DIGITIZING PRODUCTS:
CREATING DEMONSTRATORS
FOR FUTURE EDUCATION

digi demo

Mobile Modular Platform

Demonstrator classification and documentation

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Project consortium

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Dissemination level

Code	Access granted to	
PU	Public	PU
PP	Restricted to other programme participants (including the Commission Services)	
CO	Confidential, only for members of the consortium (including the Commission Services)	

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About the DigiDemo project

Environmental challenges and digital transformation are two of the main drivers changing the world and the way business will be is done in the future. Therefore, it is essential to enable future employees to address these drivers. The skills and competences needed to develop digitalized products and awareness of the environmental challenges are therefore crucial for the European workforce and industry to continue being competitive in a future green economy and to maintain jobs across Europe.

The DigiDemo project addresses these challenges by developing demonstrators especially for higher education allowing to improve mainly mechanical engineering studies by integrating skills and competences allowing them to understand, develop and commercialise connected products. The results will be publicly available and can be used by every institution interested in integrating this type of training in their cursus.

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Revision history

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1.0	2022-05-16	Iversen	Initial draft
1.0.1	2022-08-22	Iversen	Corrected formatting errors
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Document status

Status description
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Abbreviations

ESTA	ESTA Belfort (France)
FHV	Fachhochschule Vorarlberg (Austria)
FiV	Fagskolen i Viken (Norway)
UCN	University College Nordjylland (Denmark)
UBB	Universitatea "Babes-Bolyai" din Resita (Romania)
VOC	Volatile Organic Compound
SBC	Single Board Computer
IoT	Internet of Things
WiFi	Wireless network (Wireless Fidelity)

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1 Introduction

This demonstrator focusses on creating a generic basic modular platform, that will allow work to happen independently across study programmes. It can be used as a demonstrator in mechanical design, electronics design, (embedded) programming, wireless communication and autonomous navigation and pathfinding algorithms.

The demonstrator is based on the Parallax Arlo platform [1] and uses a Raspberry Pi [2] SBC for programming and communication. It could use other small computers like a Nvidia Jetson Nano [3] instead. The Jetson could be appropriate for heavy processing purposes, as for instance with image recognition with autonomous navigation and dynamic obstacle avoidance.

Possible use cases are transporting boxes or pallets around in a warehouse or production setting. The lifting mechanism would then be using RFID, barcode reader, or similar technologies to identify payloads. Another use case would be navigation follow lines, optical navigation, or mapping with onboard camera or lidar.

2 Overview

The key properties of the focus project are:

Table 1: Specification of key properties of the focus project

Key Property	Value
EQF level	5 (Technician)
Year of study	2
Domain	Mechatronics
Objective	Hands-on
Workload	5+ ECTS (depending on setup)
Keywords	Robotics, Micro Controller Unit (MCU), Distributed Programming, Embedded Programming

The demonstrator is centred around an embedded microcontroller mounted on a standard robot platform from Parallax *(Note the complete package is discontinued from the supplier so the parts must be acquired separately and assembled)*. A custom scissor lift/table is mounted on top of robot platform and both platform and lift are controlled by a Raspberry Pi[2] single board computer (SBC). The Raspberry Pi controls two motor controllers: One as part of the Parallax platform for navigation via a serial link and another external one for the lifting mechanism.

The demonstrator is thought to be interdisciplinary from mechanics over electronics to software development.

3 Description of fulfilment of keywords/characteristics

The demonstrator will improve teaching, by showing digitalization and value-adding of a well-known object.

The demonstrator will be replicable, as most of the hardware will be based on readily available modules, and further instructions on system fitting will be provided.

The demonstrator will be interdisciplinary, covering the following fields: Production Technology AP - Mechanics of lifting mechanism. IT-technology AP – Embedded low-level hardware abstraction of sensors and motors. Computer Science AP – Autonomous navigation and pathfinding algorithms.

