Co-funded by the
Erasmus+ Programme
of the European Union

Master Degree in Industry 4.0

Ind4.0 (610455-EPP-1-MY-EPPKA2-CBHE-JP

DELIVERABLE OF ERASMUS+IND4.0 WP2
D3.1 Ind4.0 Courses – Learning Materials

D3.1 Ind4.0 Courses – Learning Materials

Projection Information	
Project Acronym	InD4.0
Project Full Title	Master Degree in Industry 4.0
Project No	601455-EPP-1-2019-1-MY-EPPKA2-CBHE-JP
Funding Scheme	ERASMUS+ KA2 Capacity Building in the field of Higher Education
Coordinator	Universiti Teknologi MARA (UiTM)
Project Website	https://www.ind4-0-eu.my/

Work Package	3. Development of educational material, labs infrastructure & Capacity building
Deliverable:	3.1 InD4.0 Courses – Learning Material
Type:	Document
Dissemination level:	Public
Version:	Final
Delivery date:	15/10/2021
Keywords:	OER, Virtual library, training and learning resources
Abstract:	This deliverable includes a space designed for the students of the Ind4.0 MSc programme. It will be an OER space, freely accessible with material relevant with the Ind4.0 MSc Course's scientific foci. It will be an OER online platform compatible with the Web Content Accessibility Guidelines (WCAG).

Authors	Federica Funghi Ilaria Reggiani Alessandra Pezzati *Guglielmo Marconi University*
Contributors	Prof. Alberto Garinei (USGM) Prof. Bill Vassiliadis (HOU) Prof. Ioannis Chatzigiannakis (Sapienza)

Collection of OERs

- **N° of OERs collected: 53 (30/03/2022)**
- **N° of modules of MSc programme covered: at least one OER per module available (30/03/2022)**

List of courses

CORE COURSES

COMPULSORY COURSES

ELECTIVE COURSES

ORIENTATION COURSES

VET Courses		
Code	**Course Title**	**Durations (in hours)**
INDVET1	Introduction to Manufacturing 4.0	4
INDVET2	Introduction to Agriculture/Aquaculture 4.0	4
INDVET3	Introduction to Pervasive Health/ Health 4.0	4

Index of OER

CO1 OERs

CO1-OER1 - Cybercrime and Cyber security Techniques

Title	Cybercrime and Cyber security Techniques
Resource Link(s)	https://academicworks.cuny.edu/ho_oers/4/
Resource Author(s)	Amy J Ramson, Shalom Cohen
Resource Reference	
Publication Date	2020
Language	English
Content type	Presentation
License	CC BY-NC-SA
Country	USA
Relevant for the IND 4.0 course module(s)	CO1
Relevant Learning Outcome with degree of relevance	define ICT security landscape, analyze ICT network architecture and break down into hardware and software components, identify connected services, interact with industrial and ICT domain specialists for all issues related to information security,
Justification of relevance (contribution)	The specific educational material provides the learner with the necessary knowledge to better understand the particular subject. Then with the help of other open educational resources, he will be able to delve more easily into the specific topic of knowledge.
Estimated study time	2 weeks
Keywords	Cybercrime, ubiquitous crime, cyber security techniques, hacking, legislation
Abstract / short description	This lecture presents information about cybercrime, which has become the most ubiquitous crime world-wide and affects individuals, companies and government. The lecture indicates that 95% of all cybercrime is preventable and describes a myriad of cyber security techniques that are available to prevent hacking. Legislation to combat cybercrime is presented as well as the places where cybercrime should be reported.

CO1-OER2 - A Review of Cybersecurity Guidelines for Manufacturing Factories in Industry 4.0

Title	A Review of Cybersecurity Guidelines for Manufacturing Factories in Industry 4.0
Resource Link(s)	https://ieeexplore.ieee.org/document/9345803
Resource Author(s)	Valentin Mullet, Patrick Sondi, Eric Ramat
Resource Reference	
Publication Date	2021
Language	English
Content type	
License	CCL
Country	France
Relevant for the IND 4.0 course module(s)	Get an overview of the guidelines of different organizations involved in cybersecurity harmonization and standardization in the world
Relevant Learning Outcome with degree of relevance	
Justification of relevance (contribution)	The specific educational material provides the learner with the necessary knowledge to better understand how broad the landscape is, from classical cybersecurity countermeasures to innovative ones, such as those based on honeypots and digital twins.
Estimated study time	2 days
Keywords	Computer security, Production facilities, Industries, Manufacturing, Guidelines, Business, Companies
Abstract / short description	Industry 4.0 is a revolution in manufacturing by introducing disruptive technologies such as Internet of Things (IoT) and cloud-computing into the heart of the factory. The resulting increased automation and the improved production synergy between stocks, supply chains and customer demands, come along with the threats and attacks from the Internet. Despite extensive literature on the cybersecurity topic, many actors in manufacturing factories are just realizing the impact of cybersecurity in the preservation of their business. This paper introduces step-by-step the concepts and practical aspects of an Industry 4.0 manufacturing factory that are related to cybersecurity. Based on a subdivision of a typical factory into several generic perimeters, we present the vulnerabilities and threats regarding the network and devices usually found in each

	perimeter. Therefore, it is more efficient to present the recent proposals of the literature regarding cybersecurity guidelines and solutions in Industry 4.0. Instead of spreading a lot of references regarding every aspect of cybersecurity, we focused on a limited number of papers among the recent references. However, for each paper, we provide the details about the purpose of the proposal, the methodology adopted, the technical solution developed and its evaluation by the authors. These solutions range from classical cybersecurity countermeasures to innovative ones, such as those based on honeypots and digital twins. In order to deliver a review also useful to non scientists, we present our guidelines along with those of some organizations involved in cybersecurity harmonization and standardization in the world.

CO2 OERs

CO2 - OER1 - Application areas and Use cases, Networking Technologies, Data processing architectures, Opportunities and Challenges

Title	Application areas and Use cases, Networking Technologies, Data processing architectures, Opportunities and Challenges
Resource Link(s)	http://ichatz.me/uniroma1/iot-2020/uniroma1-internet_of_things-2020-ichatz-talk2.pdf
Resource Author(s)	Ioannis Chatzigiannakis
Resource Reference	
Publication Date	2020
Language	English
Content type	Presentation
License	CC BY-NC-SA
Country	ITALY
Relevant for the IND 4.0 course module(s)	CO2
Relevant Learning Outcome with degree of relevance	identify key concepts of IoT architectures, examples of IoT applications and main service components, networking technologies, the need for data analysis, cloud vs edge computing
Justification of relevance (contribution)	The specific educational material provides the learner with the necessary knowledge to better understand the particular subject. Then with the help of other open educational resources, he will be able to delve more easily into the specific topic of knowledge.
Estimated study time	1 week
Keywords	IoT architectures, network technologies of IoT deployments, Edge Computing

Abstract / short description	This lecture analyzes how the idea of IoT evolved in the last years from the initial approaches based on wireless sensor networks, to modern approaches where connected devices are not only sensors but real computers that can contribute to the computation in the form of edge and fog computing. Introduction to the Internet of Things, Application areas and Use cases, Networking Technologies, Data processing architectures, Opportunities and Challenges.

CO2 - OER2 - Embedded Operating Systems

Title	Embedded Operating Systems
Resource Link(s)	http://ichatz.me/uniroma1/iot-2020/uniroma1-internet_of_things-2020-ichatz-talk3.pdf
Resource Author(s)	Ioannis Chatzigiannakis
Resource Reference	
Publication Date	2020
Language	English
Content type	Presentation
License	CC BY-NC-SA
Country	ITALY
Relevant for the IND 4.0 course module(s)	CO2
Relevant Learning Outcome with degree of relevance	identify key concepts of embedded operating systems, architectural challenges and core services, concept of hardware abstraction
Justification of relevance (contribution)	The specific educational material provides the learner with the necessary knowledge to better understand the particular subject. Then with the help of other open educational resources, he will be able to delve more easily into the specific topic of knowledge.
Estimated study time	1 week
Keywords	Embedded operating systems, Network stacks, Hardware Abstraction Layer
Abstract / short description	This lecture provides an introduction to embedded operating systems and offered services. Overview of IoT operating systems (Riot-OS, Mbed, ZephyrOS). Deployment methodology and offered services. Task scheduling and power management in low-power and real-time operating system.

CO2 - OER3 - Using a Digital Temperature Sensor with RIOT OS

Title	Using a Digital Temperature Sensor with RIOT OS
Resource Link(s)	https://www.hackster.io/ichatz/using-a-digital-temperature-sensor-with-riot-os-a4c213
Resource Author(s)	Ioannis Chatzigiannakis
Resource Reference	
Publication Date	2020

Language	English
Content type	Tutorial
License	CC BY-NC-SA
Country	ITALY
Relevant for the IND 4.0 course module(s)	CO2
Relevant Learning Outcome with degree of relevance	Hardware prototyping platforms. The ST Microelectronics NUCLEO platform and the ARM Cortex M architecture.
Justification of relevance (contribution)	The specific educational material provides the learner with the necessary knowledge to better understand the particular subject. Then with the help of other open educational resources, he will be able to delve more easily into the specific topic of knowledge.
Estimated study time	1 week
Keywords	Embedded operating systems, Network stacks, Hardware Abstraction Layer
Abstract / short description	This OER provides step-by-step instructions on how to create a simple sensor application using RIOT-OS and the STM Nucleo platform.

CO2 - OER4 - RIOT online course

Title	RIOT online course
Resource Link(s)	https://github.com/riot-os/riot-course
Resource Author(s)	RIOT-OS Community
Resource Reference	
Publication Date	2020
Language	English
Content type	Tutorial
License	CC BY-ND
Country	Germany
Relevant for the IND 4.0 course module(s)	CO2
Relevant Learning Outcome with degree of relevance	Embedded Operating Systems. Hardware Prototyping Platforms.
Justification of relevance (contribution)	The specific educational material provides the learner with the necessary knowledge to better understand the particular subject. Then with the help of other open educational resources, he will be able to delve more easily into the specific topic of knowledge.
Estimated study time	3 week
Keywords	Embedded operating systems, Network stacks, Hardware Abstraction Layer

Abstract / short description	This OER provides step-by-step instruction to the RIOT-OS, how to create hardware prototypes and deploy wireless sensor network.

