DIGITIZING PRODUCTS:
CREATING DEMONSTRATORS
FOR FUTURE EDUCATION

Liquid Monitoring Demonstrator

Demonstrator classification and documentation

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Project consortium

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)	

Legal Disclaimer

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.

1 Contents

Document authors

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Revision history

Version	Date	Author(s)	Description
1.0	2023-03-08	Horatiu O. Pilsan	Initial draft
1.1	2023-04-04	Robert Amann	Added educational information and did some minor corrections
1.2	2023-05-31	Horatiu O. Pilsan	Added CAD files and photos to documentation and its overview

Document status

Status description
Final Version

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)
RFID	Radio Frequency Identification

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1 Introduction

This demonstrator was set up by an incoming student as his final bachelor project. It was initiated by the Research Center for User-centered Technologies of FHV – Vorarlberg University of Applied Sciences. The research center has several research projects with nursing houses in the area and the demonstrator reflects the need to monitor the liquid intake of elderly people to avoid dehydration.

2 Overview

The key properties of the lift project are:

Table 1: Specification of key properties of the liquid monitoring project

Key Property	Value
EQF level	6 (Bachelor)
Year of study	3
Domain	Mechatronics and IoT
Objective	Hands-on
Workload	4-8 hours
Keywords	RFID, Raspberry Pi, programming, electronics, data encryption, sensors

The figure below gives an overview of the mode of operation of the demonstrator based on the data flow:

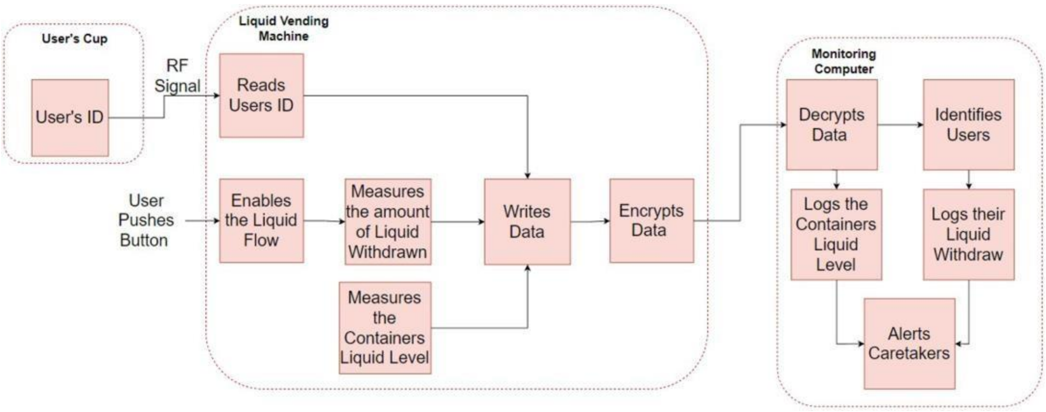

Figure 1: Data flow diagram of the demonstrator

The steps are the following:

- The user that has placed their cup in the demonstrator is identified via RFID tag.
- The demonstrator awaits the button to be pressed to enable liquid flow and to measure the amount withdrawn.
- The container's level is measured to avoid lack of liquid.
- Data is stored, encrypted, and transmitted to the monitoring computer.
- The monitoring compute decrypts data and logs both the container's liquid level and the user's liquid consumption.
- If needed an alarm is issued.

The figure below gives an overview of structure of the demonstrator and its main components:

