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Prof. Luc Martens (Luc.Martens@intec.UGent.be) and Prof. Wout Joseph (Wout.Joseph@UGent.be)

RECOMMENDER SYSTEMS | WIRELESS NETWORKS | BIOELECTROMAGNETICS | INDUSTRY

# PERSONALISED RECOMMENDATIONS AND DATA MINING

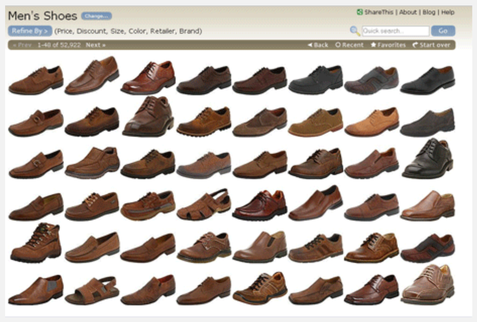
## PERSONALISED RECOMMENDATIONS

**What are recommendations?**

Personalised suggestions for content
Based on the user's preferences


**Why do we need recommendations?**

Information overload
Assist users in decision making




**Where do we find recommendations?**

At all major online companies

amazon.com LinkedIn NETFLIX telenet ebay Spotify YouTube IMDb

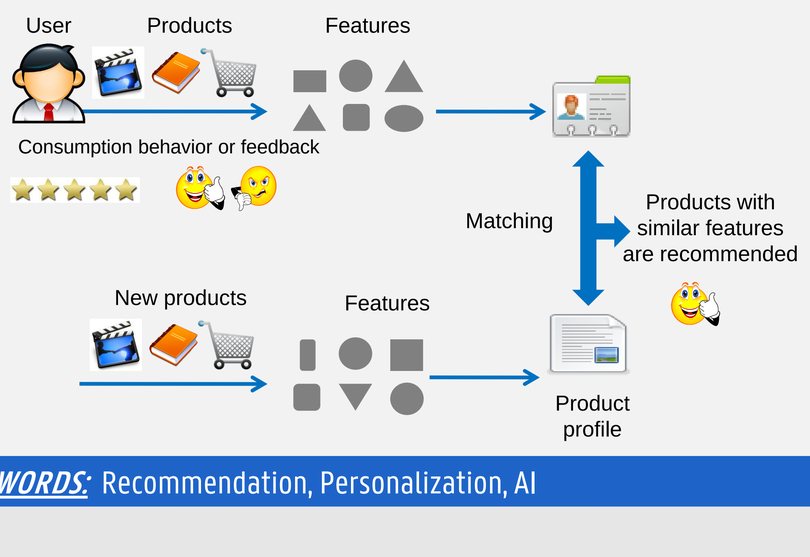
**Goal(s) of recommendations?**

Increased revenue

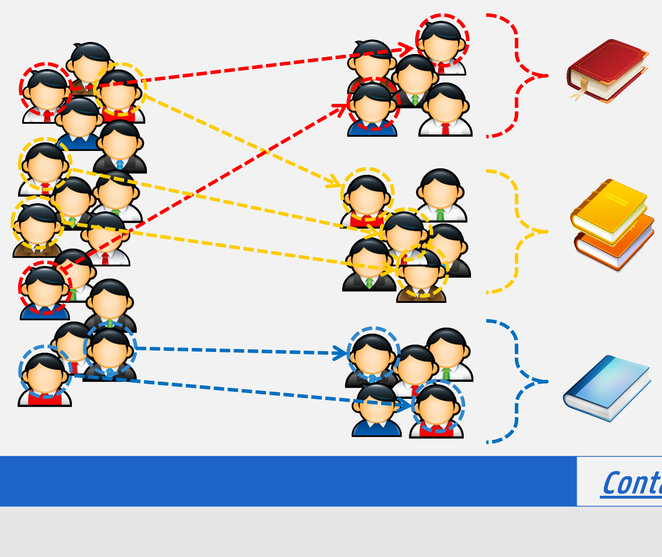
Improved user experience

**How to make recommendations?**

Based on content characteristics




Based on community behavior



**What are the open issues?**

User context

