



LABORATORY FOR THE DEVELOPMENT OF ARTIFICIAL INTELLIGENCE



With this laboratory **20** students can work simultaneously [**3** on the hardware and up to **17** on computer equipment (not included)]. Teachers can perform more than **20** experiments.

- Who is it for?
- Artificial Intelligence Engineering
 - Automation Engineer
 - Software Engineer
 - Mechatronics Engineering
 - Process Engineering
 - Information Technology
 - Technical and Professional Training

DL AI-2.0 & DL AI-2.0SW

DESCRIPTION

This didactic laboratory **DL AI-2.0** for the development of **Artificial Intelligence** solutions is a state-of-the-art platform designed to provide practical and complete experience in the development of Artificial Intelligence solutions. With software and hardware that allow students to illustrate real-life scenarios, they will develop a comprehensive understanding of problem-solving from an **AI** perspective.

Programming Fundamentals	Algorithms and data structures	Algorithm analysis and design	Programming Paradigms	Databases	Digital and analog signals
Fundamentals of Artificial Intelligence	Web development technologies (oriented to background communication)	Digital image processing	Machine learning	Machine vision	Bio-inspired algorithms
	Natural language technologies	Neural networks and deep learning	Software engineering for intelligent systems	High level communication protocol	

The laboratory **DL AI-2.0** is mainly composed of a system with hardware modules with the support of a **Server** on which all the software related to **AI** field is installed. **Three** students can work on it performing all the experiments and the proposed training objectives with the help of the provided software's as listed at the end of this catalogue in "**SOFTWARE APPLICATIONS**" & "**TRAINING OBJECTIVES**". Even the three students who work with the HW need their own PC.



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This lab also allows to increase the student's number, up to **17** (becoming **20** students total), to work on it **at the same time** (with access to the Server from their own PCs) by providing a single license each. This additional license (when and if needed) has the following code **DL AI-2.OSW**. Please refer to other suggested configurations at the end of this catalogue.

PEDAGOGICAL APPROACH

In the didactic laboratory for the development of Artificial Intelligence solutions, the challenge-based learning (CBL) approach focuses on providing students with practical, real-world challenges that allow them to apply theoretical knowledge in specific situations. Rather than simply presenting information passively, this approach engages students in solving problems and creating innovative solutions.

Students are faced with challenges that simulate real-life and industry problems, such as process optimization, anomaly detection or efficiency improvement. Using the hardware and software available in the lab, as well as artificial intelligence tools, students work in teams to develop practical solutions that address these challenges.

MAIN CHARACTERISTICS

- **Multidisciplinary:** Useful for the study of software development, artificial intelligence.
- **Economic:** By involving several disciplines, the cost of the product can be divided among different departments.
- **Open:** Provides the architecture to implement standard and new solutions, allowing the use of the product in professional and research activities.
- **State-of-the-art:** The product provides a descriptive view of software architecture for *development using artificial intelligence*.

MAIN DIDACTIC CONCEPTS

- AI basics.
- Machine Learning (ML).
- Sensors and actuators as data sources.
- Data processing and analysis.
- Programming and AI tools.
- Industrial applications.

SIMULATED INDUSTRIAL CHALLENGES

- Lighting management.
- Quality control.
- Process automation.
- Detection.
- Predictive maintenance.
- Condition monitoring.
- Optimization.






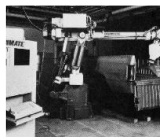








WHO IS IT FOR?

Schools, Academia and Industry (to validate theory and test concepts):

- Automation Engineer
- Software Engineer
- Mechatronics Engineering
- Process Engineering
- Information Technology
- Technical and Vocational Education and Training (TVET)