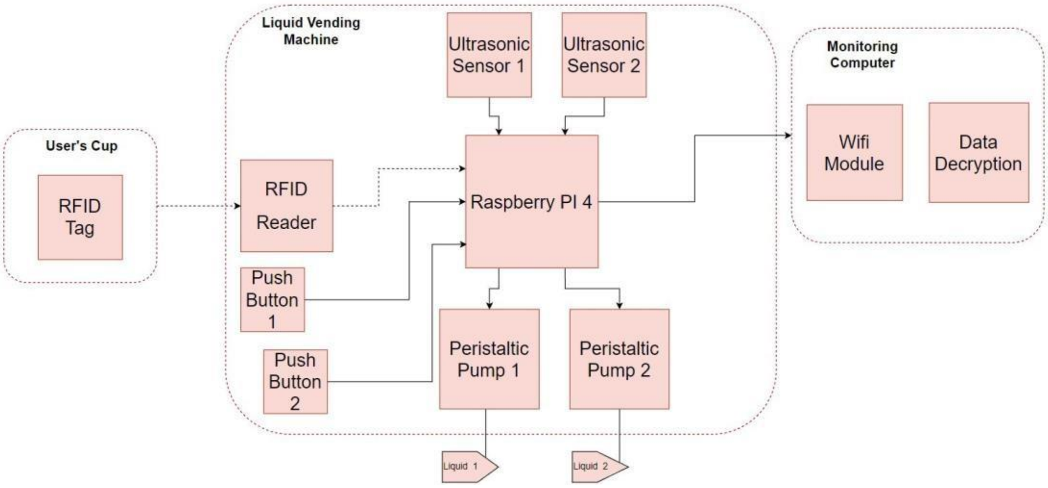

Figure 2: Structure diagram of the demonstrator

As can be seen in the figure above the demonstrator consists of three main subsystems: the user's cup, the liquid dispensing machine, and the monitoring computer. The description of the components is given below.

2.1. The user's cup

The first subsystem is the simplest and smallest. It starts from the fact that each user will have a cup with its own unique radio frequency identifier (RFID).
As can be seen in the figure above, this vessel is the first element that must be present for the system to execute an iteration.

2.2. Liquid dispensing machine

This second subsystem is the largest of the three. Most of this project revolves around this subsystem because it is made up of all the electronic components that can be seen in the figure above.

The behavior of this subsystem is given in the flowchart diagram below.

