OPM 761 – Research Seminar Production Management

Spring Term 2021

The goal of this seminar is to introduce the participants to conduct scientific research. Thereby, it prepares the students for the writing of their Master's thesis. The seminar is geared towards students intending to write their thesis at the Chair of Production Management.

Participants will explore one of the topics listed below. They will review and critically assess the corresponding scientific literature and present their findings in a written report (15 to 20 pages) as well as in an in-class presentation (15 - 20 min + 20 min discussion). Each participant is also expected to critically assess the presentations of the other students in the ensuing discussion.

Applications will be accepted from **November 13th, 2020** until **November 23rd, 2020**. Admission to the seminar will be confirmed by e-mail at latest on November 27th, 2020 and must be reconfirmed by the participant at the kick-off meeting.

The **Kick-off meeting** will be held on **November 30th, 2020** between 08:30 and 10:00 o'clock in Zoom. During this meeting, an introduction to scientific writing and presentations for term papers will be given.

A brief session on introduction to Overleaf and LaTeXwill also be offered. The time and date of this session will be decided in the Kick-off meeting among the interested students.

The **written reports** have to be submitted by Wednesday, **March 31st, 2021** in the following formats:

- Two-fold hard copy version.
- Electronic version including a copy of the references cited in the report and auxiliary information (tables, data, programming code, etc.).

The **presentations** will be held as a blocked session on **April 12th, 2021**. Attendance at all presentations is mandatory.

The final grade for the seminar is composed of the following components: Written report (60%), presentation (30%), and contribution to the discussion (10%).

There is a joint application process for all seminars offered by the chairs of the Area Operations Management. In the Spring term 2021, this includes the following seminars:

- **OPM 701:** Research Seminar Supply Chain Management
  Chair of Logistics and Supply Chain Management, Prof. Dr. Moritz Fleischmann
  (Topics labeled with "L"),
- **OPM 761:** Research Seminar Production Management,
  Chair of Production Management, Prof. Dr. Raik Stolletz
  (Topics labeled with "P"),

- **OPM 781:** Research Seminar Service Operations Management
  Chair of Service Operations Management, Prof. Dr. Cornelia Schön
  (Topics labeled with "S"),
- **OPM 792:** Applied Seminar Procurement
  Endowed Chair of Procurement, Prof. Dr. Christoph Bode
  (Topics labeled with "B").

Detailed information on the seminar topics and the link to the online registration tool are available on the home pages of the respective chairs. In their applications, students can indicate up to five preferred topics from all seminars.

In addition, applicants for OPM 761 must send an email with (1) CV, (2) official B.Sc. and M.Sc. grades overviews, and (3) the list of courses in the Area Operations that you are currently enrolled in to opm761@bwl.uni-mannheim.de. For any further question concerning the seminar please also contact the chair via opm761@bwl.uni-mannheim.de.

Topics Catalog

P1 – Artificial Neural networks in manufacturing processes – A systematic review

Objectives: Artificial Neural Networks are powerful and flexible tools that provide high performance also when applied to complex environments due to their ability to adapt and learn. Thus, also interest in their application to manufacturing in a variety of related contexts increased in recent years.
In this seminar, the student is expected to conduct a comprehensive literature review and present an overview of Artificial Neural Network approaches used in different parts of manufacturing processes for varying purposes with special attention to recent publications. Equalities and differences in the identified literature with respect to the type and structure of the Neural Network on the one hand and the characteristics of the manufacturing process on the other hand (e.g. on the specific optimization problem, the industry, ...) are to be characterized and structured in a systematic manner. In addition, promising options for further research are to be pointed out.

