TUM School of Management
Technical University of Munich

MARCH 7-8, 2023

WORKSHOP

DATA-DRIVEN DYNAMIC AND ROBUST RESOURCE MANAGEMENT

TUM CAMPUS HEILBRONN

HOSTS:
PROF. JINGUI XIE
CENTER FOR DIGITAL TRANSFORMATION
TUM CAMPUS HEILBRONN

PROF. THIERRY GARAIX
ÉCOLE NATIONALE SUPÉRIEURE
DES MINES DE SAINT-ÉTIENNE

PROF. XIAOLAN XIE
ÉCOLE NATIONALE SUPÉRIEURE
DES MINES DE SAINT-ÉTIENNE

WELCOME
WILLKOMMEN
BIENVENUE

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Dear Guests,
Dear Colleagues,

We are very pleased to welcome you at TUM Campus Heilbronn for the Workshop on Data-Driven Dynamic and Robust Resource Management.

We are very much looking forward to this opportunity to meet and work with all of you, exchange knowledge and broaden our horizons.

In this brochure you will find more information about the workshop program, the presentations, and organizational information.

If you need any information during your stay in Heilbronn, please feel free to contact us. We are always happy to help you.

Jingui Xie
Professor of Business Analytics at TUM Campus Heilbronn

OBJECTIVES OF THE WORKSHOP

Capacity planning and resource allocation is a fundamental challenge in the face of global crises such as the Covid-19 pandemic. One needs to understand the variabilities in time-varying demand for resource planning. Machine learning models typically predict the mean values of the demands in both the temporal and spatial dimensions. Some works focus on forecasting the evolution of the epidemic based on historical data and the resource needs over the days and weeks to come. However, they seldom provide predictions or estimations of demand variabilities and, therefore, are insufficient for robust capacity planning. The diversity of decisions, system dynamics over time, and demand uncertainties make decisions challenging even with good forecasts. Using data analytics, machine learning models, and data-driven robust optimization methods, it appears that resource management according to the evolution of needs linked to the epidemic would make it possible to utilize better the limited resource and hedge against the temporal and spatial prediction uncertainties.

WORKSHOP SCHEDULE

07 MAR

08:15 AM - 08:50 AM	Arrival and Registration
08:50 AM - 09:00 AM	Welcome address: Jingui Xie
09:00 AM - 10:00 AM	Invited Presentation 1: Richard Boucherie Dynamic assignment of capacity and fair balancing of COVID-19 patients over hospitals
10:00 AM - 10:30 AM	Coffee break
10:30 AM - 11:30 AM	Invited Presentation 2: Houyuan Jiang Contracting Advice and Guidance Service
11:30 AM - 12:30 PM	Invited Presentation 3: Mohamed El Habib Messabis Healthcare response tool for a territorial hospital group during a pandemic
12:30 PM – 02:00 PM	Lunch break (Group photo at 1:45 PM)
02:00 PM – 03:00 PM	Invited Presentation 4: Nadia Lahrichi Integrating bed use and patient selection to the master surgical planning in the OR
03:00 PM – 04:00 PM	Invited Presentation 5: Jean Pauphilet Predictive Analytics for Hospital Inpatient Management
04:00 PM – 04:30 PM	Coffee break
04:30 PM – 05:30 PM	Invited Presentation 6: Alba Olivares Nadal Optimal Patient Selection into Care Management Programs
05:30 PM – 06:15 PM	Open Discussion: Thierry Garaix
07:00 PM – 10:00 PM	Conference dinner

08 MAR

08:30 AM - 09:00 AM	Arrival
09:00 AM – 10:00 AM	Invited Presentation 7: Ettore Lanzarone Data-driven dynamic nurse-to-patient assignment problem in home care: an implementor-adversary robust framework
10:00 AM - 10:30 AM	Coffee break
10:30 AM - 11:30 PM	Invited Presentation 8: Gar Goei Loke Optimizing early discharge: Trade-offs between capacity and re-admissions
11:30 AM - 12:30 AM	Invited Presentation 9: Carolin Bauerhenne Robust Appointment Scheduling with Waiting Time Guarantees
12:30 AM - 12:45 PM	Closing Remarks: Jingui Xie
12:45 PM - 02:00 PM	Lunch break