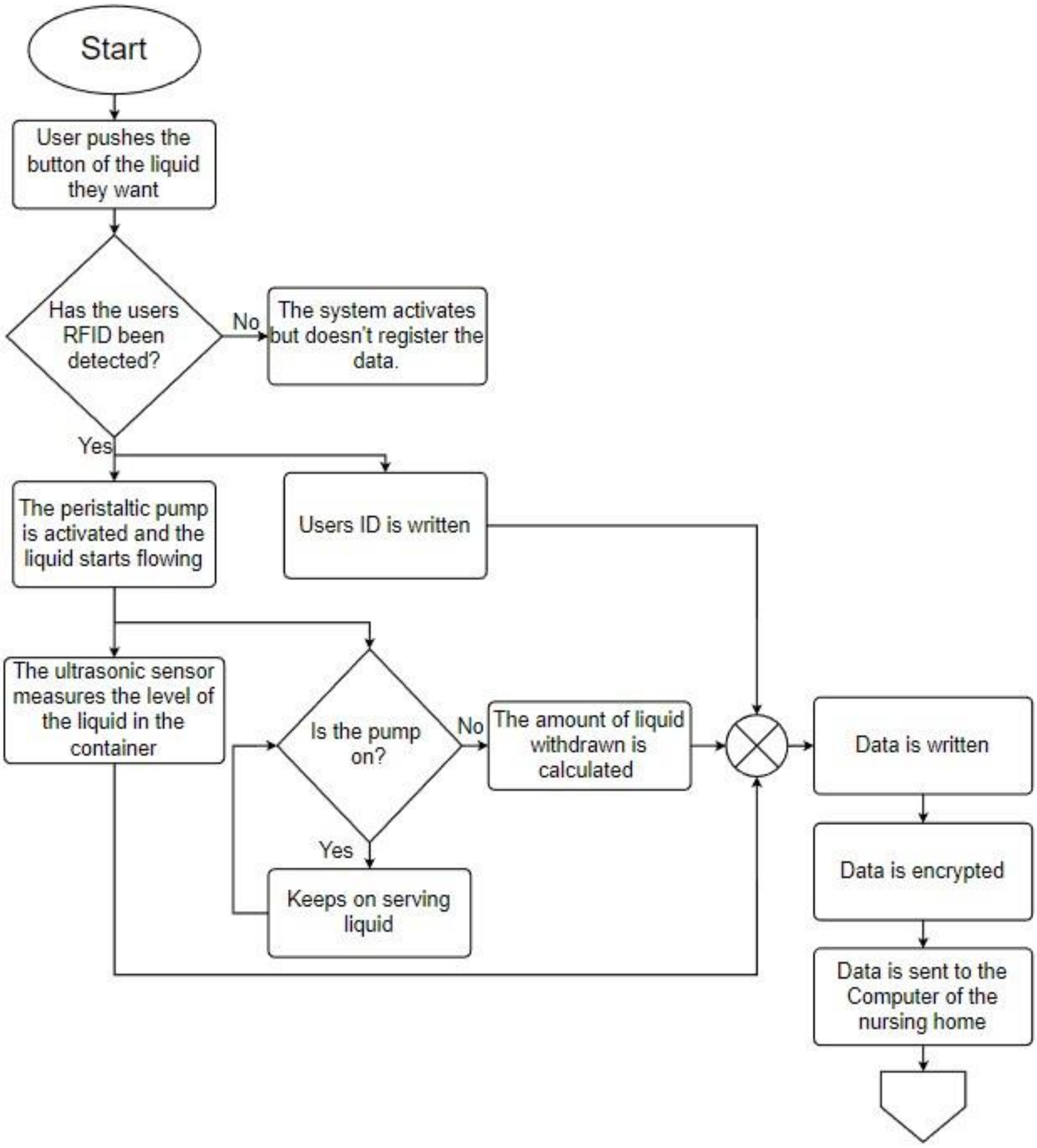

Figure 3: Flowchart diagram of the liquid dispensing software

The liquid dispensing machine has two inputs, the radio frequency signal carried by the user's cup which is picked up by the RF reader and the user-operated buttons where the user chooses which liquid to dispense.

Once the RF reader captures the signal, it is sent to the Raspberry Pi where the data is processed and identifies the user wearing the cup. When the button is actuated, an electrical signal is sent to the Raspberry Pi and then the microprocessor actuates the peristaltic pump and counts the amount of time the pump is active. Once the amount of time the pump was active is determined, it is possible to know how much liquid was extracted from the system. In parallel, an ultrasonic sensor measurement is performed on the liquid containers in order to determine the level of the contents of each one.

Once the data of the user's identity, the amount of liquid subtracted from the system and the level of the liquid inside the container are available, the data is encrypted by means of a coded program inside the Raspberry Pi and then the data is sent through the Wi-Fi module to the last subsystem.

2.3. Monitoring computer

The third and final subsystem is the monitoring computer. This subsystem receives the data sent from the second subsystem and decrypts it. Once the information has been decrypted, the program proceeds to identify and read the amount of liquid it extracted from the machine. This data will be written to the database as shown in the figure below.