CO2 - OER5 - Tutorials

Title	Tutorials
Resource Link(s)	https://github.com/RIOT-OS/Tutorials
Resource Author(s)	RIOT-OS Community
Resource Reference	
Publication Date	2020
Language	English
Content type	Tutorial
License	CC BY-ND
Country	Germany
Relevant for the IND 4.0 course module(s)	CO2
Relevant Learning Outcome with degree of relevance	Embedded Operating Systems. Hardware Prototyping Platforms.
Justification of relevance (contribution)	The specific educational material provides the learner with the necessary knowledge to better understand the particular subject. Then with the help of other open educational resources, he will be able to delve more easily into the specific topic of knowledge.
Estimated study time	4 weeks
Keywords	Embedded operating systems, Network stacks, Hardware Abstraction Layer
Abstract / short description	This OER provides step-by-step instruction to the RIOT-OS, how to create hardware prototypes and deploy wireless sensor network.

CO2 - OER6 - Performance Evaluation for IoT

Title	Performance Evaluation for IoT Test complex scenarios
Resource Link(s)	http://ichatz.me/uniroma1/iot-2020/uniroma1-internet_of_things-2020-vitaletti-talk11.pdf
Resource Author(s)	Andrea Vitaletti
Resource Reference	
Publication Date	2020
Language	English
Content type	Presentation
License	CC BY-NC-SA

Country	ITALY
Relevant for the IND 4.0 course module(s)	CO2
Relevant Learning Outcome with degree of relevance	identify key concepts of experimental evaluation, elements of network performance and wireless communication.
Justification of relevance (contribution)	The specific educational material provides the learner with the necessary knowledge to better understand the particular subject. Then with the help of other open educational resources, he will be able to delve more easily into the specific topic of knowledge.
Estimated study time	1 week
Keywords	Performance Evaluation, Network Performance, Energy Consumption
Abstract / short description	This lecture introduces the different aspects of performance evaluation for IoT applications. Elements of network performance and wireless communication. Measuring power consumption and energy efficiency. Looking into the security and privacy of data. Tools for conducting performance evaluation. Overview of software simulators. Synthetic models for wireless channels, node mobility and application traffic generation. Using real-world datasets.

CO2 - OER7 - Internet of Things Low-Power Long-Range Networks

Title	Internet of Things Low-Power Long-Range Networks
Resource Link(s)	http://ichatz.me/uniroma1/iot-2020/uniroma1-internet_of_things-2020-ichatz-talk13.pdf
Resource Author(s)	Ioannis Chatzigiannakis
Resource Reference	
Publication Date	2021
Language	English
Content type	Presentation
License	CC BY-NC-SA
Country	ITALY
Relevant for the IND 4.0 course module(s)	CO2
Relevant Learning Outcome with degree of relevance	identify key concepts of wireless sensor networks, low-power communication, long-range networking
Justification of relevance (contribution)	The specific educational material provides the learner with the necessary knowledge to better understand the particular subject. Then with the help of other open educational

	resources, he will be able to delve more easily into the specific topic of knowledge.
Estimated study time	1 week
Keywords	Low-Power Networking, Wireless Sensor Networks, Long-Range Connectivity
Abstract / short description	This lecture introduces relevant networking technologies and standards for low-power and long-range wide area networks.

CO2 - OER8 - Internet of Things

Title	Internet of Things
Resource Link(s)	http://ichatz.me/uniroma1/iot-2020/uniroma1-internet_of_things-2020-ichatz-talk13.pdf http://ichatz.me/uniroma1/iot-2020/uniroma1-internet_of_things-2020-ichatz-talk15.pdf
Resource Author(s)	Ioannis Chatzigiannakis
Resource Reference	
Publication Date	2021
Language	English
Content type	Presentation
License	CC BY-NC-SA
Country	ITALY
Relevant for the IND 4.0 course module(s)	CO2
Relevant Learning Outcome with degree of relevance	identify key concepts of wireless sensor networks, low-power communication, wireless mesh networks
Justification of relevance (contribution)	The specific educational material provides the learner with the necessary knowledge to better understand the particular subject. Then with the help of other open educational resources, he will be able to delve more easily into the specific topic of knowledge.
Estimated study time	2 week
Keywords	Wireless Ad-hoc Networks. Routing in Low-Power Wireless Networks. The 802.15.4 communication protocol. The 6LoWPAN and IPv6 for the IoT.
Abstract / short description	This lecture introduces the concept of wireless ad-hoc networks and the need to form wireless mesh networks. Presents the technical challenges and key problems of ad-hoc routing protocols for wireless sensor networks. Introduces the RPL protocol.

CO2 - OER9 - Internet of Things

Title	Internet of Things

Resource Link(s)	http://ichatz.me/uniroma1/iot-2020/uniroma1-internet_of_things-2020-vitaletti-talk16.pdf
Resource Author(s)	Andrea Vitaletti
Resource Reference	
Publication Date	2021
Language	English
Content type	Presentation
License	CC BY-NC-SA
Country	ITALY
Relevant for the IND 4.0 course module(s)	CO2
Relevant Learning Outcome with degree of relevance	identify key concepts of network security, technical challenges of securing Ind4.0 wireless deployments, existing tools for developing secure Ind4.0 platforms.
Justification of relevance (contribution)	The specific educational material provides the learner with the necessary knowledge to better understand the particular subject. Then with the help of other open educational resources, he will be able to delve more easily into the specific topic of knowledge.
Estimated study time	1 week
Keywords	Securing the Internet of Things, TinyDTLS and Elliptic Curve Cryptography.
Abstract / short description	This lecture introduces the different aspects of cybersecurity for Ind4.0 deployments. Introduces low-power cryptographic mechanisms for data encryption and network security.

CO2 - OER10 - Sensor Technologies - Healthcare, Wellness, and Environmental Applications

Title	Sensor Technologies Healthcare, Wellness, and Environmental Applications
Resource Link(s)	http://library.oapen.org/handle/20.500.12657/28153
Resource Author(s)	McGrath, Michael J., Scanaill, Cliodhna Ní
Resource Reference	*10.1007/978-1-4302-6014-1*
Publication Date	2013
Language	English
Content type	Book
License	CC BY-NC-ND 4.0
Country	Switzerland
Relevant for the IND 4.0 course module(s)	CO2

Relevant Learning Outcome with degree of relevance	Sensors
Justification of relevance (contribution)	The specific educational material provides the learner with the necessary knowledge to better understand the particular subject. Then with the help of other open educational resources, he will be able to delve more easily into the specific topic of knowledge.
Estimated study time	2 months
Keywords	Computer science, monitoring, health, wellness, environment
Abstract / short description	In this book we explore a wide range of topics related to sensing, sensor systems, and applications for monitoring health, wellness, and the environment. The book targets clinical and technical researchers, engineers, students, and members of the general public who want to understand the current state of sensor applications in the highlighted domains. The reader should gain a full awareness of the key challenges, both technical and non-technical, that need to be addressed in the development of successful end-to-end sensor applications. We provide real-world examples to give the reader practical insights into the successful development, deployment, and management of sensor applications. The reader will also develop an understanding of the personal, social, and ethical impact of sensor applications, now and in the future. The book provides an application-based approach to illustrate the application of sensor technologies in a practical and experiential manner.

CO2 OER11 - Sensor Technologies

Title	Sensor Technologies
Resource Link(s)	http://library.oapen.org/handle/20.500.12657/28153
Resource Author(s)	McGrath, Michael J., Scanaill, Cliodhna Ní
Resource Reference	10.1007/978-1-4302-6014-1
Publication Date	2013
Language	**English**
Content type	Book
License	CC BY-NC-ND 4.0
Country	Switzerland
Relevant for the IND 4.0 course module(s)	CO2
Relevant Learning Outcome with degree of relevance	Sensors

Justification of relevance (contribution)	The specific educational material provides the learner with the necessary knowledge to better understand the particular subject. Then with the help of other open educational resources, he will be able to delve more easily into the specific topic of knowledge.
Estimated study time	2 months
Keywords	Computer science, monitoring, health, wellness, environment
Abstract / short description	In this book we explore a wide range of topics related to sensing, sensor systems, and applications for monitoring health, wellness, and the environment. The book targets clinical and technical researchers, engineers, students, and members of the general public who want to understand the current state of sensor applications in the highlighted domains. The reader should gain a full awareness of the key challenges, both technical and non-technical, that need to be addressed in the development of successful end-to-end sensor applications. We provide real-world examples to give the reader practical insights into the successful development, deployment, and management of sensor applications. The reader will also develop an understanding of the personal, social, and ethical impact of sensor applications, now and in the future. The book provides an application-based approach to illustrate the application of sensor technologies in a practical and experiential manner.

CO2 - OER12 - Significance of sensors for industry 4.0: Roles, capabilities, and applications

Title	Significance of sensors for industry 4.0: Roles, capabilities, and applications
Resource Link(s)	https://www.sciencedirect.com/science/article/pii/S2666351121000310?via%3Dihub
Resource Author(s)	Mohd Javaid, Abid Haleem, Ravi Pratap Singh, Shanay Rab, Rajiv Suman
Resource Reference	
Publication Date	2021
Language	English
Content type	
License	CCL
Country	India
Relevant for the IND 4.0 course module(s)	Get an overview of the applications of sensors in Industry 4.0
Relevant Learning Outcome with degree of relevance	

Justification of relevance (contribution)	The specific educational material provides the learner with the necessary knowledge to better understand the role of sensors for industry 4.0, and how they can develop possibilities for technological advances in Industry 4.0
Estimated study time	1 day
Keywords	Sensors Automation, Industry 4.0, Capabilities Process management, Digital supply chain
Abstract / short description	Sensors play a crucial role in factory automation in making the system intellectual. Different types of sensors are available as per the suitability and applications; some of them are produced in mass and available in the market at affordable costs. The standard sensor types available are position sensors, pressure sensors, flow sensors, temperature sensors, and force sensors. They are used in many sectors, such as motorsport, medical, industry, aerospace, agriculture, and daily life. The objective of Industry 4.0 is to increase efficiency through automation. Sensors are vital components of Industry 4.0, allowing several transitions such as changes in positions, length, height, external and dislocations in industrial production facilities to be detected, measured, analysed, and processed. Smart factories will also enhance sustainability by tracking real-time output, and automated control systems will minimise potential factory maintenance costs. It can also be seen that digitalisation can improve production mobility, which gives advanced manufacturing firms a competitive advantage. This paper discusses sensors and their various types, along with significant capabilities for manufacturing. The step-by-step working Blocks and Quality Services of Sensors during implementation in Industry 4.0 are elaborated diagrammatically. Finally, we identified thirteen significant applications of sensors for Industry 4.0. Industry 4.0 provides an excellent opportunity for the development of the sensor market across the globe. In Industry 4.0, sensors will enjoy higher acceptance rates and benefit from a fully enabled connecting and data exchange and logistics integration. In the coming years, sensor installations may grow in process management, automated production lines, and digital supply chains.

