The 23rd ECMI Modelling Week
European Student Workshop
on Mathematical Modelling
in Industry and Commerce

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Project 1:

Using oil booms to clean up large oil spills

In case of an oil spill at sea, stopping the spill from reaching shore is critical. One of the most important tools in such operations is the oil containment boom, floating booms that stop the formation of large oil films, concentrating the oil in thicker layers that can be skimmed. The Norwegian company Norlense produces containment booms of different types for different operating conditions and perform full scale tests with this equipment. The assignment will consist in modeling one or more aspects of oil boom operation, and possibly to investigate some proposed modifications Norlense are working on.

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Students: **Xuedi Rachel Deng**, ESIM, Kaiserslautern, Germany
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Stefan Mühlböck, Linz, Austria
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Room nr **4.01, C-13**

PROJECT 2:

How do bees breed?

In a beehive bees can influence their offspring by controlling temperature in the broodcombs. This way they "produce" queens, drone bees and worker bees by specifically heating different areas of the beehive. We are interested in optimal heating strategies to obtain certain temperature distributions.

Instructor: **MARTIN BRACKE**, Kaiserslautern, Germany

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Room nr **4.02, C-13**

Project 3:

How to enhance the exploratory power of Qlucore Omics Explorer?

Qlucore Omics Explorer (QOE) is a data analysis tool from Qlucore. Information about the company, the data analysis software and a free evaluation version of the software can be found at http://www.qlucore.com/

Using QOE a researcher can explore huge datasets looking for patterns and structure. Powerful statistical methods in QOE secure that possible findings are statistically relevant. Customers from biomedical research laboratories and other life science clients use the software to find structure in datasets coming from for example genome wide RNA or DNA expression analysis experiments, so called microarray experiments. An example (Ross et.al. "Classification of pediatric acute lymphoblastic leukemia by gene expression profiling", Blood 2003, Vol. 102, No 8 pp. 2951-2959) of such a dataset is provided in QOE as an example dataset.

Working with QOE the researcher uses only the information provided in the current dataset. Normally, apart from the actual measurements, there is additional biological information provided by the laboratory as annotations to the dataset, but usually these annotations represent only a very small fragment of all previously known biological facts concerning the participating genes, proteins or other present biological variables.

There exist huge databases on the internet where a lot of additional biomedical information can be found. The most prominent examples regarding information concerning genes or proteins are Gene Ontology, see http://www.geneontology.org/, and the Gene Set Enrichment Analysis database Molecular Signatures Database (MSigDB), see http://www.broadinstitute.org/gsea/msigdb.

The goal of the project is to suggest ways and possible methods to enhance the exploratory power of QOE, when scanning huge RNA and DNA expression analysis experiments, by using the additional biomedical information provided by for example the MSigDB.

A direct problem could be how to compare lists of genes having known biological functions (extracted from e.g. the MSigDB) with lists of genes found using QOE on the measurements coming from a microarray experiment, in such a way as to extract additional biologically useful information.

The Gene Set Enrichment Analysis (GSEA) is actually an analytical method designed to compare lists of biologically defined genes with lists of genes found by other means. One starting point of the project could be the article by Subramanian et.al. "Gene set enrichment analysis: A knowledge-based approach for interpreting genome-wide expression profiles" PNAS 205 Vol. 102, No 43 pp. 15545-15550.

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Room nr **4.03, C-13**

PROJECT 4:

How to climb a mountain?

We are searching the optimal way to reach the top of a mountain.

Instructor: **THOMAS GOETZ**, Kaiserslautern, Germany

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Rasmus Henningsson, Lund, Sweden
Miłosz Marzec, Wrocław, Poland
Sina Meister, Dresden, Germany
Till Schröter, Oxford, UK

Room nr **4.04, C-13**

PROJECT 5:

Influence of physical and economical factors on electricity spot market price.

Electricity spot prices are one of the most difficult types of financial time series in terms of forecasting, mainly because of the non-storability of electricity. This feature, which makes electric power unlike most other commodities, causes outstanding price spikes. Moreover, the last several years in the financial world seem to show that 'spiky' behaviour of time series is no longer an exception, but rather a regular phenomenon.

Specialists claim that most of the price spikes occur in situations of physical transmission constraints. Moreover, high price changes may follow sudden difficult weather conditions. To proceed with electricity price modelling we intend to have price series cleared of observations that can be explained by physical or economical factors.

The problem includes:

- identifying high price changes caused by physical/weather/economical factors,
- working out a method of removing those observations from data series.

Data sets available for the problem are:

- Nord Pool spot prices, electricity flow, weather data,
- New Zealand spot prices, transmission constraints, weather data.

Instructor: **MATYLDA JABŁOŃSKA**, Lappeenranta, Finland

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Room nr **4.05, C-13**

PROJECT 6:

Optimal strategies in the electricity market

Due to the deregulation processes in the electricity market, its participants become exposed to the significant price risk. Sudden increase of the spot price during a delivery period could cause very high losses for a trading company. Thus, efficient hedging strategies should be constructed. The problem involves building an optimal trading portfolio, including derivatives such as forward contracts, options and contracts for difference. The special features of electricity prices such as seasonality, non-storability and correlation with other commodities should be taken into account. The data sets will be available for the spot prices, derivative prices, system capacity and gas prices from the Nord Pool.

Instructor: **JOANNA JANCZURA**, Wrocław, Poland

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Alessandro Mattavelli, Milan, Italy
Jean-Yves Tissot, Grenoble, France

Room nr **4.06, C-13**

PROJECT 7:

How to connect two pipes of circular and rectangular profiles?

The aim of the project is to design an element connecting a circular-profile pipe with a rectangular-profile one, see Figure 1. The element should be easy to be made by means of turning down and/or rolling the sheet-metal pieces of the appropriate shapes and then welding them. It should provide perfect air-tightness of the obtained part of internal-combustion system.

