Chair of Information Systems and Business Process Management (i17)
Department of Computer Science
TUM School of Computation, Information and Technology
Technical University of Munich

Master's Thesis in Informatics

Nicolás Mario Arteaga García

Cotton Candy Digital Twin: Prescriptive Creation of Digital Twins

TUM Uhrenturm

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Titel der Abschlussarbeit

Thesis for the Attainment of the Degree
Master of Science

at the TUM School of Computation, Information and Technology,
Department of Computer Science,
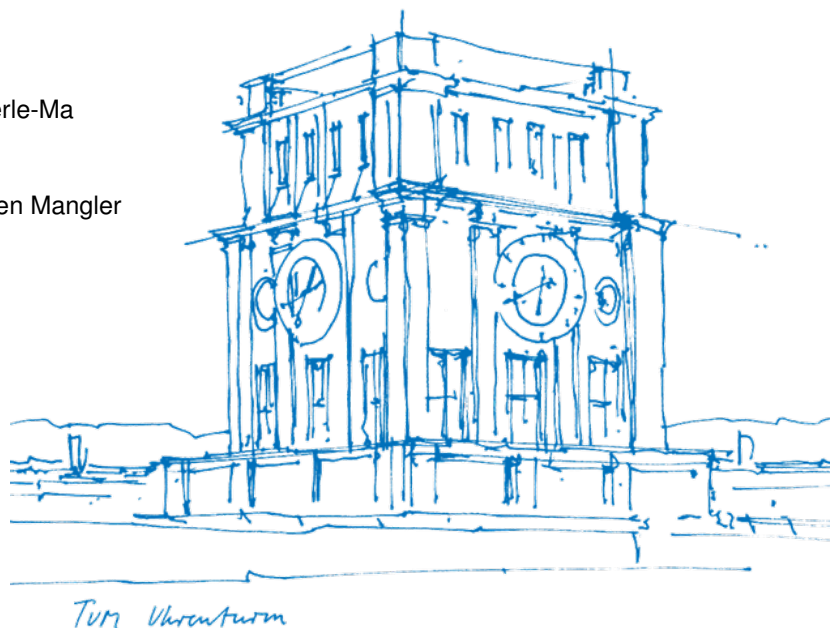Chair of Information Systems and Business Process Management (i17)

Examiner
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Supervised by
Dr. rer. soc. oec. Juergen Mangler

Submitted on
01.06.2025

TUM Uhrenturm

Declaration of Academic Integrity

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This thesis was not previously presented to another examination board and has not been published.

Garching, 01.06.2025   Nicolás Mario Arteaga García

Abstract

150 - 180 words

Keywords: Digital Twin, Cotton Candy, BPTM

Include three to five words, phrases, or acronyms as keywords.

Contents

List of Tables

List of Figures

Introduction

For exposes, create this chapter, plus start with chapter 2 (Related Work).

Motivation

Why are we doing it? About 1 page.

As industries evolve, the ability to optimize processes while minimizing waste has become increasingly important. Digital twins (virtual models of physical systems) are transforming how we monitor, analyze, and improve these processes. While reactive digital twins respond to events as they occur, providing immediate but limited feedback, predictive digital twins forecast potential outcomes based on historical and real-time data, allowing proactive adjustments. However, the growing focus on prescriptive digital twins introduces a new frontier: systems that not only predict outcomes but also recommend specific actions to achieve goals such as improving efficiency, reducing energy consumption, or enhancing product quality.

This thesis explores the development of prescriptive digital twins using the Cotton Candy Automata, a robotic system developed in the chair to automate cotton candy production, as a practical and measurable test case. This scenario provides an ideal environment for evaluating two distinct approaches to digital twin design—bottom-up and top-down—by analyzing key variables such as heating time, spinning duration, sugar amount, and energy usage. Each approach takes a unique perspective:

Bottom-Up Approach: Focuses on physical measurements and process models, leveraging real-time sensor data to guide system optimization.

Top-Down Approach: Relies on historical data and advanced computational methods, including interpolation, selection of closest historical values, and machine learning models like Recurrent Neural Networks (RNNs), to model and optimize the system.

The goal of this thesis is to provide a comprehensive evaluation of these two approaches, comparing their strengths, limitations, and suitability for different scenarios. By analyzing metrics such as energy savings, time efficiency, and production quality, the research aims to determine which method

offers the greatest value (for this process/for specific process types?). Applying both methodologies to the same scenario enables a deeper understanding of their trade-offs and practical implications, offering insights that can guide future efforts in digital twin development.

Ultimately, this work contributes to the broader understanding of how to design and implement prescriptive digital twins, providing actionable recommendations for selecting the best approach based on system goals, constraints, and operational contexts.

Research Questions

At least 3 questions. They should not be answerable yes/no. Questions should be questions (1 sentence). But you are allowed to explain them in more detail. In the explanation also tell how you plan to prove that your potential future solution is good.

About 1 page.

Fexamples: (1) How can we design and implement prescriptive digital twins for the Cotton Candy Automata? (2) MMM What are the strengths and limitations of each approach, and how do they impact key metrics such as energy savings, time efficiency, and production quality?

Contribution

What will/have I do/done that nobody else has done before. About 1/2 page.

Methodology

Design Science in Information System (Hevner). How are we doing research?

(1) Summary what design science is (it uses stakeholders, artefacts, steps, ...).

(2) What are the stakeholders, artefacts, steps for MY case. What does it mean for my thesis?

About 1.5 pages.

Evaluation

How will I evaluate that my proposal is good. This ties into the research questions.

About 1 page.

Structure

Which chapters will my thesis have, and what are they all about. About 1/4 page.

Related Work

Related Work - There is a girl with long dark hair doing a thesis on digital twin as a research analysis. ask her per discord

google scholar in-title digital twin / business processes, search queries that give you less than 20 papers and decide 1 or 2 papers in the end. How many papers did we eliminate? why? bc too

backgorund 1-2 sentences -> Why am I doing something different to this related work

Final max 4-5 papers that really relate to what Im doing

THis one doesnt work bc, its for bridges and civil engineering https://www.sciencedirect.com/science/article/pii/S0141029623(

this one looks good :)) https://www.sciencedirect.com/science/article/pii/S0360835224003620

Solution Design

Implementation

Evaluation

Discussion

Conclusion

Figure 1

My Figure Caption

A note describing the figure

Appendix

Table 1

Your first table

Value 1	Value 2	Value 3
α	β	γ
1	1110.1	a
2	10.1	b
3	23.113231	c

A note describing the table.

Figure 2

My Figure Caption

A note describing the figure