INVITED PRESENTATIONS

Session 1 – Crisis and service management

Session chair:
Prof. Katja Schimmelpfeng,
University of Hohenheim

// 1 Prof. Richard Boucherie, University of Twente

Title: Dynamic assignment of capacity and fair balancing of COVID-19 patients over hospitals

Abstract: We introduce models that support dynamic fair balancing of COVID-19 patients over hospitals in a region and across regions. Patient flow is captured in an infinite server queueing network. Input for the model is an accurate real-time forecast of the number of COVID-19 patients hospitalised in the ward and the Intensive Care Unit of the hospitals based on the predicted inflow of patients, their Length of Stay and patient transfer probabilities among ward and ICU. For given number of available beds, we introduce a dynamic load balancing model for assignment of patients to hospitals within a region, and a stochastic program for allocation of patients across regions. Subsequently, we consider optimal up- and downscaling of capacity for COVID-19 patients leaving maximum capacity for regular (non-COVID) patients. We illustrate our models using data from the second COVID-19 peak from hospitals' data warehouses and regional infection data as recorded in the Netherlands.

// 2 Prof. Houyuan Jiang, University of Cambridge

Title: Contracting Advice and Guidance Service

Abstract: In the UK, general practitioners (GPs) act as the first-level of contact for patients to perform initial assessment and treatment. Specialist consultations, other than in an emergency, require a referral by GPs. The quality of gatekeeping function is critical for the success of the system. However, the system experiences diagnostic and referral errors and inefficiencies. Due to the COVID-19 crisis, the England Health System currently faces worrying long waiting lists of more than seven million patients for different healthcare services. It is vitally important to reduce unnecessary demand for secondary services. To deal with these inefficiencies and the concerns of the sustainability in the traditional outpatient services, Advice & Guidance (A&G) service is introduced to perform as an additional and optional gatekeeper before referrals to outpatient appointment. We study different incentive mechanisms to ensure that the A&G service reaches its potential in terms of eliminating inefficiencies. We propose a game-theoretic model to study this new scheme with A\&G to evaluate the system performance under different regulations/contracts. We show that with no regulation, traditional fee-for-service (FFS) contract and turnaround-time-target contract, the social optimal will not be obtained. Furthermore, we propose a group of new coordinating contracts which helps incentives both the commissioner and the hospital to achieve the social optimal with flexibility and robustness. Our research shows that with the hospital's tendency to run A&G slowly when no regulation is performed, due consideration should be given to regulate/contract the A&G services to maximize its potential in improving the system referral efficiency.

// 3 Mohamed El Habib Messabis, Ecole des Mines de Saint-Etienne

Title: Healthcare response tool for a territorial hospital group during a pandemic

Abstract: The ongoing COVID-19 pandemic has shown to be most difficult to handle due to how rapidly it has spread, resulting in a considerable amount of infected people in need of hospitalisation. It has unveiled a great deficit in hospital resources necessary to support the sudden surge in demand for hospital care, as well as the lack of robust patient management strategies essential to alleviate the pressure of high rate patient arrivals endured by healthcare facilities ([2, 3, 7]). Several researchers studied the problems of capacity management and scarce-resource sharing since the COVID-19 outbreak such as [1, 4, 5, 6], where optimisation strategies and decision aiding tools have been developed to assist healthcare facilities. Herein, the main focus lies on COVID-19 patients, our goal is to develop a dynamic response tool capable of arming and disarming healthcare facilities in order to handle the surge in COVID patients. The novelty of this response tool is that throughout a time horizon, healthcare facilities are added, removed or have their capacities altered in a dynamic fashion following the progress of the pandemic.

INVITED PRESENTATIONS

Session 2 – Data-driven and dynamic management

Session chair: Prof. Xiaolan Xie,
Ecole des Mines de Saint-Etienne

// 4 Prof. Nadia Lahrichi, Polytechnique Montréal

Title: Integrating bed use and patient selection to the master surgical planning in the OR

Abstract: In this talk, I will introduce a novel approach to the master surgical planning in the operating room. Patient case mix is integrated to the problem to have a finer estimation of the use of resources. This problem consists of selecting patients (from the wait list) to be on the operating list for a selected horizon, and assigning a day, an operating room, and a time block to each specialty. Bed resources in the surgical wards and in the ICU are also considered. Two case studies will illustrate this approach. The first one focuses on clusters of patients to be scheduled to better use the beds in a deterministic setting. In the second one, I will show how the integration of the cancellation probability due to congestion in the intensive care unit can be done. The approach is based on integrating the graph derived from a Markov Decision Process that computes the probability of canceling cases on each day. We show that prioritizing patients based on wait times only increases the quality of the schedule without decreasing the occupancy rate of the OR.

