GOSPACE LABS: Prediction of Parking Space Occupancy in Towns

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Project name: Prediction of parking space occupancy in towns Project's period: October 2024 – April 2025 Partner: GOSPACE LABS s. r. o.

The industry partner needed a way to better understand and forecast parking-lot behavior, where user arrivals and occupancy can shift by hour, day, and season. They were looking for more than a single best-guess forecast: they needed predictions that could also express uncertainty, so operational decisions could be made with clearer risk awareness. As the collaboration evolved, new longer-horizon data arrived, which increased the need for a scalable and repeatable modeling workflow.

How we approached it

We approached this by combining two complementary modeling tracks in one reproducible machine-learning pipeline:

First, we built time-dependent Markov-chain models to capture occupancy-state transitions for both whole-lot and individual-slot behavior.
Second, we implemented conformal prediction methods on top of the point-forecast models to produce statistically grounded prediction intervals.

We used DVC (Data Version Control) to manage both tracks, allowing preprocessing, training, prediction, and evaluation to be rerun reproducibly across dataset versions.

"Quality prediction in smart parking isn't just about achieving the lowest possible model error — it's primarily about the ability to quantify uncertainty and carry it into decision-making. By combining Markov state models and conformal prediction, we created a solution that doesn't offer just a single forecast of the future, but a realistic interval of possible scenarios."

Philipp Miotti

Research Engineer

What we delivered

The delivered result was a full end-to-end forecasting framework for parking management: data processing, feature engineering, model training, prediction generation, and automated evaluation outputs. It provides occupancy forecasts at multiple levels (aggregate and slot-level), and produces decision-ready artifacts such as interval plots, performance metrics, and model visualizations. In practical terms, the partner received a maintainable system for parking predictions with transparent confidence estimates, ready for iterative improvement as new data arrives.

Partner’s perspective (GOSPACE LABS)

We supplied occupancy data from our IoT parking sensors and defined the questions the model had to answer. What we wanted was probabilistic: for a given hour and day, how many spaces are likely to be free, expressed with a confidence level rather than a single number, and projected a day ahead. We also asked for forecasts at the level of individual bays and for patterns in how our most active users behave. The reason is operational. Reliable occupancy forecasts let us share the same physical spaces more efficiently and support dynamic pricing, since demand is not constant. Occupancy climbs in bad weather, for example, when more people drive instead of walk. The forecasts also power what we call easy sharing: when a driver reliably commutes on the same days and time window, we can offer their bay to someone else while it sits empty, and still hold back enough capacity for the small share of drivers who arrive unpredictably. Knowing that probability tells us exactly how many spaces to keep in reserve.

“A forecast is only useful if you can act on it. We did not need a single prediction, we needed a confidence range: how many spaces will be free in a given hour, and how sure we can be. That is what lets us share bays, price by demand, and still guarantee a spot for the driver who turns up unannounced.”

Ján Hrončák

Head of Business Development at Fleximodo by GOSPACE LABS

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