

Research Projects BSc 2014

Natural Computing Group

LIACS

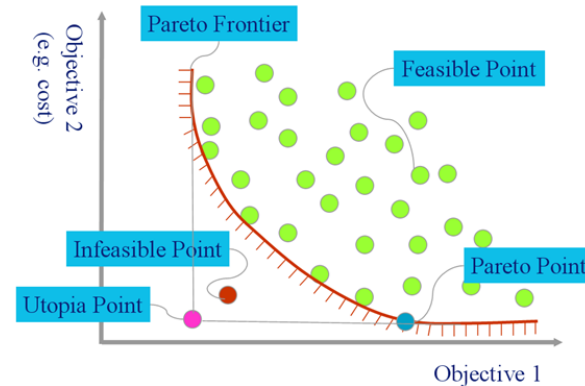
Dr. Michael Emmerich

See also:

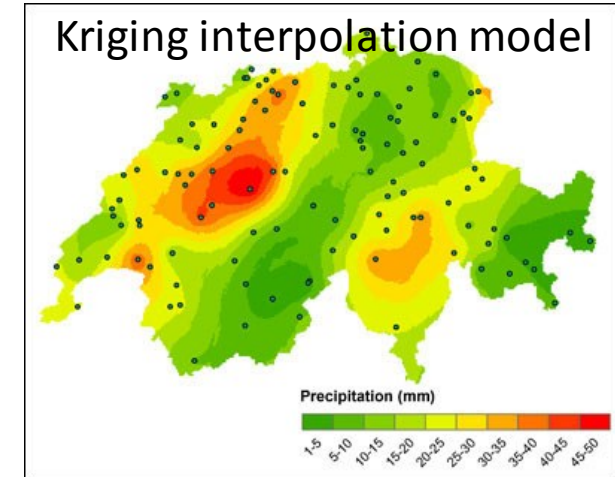
<https://moda.liacs.nl>

Multicriteria Optimization and Decision Analysis (MODA) Research Group

- We design algorithms for solving optimization and learning problems with multiple constraints and objective functions
- Core technologies:
 - Natural Computing
 - Pareto front approximation with stochastic and deterministic algorithms
 - Modelling of response surfaces (learning functional mappings)
 - Set-oriented approaches to solving classification and prediction problems
- Where used: Scientific Databases, Computer Aided Design, Scheduling

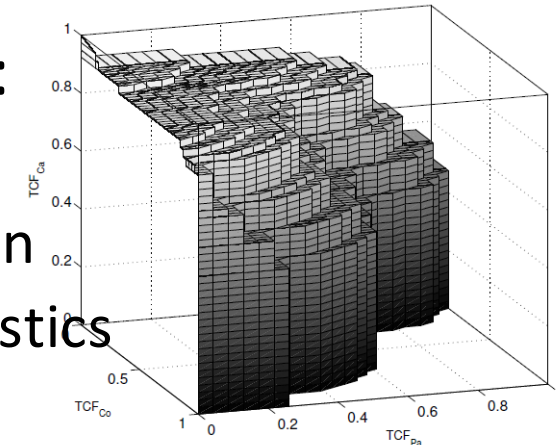


Pareto front (=optimal set) of a problem with 2 objectives.



- Core application fields:
 - Drug Discovery
 - Computer Aided Design
 - SPAM/Medical Diagnostics
 - Logistics
 - Engineering Design

3-D ROC of a 3-class classifier



Industry Projects

Projects in close collaboration with industry



Bachelor Thesis:

Supervisor LIACS:	Prof. dr. Michael Emmerich
In cooperation with:	Gijs Willem Sloof (Stabiplan)
Start date:	2.9.2014 (immediately)
Contact:	emmerich@liacs.nl

Gijs Willem Sloof MSc managing director
Stabiplan BV www.stabiplan.nl disclaimer:
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Generate parametric components from the Stabacad graphic library.

Stabacad components that are drawn in a BIM project are generated from our graphic library. The input for this library is a parametric database, fed by manufacturer catalogs, containing size information of the components. The generated components are not parametric, so users cannot change them by adjusting parameter values.. We want to change the way the components are generated: the parameters of the database should be included as adjustable parameters in the components. The main reason is that in a manufacturers catalog, a component is often part of a series, and users want to be able to easily change a component to another instance of the series. So the goal of this project is to implement the parametric structure of the database in the generated components and to design a infrastructure to implement the concept of series in these components.



Bachelor Thesis:

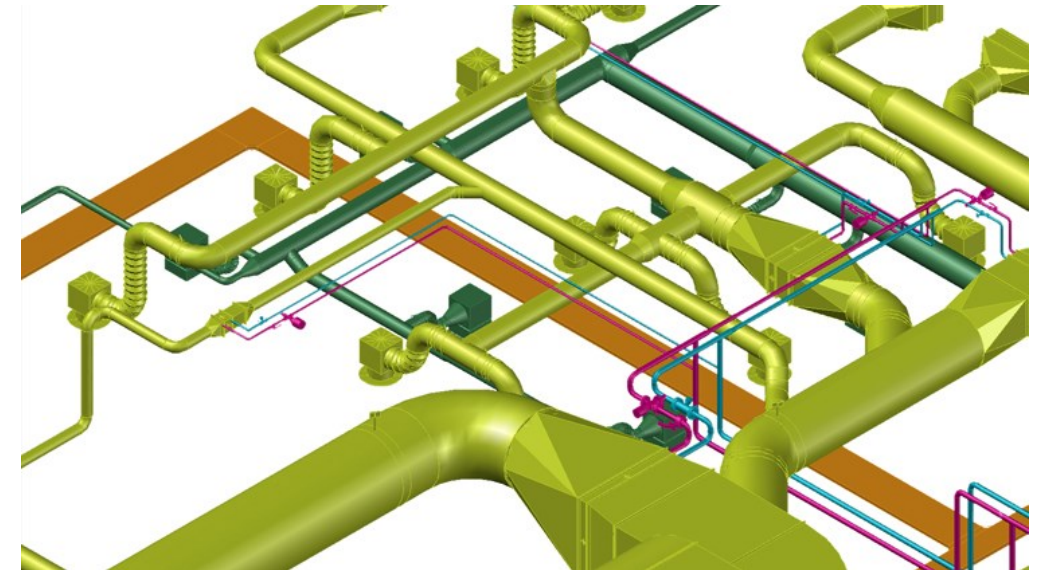
Supervisor LIACS:	Prof. dr. Michael Emmerich
In cooperation with:	Gijs Willm Sloof (Stabiplan)
Start date:	2.9.2014 (immediately)
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Gijs Willem Sloof MSc managing director
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Design of a generic algorithm for dimensioning of distribution systems.

In the field of building services, we have several types of distribution systems, e.g. gas, tapwater, waste water, ventilation ducts, heating/cooling, sprinkler. For each of these systems, calculation algorithms are describe in standard documents (often country specific) how to dimension them. In Stabacad, we've implemented these calculation algorithms as separate calculation modules, with some parts of the implementation shared. When we consider it a bit more abstract, all these calculation algorithms are similar: There are some constraints (e.g. velocity and/or pressure loss restrictions), and we have to find an optimal (often with respect to costs) solution satisfying these constraints. These kind of problems is also suited to be solved with iterative algorithms, which are often easy to implement in software. Especially for circular systems, the iterative way saves a lot of complexity.

The goal is to design a generic algorithm being able to calculate all those different types of systems, preferably in a iterative way. This will make it possible to support new types of systems or new localizations of a system with minimal effort. The algorithm should be verified with the implementation of new calculation module or re-implementation of an existing one.



Bachelor Project: Data Mining and Visualization for APP data in Outdoor Sports

Supervisor LIACS:	Prof. dr. Michael Emmerich
In cooperation with:	Dipl. Inform. M. Özdemir
Start date:	15.9.2013 (immediately)
Contact:	emmerich@liacs.nl

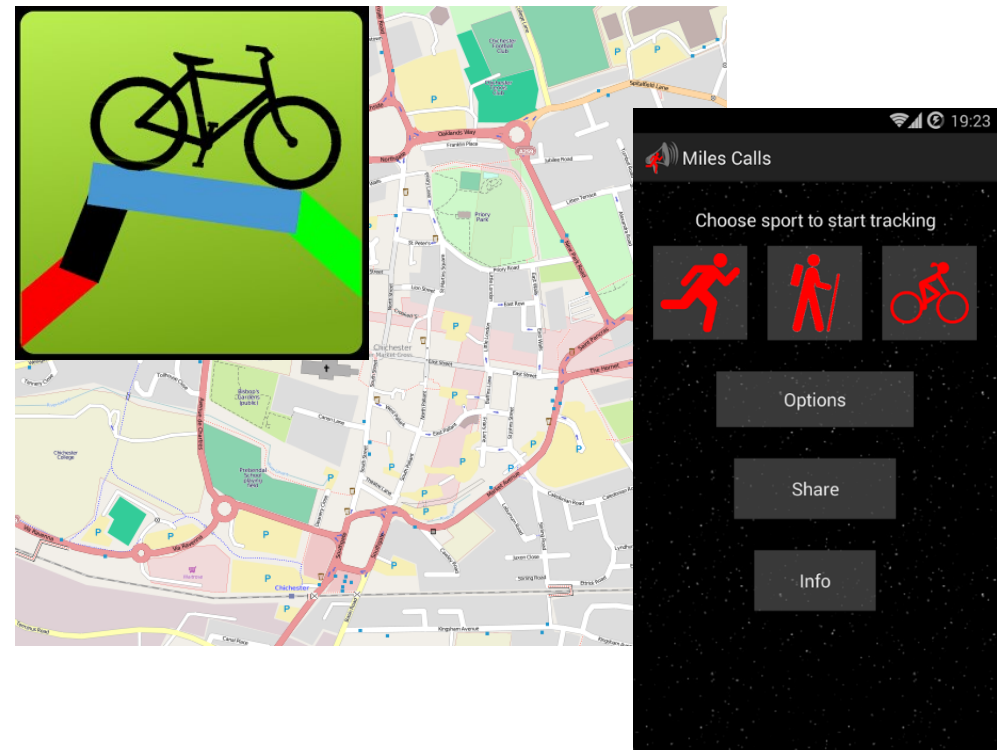
This project is in collaboration with the Company Dostware, Dortmund

