86th ESGI

European Study Groups with Industry in Portugal

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LEMA, Instituto Superior de Engenharia do Porto
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PT MATHS IN
rede portuguesa de matemática para a indústria e inovação

working groups

CHALLENGE 1

Service scheduling in garden maintenance
industry_ **Neoturf**
sector_ **Services**

Neoturf is a portuguese company working in the area of project, building and garden maintenance. Concerning maintenance services, a specific issue is related to service scheduling. Among others, the following restrictions and specifications must be taken into account:

- Each client is allocated to one maintenance team.
- The number of services per client and per year is previously determined at the beginning of the year, with differences between the Spring/Summer and Autumn/Winter periods.
- There are several maintenance activities, as well as several different machines that may be allocated to these activities.
- Some clients have a fixed day for maintenance that cannot be changed.
  There are some unpredictable variables that may imply a sudden change in the scheduling (weather, last minute cancelations, etc.).
- Their costumer portfolio is geographically spread over a wide region, with the distance between different clients thus becoming an important factor in the final scheduling.
  Neoturf would thus like to develop an efficient and flexible way to organize its scheduling, taking into account the optimization of existing resources.

CHALLENGE 2

Optimal scheduling of the engine repair process
industry_ **TAP Maintenance and Engineering**
sector_ **Aeronautic**

TAP Maintenance and Engineering is aiming to optimize the maintenance services, and become even more competitive, focusing on the reduction of the engines repair turnaround time. As part of this effort, the Engine Shop Production Planning Department would like to have a mathematical model for the repair process with the aim of minimizing delays and determining the optimal sequencing of tasks within the different stations.

CHALLENGE 3

Modelling fiber flow in fiberboard manufacturing
industry_ **Sonae Industria - Produção e Comercialização de Derivados de Madeira, S.A**
sector_ **Manufacturing of wood products**

Wooden chips and resin are the two main components in the manufacturing of medium-density fiberboard (MDF). One of the most important parts of the production process is the combination of these two materials into a fiber mat which is then pressed into boards. This process involves first applying high temperatures to the chips to refine them into fibers and then sending these fibers to flow into a blow-line together with water vapour, where they are combined with resin injected at different points (injectors). The company would like to understand better the behaviour of the fiber flow on the blow-line in what concerns speed, pressure and dead zones. This information about the process is then to be used for the optimization of the design of the blow-line to increase efficiency and reduce costs.

CHALLENGE 4

Modelling drying process in paper manufacturing
industry_ **Euroresinas - Indústrias Quimicas, S.A.**
sector_ **Pulp, Paper and Cork**

Euroresinas produces different types of resin-impregnated paper at their factories. After the paper goes through the resin bath, it is lead through a drying process which is a fundamental step in the process. Although the temperature is controlled by a heating system, the actual values inside the chain of dryers are only measured at a few points away from where the paper is actually flowing. The company would like to be able to model the temperature profile inside the dryers to better understand problems such as dusting and sticking, as well as the optimization of different variables related to bathing and drying times and energy consumption.

CHALLENGE 5

Modelling power networks
industry_ **INESC**
sector_ **Engineering and Research**

A power network (nodes, branches) is regulated by flow equations based on the 1st and 2nd Kirchhoff Laws.
LAW 1: the net flow in a node of the network is zero: $\sum_j F_{ij} + \sum_j F_{ji}$

The network topology is a graph that may be described by a branch-node incidence matrix **T** (composed of elements with values -1, 1 or 0 only). Nodal injections are described by a vector **L**. The 1st Law may be translated into the matrix equation **TF=L**
LAW 2: the flow in a branch is proportional to the difference in potential **P** between its extreme nodes: $F_{ij} = b_{ij}(P_i - P_j)$
This may be globally translated into a matrix equation where **B** is a diagonal matrix: $F = B\,T^T P$
The combination of the two Laws produces a well-known circuit equation $T\,B\,T^T P = L$ or $Y P = L$ where **Y** is sometimes called a nodal-admittance matrix and **P** is a vector of nodal potentials.
The industrial partner would like the studygroup to be focussed on the following questions:

- Admit that in a network with n nodes and m branches, one has available k measurements, with k > n. These measurements may by on a mix of injections **L**, nodal potentials **P** and branch flows **B**.
  Admit that these measurements are contaminated with noise. Therefore, the measurements do not form a set compatible with the circuit equation or the Kirchhoff Laws.
  Admit that this noise is Gaussian, and independent for each measurement. Admit that the variance is any case is small.
  One wishes therefore to find a set of Potentials p that would minimize some reasonable definition of an error between the measurement vector and the vector of values (F, L or P) that is compatible with the circuit equations.
- Admit that some of the measurement errors are gross errors (much larger than the errors admitted previously), and that it is unknown where such gross errors occur. These may severely contaminate the estimation of **p**.
  Discover which measurements contain gross errors (instead of small errors) and achieve an estimation of **p** ignoring these gross errors.
- Admit now that there are switches scattered in the network branches. They can assume a state of open (S = 0) or closed (S = 1). An open switch interrupts the branch flow and eliminates this branch from the network (namely, from matrix **T**).
  Admit that there are measuring devices that report each switch status.
  Assume that, beside the k measurements of (**F**, **L** or **P**), some switch status signals are missing – so, the network topology becomes unknown.
  The challenge is double: to guess correctly the network topology and thus to estimate **p**.

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