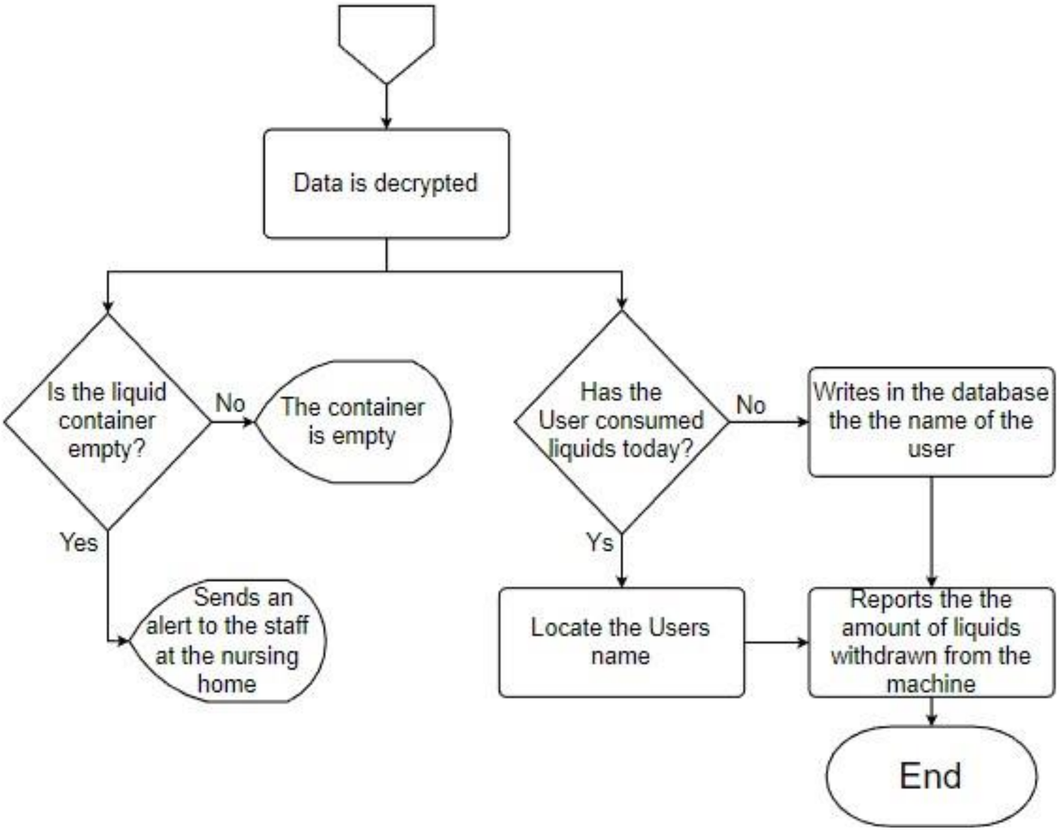

Figure 4: Flowchart diagram of the staff computer software

Another piece of data that is of interest to the system is the level of liquid in the container. If the liquid container is found to be low, the program will send an alert to warn the staff that it needs to be refilled.

The monitoring computer also needs to track the amount of liquid different people have consumed over a given time span and alert the staff if anomalies are observed. This software is out of the scope of the demonstrator.

3 Description of fulfilment of characteristics

The demonstrator fulfils the characteristics required as follows:

Table 2: Description of fulfilment of demonstrator characteristics

Characteristic	Description
Teaching improvement	The lift demonstrator allows the students to understand the concepts of mechatronic systems with cloud coupling in the context of a mechatronic system used in nursing.
Sustainability awareness	Besides technical sustainability issues (energy, materials, reparability, recycling) the students get acquainted to other sustainability goals due to the application domain of the system.
Replicability	The demonstrator is implemented using off the shelf components, which are easy to replicate.
Industry needs	This demonstrator does not follow industry needs, but general society needs usually explicitly problematic in nursing houses with elderly people.
Interdisciplinarity	This demonstrator includes different disciplines related to mechatronics (liquid mechanics, electronics, software) and to IoT (networking, security), but is also related, due to its application are to a completely different world: nursing.

4 Classification according to the dimensions

The demonstrator can be classified according to the dimension as follows:

Table 3: Classification of the liquid monitoring 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	400
Costs (operation)	EUR	0
Workload (implementation)*	Hours	100

Dimension	Property	Value
Workload (operation)*	Hours	4
Size	m	0.4 x 0.3 x 0.5
Weight	kg	1
Special requests	no/yes, if yes: which	no

* The workload refers to the effort needed by the teacher for implementation and operation of the demonstrator. As for the workload of the students please refer to chapter 5.

5 Educational information

5.1 Learning Goals

Mechanical structure: construction of cup with RFiD tag, mechanical design of liquid vending machine:

- Students know design principles for constructing ergonomic devices.

Sensors: level measurement with ultrasonic distance sensor

- Students understand the concept of ultrasonic distance measurement.
- Students can use analog-digital signal conversion.

Actuators: digital peristatic pump

- Students know the function principle of peristatic pumps.
- Students can use PPM signals for controlling actuators.

Edge device: Raspberry Pi 4

- Students can setup and use communication protocols (TCP/IP, MQTT, …).
- Students can use data encryption for data transmission.

Programming: liquid vending machine, monitoring computer

- Students can program a Python program according to a given specification.
- Students can use simple database systems.

5.2 Typical Task Description

A typical task description could be:

Implement and test a program for the Raspberry Pi which observes following specification:

- Read the signals from the RFID reader.
- Identify the user.
- When the button is actuated, activate the pump.
- Measure the amount of liquid while the pump is active.
- Measure the level using the ultrasonic sensor and stop the pump when the cup is full.

