

# Thomas D. Lehmann

Edmonton, AB, Canada

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## Work and Research Experience

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### Elementiam – Materials and Manufacturing

Edmonton, Canada

CONTRACTOR

Aug. 2021 - present

- Electrical design of a control cabinet for a 5-axis CNC-based Hybrid Manufacturing platform
  - Development of specifications, layout design, electrical schematics, design documentation, readiness for CSA approval

### Additive Design and Manufacturing Systems Lab, MECE Department, University of Alberta

Edmonton, Canada

POSTDOCTORAL FELLOW

Oct. 2018 - present

- *Primary project:* Robotic large-scale metal wire and arc additive manufacturing (WAAM) in collaboration with InnoTech Alberta (Oct. 2018 - Apr. 2021)
  - Procurement, commissioning and installation of robotic large-scale WAAM platforms
  - Design and development of a ROS-based, hardware-agnostic software toolchain for robotic large-scale AM – from tool path to real-time computer-integrated execution
  - Systems and sensor integration (ROS-based for welding system, sensing systems, IR cameras)
  - Research on deposition parameter identification and optimization, and sensor-fusion-based and machine-learning-based process optimization and control
  - Supervision of undergraduate and graduate students conducting research and development on process modeling, in-situ process monitoring and control, process planning, system setup and integration, and other related topics
  - Supervision and management of software development, code review and approval
- *Secondary projects:*
  - Automated repair of worn parts through 3D scanning and hybrid manufacturing
  - Robotic polymer AM

### Telerobotic and Biorobotic Systems Lab, ECE Department, University of Alberta

Edmonton, Canada

RESEARCHER

Feb. 2018 - Sep. 2018

- Introduction of the robot middleware *Robot Operating System* (ROS) to the Telerobotic and Biorobotic Systems Lab
  - Development of point streaming interfaces for industrial robots using ROS-Industrial
  - Design and implementation of teleoperation for industrial robots using point streaming
  - Design and implementation of an admittance controller for industrial robots

### Telerobotic and Biorobotic Systems Lab, ECE Department, University of Alberta

Edmonton, Canada

RESEARCH ASSISTANT

Sep. 2013 - Jan. 2018

- Research on PhD thesis topic: “Novel sensing and actuation methods for needle steering in soft tissue with application to prostate brachytherapy”
- Developing novel methods for deflection estimation and control of a bevel-tipped needle during insertion
- Design of a 2-DOF experimental needle insertion robot (hardware and software in Matlab and Simulink Real-Time) for validation of deflection estimation and control algorithms

### ECE Department, University of Alberta

Edmonton, Canada

TEACHING ASSISTANT

Sep. 2014 - Dec. 2017

- Responsibilities: Instruction/supervision of laboratory and report/assignment grading
  - *Fall Term 2014:* ECE 210 – Introduction to Digital Logic Design
  - *Winter Term 2015:* ECE 212 – Introduction to Microprocessors
  - *Fall Term 2015, 2016 & 2017:* ECE 464 – Medical Robotics
  - *Winter Term 2016 & 2017:* ENCOMP 100 – Computer Programming for Engineers

### Institute of Technical Medicine (ITeM), Furtwangen University

Schwenningen, Germany

RESEARCH ASSISTANT

Mar. 2013 - Aug. 2013

- Design and implementation of a Java-based patient simulator
- Re-implementation of various mathematical models of the cardiovascular system, heart, and respiratory system

## Telerobotic and Biorobotic Systems Lab, ECE Department, University of Alberta

Edmonton, Canada

### RESEARCH ASSISTANT

Sep. 2012 - Feb. 2013

- Research on Master's thesis titled: "Development of an Intelligent Surgeon's Assistant for Needle Adjustment in Prostate Brachytherapy"
- Development of a virtual sensor for estimating needle deflection during insertion into soft tissue
- Design of an experimental setup for automated needle insertion

## Institute of Technical Medicine (ITeM), Furtwangen University

Schwenningen, Germany

### RESEARCH ASSISTANT

Nov. 2011 - Aug. 2012

- Implementation of a Java-based tool for real-time plotting of a ventilation support simulator for Android mobile devices