Summary:

The software MilesCalls is an APP developed by Dostware that collects GPS data during running or bicycling and announces the finished kilometers. The GPS data is sent in SVG format to the user and can be visualized in google maps. The goal is to make a more advanced visualization tool for the track and analyze the data. The tool should be tailored to the needs of people who are following a training program and show interesting trends and aggregations in training data. In addition, the computation of derived measures, such as the amount of burned calories, should be computable.

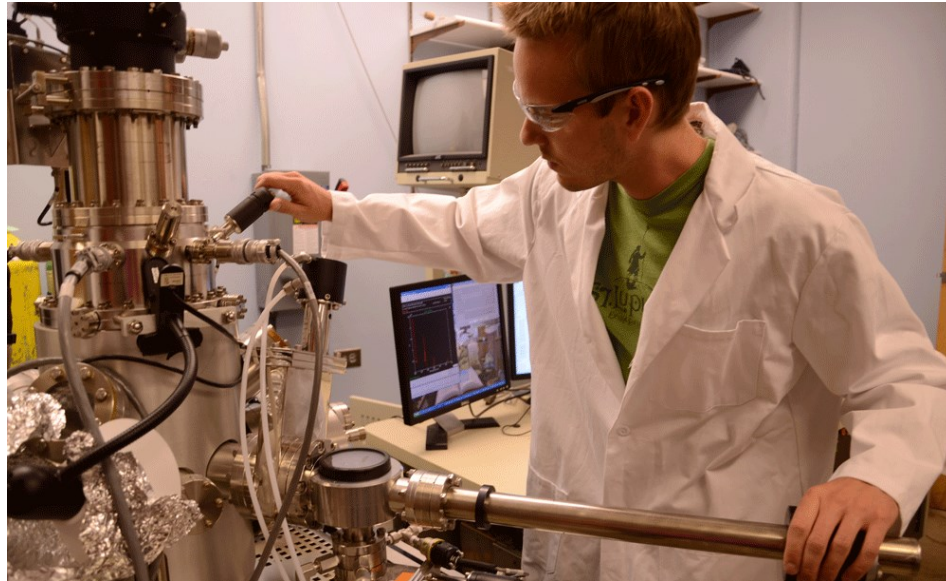
Prerequisites (helpful, not mandatory):

Interest in data analytic, geographical applications, JAVA/C++, XML, time series analysis.



Multidisciplinary Projects

Applying MODA in other scientific fields



Project: Optimal Selection of Drug Candidates in Molecular Databases

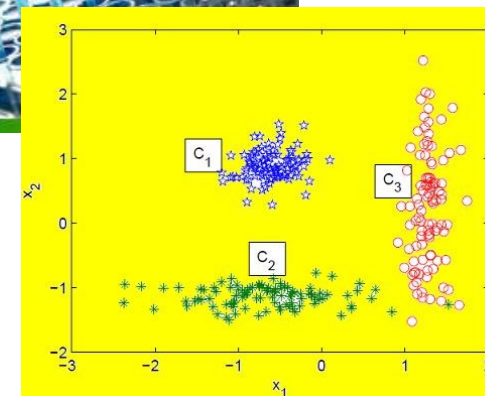
Supervisor LIACS:	Prof. dr. Michael Emmerich
In cooperation with:	Dr. Iryna Yevseyeva, Bart Lenselink (LACDR)
Start date:	2.9.2014 (immediately)
Contact:	emmerich@liacs.nl

The research will be in collaboration with the Leiden Academic Center of Drug Research

Summary: In high throughput screening the problem is to select subsets of chemicals from large databases. Portfolio optimization balances risk and return. To find an optimal portfolio a small subset has to be extracted from a large set – an NP hard problem. Instead of quadratic programming, which is too slow for large sets, a fast construction and genetic algorithms will be used and tested on some problem instances.

Prerequisites (helpful, not mandatory):

Interest in Algorithm Design, Statistical Quality Assessment, Interest in Cheminformatics (no specific knowledge in chemistry will be required).



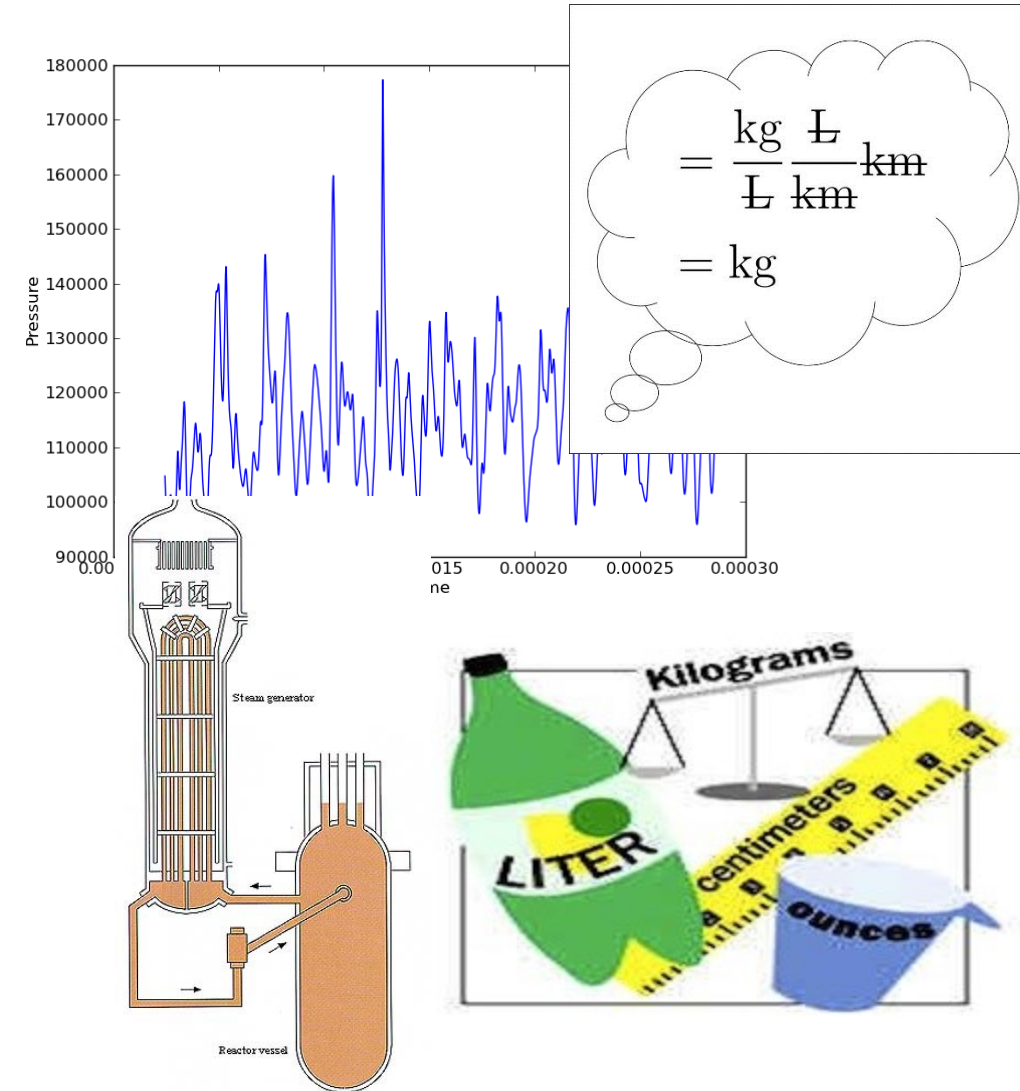
Research Project: Genetic Programming for Symbolic Regression on Science Data

Supervisor LIACS:	Prof. dr. Michael Emmerich
In cooperation with:	Dr. Ingo Schwab (IAF Karlsruhe) Aske Plaat (LIACS)
Start date:	15.9.2013 (immediately)
Contact:	emmerich@liacs.nl

Summary: Prerequisites (helpful, not mandatory):

Symbolic regression is a versatile tool for the generation of knowledge from data. It allows to automatically find expressions that well describe data sets. In scientific application not all expressions are meaningful. Dimensional analysis restricts search space of formulas to physically meaningful formulas. For instance a term that has the unit [kg] cannot be added to a term that has the unit [m]. In the thesis a genetic programming algorithm that evolves formulas will be designed and the hypothesis will be tested of whether or not a compact representation yields a more precise and reliable tool for symbolic regression.