Recommendations for groups

Gathering implicit feedback


***KEY WORDS:*** Recommendation, Personalization, AI

***Contact:*** Toon.DePessemier@UGent.be

## DATA MINING

**More available data: Everyone is data producer**

Transport, navigation


Health

Telecommunication

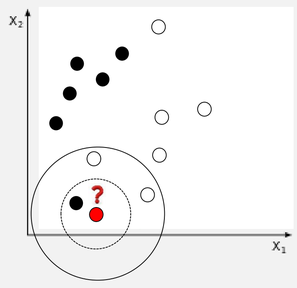
Sports, physical activities

Entertainment

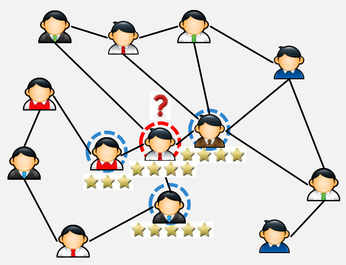
Machine learning
Big data technologies
Cloud storage
Predictive analytics

**Examples:**

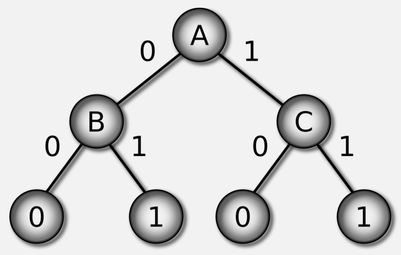
**Classification**



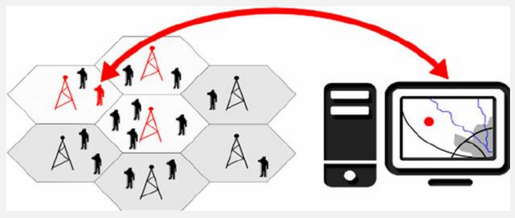

**Nearest neighbour**



**Decision tree**




**Location estimation and prediction**



**Identifying routes, PoI, Events**

***KEY WORDS:*** Mobile, Big data, Android, Machine learning

***Contact:*** Toon.DePessemier@UGent.be

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# SIGNAL PROPAGATION, LOCALISATION AND GREEN WIRELESS & UAV-AIDED NETWORKS