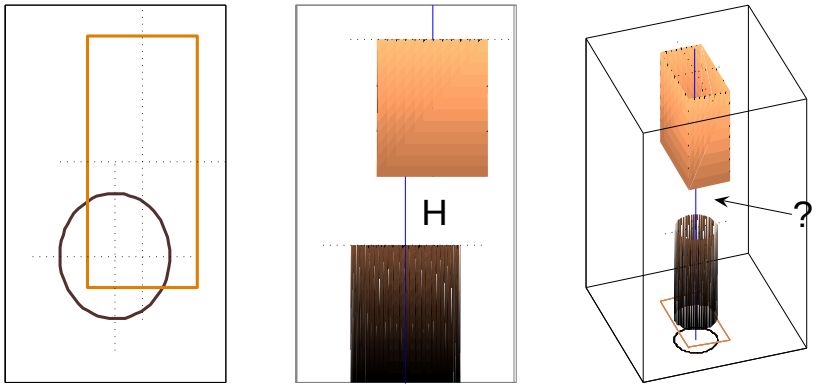

Figure 1.

Hint: consider first the case of circular- and square-profile pipes that have the same symmetry axis, see Figure 2.

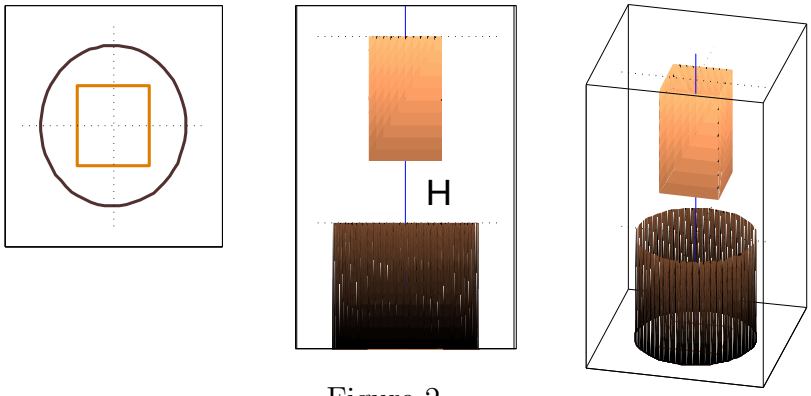

Figure 2.

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Jonathan Wulcan, Lund, Sweden

Room nr **3.11, C-11**

PROJECT 8:

An inverse problem in biology: Estimating microbial production rates from nutrient concentration profiles in sea water

We are interested in finding microbial production or consumption rates from measured nutrient concentration profiles in vertical sections through the sea water colum of sea-floor sediments. The knowledge of these rates can be used to identify zones with high biological activity. Unfortunately, it is quite difficult to measure these rates directly. It is therfore common practice to use indirect measurements, e.g. the nutrient concentration rates, and to indirectly infer from these data to the production and consumption rates. Using an ODE model that relates nutrient rates to microbial rates this indirect interference turns out to be an inverse problem and ill-posed problem. In order to solve it, regularization has to be used. It is the main goal of this project to understand, model and solve the direct and inverse problem by numerical methods using appropriate regularization schemes.

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Room nr **4.37, C-13**

PROJECT 9:

Ranking American College Football Teams

Each December, college football fans and pundits across America debate which two teams should meet in the NCAA Division I-A National Championship game. The Bowl Championship Series (BCS) standings employed to select the teams invited to this game are intended to provide an unequivocal #1 versus #2 game for the championship. However, this selection process has itself been highly controversial in recent years. The goal of this project is to generate and analyze alternative ranking algorithms.

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Room nr **3.06, C-13**

PROJECT 10:

How to finish a cycling race in shortest possible time?

Optimal strategies how to pace oneself shall be found.

Instructor: **ELISA ROEHRIG**, Kaiserslautern, Germany

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Shilan Mistry, Oxford, UK
Nicole Noack, Dresden, Germany
Jarno Rantala, Tampere, Finland
Reena Undla, Tartu, Estonia

Room nr **3.01, C-13**

PROJECT 11:

Improving the Efficiency of Allergy Tests

Allergy tests are utilized to detect allergic reactions to certain substances (allergenes). A well known standard procedure is the prick-test (or scratch- test). Potentially allergy inducing substances are applied onto the skin which is then pricked slightly to allow the allergenes to enter the upper dermis. After some time (approx. 20 min), the allergic reaction can be evaluated by means of the degree of redness and the size of the wheals of the affected region. The skin is pricked once for each allergen in this procedure, i.e. for n substances n pricks are needed, where n is about 20 in a usual medical examination.

In order to design a more elaborate treatment with less pricks, one can apply several substances, each consisting of a mix of allergenes. The test will then have a positive result if the patient is allergic to at least one if its components. Actually, one has to regard potiental reactions among the ingredients impacting the result, i.e. the reaction of the upper dermis. In our model we will exclude the consideratiuon of these dependencies.

The aim is to develop a method to find the substances a patient is allergic to with as few pricks as possible. More precisely, $q < n$ compounds of allergenes shall be analyzed in terms of their skin irritations. The reaction pattern may allow to detect the involved allergenes unambiguously.

Obviously, one can not expect to get a correct result for every combination of allergic substances since the number 2^q of possible outputs is less then the number 2^n of possible allergic reactions. However, the exact answer is important only for a small number $k < n$ of allergenes in many cases. If the number of allergic substances exceeds k then a polyallergy is diagnosted which is treated in a different way less fitted to the included allergenes. We assume the number k to be about 5. The number of tests q is supposed to be as small as possible, but will increase while k is growing.

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