In this task description, it is assumed that the rest of the program which includes data transmission to the monitoring computer is given.

5.3 Literature

Mark Lutz (2003). Learning Python (2nd. ed.). O'Reilly & Associates, Inc., USA.

5.4 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 suggested that the students in groups answer the questions and then present the result of the discussion on class.

The questions below are divided into three main categories, general considerations, recycling, and product integrity, where the last two categories are addressing this specific demonstrator.

General considerations

- Which SDG (Sustainable Development Goal) does the demonstrator primary address?
- Does the making or use of the product create pollution?
- How can the energy consumption of the demonstrator be reduced?
- How can the material consumption needed for the demonstrator be reduced?

Recycling

- Can the demonstrator, or parts of it be recycled?
- Can all the materials be recycled – are they "pure" or do they need special treatment?
- How can the recycling of the demonstrator or its parts be improved?

Product integrity

- Which parts of the demonstrator need maintenance?
- Can parts which should be maintained be easily disassembled from the demonstrator?
- Can an update of components (which?) be foreseen to enlengthen its lifespan?
- Is the software of the demonstrator easy to update?

6 Organizational information

For the organization of the project the following apply:

- Project duration: approx. 50 hours
- Team size: 2 students.
- Preparatory and follow-up activities. No special activities are needed.

7 Description of the technology and the setup

7.1 Demonstrator Documentation

The overview of the files supplied together with this description of the demonstrator is given below. It includes all files (e.g. CAD files, electrical drawings) needed to replicate the demonstrator.

File Structure:	**Liquid Monitoring**		
	Filename/Folder	Comment	Software
00_Notes			
	FileStructure.xlsx	Description of the files = this document	
	Price_Calculation.xlsx		
01_Pictures			
	Smart_Liquid_CAD.png	CAD drawing	
	Smart_Liquid_Photo.jpg	High resolution photo	
	Smart_Liquid_Photo_small.jpg	Low resolution pfoto	
10_Documents			
20_ExportImport			
30_AdditionalEquipment			
	Peristatic_pump_3161982.pdf	Datasheet of the peristatic pump	
	raspberry-pi-4-reduced-schematics.pdf	Schematic of the Raspberry Pi 4B	
	RFiD_Tag_Web.pdf	Datasheet of the RFID tag for the user's cup	
	RFID_vma405_a4v03.pdf	Datasheet of the amplifier RFID reader and writer module	
	rpi_DATA_2711_1p0_preliminary.pdf	Datasheet of the Raspberry Pi 4B	
	Ultrasonic_sensor_3942_Web.pdf	Datasheet of the ultrasonic sensor	
40_Simulation			
50_CAD			
	Several files of the mechanical structure of the setup. The top file is:	ASS_SmartLiquidFountains_by_Ian_Coberly.prt	
60_ElectricalLayouts			
	BD5lvl.jpg	Schematic and layout of the demonstrator	
70_Programming			
	Alarm_Clock.py	Source: timer	
	Data_Encription.py	Source: encription	
	Gravity_Pump.py	Source: pump	
	mainv1.py	Source: main file	
	PushButton.py	Source: button	
	read.py	Source: read function	
	Timer.py	Spurce: timer	
	Ultrasonic_Distance.py	Source: sensor	
	write.py	Source: write function	

Figure 5: File overview of the liquid monitoring project documentation

7.2 Price Calculation

Details of the price calculation can be found in the table below:

Table 4: Price calculation of the liquid monitoring demonstrator

Quantity (Unit)		Description	Price (per Unit)		Price (total)
3	pc	Gravity Digital Peristaltic Pump	€ 35,00	€/pc	€ 105,00
1	pc	RFID Reader/Writer	€ 20,00	€/pc	€ 20,00
2	pc	UHF RFID TAGS	€ 4,00	€/pc	€ 8,00
1	pc	Raspberry Pi	€ 200,00	€/pc	€ 200,00
2	pc	Ultrasonic Sensor	€ 4,00	€/pc	€ 8,00
1	pc	Small material	€ 59,00	€/pc	€ 59,00
					400,00

References