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PLANET 4

Practical Learning
of Artificial Intelligence
on the Edge for indusTry 4.0

Taxonomy of Industry 4.0 Needs/Enabling Technologies and Challenge Template

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Why a taxonomy for Industry 4.0?

One of the biggest challenges in Industry 4.0 adoption is the lack of mutual understanding between the academic and the industrial worlds.

This can lead to:

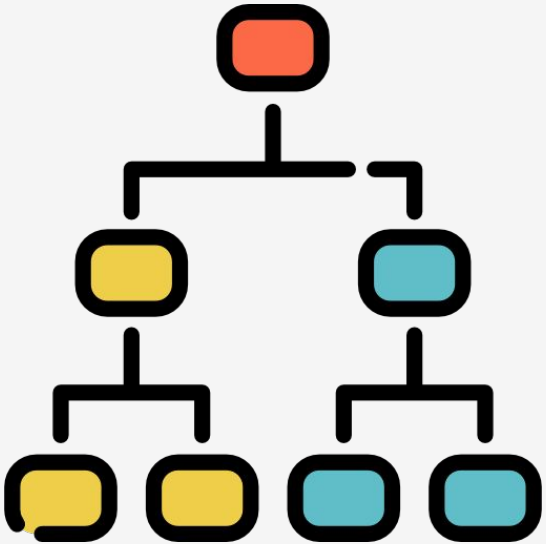
- ➔ fail in applying new technologies and innovations coming from the research,
- ➔ difficulties in focusing on real-world applications and needs.

The Planet4 Taxonomy

The purpose of the taxonomy is to provide a useful tool to both the industry and the academia, capable to bridge the gap between this 2 worlds creating a common ground.

An actionable resource for classifying industrial problems that can be addressed with data-powered solutions.

PLANET4 TAXONOMY



But what is a taxonomy?

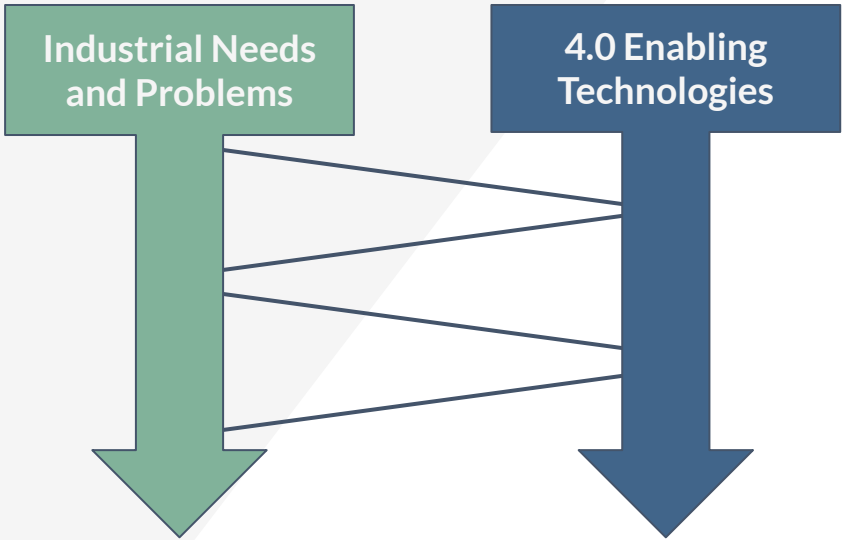
A taxonomy is a simple classification system in which terms are organised in a hierarchical order (from broader to narrower).

In this way it is possible to organise the knowledge of a specific field of study, in our case Industry 4.0.

More specifically, the PLANET4 Taxonomy classifies the Business/Industrial needs and the Enabling Technologies, all related to I4.0.

The building process

Given the twofold purpose and scope of the taxonomy, the building process itself took place through two parallel and yet interconnected developments:



Sources

We selected 441 sources published from 1999 to 2021.

