RECOMMENDER SYSTEMS | WIRELESS NETWORKS | BIOELECTROMAGNETICS | INDUSTRY

PERSONALISED RECOMMENDATIONS AND DATA MINING

PERSONALISED RECOMMENDATIONS

Why do we need recommendations?
- Information overload
- Assist users in decision making

Where do we find recommendations?
- At all major online companies

Goal(s) of recommendations?
- Increased revenue
- Improved user experience

How to make recommendations?

Based on content characteristics
- User
- Products
- Features

Based on community behavior
- New products
- Features
- Matching
- Products with similar features are recommended

DATA MINING

More available data: Everyone is data producer

- Transport, navigation
- Health
- Telecommunication
- Sports, physical activities
- Entertainment

Examples:

- Classification
- Nearest neighbour
- Decision Tree
- Location estimation and prediction

KEY WORDS: Recommendation, Personalization, AI

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

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**WAVES**

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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

**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

**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, 6G, deployment tool, drone, emergency network, energy consumption, UAV, wireless networks

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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

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)

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

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

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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

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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 4th 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 scheduling**

- Manual production scheduling in spreadsheets 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 costly (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, CO2 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**

Measured power vs. time

Energy profiling

**Volatile energy price**

Energy cost reduction

**Labor shift**

<table>
<thead>
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<th>Labor</th>
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<th>Late shift</th>
<th>Night shift</th>
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<tr>
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<tr>
<td>Technician 1</td>
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</tr>
<tr>
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</tbody>
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**Optimization**

- Single/multi-objective optimization
- Mathematical programming
  - Integer/mixed-integer programming
  - Linear/non-linear programming
- Metaheuristics
  - Genetic algorithm
  - Memetic algorithm
  - Particle swarm optimization
  - Ant colony optimisation
  - 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

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