## University of Canterbury

Christchurch, New Zealand

### VISITING STUDENT

Oct. 2010 - Mar. 2011

- Research for Bachelor's thesis titled: "Software Development for an Autonomously Operating Robot Truck for the Location and Recovery of Objects"
- Research and development of image processing methods for object detection under noisy conditions
- Development of a state-machine-based algorithm for automatic maneuvering and decision-making

## Aesculap AG

Tuttlingen, Germany

### INTERN

Mar. 2009 - Aug. 2009

- Development of microcontroller software in C for automatic detection of various types of surgical drills
- Design and assembly of electronic circuits

## Education

### University of Alberta, Department of Electrical and Computer Engineering

Edmonton, Canada

#### PHD IN BIOMEDICAL ENGINEERING

Sept. 2013 - Jan. 2018

- *Areas of study:* Medical robotics, biomedical engineering, mechanics-based modeling, needle insertion, needle steering
- *Areas of research:* Needle insertion, needle steering, needle deflection modeling, sensing and estimation

### Furtwangen University

Schwenningen, Germany

#### MSC IN BIOMEDICAL ENGINEERING

Oct. 2011 - Jun. 2013

- *Areas of study:* Physiological modeling, simulation, machine learning, decision support systems for medical ventilation of patients
- *Areas of research:* Decision support systems for medical ventilation of patients, needle insertion, needle deflection sensing and estimation

### Furtwangen University

Schwenningen, Germany

#### BSC IN MEDICAL ENGINEERING

Mar. 2007 - Mar. 2011

- *Area of study:* Biomedical Technology

## Skills

### Programming languages

C/C++, Python, Java (Java SDK, Android SDK), JavaScript, MATLAB/Simulink, Motoman INFORM