CO3 OERs

CO3 - OER1 - Robotic Process Automation and Artificial Intelligence in Industry 4.0 A Literature review

Title	Robotic Process Automation and Artificial Intelligence in Industry 4.0 –A Literature review
Resource Link(s)	https://www.sciencedirect.com/science/article/pii/S1877050921001393?via%3Dihub
Resource Author(s)	Jorge Ribeiro, Rui Lima, Tiago Eckhardt, Sara Paiva
Resource Reference	
Publication Date	2021
Language	English
Content type	
License	CCL
Country	Portugal
Relevant for the IND 4.0 course module(s)	Get an overview of the Robotic Process Automation with AI for ERP-related processes
Relevant Learning Outcome with degree of relevance	
Justification of relevance (contribution)	The specific educational material provides the learner with the necessary knowledge to better understand how the Robotic Process Automation tools associated with AI can contribute to the improvement of the organizational processes associated with Industry 4.0
Estimated study time	1 day
Keywords	Robotic Process Automation, Artificial Intelligence, Industry 4.0
Abstract / short description	Taking into account the technological evolution of the last decades and the proliferation of information systems in society, today we see the vast majority of services provided by companies and institutions as digital services. Industry 4.0 is the fourth industrial revolution where technologies and automation are asserting themselves as major changes. Robotic Process Automation (RPA) has numerous advantages in terms of automating organizational and business processes. Allied to these advantages, the complementary use of Artificial Intelligence (AI) algorithms and techniques allows to improve the accuracy and execution of RPA processes in the extraction of information, in the recognition, classification, forecasting and

	optimization of processes. In this context, this paper aims to present a study of the RPA tools associated with AI that can contribute to the improvement of the organizational processes associated with Industry 4.0. It appears that the RPA tools enhance their functionality with the objectives of AI being extended with the use of Artificial Neural Network algorithms, Text Mining techniques and Natural Language Processing techniques for the extraction of information and consequent process of optimization and of forecasting scenarios in improving the operational and business processes of organizations.

CO4 OERs

CO4 - OER1 - Internet of things

Title	Internet of things
Resource Link(s)	http://ichatz.me/uniroma1/iotphd-2020/uniroma1-internet_of_things-2020-ichatz-talk5.pdf http://ichatz.me/uniroma1/iot-2020/uniroma1-internet_of_things-2020-ichatz-talk10.pdf
Resource Author(s)	Ioannis Chatzigiannakis
Resource Reference	
Publication Date	2021
Language	English
Content type	Presentation
License	CC BY-NC-SA
Country	ITALY
Relevant for the IND 4.0 course module(s)	CO4
Relevant Learning Outcome with degree of relevance	identify key concepts of IoT data processing architectures, examples of big data analytics in IoT enabled applications, streem based processing.
Justification of relevance (contribution)	The specific educational material provides the learner with the necessary knowledge to better understand the particular subject. Then with the help of other open educational

	resources, he will be able to delve more easily into the specific topic of knowledge.
Estimated study time	2 week
Keywords	IoT data processing architectures, Big Data analytics, Stream Analytics
Abstract / short description	This OER provides an introduction to data processing architectures. Introduces AWS IoT technologies and how to use the cloud computing paradigm to integrate sensors data with web and mobile services. Presents the main concepts of combining Big Data analytics for stream processing of sensor data, introduces the Map Reduce paradigm and how it can be used for Stream Analytics.

CO4 - OER2 - Internet of things

Title	Internet of things
Resource Link(s)	http://ichatz.me/uniroma1/iot-2020/uniroma1-internet_of_things-2020-vitaletti-talk19.pdf
Resource Author(s)	Andrea Vitaletti
Resource Reference	
Publication Date	2021
Language	English
Content type	Presentation
License	CC BY-NC-SA
Country	ITALY
Relevant for the IND 4.0 course module(s)	CO4
Relevant Learning Outcome with degree of relevance	identify key concepts of IoT data processing architectures, confidential data, the need to protect privacy, privacy preserving computation, Artificial Intelligence of IoT (AIOT)
Justification of relevance (contribution)	The specific educational material provides the learner with the necessary knowledge to better understand the particular subject. Then with the help of other open educational

	resources, he will be able to delve more easily into the specific topic of knowledge.
Estimated study time	2 weeks
Keywords	IoT data processing architectures, Privacy Preserving Computation. Privacy preserving aggregation and group computation. Federated Learning.
Abstract / short description	This OER provides an introduction to the need for protecting the privacy in Ind4.0 deployments. Provides a high-level introduction to IoT and Privacy preserving computation. Introduction to Federated Learning.

CO4 - OER3 - Internet of things - Blockchain and IoT

Title	Blockchain and IoT
Resource Link(s)	http://ichatz.me/uniroma1/iot-2020/uniroma1-internet_of_things-2020-vitaletti-talk17.pdf
Resource Author(s)	Andrea Vitaletti
Resource Reference	
Publication Date	2021
Language	English
Content type	Presentation
License	CC BY-NC-SA
Country	ITALY
Relevant for the IND 4.0 course module(s)	CO4
Relevant Learning Outcome with degree of relevance	identify key concepts of Blockchains, Distributed Ledger Technologies and IoT.
Justification of relevance (contribution)	The specific educational material provides the learner with the necessary knowledge to better understand the particular subject. Then with the help of other open educational resources, he will be able to delve more easily into the specific topic of knowledge.
Estimated study time	2 weeks

Keywords	Distributed Ledger technologies. Blockchains. Smart Contracts.
Abstract / short description	This OER provides an introduction to distributed ledger technologies. An overview of technologies for blockchains is provided along with a reference architecture. The concept of oracles is presented and how it can facilitate the use of IoT data within blockchains and smart contracts.

CO4 - OER4 - IOT - BC hands-on class

Title	IOT - BC hands-on class
Resource Link(s)	https://github.com/marcozecchini/iot-bc-handson
Resource Author(s)	Marco Zecchini
Resource Reference	
Publication Date	2021
Language	English
Content type	Tutorial
License	CC BY-NC-SA
Country	ITALY
Relevant for the IND 4.0 course module(s)	CO4
Relevant Learning Outcome with degree of relevance	identify key concepts of Blockchains, Distributed Ledger Technologies and IoT.
Justification of relevance (contribution)	The specific educational material provides the learner with the necessary knowledge to better understand the particular subject. Then with the help of other open educational resources, he will be able to delve more easily into the specific topic of knowledge.
Estimated study time	2 weeks
Keywords	Distributed Ledger technologies. Blockchains. Smart Contracts.
Abstract / short description	This OER provides a hands-on tutorial on distributed ledger technologies for IoT data. The concept of transactions with Algorand is presented along with practical examples. Detailed examples on how to exchange data using Algorand is presented. Introduction to IOTA and its goals to allow devices on the Internet of Things (IoT) to transfer data and make payments among each other. IOTA application blueprints.

CO4 - OER5 - Towards the next generation of manufacturing: implications of big data and digitalization in the context of industry 4.0

Title	Towards the next generation of manufacturing: implications of big data and digitalization in the context of industry 4.0
Resource Link(s)	https://www.tandfonline.com/doi/full/10.1080/09537287.2020.1810767
Resource Author(s)	Thanos Papadopoulosa , Surya Prakash Singh, Konstantina Spanakic , Angappa Gunasekarand and Rameshwar Dubey
Resource Reference	
Publication Date	2020
Language	English
Content type	
License	CCL
Country	UK
Relevant for the IND 4.0 course module(s)	Get an overview of advanced and emerging technologies in the next generation of manufacturing.
Relevant Learning Outcome with degree of relevance	
Justification of relevance (contribution)	The specific educational material provides the learner with the necessary knowledge to better understand the implications of Industry 4.0 in production planning and operations management.
Estimated study time	1 day
Keywords	
Abstract / short description	Industry 4.0 has come as a consecutive and predicted outcome of the previous industrial periods, recently dubbed Industry 1.0, 2.0 and 3.0 (Pereira and Romero 2017). As an expected outcome, companies were proactively prepared for the transformational potential of this opportunity by defining in advance the most suitable manufacturing models, operational processes and targets -coming prepared for the associated challenges (Almada-Lobo 2016; Pereira and Romero 2017). From a technical perspective, the context of Industry 4.0 can be described as 'increased di to increased communication enabled by the creation of a digital value chain' (Oesterreich a fully agreed telrma, ''sIlnidpu (Pereira and Romero 2017), however undoubtedly the term 'Industry 4.0' is an evol

	interest from both practitioner and academic communities (Liao et al. 2017; Fatorachian and Kazemi 2018). Industry 4.0 primarily includes the internet of things (IoT), cloud and cognitive computing, and digital manufacturing and cyber-physical systems that collect, transfer and make sense of Big Data (Zhou, Liu, and Zhou 2015) in order to develop smart industries and respond to fluctuatio for high-quality products. Industry 4.0 has been used in manufacturing and in the car industry by companies such as BMW and Jaguar Land Rover, and also in the food industry by companies such as Mondelez and Nestlé to enhance their overall operational efficiency. While literature has acknowledged the power of Big Data and the implied disruption in the product and service models (Baines et al. 2017; Papadopoulos et al. 2017; Spanaki et al. 2018; Yoo et al. 2012), Industry 4.0 implies a wave of innovation. There are potential opportunities for organisations and supply chains to innovate, to create strategic advantage and to generate new business value from the data (Gandomi and Haider 2015), but a rigorous approach of the associated disruption is still missing (Fatorachian and Kazemi 2018; Santos et al. 2017). The aim of this Special Issue is to facilitate an ongoing discussion for researchers or practitioners, to showcase their findings, and to explore the implementation of advanced and emerging technologies in the next generation of manufacturing and the wider implications of Industry 4.0 in production planning and operations management.

