A Simulation Model for FIU's Parking Garages

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ABSTRACT

Parking guidance systems which provide information and recommendations on finding available parking in parking garages are significantly beneficial to users. These systems require calibration and evaluation before their application in the field. One way to accomplish this step is to evaluate them in a simulated environment. In this work, we report on a discrete simulation model of cruising for garage parking that serves as a virtual test bed for calibrating and evaluating the garage parking guidance algorithms. The developed model has been validated based on real-world data of several of Florida International University's (FIU) parking garages. The validation results show an average deviation of under 10%.

BACKGROUND

Informed Traveler Program and Applications (ITPA) is an advanced consumer-oriented and multimodal transportation management software and technology system currently under development by Florida International University High Performance Database Research Center. ITPA will provide customized real-time and predictive information in the areas of multimodal and intermodal transportation. It will offer innovative solutions using real-time and predictive data to improve the decisions each individual can make before determining traveling to an intermodal station, desired parking space and final destination. ITPA will also provide management support to traffic, transit, and parking providers, enabling them to manage their resources more effectively and more efficiently.

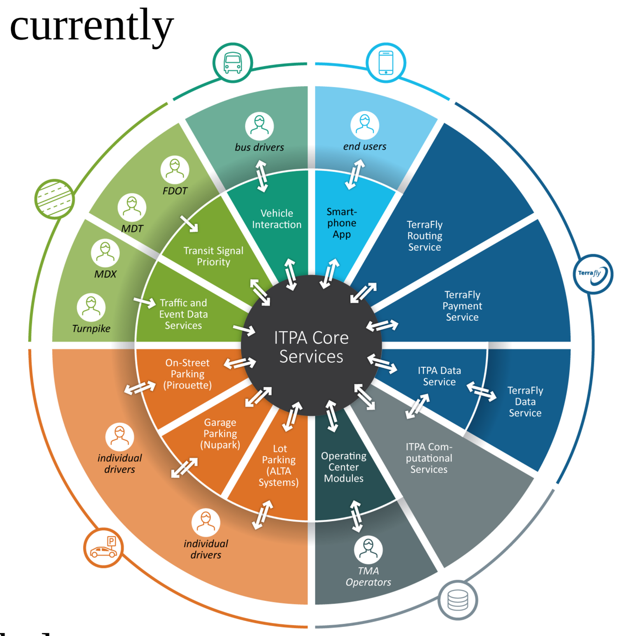


Figure 1: ITPA components and environment

PARKING SIMULATION MODEL

- An agent-based simulation model usually includes two components: the agents themselves and the environment they interact with.

Modeling parking garages

- The parking garage is modeled as an attributed graph G(A,E).
- A node a ϵ A represents an area of the parking garage.
- Each node a ϵ A is attributed by its total number of parking slots z_a, the number of currently occupied slots o_a at time t, by extension also the number of free slots $f_a(t) = z_a - o_a(t)$ at time t, and the average time r_a a car needs to traverse and search the area.
- An edge e(a_i,a_j) ϵ E with a_i,a_j ϵ A represents a direct connection between two areas a_i and a_j which is traversable by car.
- Each edge e(a_i,a_j) ϵ E is attributed by a time r_e a car needs to move from area a_i to area a_j. In cases where areas are directly adjoining, r_e = 0 can be assumed.