Prerequisites: Basic knowledge in Neural Networks (e.g. OPM 562) and knowledge in planning models for Production Management (e.g. OPM 661 or OPM 662)

Basic Papers: Zhang and Huang (1995), El-Bouri et al. (2000), Weichert et al. (2019)

> **Abstract**: Artificial intelligence has been claimed to yield revolutionary advances in manufacturing. While most of the survey papers about artificial intelligence in manufacturing have been focused on knowledge-based expert systems, fewer attentions have been paid to neural networks. However, neural networks are able to learn, adapt to changes, and can mimic human thought processes with little human interventions. They could be of great help for the present computer-integrated manufacturing and the future intelligent manufacturing systems. This paper presents a state-of-the-art survey of neural network applications in manufacturing. The objective of this paper is to update information about the applica-

tions of neural networks in manufacturing, which will provide some guidelines and references for the research and implementation.

P2 – Artificial neural network hyperparameter optimization for queue length prediction

Objectives: Artificial Neural Networks have the potential to show good performance in the analysis of queuing systems. The creation of an artificial neural network requires the determination of a number of parameters, which are determined externally – called hyperparameters. These hyperparameters have a huge impact on the accuracy of the Artificial Neural Network. Until now, there is no consensus on their optimal choice, but a variety of methods for their determination.
The student is expected to explain in detail the problem and the challenges of finding optimal hyperparameters for Neural Networks. In addition, a Neural Network for the prediction of a set of properties of a stationary queue (e.g. M/M/1, M/M/C and/or M/M/1/K) is to be trained. Based on this, a numerical study on the optimal choice of the hyperparameters for the Neural Network using (at least two) different optimization methods of student's choice and a comparison and discussion of the results are to be conducted.

Prerequisites: Knowledge of Artificial Intelligence approaches and knowledge of a programming language (e.g. OPM 562) and basic knowledge in queueing theory (e.g. OPM 661)

Basic Papers: Bakhteev and Strijov (2019), Feurer and Hutter (2019)

Abstract: The paper investigates hyperparameter optimization problem. Hyperparameters are the parameters of model parameter distribution. The adequate choice of hyperparameter values prevents model overfit and allows it to obtain higher predictive performance. Neural network models with large amount of hyperparameters are analyzed. The hyperparameter optimization for models is computationally expensive. The paper proposes modifications of various gradient-based methods to simultaneously optimize many hyperparameters. The paper compares the experiment results with the random search. The main impact of the paper is hyperparameter optimization algorithms analysis for the models with high amount of parameters. To select precise and stable models the authors suggest to use two model selection criteria: cross-validation and evidence lower bound. The experiments show that the models optimized using the evidence lower bound give higher error rate than the models obtained using cross-validation. These models also show greater stability when data is noisy. The evidence lower bound usage is preferable when the model tends to overfit or when the cross-validation is computationally expensive. The algorithms are evaluated on regression and classification datasets.

P3 – Transient performance analysis of serial production lines

Objectives: Manufacturing systems are often analyzed in steady-state. However, actually it takes some time before a system can reach this steady-state. This period is called the transient phase of the system. It can occur due to several reasons such as ramp-ups, service breakdowns or parameter changes e.g. due to a change in demand. Manufacturing systems can only be characterized accurately when their operation in steady-state as well as in transient periods is reasonably investigated. Nevertheless, the analysis of the transient behavior is much more complex than the study of the steady-state. In the base paper, an approach is developed for the analysis of the transient phases of serial production lines and machines with breakdown and repair probabilities and finite buffers.
The student is expected to comprehensively discuss the approach for single and two-machine lines presented in the base paper in detail. In a literature review, the basic paper is to be embedded in the relevant literature on the analysis of transient queues in a structured way. This is followed by a critical investigation of the methodology with respect to advantages, shortcomings and alternative approaches.

