Algorithms and Simulation Scenarios for Countdown Traffic Signals

Master‘s Thesis of Can Doğramacı

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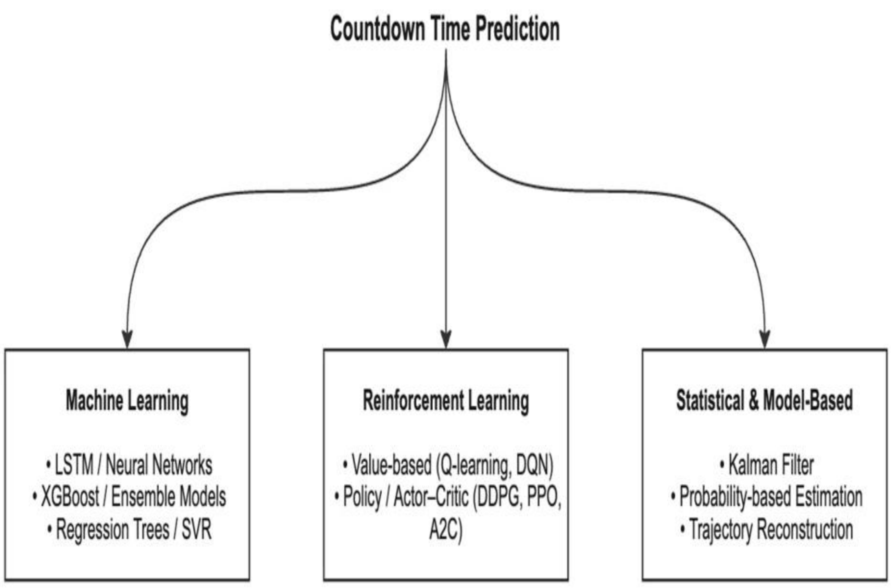
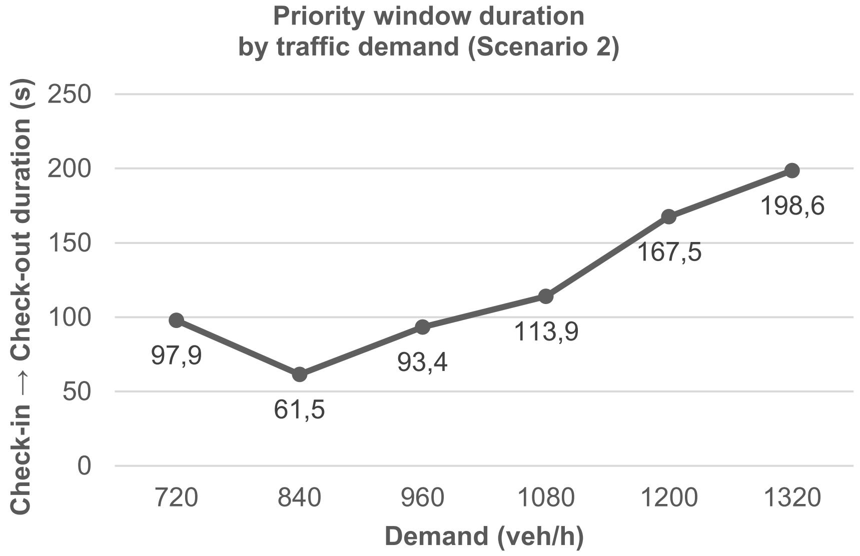


Simulation Testbed & Scenarios

The simulation uses a calibrated SUMO simulation of the TUM-VT Ottobrunn intersection, including realistic lane geometry, loop detectors, pedestrian crossings, and a public-transport corridor.