PARKING SIMULATION MODEL

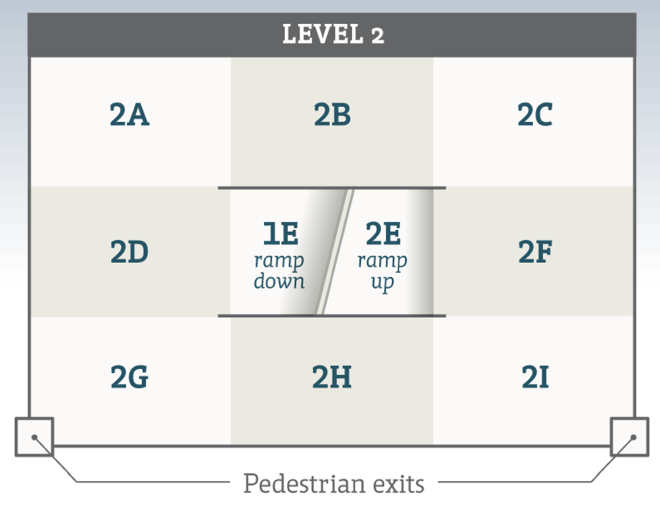


Figure 2: Simplified parking garage level

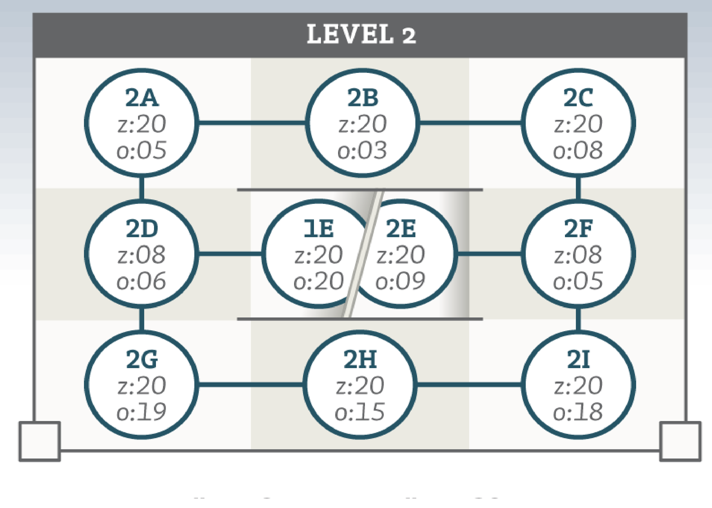
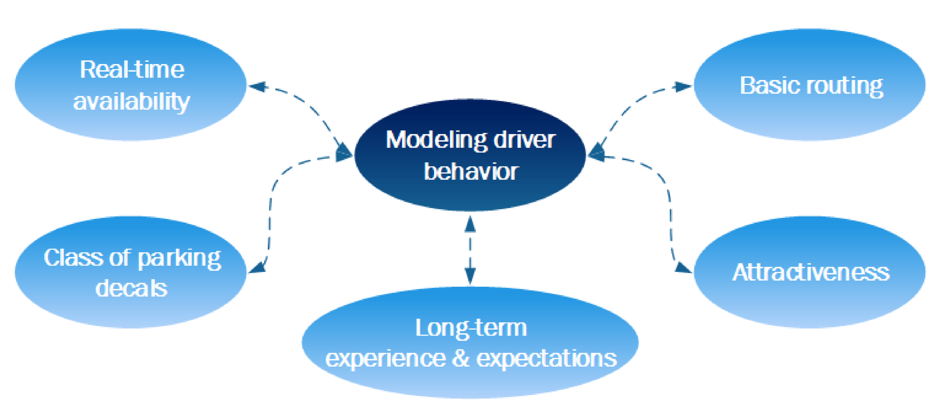


Figure 3: Partial model graph of parking garage level

Modeling driver behavior

While searching an area for available parking, agents have to make one of two decisions: they have to decide whether to park in the current area (parking decision) and, if not, where to go next (routing decision). To enable the agents to make these decisions, the model considers a number of aspects:



- **Basic routing:** During the course of the simulation run, agents move from area a_i to area a_j via an edge e(a_i,a_j) ϵ E. An agent increments a counter $v(a_i)$, which represent the number of times an area a_i has been visited by that agent. If an agent always chooses one of the routing options a_j with the lowest $v(a_j)$, every loop will eventually be broken.
- **Attractiveness:** The model assumes that a driver prefers to park in a slot which is as attractive as possible. The model, therefore, assumes an order of attractiveness on areas of a parking garage: $1.0 \geq c(a_{i_1}) \geq \ldots \geq c(a_{i_n}) \geq 0.0$. Agents prefer areas with greater values of c(a_i) to areas with lower attractiveness.
- **Real-time availability:** Drivers also consider real-time availability: if they observe that no spaces are available in a specific area, they are not attracted to it.
- **Classes of parking decals:** FIU offers various classes of parking decals (e.g., administration, faculty/staff, student, etc.) with some classes having more options than others. This is modeled by assigning each agent a decal class and by assigning each slot to one of these classes.
- **Long-term experience and expectations:** Drivers with long-term experience already know the attractiveness of each area and can also estimate the individual area's attractiveness. These experiences and expectations can be modeled by extending the look-ahead set to the whole graph, and by replacing the exact knowledge $f_a(t)$ by a "*guessing function*" $h_a(t) = f_a(t) \pm random$, which includes a small random component.

VALIDATION AND RESULTS

- The Florida International University Parkview Housing Garage provides students living in adjacent dorms with 282 parking slots on three levels.
- It consists of 16 areas with an average of 17.6 slots.
- The model was applied to simulate 100 operational days.
- A simulation run generates approx. 1,700,000 events of nine event types.