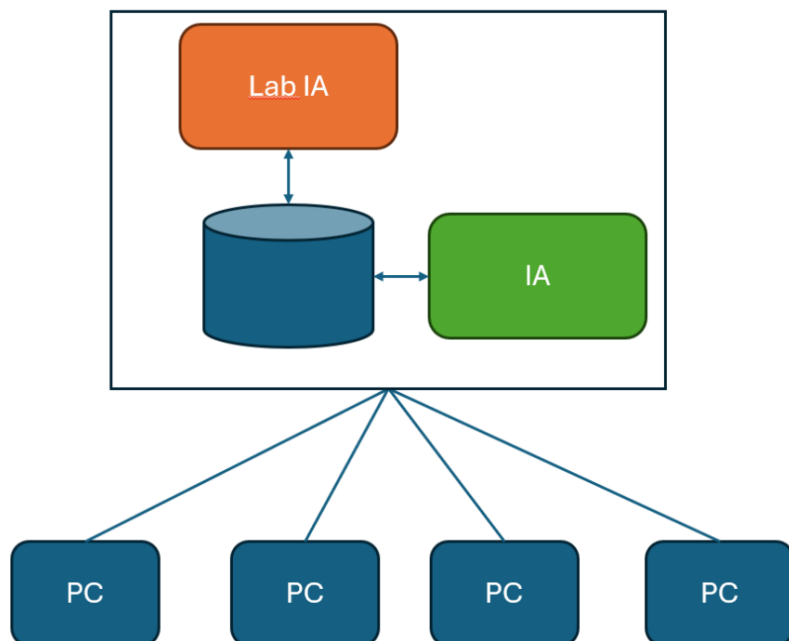
INTRODUCTION TO AUTOMATION 4.0 AND ARTIFICIAL INTELLIGENCE

Industry 4.0 is now a reality, revolutionizing production facilities around the world. To fully exploit its potential, technicians with expertise in software engineering and automation are increasingly essential, and professionals with interdisciplinary skills are needed more than ever, Industry 4.0 thrives on the generation, storage, analysis and application of data for decision making, which requires specialized software. Technicians must understand software engineering to manage systems and automation engineering to understand industrial architectures and optimize the use of data. In this context, Artificial Intelligence (AI) is beginning to transform industrial processes by addressing needs that were traditionally met with sensors and human intervention. Although AI is poised to replace certain algorithms and sensors, this change is limited by the shortage of professionals who can bring together automation and software to develop Artificial Intelligence (Machine Learning, Neural Networks, etc.) for industrial applications, *The laboratory for the development of artificial intelligence* (the product) aims to close this gap by training software engineers with essential knowledge of automation and mechatronics, and vice versa.

<p>1785</p>  <p>First Steam Engine: James Watt Improves on the Steam Engine, Driving Automation in the Industrial Revolution.</p>	<p>1913</p>  <p>Ford Assembly Line: Henry Ford introduces the first mass assembly line, revolutionizing industrial production.</p>	<p>1946</p>  <p>ENIAC: The first general-purpose digital electronic computer is built, paving the way for computational automation.</p>	<p>1959</p>  <p>First industrial robot (Unimate): It is installed in General Motors to automate repetitive tasks on the assembly line.</p>	<p>1969</p>  <p>PLC (Programmable Logic Controller): The first PLC (Modicon 084) is created to replace hardwired logic circuits, allowing greater flexibility in industrial automation.</p>	<p>1980</p>  <p>Advanced robotics: The use of robots is becoming popular in industry to perform more complex and repetitive tasks, such as welding and assembly.</p>
<p>1997</p>  <p>Deep Blue vs. Kasparov: IBM's computer, Deep Blue, defeats world chess champion Garry Kasparov, showing the potential of artificial intelligence in complex tasks.</p>	<p>2000</p>  <p>First "smart" factory: Advanced automated control and monitoring systems with machine-to-machine communication are implemented, a precursor to the concept of Industry 4.0. Siemens (Amberg, Germany)</p>	<p>2001</p>  <p>Image recognition: The first image recognition technologies with convolutional neural networks are introduced, allowing machines to interpret images and videos.</p>	<p>2011</p>  <p>IBM's Watson: Watson wins in the Jeopardy! program, demonstrating AI's ability to process natural language and make complex decisions.</p>	<p>2020</p>  <p>Artificial Intelligence in Industry 4.0: The use of AI and machine learning to optimize production processes, predictive maintenance and real-time data analysis in manufacturing is consolidated.</p>	<p>2022</p>  <p>ChatGPT: ChatGPT is launched based on OpenAI's GPT-3 architecture, revolutionizing natural language processing and human interaction with machines using advanced generative models.</p>



ELEMENTS THAT COMPOSE IT



The laboratory constantly generates readings on the sensors, the information is integrated into the database. Students connect and extract the information from the database, creating different AI models and using the information from the DB, also from the sensors, they can interact directly with the actuator panel to verify the result created in the AI.