- Interest and basic knowledge in statistical distributions, algorithm complexity, and calculus
- MATLAB , or C
- evolutionary algorithms



Bachelor Project: A portfolio approach to geo-exploration

Supervisor LIACS:	Prof. dr. Michael Emmerich
In cooperation with:	Dr. Zhiwei Yang
Start date:	15.9.2013 (immediately)
Contact:	emmerich@liacs.nl

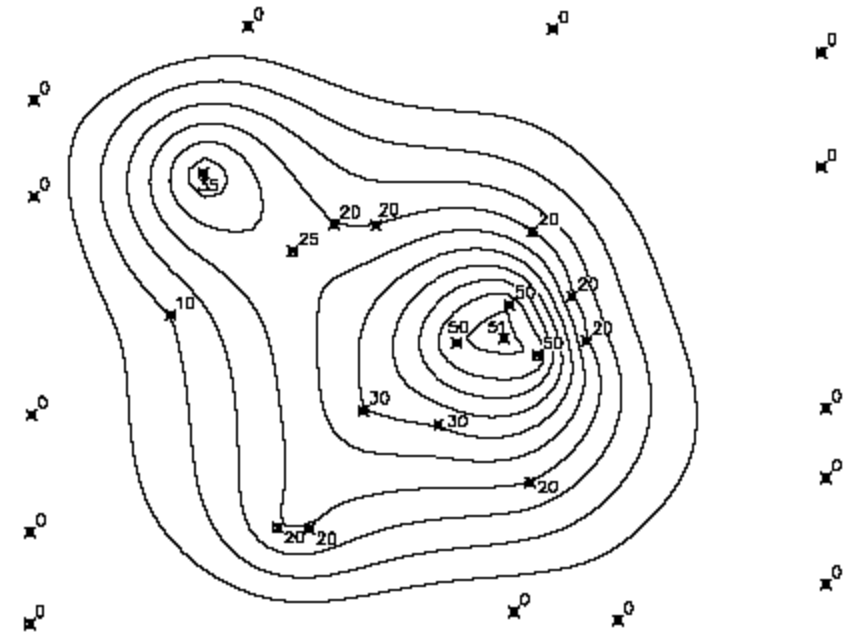


Summary:

Geological exploration has to plan sites for digging. This can be for archeological artefacts but also for minerals. From the knowledge previous 'digs' and constraints we can plan new sites. The envisioned new method allows to plan multiple sites, cost data, and to include the user's knowledge.

Prerequisites (helpful, not mandatory):

Interest in algorithms, geographical applications, JAVA/C++, XML.



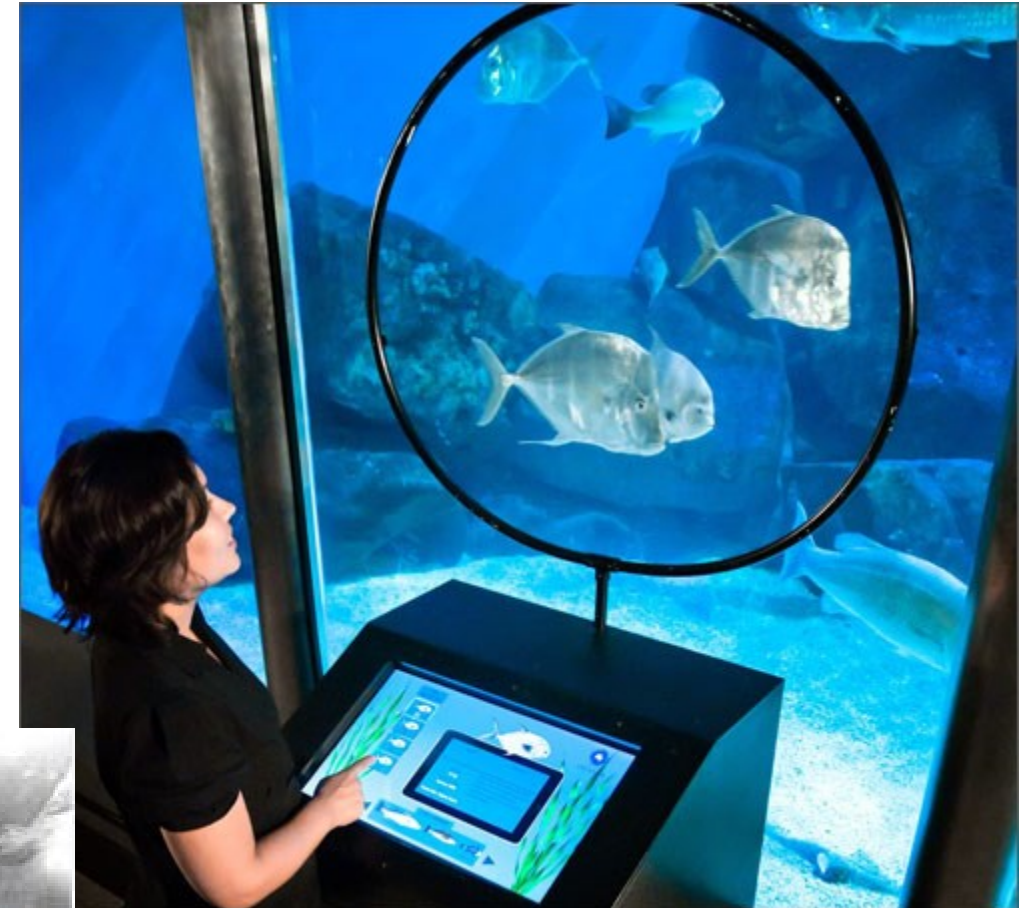
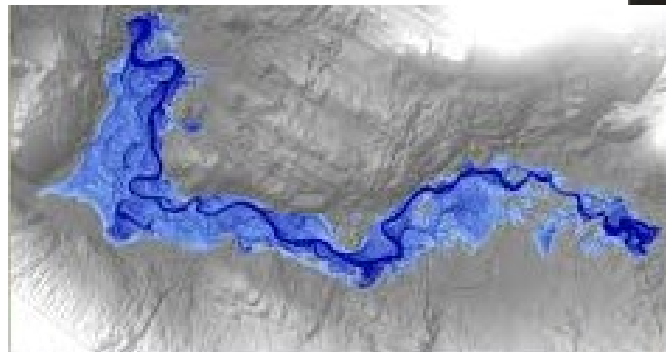
Research Project: How deep is the water?

Supervisor LIACS:	Prof. dr. Michael Emmerich
In cooperation with:	INTECH, Enschede
Start date:	15.9.2013 (immediately)
Contact:	emmerich@liacs.nl

Summary: Prerequisites (helpful, not mandatory):

The INTECH company collects data about the depth of water in the canals of the netherlands. An open question is how dense the number of measurement points have to be to get a good prediction and to what extend noisy measurements can be used for this. Research is in the direction of using geostatistical methods for profiling waterways using some simulated cases. A graphical representation of results is required. The Gaussian process learning framework will be a starting point for the investigation.

- MATLAB , or C
- evolutionary algorithms
- Numerical computations



Multicriteria Network Analytics for Vehicle Routing

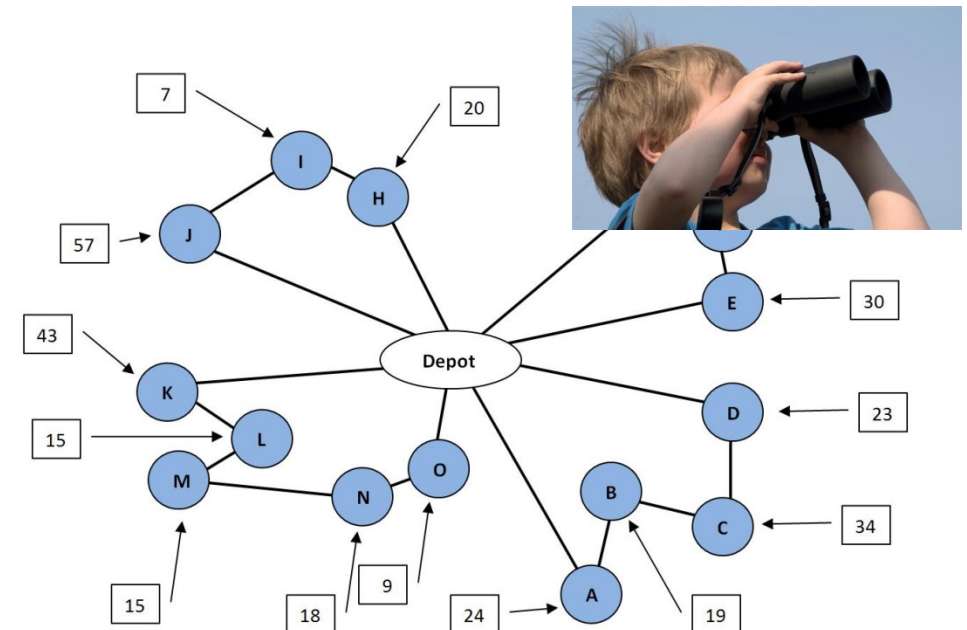
Supervisor LIACS:	Prof. dr. Michael Emmerich
In cooperation with:	Dr. Zhiwei Yang
Start date:	2.9.2014 (immediately)
Contact:	emmerich@liacs.nl

In collaboration with Trigion

Summary: Dynamical vehicle routing makes it possible to plan a fleet of vehicles over a period of time with new events coming in during the day. A challenge is to predict new events based on past distribution of events. An example is given by a emergency company for which alarms in different nodes of the network will be simulated based on the distribution of past events. The task is to learn event distributions in networks and use them in predictive optimization. We will collaborate with a security company (Trigion, NL).