Table 2: Description of fulfilment of demonstrator characteristics for the focus project

Characteristic	Description
Teaching improvement	The focus project allows the students to go through the entire process of development of a mechatronic product starting with requirements, through design, implementation, test, and integration of both mechanical and electronic components with software. They work in interdisciplinary teams.
Sustainability awareness	The project covers the following UN SDGs
Replicability	The demonstrator is implemented using off the shelf components, which are easy to replicate.
Industry needs	Similar concept devices is widely used in industry.
Interdisciplinarity	The demonstrator requires both electrical and mechanical engineers to cooperate in implementing a mechatronic system. Microcontroller programming is also part of the project.

4 Classification according to the dimensions

Table 3: Classification of the focus project according to the dimensions

Dimension	Property	Value
Value chain	development	☑
	production	☑
	sales	☑
	after-sales-support	☐
	end-of-life	☐
Chain of technology	mechanical structure	☑
	sensors	☑
	electronic circuits	☑
	edge device	☑
	data transmission	☑
	cloud	☐
Sustainability	energy reduction	☐
	material reduction	☐
	better materials	☐
	better production	☑
	reparability	☐
	recycling	☐
Physicality	physical setup	☑
	simulation	☐
Degree of student freedom	demonstrated	☐
	guided	☑
	coached	☑
	autonomous	☑
Transportability	fixed	☐
	transportable	☑
	portable	☐
Costs (implementation)	EUR	1200 – 1700
Costs (operation)	EUR	NA
Workload (implementation)	Hours	10 – 30
Workload (operation)	Hours	30 – 60

Dimension	Property	Value
Size	m	< 1
Weight	kg	5 – 15
Special requests	no/yes, if yes: which	no

5 Educational information

5.1 Electronics Development

The demonstrator is to be used by students with a minimum of one semesters experience in low/mid-level programming, as well as knowledge about digital electronics. The following description assumes that Python is used for programming the Raspberry Pi 3/4 based unit. The learning goals are written based on Biggs work[4].

5.1.1 Intended Learning Outcomes

The demonstrator is thought to be used over several teaching sessions with exercises. These sessions consist of 4 modules of 45 minutes each. It is expected that the student after the demonstrator sessions session can

- Explain the workings of the UART protocol
- Read a technical datasheet and extract information
- Implement driver functions to control motors
- Use encoder feedback for precise navigation

The students are taught about UART communication and are expected to utilize the instruction set for accompanying the Parallax DHT-10 controller board in order to navigate and are then asked to solve the following exercises:

