Philipp Tempel

Doctor of Engineering (Engineering Cybernetics)

You have three options in live: give in, give up, or give everything.

- Highly self-motivated doctor of engineering with demonstrated research expertise modeling flexible multi-body systems
- Rich experience in modeling and computer simulation, using MatLab, MAPLE, Python (Scipy, Sympy)
- Additional experience in numerical integration schemes and mechanical integration schemes

Education

07/2015 to 07/2019 **Doctor of Engineering (Doktoringenieur)**, *Stuttgart Research Centre for Simulation Technology (SRC SimTech) and Institute for Control Engineering (ISW)*, University of Stuttgart, magna cum laude.

Dynamics of Cable-Driven Parallel Robots with Elastic and Flexible, Time-Varying Length Cables

- Development of models and algorithms for forward and inverse dynamics of kinematically overconstrained cable robots
- Modeling of dynamics of elasticity and flexibility of cables based on Rayleigh-Ritz approaches using spatial discretization and assumed mdes
- Experimental identification of mechanical cable properties and experimental validation of derived models

Committee members:

- Dr.-Ing. Andreas Pott, adjunct professor, Institute for Control Engineering of Machine Tools and Manufacturing Units, University of Stuttgart, Germany
- Marc Gouttefarde, Ph.D., Laboratoire d'Informatique, de Robotique et de Microélectronique de Montpellier (LIRMM), Montpellier, France
- Prof. Bernard Haasdonk, Institute of Applied Analysis and Numerical Simulation, University of Stuttgart
- Prof. Remco I. Leine, Institute for Nonlinear Mechanics, University of Stuttgart

10/2007 to 03/2013 **Graduate Engineer (Diplomingenieur) Engineering Cybernetics**, *University of Stuttgart and University of Delaware*, Stuttgart and Newark, DE, USA.

Graduation thesis: *A Novel Way to Learning to Fly Quadrotors Using a Force Feedback Joystick*. Showed that a force feedback joystick can be used to teach novices how to fly quadrotors commanding directly the rotor torques

- Thesis supervised by Sunil K. Agrawal at Mechanical Systems Laboratory, University of Delaware, Newark, DE, USA
- Major in Control Theory
- Minor in Biomedical Engineering, and Optical Systems

Research

since 10/2019 **Postdoctoral Research Associate**, *Delft University of Technology, Department of Precision and Microsystems Engineering, Just L. Herder's Lab*, Delft, The Netherlands.

Intra-faculty cohesion project of the *Art and Technology* group at the Department of Materials Science and Engineering and the *Mechatronic System Design* group at the Department of Precision and Microsystems Engineering. I design a cable-driven parallel robot for scanning and inspection of art objects like paintings, reliefs, or statues. The robot shall be able to automate scanning of art objects in 5 degrees of freedom over a large workspace while being accurate in submillimeter range.

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12/2013 to 09/2019 **Research Assistant**, *Institute for Control Engineering of Machine Tools and Manufacturing Units ISW*, Stuttgart, Germany.

Research project was funded by SRC SimTech and the German Research Foundation DFG, while additional projects were primarily industry funded. Supervised 23 bachelor and master theses; am a teaching assistant in charge of one lab session and two lectures, creating and supervising assignments.

- Development of models and algorithms for forward and inverse dynamics of kinematically overconstrained cable robots
- Mechanic and control design of two cable robots for the German pavilion at the universal exposition *Expo Milano 2015*
- Development and comissioning of two redundantely restrained and one suspended cable robot for applications in additive manufacturing (printing with FDM, PLM, and concrete)

03 to 06/2016 **Visiting Researcher**, *Team DEXTER, Robotics Department, LIRMM*, Montpellier, France.

Compulsory research visit mandated by the SRC SimTech. Extended modeling of cable robots to also describe suspended systems and to validate my simulation framework on two different cable robots.

04 to 06/2014 **Visiting Researcher**, *RRI, Chonnam National University*, Gwangju, Republic of Korea.

Invitation by Dr. Pott to visit Joint Robotics Laboratory of Fraunhofer IPA and of Robotics Research Initiative RRI. We designed and commissioned two spatial cable robots and performed studies on using planar cable robots for rehabilitation of upper arm and shoulder immobility.