// 5 Prof. Jean Pauphilet, London Business School

Title: Predictive Analytics for Hospital Inpatient Management

Abstract: Access to accurate predictions on patients' outcomes can enhance medical staff's decision-making, which ultimately benefits all stakeholders in the hospital. In this talk, we present two collaborations with large hospital networks in the US to develop machine learning models that predict short-term and long-term outcomes for inpatients. In particular, we predict the probability of patients being discharged and that of patients being transferred from/to an intensive care unit in the next 24/48 hours, as well as the probabilities of mortality and other discharge dispositions. We implement an automated pipeline that extracts new data every morning and dynamically updates our predictions, as well as a user-friendly software to communicate these predictions to the clinical teams. We have deployed our tools in each of the hospital networks. In addition to increased accuracy in discharge date and discharge volume prediction, we observe a significant reduction in average length-of-stay following the tool's adoption, and anticipate substantial financial benefits for the system.

// 6 Dr. Alba Olivares Nadal, University of Zurich

Title: Optimal Patient Selection into Care Management Programs

Abstract: Care Management Programs (CMPs) coordinate the care for patients with complex care needs and older frail adults, who usually represent the top of healthcare spending. Although CMPs have appeared as credible avenues for reducing healthcare utilization, empirical evidence showed mixed results. Using patient-level data we evaluate the causal impact of the CMP from the University of Chicago Medical Center, and we find no impact on five healthcare utilization measures. In the light of these negative results, one wonders how can CMPs be improved. To address this question, we use Markov Decision Processes (MDPs) and Dynamic Programming to model the task of optimally allocating treatment amongst patients while fulfilling some capacity constraints. The complexity of such a problem may be very high, as healthcare populations may be large enough so gathering information of the current status of each patient and tracking the evolution of their covariates is untenable. To manage this issue we develop the so-called measurized theory, which allows to model MDPs that optimize the distribution of treated and untreated patients instead of dealing with identifed patients. This abstraction transforms a complicated problem into an intuitive formulation and clinically implementable solution approaches.

INVITED PRESENTATIONS

Session 3 – Robust and risk management

Session chair: Prof. Rainer Kolisch, Technical University of Munich

// 7 Prof. Ettore Lanzarone, University of Bergamo

Title: Data-driven dynamic nurse-to-patient assignment problem in home care: an implementor-adversary robust framework

Abstract: A major challenge in managing Home Health Care services is to ensure continuity of care despite uncertain patients' evolutions when assigning nurses to patients. Providers must face the trade-off between reassigning patients to balance workloads and keeping the assignments to guarantee continuity of care. In practice, the patients with weaker continuity requirement are dynamically reassigned at the last moment when all patients' conditions and service times are known. However, this reassignment strategy has never been formalized in the literature so far. We consider a nurse-to-patient assignment problem where patients require three different capacity of care levels. We propose an approach that includes such dynamic reassignments along with uncertain and time-correlated service times, where the problem is solved on a long planning horizon, to provide the assignments of nurses to all patients, and the assignments of the patients with a weaker continuity of care are periodically rediscussed when the actual service times are known. The long-term assignments are provided by solving a robust model through the implementor-adversary approach, to include time-correlation in the uncertainty set of patients' service times. We provide two objective functions for the problem, with either constant or increasing overtime cost. The Adversarial problem aims at building the service times realizations that maximize the costs while selecting the short-term assignments that minimize them. As it turns out to be a challenging problem, we also provide three heuristic approaches to speed up the process. The framework has been applied to realistic instances, and the results confirm the effectiveness of the approach.

