<table>
<tr><td>课程名称</td><td colspan="5"></td></tr>
<tr><td>英文名称</td><td colspan="5">Practical Optimization Algorithm Design</td></tr>
<tr><td>课程编号</td><td></td><td>总学时</td><td></td><td>学　分</td><td></td></tr>
<tr><td>预修课程</td><td colspan="3"></td><td>开课学期</td><td></td></tr>
<tr><td>大纲撰写人</td><td colspan="5">Thomas Weise</td></tr>
<tr><td colspan="6">一、教学目标和基本要求</td></tr>
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The prosperity of any company largely depends on the quality of its products and the economic efficiency of its internal decisions. Many tasks in business and engineering are basically optimization problems, and most of them fall in the category mentioned above. The profit of a logistics company, for instance, largely depends on its timeliness and the resources (gas, drivers, vehicles) it needs to fulfill the customer's transportation orders[1]. The layout of an electrical circuit largely influences its behavior, power consumption, heat production, total area, and costs. The shape of a car or an airplane's wing determines its aerodynamic drag, stability, and, as a consequence, the gas consumption. Large companies such as producers of chemicals have to purchase raw material and refine them in a stepwise process. In order to be efficient, they must be able to fulfill customer's orders in time and purchase the basic goods in the right amount so that no intermediate production step runs out of input or internal silo overflows.

Today, such tasks are often solved manually and with engineering rules-of-thumb, which is costly, time consuming, and leads to results which are far from perfect. However, with many of these processes can be automated with the aid of optimization algorithms. In this course, we will especially focus on metaheuristic optimization methods. Metaheuristics encompass stochastic algorithms for solving complex numerical or combinatorial optimization problems. These algorithms most often do not guarantee to find the best possible solution, but to find a good solution within a short time. They therefore can be applied to problems which are too complex (e.g., NP complete) to be solved by traditional, exact methods in an acceptable time.

Metaheuristic optimization algorithms such as Evolutionary Algorithms (which mimic nature's way of finding solutions), are often able to solve problems like those mentioned before in a much shorter time than human beings while easily surpassing the manually reached solution quality. Companies offering such solutions as part of their portfolio began to appear all over the globe during the last decades, including SolveIT Software, Natural Selection, Inc., and Micromata[1]. On one hand, there is the sheer infinity of possible applications of metaheuristics in order to make businesses more profitable, to solve engineering (and software engineering[2]) tasks more efficiently, and to minimize the consumption and waste of resources. On the other hand, no two such problems are alike and thus, experience and understanding of metaheuristics can become a valuable asset time and again during an IT professional's work life and an ability distinguishing her/him from the coworkers.

This course will provide the students with the ability to recognize optimization problems as such, to formulate them properly, to select the best technique for finding good solutions, to implement and customize this technique for the problem at hand, to be aware of hidden pitfalls and looming mistakes during this process, and to critically evaluate the utility of the developed approach. With the abilities acquired in this course, they will be able to solve or to act as advisor/consultant a variety of tasks and practical, real-world applications.

[1] The lecturer acted as external advisor in a project where the Micromata company developed an Evolutionary Computation-based transportation planning system for the DHL, one of the world's leading logistics companies.

二、课程简介
In this course, we will first analyze the features which constitute an optimization problem, the different classes of optimization problems (combinatorial/numeric, single/multi objective, constraint/unconstraint). We will discuss the features that make a problem complicated and how we can avoid them. From there on, we will introduce different techniques such as simple Hill Climbers, Evolutionary Algorithms (Genetic Algorithms, Genetic Programming, Evolution Strategy), Swarm Intelligence (Particle Swarm Optimization, Ant Colony Optimization), Simulated Annealing, Tabu Search, etc. to solve optimization tasks. The area of Evolutionary Computation will be in the center of this course. Genetic Algorithms are metaheuristics which try to improve a set of many candidate solutions – the so-called population – in cycles ("generations"). In this process, they mimic the natural evolution following Darwin's laws: Different candidate solutions compete with each other in a process of (natural) selection whose survivors are mutated and combined, leading to solutions which are better adapted to the problem at hand. EAs their many facets, parameters, and operations will leave us much room for exploring different algorithm configurations and problem formulations and their impact on the solution quality. The course is accompanied with smaller practical experiments so that the students can test their newly acquired knowledge and a larger project work in which a problem close to the real world is tackled.
三、教学重点、难点
The course is mostly about understanding the basics of optimization, gaining experience in spotting optimization problems when seeing them, acquiring the ability to choose the right (metaheuristic) approach for the right problem, as well as obtaining sufficient knowledge to avoid common pitfalls. The mathematical and the theoretical requirements are moderate, since the focus of the course is in training practical ability.
四、教材名称及主要参考书
Thomas Weise, Global Optimization Algorithms – Theory and Application, http://www.it-weise.de/projects/book.pdf A new third edition of the above (free) book will be developed as teaching material especially for this course. The 2nd version of the book is already used as teaching material by lecturers in courses in e.g., the US, is frequently referenced in scientific publications, and is a primary resource linked from may collections on Evolutionary Computation in the web as well as from Wikipedia. Inside this book, links to a variety of different sources, books, papers, literature, journals, and conferences are given in the beginning of each section, so the students can easily obtain complementary reading material.

