

APPLICATION: „Danubius Young Scientist Award 2016” (Dr. Aleš Zamuda, Slovenia)

A) SUMMARY OF THE SCIENTIFIC WORK

Doctoral dissertation - PhD received 19 May 2012

ZAMUDA, Aleš. *Differential evolution for parameterized procedural woody plant models reconstruction*, at [University of Maribor](http://dkum.uni-mb.si/Dokument.php?id=30084), 2012. XXII, 164 pp., <http://dkum.uni-mb.si/Dokument.php?id=30084>. [COBISS.SI-ID 16001302]

Doc. dr. Aleš Zamuda is affiliated with the **Faculty of Electrical Engineering and Computer Science** at **University of Maribor**, where he is included in teaching at different undergraduate and postgraduate studies. Also, he is additionally employed on a research programme **P2-0041 Computer Systems, Methodologies, and Intelligent Services** at the faculty, which is funded by Slovenian Research Agency. He is an active member of **Institute of Electrical and Electronics Engineers (IEEE)** and **IEEE Computational Intelligence Society**.

Scientific excellence and innovative approach of the academic work

Dr. Zamuda researches in the meta-heuristics [SWEVO2015] and algorithms within computer science, applying them over various natural and economic *state-of-the-art geographically unbound and Danubian region bound challenges*. As confirmed by **400 Scopus citations** from various application domains [FRAI2016], his work is **referred to by researchers globally, from several different research fields**, including the energy sector [APEN2015]. He introduced an environmental framework for ecosystem simulation (see [INS2013] in the CV below) in fast rendering and animation of forest ecosystems (see Fig. 1), on real terrain data of hillsides nearby Maribor at Slovenian vicinity to Austria, thereby utilizing several ecological models and programming a novel visualization engine. In the spatial modeling of trees, he introduced automatic reconstruction of tree geometry from natural images [INS2014], hereby laying path for an ever-more emerging meta-heuristical approach to geometry and morphology evolution for natural objects [ASOC2011], modeling of which is also actively tackled by other researchers in the Danube region.