### IDEs, build environments

eclipse, Qt Creator, Visual Studio, VS Code, cmake, catkin

### Robotics software frameworks/ecosystems:

ROS, ROS-industrial, RViz, MoveIt!, Descartes, Robot Web Tools, roserial-arduino

### Operating systems

Linux (Debian, Ubuntu), MS Windows

### CAD, rapid prototyping, 3D printing (polymer)

SolidWorks, FlashForge Creator Pro, ReplicatorG, Cura, Slic3r

### Documentation, word processing, productivity

LaTeX, MS Office, LibreOffice, Google Suite, Inkscape

### Version control

Git, GitHub, Pull Request Workflow, Gitflow Workflow

### Certificates

Yaskawa Motoman - DX200 Welding Programming and Motosim Overview

### Languages

German (native), English

# Publications

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## Journals

- [1] T. Lehmann, D. Rose, E. Ranjbar, M. Ghasri-Khouzani, M. Tavakoli, H. Henein, T. Wolfe, A. J. Qureshi, “Large-scale metal additive manufacturing: a holistic review of the state of the art and challenges,” *International Materials Reviews*, 2021.
- [2] T. Lehmann, A. Jain, Y. Jain, H. Stainer, T. Wolfe, H. Henein, A. J. Qureshi, “Concurrent geometry- and material-based process identification and optimization for robotic CMT-based wire arc additive manufacturing,” *Materials & Design*, vol. 194, p. 108841, Sep. 2020.
- [3] T. Lehmann, R. Sloboda, N. Usmani and M. Tavakoli, “Model-Based Needle Steering in Soft Tissue via Lateral Needle Actuation,” in *IEEE Robotics and Automation Letters*, vol. 3, no. 4, pp. 3930-3936, Oct. 2018. Also, selected for presentation at the IEEE/RSJ International Conference on Intelligent Robots and Systems, Madrid, Spain, 2018.
- [4] T. Lehmann, R. Sloboda, N. Usmani, and M. Tavakoli, “Human-machine collaboration modalities for semi-automated needle insertion into soft tissue,” *IEEE Robotics and Automation Letters*, vol. 3, no. 1, pp. 477–483, 2018.
- [5] T. Lehmann, C. Rossa, N. Usmani, R. Sloboda, and M. Tavakoli, “Intraoperative Tissue Young’s Modulus Identification During Needle Insertion Using a Laterally Actuated Needle,” *IEEE Transactions on Instrumentation and Measurement*, vol. 67, no. 2, pp. 371–381, 2018.
- [6] T. Lehmann, C. Rossa, N. Usmani, R. Sloboda, and M. Tavakoli, “Deflection modeling for a needle actuated by lateral force and axial rotation during insertion in soft phantom tissue,” *Mechatronics*, vol. 48, pp. 42–53, 2017.
- [7] T. Lehmann, C. Rossa, N. Usmani, R. Sloboda and M. Tavakoli. “A real-time estimator for needle deflection during insertion into soft tissue based on adaptive modeling of needle-tissue interactions”. *IEEE/ASME Transactions on Mechatronics*, vol. 21, issue 6, pp. 2601–2612, 2016.
- [8] C. Rossa, T. Lehmann, R. Sloboda, N. Usmani and M. Tavakoli. “A data-driven soft sensor for needle deflection in heterogeneous tissue using just-in-time modelling”. *Medical & Biological Engineering & Computing*, pp. 1–14, 2016.
- [9] J. Kretschmer, B. Laufer, T. Lehmann, P. Stehle, D. Redmond, and K. Möller. “Ein softwarebasierter Patientensimulator zur Evaluierung medizinischer Entscheidungssysteme (A software-based patient simulator to evaluate medical decision support systems)”. *at – Automatisierungstechnik*, vol. 64, issue 11, pp. 878–893, 2016.
- [10] P. Stehle, T. Lehmann, D. Redmond, K. Möller, and J. Kretschmer, “A java based simulator with user interface to simulate ventilated patients,” *Current Directions in Biomedical Engineering*, vol. 1, no. 1, pp. 423–427, 2015.
- [11] T. Lehmann, M. Tavakoli, N. Usmani and R. Sloboda. “Force-Sensor-Based Estimation of Needle Tip Deflection in Brachytherapy”. *Journal of Sensors*, vol. 2013, 2013.

## Conferences (peer-reviewed)

- [12] T. Lehmann, C. Rossa, N. Usmani, R. Sloboda and M. Tavakoli. “Needle path control during insertion in soft tissue using a force-sensor-based deflection estimator”. *Proceedings of the 2016 IEEE International Conference on Advanced Intelligent Mechatronics*, Banff, Canada, July 12–15, 2016, pp. 1174–1179.
- [13] J. Kretschmer, T. Lehmann, D. Redmond, P. Stehle and K. Möller, “A Modular Patient Simulator for Evaluation of Decision Support Algorithms in Mechanically Ventilated Patients”, *XIV Mediterranean Conference on Medical and Biological Engineering and Computing 2016 (MEDICON 2016)*, 2016.
- [14] T. Lehmann, C. Rossa, N. Usmani, R. Sloboda and M. Tavakoli. “A virtual sensor for needle deflection estimation during soft-tissue needle insertion”. *Proceedings of the 2015 IEEE International Conference on Robotics and Automation*, Seattle, USA, 2015, pp. 1217–1222.
- [15] T. Nguyen, T. Lehmann, J. Kretschmer and K. Möller, “Bringing model based ventilation therapy to the bedside”, *2013 ICME International Conference on Complex Medical Engineering*, Beijing, China, 2013, pp. 666-669.

# Presentations

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### The International Symposium on Medical Robotics (ISMR 2018)

Atlanta, USA

Presented poster titled “Intraoperative Identification of Tissue Young’s Modulus During Prostate Brachytherapy”

Mar. 2018

### The 2016 IEEE International Conference on Advanced Intelligent Mechatronics (AIM)

Banff, Canada

Presented paper titled “Needle path control during insertion in soft tissue using a force-sensor-based deflection estimator”

Jul. 2016

### The 2015 IEEE International Conference on Robotics and Automation (ICRA)

Seattle, USA

Presented paper titled “A virtual sensor for needle deflection estimation during soft-tissue needle insertion”

May 2015

## Awards & Scholarships

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- 2020 **Mitacs Accelerate Scholarship**, *Mitacs*
- 2018 **Travel Award**, *International Symposium on Medical Robotics*
- 2016 **Graduate Travel Award**, *University of Alberta*
- 2015 **Graduate Travel Award**, *University of Alberta*
- 2013 **Doctoral Recruitment Scholarship**, *University of Alberta*