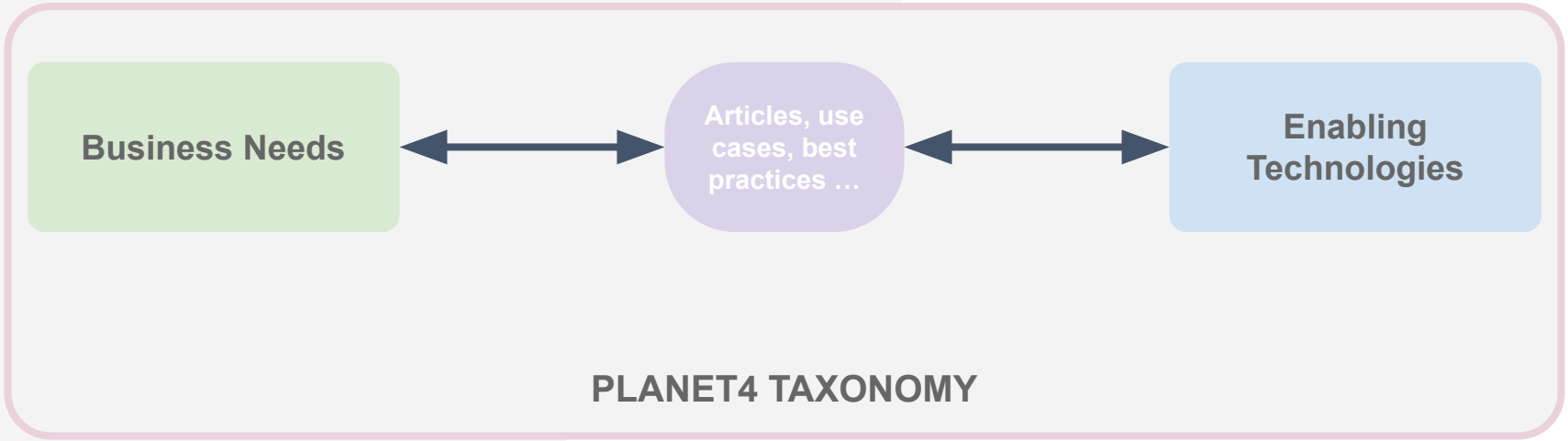
- 365 (82.8%) scientific papers,
- 76 (17.2%) company/consultancy white papers and reports, company use cases.

Sources

Search Engine	Query		Results
Academic Literature: Scopus	(“*Internet of Things*” **OR** “*IoT*” **OR** “*Smart Factory*” **OR** “*Industry 4.0*” **OR** “*Cyber Physical System*” **OR** “*Wireless Sensor Network*”) **AND**	*Change Management*	780
		Digital Management	762
		Innovation Management	739
		Technological Management	542
Grey literature: Google	“*Industrial*” **AND** (“*Problems*” **OR** “*Needs*” **OR** “*Issues*” **OR** “*Challenges*”)		107
	(“*Industry 4.0*” **OR** “*Smart Manufacturing*” **OR** “*Smart Industry*”) **AND** (“*Solutions*” **OR** “*Technologies*” **OR** “*Examples*” **OR** “*Usecases*” **OR** “*Projects*” **OR** “*Products*” **OR** “*Case studies*” **OR** “*News*”)		126

PLANET4 TAXONOMY

Using the PLANET4 Taxonomy you can retrieve articles, use cases and best practices that can help you solving Industry 4.0 challenges, or identifying possible applications for specific technologies:

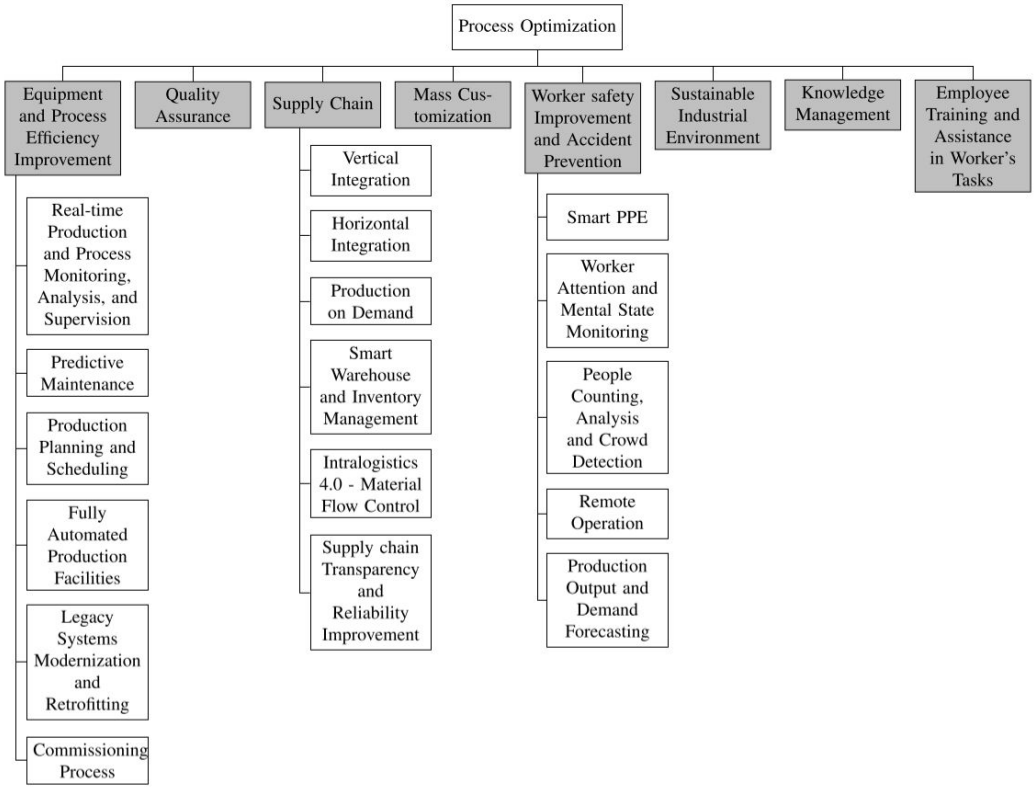


Industrial Needs and Problems

Classification into two main categories:

Process Optimization	It is related to the macro need to improve production processes' efficiency to reduce production costs. In general, industrial processes can be optimized by improving the efficiency of equipment, workforce and supply chain.
Product Innovation	It is related to companies who need to build a new generation of products that are typically IoT connected, thus migrating the business toward a service-based solution. Product Innovation actions also aim to improve products' usability by making them easier to use and understand (User Experience redesign).