Prerequisites (helpful, not mandatory):

Knowledge in Vehicle Routing or TSP, Programming in JAVA and C++. Programming with threads. Interest in probability and statistics.



Bachelor Project: SPAM filters based on Data Compression and Kolmogorov Complexity – How well does this work?

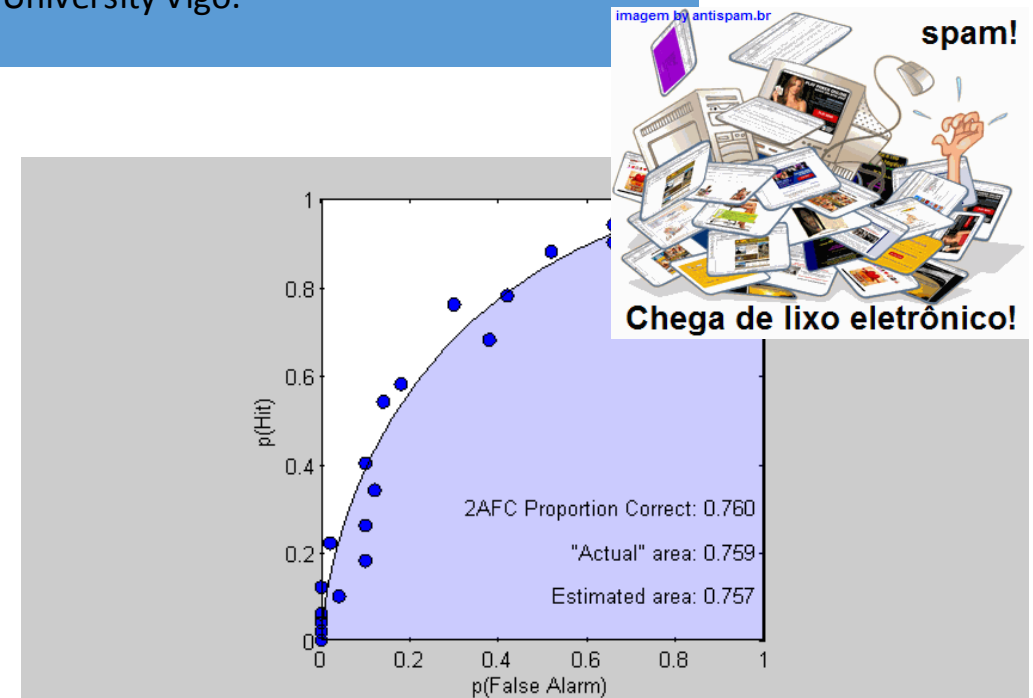
Supervisor LIACS:	Prof. dr. Michael Emmerich
In cooperation with:	Dr. Rui Li
Start date:	15.9.2013 (immediately)
Contact:	emmerich@liacs.nl

The research is conducted in collaboration with researchers from ICCI Portugal and University Vigo.

Summary:

Researchers from LIACS have recently discovered a new algorithm for learning classifiers based on RoC curve approximation --- it is based on multiobjective evolutionary optimization and called CHEMOA. The algorithm seeks to find RoC curves with minimal area under the RoC. Currently it maximizes the number of correct alarms while minimizing the number of false alarms. The new research will extend the capability towards minimal parsimony – that is the number of rules for machine learning is to be minimized.

Prerequisites (helpful, not mandatory): Interest in data mining, machine learning, and evolutionary algorithms. Source code is available in JAVA and needs to be extended



Bachelor Project: Building Design Optimization in 4-D

Supervisor LIACS:	Prof. dr. Michael Emmerich
In cooperation with:	Dr. Zhiwei Yang
Start date:	15.9.2013 (immediately)
Contact:	emmerich@liacs.nl



Summary:

The goal is to design buildings based on four objectives -- cost, comfort, energy, and robustness. We have a simulator for buildings that can be used as a black box objective function. The challenge is to find 4-D Pareto fronts and visualize them using transparent plots. Recently there exists a software for transparent plots. The task is to couple this software with a 4-D evolutionary multiobjective optimizer – SMS-EMOA and to test this approach on a real world scenario.

Prerequisites (helpful, not mandatory): Interest in real world optimization problems, OpenGL, basic knowledge evolutionary algorithms



Bachelor Project: Finding Drugs

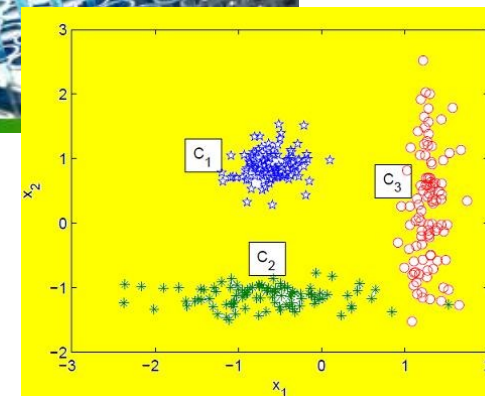
Supervisor LIACS:	Prof. dr. Michael Emmerich
In cooperation with:	Dr. Iryna Yevseyeva
Start date:	15.9.2013 (immediately)
Contact:	emmerich@liacs.nl

The research will be in collaboration with the Leiden Academic Center of Drug Research

Summary: In high throughput screening the problem is to select subsets of chemicals from large databases. Portfolio optimization balances risk and return. To find an optimal portfolio a small subset has to be extracted from a large set – an NP hard problem. Instead of quadratic programming, which is too slow for large sets, a fast construction and genetic algorithms will be used and tested on some problem instances.

Prerequisites (helpful, not mandatory):

Interest in Algorithm Design, Statistical Quality Assessment, Interest in Cheminformatics (no specific knowledge in chemistry will be required).



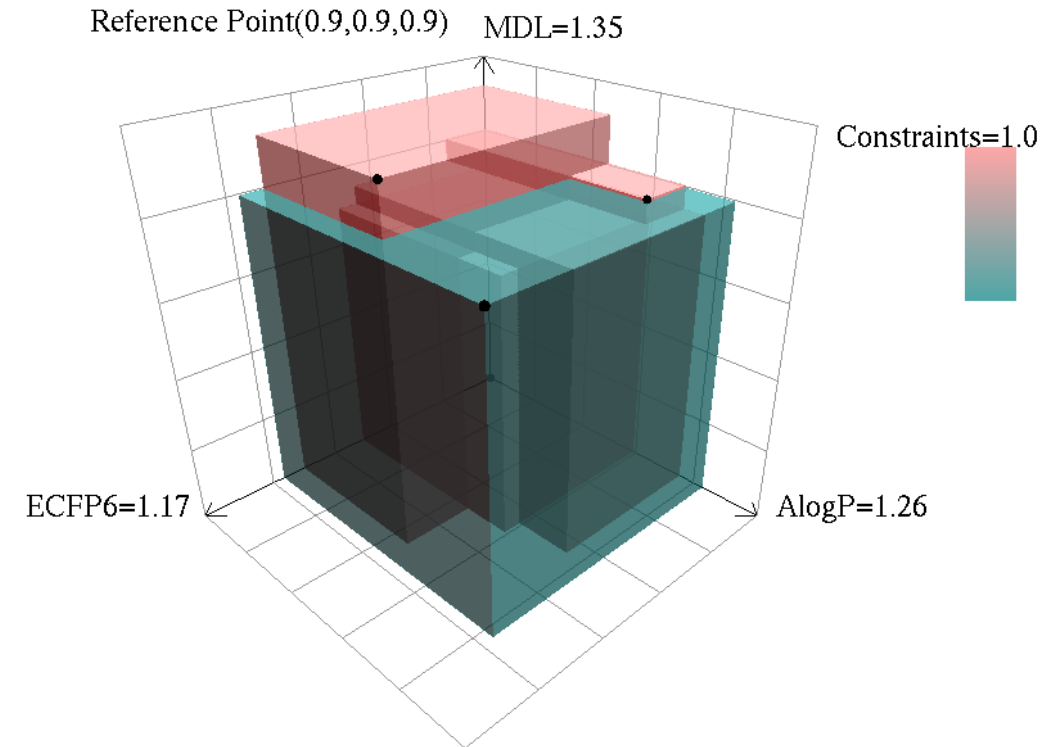
Research Project: 4-D Pareto fronts in 3-D

Supervisor LIACS:	Prof. dr. Michael Emmerich
In cooperation with:	Dr. Christina Hopfe
Start date:	15.9.2013 (immediately)
Contact:	emmerich@liacs.nl

Summary: Prerequisites (helpful, not mandatory):

- LIACS has developed a 4-D Visualization tool for Pareto fronts. **The task is to develop a viewer or concept for a viewer for a 4-D stereo-vision multiobjective evolutionary multiobjective optimizer and apply it to examples from engineering design.** -

Preliminaries: Graphics programming, evolutionary algorithms, ideally: interest in MPO or other 3-D format



Thesis: Building Design Optimization in 4-D*

Supervisor LIACS:	Prof. dr. Michael Emmerich
In cooperation with:	Dr. Zhiwei Yang
Start date:	2.9.2014 (immediately)
Contact:	emmerich@liacs.nl



Summary:

The goal is to design buildings based on four objectives -- cost, comfort, energy, and robustness. We have a simulator for buildings that can be used as a black box objective function. The challenge is to find 4-D Pareto fronts and visualize them using transparent plots. Recently there exists a software for transparent plots. The task is to couple this software with a 4-D evolutionary multiobjective optimizer – SMS-EMOA and to test this approach on a real world scenario.