CO5 OERs

CO5 - OER1 - Introductory course to AWS Cloud and Core Services

Title	Introductory course to AWS Cloud and Core Services
Resource Link(s)	http://ichatz.me/uniroma1/aws-2021/uniroma1-aws-2021-ichatz-talk1.pdf
Resource Author(s)	Ioannis Chatzigiannakis
Resource Reference	
Publication Date	2020
Language	English
Content type	Presentation
License	CC BY-NC-SA

Country	ITALY
Relevant for the IND 4.0 course module(s)	CO5
Relevant Learning Outcome with degree of relevance	identify key concepts of cloud computing services and technologies, key concepts of Amazon Web Services, cloud storage technologies, Amazon Web Services Simple Storage Service (S3)
Justification of relevance (contribution)	The specific educational material provides the learner with the necessary knowledge to better understand the particular subject. Then with the help of other open educational resources, he will be able to delve more easily into the specific topic of knowledge.
Estimated study time	1 week
Keywords	Cloud, virtualization, scalability, network topology, services
Abstract / short description	This lecture presents information about Cloud Computing, the concepts of Virtualization and the key concepts of Amazon Web Services. Students will review the definition of the cloud, dive into more examples of the cloud, and understand the role of a cloud service provider. In this lecture students will create an S3 Bucket, upload two objects, and then configure and test the bucket as a static website.

CO5 - OER2 - Amazon Web Services

Title	Amazon Web Services
Resource Link(s)	https://docs.aws.amazon.com/AmazonS3/latest/userguide/WebsiteHosting.html
Resource Author(s)	Amazon Web Services
Resource Reference	
Publication Date	2021
Language	English
Content type	Tutorial
License	CC BY-NC
Country	USA
Relevant for the IND 4.0 course module(s)	CO5
Relevant Learning Outcome with degree of relevance	Create and configure Amazon Web Services, Deploy static web content on Amazon Web Services Simple Storage Service (S3)

Justification of relevance (contribution)	The specific educational material provides the learner with the hands on, step-by-step activity to better understand how to create a configure a cloud service.
Estimated study time	1 week
Keywords	Cloud services management, deploy static web content
Abstract / short description	This hands-on activity provides information on how to create and configure Amazon Web Services for deploying static web content. In this OER students will create an S3 Bucket, upload objects, and then configure and test the bucket as a static website.

CO5 - OER3 - Introductory course to AWS Cloud and Core Services

Title	Introductory course to AWS Cloud and Core Services
Resource Link(s)	http://ichatz.me/uniroma1/aws-2021/uniroma1-aws-2021-ichatz-talk2.pdf
Resource Author(s)	Ioannis Chatzigiannakis
Resource Reference	
Publication Date	2020
Language	English
Content type	Presentation
License	CC BY-NC-SA
Country	ITALY
Relevant for the IND 4.0 course module(s)	CO5
Relevant Learning Outcome with degree of relevance	Create and configure Amazon Web Services, Setup a virtual machine using Elastic Cloud Compute (EC2), Remote connect using SSH to the EC virtual machine. Build dynamic web services utilizing EC2.
Justification of relevance (contribution)	The specific educational material provides the learner introduction to the Elastic Cloud Compute service of Amazon Web Services. Key concepts are presented related to virtualization of computation and storage utilizing cloud resources.
Estimated study time	1 week
Keywords	Cloud services management, deploy dynamic web services
Abstract / short description	This OER presents the purpose of Elastic Cloud Compute and how to use it, Explain the purpose of an AMI, Describe basic features, functions, and billing of an EC2 instance, Discuss why and when an EC2 instance type might need to be changed, Provision and launch an EC2 instance, Create a key pair, SSH into the virtual machine you create.

CO5 - OER4 - Amazon Web Services

Title	Amazon Web Services
Resource Link(s)	https://docs.aws.amazon.com/AWSEC2/latest/UserGuide/EC2_GetStarted.html
Resource Author(s)	Amazon Web Services
Resource Reference	
Publication Date	2021
Language	English
Content type	Tutorial
License	CC BY-NC
Country	USA
Relevant for the IND 4.0 course module(s)	CO5
Relevant Learning Outcome with degree of relevance	Provision and launch an resources on Elastic Cloud Compute. Set up a dynamic web service utilizing cloud resources. Remote control virtual machines deployed on cloud resources.
Justification of relevance (contribution)	The specific educational material provides a hands-on activity to the Elastic Cloud Compute service of Amazon Web Services. Technical details are presented related to virtualization of computation and storage utilizing cloud resources.
Estimated study time	1 week
Keywords	Cloud services management, deploy dynamic web services
Abstract / short description	This OER presents to the students how to build a cloud webserver, create a key pair, and SSH into the Amazon Elastic Compute Cloud (EC2) instance. How to launch, connect to, and use a Linux instance. An instance is a virtual server in the AWS Cloud. With Amazon EC2, you can set up and configure the operating system and applications that run on your instance.

CO5 - OER5 - Introductory course to AWS

Title	Introductory course to AWS
Resource Link(s)	http://ichatz.me/uniroma1/aws-2021/uniroma1-aws-2021-ichatz-talk4.pdf
Resource Author(s)	Ioannis Chatzigiannakis
Resource Reference	
Publication Date	2020
Language	English
Content type	Presentation
License	CC BY-NC-SA

Country	ITALY
Relevant for the IND 4.0 course module(s)	CO5
Relevant Learning Outcome with degree of relevance	Key concepts and technologies of serveless computing, introduction to the architecture paradigm of microservices
Justification of relevance (contribution)	The specific educational material provides the learner an overview of the evolution of cloud services towards serverless computing. The learners will look into the architectural and organizational approach of microservices for building advanced web services utilizing cloud resources.
Estimated study time	2 weeks
Keywords	Cloud services management, microservices, containers, deploy cloud-native web services
Abstract / short description	This OER provides and overview of the evolution of cloud computing and introduces the concepts of managed hosting vs cloud-native solutions. The concepts of virtual machines and containers are presented and compared. The lecture will introduce students to Serverless Compute on AWS Lambda and Amazon API Gateway.

CO5 - OER6 - Amazon Web Services

Title	Amazon Web Services
Resource Link(s)	https://docs.aws.amazon.com/AWSEC2/latest/UserGuide/EC2_GetStarted.html
Resource Author(s)	Amazon Web Services
Resource Reference	
Publication Date	2021
Language	English
Content type	Article
License	CC BY-NC
Country	USA
Relevant for the IND 4.0 course module(s)	CO5
Relevant Learning Outcome with degree of relevance	Key concepts and technologies of serveless computing, introduction to the architecture paradigm of microservices
Justification of relevance (contribution)	The specific educational material provides the learner an overview of the evolution of cloud services towards serverless computing. The learners will look into the architectural and organizational approach of microservices for building advanced web services utilizing cloud resources.
Estimated study time	1 week

Keywords	Cloud services management, microservices, cloud-native services
Abstract / short description	This OER provides and overview of the evolution of cloud computing and introduces the concepts of managed hosting vs cloud-native solutions. The concepts of virtual machines and containers are presented and compared.

CO5 - OER7 - Amazon Web Services

Title	Amazon Web Services
Resource Link(s)	https://aws.amazon.com/getting-started/hands-on/run-serverless-code/
Resource Author(s)	Amazon Web Services
Resource Reference	
Publication Date	2021
Language	English
Content type	Tutorial
License	CC BY-NC
Country	USA
Relevant for the IND 4.0 course module(s)	CO5
Relevant Learning Outcome with degree of relevance	Key concepts and technologies of serveless computing, introduction to the architecture paradigm of microservices. Create a Lambda function, Test and Debug the Lambda function, Create an API method, Test the API method.
Justification of relevance (contribution)	The specific educational material provides a hands-on activity to the AWS Lambda and Amazon API Gateway services of Amazon Web Services. Technical details are presented related to virtualization of computation utilizing cloud-native technologies.
Estimated study time	1 week
Keywords	Cloud services management, microservices, API, deploy cloud-native web services
Abstract / short description	This OER presents to the students the basics of running code on AWS Lambda without provisioning or managing servers. Students will create a simple lambda function using Python, execute the function in a fully managed service, learn how to create, publish, maintain, monitor, and secure APIs at any scale using Amazon API Gateway.

CO5 OER8 - CSCI 49378: Lecture 6: Cloud Computing Concepts

Title	CSCI 49378: Lecture 6: Cloud Computing Concepts
Resource Link(s)	https://academicworks.cuny.edu/cgi/viewcontent.cgi?article=1023&context=hc_oers
Resource Author(s)	Bonan Liu
Resource Reference	
Publication Date	2020
Language	English
Content type	Presentation
License	CC BY-NC-SA
Country	USA
Relevant for the IND 4.0 course module(s)	CO5
Relevant Learning Outcome with degree of relevance	identify key concepts of cloud computing services and technologies, manage cloud computing services,
Justification of relevance (contribution)	The specific educational material provides the learner with the necessary knowledge to better understand the particular subject. Then with the help of other open educational resources, he will be able to delve more easily into the specific topic of knowledge.
Estimated study time	2 weeks
Keywords	Cloud, virtualization, scalability, security, hybrid
Abstract / short description	This lecture presents information about Distributed Systems and Cloud Computing - "Cloud Computing Concepts. Cloud computing is a general term for anything that involves delivering hosted services over the internet. These services are divided into three main categories: infrastructure as a service (IaaS), platform as a service (PaaS) and software as a service (SaaS).

CO6 OERs

CO6 - OER1 - Robotic Knitting

Title	Robotic Knitting
Resource Link(s)	https://library.oapen.org/handle/20.500.12657/47130
Resource Author(s)	Treusch, Pat
Resource Reference	ONIX_20210309_9783839452035_18
Publication Date	2020
Language	English
Content type	Book
License	CC BY-NC-ND 4.0
Country	Germany
Relevant for the IND 4.0 course module(s)	CO6
Relevant Learning Outcome with degree of relevance	discuss human-robots interaction and collaboration
Justification of relevance (contribution)	The specific educational material provides the learner with the necessary knowledge to better understand the particular subject. Then with the help of other open educational resources, he will be able to delve more easily into the specific topic of knowledge.
Estimated study time	1 month
Keywords	Robots; Technofeminsim; Cobots; Interdisciplinarity; AI; Technology; Gender; Science; Sociology of Technology; Gender Studies; Sociology of Science; Body; Sociology
Abstract / short description	As a reaction to typically dead-end debates on future human and robot collaboration that tend to be either dismissive or overly welcoming towards »cobot« technologies, this book provides a technofeminist intervention. Pat Treusch not only shows how both the fields of technofeminism and robotics can engage in a practical exchange through knitting, but also contributes a tangible example of coboting dynamics. Robotic Knitting re-negotiates the boundaries between formalisation and embodiment, craft and high-tech as well as useful and dysfunctional machines. It re-crafts the nature of collaboration between human and robot. This finally entails an alternative mode of relating - a mode that enables an account of careful coboting.