Industrial Needs and Problems: Process Optimization



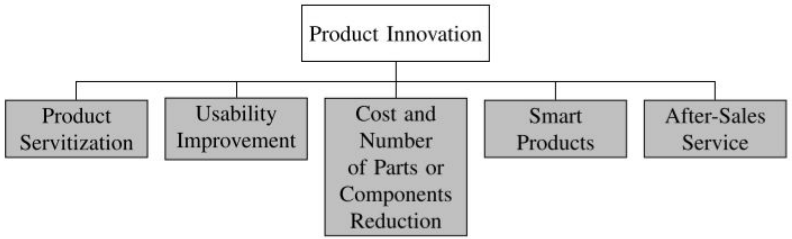
Industrial Needs and Problems: Process Optimization

1. **Equipment and Process Efficiency Improvement:** Concerns activities related to the manufacturing ecosystem connectivity for alerting, running data analytics processes, and all the maintenance processes that ensure continuous readiness and operation of the industrial equipment without unplanned disruptions. It also involves initiatives for a) production planning and scheduling, b) employing industrial units that work independently without human intervention, c) legacy systems modernization and retrofitting, and d) commissioning processes.
2. **Worker security improvement and accident prevention:** Problems in this area are related to the use of effective means for workers' personal and collective protection.
3. **Supply Chain:** Needs that ensure a smooth flow of information and materials inside the company between individual production departments (internal suppliers and customers) and between the company and its external suppliers and customers.
4. **Mass Customization:** Individualization of the production process while remaining profitable for the enterprise. That is to implement technologies allowing for unlimited adaptation of products to individual customer requirements without affecting the unit production costs.
5. **Quality Assurance:** It is connected with the necessity to monitor the operation of machines and process parameters to identify quality disturbances and take immediate corrective and preventive actions.
6. **Sustainable industrial environment:** Is related to the appropriate management of industrial processes purposing of reducing energy consumption and minimizing/utilizing wastes, among others, from an environmental, economic and social perspective.

Industrial Needs and Problems: Process Optimization

7. **Employee training and Assistance in worker's tasks:** The use of appropriate technologies that help prepare employees to perform a new job and support them in implementing current jobs (e.g., product design, manual assembly, inspection activities, maintenance tasks, and order picking), minimizing the risk of human errors.
8. **Knowledge management**: The manufacturing companies' needs on the acquisition, organization, and automatic retrieval of information from different content resources, such as technical documentation, videos, images, schematics, audio, web pages and much more, in the different phases of the industrial process.

Industrial Needs and Problems: Product Innovation



Industrial Needs and Problems: Product Innovation

1. **Product Servitization:** The innovation of the organization's capabilities and processes to better create mutual value through a shift from selling products to selling Product-Service Systems capable of fulfilling a more comprehensive range of customer needs.
2. **Usability improvement:** The need for solutions to user problems (e.g., the design of better user interfaces) that make it easier for the user to complete a task with effectiveness, efficiency and satisfaction by using the manufactured product.
3. **Smart products:** Disruptive initiatives aimed at building a new generation of products that completely change the usage and the associated business model.
4. **Cost and Number of Parts or Components Reduction:** It aims at optimizing the BOM (Bill of Material) of products, thus reducing product and production management costs.
5. **After-Sales Service:** The improvement of all those services that link the customer to the production company after selling the product (e.g., complaint management, warranty, field technical assistance responsible for installation, check-ups, out-of-warranty repairs and product disposal, usage monitoring, user analytics and profiling, automatic consumables reorder, etc.).