Prerequisites (helpful, not mandatory): Interest in real world optimization problems, OpenGL, basic knowledge evolutionary algorithms



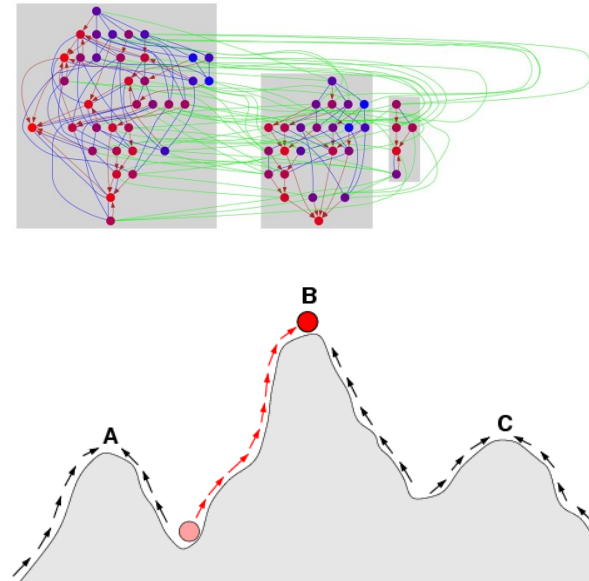
Project: Landscapes of Complex Codes: Facticity, NK-Fitness, vs. Bitcoins

Supervisor LIACS:	Prof. dr. Michael Emmerich
In cooperation with:	Prof. Thomas Bäck
Start date:	1.9.2014 (immediately)
Contact:	emmerich@liacs.nl

Note: The project is in collaboration with Almende e.V., Rotterdam, who provides professional solutions for VRP problems.

Summary: Bit-coin codes, Facticity (compressibility) and Nk Landscapes are examples for binary problems with a neighborhood structure. Local Search and Evolutionary Optimization are often used to find global optima for these problems. Though, gradual improvement strategies are often proposed, it is widely unclear how landscapes of these problems look like and whether they provide a structure that makes local search heuristics reliable and efficient. In a previous research project Barrier tree analysis has been used as a tool that can reveal the local optima structure of these problems. An alternative approach is to use local optima networks that were. Once we know the landscape structure, efficient algorithms can be designed to find maxima and minima.

Prerequisites (helpful, not mandatory): GraphViz, MATLAB, Combinatorial Optimization Algorithms



Genetic Programming for Making Bit Coins? What can we learn about the code by data mining?

Supervisor LIACS:	Prof. dr. Michael Emmerich
In cooperation with:	Prof. Thomas Bäck
Start date:	2.9.2014 (immediately)
Contact:	emmerich@liacs.nl



Summary:

The bitcoin is a virtual currency based on cryptographic functions. In the SHA-256 cryptography algorithms preimages of a function needs to be computed. BitCoin uses the SHA-256 hash algorithm to generate verifiably "random" numbers in a way that requires a predictable amount of CPU effort. Generating a SHA-256 hash with a value less than the current target solves a block and wins you some coins. This means that the deviation from a result needs to be minimized. Genetic programming are powerful minimization algorithms. The assignment it to represent the problem of finding a preimage of a hash funtion (SHA-256) as a search problem for genetic algorithms and find out how close these algorithms get to preimages. There is a small chance that they are even capable to solve the problem, in which case the bachelor thesis will yield a major result – i.e. an algorithm that creates money.

Prerequisites (helpful, not mandatory):

Interest in genetic algorithms and cryptography. Curiosity. Programming skills in C.



Thesis: An Evolutionary Machine Learning Engine and its use for SPAM and/or Toxicity classification*

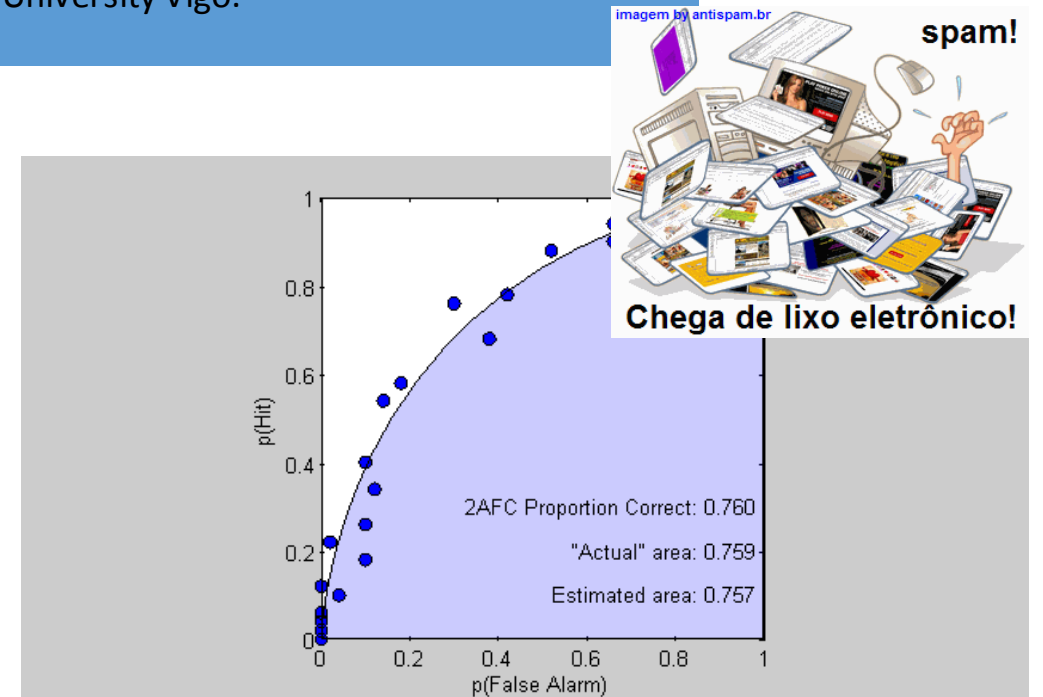
Supervisor LIACS:	Prof. dr. Michael Emmerich
In cooperation with:	Dr. Vitor Basto Fernandes (ICCI Leiria, Portugal)
Start date:	2.9.2014 (immediately)
Contact:	emmerich@liacs.nl

The research is conducted in collaboration with researchers from ICCI Portugal and University Vigo.

Summary:

Researchers from LIACS have recently discovered a new algorithm for learning classifiers based on RoC curve approximation --- it is based on multiobjective evolutionary optimization and called CHEMOA. The algorithm seeks to find RoC curves with minimal area under the RoC. Currently it maximizes the number of correct alarms while minimizing the number of false alarms. The new research will extend the capability towards minimal parsimony – that is the number of rules for machine learning is to be minimized.

Prerequisites (helpful, not mandatory): Interest in data mining, machine learning, and evolutionary algorithms. Source code is available in JAVA and needs to be extended



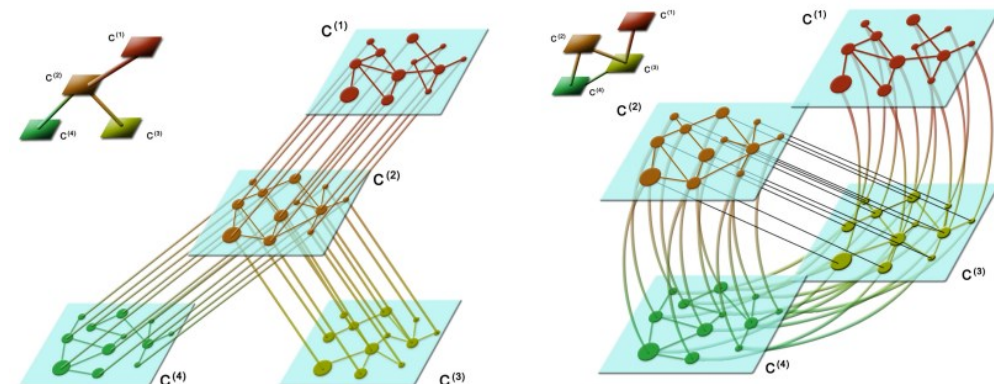
Thesis: Finding Conflicting Patterns in Multiplex Networks

Supervisor LIACS:	Prof. dr. Michael Emmerich
In cooperation with:	Diego Garlaschelli , Physics Department, Leiden Univ.
Start date:	2.9.2014 (immediately)
Contact:	emmerich@liacs.nl

The research is conducted in collaboration with researchers from ICCI Portugal and University Vigo.