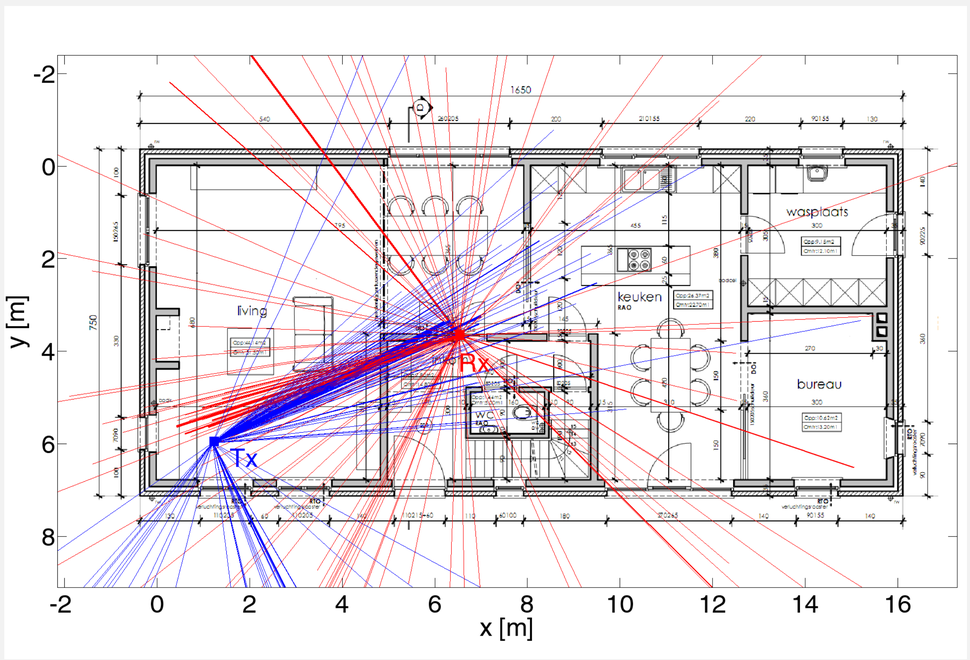
## SIGNAL PROPAGATION

**Radio channel sounding**
- Channel sounding = measuring the complex channel gain from transmitter to receiver
- Multidimensional measurements: gain as function of space (antenna position), frequency, time and polarisation

**Multipath component estimation**
- Multipath components = plane waves emanating from the transmitter and reflecting off the environment before arriving at the receiver
- Estimated from radio channel sounding data with signal processing algorithms (figure)
- Focus on fast-converging maximum-likelihood algorithms: SAGE and RiMAX

**Radio channel modelling**
- Hybrid deterministic ("ray-traced") and statistical models of multipath component parameters
- Multipath component parameters: power, direction of arrival and departure, time of arrival, Doppler shift and polarisation

**Visible light channel modelling**
- Impact of reflections, dust, spectral light distribution




***KEY WORDS:*** channel sounding, multipath components, channel modelling

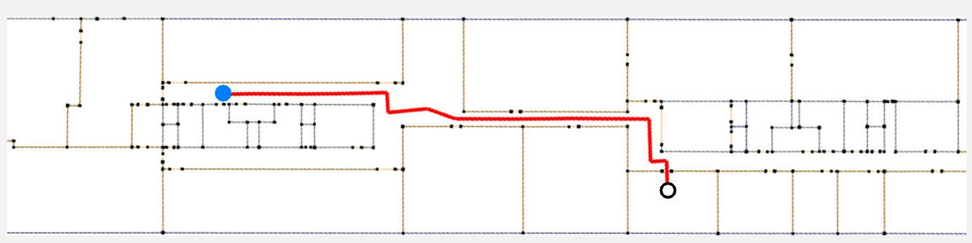
***Contact:*** Emmeric.Tanghe@UGent.be

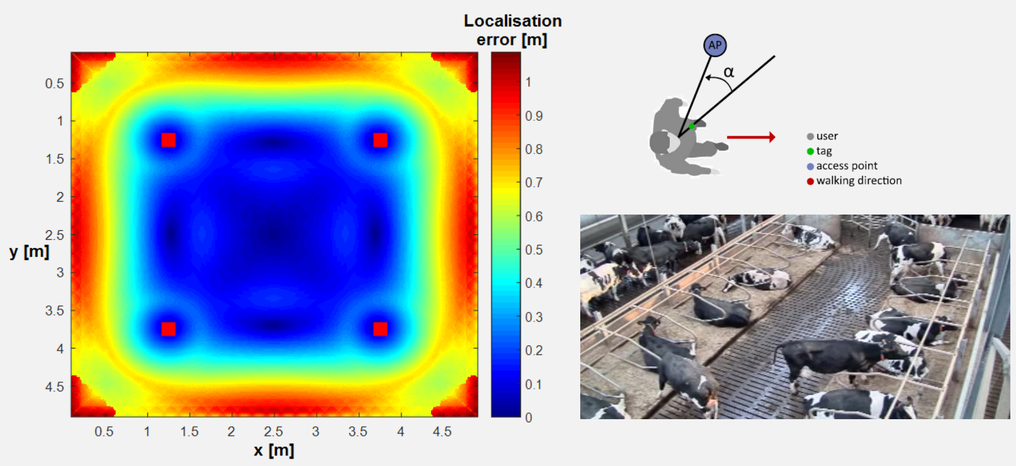
## LOCALISATION

**Active localization**
- Signal strength based localisation techniques: WiFi, Zigbee, BLE, LoRa
- Angle-of-Arrival based localisation: antenna array to estimate the angle of incidence
- Time-of-Arrival based localisation: time of flight to estimate distance between nodes
- Combination of multiple techniques
- Android App for indoor navigation
- Visible light positioning (VLP): impact of LED pattern, field-of-view of photo diode, propagation channel aspects
- Acoustic localisation
- Internet-of-Animals

