Main objective

Design and implement a self-organizing, adaptive, distributed and monitoring-aware approach to traffic light control

• Based on information coming from V2X communication
• Automatically selecting the proper policy
• Receiving feedback on its choice
• Automatically tuned
Self-organizing traffic light control: the concept

Control Loop

- Sensing
- Policy selection
- Policy execution
- Evaluation
- Feedback

We developed the **Swarm controller** based on swarm intelligence concepts
Traffic light controller policies

- Different traffic situations need different policies
  - Policy specialization
    - Low traffic
    - High traffic
    - Not homogeneous traffic
    - Congestions & burst

- Selection of the lanes and the length of the green phase
Pheromone abstracts traffic conditions

Every car leaves a **virtual pheromone trail** on the road

Pheromone proportional to the **level of congestion**

More robust than simply counting vehicles (w.r.t. incomplete information)
The pheromone computation relies on the average speed and its derivative (acceleration) of the vehicles.

\[ f_i(k+1) = \beta f_i(k) + \gamma v(l,k); f_i(0) = 0 \]

\[ v(l,k) = \frac{MaxSpeed(l) - MeanVehicleSpeed(l,k)}{dMeanVehicleSpeed(l,k)/dk} \]
- **Specialized policies** for every traffic conditions
- The controller is pushed to **chose a policy**
- Probabilistic selection
- Each policy has its own stimulus function
- The **stimulus functions** are represented by a set of Gaussians in the pheromone space

\[ s_{i,j} : [0, f_{max}] \times [0, f_{max}] \rightarrow \mathbb{R}^+ \]
Synthetic but realistic scenarios

- RiLSA
- Corridor
- Grid

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Monza scenario: a real world example
Realistic traffic conditions

Considering realistic daily load curves
Penetration Rate

Comparing the Swarm Controller With:

- **Classic Static** Controller
- **Actuated** Controller (inductive loops knowledge ➔ 100%)
- **Swarm** Controller (inductive loops knowledge ➔ 100%)
- **Swarm** Controller (incomplete knowledge ➔ 25%)

Evaluation on the average waiting time

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Monza results

<table>
<thead>
<tr>
<th>Waiting time</th>
<th>Static</th>
<th>Actuated 100%</th>
<th>Swarm 100%</th>
<th>Swarm 25%</th>
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</thead>
<tbody>
<tr>
<td>42.5</td>
<td>40.89</td>
<td>36.54</td>
<td>35.97</td>
<td>36.05</td>
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Conclusions

- We developed a swarm based traffic light controller
- Extensive evaluations shows promising results
- The system has been extended to manage:
  - Pedestrian
  - Bicycles
  - Emergency vehicles
  - Public transport