

## PhD thesis review

Name of the thesis: **Metaevolution – Synthesis of Evolutionary Algorithms by Means of Symbolic Regression**

Student: **Ing. Zuzana Oplatková**

The student has chosen the stated topic, which is concerned to a novel approach of optimization algorithm design. These new algorithms use metaoptimization for finding a suitable structure of evolutionary optimization operators. Designed algorithms have been tested on a number of difficult tasks described in section 7.

Seven relatively ambitious aims are stated in the thesis. Designed algorithms use regression model which is optimized evolutionary. New operator structures are generated on the principle of Analytic Programming. Complexity of stated aims were given also by choice of tested tasks.

**Conclusion: PhD thesis has fulfilled 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 regression model defining a structure of optimization operators. Obtained results were published at research conferences. I witnessed the participation in the student presentations e.g. a presentation at the international conference Mendel 2006, where the presentation of results had significant impact. Special appreciation is attributed to the extensive amount of test computation in section 7, which verify and validate the designed concept.

**Conclusion: PhD thesis brings new knowledge in the area of evolutionary algorithms with regression construction of operators structure.** On the basis of list of author research activities and her oral presentations at the conferences is possible to state that **Ing. Zuzana Oplatková has an enough research erudition required to obtain the academic title.**

Other contributions of the work is, that it serves as a compact overview of current and designed optimization methods based on a combination of Analytic Programming and evolutionary algorithms. Thesis consists of several new methods described in section 6. Reached results are contributing to area of knowledge and there is great hope that this new approach to the design of optimization 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 optimization algorithms with use of evolutionary operators.**

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 for example: in czech resume abbreviation „AP“ is used earlier than it was explained, distinguish prepositions from variables by means of other font („k“ in resume 5th line from bottom). It is not defined what computations in 100 repetitions are different in. Small typing errors as in the czech word žádný (comma is missing) atd. Small text inaccuracies as on page 23 (10th line from top „fields“ of what?). What is the difference between terminal, nonterminal, constant and variable on the page 29, 3rd line from bottom? On page 32, there is not explained the dependency between Fig. 3.6 and equation (3.6) – usage of operator Mod. On page 33, reason of implementation of constants in the shape (3.8) is not explained. Statement on page 34, 10th line from top is inaccurate and a better comparison with GE, or paralel GE is missing. On the

page 58, 8th line from top a migrating operator could be mentioned. This belongs surely between good operators, mainly in the group of paralel evolutionary algorithms. In section 6, a dynamic testing environment could be mentioned. The position of the optimum is changed during the time there.

### Questions to the defense:

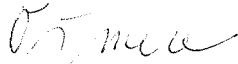
- 1) Is it possible to use hiarchic stucture in the construction of algorithms with evolutionary operators?
- 2) What is the difference between parallelization of algorithm calculation and parallel methods, which contain a parallel stucture right inside them?
- 3) How can it be explained that no algorithm obtained the best status in all test functions?
- 4) How would obtained results change if functions (5.3) and (5.4) contain also different phases? (e.g.  $\sin(x+2)$  etc.).

With respect to facts listed in the thesis review (despite the listed insufficiencies), I recommend PhD thesis by **Ing. Zuzany Oplatkové** to defense. After successful tract and conclusion of the defense, I recommend further to give an academic titul

**„ Ph.D.“**

to Ing. Zuzaně Oplatkové according the law par. 47 odst.5 Zákona č. 111 about Universities.

In Brno 4.1.2008

  
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20th December 2007

Our ref:  
Your ref:

Dear Colleague,

## **RE: PHD THESIS REVIEW ZUZANA OPLATKOVA**

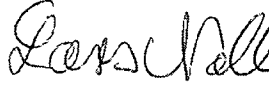
In my opinion, the doctoral thesis entitled "Metaevolution - Synthesis of Evolutionary Algorithms by means of Symbolic Regression" submitted by Ing Zuzana Oplatkova represents a significant contribution to both the field of computational optimisation and machine learning by providing a new novel approach to the problem of optimisation algorithm design. Here, not only control parameter settings for existing optimisation algorithms are evolved, but also the algorithms themselves.

This unique approach was applied to a number of test problems and the methodology applied is scientifically sound and appropriate: Based on a large number of experiments, the candidate analysed the performance of the evolved algorithms and compared them with well-established computational optimisation meta-heuristic. I was especially intrigued that standard algorithms were found by the new Metaevolution approach. The candidate then compared the efficiency of the new approach and analysed and discussed it in a critical and objective way. The literature review is sufficient and up-to-date and the thesis is well structured and clearly written. It is well prepared (apart from some minor points, e.g. spelling mistakes or grammar) and presented and I enjoyed reading it.

The candidate has demonstrated the exercise of independent critical powers by providing a very detailed analysis and critical discussion of the approach developed. She also suggested future improvements of the approach. The work represented in the thesis is of high academic standard and, in my opinion, definitely represents PhD level research. In conclusion, I recommend that the candidate be granted the degree of Doctor of Philosophy.