**Passive localization**
- Radar
- Visible light technology

**Sensor fusion and added intelligence**
- Explore possibilities of accelerometer, gyroscope, environmental (walls, door,…) information, human body information… to enhance location estimations






***KEY WORDS:*** localisation, algorithms, sensor fusion, IoT

***Contact:*** David.Plets@UGent.be

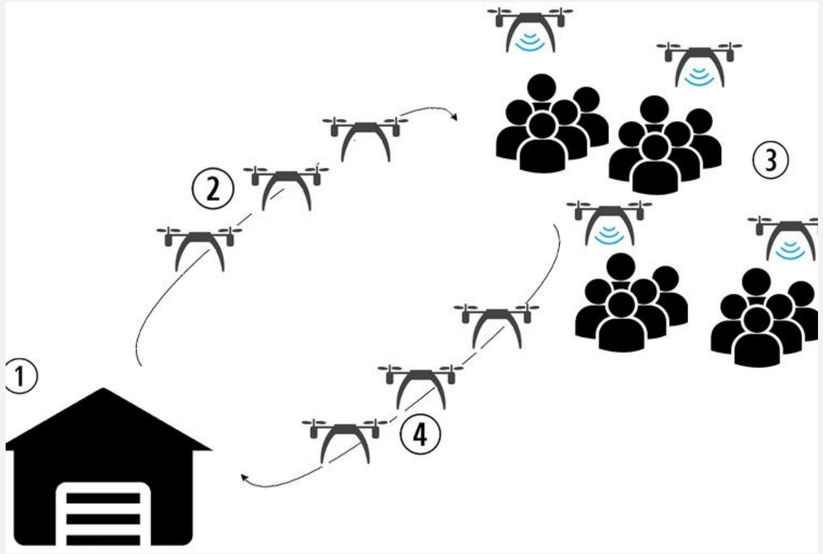
## Green wireless & UAV-aided networks

**Green wireless access networks**
- Green wireless access network: energy consumption & human exposure are important!
- WAVES developed a deployment tool (JAVA) for green wireless access networks, i.e., optimizing power consumption & human exposure
- Heterogeneous network: supporting multiple wireless technologies & different base station types in one network

→ *Can the support of heterogeneous networks reduce the network's power consumption?*

**UAV-aided networks**
- Wireless networks can be unreliable & become quickly saturated in case of a disaster scenario (e.g., storm, traffic jam, terror attack)
- WAVES developed a deployment tool (JAVA) for drone based emergency ad-hoc networks
- Promising research topic, but high amount of drones is required

→ *Can moving public transport & emergency vehicles reduce the traffic load of the drone mounted base stations?*
→ *Can we improve the drone's service time by using solar energy?*
→ *Multicopter or winged drone: which one is preferred?*
→ *Can we use a mesh networks between the drones for backhauling?*
→ *Evaluating the human exposure of a drone based network*




***KEY WORDS:*** 4G, 5G, B5G, deployment tool, drone, emergency network, energy consumption, UAV, wireless networks

***Contact:*** Margot.Deruyck@UGent.be

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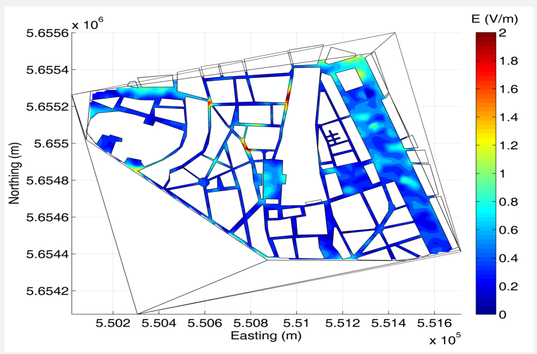
# ELECTROMAGNETIC FIELDS: EXPOSURE AND MEDICAL APPLICATIONS