// 8 Prof. Gar Goei Loke, Rotterdam School of Management

Title: Optimizing early discharge: Trade-offs between capacity and re-admissions

Abstract: In this work, we consider the ward capacity management problem where the decision-maker seeks to optimize elective schedule and an early discharge policy, so as to minimize the chance of bed shortages in the ward. In particular, the decision-maker needs to balance the trade-off between the immediate capacity freed up by early discharges and the increased chance of re-admissions. The presence of such re-entry makes it difficult to model this problem via traditional methods. We appeal to the Pipeline Queues (Bandi 2018) framework, and propose an optimization model where the early discharge policy is expressed as a linear state-dependent decision rule. The model has a reformulation, which can be solved as a sequence of convex program with asymptotically linear constraints. We numerically examine the conditions under which early discharge is favoured.

// 9 Carolin Bauerhenne, Technical University of Munich

Title: Robust Appointment Scheduling with Waiting Time Guarantees

Abstract: Appointment scheduling under uncertainty encounters a fundamental trade-off between maximizing capacity utilization and minimizing customer waiting times. Most existing approaches to appointment scheduling tackle this trade-off using a weighted sum approach, resulting in a low consideration of individual customer waiting times and thus of customer satisfaction. In contrast, we study how to maximize capacity utilization while guaranteeing acceptable waiting times for all customers. Therefore, we derive a mixed-integer linear model in a robust optimization framework with box uncertainty sets. We prove NP hardness of the general problem and present optimal polynomial-time scheduling and sequencing rules for special cases. These rules generalize the well-known Bailey-Welch rules and the least variance rules to consider not only but in particular maximum waiting times. Furthermore, our case study with real data from a radiology department of a large hospital demonstrates that our approach not only guarantees acceptable waiting times but, compared to existing robust approaches, can also reduce costs incurred by idle time, for the worst-case and on average.

ORGANIZATIONAL INFORMATION

// 1 Your Presentation

If you are presenting, please send us your presentation by March 4, 2023, as we would like to store and test your presentation on our computer beforehand. Each presentation is planned for 40-50 minutes and questions can be asked in between and at the end.

// 2 Travel Cost Reimbursement

Please fill out the appropriate fields in the travel cost reimbursement form on page 3. If your residence or bank account is outside Germany, please also complete the tax declaration form found on page 4. Please sign the forms and bring them with you to the workshop. Please hand in the form and the receipts to be reimbursed to the organization team (Julia Zahn/Franziska Schmidt) on March 7, 2023 (if necessary as a copy if you need the original tickets for your return trip).

// 3 Accommodation

The following accommodation has been booked for you:

Address:
Insel-Hotel
Willy-Mayer-Brücke
74072 Heilbronn
Germany

https://insel-hotel.de/

If you leave the main station at the main entrance, you can reach the hotel on foot in 5-10 minutes.

Payment
The reservation is in your name, the cost of your accommodation will be paid directly by us. Other costs, e.g. for food and drinks, please pay yourself at check-out (please also return the room card to a staff member at the reception).

Photo: Insel Hotel

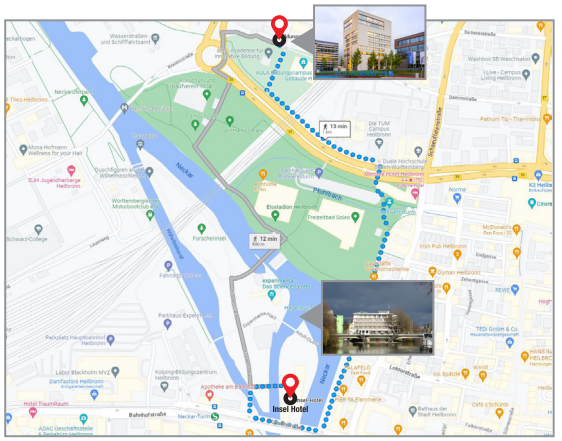
Check-in and reception hours:
You can check in the hotel after 3 p.m. The reception is open until 9 p.m. If you check in before 3 p.m. or after 9 p.m., please let the hotel know a few days in advance with your full name and reference to the “TUM Reservation” at this e-mail address: info@insel-hotel.de
The reception is available at +49 (0)7131 6300

Parking
Parking is available directly at the hotel entrance on the parking deck or in the hotel garage at EUR 12.00 per vehicle per night (for the hotel garage with e-charging station a reservation is necessary, cost: EUR 18.00 per vehicle). Input navigation system: Willy-Mayer-Brücke
Please note: Parking fees cannot be covered by the organizer and must be paid by the guest on departure.