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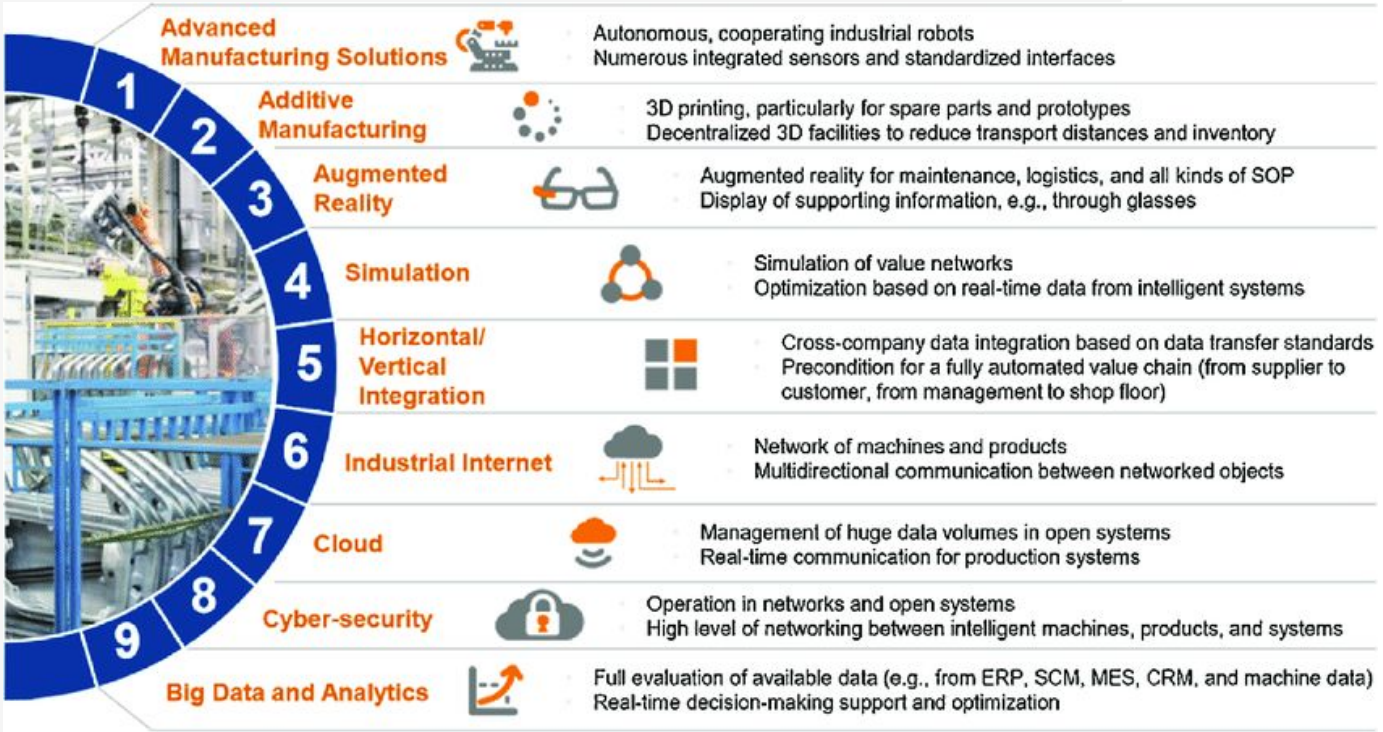
4.0 Enabling Technologies

We started from the European Commission classification of the enabling technologies for Industry



+ Artificial Intelligence

4.0 Enabling Technologies

Big Data

- Big Data Frameworks
- Data Sources/Ingestion
  - Streaming and Messaging
  - Orchestration and Pipelines
  - Query/Data Flow
- Data Storage
  - Databases
  - Data Warehouses
- Data Analytics
  - Unified Data Analytics Engines
  - Unified stream-processing and batch-processing frameworks
  - Business Intelligence (BI) Tools
  - Data Visualization Tools and Platforms
  - Logging and Monitoring
  - Spreadsheet Applications
  - Data Mining
  - Process Mining

Artificial Intelligence

- Machine Learning
  - Supervised Learning
  - Unsupervised Learning
  - Deep Learning
  - Transfer Learning
  - Reinforcement Learning
  - Deep Reinforcement Learning
  - Semi-Supervised Learning
  - Federated learning
- Computer Vision
- Natural Language Processing, Natural Language Generation
- Intelligent Agents and Multiagent Systems
- Soft Computing
  - Fuzzy Set Theory
  - Neurocomputing
  - Optimization Techniques
  - Probabilistic Reasoning

Cloud Computing

- Infrastructure as a Service (IaaS)
  - Cloud Data Storage and Computing
- Platform as a Service (PaaS)
  - Device Management
  - Operating System
- Software as a Service (SaaS)
  - Media Streaming Software Platforms
  - Website Building
  - IoT Analytics Software and Platforms
- Infrastructure as Code (IaC)
  - Provisioning Tools
- Container Technology (Container as a Service)
  - Containerization Platform
  - Container Orchestration
- Serverless Programming
- Edge Computing
- Fog Computing

IoT and IoE

- Industrial IoT
  - Industrial Communication Protocols
  - Industrial (IoT) Gateways and Data Acquisition Devices
  - Software Data Adapters
- Physical Devices and Controllers
  - Embedded Computing
  - Sensors (hardware)
- Signal Processing
- Connectivity
  - Radio Communication Technologies
  - Optical Communication Technologies
  - IoT Messaging Protocols
  - Application Programming Interfaces and Programming Tools
- IoE (Internet of Everything)

