Introducing TML

Artificial Intelligence
Traffic Management
The Rise of Autonomous Vehicles
Further Issues
What is artificial intelligence?

- **Artificial narrow intelligence (‘weak AI’)**
  - Very narrow, specific purpose
  - Big Data and complex algorithms (chess players, Facebook wall, …)
  - Will not pass Turing test

- **Artificial general intelligence (‘strong/true AI’)**
  - AI thinks as humans do (incl. intentionality)
  - Machines that are good at doing what comes easily for humans
  - Eventually learns and upgrades itself, on its own (~ 2035)

- **Artificial superintelligence**
  - Behold, the technological singularity! (~ 2040)
  - Cannot be easily ‘turned off’
AI in a nutshell

● Background:
  – The study of ‘intelligent agents’ (optimisation)
  – Goal: mimic cognitive functions learning / problem solving

● Techniques:
  – Multi-objective/level optimisation
  – (Fuzzy) reasoning engines
  – Multi-agent systems (MAS)
  – Artificial Neural Networks (ANNs)
  – Reinforcement learning
  – Classification and regression

➔ In general: machine learning through statistics
What about the ‘intelligence’?

● Some key ingredients:
  – Incremental problem solving (incl. learning)
  – Real-time adaptation to changing context/environment
  – Self-analysis (success ⇔ failure at tasks)
  – Memory (short- and long-term storage)
  – Cope with large volumes of data (cf. Vol/Var/Vel/Val/Ver)

● AI’s highs and lows
  – Expectation management
  – AI Winters (’70-’90) and Summers
  – Nowadays: deep learning
Classic traffic management

- **Scope (for road traffic):**
  - The focus lies heavily on urban traffic management (i.e., traffic lights)

- **Techniques:**
  - Classic algorithmic solutions, simple heuristics, expert systems, ...
  - Ramp metering, speed harmonisation, route guidance, incident detection, ...
  - Some fancier stuff: congestion prediction (MPC), fuzzy logic, ...

- **Tools:**
  - Traffic Network Study Tool (TRANSYT)
  - Split Cycle Offset Optimisation Technique (SCOOT)
  - Urban Traffic Optimisation by Integrated Automation (UTOPIA)
  - OPAC / Rhodes / OMNIA / MOTION / SCATS / Optimax / Green Logic / MOVA / LHOVRA / COCON / ...
  - LISA+ / VERA+ / ANNA+ / INES+ / SYLVIA+
Hierarchical control

• Similar to the Open Systems Interconnection (OSI)
  – PATH framework (US) / Dolphin framework (Japan)
  – Auto21 Collaborative Driving System (CDS) framework
  – Cooperative Vehicle-Infrastructure Systems (CVIS) (EU)
  – SafeSpot (EU FP6) / PReVENT (EU) / …

• Possible layers:
  – Handheld ⇔ in-vehicle ⇔ roadside systems
  – Physical ⇔ regulation ⇔ coordination ⇔ planning ⇔ link ⇔ network

• Scope of the layers:
  – Controlling vehicle dynamics, manoeuvring, HMI, V2X, …
  – Path/network/congestion control (platoon sizes, route assignments), …
  – Global ⇔ locally distributed controllers
Organising complex systems

- Cf. Helbing’s classification:
Including ‘social’ aspects

- Shifting perspective towards the individual (informing)

- Input data for personalised services:
  - Twitter feeds / WhatsApp / Facebook traffic-related content
  - On-demand ride matching
  - Waze / Google Maps probes
  - Various floating vehicle data
  - C-ITS

- Social traffic management:
  - Leverage the power of the community
  - Accomplish large-scale behavioural changes
Current AI and traffic cases

- Traffic light control:
  - Congestion / queue length predictions

- In the automotive sector:
  - Traffic sign / context recognition, ACC, ISA, route guidance, ...

- The Theory-Practice Gap (*experimental ⇔ mainstream*)
  - Only limited advancements are exploited in the field
  - Currently AI is mostly used as a building block
  - Dealing with long platoons
  - Scalability (from a single freeway to network-wide coordination)
AI and traffic lights

- Intersection control has non-linearities and NP-hard

- Techniques:
  - Vehicles and intersections as intelligent agents
  - Self-organisation through ant-based optimisation
    - Information exchange (pheromones and evaporation)
    - ‘Antiquette’ (moving aside)
    - **Ants speed up with density**
  - Examples of decentralised control:
    - Pittsburgh: I2I(V) (+ unknown AI algorithms)
    - Toronto/Burlington (MARLIN): game theory + learning
    - Dresden: multimodal + model-based predictions

- Benefits: 25%↓ TTs, 40%↓ idling time, 20%↓ braking, ...
AI adoption and AVs

cooperative connected automated mobility (CCAM)

- AVs require a model of the world around them
  - Lots of sensor inputs (camera’s, LIDAR, wheel encoder, GPS, ...)
  - Goal: remove the (absolute) need for pre-programmed maps

- AV levels:
  - Level 3 → feasible
  - Level 4 → promised 2025 (Honda)
  - Level 5 →

- The AV revolution will enable/require traffic management on a higher and broader level (+ infrastructure modifications)
No more traffic lights?

- “Traffic lights are no solution, they cause people to speed like hell and brake like idiots”

- It’s not about structurally changing into a roundabout

- Experiments with traffic lights switched off (UK)

- But mostly operating very locally and with low volumes (+ at the cost of pedestrians’ waiting times)
AVs negotiating intersections

- Slot-based (platoons ⇔ individual vehicles)
Network-wide management

● Currently: ATMS ⇔ ATIS interactions + manual work
● Go beyond ‘multiple intersections’ (automatically!)
● Singapore:
  – Intelligent route finding algorithms
  – Minimise probability of traffic breakdown
  – Crucial element: non-linearity of congestion (10% connected)
● Traffic Management 2.0 (www.tm20.org)
  – Collaborations between road operators and service providers
  – Common interfaces, principles, and business models
Further issues

● Dealing with transition areas (e.g., road works)
  – (Early) warning systems
  – Pro-active (mandatory) control of approaching vehicles

● To what degree can we automate the processes?
  – Discovering seeds of congestion (different patterns)
  – Finetuning ramp metering, VMS, ...
  – Where to put the emphasis (i.e., what goal to optimise)?

● Various other issues:
  – Responsibilities and ethics (cf. AV debates)
  – Standards (EC ⇔ OEM ⇔ global consortia)
A note on the future of AI

● The evolution of the human race will go much quicker than that of the AI (cf. 2035-2040 time horizon)
  – Changes in mobility patterns
  – Changes in travel behaviour
  – Changes in infrastructure, vehicles, and communication

● Good ⇔ Bad AI (= human concepts)

(abstract away)
More information?

- **Transport & Mobility Leuven:**
  
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