ORGANIZATIONAL INFORMATION

// 4 Venue March 7-8, 2023

The event will be held at TUM Campus Heilbronn.

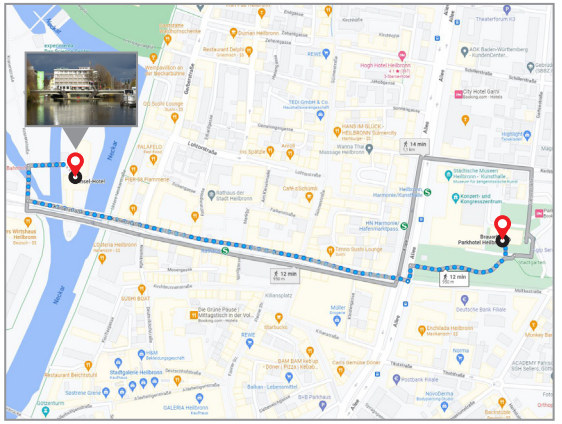


TUM School of Management
L Building, room L.1.11 (1st floor)
Bildungscampus 9
74076 Heilbronn

Insel-Hotel
Willy-Mayer-Brücke
74072 Heilbronn

// 5 Conference Dinner on March 7, 2023

The conference dinner will be held at Brauart Restaurant (part of Parkhotel Heilbronn)
Start: 7:00 p.m.



Location:
Brauart in Parkhotel Heilbronn
Gartenstraße 1
74072 Heilbronn

Insel-Hotel
Willy-Mayer-Brücke
74072 Heilbronn

ABOUT US

Technical University of Munich (TUM)

The Technical University of Munich (TUM) is one of the leading research universities in Europe, specializing in the interface of technology and management. TUM's unparalleled range of disciplines covers engineering and natural sciences, life sciences and medicine, management and social sciences. As the Entrepreneurial University, it doesn't just seek to understand the world – it sets out to improve it. That is why the entire university revolves around one core goal: innovation. TUM leads Germany in terms of the number of start-ups it produces – the result of a support infrastructure unrivaled in Europe.

TUM School of Management

TUM School of Management is an integral part of TUM and conducts cutting-edge research and teaching at the interface of management and technology. Founded in 2002, it consistently leads the ranking of business schools in Germany. Since 2017, TUM School of Management has been a member of a select international group of business schools that are accredited as "Triple Crown" by the AACSB, the AMBA and the EQUIS, a certification that is internationally recognized as a seal of quality for students and academics.

TUM School of Management attracts students and researchers from all over the world. Its mission is to turn enthusiasm for innovation and technology into real products by teaching the necessary management skills. We believe that entrepreneurship and social responsibility go hand in hand. These are the values we pass on to our students.

Through our interdisciplinary teaching approach, we train future managers to feel equally at home talking to management experts, engineers or scientists. Thanks to the entrepreneurial environment at TUM, a considerable number of our graduates create their own businesses in technology-based industries.

TUM Campus Heilbronn

Part of an initiative by the Dieter Schwarz Foundation, TUM School of Management has created a teaching and research facility at the state-of-the-art Heilbronn Education Campus. At TUM Campus Heilbronn, excellence in research and teaching meets the exciting entrepreneurial challenges of one of the most innovative regions in Germany.

TUM School of Management started operating at the Heilbronn campus in the winter semester of 2018/2019 and currently offers three study programs as well as cutting-edge research at its Center for Digital Transformation and the Global Center for Family Enterprise at the Campus.

Students and researchers investigate areas such as the management of digital transformation and family businesses, highly sought-after competencies in companies of all sizes.

Since the winter semester 2022/23, the TUM School of Computation, Information and Technology also started operating in Heilbronn

Center for Digital Transformation at TUM Campus Heilbronn

Digitalization is transforming vast areas of our live, and new technologies are fundamentally changing the way companies work. From processes to business models and management styles – everything must be put to the test. The Center for Digital Transformation (CDT) is part of the TUM School of Management, located at TUM Campus Heilbronn and researches issues related to the impact of digital technologies on business, data-driven decision making and digital platforms. The goal of the CDT is to develop solutions through practice-oriented research and thus generate direct benefits for the economy and society. New findings flow directly into teaching to prepare students for the tasks of the future.

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