

Verification and Validation of Knowledge-Based Systems

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Abstract—Knowledge-based systems (KBS) are being used in many applications areas where their failures can be costly because of the losses in services, property, or even life. To ensure their reliability and dependability, it is therefore important that these systems are verified and validated before they are deployed. This paper provides perspectives on issues and problems that impact the verification and validation (V&V) of KBS. Some of the reasons V&V of KBS is difficult are presented. The paper also provides an overview of different techniques and tools that have been developed for performing V&V activities. Finally, some of the research issues that are relevant for future work in this field are discussed.

Index Terms—Expert systems, knowledge-based systems, verification, validation, reliability, dependability, testing.

1 INTRODUCTION

EXPERT systems (ES) are intelligent computer systems whose problem-solving performance would rival or exceed human performance in narrow areas of human endeavor, whereas knowledge-based systems (KBS) are computer systems that assist in problem solving. Expert systems and knowledge-based systems are among the fruitful spin-offs from artificial intelligence. Worldwide expert system expenditures in 1993 totaled \$595 million. Today, these systems have found their way into many applications such as knowledge publishing, shuttle mission experiment planning, crew scheduling, medical diagnosis, computer configuration, process control, regulation compliance advising, financial advising, and nuclear engineering.

As these knowledge systems (KS)—we use KS to denote either ES or KBS—are deployed in settings where system failures may result in loss of productivity, decision-making, property, business, services, or even life, the reliability and dependability of the systems become important. It is imperative that the systems are thoroughly verified and validated before they can be deployed in the field. Verification and validation (V&V) of KS therefore is a key aspect of the development of KS. Many V&V techniques and tools have been proposed, developed, and implemented [1], [12], [16], [17], [19], [24], [28], [30], [32], [34], [35], [37], [48].

As the use of KS in various areas grows, many commercial KS are being developed. Many techniques have been applied to the development of these KS and experience has been gained about some of the specific issues and problems faced during the development of KS in the industry. These issues can be useful in understanding the progress made and some of the shortcomings of existing V&V techniques for KS in the context of industrial environments. Table 1 summarizes one survey about current industrial practice in V&V of KS [18], [33].

From Table 1, it is apparent that KS share many characteristics with conventional software. The lack of well-documented requirements, the use of prototypes as requirements and the absence of a well-defined life-cycle model are common to many conventional software development environments also. For instance, inconsistencies, incompleteness, and ambiguity in requirements specifications have been identified as major sources of bugs in software development [5]. But KS also have certain components such as the Inference Engine (IE) and domain knowledge stored in a KB, which are not present in conventional software. Thus, while many issues that impact the V&V of conventional software such as the lack of requirements documents need to be considered, additional issues such as the validation of the IE and its interactions with the KB also need to be addressed. This paper presents a perspective on the issues related to the V&V of KS and some of their goals.

2 DEVELOPMENT OF KS

The development process for a software product specifies how the development tasks are decomposed into subtasks or phases. It also determines what by-products are used and generated during the development process. V&V require checking some properties (such as internal consistency) of a by-product (such as requirements specification) or a comparison of two by-products (such as a specification

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Validation Verification And Tests Of Knowledge Based Systems

Antoni Ligeza



Validation Verification And Tests Of Knowledge Based Systems:

Validation, Verification and Test of Knowledge-based Systems Marc Ayel, Jean-Pierre Laurent, 1991-11-27

Validation Verification and Testing VVT are important and difficult to achieve for any software product Knowledge Based Systems KBS present particular problems dealing as they do in probabilities uncertainties and approximations This collection of papers looks at current research and implementation issues describes tools techniques and validation and verification criteria discusses particular projects and includes a survey of developers *Validation and Verification of Knowledge Based Systems* Anca Vermesan, Frans Coenen, 2013-04-17

Knowledge based KB technology is being applied to complex problem solving and critical tasks in many application domains Concerns have naturally arisen as to the dependability of knowledge based systems KBS As with any software attention to quality and safety must be paid throughout development of a KBS and rigorous verification and validation V V techniques must be employed Research in V V of KBS has emerged as a distinct field only in the last decade and is intended to address issues associated with quality and safety aspects of KBS and to credit such applications with the same degree of dependability as conventional applications In recent years V V of KBS has been the topic of annual workshops associated with the main AI conferences such as AAAI IJACI and ECAI Validation and Verification of Knowledge Based Systems contains a collection of papers dealing with all aspects of KBS V V presented at the Fifth European Symposium on Verification and Validation of Knowledge Based Systems and Components EUROVAV 99 which was held in Oslo in the summer of 1999 and was sponsored by Det Norske Veritas and the British Computer Society's Specialist Group on Expert Systems SGES

Knowledge-Based Systems, Four-Volume Set Cornelius T. Leondes, 2000-07-11 The design of knowledge systems is finding myriad applications from corporate databases to general decision support in areas as diverse as engineering manufacturing and other industrial processes medicine business and economics In engineering for example knowledge bases can be utilized for reliable electric power system operation In medicine they support complex diagnoses while in business they inform the process of strategic planning Programmed securities trading and the defeat of chess champion Kasparov by IBM's Big Blue are two familiar examples of dedicated knowledge bases in combination with an expert system for decision making With volumes covering Implementation Optimization Computer Techniques and Systems and Applications this comprehensive set constitutes a unique reference source for students practitioners and researchers in computer science engineering and the broad range of applications areas for knowledge based systems **Database and Expert Systems Applications** Mohamed Ibrahim, 2000-08-25