04 to 12/2013 **Research Assistant**, *Institute for Biomedical Engineering, BMT*, Stuttgart, Germany.

Designed lab sessions for measurement of otoacoustic emissions and on electrical impedance tomography for 2nd year bachelor students. Bachelor and master students were working under my supervision on developing and implementing algorithms for reconstructing molar mass signal of respiratory gas in a double-tracer gas single-breath washout.

Vocational

10/2015 to 12/2017 **Project Manager**, *FastStorageBW2: Demonstrators, Field and Safety Tests*, Stuttgart, Germany.

Project goal was development of high-performance battery-capacitor hybrid energy storage systems, termed *PowerCaps*. In charge of subproject for demonstrators, field and safety tests.

- Organziational tasks to ensure the project partners and their tasks stay on track
- Dimensioned PowerCaps components for demonstrators of industrial applications
- Developed demonstrators to demonstrate industrial applicability: high-bay storage and retrieval system, e-bike, automated guided vehicle system
- Experimental verification of reduction of connected power consumption using PowerCaps in high-bay storage and retrieval systems

09/2016 to 05/2017 **Project Manager**, *Automation and Digitalization in Manufacturing of Control Cabinets*, Stuttgart, Germany.

Conducted a survey on the challenges and chances of automation and digitalization in the manufacturing of control and switch cabinets for classical mechanical and plant engineering.

07/2008 to 03/2012 **Student representative body**, *Fachschaft Maschinenbau & Co.*, Stuttgart, Germany.

Helped to-be students and enrolled students with their questions, concerns, and ideas and acted as a spokesman for their interest

- Member in several appointments committees of the faculty
- Contributed to faculty and university-wide policy on higher education
- Member of advisory board/committee of study affairs in course *Engineering Cybernetics*
  - Contribute to implementation of the Bologna process i.e., transition from diploma course to bachelor and master course
  - Public relations activities to promote the course to high school graduates
- Organized annual orientation week for first semester student's of the faculty for several years
- Organized field trips for students to various companies in and near Stuttgart, Germany
- Provided students with voluntary coaching in various lectures

10/2009 to 09/2011 **Student representative to the faculty council**, *Faculty of Engineering Design, Production Engineering and Automotive Engineering*, Stuttgart, Germany.

Represented students' interests and wishes in the faculty council of my faculty over two legislative periods

- Partake in appointments committees for several professorships
- Review proposals for funding of student-related projects

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Teaching

10/2015 to 03/2019 **Modeling, Analysis, and Design of New Robot Kinematics**, *Lecture*, University of Stuttgart .
Teaching 1st and 2nd year master students the basics of parallel robots kinematics and dynamics, as well as how to use this knowledge and the methods learned to design a parallel robot for a specific task. Besides a slide-based lecture, the course also comprised practical sessions during which students applied what they have learned to various tasks I gave them. On average, 12 students per semester.

10/2017 to 03/2019 **Planning of Robotic Systems**, *Lecture*, University of Stuttgart .
Teaching 2nd year master's students how to design robotic systems focusing more on the overall design process than the kinematic or topology of a robot i.e., students learned about requirement definition and how to choose a task-suitable robot, as well as safety and operational questions. On average, 15 students per semester.

10/2014 to 03/2019 **Simulation of Closed-loop Controls of Feed Axes using MATLAB and Simulink**, *Lab session*, University of Stuttgart .
Computer-based lab session teaching students how to create a simulation model from Newton-Euler equations and making it simulate in MATLAB and Simulink. Students' designed a conventional cascaded feed axis control using frequency response technique. Later, they extended it with a state-feedback control shaped via root locus analysis that allows choosing more aggressive control parameters of the cascaded feed axis control while keeping the closed-loop stable.

Research and Software Skills

research kinematics and dynamics modeling, parallel robots, multi-body simulation, numerical integration schemes.

software C/C++, Git, LaTeX, Maple, MATLAB, Python, SolidWorks, TwinCAT.