1) Assemble platform

a) Connect all components as indicated by the diagram

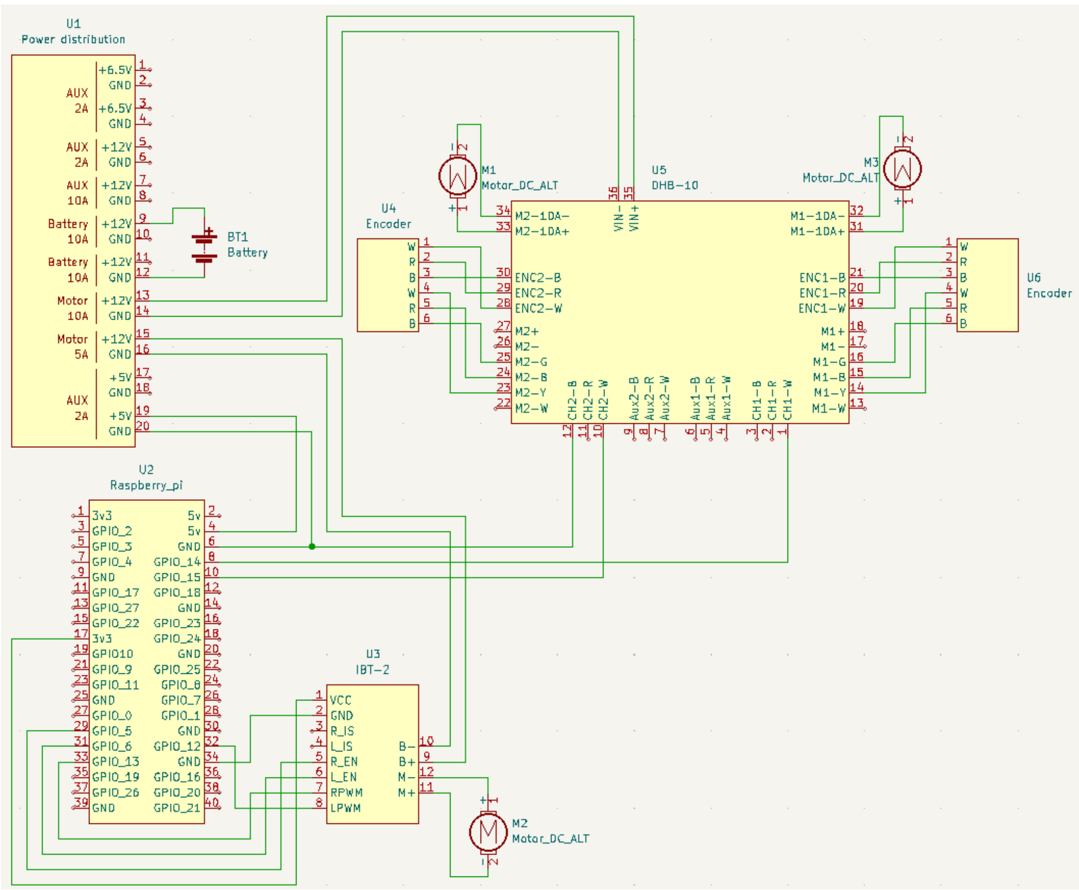

Figure 1: Electronics schematic

b) Connect the Raspberry Pi via SSH over WiFi.
c) Create a program to control the lift motor with console commands
d) Add functionality to send commands to the DHT-10 board.

5.2 Mechanical development

The demonstrator is to be used by students with a minimum of one semesters experience in mechanical mechanisms and understanding of forces in moving systems.

5.2.1 Intended Learning Outcomes

The demonstrator is thought to be used over several teaching sessions with exercises. These sessions consist of 4 modules of 45 minutes each. It is expected that the student after the demonstrator sessions can calculate forces and speed of a lifting platform, and further use these calculations to find and choose suitable machine elements (motor, gearbox, lead screw, bearings etc) to make the mechanical part of the system fully operational. It is also intended that the mechanical students will be able to specify the desired output from the motor controls and understand the use of position sensors.

5.2.2 Principle of operation

It is foreseen to use a scissor-type lifting platform. To make the lift a separate unit, ready to install on the Parallax moving platform, or any other vehicle, it will make use of both a baseplate and a topplate. The lifting force will be by electric dc-motor and a finished set of industry grade leadscrew and nut.

Most existing scissorlifts that use lead screw, has the screw placed under the top plate, or in the middle of the sax, for ergonomic reasons, when manual power is used. Since this lift will be machine operated, the lead screw and motor will be placed on the base plate. This will avoid having motor cables hanging loose to allow extension during moving.

Since this lift is intended for learning, and is expected to lift only light loads, the plates and arms can be made from metal or wood, depending on the available workshop possibilities. The hinges can be pins or even just screws.

The baseplate can be fitted with position sensors if using a dc motor, or position could be determined by using a stepper motor instead.

Picture (to be improvedlater)

Parts list:

Base plate,	MDF wood plate 200*300*9 mm
Topplate,	MDF wood plate 200*300*9 mm
Arm	Pine wood, 15*15*400 mm, 4 pieces
Stabilizer	Pine wood, 15*15*180 mm
Stabilizer	Pine wood, 15*15*160 mm
Wheel	Plastic (PP or PA) ø20*10 mm, or similar, 4 pieces
Pins for hinges	Ø 4*20 mm steel, or ~4 mm screws, 10 pieces
Lead screw	M8 trapezgevindspindel, 4x8x8 - 540mm
Nut for lead screw	M8 Trapez gevind blok med anti-slør, 4x8x8
Bushing for lead screw	M8 låsekrans
Flexible coupling motor/screw	Kopling - 8mm til 5mm Ø20
DC motor	12V - 50 RPM
Fixing bracket for DC motor	Beslag

The hardware was purchased from Martronics.dk, but is available from several suppliers

5.3 Sustainability – questions for reflection

The questions below are meant as inspiration for the teacher using the demonstrator. The aim is to strengthen the student's awareness regarding sustainability through reflecting upon questions related to the demonstrator. The questions can be used during the lecture or as the starting point for individual or group work, connected to the lecture. It is recommended that the students answer the questions in groups and the present the result of their discussion on class. The same questions can be used in all the subjects involved in the demonstrator.