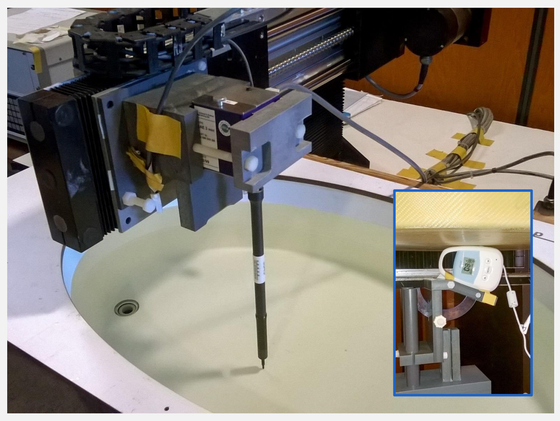
## EXPOSURE TO ELECTROMAGNETIC FIELDS

- The population is exposed to Radio Frequency (RF) electromagnetic fields
- Telecommunication evolves, so research into measurement techniques and characterization of electromagnetic fields is necessary for keep up with current (4G, LTE) and future technologies (5G)




### In-situ exposure measurements

- Static field measurements using free-space RF probes
- Dynamic RF measurements using (unmanned) vehicles and personal exposure meters



### Compliance testing

- Exposure and absorption are regulated in order to prevent excessive heating
- Regulation requires compliance measurements, but these are time consuming and not straightforward for any device
- Research on improving accuracy and speed of RF compliance measurements


### Numerical RF dosimetry

- RF fields are also absorbed in the human body, which causes dielectric heating
- Numerical RF dosimetry tries to quantify this absorption using simulations, mainly Finite-Difference Time-Domain (FDTD)

### Exposure systems

- Tissue simulating liquids for mmWave frequencies

***KEY WORDS:*** Electromagnetic field exposure, numerical and experimental dosimetry, tissue simulating liquids, compliance assessment, in-situ exposure assessment

***Contact:*** Gunter.Vermeeren@UGent.be
Arno.Thielens@UGent.be

## MEDICAL APPLICATIONS OF ELECTROMAGNETIC FIELDS

**Neurostimulation**

- Modulation of the firing pattern of neurons and neuronal networks in the central nervous system
- The modulatory signals are commonly low-frequency (100 Hz) pulse trains delivered invasively or non-invasively by an electrode
- Goal is to reverse the abnormal firing behaviour associated with neurological diseases
- Deep brain stimulation for Parkinson's disease, essential tremor, obsessive-compulsive disorder
- Auricular vagus nerve stimulation for peripheral artery disease