Languages

native German

fluent English *TOEFL iBT: 114/120pts, (taken 05/2013)*

comfortable French *Level B2*

Publications

Books

2019 P. Tempel, *Dynamics of Cable-Driven Parallel Robots with Elastic and Flexible, Time-Varying Length Cables*, ser. Stuttgarter Beiträge zur Produktionsforschung. Stuttgart: Fraunhofer Verlag, 2019, vol. 94, ISBN: 978-3-8396-1536-2. DOI: 10.18419/opus-10818.

Peer Reviewed Articles

2019 C. Reiff, F. Eger, P. Tempel, M. C. Magnanini, J. A. Ortiz, M. Colledani, A. Verl, and I. Sarries, "Smart Centering for Rotation-Symmetric Parts in Multi-Stage Production Systems for Zero-Defect Manufacturing", *Procedia CIRP*, vol. 79, pp. 27–32, 2019, ISSN: 2212-8271. DOI: 10.1016/j.procir.2019.02.006.

2017 J. Port, Z. Tao, A. Junger, *et al.*, "A Simple Method to Reconstruct the Molar Mass Signal of Respiratory Gas to Assess Small Airways with a Double-Tracer Gas Single-Breath Washout", *Medical & biological engineering & computing*, vol. 55, no. 11, pp. 1975–1987, 2017. DOI: 10.1007/s11517-017-1633-y. eprint: 28357624.

2016 P. Tempel and A. Pott, "Parallele Seilroboter in Theorie und Praxis, Leichtbau, Energieeffizienz und hohe Dynamiken als Potential, Elastizität als Hauptherausforderung", *wt Werkstatttechnik online*, vol. 106, no. 9, pp. 643–647, 2016, ISSN: 1436-4980.

2015 P. Tempel, P. Miermeister, A. Lechler, and A. Pott, "Modelling of Kinematics and Dynamics of the IPAnema 3 Cable Robot for Simulative Analysis", *Applied Mechanics and Materials*,

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vol. 794, pp. 419–426, 2015, ISSN: 1662-7482. DOI: 10.4028/www.scientific.net/AMM.794.419.

P. Tempel, F. Schnelle, A. Pott, and P. Eberhard, "Design and Programming for Cable-Driven Parallel Robots in the German Pavilion at the EXPO 2015", *Machines*, vol. 3, no. 3, pp. 223–241, 2015, ISSN: 2075-1702. DOI: 10.3390/machines3030223.

Peer Reviewed Conferences Proceedings

2021 P. Tempel, M. Alfeld, and V. van der Wijk, "Design and Analysis of Cable-Driven Parallel Robot CaRISA, a Cable Robot for Inspecting and Scanning Artwork", in *ROMANSY 23 - Robot Design, Dynamics and Control*, Proceedings of the 3rd CISM IFToMM Symposium (Sapporo, Japan, Sep. 20–24, 2020), G. Venture, J. Solis, Y. Takeda, and A. Konno, Eds., ser. CISM International Centre for Mechanical Sciences, International Centre for Mechanical Sciences and International Federation for the Promotion of Mechanism and Machine Science, vol. 601, Cham: Springer Nature and Springer International Publishing, 2021, pp. 136–144. DOI: 10.1007/978-3-030-58380-4_17.

2020 T. Reichenbach, P. Tempel, A. Verl, and A. Pott, "On Kinetostatics and Workspace Analysis of Multi-Platform Cable-Driven Parallel Robots with Unlimited Rotation", in *Robotics and Mechatronics (ISRM 2019)*, Proceedings of the 6th IFToMM International Symposium on (Taipei, Taiwan, Oct. 28–30, 2019), C.-H. Kuo, P.-C. Lin, T. Essomba, and G.-C. Chen, Eds., ser. Mechanisms and Machine Science, International Federation for the Promotion of Mechanism and Machine Science, vol. 78, Cham: Springer, 2020, pp. 79–90. DOI: 10.1007/978-3-030-30036-4_7.

F. Trautwein, T. Reichenbach, P. Tempel, A. Pott, and A. Verl, "COPacabana, Ein modularer paralleler Seilroboter", in *Sechste IFToMM D-A-CH Konferenz 2020*, (Lienz, Austria, Feb. 27–28, 2020), M. Pfurner and F. Dohnal, Eds., International Federation for the Promotion of Mechanism and Machine Science Germany, 2020, ISBN: 978-3-940402-28-8. DOI: 10.17185/duepublico/71189.

