# OPINION

by Prof. Ivan Tomov DIMOV, Institute of Information Technology - BAS of the dissertation work of Assoc. Prof. Dr. Stoyan Milkov MIHOV on the topic:
*Finite-State Automata, Transducers and Bimachines: Algorithmic Constructions and Implementations,*
presented for the Doctorate of Science degree in 4.6 Informatics and Computer Science

According to Order No. 346 / 30.12.2019 of the Director of the Institute of Information and Communication Technologies of the Bulgarian Academy of Sciences (IICT-BAS) and Minutes No 11 / 18.12.2019 of a meeting of the Scientific Council of IICT-BAS I have been designated as a member of the scientific jury. According to Order No. 312 / 02.12.2019 of the Director of IICT-BAS, the draft of the dissertation work was discussed and aimed at defense.

## 1. General description of the dissertation materials

Word processing and natural language, as well as the presentation of knowledge, have become one of the main tools of artificial intelligence and are increasingly important for the study of phenomena and processes in science and life, as well as in decision-making processes. The theory of finite state automata offers computationally efficient solutions. It is being applied more and more widely, as a new branch in modern science.

Stoyan Mihov's dissertation is in the field of finite state automata. This current field of modern computer science requires competence in the fields of mathematical logic, language, computational mathematics, theory of algorithms and important aspects related to applications.

The dissertation submitted has a volume of 226 pages and contains eight chapters, an introduction, a conclusion and a bibliography. 48 titles have been cited, most of which have been published in recent years. Also included are 11 articles and one book chapter. Of these, 3 have been published in Impact Factor (IF) journals, 7 with SJR factor. All 12 works on which the dissertation is based are co-authored.

The Applicant has submitted a Certificate for Compliance with the Minimum Requirements of the IICT-BAS for the Doctor of Science degree, which shows that the requirements of the procedural rules are met.

## 2. Scientific and applied scientific contributions

In the dissertation of Assoc. Prof. Mihov the basics of the theory of finite state automata, converters and Bimachines are presented, with mathematical proofs for the correctness of the presented structures. I value this approach because it allows the author to formulate constructions for finite-state devices with appropriate proofs of correctness, and to apply appropriate procedures based on finite-state techniques for solving practical problems.

I will focus on the individual results obtained in the dissertation.

Chapter 1 of the dissertation deals with the basic mathematical concepts necessary to present the results of the following chapters. It gives a mathematical interpretation of the main objects in the thesis, namely, languages, relations and functions between strings, as well as basic operations on languages, relations and functions. Following the introduction of algebraic structures describing words and n-quotes of words, the basic properties of monoids are introduced. This introduction is necessary as it is used in the following chapters for the study of Monoidal finite-state automata.

The next Chapter 2 is devoted to the monoid finite state automata. Definitions and basic properties of monoid finite state automata are given. Monoid regular languages and monoid regular expressions are defined.

Chapter 3 looks at classic finite state automata and regular languages. This chapter discusses the basic properties associated with the determination of classical finite state automata.

This chapter defines the deterministic finite state automata. Shown is a construction by which some equivalent deterministic classical finite state automata can be obtained from any monoid end automata over a free monoid. Minimal deterministic finite state automata are considered. A summary of the concept of a deterministic finite state automata, called a colored deterministic finite state automata, is introduced. It is shown that the definition of a deterministic monoid finite state automata for any monoid is not natural. In this connection, a lesser term is introduced, taking into account the fact that each monoidal finite state automata is a homomorphic image of a classical finite state automaton.

Chapter 4 consists of 6 paragraphs. Here is a summary of classical finite state automata, namely multi-band finite state automata, which are actually relations. They are introduced as a special case of monoid end automata. This chapter defines monoidal end converters, which are a special case of monoidal multi-band end automata.

Chapter 5 focuses on the study of deterministic inverters. Converters detected along the input bar are considered. Such converters are called sequential and sub-sequential.

Chapter 6 examines a specific class of deterministic automata with a finite number of conditions, namely, automata. Bimachines represent the class of regular functions between words.

Chapter 7 introduces the C (M) programming language. The expressions in this language resemble those used to represent formal constructs in set theory. The C (M) language, in contrast to the imperative languages, is a functional de-

clarative language. The C (M) compiler compiles the C (M) program, turning it into an effective C code, which is then compiled and executed. This makes the C (M) language accessible and easy to implement.

Chapter 8, C(M) implementation of finite-state devices, introduces the C (M) implementations of the automatic structures presented in the dissertation.

The abstract correctly reflects the main results obtained in the dissertation. The dissertation and abstract are well designed and properly structured.

**The contributions** to the dissertation are formulated in the Author's Reference. In my opinion, the essential contributions of the thesis are as follows:

A coherent statement of the theory of Finite-State Automata, Transducers and Bimachines is presented and basic properties and correctness of structures are proved.

A new construction for canonization of a sub-serial converter is presented, which has polynomial complexity.

A direct construction of a drill with proof of correctness is presented. This approach does not require converting Bimachines to symbolic end converters.

A new C (M) programming language has been developed that allows the researcher to focus on mathematical steps at an abstract level. Finite-State Automata, Transducers and Bimachines for important tasks, such as spelling correction, poetization, etc., have been implemented.

I have no **critical notes** on the thesis. It has happened over the years that I review the works of Assoc. Prof. Stoyan Mihov and listen to his papers at seminars. I would like to state that he always answered the questions asked very professionally and precisely.

**Personal impressions**

I have known Stoyan Mihov for many years. I think that there is a high authority of a scientist in his scientific community. He is respected and respected as one of the leading researchers in his field. He is a scientist with proven aptitude for research in the field of finite state automata and a proven affinity for new, original approaches that lead to important practical realizations.

**Conclusion:** The scientific and applied results presented in the dissertation, some of which are novelty for science, and others enrich some already known knowledge, give me the reason to conclude that the dissertation "*Finite-State Automata, Transducers and Bimachines: Algorithmic Constructions and Implementations*" satisfies the requirements of ZRAS, PPZRAS, as well as the specific requirements of IICT-BAS. Therefore, I strongly recommend that the scientific jury propose that the degree of Doctor of Sciences be awarded to As-

soc. Prof. Dr. Stoyan Milkov MIHOV in Research direction 4.6 Informatics and Computer Science.

04/12/2020 Signature:



Sofia Professor, Dr Ivan Dimov