

OVERVIEW

Verification is the process of determining whether a system or software is being built correctly. Validation is the process of determining whether a system or software is solving the correct problem. There are several verification and validation (V&V) standards and texts written to address the application of V&V activities on traditional software systems. Traditional software systems are explicitly coded to perform an intended function and do not change behavior or functionality during normal system usage. Most software developed falls within this category.

In contrast to traditional software, adaptive software systems can change behavior, function, internal parameters, or realization while in operation. Adaptive software may be implicitly designed with the final form obtained through optimization techniques, probabilistic methods, or learning algorithms. Adaptive systems can be implemented with neural networks, genetic algorithms, fuzzy logic, machine learning, expert systems, autonomous planning software, formal logic, or combinations of these and other approaches.

The field of software engineering for adaptive systems is relatively young compared to software engineering for traditional software systems. Traditional software systems have many mature techniques that can be used to understand how they behave. With the uncertainties and complexities associated with adaptive software systems, there is no similar set of mature techniques. Each adaptive system may have its own intrinsic V&V problems and some adaptive software system algorithms are so new that they have never been applied to production or high-assurance projects.

To help address this need, this book contains guidance related to the V&V activities for adaptive software systems. The guidance is based on lessons learned and applied research from development and V&V of a safety- and mission-critical adaptive flight control system. To improve its practicality, the guidance has been written to align with the widely used *IEEE Standard for Software Verification and Validation, IEEE Std 1012-1998* [IEEE 1998].

Mirroring the generalities of some V&V activities, parts of this guidance are applicable to any form of adaptive system. Other parts of this guidance target a subset of adaptive systems, specifically, neural networks. This choice is based on the experience captured from projects that have used adaptive neural network systems and is not an indicator that neural networks are the best choice amongst all possible adaptive systems. Based on this

experience, the guidance emphasizes areas for which special consideration should be given when verifying and validating neural networks. In addition, supplemental directives for neural networks were added to the original tasks of IEEE Std 1012, and guidance is also provided for these directives. Even though there is special consideration for neural networks, some of the recommendations are applicable to other types of adaptive software systems.

This guidance is intended for application to adaptive software being developed, maintained, or reused. Software is a key contributor to system behavior and performance. This relationship requires that software V&V processes take software interactions with all system components into consideration. The user of this guidance should consider V&V as a part of the adaptive software life cycle process and not as something done at the end of development. This view of V&V is consistent with IEEE Std 1012 with its provision of V&V processes throughout the (traditional or nontraditional) software life cycle.

1.1 DEFINITIONS AND CONVENTIONS

From IEEE Std 1012, the following definitions are provided:

Verification: (A) The process of evaluating a system or component to determine whether the products of a given development phase satisfy the conditions imposed at the start of that phase. (B) The process of providing objective evidence that the software and its associated products conform to requirements (e.g., for correctness, completeness, consistency, accuracy) for all life cycle activities during each life cycle process (acquisition, supply, development, operation, and maintenance); satisfy standards, practices, and conventions during life cycle processes; and successfully complete each life cycle activity and satisfy all the criteria for initiating succeeding life cycle activities (e.g., building the software correctly).

Validation: (A) The process of evaluating a system or component during or at the end of the development process to determine whether it satisfies specified requirements. (B) The process of providing evidence that the software and its associated products satisfy system requirements allocated to software at the end of each life cycle activity, solve the right problem (e.g., correctly model physical laws, implement business rules, use the proper system assumptions), and satisfy intended use and user needs.

Within this book, the V&V practitioner is simply referred to as the “practitioner.” Any person responsible for the design, training, and implementation of the adaptive system is referred to as the “developer” or “designer”. Any person responsible for the testing of the adaptive system is referred to as the “tester.”

1.2 ORGANIZATION OF THE BOOK

This book aligns with IEEE Std 1012. The alignment will allow the practitioner the ability to quickly reference information on specific areas of interest. This book is organized into three chapters. Chapter 1 provides an introduction and overview of the book. Chapter 2 provides a summary of areas of consideration when using adaptive systems/neural networks. Chapter 3 is the most important chapter and gives the detailed, specific guidance for all life cycle processes, activities, and tasks related to adaptive systems/neural networks. Chapter 3 is organized such that the reader can easily map between the guidance provided

and the IEEE standard. Chapter 4 provides a look at the recent update to the standard, IEEE Std 1012-2004, and how updates to the standard impact the practitioner using the guidance provided in this book. Appendices provide lists of references cited, acronyms used, and definitions of terms used throughout the book.