2019 F. Eger, P. Tempel, M. C. Magnanini, C. Reiff, M. Colledani, and A. Verl, "Part Variation Modeling in Multi-Stage Production Systems for Zero-Defect Manufacturing", in *Industrial Technology (ICIT 2019)*, 2019 IEEE International Conference on (Melbourne, VIC, Australia, Feb. 13–15, 2019), Institute of Electrical and Electronics Engineers, IEEE, 2019, pp. 1017–1022. DOI: 10.1109/ICIT.2019.8754964.

A. Pott and P. Tempel, "A Unified Approach to Forward Kinematics for Cable-Driven Parallel Robots Based on Energy", in *Advances in Robot Kinematics (ARK 2018)*, Proceedings of the 2018 16th International Symposium on (Bologna, Italy, Jul. 1–5, 2018), J. Lenarčič and V. Parenti-Castelli, Eds., ed. by B. Siciliano and O. Khatib, ser. Springer Proceedings in Advanced Robotics, International Centre for Mechanical Sciences and International Federation for the Promotion of Mechanism and Machine Science, vol. 8, Cham: Springer, 2019, pp. 401–409, ISBN: 978-3-319-93187-6. DOI: 10.1007/978-3-319-93188-3_46.

A. Pott, P. Tempel, A. Verl, and F. Wulle, "Design, Implementation and Long-Term Running Experiences of the Cable-Driven Parallel Robot CaRo Printer", in *Cable-Driven Parallel Robots (CableCon 2019)*, Proceedings of the Fourth International Conference on (Krakow, Poland, Jul. 1–4, 2019), A. Pott and T. Bruckmann, Eds., ser. Mechanisms and Machine Science, International Federation for the Promotion of Mechanism and Machine Science, vol. 74, Cham: Springer, 2019, ISBN: 978-3-030-20750-2. DOI: 10.1007/978-3-030-20751-9_32.

T. Reichenbach, P. Tempel, A. Verl, and A. Pott, "Static Analysis of a Two-Platform Planar Cable-Driven Parallel Robot with Unlimited Rotation", in *Cable-Driven Parallel Robots (CableCon 2019)*, Proceedings of the Fourth International Conference on (Krakow, Poland, Jul. 1–4, 2019), A. Pott and T. Bruckmann, Eds., ser. Mechanisms and Machine Science, International Federation for the Promotion of Mechanism and Machine Science, vol. 74, Cham: Springer, 2019, ISBN: 978-3-030-20750-2. DOI: 10.1007/978-3-030-20751-9_11.

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P. Tempel, D. Lee, F. Trautwein, and A. Pott, "Modeling of Elastic-Flexible Cables with Time-Varying Length for Cable-Driven Parallel Robots", in *Cable-Driven Parallel Robots (CableCon 2019)*, Proceedings of the Fourth International Conference on (Krakow, Poland, Jul. 1–4, 2019), A. Pott and T. Bruckmann, Eds., ser. Mechanisms and Machine Science, International Federation for the Promotion of Mechanism and Machine Science, vol. 74, Cham: Springer, 2019, pp. 295–306, ISBN: 978-3-030-20750-2. DOI: 10.1007/978-3-030-20751-9_25.

P. Tempel, F. Trautwein, and A. Pott, "Experimental Identification of Stress-Strain Material Models of UHMWPE Fiber Cables for Improving Cable Tension Control Strategies", in *Advances in Robot Kinematics (ARK 2018)*, Proceedings of the 2018 16th International Symposium on (Bologna, Italy, Jul. 1–5, 2018), J. Lenarčič and V. Parenti-Castelli, Eds., ed. by B. Siciliano and O. Khatib, ser. Springer Proceedings in Advanced Robotics, International Centre for Mechanical Sciences and International Federation for the Promotion of Mechanism and Machine Science, vol. 8, Cham: Springer, 2019, pp. 258–265, ISBN: 978-3-319-93187-6. DOI: 10.1007/978-3-319-93188-3_30.

