SRS	Secondary Reviewer	Review the SRS document
Yi-Leng Chen	VnV Plan	Secondary Reviewer	Review the VnV plan.
Cynthia Liu	MG + MIS	Secondary Reviewer	Review the MG and MIS document.

Table 1: Verification and validation team

3. It is the responsibility of the author, Tanya Djavaherpour, to respond to and resolve these issues, incorporating feedback from both primary and secondary reviewers, as well as addressing any recommendations provided by the instructor, Dr. Spencer Smith.

3.3 Design Verification Plan

The verification of the design documentation, including the Module Guide (MG) and Module Interface Specification (MIS), will be conducted via a static analysis approach, namely document inspection. As shown in Table 1 this process will be led by the domain/primary expert, Fatemeh Norouziani, and supported by the secondary reviewer, Cynthia Liu. Additionally, Dr. Spencer Smith, the class instructor, will also conduct a review of these documents. Reviewers are encouraged to provide their feedback directly to the author by creating issues in the project's GitHub repository. It is the responsibility of the author to address and resolve these issues, taking into account all the suggestions made. The review process will be facilitated by utilizing

the MG Smith (2022a) and MIS Smith (2022b) Checklists, which have been formulated by Dr. Spencer Smith.

3.4   Verification and Validation Plan Verification Plan

Following the structure outlined in Table 1, the development and preliminary verification of the Verification and Validation plan will be undertaken by Author, Tanya Djavaherpour. Subsequent to this phase, domain expert, Fatemeh Norouziani, along with Yi-Leng Chen as a secondary reviewer, will review it. They give feedback and suggestions via GitHub issues. Once done, Instructor will do final review of the VnV plan. The whole review process will be aligned with the VnV Checklist Smith (2022d) that Dr. Smith has prepared. It is the author's responsibility to check the submitted issues regularly and make necessary modifications.

3.5   Implementation Verification Plan

The implementation of the software will be verified using several techniques involving manual and automated techniques as outlined below:

• **Static Verification Techniques:** Code Walkthroughs will be the primary technique used for static verification. These sessions involve the development team, consisting of the author, Tanya Djavaherpour, and the domain expert, Fatemeh Norouziani, reviewing the code together. The final version of the code will be shared with the domain expert prior to the meeting, during which important test cases will be manually examined. This process allows the domain expert to present findings and raise questions, facilitating a comprehensive review.

• **Dynamic Testing:** Evaluation of the code will include both unit and system testing, focusing on the functional and nonfunctional requirements outlined in the SRS Djavaherpour (2024b) document. The tools used for these evaluations will be detailed in 3.6. Furthermore, the test cases used in system and unit testing will be stated in sections 4 and 5 (will be added), respectively. This approach ensures a thorough validation of the software across various levels of testing.

3.6 Automated Testing and Verification Tools

In this image classification project, Pylint Python Code Quality Authority (2023) and a regular testing process with a dedicated testing dataset of CIFAR-10 Krizhevsky (2009) are employed for automated testing and verification. Pylint Python Code Quality Authority (2023) is key for enhancing code quality by identifying coding errors, enforcing standards, and encouraging best practices. Alongside, a robust testing process, involving thorough evaluation on a separate testing dataset, ensures the accuracy and reliability of the image classification model. The combination of Pylint Python Code Quality Authority (2023) for code quality analysis and performance validation through targeted testing provides a comprehensive approach to maintaining robustness and effectiveness in the image classification system.

3.7 Software Validation Plan

Validation is the process of comparing the outputs of models to experimental values. Since the CIFAR-10 dataset Krizhevsky (2009) does not come with a predefined validation set and there is not enough experimental data, the validation of the implemented ANN cannot be measured in a traditional sense. Instead, as mentioned previously in 3.6, the network will be tested to find the accuracy using testing data.

It's essential to understand that this approach, while deviating from conventional validation methods due to dataset constraints, still provides a valid assessment of the model's performance. This testing process offers a reliable evaluation of the model's ability to generalize and perform accurately on unseen data.

