

# REVIEW REPORT

by Prof. Dr. Boyan Paskalev Bontchev

on a PhD dissertation on a topic

*"DISTRIBUTED MANAGEMENT OF CONVEYOR SYSTEMS"*

with author Mag. Eng. Ivaylo Todorov Andonov - PhD full-time student,

Department of Mechatronics, Robotics and Mechanics

at the FMI of Sofia University "St. Kliment Ohridski",

for obtaining the educational and scientific degree "Doctor",

in professional field 4.6 "Informatics and computer science"

(Doctoral Program "Computer Science - Distributed Systems")

According to Order №RD38-125 / 26.02.2021. of the Rector of Sofia University "St. Kliment Ohridski" I have been appointed a member of the scientific jury in connection with the procedure for defense of the dissertation of Ivaylo Todorov Andonov on "Distributed management of conveyor systems" for obtaining the educational and scientific degree "Doctor", field of higher education: "4. Natural Sciences, Mathematics and Informatics ", professional field: 4.6. Informatics and Computer Science ", specialty 01.01.12. Informatics ", doctoral program "Computer Science - Distributed Systems"). By decision of the scientific jury (Protocol № 1 of March 22, 2021) I was appointed a reviewer of the dissertation.

As a member of the scientific jury I have received the necessary documents that meet the regulatory requirements of both ZRASRB and the Rules for implementation of ZRASRB of the Council of Ministers of the Republic of Bulgaria and that of Sofia University "St. Kliment Ohridski", which gives me reason to review this dissertation work.

## **1. Relevance of the problem**

The dissertation work developed by Ivaylo Todorov Andonov is in a topical and dynamically developing field - that of optimizing the distributed management of conveyor systems transporting goods. The use of software management agents makes it possible to test and implement new algorithms in order to achieve high average conveyor speed and increase the density of objects moving through the system, by using information about the position of the engines, the state of the control modules of the zones. and a video stream from appropriately positioned cameras. The high speed of modern communication networks and the increasing computing power of the zone management modules enable the creation of complex and intelligent software agents for optimized system management. This is extremely useful for businesses using conveyors with reduced cost and increased efficiency in automated warehouses, logistics centers, airports, manufacturing plants and more.

The work proposed for review is dedicated to the identified problems in the field of transport conveyor systems with distributed drive and with decentralized control of the motorized roller. It proposes methods for improving the efficiency of such distributed drive conveyor systems by using new control algorithms in roller controllers that optimize the density of objects on the conveyor or their average speed of movement, based on the use of statistical information on the behavior of the system and its current parameters.

The main goal of the dissertation (p. 32) is "to propose a solution for distributed management of conveyor systems based on software agents, which improves the global characteristics of the system by using the available information about the loads traveling on the conveyor". The doctoral student sets the following additional goals (actually representing tasks for achieving the main goal):

1. Verification of the proposed method for distributed control of conveyor systems, using simulation software.
2. Design and implementation of methods for:
  - establishment and distribution of the energy consumed by the power sources;
  - increase the reliability of data transmission between electric motors and the controller;
  - securing controllers against cloning.

## **2. Knowing the state of the problem**

From the dissertation and the presented publications it is clear that the doctoral student is very well acquainted with the issues. The paper cites a relatively small number of literature sources - a total of 51 references, the list contains only one author's publication (patent for a drive for a roller conveyor and a method for its application), which is not included in the list of publications on the dissertation. Five of the sources are hypertext documents available online. All the references are in English, except for two of them, which belong to Bulgarian authors. Most of them are modern (since 2010), citing only five sources from the last century, which testifies to the relevance of the studied problem.

Regarding the applied problems solved in the work, the doctoral student has used his practical experience in the field of hardware and software solutions for conveyor systems. It has penetrated deeply into the application of modern software agents for conveyor management in order to achieve high average speed and efficiency of the conveyor system.

## **3. Research methodology**

The methodology of the research and the practical work is appropriately chosen in accordance with the topic of the work. The work begins with a study of the current state in the subject area of the dissertation. A critical analysis is made of the problems with conveyors with decentralized control of the motorized roller, of the peculiarities of the power supply of such conveyor systems, of problems in the protection of intellectual property on the realization of the control modules. From the conclusions naturally follow the purpose and tasks of the dissertation. The following is a proposal of solutions for improving the characteristics of the conveyor system and for improving the subsystems for power supply,

measurement and communication. The proposed methods for improved distributed control, for improving the power supply and for the method for protection of the cloning modules have been implemented, and the method for distributed control has been verified by computer simulations. After its verification, it is implemented on a real conveyor system.

#### **4. Characteristics and evaluation of the content of the dissertation**

The dissertation of Ivaylo Todorov Andonov presents a research in the field of methods for improving the distributed management of transporting conveyor systems, based on software agents. Its content and structuring are determined by the set tasks and following the chosen methodology. The work has a volume of 100 typewritten pages and includes 76 figures. No applications and results are presented in tabular form. The bibliography includes 51 titles and 5 internet sources.