Detectors logging events that would trigger actuation in a real controller without altering the sequence. To examine when countdown prediction becomes challenging so that worth to test, four scenarios were designed :

S1 – Natural gap-outs: Measures how often random headways create early-termination or extension opportunities, and whether these alignments stay irregular or become more systematic as demand increases.
S2 – PT priority: Assesses how much the PT sign-in → sign-out sequence varies in length with increasing demand, and identifies which component is the main driver of that variability.
S3 – Single-side ped. calls: Evaluates how often single side ped. requests occur and how demand influences their frequency, given their inherently stochastic and hard-to-predict nature.
S4 – Dual pedestrian calls: Checks how frequently simultaneous ped. calls appear under different demand levels, since frequent dual calls require controller decisions that must balance pedestrian service with vehicle flow.

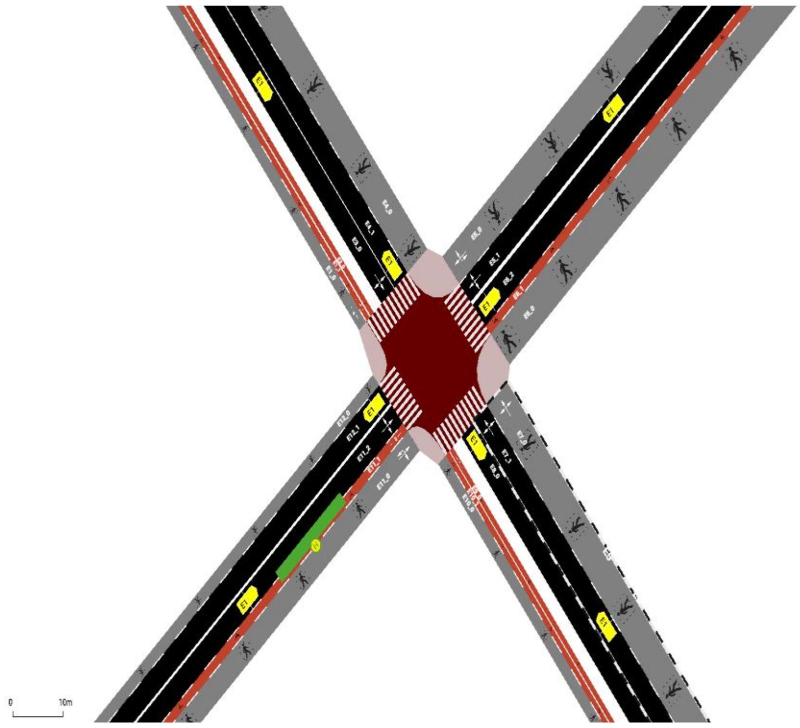


Motivation & Aim

Germany relies almost entirely on traffic-actuated signal control, where phase lengths vary cycle-to-cycle. Because the remaining green or red time is not fixed, classic countdown timers cannot be deployed, even though countdowns abroad have shown safety and comfort benefits.

With increasing availability of detector data and SPaT information, predictive countdowns have become technically feasible — but their applicability under German actuation remains unclear.

This thesis identifies which operational conditions are worth testing by designing representative simulation scenarios that capture real variability (gap-outs, PT priority, pedestrian calls). It investigates under which conditions countdown predictions could work reliably and which algorithm families (statistical/model-based, ML, RL) are most suitable, forming the basis for future experimental testing at the TUM-VT Ottobrunn site.



Key Findings

Patterns show what countdown prediction must handle in actuated settings. S1 produces short-horizon, irregular gap-out triggers, making conditional-probability models and Kalman filters the most suitable. S2 has a structured PT-priority process whose timing still varies with travel, dwell, and clearance times,requiring stage-aware ML and hybrid models (e.g., XGBoost + Bayesian or LSTM ensembles). S3 shows the weakest pattern of all scenarios, as single-side pedestrian calls are too rare to form any consistent structure, best handled by a Bayesian framework; while S4 reveals frequent, synchronized dual calls at higher demand—shifting the challenge from predicting events to other concerns between competing modes, where actor–critic RL agents become relevant.

Capacity performance indicators remain rather stable. Together, the scenarios highlight where prediction is most stable, where it becomes difficult to anticipate, and how these insights support a roadmap of scenarios worth testing toward controlled field trials.