**Simulation of the electromagnetic field generated by the neurostimulator**

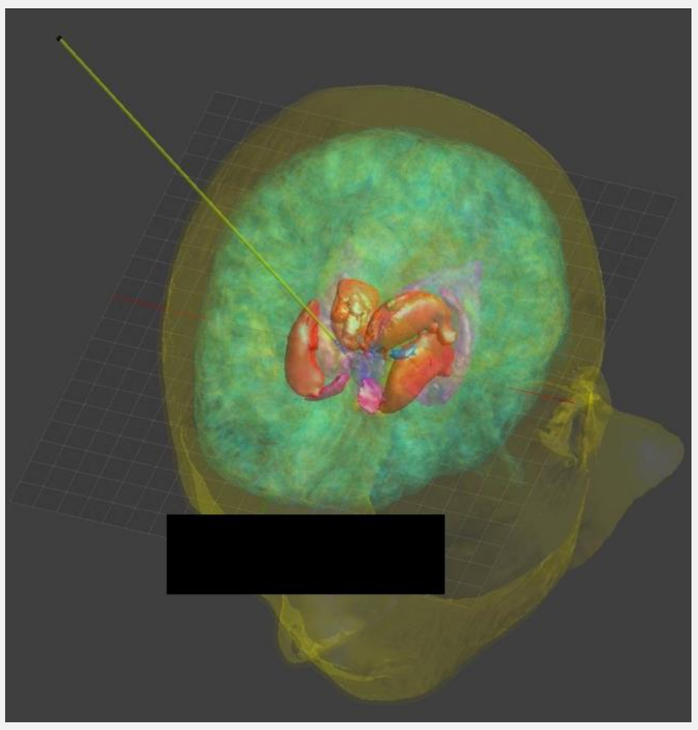
- Finite-element method (low frequency)
- Realistic discretised anatomical models of humans complete with the electromagnetic constitutive parameters of the biological tissues (top figure)
- Outcome: electric field, electric potential and current distribution in the vicinity of the neurostimulator

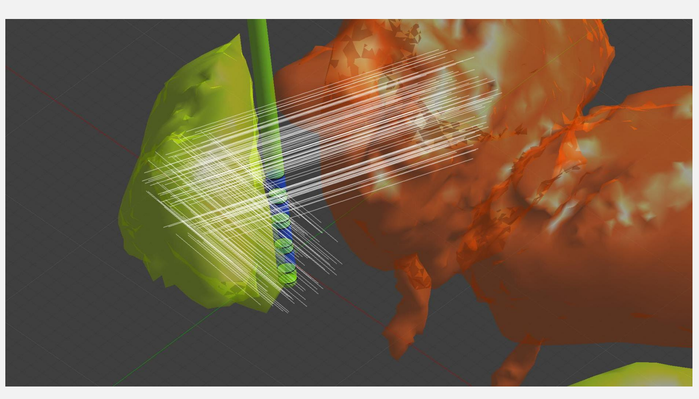
**Simulation of the neuronal response to the induced electromagnetic field**

- Based on cable theory = equivalent electrical circuit representation of a neuron
- Cable model includes active parts that can be excited by the induced electric field
- Neurons are interconnected with synaptic models to form neuronal networks (bottom figure)

**Assessing the effect of the neurostimulator on the pathological firing pattern**

- Frequency spectrum
- Firing rate
- Information entropy





***KEY WORDS:*** neurostimulation, electromagnetic field simulation, neuron simulation

***Contact:*** Emmeric.Tanghe@UGent.be

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# ENERGY AND COST OPTIMISATION OF INDUSTRIAL PROCESSES

**Production scheduling** is the allocation of available production resources over time to best satisfy some criteria , such as reduced makespan and production cost. Its importance is increasing due to the 4$^{th}$ industrial revolution in different countries around the world, such as Industry 4.0 in Germany, Industrial Internet in the USA, and Made in China 2025.

➡ This research aims to integrate **energy efficiency** in a conventional production scheduling engine such that **sustainable production** is enabled, where the sustainability will provide economic, environmental, and social impact.

➡ Potential **collaboration**: SIMTech - A*STAR @ Singapore (Singapore Institute of Manufacturing Technology affiliated within Singapore Agency for Science, Technology and Research)
Loughborough university & University of Glasgow @ UK