Summary: So far it is unclear how to visualize conflict in multiplex networks. A promising approach is to analyse this problem with many-objective optimization algorithms. This can be done using existing tools for many objective optimization from a toolbox (Jmetal) and apply them on the analysis of network measures such as modularity. The insights will be valuable to the management of large social or biological networks with interacting agents.

Prerequisites (helpful, not mandatory): Interest in data mining, machine learning, and evolutionary algorithms. Source code is available in JAVA and needs to be extended



Bachelor Project:

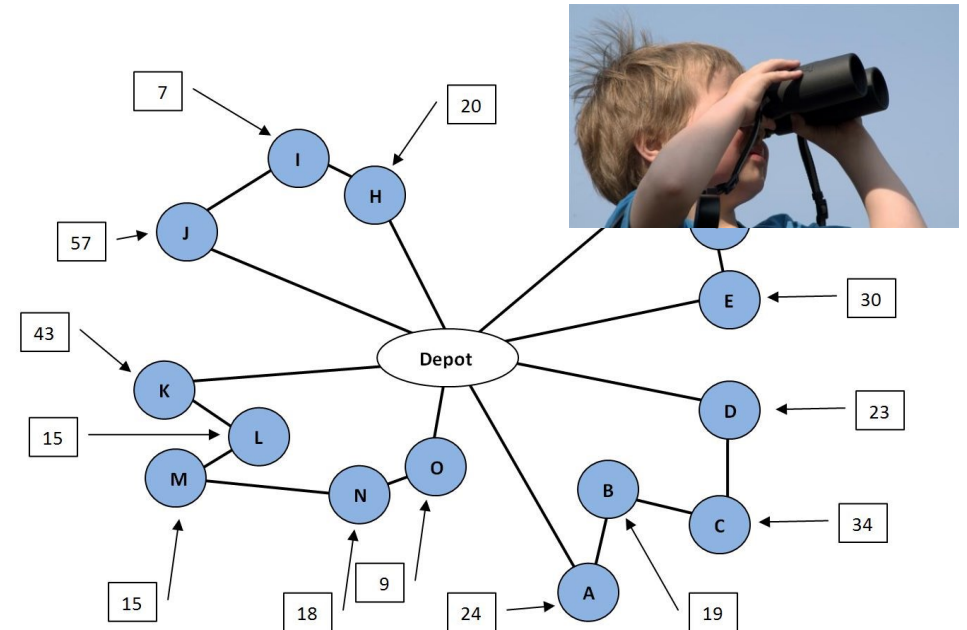
Supervisor LIACS:	Prof. dr. Michael Emmerich
In cooperation with:	Dr. Zhiwei Yang
Start date:	15.9.2013 (immediately)
Contact:	emmerich@liacs.nl

In collaboration with Trigion

Summary: Dynamical vehicle routing makes it possible to plan a fleet of vehicles over a period of time with new events coming in during the day. A challenge is to predict new events based on past distribution of events. An example is given by a emergency company for which alarms in different nodes of the network will be simulated based on the distribution of past events. The stochastic simulation will be implemented and used in an existing optimization algorithm to improve solutions. Implementing and testing the approach is the goal of the thesis. We will collaborate with a security company (Trigion, NL).

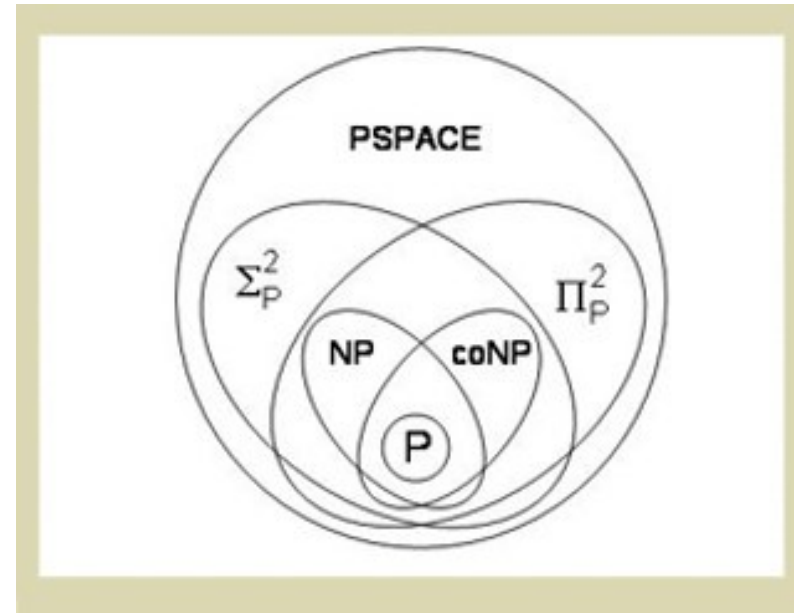
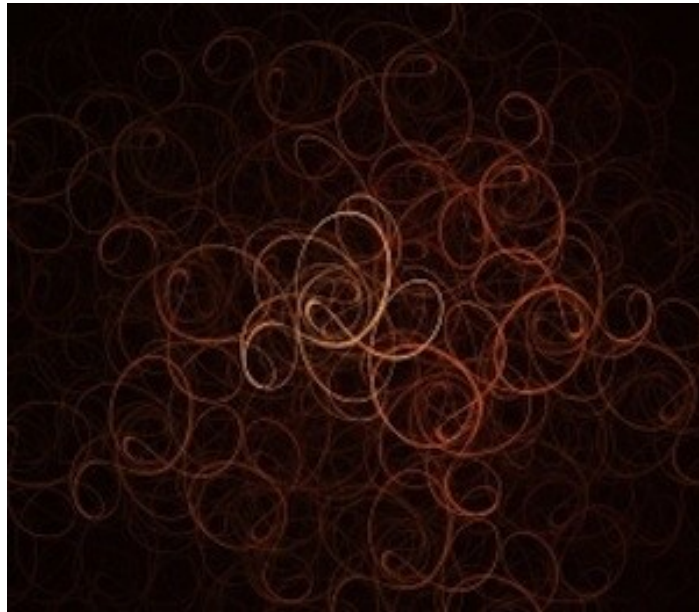
Prerequisites (helpful, not mandatory):

Knowledge in Vehicle Routing or TSP, Programming in JAVA and C++. Programming with threads. Interest in probability and statistics.



Theory and Algorithm Design

Developing theoretical foundations of optimization and new algorithms



Research Project: New insights from biological evolution theory enhance evolutionary algorithms?

Supervisor LIACS:	Prof. dr. Michael Emmerich
In cooperation with:	Dr. Patsy Haccou (biologist)
Start date:	15.9.2013 (immediately)
Contact:	emmerich@liacs.nl

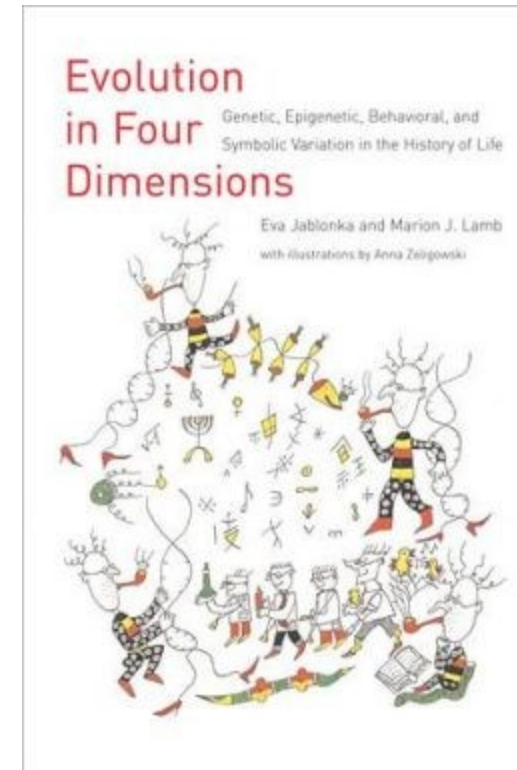
Note: The supervisor is a leading Researcher on this question and has developed HSSP selection for special cases. There are some ideas that can be tried.

Summary:

Evolutionary algorithms are search algorithms based on principles from Darwinian Evolution. Whereas in the classical neo-darwinian model of evolution the variation of genes by mutation and recombination was considered the main innovation source in evolution, in a modern view besides genetic variation also epigenetic behavioral and symbolic variation are considered as driving forces of evolution. Moreover, in modern works the competitive advantage of certain traits are evaluated in a multiobjective and co-evolutionary setting. A recent trend in the design of evolutionary algorithms is to adopt some of the insights into the development of nature inspired adaptive algorithms. This research project is to summarize and assess recent developments in this direction, and optionally extend this work into the development of a nature inspired algorithm.

Prerequisites (helpful, not mandatory):

Interest in bio-inspired algorithm, reading/summarizing multidisciplinary literature, conceptual modeling.