If I can be of further assistance or if you need further information please do not hesitate to contact me.

Yours Sincerely

  
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**Review of the Ph.D. thesis**  
**„*Metaevolution – Synthesis of Evolutionary Algorithms***  
***by Means of Symbolic Regression***

**by Ing. Zuzana Oplatková**

The author in her Ph.D. thesis formulates many ambitious aims, where probably the most important is the aim to create a new optimisation algorithm of an evolutionary character using analytic programming that would be robust and efficient in searching optimum of complex optimisation problems. The author follows and develops works of her supervisor Assoc. Prof. Ivan Zelinka, who proposed the analytic programming (AP) method, and she also develops her own works or works prepared altogether with her supervisor.

An assumption of reaching the above mentioned aim is a verification whether the analytic programming is able to provide symbolic regression and work not only with numeric values and mathematical operators, but also with linguistic expressions. The verification of these properties of AP is one of many other aims of the Ph.D. thesis. Specified aims are non-trivial and there is no doubt that the work is dissertable.

In connection with the aims, the author means by the term *metaevolution* just finding a new algorithm (or new algorithms) using AP, which differs from the usual approach, where the metaevolution is understood as finding suitable parameter settings of an algorithm (expressed in the form of a general framework) for solving a problem using another algorithm.

In accordance with the stated aims, the Ph.D. thesis can be divided into a theoretical and practical part. The theoretical part covers Chapters 2-4 and it is rather brief, but the practical part is very large, it includes 150 pages with results in a wide class of benchmarks reached by means of modern evolutionary algorithms including their modifications derived by the author. By expectations and confirmed by the author in her discussion, none of the methods is better than the other ones in the whole class of benchmarks. This means that a suitable selection of a method depends on the solved problem or on the size of the problem instance.

The Ph.D. thesis has a very good graphical form, text is logically structured into chapters and subchapters, all necessary notions are clearly explained and then demonstrated by examples. All results are compared with results of the competitive methods published in the recent literature. However, the Ph.D. thesis omits details to the implementation of her methods. The author only restricts to a brief comment that algorithms were implemented in MATHEMATICA. It would be suitable at least sketch the key program modules or enclose CD with source codes.

I have only two formal comments:

- Page 47: “Equations (5.1) – (5.4)” – (5.1) – (5.4) are not equations but expressions.
- Page 86: Many functions, used as benchmarks, are not described here and their analytic expression (with exception of the De Jong and Schwefel function described on page 61) may be found in Appendix, but there is no information about this fact, it would be suitable to include corresponding references.

With respect to the size of the Ph.D. thesis, it contains several (typing) errors, mainly in two pages of the Czech summary,

Errors in English are very rare, e.g.:

- Page 18: Instead of “algorithms *belongs*”, “algorithms *belong*” should be used.
- Page 19: “*pareto*” should be written “*Pareto*”, because it is the surname of the Italian economist and sociologist Vilfredo Pareto.
- Page 20: The sentence “In the final part can be found the discussions ...” should have another order of words - “In the final part, the discussions ... can be found”.
- Page 34: “To the same elements belongs the aim ...” – it should in the following form: “To the same elements the aim ... belongs”.
- Page 35: Instead of “hybrid methods which *uses* ...”, “... *use*” should be used.
- Page 36: “*Breadth* - First” – “*Breadth ...*” (*breadth-first search*).
- Page 36: “we are talking often” – “we often talk”.
- Page 54: Instead of “anticlockwise direction”, “counter-clockwise turning” should be used.
- Page 66 (twice): Instead of “*less* cost value”, “*lower* cost value” should be used.
- Page 73: “costfunction” – “cost function”.
- Page 73: “Following tables ... *shows* settings” – “... tables ... *show*”.
- Page 74-75: “nonsuccessfull” – “unsuccessfull”.

These comments on the Ph.D. thesis are not substantial and do not cast doubt on its scientific level.

We can conclude that the author fulfilled given aims and evidenced abilities of creative invention based on a wide scope of knowledge in the theoretical literature and high level in work with modelling and simulation software tools.

The author’s main contribution is an extension of the class of methods that can be used for solving complex optimisation problems, because it increases a chance to find a global optimum or a value close to the optimum.

#### **Question:**

1. Experiments in Chapter 7 are mainly focused on standard multimodal functions. Have you tried proposed algorithms also for tasks of a different type, e.g., from the area of combinatorial optimization (Travelling Salesman Problem, scheduling problems)? In positive case, what results did you get?

#### **Conclusion:**

In my opinion, Ing. Zuzana Oplatková has proved to be capable of solving difficult research problems. Her Ph.D. thesis satisfies conditions of the Czech Act 111/1998 and its Section 47, parts of the thesis have been published in 20 international conference papers and they are also included in technical reports of research projects, and therefore

**I recommend**

Zuzana Oplatková's Ph.D. thesis to be accepted by the Committee to be presented and defended in the Technical Cybernetics study branch.

Brno, January 2, 2008

A handwritten signature in black ink, appearing to read 'Šeda'.

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