From the results presented in the four chapters of the dissertation it can be concluded that the doctoral student has successfully completed the tasks set before the dissertation. The work begins with a brief introduction to the subject area, emphasizing the relevance and challenges of research. In addition to the analysis of the subject area, the first chapter includes a description of the problems with conveyors with decentralized control of the motorized roller, the peculiarities of the power supply of such conveyor systems and data reliability in a noisy environment, as well as problems related to intellectual property protection. of control modules. The chapter ends with a description of the purpose and tasks of the dissertation.

The second chapter proposes solutions to improve the performance of the pipeline system by adding intelligence, in which each zone is treated as a separate agent, solving a distributed part of the overall task of improving the global performance of the whole system. Solutions are also proposed to improve the power, metering and communication subsystems.

The third chapter presents the implementation of the individual components of the system and their integration. The implementation of the proposed method for improving the quality of the data for the position of the motors, of the proposed method for improving the power supply and of the method for protecting the modules from cloning are described. The proposed method for distributed control is verified by computer simulations, and then implemented on a real pipeline system.

The fourth chapter is devoted to testing solutions through real experiments and analysis of the results achieved. Description are experiments with the proposed method of distributed control in order to improve the quality of data on the position of the motors and improve the power supply. Computer simulations were performed using Flexsim, which prove the operability of the proposed algorithm and method, as well as experiments on a real conveyor system. Thanks to the use of the method, a better throughput of the conveyor and a better density of the loads on the system have been achieved.

#### **5. Contributions of the dissertation**

The work presents significant scientific, scientific-applied and applied contributions, which are the original work of the author.

As a scientific contribution to the dissertation I would define the creation of a new algorithm for distributed control of conveyor systems. Improving the efficiency of conveyor systems by applying the created algorithm is a scientifically applied contribution of the dissertation. Another such contribution is the performed modeling and computer simulation of the proposed method for distributed control.

The applied contributions of the dissertation can be summarized as follows:

- A prototype of a conveyor system has been implemented, through which to validate the operability of the distributed control method;
- New methods have been implemented, improving the operation of the subsystems for measurement, power supply and communication;
- Methods and techniques for protecting devices from copying are proposed.

## **6. Degree of independence of the contributions of the dissertation**

Taking into account the contributions of the work and the four publications presented, as well as the cited author's patent for a roller conveyor drive and a method for its application, I believe that the main results and contributions of the dissertation have a significant degree of independence.

## **7. Evaluation of publications**

In connection with the dissertation, four publications of the doctoral student are cited, one of which is single-author publication and three are co-authored with the scientific supervisor. One of the publications was made in a Bulgarian journal and three - in proceedings of prestigious international conferences. The results of the work were presented at two conferences of the IEEE (International Conference on Intelligent Systems) and the Balkan Conference in Informatics, which is a certificate of significance of the achieved results.

## **8. Usability of the results in practice**

The successfully tested approbation of the method for distributed control in a real conveyor system proves the applicability and usefulness of the results achieved by the doctoral student.

## **9. Opportunities for future use of the dissertation contributions**

The proposed in the dissertation methods for improving the efficiency of transport conveyor systems with distributed drive provide opportunities for conducting additional experimental studies. The continuation of the work with the creation of a method for automatic configuration of the parameters by using neural networks shows the potential for future development and upgrading of the achieved results.

## 10. Dissertation abstract

The dissertation abstract contains 37 typewritten pages and correctly and adequately reflects the contributions and results achieved in the dissertation.

## 11. Critical remarks

The reviewer has a number of critical remarks on the dissertation as follows.

### *A. Regarding the content of the work:*

- No quantitative results are presented regarding the increase of the efficiency, productivity and reliability of the system due to the improved conveyor throughput and load density - obtained both by computer simulations with the Flexsim product and by practical experiments on a real conveyor system;
- The aim of the dissertation is formulated on page 9 too generally: "The aim is to extract possible useful information and use it in the best way to improve the efficiency of the conveyor system".
- There are not given definitions and citations (references to literature sources) for many of the terms used, such as software agents, machine learning and neural networks;
- No list of citations of the doctoral student's publications is presented.

### *B. Regarding the layout of the work:*

- There is no dictionary of terms and abbreviations;
- Some literature sources are incompletely described;
- The abbreviation of brushless DC motors was used repeatedly in the text before it was clarified (on page 71).
- In both the dissertation and the abstract, syntactic errors (articulation, lack of prepositions, incorrect punctuation, etc.) and stylistic inaccuracies have been made in many places.

## 12. Conclusion

Regardless of the critical remarks made, my overall assessment of Ivaylo Andonov's dissertation, abstract and scientific publications is positive. Taking into account the original scientific, scientific-applied and applied contributions of the dissertation and the scientific publications made in this regard, as well as the achieved practical results, I find that the doctoral student has in-depth theoretical knowledge in the field and abilities for independent research. In this sense, the dissertation meets the requirements of ZRASRB and the rules for application of ZRASRB cited at the beginning of this review, which gives me reason to propose to award the educational and scientific degree "Doctor" to Ivaylo Todorov Andonov in professional field: sciences, scientific specialty: 01.01.12 - Informatics, doctoral program "Computer science - distributed systems".

04/05/2021

Signature: .....

/Prof. B. Bontchev/