CO6 - OER2 - Substantial capabilities of robotics in enhancing industry 4.0 implementation

Title	Substantial capabilities of robotics in enhancing industry 4.0 implementation
Resource Link(s)	https://www.sciencedirect.com/science/article/pii/S2667241321000057?via%3Dihub
Resource Author(s)	Mohd Javaid, Abid Haleema, Ravi Pratap Singh, Shanay Rab, Rajiv Suman
Resource Reference	
Publication Date	2021
Language	English
Content type	
License	CCL
Country	India
Relevant for the IND 4.0 course module(s)	Get an overview of major applications of Robotics for Industry 4.0
Relevant Learning Outcome with degree of relevance	
Justification of relevance (contribution)	The specific educational material provides the learner with the necessary knowledge to better understand the role of Robotics as a key technology of Industry 4.0
Estimated study time	2 days
Keywords	Artificial Intelligence Cobots, Industry 4.0, Manufacturing Robotics, Robotics Applications
Abstract / short description	There is the increased application of new technologies in manufacturing, service, and communications. Industry 4.0 is the new fourth industrial revolution, which supports organisational efficiency. Robotics is an important technology of Industry 4.0, which provides extensive capabilities in the field of manufacturing. This technology has enhanced automation systems and does repetitive jobs precisely and at a lower cost. Robotics is progressively leading to the manufacturing of quality products while maintaining the value of existing collaborators schemes. The primary outcome of Industry 4.0 is intelligent factories developed with the aid of advanced robotics, massive data, cloud computing, solid safety, intelligent sensors, the Internet of things, and other advanced technological developments to be highly powerful, safe, and cost-effective. Thus, businesses will refine their manufacturing for mass

	adaptation by improving the workplace's safety and reliability on actual work and saving costs. This paper discusses the significant potential of Robotics in the field of manufacturing and allied areas. The paper discusses eighteen major applications of Robotics for Industry 4.0. Robots are ideal for collecting mysterious manufacturing data as they operate closer to the component than most other factory machines. This technology is helpful to perform a complex hazardous job, automation, sustain high temperature, working entire time and for a long duration in assembly lines. Many robots operating in intelligent factories use artificial intelligence to perform high-level tasks. Now they can also decide and learn from experience in various ongoing situations.

CO7 OERs

CO7 - OER1 - Cyber-physical-system for representing a robot end effector

Title	Cyber-physical-system for representing a robot end effector
Resource Link(s)	https://www.sciencedirect.com/science/article/pii/S2212827121005369?via%3Dihub
Resource Author(s)	Fabian Müller, Christian Deuerlein, Michael Koch
Resource Reference	
Publication Date	2021
Language	English
Content type	
License	CCL
Country	Germany
Relevant for the IND 4.0 course module(s)	Get an overview of programming and simulation methods of robots for industrial use.
Relevant Learning Outcome with degree of relevance	
Justification of relevance (contribution)	The specific educational material provides the learner with an example that is useful to better understand the Cyber-Physical-Systems (CPS) and their validation.
Estimated study time	2 days
Keywords	Industrial robot, cyber physical system, programming by demonstration, digital twin, augmented reality

Abstract / short description	Programming by Demonstration (PbD) is a method to program robots through the performance of a task by humans. Most implementations are online methods that use visual or force feedback of the demonstrator. However, we developed an offline programming approach for PbD with a special input device within an Augmented Reality Environment. Therefore, this paper aims to answer how the characteristics and functionality of the end effector of a jointed-arm robot can be represented by a haptic input device in order to perform PbD. The PbD process is first carried out on a digital twin of the robot, visualized to the user in real physical space by means of augmented reality technology. The programming of the digital twin can later be transferred to the real robot. The haptic input device in this context is the main part of the Cyber-Physical-System (CPS), which enables the user to interact with the virtual robot. Therefore, the specification of the mechanical and software components of the CPS is of main importance. Within this paper, strategies for the implementation of shape and function abstraction, as well as for ensuring communication, have been worked out. The physical shape of the CPS is kept generic and is only subject to ergonomic restrictions. However, Augmented Reality overlays the physical shape with an exact digital image of the end effector used later in the process. Nevertheless, the physical characteristics of the real robot should be represented as real as possible by the CPS. Therefore, the CPS is equipped with various sensors and actuators. With the CPS it is possible to determine contact forces and to manipulate objects to a certain extent in order to teach gripping strategies to the digital twin. An operating system was developed for communication and control of the electronic components. For the validation of the functionality of the CPS an exemplary PbD process was developed, the results were analyzed and evaluated.

EL1 OERs

EL1 - OER1 - How digital transformation can influence business model, Case study for transport industry

Title	How digital transformation can influence business model, Case study for transport industry
Resource Link(s)	https://www.sciencedirect.com/science/article/pii/S2352146519303151?via%3Dihub
Resource Author(s)	Tatiana Genzorova, Tatiana Corejova, Natalia Stalmasekova

Resource Reference	
Publication Date	2019
Language	English
Content type	
License	CCL
Country	Slovak Republic
Relevant for the IND 4.0 course module(s)	Get an overview of the influence of Industry 4.0 according to digitalization in business models, with a focus on the transport companies.
Relevant Learning Outcome with degree of relevance	
Justification of relevance (contribution)	The specific educational material provides the learner with an example that is useful to better understand how digital transformation can influence business model
Estimated study time	1 day
Keywords	digital disruption, agile approach, Design Thinking, digital workplace, transport
Abstract / short description	The digital disruption is a situation which occurs in nowadays business very often. With the development of digital technologies, the classical system of doing business has been disrupted and many companies have to react to digitalization. The digital transformation brings innovations not only into the delivering of product. The companies are trying to rebuild a waterfall approach to agile by using a platform. The aim of this paper is to describe how the transport companies which start their business before digital disruption can change business model according to digitalization. It will include identifying current trends in digital transformation. The case study deals with the process of designing the new tool for recording hours spent by the employees on the different activities or projects typical for transport industry, value or supply chain of transport services and is based on the agile approach.

EL2 OERs

EL2 - OER1 - Running Lean, 2nd Edition by Ash Maurya

Title	Running Lean, 2nd Edition by Ash Maurya
Resource Link(s)	https://www.oreilly.com/library/view/running-lean-2nd/9781449321529/ch01.html

Resource Author(s)	Ash Maurya
Resource Reference	
Publication Date	2021
Language	English
Content type	Article
License	CC BY-NC
Country	USA
Relevant for the IND 4.0 course module(s)	CO5
Relevant Learning Outcome with degree of relevance	identify key concepts of lean startups, digital entrepreneurship, bootstraping a company, customer development
Justification of relevance (contribution)	The specific educational material provides the learner with the necessary knowledge to better understand the particular subject. Then with the help of other open educational resources, he will be able to delve more easily into the specific topic of knowledge.
Estimated study time	1 week
Keywords	Digital Enterpreneurship, Lean Canvas
Abstract / short description	This OER presents key concepts of digital enterpreneurship, the idea of lean startups for managing innovation and identifying the business model hypothesis. The lean canvas tool is presented in details and how to identify risks in the plan.

EL2 - OER2 - Internet of things

Title	Internet of things
Resource Link(s)	http://ichatz.me/uniroma1/iot-2020/uniroma1-internet_of_things-2020-ichatz-talk9.pdf
Resource Author(s)	Ioannis Chatzigiannakis
Resource Reference	
Publication Date	2020
Language	English
Content type	Presentation
License	CC BY-NC-SA
Country	ITALY

Relevant for the IND 4.0 course module(s)	EL2
Relevant Learning Outcome with degree of relevance	How to build a smart product, user experience, UX design process, Product development lifecycle
Justification of relevance (contribution)	The specific educational material provides the learner with the necessary knowledge to better understand the particular subject. Then with the help of other open educational resources, he will be able to delve more easily into the specific topic of knowledge.
Estimated study time	1 week
Keywords	Smart Product design, UX design process, User Experience
Abstract / short description	This OER presents key concepts of the UX design process for smart products, the idea of user experience and how to take into account while designing new products for Ind 4.0.

EL2 - OER3 - Developing Digital Transformation Strategy for Manufacturing

Title	Developing Digital Transformation Strategy for Manufacturing
Resource Link(s)	https://www.sciencedirect.com/science/article/pii/S1877050920306372?via%3Dihub
Resource Author(s)	Saeed Albukhitan
Resource Reference	
Publication Date	2020
Language	English
Content type	
License	CCL
Country	Saudi Arabia
Relevant for the IND 4.0 course module(s)	Get an overview of the digital transformation process.
Relevant Learning Outcome with degree of relevance	
Justification of relevance (contribution)	The specific educational material provides the learner with the necessary knowledge to better understand the main concerns in developing and implementing a digital transformation strategy.
Estimated study time	
Keywords	digital transformation strategy, digitalization, Industry 4.0, manufacturing

Abstract / short description	The digital era is characterized by fast development, growth, innovation, and disruption. Organizations that want to survive must be ready to adapt to the new digital landscape. The digital transformation process is more than just implementing new technology, investing in tools, or upgrading existing systems. These steps are important, but they are not the whole picture. If an organization wants to stay competitive able to respond to changes, it should expect them and stimulate innovation itself. To do this, companies need to plan ahead and be active designers for their future. This is where the digital transformation strategy comes in. The digital transformation strategy helps leaders answer the questions for their business such as the current digitalization level, future vision, and how to get there. To be protected from digital disruption, companies need to develop three core competencies related to awareness, informed decision-making, and rapid implementation. The development and implementation of a digital transformation strategy have become a key concern for many organizations across manufacturing industries, but how such a strategy can be developed remains an open question. In this paper, we will be discussing how manufacturing could develop a digital transformation strategy that including a different aspect of the strategy tailored to the nature of the manufacturing sector.