The questions below are divided into three main categories, (1) general considerations, (2) recycling/reuse, and (3) product integrity, where the last two categories are addressing the specific demonstrator.

(1) General considerations

- Does the making or use of the product create pollution?
    - Looking at transportation of the components
    - Energy used during production
    - Energy used during product life (at the consumer and at the sales chain)
- Can the material and energy used to make or use this product be reduced?
    - Are there any stations for collecting the product for reuse?
- Can nature regenerate the resources used to make or use this product?
- Why would you want/need a Mobile Modular Platform?

(2) Recycling/Reuse

- What are the main materials used for the Mobile Modular Platform?
- Can all the materials be recycled – are they "pure"?
- How should the parts be connected in order to be reused?
    - Can the modularity be increased in some way?
    - Does the modularity increase the sustainability of the product?
- Can the parts of the product be disassembled and used in other products?
- Can the platform be created from recycled/disassembled other products?
- Can the product with few modifications be used in other environments/use-cases?

(3) Product integrity

- What are the key aspects to obtain a durable product, in terms of construction and material?
- Can the parts of the product be replaced with components that are more sustainable?
    - Replace the plastic with wood?
- What are they most important components to be able to maintain?
    - Can spare parts still be purchased from the manufactory or after market parts?
- Do you foresee the need to update any components in order to maintain the integrity of the product (e.g., the sensors, platforms, or motors)?
- Are there any standard interfaces that can be used in the product (e.g. a wireless interface, can it be integrated into standard robotics control interfaces)?
- Can you see further ways to increase the life quality of the product?

6 Organizational information

6.1 Electronics, software, and mechanics development

The following requirements apply

- Project duration: 4 sessions during a semester. Each session consists of 4 modules of 45 minutes per module.
- Group size: Ideally in smaller groups, depending on the number of available platforms. Groups can timeshare and run programs on it in turn.
- Prerequisites: None.

7 Description of the technology and the setup

7.1 Bill of Materials

The following table will outline the materials needed to produce the demonstrator. Note this is the equipment for one platform.

Table 4: Classification of the focus project according to the dimensions

Quantity (Unit)	Description	Price (per Unit)	Price (total)
1 pc	Raspberry Pi 4B, 4 GB	64 €/pc	64
1 pc	Black Aluminum Case for Raspberry Pi 4B	30 €/pc	30
1 pc	16 GB micro SD card	12 €/pc	12
1 pc	Arlo Complete Robot System	1000 €/pc	1000
1 pc	Motordriver	4 €/pc	4
1 pc	Adjustable platform	50 €/pc	50
1 set	Lead screw and connections	25 €/pc	25
1 pc	Motor	18 €/pc	18
			1203

Cables are not included.

8 References

[1] Parallax, “Arlo Complete Robot System - Parallax.” [Online]. Available: https://www.parallax.com/product/arlo-complete-robot-system/. [Accessed: 16-May-2022].

[2] Raspberry Pi, “Teach, learn and make with raspberry pi,” 2021. [Online]. Available: https://www.raspberrypi.org/. [Accessed: 24-Feb-2021].

[3] NVidia, “NVIDIA Jetson Nano Developer Kit | NVIDIA Developer.” [Online]. Available: https://developer.nvidia.com/embedded/jetson-nano-developer-kit. [Accessed: 16-May-2022].

[4] John Biggs and C. Tang, *Teaching for Quality Learning at University*, 3rd ed. McGraw-Hill/Society for Research into Higher Education & Open University Press, 2007.