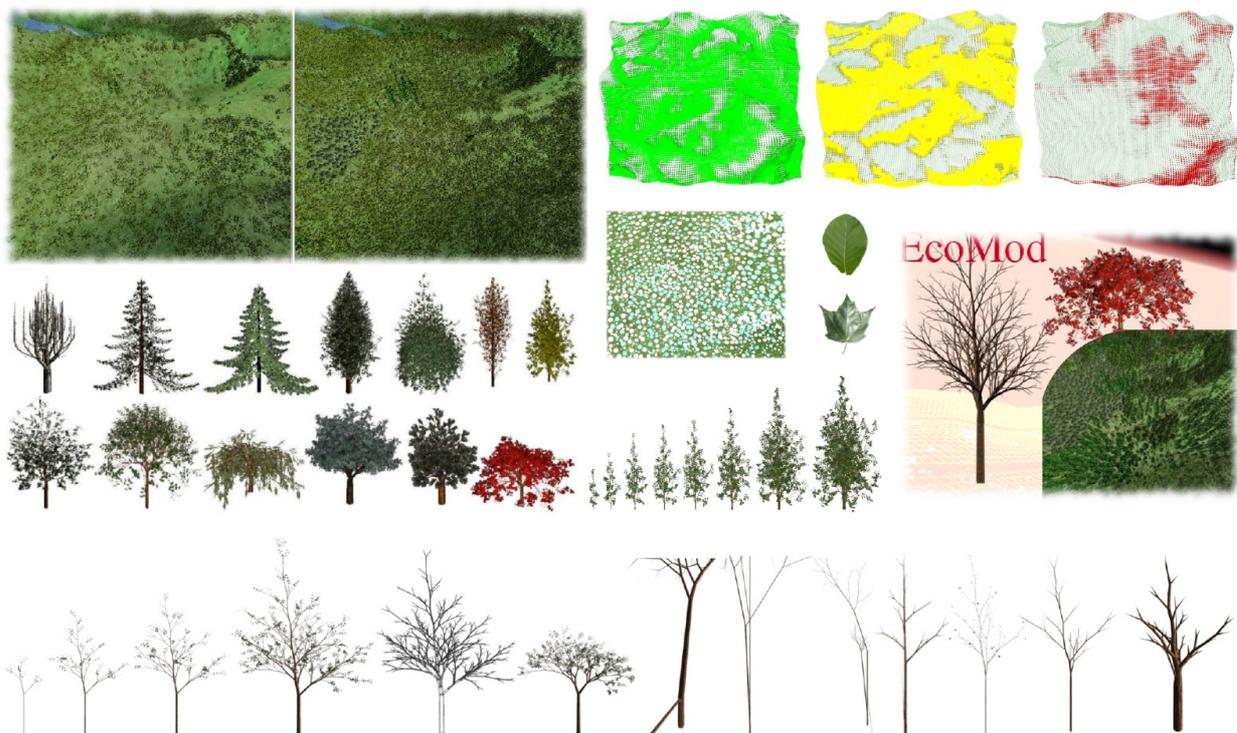


Fig. 1: Graphical abstract of the artificial life and ecological models (EcoMod) research, published in [ASOC2011, INS2013, INS2014]. Top of the figure: enhanced environmental framework model for ecosystem simulation with various new terrain factors models. Bottom of the figure: the novel approach in computer vision and first spatial tree geometry reconstruction for animation.

Thematic relevance of the scientific work for issues/problems of the Danube region

Spatial morphological reconstruction is a major challenge, because it usually computes millions and greater scale of data nodes in a time stream and also includes large-scale computation [INS2013]. As an example of spatial structures in nature are tree models. These are important in forestry, one of most promising sectors for urgent further development of Slovenian economy provided by a high forest coverage of the country and EU recommendations. The developed spatial tree models are used in landscape visualizer, which can also animate afforestation simulation, e.g. after a catastrophe. Forests in Slovenia witness catastrophes such as fires and a recent sleet catastrophe, after which spontaneous afforestation takes place due to certain laws.

Use of procedural models enables a very compact representation of tree structure and its features. The parameters of a procedural model can also be stored in a digital archive for later analysis. From a parameterized model, geometrical models are obtained, which are useful for rendering and analysis (measuring crown, base trunk, wood mass). From the viewpoint of virtual worlds, the archived tree models are useful in virtual landscapes, for historic archiving (virtual heritage) and augmented reality.

Relevance of the scientific work beyond the national borders

Dr. Zamuda also introduced several enhancements to evolutionary algorithms [SWEVO2015], especially the world-champion level algorithm family, the differential evolution, attaining several top ranking positions in these world-competitions on evolutionary algorithms during several years at IEEE Congress on Evolutionary Computation [CEC2007/8/9/10/12]. The algorithms were ranked at IEEE CEC world competitions on performance assessment of evolutionary algorithms, where they several times from 2007 to 2010 were ranked among 5 best performing algorithms. See also below on EcoMod application and the Relevance of the scientific work beyond the national borders.

Potential of the candidate (for example: integration in international networks, participation in scientific projects, publication history, experience in teaching)

The applicability of the results of his research is seen in numerous publications that take these results directly from his published articles in the international literature and compare their own results or just use his proposed mechanisms for new domains. Since his research deals with meta-heuristics, especially **differential evolution**, which currently forms practically the most popular family of evolutionary algorithms, application of the results are already found in many areas of research and industry, both in the public, private, and military sector. The potential results of research in the short term is seen especially in improvements for number of applications and meta-heuristics absorbing knowledge presented in his scientific publications. He is also an **editor at Frontiers in Robotics and AI**, featuring **Evolutionary Optimization and Robotics Intelligence**. The main consideration of his research, spatial reconstruction of trees, has potential applicability both in the domain of **computer animation, computer-aided forestry**, as well as **robot vision, design of natural objects**, and **energy production**. Besides regular teaching at University of Maribor, a **video overview of his research is available through an invited set of lectures online**, from the publisher IGI Global, under the series of InfoSci videos at: <http://www.igi-global.com/video/differential-evolution-large-scale-optimization/14887>.