[2] USTC's world-renowned Professor Yao leads a research institution focused on metaheuristics in the UK which currently participates in multiple Software Engineering research projects.

五、课程章节主要内容及学时分配		
Unit 1	Introduction to Optimization	4 periods
Unit 2	The Structure of Optimization	8 periods
Unit 3	Simple Hill Climbers and Random Walks	5 periods
Unit 4	Difficulties in Optimization	6 periods
Unit 5	Simulated Annealing and Quenching	4 periods
Unit 6	Genetic Algorithms: The Basic Evolutionary Algorithms	3 periods
Unit 7	Evolutionary Algorithms in General	3 periods
Unit 8	Evolution Strategy	5 periods
Unit 9	Random Keys Encoding	3 periods
Unit 10	Differential Evolution	3 periods
Unit 11	Genetic Programming	4 periods
Unit 12	Estimation of Distribution Algorithms	4 periods
Unit 13	Multi-objective Evolutionary Algorithms	4 periods
Unit 14	Particle Swarm Optimization	2 periods
Unit 15	Ant Colony Optimization	2 periods
		60 periods

The course is accompanied by homework which allows the students to apply their newly attained knowledge to problems close to real-world situations. These homework tasks will always consist of the definition of a certain optimization problem. The students will be completely free on how to solve the problem. The goal is to allow for a competition between different approaches to see who can find the best solutions and how she/he manages to find these solutions.

六、系主任审批意见

系主任签字：　　　年　月　日

附表 2 **实验课程教学大纲**

<table>
<tr><td>实验课程名称</td><td colspan="6"></td></tr>
<tr><td>英文名称</td><td colspan="6">Solving a Real-World Optimization Problem</td></tr>
<tr><td>课程编号</td><td></td><td>总学时</td><td colspan="2"></td><td>学　分</td><td></td></tr>
<tr><td>实验项目数</td><td></td><td>实验课类型</td><td colspan="4">☐基础　☐专基　☐专业　X 上机</td></tr>
<tr><td>预修实验课程</td><td colspan="4"></td><td>开课学期</td><td></td></tr>
<tr><td>大纲主撰写人</td><td colspan="6">Thomas Weise</td></tr>
<tr><td colspan="7">一、实验教学目标与基本要求</td></tr>
<tr><td colspan="7">The goal of the project is to solve an optimization problem from the industry, the real world. This problem is provided in cooperation the Micromata from Germany. The basic task is to find an efficient way to route and schedule a fleet of transportation vehicles of a large logistics company in order to fulfill all the transportation orders of its clients. The involved data and constraints are realistic, and occur in exactly this way every day in logistics companies. The document “Solving Real-World Vehicle Routing Problems with Evolutionary Algorithms”[3] outlines the basic elements of the task which will be published in detail later.

The students are completely free in the way in which they solve the task. No restrictions of any kind will be given. Because of this freedom, this project is intended to be a competition to find out who can best solve the task. At the end of the semester, the results of the students will be compared and they will present their solution approaches. The best solutions will receive a small award.</td></tr>
<tr><td colspan="7">二、实验项目内容及学时分配</td></tr>
<tr><td>序号</td><td colspan="2">实验项目内容</td><td colspan="2">学　时</td><td colspan="2">实验内容类型</td></tr>
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<tr><td colspan="7">三、实验讲义、参考书</td></tr>
<tr><td colspan="7"></td></tr>
<tr><td colspan="7">四、系主任审批意见</td></tr>
<tr><td colspan="7">系主任签字：　　　　　年　　月　　日</td></tr>
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*实验内容类型：注明该项实验是验证型、演示型、开放型、综合型或设计型等。

[3] http://www.it-weise.de/documents/files/WPG2009SRWVRPWEA.pdf