Ruhr Master School
of Applied Sciences

Dieses Wahlpflichtmodul ist ein Angebot der:

Fachhochschule Dortmund
University of Applied Sciences and Arts

Masterstudiengang Embedded Systems Engineering / Digital Transformation

Indoor positioning based on the UWB technology

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University of Applied Sciences and Arts

Westfälische Hochschule
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University of Applied Sciences

STIFTUNG MERCATOR

Module Description for Block Week Module:

Module title	**Indoor positioning based on the UWB technology**
Offering course of studies	Embedded Systems Engineering / Digital Transformation
University Campus	FH Dortmund / Online
Language	English
Module representative/ Full-time lecturer	Prof. Dr. Damian Grzechca (Silesian University of Technology) Prof. Dr. Andreas Becker (FH Dortmund)
Contact	Andreas.becker@fh-dortmund.de

Abbreviation	Workload	Credits	Semester (WiSe/SuSe)	Planned group size	
	90	* 3 / 6		minimum	maximum
				5	20

Courses/course types Attendance	Contact time		Self-study	
Online	Attendance during block week	Additional contact time during preparation and postprocessing e.g. videoconference	Guided during preparation and postprocessing	selfdirected
	40	10	5	35
Teaching types preparation	Online training material			
Teaching types postprocessing	Online meetings and consulting			

* The block week can be used as assignment for various courses (e.g. Signals and Control Systems 1, Trends in Embedded and Mechatronic Systems)

Teaching results/ teaching goals/competences
Goal: Object tracking path calculation based on data provided. Application of data fusion algorithms to enhance tracking/positioning accuracy. Based on the various scenarios a raw data is provided for further investigation in

software environments like Matlab or Python. Students should design a data processing algorithm for object path description and evaluate system accuracy while considering system delay.

Final outcome: Reports from projects based on the initial assumption, requirements, instruction, and data provided (Students send reports for evaluation).

Contents
Global navigation satellite system (GNSS) is currently used in a wide range of applications, its accuracy and time resolution are limited due to various geographical aspects and weather condition. However, the GNSS is good enough for the outdoor positioning of relatively big objects, it is not of great importance for indoor areas. Modern warehouses and even Industry 4.0 require up-to-date positioning of objects with centimeter accuracy because of e.g. the logistic optimization, safety, and precise tracking. Among various methods for object tracking (e.g. visual algorithms for detection and tracking), the course will give you essential knowledge of the UWB positioning hardware by providing basic issues of the tracking objects like AGV (Automated Guided Vehicle). Students will be given instruction for acquiring, processing UWB positioning system at the laboratory: low level configuration of the Tag and Anchors based on the STM-Nucleo development board, point to point ranging, determining accuracy and delay of the ranging process, positioning in 2D/3D environment, data processing from the designed system and acquire other movement parameters for evaluation, e.g. AHRS, encoders. Application of the trilateration algorithm and smoothing data filtration to show the tracking trail of an object. Data comes from the UWB positioning system (based on decawave/quorvo modules), i.e. system has 4 reference points (anchors) and a tag (tracked object, e.g. AGV or bike). Hint: Position estimation can be obtained by Nelder-Mead or the least square methods.

Participation requirements	fundamentals of C/C++ (STM programming), smoothing algorithms (filters like median, moving average, Savitzky-Golay), fundamentals of Matlab (Python is also acceptable).
Examination types	Individual (see below)
Requirement for rewarding credit points	Course can be used as assignment for different modules. Requirements differ. In general: Written documentation
Application of the modul (in other courses)	siehe hierzu Homepage der Ruhr Master School
Literature	(recommended but not limited): 1. https://www.decawave.com/ 2. https://www.decawave.com/wp-content/uploads/2021/01/DWM3000-Datasheet-1.pdf 3. Paszek, Krzysztof, Damian Grzechca, and Andreas Becker. 2021. "Design of the UWB Positioning System Simulator for LOS/NLOS

	Environments" Sensors 21, no. 14: 4757. https://doi.org/10.3390/s21144757 4. Alarifi, Abdulrahman, AbdulMalik Al-Salman, Mansour Alsaleh, Ahmad Alnafessah, Suheer Al-Hadhrami, Mai A. Al-Ammar, and Hend S. Al-Khalifa 2016. "Ultra Wideband Indoor Positioning Technologies: Analysis and Recent Advances" Sensors 16, no. 5: 707. https://doi.org/10.3390/s16050707 5. Grzechca, Damian, Paszek, Krzysztof. „Short-term positioning accuracy based on mems sensors for smart city solutions". Metrology and Measurement Systems 26, nr 1 (2019): 95–107. http://dx.doi.org/10.24425/mms.2019.126325 6. Tran, Tien Q., Andreas Becker, and Damian Grzechca. 2021. "Environment Mapping Using Sensor Fusion of 2D Laser Scanner and 3D Ultrasonic Sensor for a Real Mobile Robot" Sensors 21, no. 9: 3184. https://doi.org/10.3390/s21093184 7. Hanzel, K.; Paszek, K.; Grzechca, D. The Influence of the Data Packet Size on Positioning Parameters of UWB System for the Purpose of Tagging Smart City Infrastructure. **2020**, doi:10.24425/BPASTS.2020.134173. 8. https://www.mathworks.com/
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