Digital Twins

- Computer-aided design (CAD) Software
- Finite Element Analysis (FEA) Software
- Simulation Software
- DTs Management and Orchestration Frameworks
- Digital Twin Data Modelling
- Virtual Process Controllers (VPC)

Industrial Robotics

- Offline Programming and Simulation
- Middleware

Augmented Reality (AR) and Virtual Reality (VR)

- VR
  - VR glasses
- AR
  - AR glasses
  - AR Software Development Kits
- AR and VR Software development, Platforms and Technologies

Additive Manufacturing

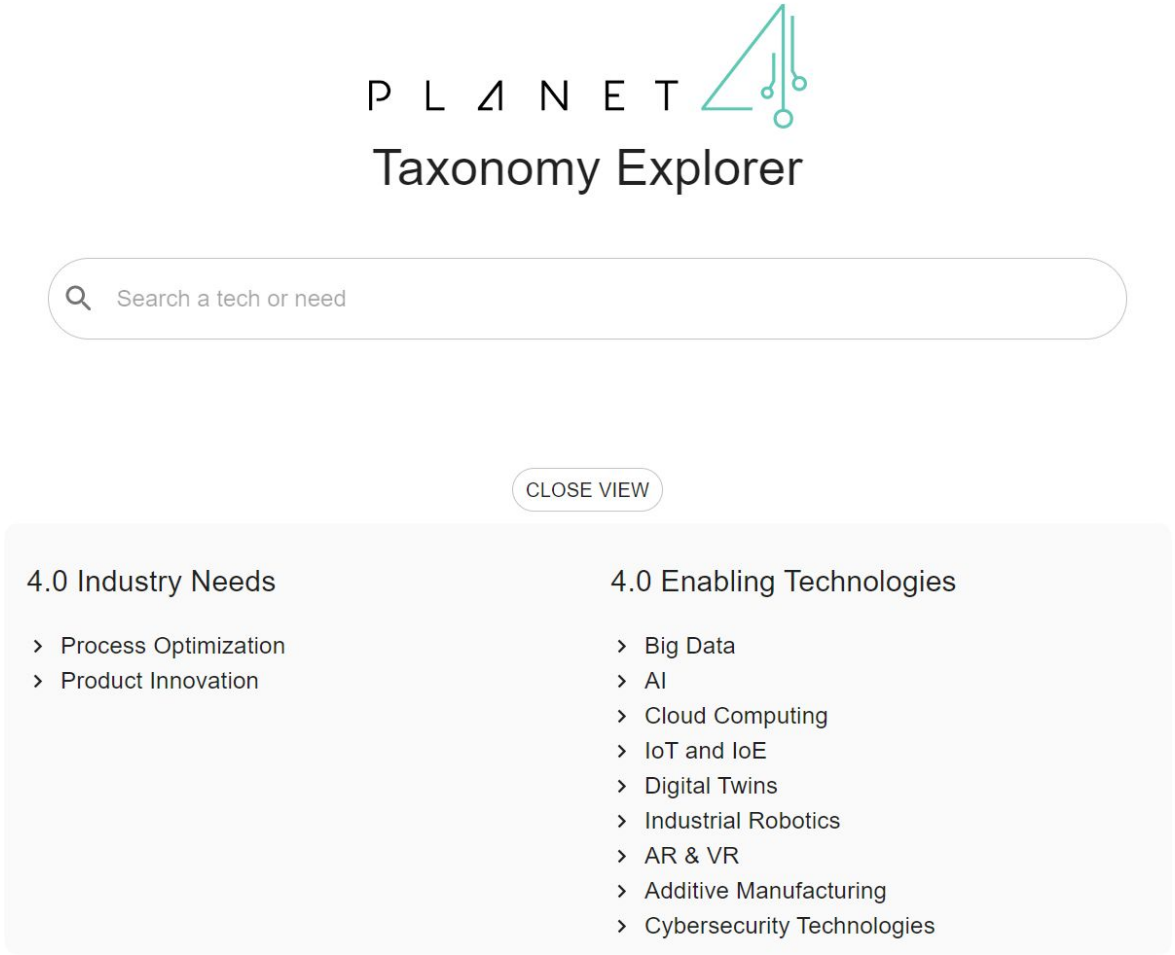
- 3D Printers
- 3D Printing Technologies

Cybersecurity Technologies

- Security Virtualization
  - Virtual Machine Monitor (VMM)
- Data Protection
  - Secure Communication Protocols
  - Key Management System (KMS)
  - Public Key Infrastructure (PKI)
  - Encryption
  - Tokenization
  - Blockchain
- Identity and Access Management
  - Protocols
  - User Management
  - Authentication
  - Authorization
- Security Operations
  - Change Management
  - Threat Detection and Analysis
- Foundational Security
  - Network