4 System Test Description

4.1 Tests for Functional Requirements

The functional requirements are described in the SRS Djavaherpour (2024b) section 5.1. Implemented ANN will detect invalid inputs and, although the accuracy will not be 100%, classes of uploaded image will be determined. There are five functional requirements for this system. Testing R1 and R2 will be explained in the input verification section. R3, R4 and R5 will be explained in the output verification test.

4.1.1 Input Verification

The inputs will be tested to satisfy R1 and R2 from ANN SRS Djavaherpour (2024b). Specifically, this test will ensure values of the inputs align with the input constraints. Table 2 displays the inputs and outputs of test cases for the input constraints tests.

Input Verification Test

ID	Input (an imgae)		Output	
	type	*size*	valid?	Error Message
TC-ANN-1	PNG	mxn	Y	NONE
TC-ANN-2	JPG	mxn	Y	NONE
TC-ANN-3	GIF	mxn	N	Invalid Input Type
TC-ANN-4	PNG	(m+1)x(n)	N	Invalid Input Size
TC-ANN-5	JPG	(m+1)x(n)	N	Invalid Input Size
TC-ANN-6	GIF	(m+1)x(n)	N	Invalid Input Type and Size
TC-ANN-7			N	Empty

Table 2: TC-ANN- Test Cases for Input Verification

1. T1: Valid Inputs

   Control: Automated Test

   Initial State: Pending Input

   Input: Set of input values for area of particular object given in the Table 2.

   Output: Either give an appropriate error message for TC-ANN-1-3 to TC-ANN-1-7, or the class of the image object identified by the ANN as an output defined in the Table 2.

   Test Case Derivation: Justified by the ANN's training to accurately classify valid input images according to the SRS Djavaherpour (2024b) specifications.

How test will be performed: An automated script will input valid and invalid images to the ANN, comparing the output classifications with expected results to verify accuracy.

4.1.2 Output Verification Test

To satisfy R3, R4 and R5 from the SRS Djavaherpour (2024b), any input image should be properly classified and related to the correct output label from the set of 10 classes of CIFAR-10 Krizhevsky (2009).

1. T2: Classifier Test

   Control: Automated Test

   Initial State: Loading Trained ANN

   Input: One image with one object

   Output: Class of the image object

   Test Case Derivation: The test is designed to evaluate the ANN's precision in classifying an individual image, reflecting its real-world application for singular image analysis.

   How test will be performed: This test will be conducted using an automated script that inputs a single, randomly selected test image with one object into the trained ANN. The output will be the classified label provided by the ANN, which will then be compared to the actual label of the image to verify the accuracy of the classification.

4.2 Tests for Nonfunctional Requirements

NonFunctional requirements for ANN are given in SRS Djavaherpour (2024b) section 5.2.

4.2.1 Nonfunctional: Accuracy

Accuracy

1. T3: Accuracy Test

   Control: Automated Test

Initial State: Loading Trained ANN

Input: Set of test images form the CIFAR-10 dataset Krizhevsky (2009)

Output: System accuracy based on prediction of class of the image object

How test will be performed: The test will be executed using an automated script that feeds a batch of test images from the CIFAR-10 dataset Krizhevsky (2009) into the trained ANN. The script will then compare the ANN's predicted class for each image against the known label, calculating the overall accuracy of the system. This process will quantify the model's performance in terms of correct classifications, providing a clear measure of its effectiveness in fulfilling the specified requirements.

4.2.2 Nonfunctional: Usability

Usability

1. T4: Usability Test

   Control: Manual with group of people

   Initial State: None

   Input: None

   Output: A survey to gather user perspectives on the system's usability

   How test will be performed: A diverse group of users will be asked to install and interact with the software, performing specified tasks. Following this, they will complete a survey focusing on aspects of usability such as ease of use, intuitiveness, and overall satisfaction. The survey results will be analyzed to identify areas for improvement in the software's usability. The questions are given in Table 3.

