Turbulence - the standard deviation of wind speed fluctuations - occurs naturally but also due to objects that disturb the free wind flow. In offshore wind farms, upstream wind turbines cause so-called wake-added turbulence on downstream turbines. Higher levels of turbulence translate into higher fatigue loads on turbine components (such as blades) and result in a reduced lifetime. The IEC 61400 standard, a collection of design requirements for wind turbines, defines a condition to evaluate whether the turbulence experienced by a turbine inside a wind farm is acceptable or not. It uses the so-called Frandsen model to assess turbulence for all turbines inside a wind farm. A common way to ensure feasibility of a wind farm layout with respect to turbulence conditions is the use of a minimum-distance constraint in the layout design phase. This approach, however, is conservative, because it imposes the same minimum distance for all wind directions and turbines, and implicitly limits the maximum number of turbines to place in a given area. We present alternative, less conservative ways of considering turbulence in wind farm layout optimization that explicitly exploit the properties of the Frandsen turbulence model. We test those ideas in a state-of-the-art wind farm layout optimizer, and assess their computational cost as well as their impact on the layout design and performance.

■ TC-31

Tuesday, 12:30-14:00 - Virtual Room 31

Decision Support Systems Applications - 1

Stream: DSS
Invited session
Chair: *Jason Papathanasiou*

1 - Inbound logistics optimization solution for Toyota built on top of DecisionBrain Gene platform

Giulia Burchi, Guillaume Vantroeyen

In this presentation, DecisionBrain will talk about an inbound logistics optimization solution for Toyota, considered a worldwide reference in supply chain management, which resulted in over 10% cost reductions. The project was completed in 8 months, from conception to go-live. This produced a high ROI and a payback time of less than one year.

Toyota wanted to streamline the logistics from its suppliers to its assembly plants, just-in-sequence and just-in-time, targeting a 2% transportation costs reduction. Due to the very high volume of vehicles produced, the inbound logistics planning process, mainly performed manually, was very complex and human-intensive.

DecisionBrain used mathematical models to replicate the planners' decision-making, reducing the planning time from 2.5 days to 1 hour. On top of that, optimization techniques were applied to increase efficiency, reducing transportation costs while preserving service level.

Our solution focused on optimizing the Orders Grouping, Trucks Routing: and 3D packing (matching the package size to each truck's volume).

The fast application development was possible thanks to DecisionBrain Gene (DBGene) platform. DBGene provides an enterprise platform for building and deploying decision support applications. Its main purpose is to facilitate the process of making mathematical optimization available to business users, i.e. bringing optimization decision-making capabilities into the business operation.

2 - Digital Twin in warehousing: A state-of-the-art survey with focus on order picking operation

Anastasios Gialos, Vasileios Zeimpekis

Over the last years the complexity of warehouse operations has increased significantly due to the interaction of numerous parameters in a highly dynamic environment. Especially in order picking operations, the complexity as well as the need for variable picking strategies usually affect in a negative way the performance of the pickers as well as the operational cost. To this end, the development of a decision-making tool which will support order picking operations in an efficient and accurate way in real time, especially in case of unexpected deviations, is of high interest. The development of Internet of Things coupled with computer simulation integration with virtual reality systems and operation data, have formed the basis to address the above necessity via the concept of Digital Twin. The latter creates a mirror of warehouse operations and has the ability to monitor processes in real time and subsequently continuously fine tune all operations in order to improve performance, identify bottlenecks and reduce both mistakes and delays. The aim of this paper is initially to present the state-of-the-art in digital twin concept in warehouse operations. Subsequently, a framework for the development of a Digital Twin decision making tool for the planning and real time monitoring of order picking operations is described. Potential benefits from the implementation of Digital Twin in order picking operations as well as a future research agenda conclude the paper.

3 - Efficient loading and unloading operations via a booking system

Andrea Mor, M. Grazia Speranza, José Viegas

Urban distribution of parcels and goods usually requires vehicles to temporarily stop at roadside to allow for the driver to perform the last leg of the delivery by foot. The stops take place in designated areas, called loading/unloading (L/U) areas, composed of one or more parking spots. In this paper the introduction of a booking system for the management of the L/U areas in a city center is studied as a way to eliminate, or at least substantially reduce, double parking. A booking management system and the related routing problem are presented. In this system, distributors book in sequence according to their preferences and routing constraints, but subject to the bookings that have already been placed. The solution provided by the booking system is discussed and compared with the current use of the L/U areas, where the distributors do not consider the availability of a parking spot and resort to double parking if none is available.

4 - In-Vehicle Personalized Routing for A Heterogeneous Group: An Experience-Based Method for Decision Support System

Özlem Çavuş, Sehnaz Cenani, Gülen Çağdaş

Customized navigation devices allow personalized routings based on user preferences. In determining common preferences for multi-user, it may become difficult to meet at a common point due to conflict of interests. A decision support system could serve as an asset to increase the quality of decisions users take. In conventional systems, decision making ties to pre-defined preferences of a single user or a homogeneous group. Besides, the recommendation of locations ignores the functional use of the space in time. However, decision-making depends on users' experiences within a social group in regard to time and space. Therefore, this study aims to develop a decision support system for a heterogeneous group by involving this neglected side of the design knowledge. This paper proposes a method based on IoT, agent-based modelling, multi-objective optimization, and crowdsourced data. The method is exemplified over a simulation for a family car, including father, mother, and child, to show how the method works. The simulation is created in Grasshopper for Rhino using the addons as Mosquito 0.5a, Firefly, Shortest Walk, and C# script embedded in Grasshopper. The original contribution of this study would reflect itself in showing how social aspects in determining preferences of a heterogeneous group can be converted to a computational environment of personalized navigation systems. The major problem faced with is the data sharing policies.