EL3 OERs

EL3 - OER1 - Human Computer Interaction

Title	Human Computer Interaction
Resource Link(s)	https://oer.avu.org/handle/123456789/672
Resource Author(s)	Saffiong Kebbeh
Resource Reference	
Publication Date	2018
Language	English
Content type	Module
License	CC BY
Country	explain the models and theories of HCI conceptual frameworks for the design of man-man-machine interfaces,
Relevant for the IND 4.0 course module(s)	EL3
Relevant Learning Outcome with degree of relevance	identify key concepts of cloud computing services and technologies, manage cloud computing services,

Justification of relevance (contribution)	The specific educational material provides the learner with the necessary knowledge to better understand the particular subject. Then with the help of other open educational resources, he will be able to delve more easily into the specific topic of knowledge.
Estimated study time	2 weeks
Keywords	Interface, graphics, multimedia, visual design
Abstract / short description	Human-Computer Interaction (HCI) is the study of the principles and methods with which one builds effective interfaces for users. HCI is a field of study that evolves to changes in the technological landscape. During the past decade, the emergence of personal mobile devices, agent-based technologies, and pervasive and ubiquitous computing is motivated by the technique of human computer interaction which has profoundly changed the way people use technology for work and leisure. This course introduces the student to the theory and practice of developing user interfaces. Practical hands-on will be balanced by discussion of relevant literature of computer science e.g. graphics, user interface design, multimedia and visual design of HCI, cognitive psychology, and scientific information design.

EL3 - OER2 - Cognitive Manufacturing in Industry 4.0 toward Cognitive Load Reduction: A Conceptual Framework

Title	Cognitive Manufacturing in Industry 4.0 toward Cognitive Load Reduction: A Conceptual Framework
Resource Link(s)	https://www.mdpi.com/2571-5577/3/4/55
Resource Author(s)	Adriana Ventura Carvalho,Amal Chouchene, Tânia M. Lima and Fernando Charrua-Santos
Resource Reference	
Publication Date	2020
Language	English
Content type	
License	CCL
Country	
Relevant for the IND 4.0 course module(s)	Get an overview of the importance of cognitive manufacturing and understand how to define a conceptual framework that links cognitive manufacturing to a reduction of the cognitive load.

Relevant Learning Outcome with degree of relevance	
Justification of relevance (contribution)	The specific educational material provides the learner with the necessary knowledge to better understand what causes cognitive load reduction in manufacturing environments.
Estimated study time	3 days
Keywords	Industry 4.0; cognitive manufacturing; cognitive load; human – computer interaction
Abstract / short description	Cognitive manufacturing utilizes cognitive computing, the industrial Internet of things (IoT), and advanced analytics to upgrade manufacturing processes in manners that were not previously conceivable. It enables associations to improve major business measurements, for example, productivity, product reliability, quality, and safety, while decreasing downtime and lowering costs. Considering all the facts that can prejudice the manufacturing performance in Industry 4.0, the cognitive load has received more attention, since it was previously neglected with respect to manufacturing industries. This paper aims to investigate what causes cognitive load reduction in manufacturing environments, i.e., human – computer interaction technologies that reduce the identified causes and the applications of cognitive manufacturing that use the referred technologies. Thus, a conceptual framework that links cognitive manufacturing to a reduction of the cognitive load was developed.

EL4 OERs

EL4 - OER1 - Industry 4.0-Driven Development of Optimization Algorithms: A Systematic Overview

Title	Industry 4.0-Driven Development of Optimization Algorithms: A Systematic Overview
Resource Link(s)	https://www.hindawi.com/journals/complexity/2021/6621235/
Resource Author(s)	Róbert Csalódi, Zoltán Süle, Szilárd Jaskó, Tibor Holczinger and János Abonyi
Resource Reference	
Publication Date	2021
Language	English
Content type	

License	CCL
Country	
Relevant for the IND 4.0 course module(s)	Get an overview of Industry 4.0-Driven Development of Optimization Algorithms.
Relevant Learning Outcome with degree of relevance	
Justification of relevance (contribution)	The specific educational material provides the learner with the necessary knowledge to better understand the topic of optimization in Industry 4.0
Estimated study time	4 days
Keywords	
Abstract / short description	The Fourth Industrial Revolution means the digital transformation of production systems. Cyber-physical systems allow for the horizontal and vertical integration of these production systems as well as the exploitation of the benefits via optimization tools. This article reviews the impact of Industry 4.0 solutions concerning optimization tasks and optimization algorithms, in addition to the identification of the new R&D directions driven by new application options. The basic organizing principle of this overview of the literature is to explore the requirements of optimization tasks, which are needed to perform horizontal and vertical integration. This systematic review presents content from 900 articles on Industry 4.0 and optimization as well as 388 articles on Industry 4.0 and scheduling. It is our hope that this work can serve as a starting point for researchers and developers in the field.

OM1 OERs

OM1 - OER1 - Smart Manufacturing and Intelligent Manufacturing: A Comparative Review

Title	Smart Manufacturing and Intelligent Manufacturing: A Comparative Review
Resource Link(s)	https://www.sciencedirect.com/science/article/pii/S2095809920302502?via%3Dihub
Resource Author(s)	Baicun Wanga, Fei Tao, Xudong Fang, Chao Liu, Yufei Liu Theodor Freiheit

Resource Reference	
Publication Date	2020
Language	English
Content type	
License	CCL
Country	China
Relevant for the IND 4.0 course module(s)	Define critical topics discussed (origin, definitions, evolutionary path, and key technologies) of Smart Manufacturing and Intelligent Manufacturing.
Relevant Learning Outcome with degree of relevance	
Justification of relevance (contribution)	The specific educational material provides the learner with the necessary knowledge to better understand the concepts of Smart Manufacturing and Intelligent Manufacturing.
Estimated study time	4 days
Keywords	Smart manufacturing, Intelligent manufacturing, Industry 4.0, Human–cyber–physical system (HCPS)
Abstract / short description	The application of intelligence to manufacturing has emerged as a compelling topic for researchers and industries around the world. However, different terminologies, namely smart manufacturing (SM) and intelligent manufacturing (IM), have been applied to what may be broadly characterized as a similar paradigm by some researchers and practitioners. While SM and IM are similar, they are not identical. From an evolutionary perspective, there has been little consideration on whether the definition, thought, connotation, and technical development of the concepts of SM or IM are consistent in the literature. To address this gap, the work performs a qualitative and quantitative investigation of research literature to systematically compare inherent differences of SM and IM and clarify the relationship between SM and IM. A bibliometric analysis of publication sources, annual publication numbers, keyword frequency, and top regions of research and development establishes the scope and trends of the currently presented research. Critical topics discussed include origin, definitions, evolutionary path, and key technologies of SM and IM. The implementation architecture, standards, and national focus are also discussed. In this work, a basis to understand SM and IM is provided, which is increasingly important because the trend to merge both terminologies rises in Industry 4.0 as

	intelligence is being rapidly applied to modern manufacturing and human –cyber –physical systems.

OM2 OERs

OM2 - OER1 - Operating Digital Manufacturing in Industry 4.0: the role of advanced manufacturing technologies

Title	Operating Digital Manufacturing in Industry 4.0: the role of advanced manufacturing technologies
Resource Link(s)	https://www.sciencedirect.com/science/article/pii/S2212827120306405?via%3Dihub
Resource Author(s)	Elias Ribeiro da Silva, Ana Carolina Shinohara, Christian Petersson Nielsen, Edson Pinheiro de Lima, Jannis Angelis
Resource Reference	
Publication Date	2020
Language	English
Content type	
License	CCL
Country	
Relevant for the IND 4.0 course module(s)	Define digital manufacturing conceptually and its application domain.
Relevant Learning Outcome with degree of relevance	
Justification of relevance (contribution)	The specific educational material provides the learner with the necessary knowledge to define the application domain of Digital Manufacturing while considering the new industrial paradigm
Estimated study time	2 days
Keywords	Digital manufacturing, Industry 4.0, smart manufacturing, advanced manufacturing technologies, manufacturing life cycle
Abstract / short description	This study analyzes the application domain of Digital Manufacturing while considering the new industrial paradigm. Based on content analysis, joint applications of digital manufacturing tools and advanced manufacturing technologies are framed and technological trends identified. The results reveal a new comprehensive framework that defines the application domain of digital manufacturing in Industry 4.0, as well as how digital manufacturing operates within Industry 4.0.

	The presented framework covers manufacturing life cycle phases, digital manufacturing tools used in each phase, and Industry 4.0 technologies used with the respective tools. The study contributes by positioning digital manufacturing conceptually and delimiting its application domain.

OM3 OERs

OM3 - OER1 - Development of manufacturing execution systems in accordance with Industry 4.0 requirements: A review of standard- and ontology-based methodologies and tools

Title	Development of manufacturing execution systems in accordance with Industry 4.0 requirements: A review of standard- and ontology-based methodologies and tools
Resource Link(s)	https://www.sciencedirect.com/science/article/pii/S0166361520305340?via%3Dihub
Resource Author(s)	Szilárd Jaskó, Adrienn Skropa, Tibor Holczingera, Tibor Chován, János Abonyi
Resource Reference	
Publication Date	2020
Language	English
Content type	
License	CCL
Country	Hungary
Relevant for the IND 4.0 course module(s)	Define and understand how to develop manufacturing execution systems
Relevant Learning Outcome with degree of relevance	
Justification of relevance (contribution)	The specific educational material provides the learner with the necessary knowledge to better understand how recent trends in Industry 4.0 solutions are influencing the development of manufacturing execution systems.
Estimated study time	3 days
Keywords	Manufacturing execution systems (MES), Industry 4.0, Ontologies, Semantic models of Industry 4.0, Reference architectural model for industry 4.0 (RAMI 4.0)
Abstract / short description	This work presents how recent trends in Industry 4.0 (I4.0) solutions are influencing the development of manufacturing execution systems (MESs) and analyzes what kinds of trends will

	determine the development of the next generation of these technologies. This systematic and thematic review provides a detailed analysis of I4.0-related requirements in terms of MES functionalities and an overview of MES development methods and standards because these three aspects are essential in developing MESs. The analysis highlights that MESs should interconnect all components of cyber-physical systems in a seamless, secure, and trustworthy manner to enable high-level automated smart solutions and that semantic metadata can provide contextual information to support interoperability and modular development. The observed trends show that formal models and ontologies will play an even more essential role in I4.0 systems as interoperability becomes more of a focus and that the new generation of linkable data sources should be based on semantically enriched information. The presented overview can serve as a guide for engineers interested in the development of MESs as well as for researchers interested in finding worthwhile areas of research.

A1 OERs

A1 - OER1 - Characterising the Agriculture 4.0 Landscape Emerging Trends, Challenges and Opportunities

Title	Characterising the Agriculture 4.0 Landscape—Emerging Trends, Challenges and Opportunities
Resource Link(s)	https://www.mdpi.com/2073-4395/11/4/667
Resource Author(s)	Sara Oleiro Araújo, Ricardo Silva Peres, José Barata, Fernando Lidon and José Cochicho Ramalho
Resource Reference	
Publication Date	2021
Language	English
Content type	
License	CCL
Country	Portugal
Relevant for the IND 4.0 course module(s)	Get an overview of agriculture 4.0 landscape.