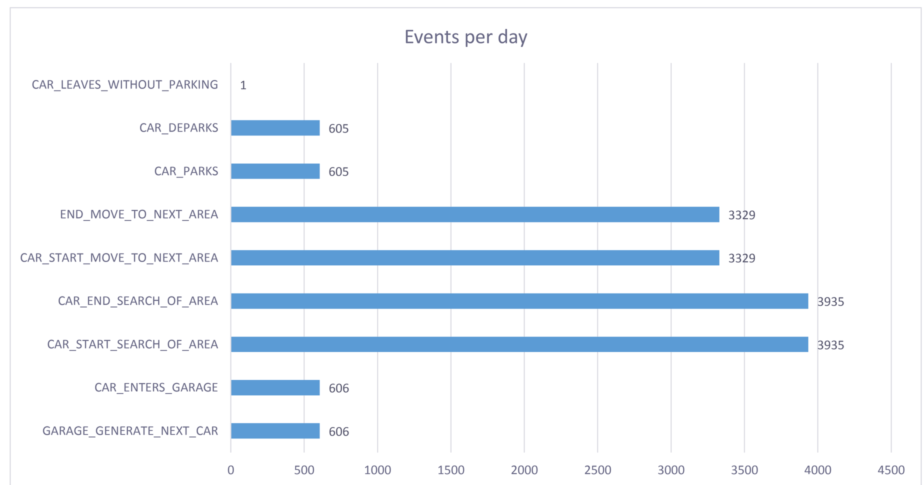


Figure 4: Number of simulation events per operational day

- The area occupancy simulation results deviate from real-world observations by an average of 9.1% (see figure 5).

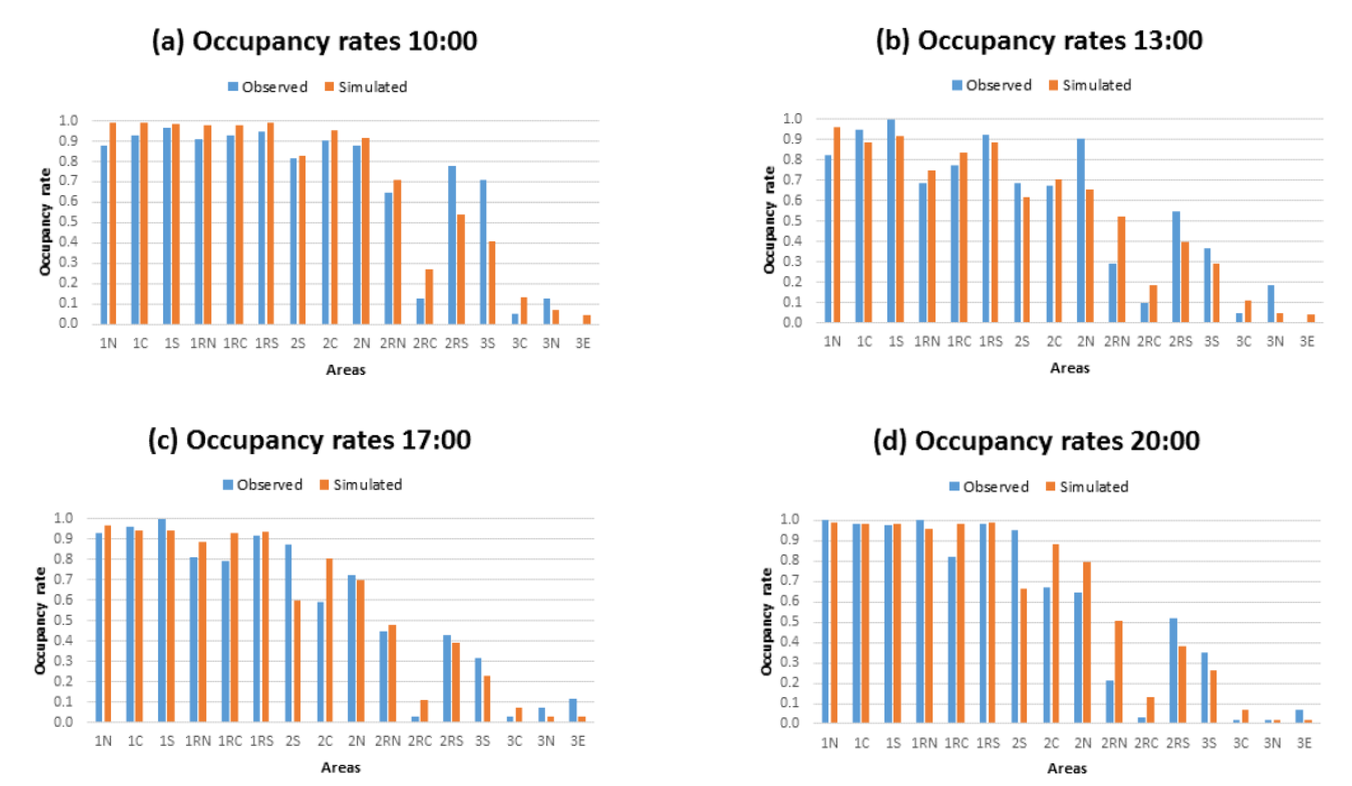


Figure 5: Validation results

CONCLUSION

- This work presented an agent based simulation model of cruising for parking in parking garages.
- The validation shows the model's capability to predict the state of a garage over the course of an operational day based upon layout data, attractiveness values, and parking durations.
- After further validation based on improved data streams, the model will be applied to the evaluation of parking recommendation methods.
- It will also be extended to accept real-time input data, and then be utilized as basis for a predictive parking information and recommendation system.