ELEMENTS THAT COMPOSE IT

IoT MODULE (NodeMCU)

- They promote learning of key concepts of electronics, IoT, automation, and embedded programming and AI.
- They facilitate the connection and testing of analog and digital sensors (temperature, humidity, light, proximity, etc.).
- They use banana terminal blocks to facilitate wiring without the need for soldering.
- They provide learning about ADC/DAC converters.
- They provide knowledge on Microcontroller programming.
- They use GPIO control for reading inputs and outputs.
- They use PWM signal generation.
- They use interrupts for real-time events.
- They use MQTT and HTTP protocols for communication.
- They create Wi-Fi sensors.
- They use actuator control.
- They facilitate interaction with Node-Red environment.
- They facilitate implementation of AI models.

AI DEVELOPMENT MODULE (Jetson NANO NVIDIA)

- They promote learning of key concepts of electronics, IoT, automation, and embedded programming and AI.
- They facilitate the connection and testing of digital sensors (temperature, humidity, light, proximity, etc.).
- They use banana terminal blocks to facilitate wiring without the need for soldering.
- They provide learning about DAC converters.
- They support for I2C, SPI, and UART protocols.
- They support development in Python.
- They use GPIO control.
- They use PWM signals control.
- They support real-time event and outage handling.
- They support real-time image processing.
- They facilitate implementation of neural networks.
- They support computer vision.
- They support HTTP integration.
- They support interaction with Node-Red.
- They support interaction with DC Motor Control, Servos and Stepper Motor.
- They facilitate the use of LIDAR.

EMBEDDED DEVELOPMENT MODULE (ARDUINO MEGA)

- They promote learning of key concepts of electronics, IoT, automation, and embedded programming and AI.
- They facilitate the connection and testing of analog and digital sensors (temperature, humidity, light, proximity, etc.).
- They use banana terminal blocks to facilitate wiring without the need for soldering.
- They use Arduino IDE and C++.
- They use GPIO control.
- They use PWM signals control.
- They facilitate Interruptions for real-time events.



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- They support for I2C and SPI.
- They facilitate communication with other microcontrollers.
- They facilitate actuator control and automation.
- They facilitate interaction with LCD and OLED screens.
- They use with matrix keypads and LED matrices.

UDP SENSOR MODULE

- They collect essential data to train AI models.
- They provide real-time information for decision making.
- They simulate real-world conditions to solve practical problems.
- They connect the physical world with AI applications.
- They facilitate experimentation with different types of data.
- They allow to measure, monitor environmental variables.
- They help to understand the impact of AI on physical systems.
- They promote the integration of hardware and software in educational projects.
- They promote active learning through direct manipulation.
- They foster innovation by exploring new AI applications.
- They constantly feed the information into the database to perform exercises with historical information.
- They provide real-time information to students who are not directly working in the device.
- They allow multiple exercises to be performed from an external computer.

DISPLAY MODULE

- They receive and deploy real-time information from UDP sensors.
- They allow the connection of multiple workstations for running software experiments.
- They keep the communication between the various environments synchronized.

SENSOR MODULE

- They collect essential data to train AI models.
- They provide real-time information for decision making.
- They simulate real-world conditions to solve practical problems.
- They connect the physical world with AI applications.
- They facilitate experimentation with different types of data.
- They allow us to measure, monitor and control environmental variables.
- They help to understand the impact of AI on physical systems.
- They promote the integration of hardware and software in educational projects.
- They promote active learning through direct manipulation.
- They foster innovation by exploring new AI applications.

ACTUATOR MODULE

- They transform AI decisions into physical actions.
- They allow tangible interaction with the environment.
- They demonstrate the applicability of AI in real systems.
- They facilitate the validation of AI predictions and models.
- They teach how to automate processes through AI.
- They simulate practical solutions to industrial problems.
- They convert processed data into useful answers.
- They integrate theoretical learning with visible results.
- They encourage creativity in the design of intelligent systems.



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- They drive understanding of the impact of AI on automation.

POWER SUPPLY MODULE

- Universal voltage input: Compatible with 110-240Vac and 50/60Hz.
- Regulated outputs: Provides 5V and 3.3V DC simultaneously.
- Current capacity: Supports up to 2A per output.
- Overload protection: Prevents damage due to overcurrent or short circuits.
- Compact design: Easy integration into prototypes or assembled systems.
- Standard connectors: Screw terminals and pins for easy connections.
- LED indicators: Displays real-time power status.
- Energy efficiency: Reduces energy loss during conversion.
- Compatibility: Ideal for powering microcontrollers such as Arduino, NodeMCU and sensors.
- Easy mounting: Can be fixed to surfaces or educational racks.