Relevant Learning Outcome with degree of relevance	
Justification of relevance (contribution)	The specific educational material provides the learner with the necessary knowledge to better understand the state of the art of the research around Agriculture 4.0.
Estimated study time	4 days
Keywords	Agriculture 4.0; artificial intelligence; cloud computing; decision support system; internet of things; robotics; sensors
Abstract / short description	Investment in technological research is imperative to stimulate the development of sustainable solutions for the agricultural sector. Advances in Internet of Things, sensors and sensor networks, robotics, artificial intelligence, big data, cloud computing, etc. foster the transition towards the Agriculture 4.0 era. This fourth revolution is currently seen as a possible solution for improving agricultural growth, ensuring the future needs of the global population in a fair, resilient and sustainable way. In this context, this article aims at characterising the current Agriculture 4.0 landscape. Emerging trends were compiled using a semi-automated process by analysing relevant scientific publications published in the past ten years. Subsequently, a literature review focusing these trends was conducted, with a particular emphasis on their applications in real environments. From the results of the study, some challenges are discussed, as well as opportunities for future research. Finally, a high-level cloud-based IoT architecture is presented, serving as foundation for designing future smart agricultural systems. It is expected that this work will positively impact the research around Agriculture 4.0 systems, providing a clear characterisation of the concept along with guidelines to assist the actors in a successful transition towards the digitalisation of the sector.

A2 OERs

A2 - OER1 - Agricultural robotics and automated equipment for sustainable crop production

Title	Agricultural robotics and automated equipment for sustainable crop production
Resource Link(s)	https://www.fao.org/3/cb2186en/CB2186EN.pdf
Resource Author(s)	Santiago Santos Valle, Agricultural Mechanization Specialist, FAO

	Josef Kienzle, Agricultural Engineer, FAO
Resource Reference	
Publication Date	2020
Language	English
Content type	
License	CCL - CC BY NC SA
Country	Italy
Relevant for the IND 4.0 course module(s)	Get an overview of the technical characteristics of robotics in Agriculture 4.0
Relevant Learning Outcome with degree of relevance	
Justification of relevance (contribution)	The specific educational material provides the learner with the necessary knowledge to better understand the applicability of robotics in the area of agricultural mechanization for crop production
Estimated study time	2 days
Keywords	
Abstract / short description	This report analyses the application of robotics in the area of agricultural mechanization for crop production, and its specific applicability in the context of sustainable development. It takes into consideration the social, economic and environmental dimensions of its adoption and explores its potential. It presents some of the technical characteristics of robotics and highlights major challenges to overcome in order to achieve its successful adoption, such as adequate infrastructure, stakeholder capacity, economic viability and data ownership. This report provides an analysis of some of the major areas of intervention that are needed for the different stakeholders, including smallholder farmers in developing countries.

A3 OERs

A3 - OER1 - Exploring the Adoption of Precision Agriculture for Irrigation in the Context of Agriculture 4.0: The Key Role of Internet of Things

Title	Exploring the Adoption of Precision Agriculture for Irrigation in the Context of Agriculture 4.0: The Key Role of Internet of Things
Resource Link(s)	https://www.mdpi.com/1424-8220/20/24/7091
Resource Author(s)	Sergio Monteleone, Edmilson Alves de Moraes, Brenno Tondato de Faria, Plinio Thomaz Aquino Junior, Rodrigo Filev Maia, André Torre Neto and Attilio Toscano
Resource Reference	
Publication Date	2020
Language	English
Content type	
License	CCL
Country	
Relevant for the IND 4.0 course module(s)	Understand the perspectives of Precision Agriculture, IoT and operations management
Relevant Learning Outcome with degree of relevance	
Justification of relevance (contribution)	The specific educational material provides the learner with the necessary knowledge to better understand the evolution of precision agriculture in the Agriculture 4.0 context.
Estimated study time	3 days
Keywords	precision agriculture; adoption; irrigation; agriculture 4.0; Internet of things; sensing technologies; weather station; satellite; farmer behavior; operations management
Abstract / short description	In recent years, the concept of Agriculture 4.0 has emerged as an evolution of precision agriculture (PA) through the diffusion of the Internet of things (IoT). There is a perception that the PA adoption is occurring at a slower pace than expected. Little research has been carried out about Agriculture 4.0, as well as to farmer behavior and operations management. This work explores what drives the adoption of PA in the Agriculture 4.0 context, focusing on farmer behavior and operations management. As a result of a multimethod approach, the

	factors explaining the PA adoption in the Agriculture 4.0 context and a model of irrigation operations management are proposed. Six simulation scenarios are performed to study the relationships among the factors involved in irrigation planning. Empirical findings contribute to a better understanding of what Agriculture 4.0 is and to expand the possibilities of IoT in the PA domain. This work also contributes to the discussion on Agriculture 4.0, thanks to multidisciplinary research bringing together the different perspectives of PA, IoT and operations management. Moreover, this research highlights the key role of IoT, considering the farme IoT sensing technologies for data collection.

H1 OERs

H1 - OER1 - Medical Imaging Systems

Title	Medical Imaging Systems
Resource Link(s)	https://library.oapen.org/handle/20.500.12657/23315
Resource Author(s)	Maier, Andreas (editor) Steidl, Stefan (editor) Christlein, Vincent (editor) Hornegger, Joachim (editor)
Resource Reference	10.1007/978-3-319-96520-8
Publication Date	2018
Language	English
Content type	Textbook
License	CC BY 4.0
Country	Switzerland
Relevant for the IND 4.0 course module(s)	H1
Relevant Learning Outcome with degree of relevance	describe the main medical imaging technologies describe the main digital image processing procedures
Justification of relevance (contribution)	The specific educational material provides the learner with the necessary knowledge to better understand the particular subject. Then with the help of other open educational resources, he will be able to delve more easily into the specific topic of knowledge.
Estimated study time	3 months
Keywords	Computer science; Optical data processing,
Abstract / short description	This open access book gives a complete and comprehensive introduction to the fields of medical imaging systems, as designed for a broad range of applications. The authors of the

	book first explain the foundations of system theory and image processing, before highlighting several modalities in a dedicated chapter. The initial focus is on modalities that are closely related to traditional camera systems such as endoscopy and microscopy. This is followed by more complex image formation processes: magnetic resonance imaging, X-ray projection imaging, computed tomography, X-ray phase-contrast imaging, nuclear imaging, ultrasound, and optical coherence tomography.

H1 - OER2 - Undergraduate Diagnostic Imaging Fundamentals

Title	Undergraduate Diagnostic Imaging Fundamentals
Resource Link(s)	https://openpress.usask.ca/undergradimaging/
Resource Author(s)	Brent Burbridge, MD, FRCPC
Resource Reference	978-0-88880-611-6
Publication Date	September 30, 2017
Language	English
Content type	Textbook
License	CC BY-NC-SA 4.0
Country	Canada
Relevant for the IND 4.0 course module(s)	H 1
Relevant Learning Outcome with degree of relevance	explain the functionality of Picture Archiving and Communication Systems (PACS) apply basic digital processing methods in medical images
Justification of relevance (contribution)	The specific educational material provides the learner with the necessary knowledge to better understand the particular subject. Then with the help of other open educational resources, he will be able to delve more easily into the specific topic of knowledge.
Estimated study time	2 months
Keywords	Imaging techniques, PACS, ODIN, Diagnostic Imaging
Abstract / short description	We have created this resource to provide basic content in Diagnostic Imaging (Radiology, Medical Imaging). Hopefully, learners who find this encounter interesting will use this resource as a stepping stone to further their education in this area. Throughout, you will find normal images and images of different abnormalities. The images displayed are simple, static, JPEG files, and although they will help you learn, they do not accurately represent the imaging that clinicians would use in their practice. To do so, you require a Picture Archiving and Communication System (PACS), which allows clinicians to interact with the images by zooming, changing level and window, annotating, and scrolling through sets of images. If

	these terms are unfamiliar, you will be more acquainted with them after reading the Principles of Imaging Techniques section of this eBook. To help you better appreciate normal and abnormal images, you can view images in the Online Dicom Image Navigator (ODIN), which provides images in a PACS-like format. Access to the full image sets is provided by clicking the links to ODIN cases. Please take advantage of these links to enhance your learning experience.

H1 - OER3 - The impact of pre- and post-image processing techniques on deep learning frameworks: A comprehensive review for digital pathology image analysis

Title	The impact of pre- and post-image processing techniques on deep learning frameworks: A comprehensive review for digital pathology image analysis
Resource Link(s)	https://www.sciencedirect.com/science/article/pii/S0010482520304601?via%3Dihub
Resource Author(s)	Massimo Salvi, U. Rajendra Acharya, Filippo Molinari, Kristen M.Meiburger
Resource Reference	
Publication Date	2020
Language	English
Content type	
License	CCL
Country	
Relevant for the IND 4.0 course module(s)	Get an overview of deep learning algorithms for image processing in the field of digital pathology.
Relevant Learning Outcome with degree of relevance	
Justification of relevance (contribution)	The specific educational material provides the learner with the necessary knowledge to better understand the potential of deep learning algorithms for image analysis.
Estimated study time	3 days
Keywords	Digital pathology, Histology, Deep learning, Image analysis, Pre-processing, Post-processing
Abstract / short description	Recently, deep learning frameworks have rapidly become the main methodology for analyzing medical images. Due to their powerful learning ability and advantages in dealing with

	complex patterns, deep learning algorithms are ideal for image analysis challenges, particularly in the field of digital pathology. The variety of image analysis tasks in the context of deep learning includes classification (e.g., healthy vs. cancerous tissue), detection (e.g., lymphocytes and mitosis counting), and segmentation (e.g., nuclei and glands segmentation). The majority of recent machine learning methods in digital pathology have a pre- and/or post-processing stage which is integrated with a deep neural network. These stages, based on traditional image processing methods, are employed to make the subsequent classification, detection, or segmentation problem easier to solve. Several studies have shown how the integration of pre- and post-processing methods within a deep learning pipeline can further increase the model's performance when compared to the network by itself. The aim of this review is to provide an overview on the types of methods that are used within deep learning frameworks either to optimally prepare the input (pre-processing) or to improve the results of the network output (post-processing), focusing on digital pathology image analysis. Many of the techniques presented here, especially the post-processing methods, are not limited to digital pathology but can be extended to almost any image analysis field.