Prerequisites: Knowledge of queueing theory and stochastic variability (e.g. OPM 661)

Basic Paper: Chen et al. (2016)

> **Abstract**: A production system is characterized by both its steady state and transient properties. While extensive research efforts have been spent in the analysis of the steady state of production systems, very few results, especially analytical ones, have been reported regarding their transient behavior. Indeed, transient behavior of production systems has significant practical and theoretical implications. A better understanding of the transient properties of production systems is critical to effective utilization of real-time production data for efficient factory floor operation and management. In the framework of serial production lines with geometric machines and finite buffers, this paper develops mathematical models for transient analysis and derives closed form expressions for evaluating the production rate, consumption rate, work-in-process, and probabilities of machine starvation and blockage, during transients. In addition, a computationally efficient algorithm based on aggregation is developed to approximate the transient performance measures with high accuracy. Numerical experiments show that the methods developed can be applied to systems with time-varying machine parameters as well.

P4 – Teaching Optimization Problems in Manufacturing Systems in Lab-based Courses

Objectives: A variety of optimization problems occur in real-world manufacturing systems. At universities, case studies or computer simulation is often used in classes to provide an abstract/ virtual environment in which these problems can be experienced. However, hands on experience is missing and critical problem solving skills cannot be taught. For example, the skill of developing an abstract model from a real system. Lab-based courses in which physical models of manufacturing systems are present bear the potential to foster the learning experience in production management.
The student is expected to provide an overview of documented efforts to teach production

management problems in labs that include demonstrative machines. The review should provide an overview of the optimization problems that are addressed, the taught solution approaches for the problem at hand, and the hardware that is used in the lab environment. Reported benefits over conventional teaching concepts have to be summarized.

Prerequisites: Knowledge of basic production management concepts (e.g. from OPM 561), and optimization problems (e.g. from OPM 662)

Basic Paper: Lugaresi et al. (2020)

> **Abstract**: Involving and stimulating students through intensive work in computer laboratories and simulation projects might be a challenging task, often due to the lack of the real manufacturing system that must be modeled and improved. Indeed, studying a manufacturing system that cannot be observed represents a real obstacle for student effective learning. In this paper, we describe the "LEGO FACTORY" initiative, an extra-curricular experience within the Master Degree Study Program in Mechanical Engineering of Politecnico di Milano. The initiative is open to students from any study course of the university. The goal is to exploit learning-by-playing principles to offer scholars the possibility to understand the most common issues in the design and management of manufacturing systems, with a focus on system integration. A miniaturized production system made with LEGO MINDSTORMS is provided to students who are asked to accomplish a project aiming at the improvement of the system performances. The participants work in teams and must introduce design modifications and develop technical solutions to address the requirements. The experience is described with the hope that the approach can be replicated in other environments

P5 – Multi-department Multi-day Shift Scheduling

Objectives: Personnel scheduling problems exist in many work environments such as banks, hospitals, restaurants and retail stores. One of the variants of the problem arise in organizations which are divided into departments and transfer of workers among the departments is possible, i.e. each department has its own staff and on top of that, it can borrow staff from other departments if need be. This flexibility helps reduce the costs, especially when there are short-term changes in the demand of departments.

The objective of this seminar thesis is to describe and analyze the optimization problem addressed in the base paper in detail. In addition, the student is supposed to position the base paper in the related stream of literature. The proposed Mixed-Integer Programming (MIP) model has to be described and implemented in a modeling system (e.g. GAMS). A numerical analysis with standard solver must be conducted to generate some managerial insights. Critical assessment of the contribution of the proposed model will conclude this thesis.

Prerequisites: Knowledge of a modeling language for MIPs (e.g. OPM 662)

Basic Paper: Dahmen et al. (2020)

> **Abstract:** In this paper, we address a personalized multi-department multi-day shift scheduling problem with a multi-skill heterogeneous workforce where employees can be transferred between departments under some restrictions. The objective is to construct a schedule that minimizes under-coverage, over-coverage,

transfer and labor costs. We propose a novel two-stage approach to solve it: the first stage considers an approximate and smaller problem based on data aggregation and produces approximate transfers. The second stage constructs personalized schedules based on the information deduced from the first stage. An exhaustive experimental study is conducted and proves the efficiency of the proposed approach in terms of solution quality and computing times.