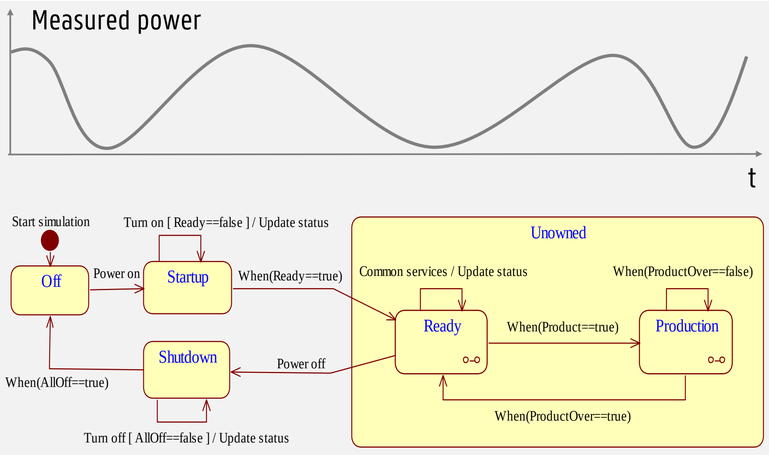
## Current production schduling

- ✗ Manual production scheduling in spreedsheets is still prevalent in factories
  - ✗ Simple dispatching rule (such as first-in-first-out)
  - ✗ Limited to small scale (in terms of number of jobs, number of machines, and number of time slots)
  - ✗ Error-prone
  - ✗ Highly costy (production scheduler is often a full-time job)
- ✗ Energy efficiency is not well considered
  - ✗ No energy awareness
  - ✗ Simple assumption of constant energy consumption per machine
  - ✗ Assumption of several incomplete machine power states without measurements
  - ✗ No or simple machine idling mode

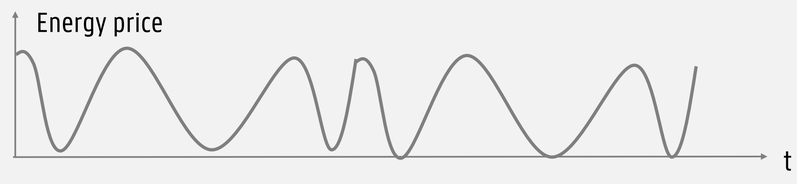
## Future production scheduling

- ✓ Automatic production scheduling engine which can be updated over time
- ✓ Integrated energy efficiency for sustainable production
  - ✓ Diverse energy-related calculations enabled by empirical energy models (such as time-stamped power curve, energy consumption, energy cost, $CO_2$ emissions, etc.)
  - ✓ Decision making on optimal machine idling mode for energy conservation
- ✓ Advanced scheduling functions
  - ✓ Job split/freezing
  - ✓ Integrated consideration of other important production aspects (such as labor cost, inventory cost, and transportation cost)
  - ✓ Large-scale yet highly-efficient optimization
  - ✓ Robust against unforeseen events (such as machine failure and rush order)

## Energy model




## Volatile energy price




## Labor shift

| Labor | Early shift | Late shift | Night shift |
|---|---|---|---|
| Operator 1 | No | Yes | No |
| Operator 2 | Yes | No | No |
| Technician 1 | Yes | No | No |
| Technician 2 | No | Yes | No |

Energy conser-vation

Energy cost reduction

Labor cost reduction

GREEN FACTORY

**Sustainable production schedule**

Efficient optimiza-tion

Flexible configu-ration

## Optimization

- Single-/multi-objective optimization
- Mathematical programming
  - Integer/mixed-integer programming
  - Linear/non-linear programming
- Methaheuristics
  - Genetic algorithm
  - Memetic algorithm
  - Particle swarm optimization
  - Ant colony optimiation
  - Cuckoo search
  - Bees algorithm
  - ...

## High-performance computing

- Speedup of optimization/scheduling algorithm
  - Parallel computing
  - Code optimization
- Design of experiment
  - Parameter sensitivity analysis
  - Algorithmic performance evaluation

## Multi-level factory model

- Single machine
- Parallel machine
- Flow shop
- Flexible flow shop
- Job shop
- Flexible job shop
- Interconnected factories

***KEY WORDS:*** computational intelligence, production scheduling, personnel scheduling, optimization, evolutionary algorithms, scalability, industrial energy efficiency, industrial demand-side management

***Contact:*** **Xu.Gong@UGent.be**
**Toon.DePessemier@UGent.be**

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