

## **Review of the Ph.D. thesis**

*The Evolutionary Computation Techniques in Chemical Engineering*

by **Ing. Tran Tron Dao**

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The main aim of the Ph.D. thesis was to propose algorithms for monitoring and predictive control of chemical reactor processes.

As solving the task characterised above requires design of methods in which modelling of complex nonlinear systems, their efficient implementation and artificial intelligence-based control, the Ph.D. thesis fits into the Technical Cybernetics study branch. The thesis brings topics that are currently very important in chemical industry.

The importance of the given topic is, besides application of modern methods, also in its economic point of view, control of chemical reactions as polymerization and polycondensation substantially impacts on quality of produced materials and reactor productivity depends on reacting speed.

The author his main attention paid to evolutionary methods. In practice, they are frequently used for problems whose models seem to be very simple, e.g. they have a combinatorial nature, but finding their exact solution need not be easy or even, for large instances, it is not reachable in a reasonable amount of time. Such problems can be found in scheduling of manufacturing processes and projects under limited resources, network optimisation, graph theory, mathematical programming, etc.

However, the problems studied in this thesis have models complex and strongly nonlinear and they are described by differential equations. In specific cases, the optimization of nonlinear constrained problems in chemical engineering practice may be based on classical nonlinear programming or, when some of the variables may be integers, on mixed integer non-linear programming approaches.

The Ph.D. thesis is logically structured into chapters and subchapters. It has a theoretical and practical part. The theoretical part covers the first four chapters. They introduce into the problems and explain their basic features and necessary notions. In Chapter 4, a survey of stochastic heuristic methods and their analysis is made. The fundamental part of the Ph.D. thesis can be found in Chapters 5, 6 and 7 where in a precise mathematical form models are derived and practical results of large set of simulations for batch reactor and continuous stirred tank reactor are presented. The author demonstrated on simulations that the chemical processes can be efficiently solved using evolutionary algorithms and these algorithms give a practical tool to their optimization.

The language in which the Ph.D. thesis is written and its typographical standard are very good, the text contains almost no misprints (on page 45 instead "Mathemtica", "Mathemtica" should be). In my opinion, it is not suitable to comment by the author, whether objectives have been achieved (chapter 7). It is a task for reviewers.

## Questions

1. Your research was focused on application of evolutionary algorithms SOMA, DE, GA and SA. May other heuristics based on different principles, e.g. particle swarm, ant colonies or neural networks, be also applicable for chemical processes?
2. Which other chemical processes do you plan to solve in the future using proposed approaches?

## Conclusion:

In my opinion, Ing. Tran Tron Dao has proved to be capable of solving difficult research problems. His doctoral thesis presents new results. He has developed algorithms that improve tools of control in chemical industry and bring economic effects in quality of produced materials. In principle, these algorithms and methodology can also be applied to other technical systems.

The Ph.D. thesis satisfies conditions of the Czech Act 111/1998 and its Section 47, parts of the thesis have been published in prestigious scientific international conferences and accepted by scientific community, and therefore

## I recommend

Ing. Tran Tron Dao's Ph.D. thesis to be accepted by the Committee to be presented and defended in the Technical Cybernetics study branch.

Brno, 6th October 2009



Prof. RNDr. Ing. Miloš Šeda, Ph.D.  
Institute of Automation and Computer Science  
Faculty of Mechanical Engineering  
Brno University of Technology

## PhD thesis review

Name of the thesis: **The Evolutionary Computation Techniques in Chemical Engineering**  
Student: **Ing. Tran Trong Dao**

The student has chosen the stated topic, which is concerned to a novel approach of control algorithm and predictive control for chemical dynamic systems. Work contains new evolutionary approaches for finding a suitable structure of control algorithms. Designed algorithms have been tested on a number of difficult tasks described in section 5 and 6.

Five relatively ambitious aims are stated in the thesis. Designed algorithms use model, which was optimized by evolutionary algorithms (SOMA, DE, SA and GA). New control laws are generated on the principle of artificial intelligence. Complexity of stated aims were given also by choice of tested tasks.

**Conclusion: PhD thesis has full-filed all stated aims, fits into the dissertation area and deals with very perspective problems of optimization algorithms.**

Obtained results of PhD thesis contribute for solutions of very difficult problems because they combine evolutionary approach with control model defining a structure of control tools. Obtained results were published at research conferences. I witnessed the participation in the student presentations e.g. a presentation at the international conference Mendel 2009, where the presentation of results had significant impact. Special appreciation is attributed to the extensive amount of test computation in section 5, which verify and validate the designed concept.

**Conclusion: PhD thesis brings new knowledge in the area of control algorithms with evolutionary optimization.** On the basis of list of author research activities and her oral presentations at the conferences is possible to state that **Ing. Tran Trong Dao has enough research erudition required to obtain the academic title.**

Other contributions of the work is, that it serves as a overview of current and designed optimization methods based on a combination of evolutionary algorithms. Thesis consists of several new approaches described in section 5 and 6. Reached results are contributing to area of knowledge and there is great hope that this new approach to the design of optimized control algorithms especially in generally used algorithms even in exponentially amount of evolutionary algorithms in the area of Softcomputing.