The website

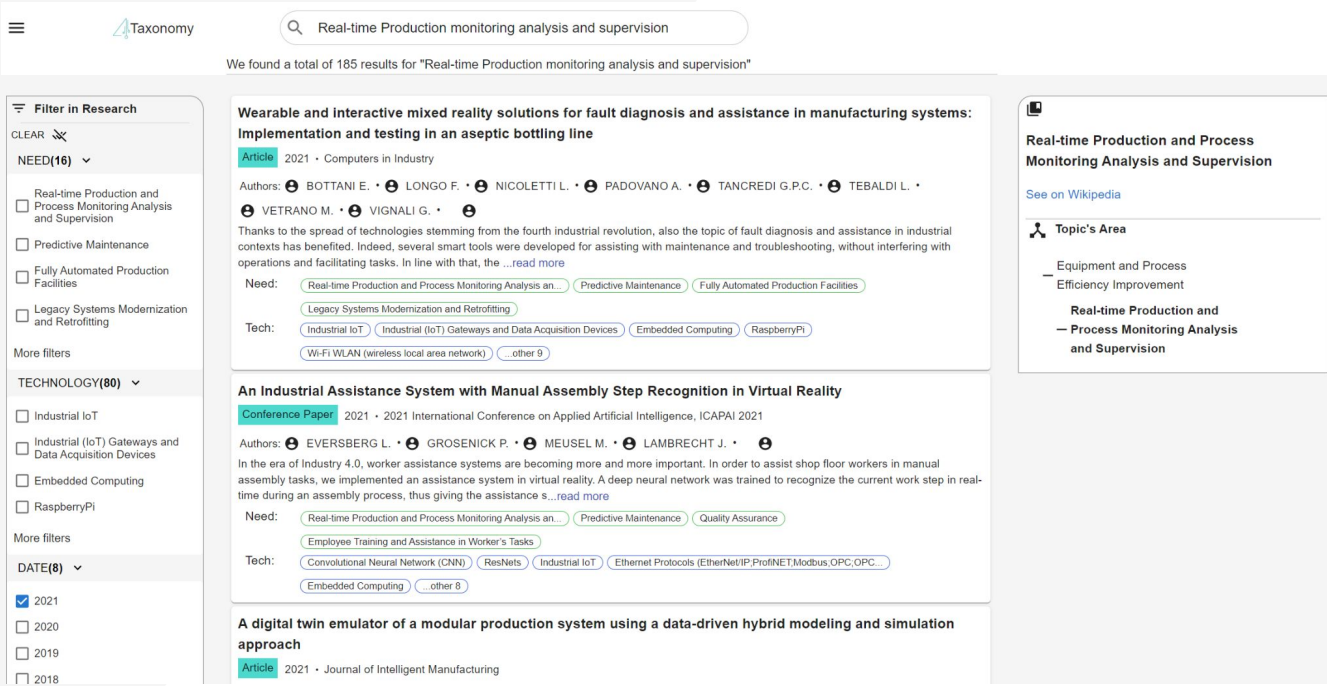
http://taxonomy.planet4project.eu/



HOW TO USE IT?

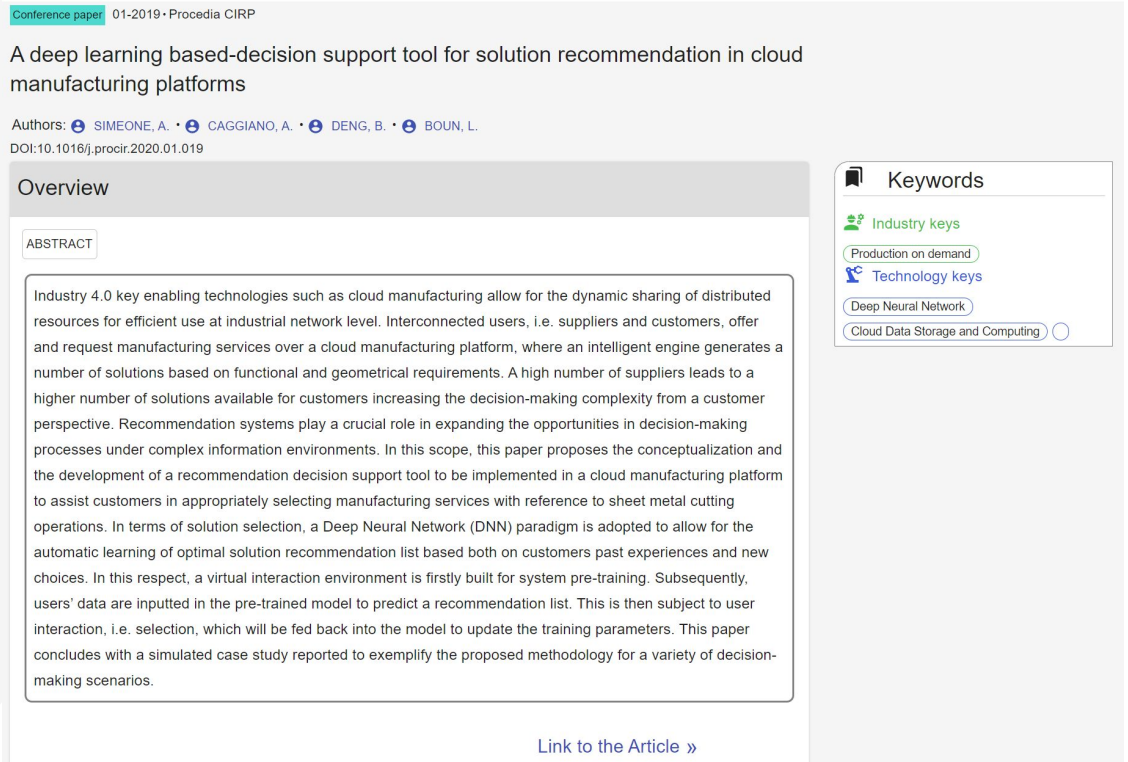
Using the website is as simple as any other search engine.