Meeting leaders of IEEE Young Professionals, with IEEE President-Elect (New York, staff). (Iceland, April 2016)

Participation in scientific projects

His funded research projects include primarily work on P2-0041 funded research unit programme by **Slovenian Research Agency**, where his publications are awarded as some of the most important socio-economic and research achievements of the program. The **P2-0041** is also the funder of the research on differential evolution and modeling trees using automatic reconstruction. Within a **EU FET grant** received by H. Hamann, project “**Florarobotica**”, he contributed on the paper [FRAI2016] (see below). Another work with industry is on projects for private companies, such as optimization of advanced production planning in logistics (PKP INEA, 2015) and package submission labeling with computer vision (**PKP RECA**), funded by the **Slovene Human Resources Development and Scholarship Fund** (each project 22,250.00 € in total). He also received travel grants from EU mechanisms, such as **COST** and Erasmus/**Erasmus+**, to travel to scientific meetings (**Forest-based Platform Technology Congress 2013** and [EUROCAST2015]) or lecturing at foreign universities (University of Las Palmas de Gran Canaria and University of Alicante), where he also collaborates with their research groups on joint research and publications (i.e. glider path planning and document understanding optimization).

The **EcoMod** application developed by dr. Zamuda [ASOC2011, INS2013, INS2014] is selected as **the most important socio-economic and research achievements** of the national research program P2-0041: Computer systems, methodologies and intelligent services (COBISS.SI-ID 16116758 and 16157206).

Dr. Zamuda as one of youngest academia received a **bronze award** from University of Maribor for **extremely important successes and achievements in scientific research and educational field and in the development of the profession and for personal contribution to the reputation of the faculty**. More awards are listed in the CV, and at labraj.feri.um.si/en/EcoMod#Awards. The EcoMod application was also cited in the global (US, EU, China) patents:

1) **Microsoft Corporation patents**: Andreas Heil, Mark Peasley, Vassily Lyutsarev: **Use of scientific models in environmental simulation**. International patents *US 8229718 B2*, *US 20100161295 A1*, *CN 102265259 A*, *EP 2368183 A2*, *WO 2010075458 A2*, *WO 2010075458 A3*.

2) **Commonwealth Scientific And Industrial Research Organisation**: Xavier Raymond Richard Sirault, Jurgen Fripp, Anthony Paproki. **Method and system for characterising plant phenotype**. International patents *US20140294247 A1, CA2858166A1, EP2788958A1, WO2013082648A1*.

Some of his scientific research on reconstruction and evolutionary optimization yielded the following original results:

- design of an algorithm for iterative reconstruction of a tree model [ASOC2011],
- design of a new model and tree renderer, allowing fast animation and sequencing of evolved instances, [INS2013]
- design of an algorithm for rendering projections of a procedural tree [ASOC2011],
- algorithm for comparison of optimized three dimensional models to reference projections [ASOC2011],
- design of comparison metric with emphasis on topological details of trees [ASOC2011],
- use of multi-objective optimization in design of decision system for evaluation of reconstructed models [CEC2012a],
- usage of self-adaptive differential evolution in reconstruction approach [ASOC2011, INS2014],
- fixed vector encoding of auxiliary matrix parameters within procedural model [ASOC2011, INS2014],
- algorithms for tree features segmentation and extraction from photographic input material [INS2014], and
- several differential evolution mechanisms [SWEVO2015], developed in different domains (such as constraint optimization, multi-objective optimization [CEC2007, CEC2012a], co-evolution [CEC2008], local search [CEC2008], and changing population size [SWEVO2015, CEC2013a]).

Further on, dr. Zamuda applied the meta-heuristics to oceanography and underwater robotics (Fig. 2), enhancing operational capabilities of **oceanic underwater gliders (oceanic underwater drones)** by optimizing their path trajectory between autonomous communication intervals on ocean-scale missions [ASOC2014, ASOC2016].