**Conclusion: Thesis is contributing to other development of science and technology, mainly in the area of control algorithms with use of evolutionary optimization.**

The thesis is elaborated, well-arranged, exemplary and it does not contain significant grammatical mistakes.

### **Remarks to the thesis:**

There are few small typographical errors in the text and right descriptions. For example in Fig.36 better name for “algorithms optimization” could be control algorithms with evolutionary optimization etc.

### **Questions to the defence:**

- 1) Is it possible to use hierarchical and hybrid structures in the construction of parallel evolutionary algorithms?
- 2) Do you know other evolutionary method that was not used in Ph.D. work?

With respect to facts listed in the thesis review (despite the listed insufficiencies), I recommend PhD thesis by **Ing. Tran Trong Dao** to defence. After successful tract and conclusion of the defence, I recommend further to give an academic title

**„ Ph.D.“**

to Ing. Tran Trong Dao according the law par. 47 odst.5 Zákona č. 111 about Universities.

In Brno 4.10.2009



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Prof. Ing. Pavel Ošmera, CSc.  
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# Review

**Ph.D. candidate :** Ing. Tran Tron Dao, FAI, UTB ve Zlíně

**Name:** The Evolutionary Computation Techniques in Chemical Engineering.

Presented doctoral thesis is evaluated using the used following criteria. Summarisation of all of these points can give the proper evaluation of the doctoral thesis. These points are:

**Importance of the given topic:** doctoral thesis are focused on relatively new algorithms, so called „evolutionary algorithms“, which has been developed approximately 35 year ago by John Holland and further developed and improved by others. Level of importance of candidate thesis directly comes from field of evolutionary techniques itself. Evolutionary techniques like for example genetic algorithms, evolutionary strategies, genetic programming, particle swarm, ant colony optimisation, grammatical evolution etc. are vitally important part of science and industrial application. The level of complexity of many of problems solved today is so high that standard numerical algorithms usually do not give acceptable results, which is not problem for evolutionary techniques.

Lets mention a few examples of all like excellent successful optimisation of Boeing jet-engines by genetic algorithms or evolutionary design of electronic circuits by genetic programming, suitable to be patented, done by J. Koza. Also excellent theoretical results have been reached on the field of evolutionary computation.

Typical example is ant colony optimisation algorithm, which gives us acceptable solution in acceptable time of so called problem of the travelling salesman, whose search for optimal solution would take time many times longer than our universe exists. Of course when enumerative algorithms would be used for the calculations. Power of the evolutionary algorithms can thus save a lot of money, when applied to industry. From this point of view is clear that topic of doctoral thesis is of high importance with highly probable impact on industrial applications.

**Relevance :** basically said relevance and importance are mutually joined points, which cannot be so easily separated. From point of view it is most suitable to evaluate relevance of the methods used in the candidate thesis. Generally said, backbone of the candidate thesis is created by evolutionary algorithms applied on chemical engineering problems. Well-introduced methods are fully accepted by scientific community, the first one is more younger, but also accepted by scientific community. Simply said, candidate used accepted scientific methods to apply them on engineering problems. This is quite important task because evolutionary algorithms, despite fact of their high performance, are also dependant on parameter settings. Its better or adaptive setting can be significant in theoretic as well as in practical applications. From that point of view I would like to say that in candidate thesis are selected relevant methods in a suitable way.

**Scientific formalism:** research and consequent scientific reports in general, have to follows some formal rules. These rules are basically how to write scientific reports, how to citate literature, how to number equations etc. Based on my experiences with doctoral

thesis from different universities I have to say, with my pleasure, that I have no found in candidate thesis serious mistakes and thus thesis can be regarded like scientific paper in general.

**Applicability:** Based on well results and applications of evolutionary algorithms itself, it is clear that designed method in doctoral thesis can be applied on real-world problems. There are only limits on programme skills of appropriate user and limits coming from optimised problems itself.

**Content and structure:** In the dissertation thesis is discussed evolutionary algorithms use on chemical reactor optimisation and control. Thesis consists of 7 chapters. It contains introduction, contemporary state and application of evolutionary algorithms. With thesis are attached also results of candidate research in the form of publications. Based on state of art it can be stated that thesis represent interesting applications of evolutionary algorithms.

**Quality and defined aims:** Quality of candidate thesis can be evaluated from graphical and formal point of view. In both views it can be stated, that level of quality is very good. Aims are defined clearly and consist of 5 items.

**Selected methods:** In proposed thesis candidate used rigorous methods and its research follows standards scientific criteria.

#### **Question and remarks**

In reviewed thesis I would like to ask following questions

- Page 65, Fig. 22. g). Why time curves depicted on this picture have so big dispersion?
- On what base did you set used parameters of selected algorithms as you reported?
- How fast/slow has to be a process to be successfully controlled by evolutionary algorithms?
- Why did You not publish the achieved scientific results in any journal (at best in reviewed scientific journal)?

#### **Conclusion**

Ph.D. candidate Ing. Tran Tron Dao has published his results on various conferences and workshops. Scientific community accepted them. In proposed thesis Ing. Tran Tron Dao clearly demonstrated ability of independent scientific work. Proposed thesis fulfil all-important criteria and thus **I recommend** proposed thesis to state Ph.D. defence.

In Zilina on 8.10.2009

  
Prof. Ing. Ivan Hanuliak, CSc.