When making a new search the website will show you the list of appropriate results that it found in the Planet4 taxonomy database.



HOW TO USE IT?

When clicking on the desired article, the website will show more information about it and gives the possibility to reach the original source.



Conference paper 01-2019 • Procedia CIRP

A deep learning based-decision support tool for solution recommendation in cloud manufacturing platforms

Authors: SIMEONE, A. • CAGGIANO, A. • DENG, B. • BOUN, L.

DOI:10.1016/j.procir.2020.01.019

Overview

ABSTRACT

Industry 4.0 key enabling technologies such as cloud manufacturing allow for the dynamic sharing of distributed resources for efficient use at industrial network level. Interconnected users, i.e. suppliers and customers, offer and request manufacturing services over a cloud manufacturing platform, where an intelligent engine generates a number of solutions based on functional and geometrical requirements. A high number of suppliers leads to a higher number of solutions available for customers increasing the decision-making complexity from a customer perspective. Recommendation systems play a crucial role in expanding the opportunities in decision-making processes under complex information environments. In this scope, this paper proposes the conceptualization and the development of a recommendation decision support tool to be implemented in a cloud manufacturing platform to assist customers in appropriately selecting manufacturing services with reference to sheet metal cutting operations. In terms of solution selection, a Deep Neural Network (DNN) paradigm is adopted to allow for the automatic learning of optimal solution recommendation list based both on customers past experiences and new choices. In this respect, a virtual interaction environment is firstly built for system pre-training. Subsequently, users' data are inputted in the pre-trained model to predict a recommendation list. This is then subject to user interaction, i.e. selection, which will be fed back into the model to update the training parameters. This paper concludes with a simulated case study reported to exemplify the proposed methodology for a variety of decision-making scenarios.

Link to the Article »

Keywords

Industry keys

Production on demand

Technology keys

Deep Neural Network

Cloud Data Storage and Computing

R3.1 Template for collecting best practices

The template is divided into 2 sections:

A. The Challenge

B1. Research Phase

B2. Proposed Solution

The Challenge

The first section presents you with the challenge and its main requirements, classifications and other info.
In the first page you find the main information in the second one the other information that can help you better contextualize the challenge.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The Challenge

The company manufactures p
products and wants to extract in
products are used and if this can
model.

Key Performance Indicators

- Perform data analytics a
  decisions;
- Increase revenues based o
- Add Always-on connectivi
- Monitor and optimize ener

PLANET

Product servitization with IoT
Build new products based on AI and IoT technologies.

Other informations
The company expects to deploy **14** devices.

Need for device management operations (such as managing or updating the software remotely)?
Yes

Strict deadlines in device operations for doing the tasks?
No

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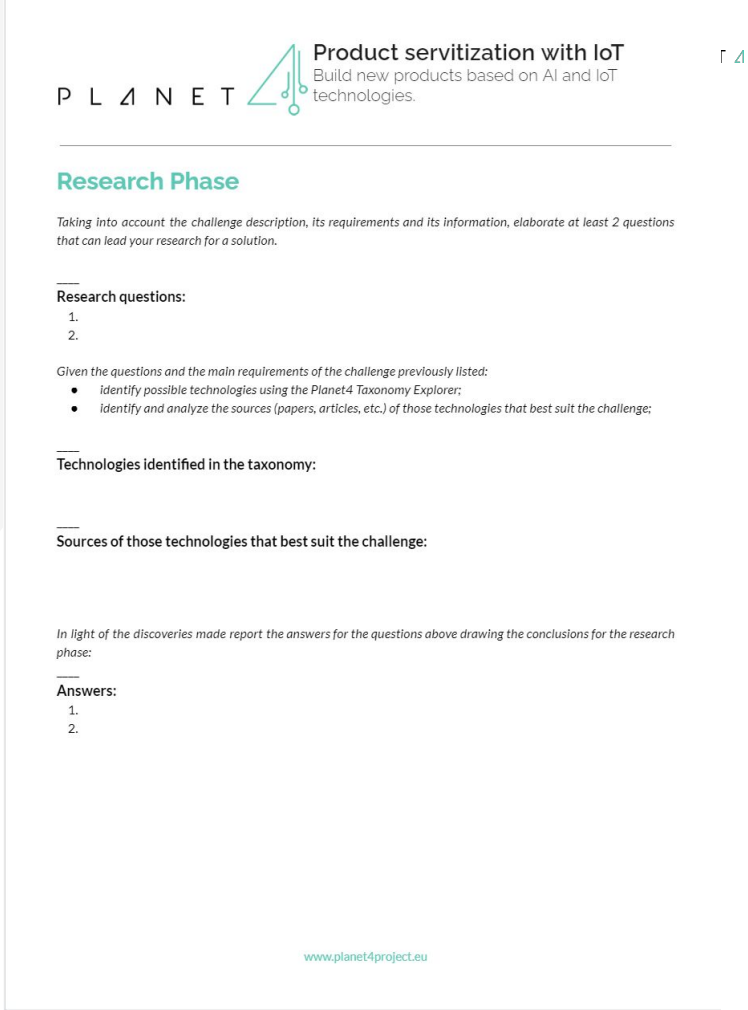
Research Phase