2018 P. Tempel, A. Schmidt, B. Haasdonk, and A. Pott, "Application of the Rigid Finite Element Method to the Simulation of Cable-Driven Parallel Robots", in *Computational Kinematics (CK 2017)*, Proceedings of the 7th International Workshop on (Futuroscope-Poitiers, France, May 22–24, 2017), S. Zeghloul, L. Romdhane, and M. A. Laribi, Eds., ser. Mechanisms and Machine Science, Cham: Springer, 2018, pp. 198–205, ISBN: 978-3-319-60867-9. DOI: 10.1007/978-3-319-60867-9_23.

F. Trautwein, P. Tempel, and A. Pott, "A Symbolic-Numeric Method to Capture the Impact of Varied Geometrical Parameters on the Translational Workspace of a Planar Cable-Driven Parallel Robot", in *Reconfigurable Mechanisms and Robots (ReMAR)*, 2018 IEEE International Conference on (Delft, Netherlands, Jun. 20–22, 2018), J. L. Herder and V. van der Wijk, Eds., Institute of Electrical and Electronics Engineers and International Federation for the Promotion of Mechanism and Machine Science, Piscataway, NJ: IEEE, 2018, pp. 1–7, ISBN: 978-1-5386-6380-6. DOI: 10.1109/REMAR.2018.8449891.

2017 P. Tempel, P.-E. Hervé, O. Tempier, M. Gouttefarde, and A. Pott, "Estimating Inertial Parameters of Suspended Cable-Driven Parallel Robots, Use Case on CoGiRo", in *Robotics and Automation (ICRA 2017)*, 2017 IEEE/RAS International Conference on (Singapore, Singapore, May 29–Jun. 3, 2017), IEEE Robotics and Automation Society, IEEE, 2017, pp. 6093–6098, ISBN: 978-1-5090-4633-1. DOI: 10.1109/ICRA.2017.7989723.

2016 P. Tempel, A. Verl, and A. Pott, "On the Dynamics and Emergency Stop Behavior of Cable-Driven Parallel Robots", in *ROMANSY 21, Robot Design, Dynamics and Control*, Proceedings of the 21st CISM-IFToMM Symposium (Udine, Italy, Jun. 20–30, 2016), V. Parenti-Castelli and W. Schiehlen, Eds., ed. by F. Pfeiffer, F. G. Rammerstorfer, E. Guazzelli, B. Schrefler, and P. Serafini, ser. CISM International Centre for Mechanical Sciences, International Federation for the Promotion of Mechanism and Machine Science and International Centre for Mechanical Sciences, vol. 569, Cham: Springer, 2016, pp. 431–438, ISBN: 978-3-319-33713-5. DOI: 10.1007/978-3-319-33714-2_48.

2015 P. Tempel, P. Miermeister, and A. Pott, "Kinematics and Dynamics Modeling for Real-Time Simulation of the Cable-Driven Parallel Robot IPAnema 3", in *Mechanism and Machine Science 2015*, Proceedings of the 14th IFToMM World Congress on (Taipei, Taiwan, Oct. 25–30, 2015), International Federation for the Promotion of Mechanism and Machine Science, vol. 2, airiti Library, 2015, pp. 117–123. DOI: 10.6567/IFToMM.14TH.WC.OS4.020.

Professional Associations

since 03/2018 IEEE Membership and IEEE Robotics and Automation Society

since 01/2018 IEEE Young Professionals

since 01/2018 Wikimedia Germany e.V.

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References

Volkert van der Wijk	Assistant professor in fast-moving dynamically balanced robotics, Department of Precision and Microsystems Engineering (PME), Delft University of Technology, v.vanderwijk@tudelft.nl.
Dr.-Ing. Andreas Pott	Adjunct professor and doctoral advisor, Institute for Control Engineering of Machine Tools and Manufacturing Units (ISW), University of Stuttgart, andreas.pott@isw.uni-stuttgart.de.
Marc Gouttefarde, Ph.D.	CNRS research scientist, Team DEXTER, Robotics Department at Laboratory of Informatics, Robotics and Microelectronics (LIRMM), marc.gouttefarde@lirmm.fr.
Prof. Joachim Nagel	Director, Institute for Biomedical Engineering (BMT), University of Stuttgart, jn@bmt.uni-stuttgart.de.

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