This book constitutes the refereed proceedings of the 11th International Conference on Database and Expert Systems Applications DEXA 2000 held in London in September 2000 The 92 revised full papers presented together with one invited paper were carefully reviewed and selected from a total of 183 submissions The book offers topical sections on object oriented and relational databases multimedia databases fundamentals workflow management systems database security XML advanced databases queries knowledge based systems data

warehouses database design and analysis data mining and knowledge discovery web database systems indexing and distributed database systems Encyclopedia of Microcomputers Allen Kent, James G. Williams, 1996-10-11 Truth Maintenance Systems to Visual Display Quality 1991 Goddard Conference on Space Applications of Artificial Intelligence James L. Rash, 1991 **Goddard Conference on Space Applications of Artificial Intelligence**, 1991 **Logical Foundations for Rule-Based Systems** Antoni Ligeza, 2006-01-10 The book presents logical foundations for rule based systems An attempt has been made to provide an in depth discussion of logical and other aspects of such systems including languages for knowledge representation inference mechanisms inference control design and verification The ultimate goal was to provide a deeper theoretical insight into the nature of rule based systems and put together the most complete presentation including details so frequently skipped in typical textbooks The book may be useful to potentially wide audience but it is aimed at providing specific knowledge for graduate post graduate and Ph D students as well as knowledge engineers and research workers involved in the domain of AI It also constitutes a summary of the Author s research and experience gathered through several years of his research work **Validating and Verifying Knowledge-based Systems** Uma G. Gupta, 1991 This collection of previously published papers brings together state of the art developments in expert system testing The volume is separated into five chapters on expert system validation knowledge base verification development and evaluation case studies and tools and general topics The paper **Verification and Validation of Knowledge Based Systems** Mit Pr, 1998 *Design and Development of Knowledge-Based Systems* Giovanni Guida, Carlo Tasso, 1994-07-12 This book focuses on how to develop large scale Knowledge Based Systems within budget and on time The authors teach step by step techniques through the knowledge based system life cycle from the initial development to maintenance of the system **Database and Expert Systems Applications**, 2001 **Knowledge Based Systems (KBS) Verification, Validation, Evaluation, and Testing (VVE & T) Bibliography: Topical Categorization**, 2003 This report contains a topical categorization of the bibliography of the literature about verification validation evaluation and test of knowledge based systems This bibliography contains 800 entries This categorization identifies more than 50 different techniques and 69 different tools The literature discusses 20 different application categories including analytical chemistry management decision aiding space telecommunications financial computer configuration law medical laboratory data analysis product design manufacturing speech and text understanding scheduling software engineering mineral exploration and natural language generation By far the most cited application was medical with 153 reference citations Thirty different specific expert systems were cited in this literature Eleven different system types were identified including embedded neural network control hybrid and production systems Of these production systems were the most cited with 68 explicit references **An Approach to the Evaluation of Expert Systems for the Selection of Reference Sources** Shiao-Feng Su, 1994 Handbook for Evaluating Knowledge-Based Systems Leonard Adelman, Sharon L. Riedel, 1997-04-30 Knowledge based

systems are increasingly found in a wide variety of settings and this handbook has been written to meet a specific need in their widening use. While there have been many successful applications of knowledge based systems some applications have failed because they never received the corrective feedback that evaluation provides for keeping development focused on the users needs in their actual working environment. This handbook provides a conceptual framework and compendium of methods for performing evaluations of knowledge based systems during their development. Its focus is on the users and subject matter experts evaluation of the usefulness of the system and not on the developers testing of the adequacy of the programming code. The handbook permits evaluators to systematically answer the following kinds of questions: Does the knowledge based system meet the users task requirements? Is the system easy to use? Is the knowledge base logically consistent? Does it meet the required level of expertise? Does the system improve performance? The authors have produced a handbook that will serve two audiences: a tool that can be used to create knowledge based systems practitioners developers and evaluators and a framework that will stimulate more research in the area academic researchers and students. To accomplish this the handbook is built around a conceptual framework that integrates the different types of evaluations into the system of development process. The kinds of questions that can be answered and the methods available for answering them will change throughout the system development life cycle. And throughout this process one needs to know what can be done and what can't. It is this dichotomy that addresses needs in both the practitioner and academic research audiences.

Readings in Knowledge Acquisition Karen L. McGraw, Christopher Ralph Westphal, 1990. A review of AI topics divided into four main sections representing current issues. The readings stress application of knowledge acquisition research and theory aiming to reflect the processes of acquiring and structuring knowledge of knowledge based and expert systems. **NASA Conference Publication**, 1991. **Proceedings of the ... Banff Knowledge Acquisition for Knowledge-Based Systems Workshop**, 1995. Library & Information Science Abstracts, 2000. **Telematics and Informatics, Volume 7, Number 1**, 1990.

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