The “Research Phase” asks you to:

- write questions arose from discussing and thinking about the challenge,
- use the taxonomy to identify technologies and sources that solved similar challenges,
- give answers to the initial questions, drawing some conclusions



PLANET 4 Product servitization with IoT
Build new products based on AI and IoT technologies.

Research Phase

Taking into account the challenge description, its requirements and its information, elaborate at least 2 questions that can lead your research for a solution.

___
Research questions:
1.
2.

Given the questions and the main requirements of the challenge previously listed:
- *identify possible technologies using the Planet4 Taxonomy Explorer;*
- *identify and analyze the sources (papers, articles, etc.) of those technologies that best suit the challenge;*

___
Technologies identified in the taxonomy:

___
Sources of those technologies that best suit the challenge:

In light of the discoveries made report the answers for the questions above drawing the conclusions for the research phase:

___
Answers:
1.
2.

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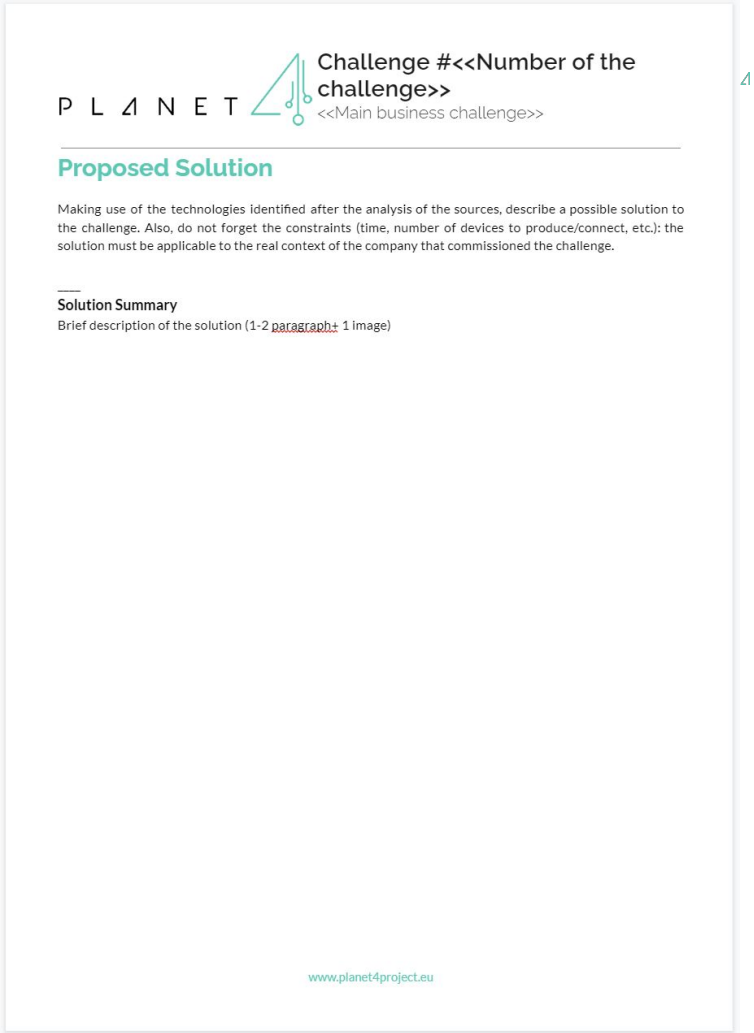
Proposed Solution

The third phase asks you to:

- write an “executive summary” that briefly describes (also visually) the solution.



Future upgrades

Taxonomy update:

- ➔ Transformation in ontology.
- ➔ Thus to allow automated indexing for new articles.

Website updates:

- ➔ New exploration features and more precise results thanks to the use of KG.

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Thank you!

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University of Ioannina

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