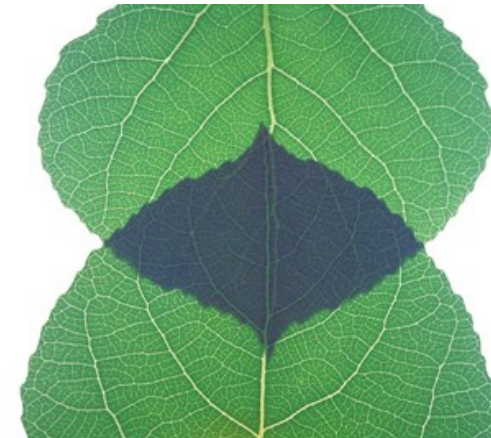
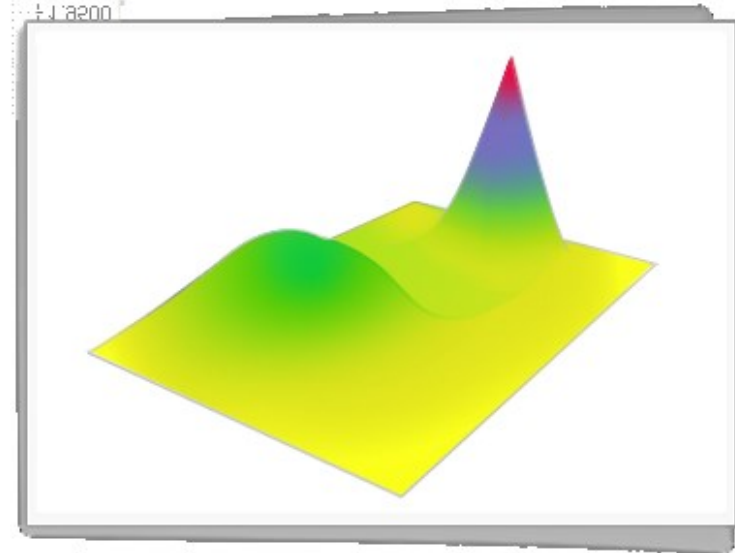
Research Project: Dynamic Updates in Monte Carlo Sampling-based Robust Optimization

Supervisor LIACS:	Prof. dr. Michael Emmerich
In cooperation with:	Dr. André Deutz
Start date:	15.9.2013 (immediately)
Contact:	emmerich@liacs.nl

Summary: Prerequisites (helpful, not mandatory):

Robust design optimization deals with finding stable optima. Testing the stability of an optimum can be extremely time consuming. Samples can be recycled and overlap can be exploited in order to reduce complexity. Gibbs samplers can make this process very efficient. Dynamic updates are used in combinatorial optimization but not yet in robust optimization, and a study of this strategy might yield a high impact result.

- Interest and basic knowledge in statistical distributions, algorithm complexity, and calculus
- MATLAB , or C
- evolutionary algorithms



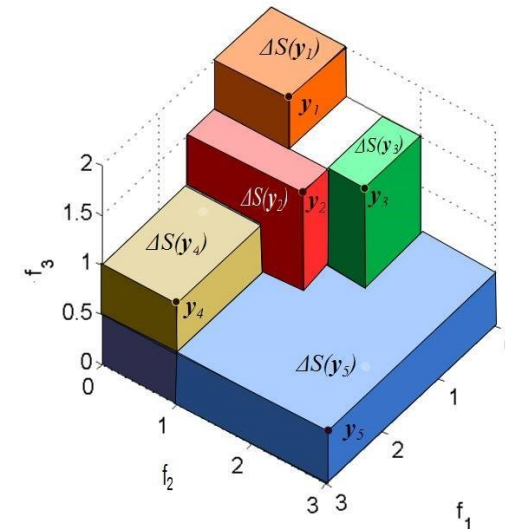
Research Project: Multiobjective Decision Analysis and Hypervolume Subset Selection – A candidate for an NP hard problem?

Supervisor LIACS:	Prof. dr. Michael Emmerich
In cooperation with:	Dr. Andre Deutz
Start date:	2.9.2014 (immediately)
Contact:	emmerich@liacs.nl

Note: The supervisor is a leading Researcher on this question and has developed HSSP selection for special cases. There are some ideas that can be tried.

Summary: Prerequisites (helpful, not mandatory):

Consider problems where n axis aligned boxes cover a volume and a selection of $k < n$ boxes need to be selected that together (union) covers a maximal volume. In 2D dynamic programming can be used, yielding a cubic time complexity, Can it be done faster? It is conjectured that hypervolume subset selection is NP hard in more than two dimensions. Is that so? The assignment will be to work on this difficult question and look for results in the field of parameterized complexity that might point towards solutions. Any progress towards the solution of this problem is very valuable to the advancement of multiobjective optimization methods.



- Interest in computational geometry and complexity

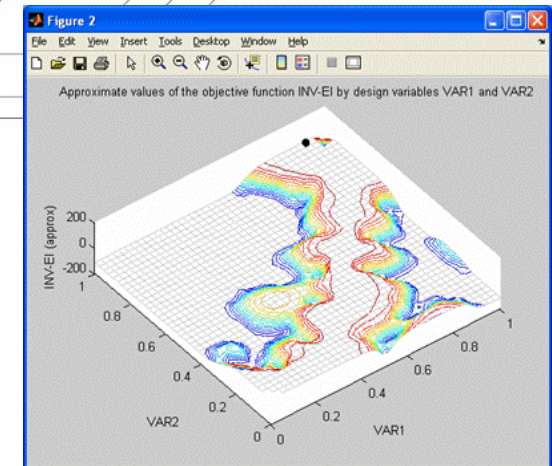
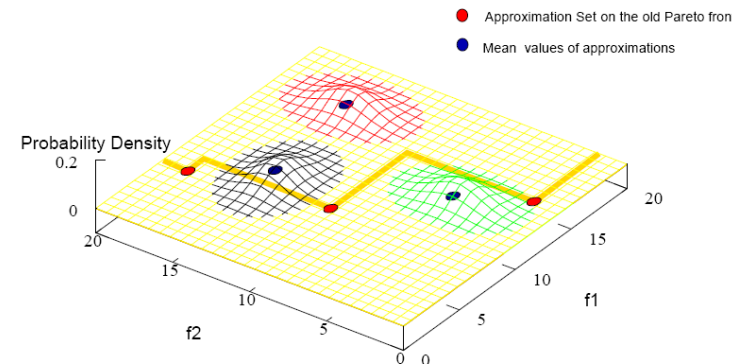
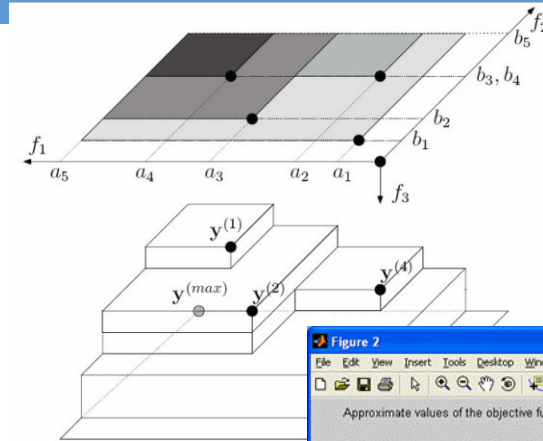
Research Project: Global Multiobjective Optimization with a Limited Budget of Experiments

Supervisor LIACS:	Prof. dr. Michael Emmerich
In cooperation with:	Dr. Rasmus Ursem, Aarhus
Start date:	2.9.2014 (immediately)
Contact:	emmerich@liacs.nl

Note: In the project it is possible to Collaborate with researchers in the University of Applied Science, Cologne Gummersbach.

Summary: Prerequisites (helpful, not mandatory): Evolutionary Multiobjective Optimization Algorithms (EMOAs) are recently widely used to approximate sets of efficient solutions in problems with multiple, possibly conflicting, objective functions. The expected improvement (EI) is a measure used in optimizing systems based on time expensive black-box evaluations to estimate the distance of a yet unevaluated point from the optimum. Since short, a precise computation has been made available by researchers of LIACS for this widely used measure. However, there is work to be done to test this algorithm on different multi-objective problems and to assess possibilities to integrate constraints.

- Interest and basic knowledge in statistical distributions. algorithm complexity, and calculus
- MATLAB and C/C++
- data structures and algorithmics



Multi-point expected improvement

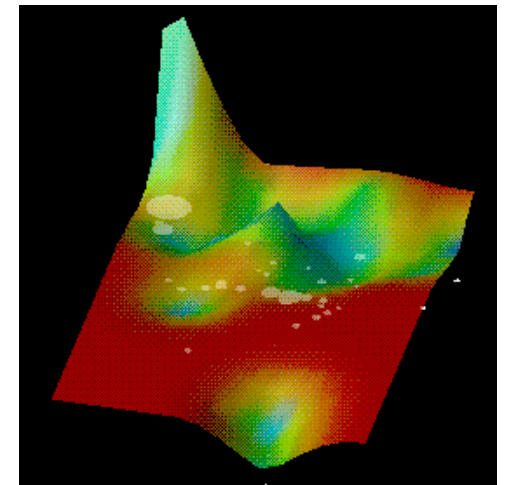
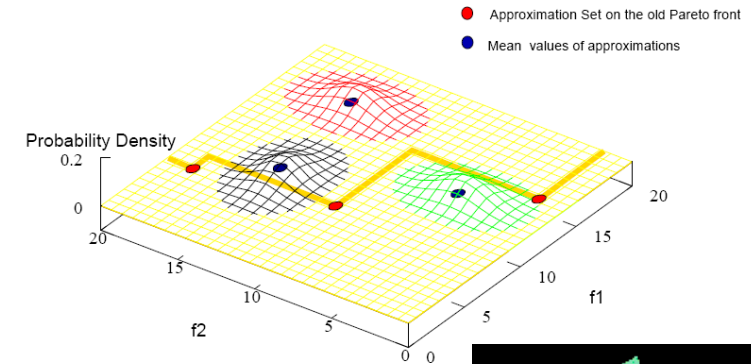
Supervisor LIACS:	Prof. dr. Michael Emmerich
In cooperation with:	Dr. André Deutz
Start date:	2.9.2014 (immediately)
Contact:	emmerich@liacs.nl

In collaboration with Newcastle University,
Dr. Iryna Yevseyeva

Summary: Expected Hypervolume improvement is a measure that can be used in experimental optimization in order to find the most promising candidate for the next experiment. It is a global optimization method for time consuming optimization. The goal is to find a method that selects multiple points, in case the experiments can be conducted in parallel. The project addresses a 'hot topic' in global optimization and a novel approach to solve this problem will be implemented, tested and possibly improved.