4.2.3 Nonfunctional: Maintainability

Maintainability

No.	Question	Answer
1.	Which operating system are you using?	
2.	Was system running smoothly on your computer?	
3.	How would you rate the response time of the software for various operations? (On a scale of 1-10)	
4.	How does the software handle errors or unexpected user actions?	
5.	Was it easy to recover from errors?	
6.	Were you able to find all the functionalities easily?	
7.	Was there sufficient help or documentation available?	
8.	What, if anything, surprised you about the experience?	
9.	What did you like the least?	
10.	Do you have any suggestions?	
11.	How likely are you to recommend this software to others? (On a scale of 1-10)	

Table 3: Usability Test Survey

1. T5: Code Walkthrough Maintainability Test

   Control: Code Walkthrough

   Initial State: None

   Input: None

   Output: Walkthrough Meeting aimed at identifying areas for improvement in system maintainability and documentation quality.

   How test will be performed: In the code walkthrough meeting, team members (referenced in Table 1) will review the software's code and documentation, focusing on readability, modularity, and documentation clarity. Key findings and action points for enhancing maintainability will be documented for future reference and implementation.

2. T6: Automatic Maintainability Test

Control: Automatic

Initial State: None

Input: None

Output: Improve code quality with Pylint Python Code Quality Authority (2023).

How test will be performed: Pylint Python Code Quality Authority (2023) will be used to check the code quality. This library can check the quality of code against different coding styles such as unused libraries and undefined variable. Which leads to easier maintenance.

4.2.4 Nonfunctional: Portability

Portability

1. T7: Portability Test

   Control: Manual

   Initial State: None

   Input: None

   Output: Successful running system over all platforms with different operating environments

   How test will be performed: The Author (Tanya Djavaherpour) will try to install and run whole software on different operating systems. Also, need to ensure regression testing that means all the given test cases pass on all different operating system.

4.3 Traceability Between Test Cases and Requirements

The traceability between test cases and requirements is indicated in Table 4

References

Tanya Djavaherpour. Cifar-10 classification using ANN. https://github.com/tanya-jp/CIFAR-Classification/blob/main/CIFAR_ANN.ipynb, 2022.

	R1	R2	R3	R4	R5	NFR1	NFR2	NFR3	NFR4
4.1.1	X	X							
4.1.2			X	X	X				
4.2.1						X			
4.2.2							X		
4.2.3								X	
4.2.4									X

Table 4: Tracebility between test cases and requirements

Tanya Djavaherpour. Problem statement and goals. https://github.com/tanya-jp/ANN-CAS741/blob/main/docs/ProblemStatementAndGoals/ProblemStatement.pdf, 2024a.

Tanya Djavaherpour. System requirements specification. https://github.com/tanya-jp/ANN-CAS741/blob/main/docs/SRS/SRS.pdf, 2024b.

Tanya Djavaherpour. System verification and validation report. https://github.com/tanya-jp/ANN-CAS741/blob/main/docs/VnVReport/VnVReport.pdf, 2024c.

Alex Krizhevsky. Learning multiple layers of features from tiny images. Technical Report, 2009.

Python Code Quality Authority. Pylint. https://pypi.org/project/pylint/, December 2023. Python static code analysis tool.

W. Spencer Smith. MG checklist. https://github.com/smiths/capTemplate/commits/9251702fdcb9800c59f6ed3d11d91e2bd62fca6d/docs/Checklists/MG-Checklist.pdf, 2022a.

W. Spencer Smith. MIS checklist. https://github.com/smiths/capTemplate/commits/9251702fdcb9800c59f6ed3d11d91e2bd62fca6d/docs/Checklists/MIS-Checklist.pdf, 2022b.

W. Spencer Smith. SRS checklist. https://github.com/smiths/capTemplate/commits/9251702fdcb9800c59f6ed3d11d91e2bd62fca6d/docs/Checklists/SRS-Checklist.pdf, 2022c.

W. Spencer Smith. VnV checklist. https://github.com/smiths/capTemplate/ blob/9251702fdcb9800c59f6ed3d11d91e2bd62fca6d/docs/Checklists/ VnV-Checklist.pdf, 2022d.