P6 – Literature Overview on Personnel Scheduling with Employee Transfers

Objectives: Personnel-related cost is the major cost component in many service and production systems. Therefore, cutting labor costs by only a small percentage will result in a significant savings in total costs. One of the options managers use to reduce the costs is the transfer of workers between different parts of the system.

The goal of this seminar thesis is to review the papers in the field of personnel scheduling that consider the transfer of workers between different parts of the system. The student is supposed to explain the underlying assumptions of optimization problems. The overview is expected to classify the literature based on the features of the problems especially with regard to the transfers.

Prerequisites: Knowledge of mathematical modeling and optimization (e.g. OPM 662)

Basic Paper: Dahmen et al. (2020)

Abstract: In this paper, we address a personalized multi-department multi-day shift scheduling problem with a multi-skill heterogeneous workforce where employees can be transferred between departments under some restrictions. The objective is to construct a schedule that minimizes under-coverage, over-coverage, transfer and labor costs. We propose a novel two-stage approach to solve it: the first stage considers an approximate and smaller problem based on data aggregation and produces approximate transfers. The second stage constructs personalized schedules based on the information deduced from the first stage. An exhaustive experimental study is conducted and proves the efficiency of the proposed approach in terms of solution quality and computing times.

P7 – A Literature Overview on Workforce Scheduling in Multi-stage Systems

Objectives: Workforce scheduling attempts to have the right staff on duty at the right time. In multi-stage systems, in addition to the classic decisions in workforce scheduling, the manager needs to decide how to allocate the workforce among different stages of the organization.

In this research seminar, the student is expected to review workforce scheduling studies considering multi-stage systems, present the underlying optimization problems and categorize them based on the structure of the system and the relationship of the stages to each other. Critical assessment of the literature and suggestions for further research in the field conclude this seminar thesis.

Prerequisites: Knowledge of mathematical modeling and optimization (e.g. OPM 662)

Basic Paper: Dahmen et al. (2020)

> **Abstract:** In this paper, we address a personalized multi-department multi-day shift scheduling problem with a multi-skill heterogeneous workforce where employees can be transferred between departments under some restrictions. The objective is to construct a schedule that minimizes under-coverage, over-coverage, transfer and labor costs. We propose a novel two-stage approach to solve it: the first stage considers an approximate and smaller problem based on data aggregation and produces approximate transfers. The second stage constructs personalized schedules based on the information deduced from the first stage. An exhaustive experimental study is conducted and proves the efficiency of the proposed approach in terms of solution quality and computing times.

P8 – Cutoff service levels in operations management

Objectives: The management of operations in manufacturing, logistics, and service operations is driven by service levels with respect to on-time delivery. So-called cutoff service levels (also known as Next Scheduled Deadline (NSD)) are widely used, for example in make-to-order manufacturing or in online retailing. Based on a cut-off time and a deadline, a certain target percentage of orders received until the cut-off time have to be processed until the deadline.

In this research seminar, the student is expected to review planning models that consider cutoff service levels and present the underlying optimization problems. The optimization problem and the solution approach addressed in the basic paper has to be discussed in detail. Critical assessment of the contribution of the proposed model will conclude this thesis.

Prerequisites: Knowledge of queueing theory and stochastic variability (e.g. OPM 661)

Basic Paper: Çeven and Gue (2017), Doerr and Gue (2013)

> **Abstract**: Service performance of an order fulfillment system is mainly determined by how quickly and accurately it fills customer orders. A higher service level can be offered with a later cutoff time, before which customers are assured of receiving their orders. However, the desire to offer a later cutoff time must be tempered by the need to provide service at low cost, which means taking advantage of economies of scale in picking operations. To strike this balance, many distribution centers release orders in large batches called waves. We develop analytical models to determine the timing and the number of order waves for fulfillment systems that operate against a daily deadline. In a case study, we apply our theoretical models to data from a large distribution center and show that optimal wave releases could significantly improve on time shipments compared to an intuitive method.

References

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