INTERACTION AND PROCESSING SOFTWARE

- User-friendly graphical interface: Makes it easy to read sensors and write to actuators.
- Integration with Python: Allows interaction of AI models in TensorFlow directly from the software.
- Real-time processing: Collects data from sensors and transmits it quickly to AI.
- Feedback system: Receives AI outputs and translates them into commands for actuators.
- Data logging: Saves information for further analysis or training of new models.
- Scalability: Supports multiple sensors and actuators for complex systems.
- They teach how to automate processes through AI.
- They simulate practical solutions to industrial problems.
- They convert processed data into useful answers.
- They integrate theoretical learning with visible results.
- They encourage creativity in the design of intelligent systems.
- They encourage the understanding of the impact of AI on automation.



SOFTWARE APPLICATIONS

Path programming



This system allows for analyzing the behaviour of the A* algorithm, which is key to several industrial processes, such as:

- Route optimization.
- Robot movement with obstacle avoidance.

It is based on the management of Euclidean distances and is ideal for exploring intelligent algorithms.

The application operates on the server and uses technology that students will review within the scope of the lab.

Associated knowledge areas:

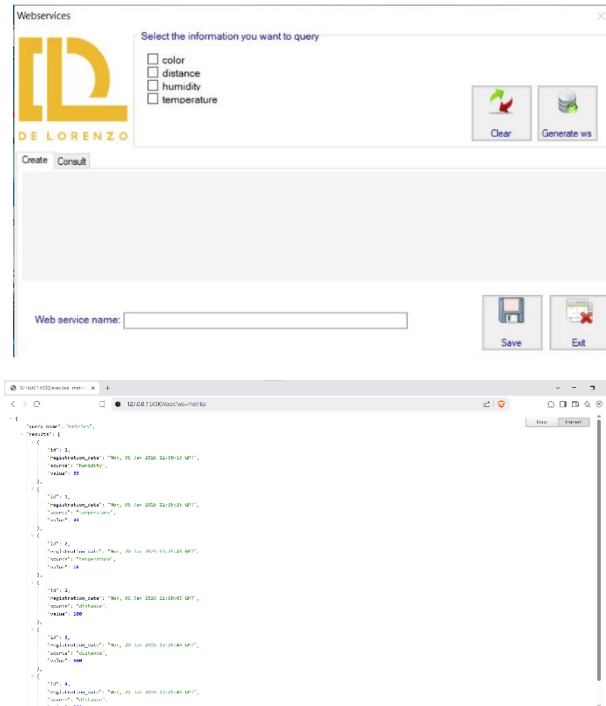
- Route planning and optimization.
- Database construction.
- Information management (SQL).

Associated practices:

- Implementation of web services in Python.
- Algorithm programming in Python.
- Communications with external systems.
- Information management and IoT storage.
- Generation of information models for AI.
- ETL (Extraction, Transformation, and Loading) from applications built in the lab.
- Implementation of web services for information exchange.



Web Server publisher



This system allows the generation of different web services to exploit the main database. It is a practical tool for exploring the extraction of information contained in a database, exemplifying what happens in a real-life industrial scenario.

Customized web services are stored in the database to be exploited whenever required.

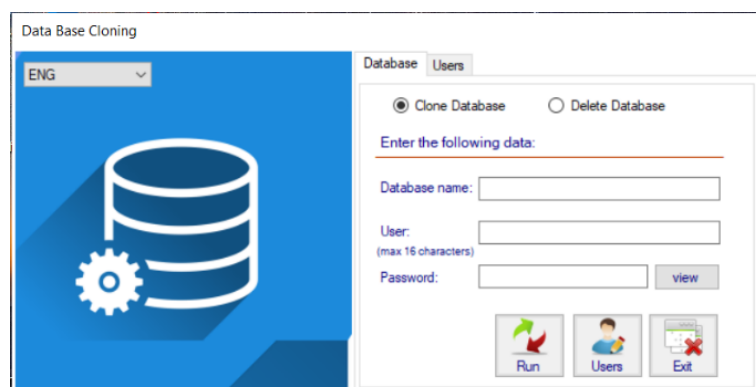
Associated knowledge areas:

- Data extraction and querying.
- Interacts with different platforms.


Associated practices:

- Information exploitation.
- Data management in JSON format.
- Development of communication interfaces for information reading (M2M).