Prerequisites (helpful, not mandatory):

Interest in optimization and mathematical software, MATLAB



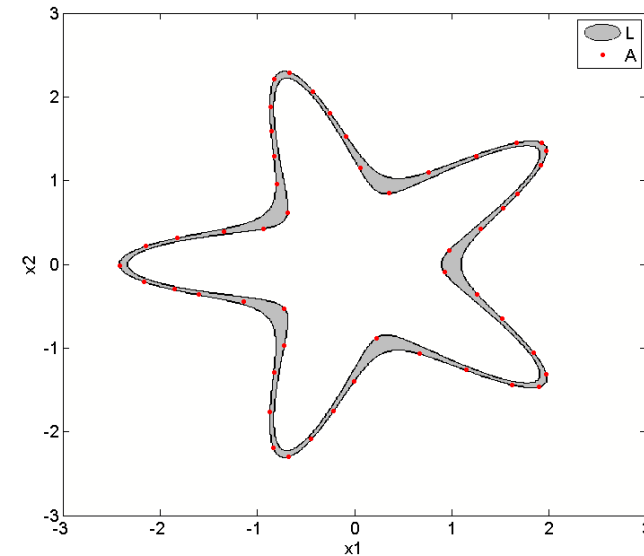
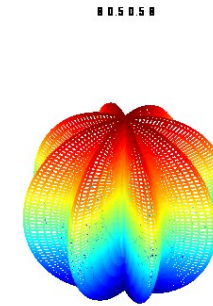
Research Project: Diversity Optimization

Supervisor LIACS:	Prof. dr. Michael Emmerich
In cooperation with:	Dr. Iryna Yevseyeva
Start date:	2.9.2014 (immediately)
Contact:	emmerich@liacs.nl

Summary: Prerequisites (helpful, not mandatory):

Finding a diverse set with prescribed properties can be formulated as an optimization problem. Since long diversification plays an important role in minimizing risks for portfolios. But there is also a great potential in using diversification in optimization, in particular in constraint optimization and in cases where objectives give rise to alternative solutions that all require inspection. More recently Diversity has been put on a axiomatic basis and this has given rise to systematic algorithm design approaches for diversity optimization. First prototypes of such algorithms have been developed in LIACS and applied for drug-discovery. The assignment is to experimentally investigate these, for instance by approximating natural shapes represented in Gielies superformula.

Prerequisites: - Interest and knowledge in evolutionary algorithms, computer graphics



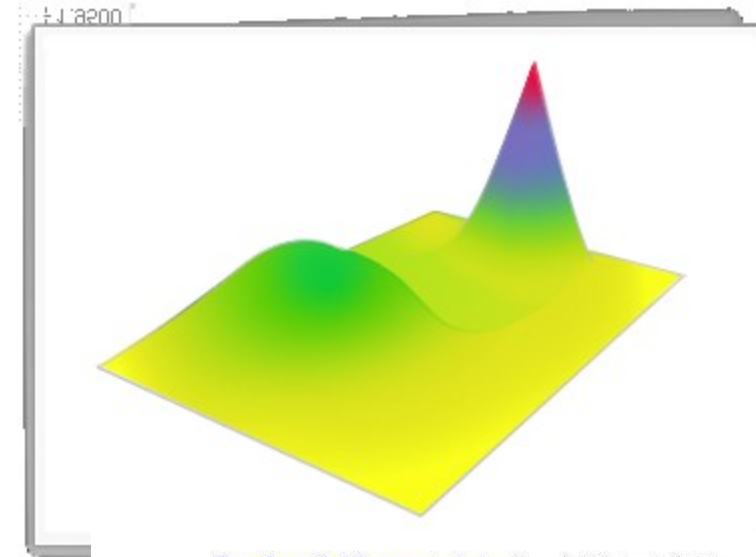
Research Project: Dynamic Updates in Evolutionary Robust Optimization

Supervisor LIACS:	Prof. dr. Michael Emmerich
In cooperation with:	Dr. Jürgen Branke
Start date:	2.9.2014 (immediately)
Contact:	emmerich@liacs.nl

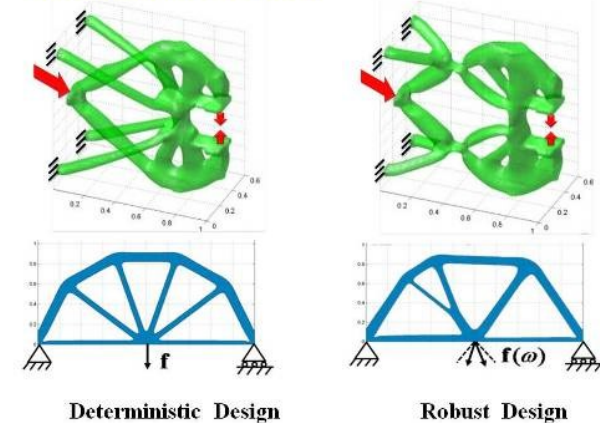
Summary: Prerequisites (helpful, not mandatory):

Robust design optimization deals with finding stable optima. Testing the stability of an optimum can be extremely time consuming. Samples can be recycled and overlap can be exploited in order to reduce complexity. Gibbs samplers can make this process very efficient. Dynamic updates are used in combinatorial optimization but not yet in robust optimization, and a study of this strategy might yield a high impact result.

- Interest and basic knowledge in statistical distributions, algorithm complexity, and calculus
- MATLAB , or C
- evolutionary algorithms



Random field uncertainty: Load, Material, Geometry



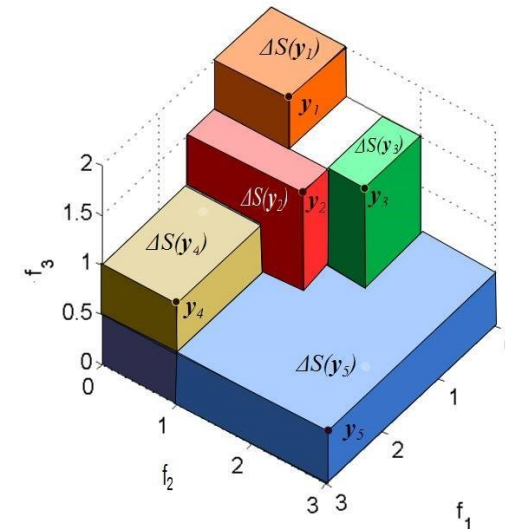
Research Project: Hypervolume Subset Selection – A candidate for an NP hard problem?

Supervisor LIACS:	Prof. dr. Michael Emmerich
In cooperation with:	Dr. Andre Deutz
Start date:	15.9.2013 (immediately)
Contact:	emmerich@liacs.nl

Note: The supervisor is a leading Researcher on this question and has developed HSSP selection for special cases. There are some ideas that can be tried.

Summary: Prerequisites (helpful, not mandatory):

Consider problems where n axis aligned boxes cover a volume and a selection of $k < n$ boxes need to be selected that together (union) covers a maximal volume. In 2D dynamic programming can be used, yielding a cubic time complexity, Can it be done faster? It is conjectured that hypervolume subset selection is NP hard in more than two dimensions. Is that so? The assignment will be to work on this difficult question and look for results in the field of parameterized complexity that might point towards solutions. Any progress towards the solution of this problem is very valuable to the advancement of multiobjective optimization methods.



- Interest in computational geometry and complexity

Project: Parallel Swarms and Set-Gradient Method for Finding Pareto Optimal Sets – Towards 3-D Algorithms

Supervisor LIACS:	Prof. dr. Michael Emmerich
In cooperation with:	Dr. André Deutz
Start date:	2.9.2014 (immediately)
Contact:	emmerich@liacs.nl

In collaboration with Dr. Oliver Schütze,
CINVESTAV Mexico

Summary:

The hypervolume gradient is a field of vectors that point in the direction of maximal net-improvement of a Pareto front approximation in multiobjective optimization. The structure and computation of it has been described in 2014 by André Deutz and Michael Emmerich from Leiden university. It is expected that using the gradient information will significantly enhance continuous multiobjective optimization methods. The aim of the thesis is to develop gradient based algorithms for multiobjective optimization and test their performance on the state-of-the art set benchmarks, both in 2-D and 3-D.

Prerequisites (helpful, not mandatory):

Interest in optimization algorithms and numerics.

