Case Study

Enabling smart factory:
Satellite positioning for indoor localization.

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Challenge

The goal of most smart factory initiatives is to automate production to the highest degree possible. In high-tech manufacturing with a large number of different products and medium volume, flexibility is required to adapt the process when the requirements change. This results in a more dynamic production, not focused on conveyor manufacturing. Often an additional challenge in the production process is the lacking transparency. Customers want to be informed about the current status of their orders in the same way that they are used to from online retail. To increase transparency in intralogistics processes, Trumpf has developed Track & Trace, a system for indoor localization capable of precisely locating thousands of parts in a production hall in real-time. The system relies on an Ultra Wide Band (UWB) technology and consists of static satellites and markers that are to be tracked. Since the cost factor always plays a role, a configuration needs to be identified which achieves the desired factory floor area coverage while keeping the number of satellites to a minimum, thus reducing the component and installation costs.

Approach

Typical approaches for the sensor positioning problem are manual expert solutions and methods using integer linear programming. Due to the high complexity in large facilities, manual solutions are impractical. Integer linear programming is NP-Hard except in some specific cases. For that reason, our first step was to formally prove that the problem at hand does not yield an integer linear programming solution. For solving the problem a number of candidate algorithms were available such as genetic algorithms, deep reinforcement learning and others, but given the size of the problem instances with sometimes more than 100 thousand potential sensor locations, we decided that the best approach would be a heuristic approximation algorithm, which is designed to exploit specific problem properties. To ensure that the calculations execute as fast as possible, efficient data structures and algorithms were selected. Spatial data structures such as KD-Trees allowed us to improve the speed of the queries. Vectorizing all data operations where possible reduced the required computational time even more. In order to achieve the shorter execution time we employed just-in-time compilation of specific portions of our Python code to ensure that if looping is required, the loops are highly efficient. Trumpf already had a web-based frontend to interact with the algorithm. We integrated the algorithm with the frontend while reducing the coupling of the algorithm and frontend using standard software engineering approaches. This allows us and our customer to replace the algorithm and have a unified interface for interaction between the frontend, the optimizer and the backend. The backend is kept simple with queues built on top of Redis queue for communication between the components and PostgreSQL to store the data.

Result

A comparison between the newly developed algorithm and the best results, provided by the off-the-shelf method used beforehand, further improved manually by human experts, showed an average improvement (reduction of the number of satellites required) of up to **30%** for large and complex scenarios. The time required to calculate the improved results is also reduced on average by **93%,** which opens a range of new possibilities for demonstrations and expert performed tuning. Overall the new sensor positioning approach is reducing the total cost of Trumpf's Track & Trace solution by reducing the total number of satellites required to cover the area of interest. This makes the system more affordable for the customer by lowering the sensor costs, installation costs, and the time to deploy the system.

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