Data Base Cloning





	<p>This system allows for the creation of copies of the main database. Students can work with the information contained therein and modify it according to their needs to execute the various experiments carried out in the laboratory. Additionally, it provides the ability to develop knowledge of database management and is also an important tool for Information Technology Engineers. This system resides on the laboratory server.</p> <p>Associated knowledge areas:</p> <ul style="list-style-type: none">• Database design,• Database construction,• Information management (SQL). <p>Associated practices:</p> <ul style="list-style-type: none">• Information management and IoT storage,• Generation of information models for AI,• ETL (Extraction, Transformation, and Loading) from applications built in the laboratory,• Implementation of Web services for information exchange.
Python	 <p>This environment allows for the development of applications using the Python programming language. Students can create custom scripts for task automation, data analysis, and interaction with sensors, actuators, or web services, depending on the requirements of each experiment conducted in the lab.</p> <p>Additionally, Python provides a powerful and versatile platform for developing skills in structured and object-oriented programming, making it an essential tool for engineers in the fields of automation, artificial intelligence, and information technology.</p> <p>This environment is installed locally and can be integrated with other lab systems.</p> <p>Associated knowledge areas:</p> <ul style="list-style-type: none">• Programming logic.• Data structures.• Object-oriented programming.• Process automation. <p>Associated practicals:</p> <ul style="list-style-type: none">• Development of scripts for data acquisition and processing.• Automation of tasks in the lab.



	<ul style="list-style-type: none">• Interaction with hardware through libraries such as pyserial, gpiozero, or RPi.GPIO.• Implementation of machine learning algorithms and data analysis using pandas, numpy, and scikitlearn.• Building applications with graphical interfaces or web servers using Flask.
TensorFlow	
MySQL	
OpenCV	

SENSORS AND ACTUATORS

The **sensor module** includes the following components:

- Ultrasonic distance sensor,
- Laser distance sensor (LiDAR),
- IMU (Inertial Measurement Unit) sensor,
- Color sensor,
- Pressure sensor,
- Light intensity sensor,



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- Humidity and temperature sensor,
- Current sensor,
- Camera sensor.

The **UDP Sensor module (Wi-Fi or IoT)** includes the following components:

- Pressure sensor,
- Light intensity sensor,
- Humidity and temperature sensor,
- Current sensor.

The **actuator module** includes the following components:

- DC motor,
- Servomotor,
- Keypad,
- RGB Led,
- Matrix Led,
- Stepper motor,
- LCD I2C,
- OLED,
- Peltier cell.

TRAINING OBJECTIVES

The final users can be able to perform the following exercises:

- Programming Anti-blocking routines (avoid information loss).
- Programming using RTOS routines.
- Use of CPU and GPU.
- PID control programming.
- Control programming using neural networks.
- Creation of data sets (taking information from web service).
- Integration of information to database for dataset generation (advanced JSON management)
- Color detection.
- Object tracking.
- Creation of filters in the camera in real time.
- Development of pathfinding and planning solution.
- Machine Learning with humidity, temperature, pressure and lighting
- Supervised learning for temperature calculation.
- Control of motor speed based on distance.



MAIN BASIC CONFIGURATION (20 students)*

- **1 x DL AI-2.0** – AI Main configuration (Hardware system, Server, Software's, and Applications) (for 3 students).
- **17 x DL AI-2.0SW.** (for 17 students)

EXAMPLES FOR OTHER CONFIGURATIONS*

If the laboratory includes less than 20 students (i.e. **15 students**), it will be necessary to have:

- **1 x DL AI-2.0.** (for 3 students)
- **12 x DL AI-2.0SW.** (for 12 students)

If it includes 30 students, it will be necessary to have:

- **2 x DL AI-2.0.** (for 6 students)
- **24 x DL AI-2.0SW.** (for 24 students)

If it includes 40 students, it will be necessary to have:

- **2 x DL AI-2.0.** (for 6 students)
- **34 x DL AI-2.0SW.** (for 34 students)

If it includes 50 students, it will be necessary to have:

- **3 x DL AI-2.0.** (for 9 students)
- **41 x DL AI-2.0SW.** (for 41 students)

If it includes 55 students, it will be necessary to have:

- **3 x DL AI-2.0.** (for 9 students)
- **46 x DL AI-2.0SW.** (for 46 students)

If it includes 60 students, it will be necessary to have:

- **3 x DL AI-2.0.** (for 9 students)
- **51 x DL AI-2.0SW.** (for 51 students)

***: even the three students who work with the HW need their own PC, and DL AI-2.0SW is a single license for the expansion of the basic hardware configuration.**