H2 OERs

H2 OER1 Big Data Analytics in Healthcare

Title	Big Data Analytics in Healthcare
Resource Link(s)	https://www.ncbi.nlm.nih.gov/pmc/articles/PMC4503556/
Resource Author(s)	Ashwin Belle, Raghuram Thiagarajan, S. M. Reza Soroushmehr, Fatemeh Navidi, Daniel A. Beard, and Kayvan Najarian
Resource Reference	10.1155/2015/370194
Publication Date	2015
Language	**English**
Content type	Article/paper
License	CC BY
Country	USA
Relevant for the IND 4.0 course module(s)	H 2
Relevant Learning Outcome with degree of relevance	Describe the main machine learning approaches, explain basic big data analytics techniques and tools

Justification of relevance (contribution)	The specific educational material provides the learner with the necessary knowledge to better understand the particular subject. Then with the help of other open educational resources, he will be able to delve more easily into the specific topic of knowledge.
Estimated study time	1 week
Keywords	Big Data Analysis, 3Vs, Healthcare
Abstract / short description	Big data analytics has been recently applied towards aiding the process of care delivery and disease exploration. However, the adoption rate and research development in this space is still hindered by some fundamental problems inherent within the big data paradigm. In this paper, we discuss some of these major challenges with a focus on three upcoming and promising areas of medical research: image, signal, and genomics based analytics. Recent research which targets utilization of large volumes of medical data while combining multimodal data from disparate sources is discussed. Potential areas of research within this field which have the ability to provide meaningful impact on healthcare delivery are also examined.

H2 OER2 - Applications of Machine Learning in Healthcare

Title	Applications of Machine Learning in Healthcare
Resource Link(s)	https://www.intechopen.com/chapters/72044
Resource Author(s)	Christopher Toh, James P. Brody
Resource Reference	10.5772/intechopen.92297
Publication Date	January 14th 2021
Language	**English**
Content type	Chapter
License	CC BY 3.0
Country	USA
Relevant for the IND 4.0 course module(s)	H 2
Relevant Learning Outcome with degree of relevance	describe the main machine learning approaches
Justification of relevance (contribution)	The specific educational material provides the learner with the necessary knowledge to better understand the particular subject. Then with the help of other open educational resources, he will be able to delve more easily into the specific topic of knowledge.
Estimated study time	3 weeks
Keywords	machine learning, healthcare, big data, medicine, genetics, disease
Abstract / short description	Machine learning techniques in healthcare use the increasing amount of health data provided by the Internet of Things to improve patient outcomes. These techniques provide promising applications as well as significant challenges. The

	three main areas machine learning is applied to include medical imaging, natural language processing of medical documents, and genetic information. Many of these areas focus on diagnosis, detection, and prediction. A large infrastructure of medical devices currently generates data but a supporting infrastructure is oftentimes not in place to effectively utilize such data. The many different forms medical information exist in also creates some challenges in data formatting and can increase noise. We examine a brief history of machine learning, some basic knowledge regarding the techniques, and the current state of this technology in healthcare.

H2 - OER3 - Transforming healthcare with big data analytics and artificial intelligence: A systematic mapping study

Title	Transforming healthcare with big data analytics and artificial intelligence: A systematic mapping study
Resource Link(s)	https://www.sciencedirect.com/science/article/pii/S1532046419302308?via%3Dihub
Resource Author(s)	Nishita Mehta, Anil Pandit, Sharvari Shukla
Resource Reference	
Publication Date	2019
Language	English
Content type	
License	CCL
Country	India
Relevant for the IND 4.0 course module(s)	Get an overview of big data analytics and artificial intelligence and understand the needs in application of these technologies in healthcare
Relevant Learning Outcome with degree of relevance	
Justification of relevance (contribution)	The specific educational material provides the learner with the necessary knowledge to better understand the state of the art of research on big data analytics and artificial intelligence in healthcare.
Estimated study time	2 days
Keywords	Healthcare, Big data analytics, Machine learning, Artificial intelligence, Systematic map

Abstract / short description	The domain of healthcare has always been flooded with a huge amount of complex data, coming in at a very fast-pace. A vast amount of data is generated in different sectors of healthcare industry: data from hospitals and healthcare providers, medical insurance, medical equipment, life sciences and medical research. With the advancement in technology, there is a huge potential for utilization of this data for transforming healthcare. The application of analytics, machine learning and artificial intelligence over big data enables identification of patterns and correlations and hence provides actionable insights for improving the delivery of healthcare. There have been many contributions to the literature in this topic, but we lack a comprehensive view of the current state of research and application. This paper focuses on assessing the available literature in order to provide the researchers with evidence that enable fostering further development in this area. A systematic mapping study was conducted to identify and analyze research on big data analytics and artificial intelligence in healthcare, in which 2421 articles between 2013 and February 2019 were evaluated. The results of this study will help understand the needs in application of these technologies in healthcare by identifying the areas that require additional research. It will hence provide the researchers and industry experts with a base for future work.

H3 OERs

H3 OER1 - Mobile Health Technologies - Theories and Applications

Title	Mobile Health Technologies - Theories and Applications
Resource Link(s)	https://www.intechopen.com/books/5172
Resource Author(s)	Wilfred Bonney
Resource Reference	10.5772/61446
Publication Date	August 31st 2016
Language	**English**
Content type	Volume
License	CC BY 3.0
Country	USA
Relevant for the IND 4.0 course module(s)	H 3
Relevant Learning Outcome with degree of relevance	integrate new Industry 4.0 healthcare services into existing systems
Justification of relevance (contribution)	The specific educational material provides the learner with the necessary knowledge to better understand the particular

	subject. Then with the help of other open educational resources, he will be able to delve more easily into the specific topic of knowledge.
Estimated study time	2 months
Keywords	mHealth, mobile app, wearable inertial sensors, eHealth, chronic disease
Abstract / short description	Mobile Health Technologies, also known as mHealth technologies, have emerged, amongst healthcare providers, as the ultimate Technologies-of-Choice for the 21st century in delivering not only transformative change in healthcare delivery, but also critical health information to different communities of practice in integrated healthcare information systems. mHealth technologies nurture seamless platforms and pragmatic tools for managing pertinent health information across the continuum of different healthcare providers. mHealth technologies commonly utilize mobile medical devices, monitoring and wireless devices, and/or telemedicine in healthcare delivery and health research. Today, mHealth technologies provide opportunities to record and monitor conditions of patients with chronic diseases such as asthma, Chronic Obstructive Pulmonary Diseases (COPD) and diabetes mellitus. The intent of this book is to enlighten readers about the theories and applications of mHealth technologies in the healthcare domain.

H3 OER2 Mobile-health: A review of current state in 2015

Title	Mobile-health: A review of current state in 2015
Resource Link(s)	https://www.sciencedirect.com/science/article/pii/S1532046415001136
Resource Author(s)	Bruno M.C.Silva, Joel J.P.C. Rodrigues, Isabel de la Torre Díez, Miguel López-Coronado, Kashif Saleem
Resource Reference	10.1016/j.jbi.2015.06.003
Publication Date	11 June 2015
Language	**English**
Content type	Article
License	CC BY-NC-ND
Country	
Relevant for the IND 4.0 course module(s)	H 3
Relevant Learning Outcome with degree of relevance	design an efficient healthcare service in terms of data processing and storage
Justification of relevance (contribution)	The specific educational material provides the learner with the necessary knowledge to better understand the particular subject. Then with the help of other open educational resources, he will be able to delve more easily into the specific topic of knowledge.

Estimated study time	1 week
Keywords	e-Health, Health telematics, Healthcare, m-Health, Mobile health, Telemedicine
Abstract / short description	Health telematics is a growing up issue that is becoming a major improvement on patient lives, especially in elderly, disabled, and chronically ill. In recent years, information and communication technologies improvements, along with mobile Internet, offering anywhere and anytime connectivity, play a key role on modern healthcare solutions. In this context, mobile health (m-Health) delivers healthcare services, overcoming geographical, temporal, and even organizational barriers. M-Health solutions address emerging problems on health services, including, the increasing number of chronic diseases related to lifestyle, high costs of existing national health services, the need to empower patients and families to self-care and handle their own healthcare, and the need to provide direct access to health services, regardless of time and place. Then, this paper presents a comprehensive review of the state of the art on m-Health services and applications. It surveys the most significant research work and presents a deep analysis of the top and novel m-Health services and applications proposed by industry. A discussion considering the European Union and United States approaches addressing the m-Health paradigm and directives already published is also considered. Open and challenging issues on emerging m-Health solutions are proposed for further works.

H3 - OER3 - Internet of things in health: Requirements, issues, and gaps

Title	Internet of things in health: Requirements, issues, and gaps
Resource Link(s)	https://www.sciencedirect.com/science/article/pii/S0169260721003059?via%3Dihub
Resource Author(s)	Jorge Calvillo-Arbizu, Isabel Román-Martínez, Javier Reina-Tosina
Resource Reference	
Publication Date	2021
Language	English
Content type	
License	CCL
Country	Spain
Relevant for the IND 4.0 course module(s)	Get an overview of the capabilities of the IoT paradigm in healthcare.

Relevant Learning Outcome with degree of relevance	
Justification of relevance (contribution)	The specific educational material provides the learner with the necessary knowledge to better the landscape of IoT applications in healthcare
Estimated study time	2 days
Keywords	Internet of Things (IoT), Healthcare, Requirements, Security, Data lifecycle
Abstract / short description	Background and objectives The Internet of Things (IoT) paradigm has been extensively applied to several sectors in the last years, ranging from industry to smart cities. In the health domain, IoT makes possible new scenarios of healthcare delivery as well as collecting and processing health data in real time from sensors in order to make informed decisions. However, this domain is complex and presents several technological challenges. Despite the extensive literature about this topic, the application of IoT in healthcare scarcely covers requirements of this sector. Methods A literature review from January 2010 to February 2021 was performed resulting in 12,108 articles. After filtering by title, abstract, and content, 86 were eligible and examined according to three requirement themes: data lifecycle; trust, security, and privacy; and human-related issues. Results The analysis of the reviewed literature shows that most approaches consider IoT application in healthcare merely as in any other domain (industry, smar the specific requirements of this domain. Conclusions Future efforts in this matter should be aligned with the specific requirements and needs of the health domain, so that exploiting the capabilities of the IoT paradigm may represent a meaningful step forward in the application of this technology in healthcare.