ATS: Adaptive Traffic System

Motivation
- Fixed-cycle traffic lights create inefficiencies, especially during uneven traffic distributions.
- Existing Intelligent Transportation Systems (ITS) for variable-cycle traffic lights rely on induction-loop sensors and push buttons.
- This infrastructure is costly to implement ($150,000/intersection) and requires heavy roadside construction and disrupts traffic.
- Additionally, current systems cannot enforce pedestrians to press the push buttons.

Proposed Solution
Induction-loop, push-button-like system
- An adaptive traffic system that assigns variable green-light times based on real-time traffic conditions and does not require substantial roadwork or construction times.

Passive recognition
- Detects vehicles and the presence of pedestrians using cameras and ping sensors, at $1/4$ the cost of the induction-loop system.

Pedestrian detection
- Estimates the trend of pedestrians throughout the day based on smartphone Wi-Fi scanning.

Algorithm: Phase Allocator
- At every iteration $t$, we calculate a weighted sum of vehicles $v$ and pedestrians $p$, scaled by $k_v$, the Pedestrian Sensitivity Factor (PSF):

\[
\begin{align*}
\phi_{i,NS} &= v_{i,NS} + k_v p_{i,NS} \\
\phi_{i,WE} &= v_{i,WE} + k_v p_{i,WE}
\end{align*}
\]

- We use this information to assign the next green-light times $\phi$ to find the queuing rate $\gamma$.
- From this, we assign the next green-light times:

\[
\begin{align*}
\phi_{i+1,NS} &= \frac{1}{\gamma} \left( T v_{i,NS} + \phi_{i,NS} \right) \\
\phi_{i+1,WE} &= \frac{1}{\gamma} \left( T v_{i,WE} + \phi_{i,WE} \right)
\end{align*}
\]

- We allocate a min/max time for each iteration, to ensure pedestrians have enough time to cross the street.

Pedestrian Detection
- Ping sensors detect waiting pedestrians with certainty based on a timed detection algorithm.
- Given the 57% mobile market penetration in the US, the average pedestrian traffic flow can be estimated by detecting the number of smartphones in a predetermined radius.
- An IEEE 802.11a/b/g/n network card is set into monitor mode, with a limited detection range.
- MAC addresses of surrounding mobile devices are obtained, filtered, and counted.

Systematic Implementation
- Four cameras (A), four ping sensors (B), and four routers (C) are used for detection.

Validation
“...one of the problems we have in the City is the failure of residents to actually push the pedestrian button. Many cross against the signal. Being able to detect our customers, without requiring them to push the button would be valuable.”

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