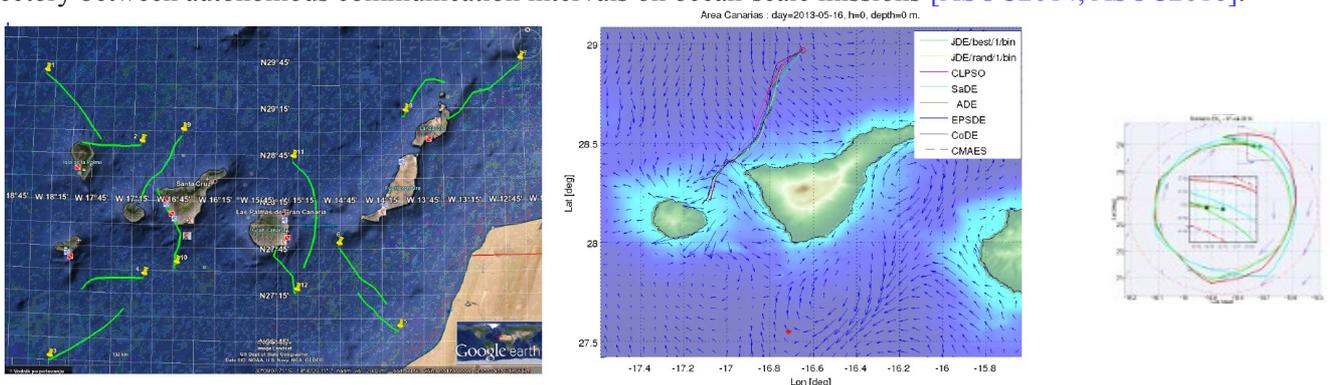


Fig. 2: Ocean glider (autonomous robotic underwater vehicle) path planning using state-of-the-art DE (several researchers from Danube region (co)-work on autonomous vehicles, also oceanic).

Moreover, dr. Zamuda also applied **differential evolution in hydro and thermal power plant scheduling and emission planning** (Fig. 3), **surpassing by far current state of research results from literature** [APEN2015]; the underlying real-data project was carried on real data in part on river Drava. His research is also in useful and applied to other industrial challenges optimization, ranging from nano-materials, chemical engineering, circular antenna design, space probe missions trajectory planning, economic power transmission planning and other [SIDE2012]. Indirect utility of his work is in other areas of computational intelligence, as well as in the field of parallel computing and systems control, his publications work is referred to by a more than 700 Google Scholar citations.

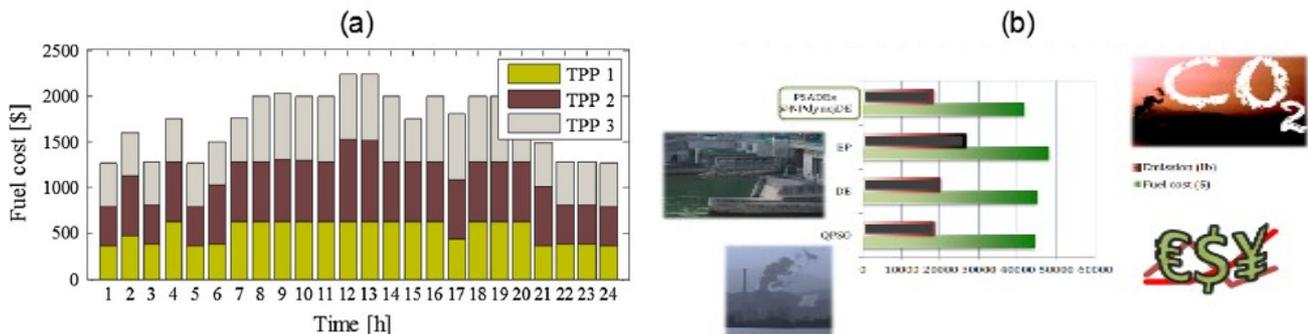


Fig. 3: Hydro and thermal power plants production (a) and emission (b) planning optimization using DE (work is very relevant for the Danube region, the underlying projects are carried out for some main industry companies for the Drava river part). [APEN2015]