EU-JAPAN VIRTUAL COACH FOR SMART AGEING

D4.8 Coaching devices for the different use cases (Final Version)

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Disclaimer

E-VITA – European-Japanese Virtual Coach for Smart Ageing

E-VITA (EU PROJECT NUMBER 101016453)

WP4 – Standards, Norms & Interoperability

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Executive Summary

This deliverable is the updated version on the previous D4.7 and provides the final overview of the coaching devices that are used in the e-VITA project. The available hardware and capabilities of coaching devices are presented.

In total, six types of coaching devices are presented: Android robots, NAO robot, Gatebox, Google Nest, Daruma-TO-4 and CelesTE. While NAO, Gatebox and Google Nest are commercially available products, Daruma-TO and CelesTE are newly developed devices in the e-VITA project. The android robots are pre-existing research prototypes that are investigated inside the e-VITA project.

The hardware of all coaching devices allows for conversation-based interactions. Beyond this, the different devices have an individual focus and additional modalities. For example, the NAO robot can use the expressivity of human-like extremities. The Daruma-TO and CelesTE are equipped with an integrated printer to offer tangible handouts. The Gatebox can display a 3D character to bond with, while Google Nest devices are smart speakers that may or may not have a built-in display. The Android mimics the facial expression and appearance of a human.

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Acronyms and Abbreviations

Acronym/Abbreviation	Explanation
TTS	Text-to-Speech
STT	Speech-to-Text
POC	Proof of Concept
RGB	Red, Green, Blue
SDK	Software development kit
LED	Light-emitting diode
API	Application Programming interface
NLP	Natural Language Processing
AI	Artificial intelligence
GB	Gatebox
3D	Three Dimensional.
Fps	Frame per Second
ASR	Automatic Speech Recognition

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1 Introduction

This deliverable will describe all the coaching devices used for interacting with users, including the existing devices, which are Android, Gatebox, NAO, Google Nest, and newly developed devices which are DarumaTO-3 and CelesTE.

All available devices will not be employed as they are but rather integrated with sensors, physically (for instance, adding sensing parts to a robot) and at a level of communication within the system. Furthermore, each device will include a different set of capabilities, which should match with form, as correspondence to a user's expectations of a device is a key to successful interactions.

The deliverable is organized into 4 chapters, including the introduction and conclusion. In chapter 2, the existing devices Android, Gatebox, NAO, and Google Nest will be introduced. In chapter 3, the newly developed devices, DarumaTO-3 and CelesTE, will be described in detail to provide a straightforward understanding of all devices.

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2 Existing Devices

2.1 Android Robot

2.1.1 Hardware

An android robot is a kind of social robot system which interacts with human for virtual coaching. The appearance of an android highly resembles human. In this project, we utilize two types of androids, Actroid-F (Kokoro Company Ltd.) and Android ST (A-Lab Co., Ltd.) as shown in Figure 1Figure 5. Gatebox Device. Figure 5. Gatebox DeviceFigure 5. Gatebox DeviceFigure 5. Gatebox DeviceFigure 5. Gatebox DeviceThe size of the body is the same as a human, and the weight is approximately 30kg. The face is made of soft silicon rubber by taking a copy from a real human face. The Figure 5. Gatebox DeviceFigure 5. Gatebox DeviceDoFs (degrees of freedom) of each robot is shown in Table 1 and Table 2Figure 5. Gatebox Device. Actroid-F has 18 DoFs and Android ST has 12 DoFs mainly in the upper bodies, which are all driven by a linear or cylindrical pneumatic actuators.

Figure 1. Android robots: Actroid-F (left) and Android ST (right)

More than half of these DoFs are located in the face to control various facial expressions like blinking, smiling, lifting eyebrows or looking sad, surprised or angry. In addition, the neck can move, that enables the robot to nod, shake her head or do inclining motions. Furthermore, it has actuators for bending in the waist, and for breathing at the shoulder. As Android ST has more DoFs, it has higher performance in showing the facial expressions and gestures. The limbs (i.e. arms and legs) of both robots are not movable. All of the DoFs are position-controlled with air servoing. The use of air actuators allows silent and robust motions without heating problems and besides only needs annual maintenance. The

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compressed air is supplied by an external air compressor. The air valves are all installed inside the body. The system runs with a 100-220V power supply. Both robots had a female appearance. The appearance can be changed to male but is stayed as female to have some comparability between both study settings. The android robots set up in the living-lab environments in Siegen University and in Tohoku University for the sub-study is shown in Figure 2.

Table 1. Overview and DoF of Actroid-F

Eyebrows (up/down, knit)	2
Eyelids (open/close)	1
Eyeballs (pan/tilt)	2
Mouth (open/close)	1
Corner of mouth (raise)	1
Head (turn, nod, lean)	3
Breath	1
Waist (bow)	1
Total	12

Table 2. Overview and DoF of Android ST

Eyebrows (up/down, knit)	2
Eyelids (open/close)	2
Eyeballs (pan/tilt)	3
Mouth (open/close)	3
Corner of mouth (raise)	1
Head (turn, nod, lean)	4
Breath	1
Waist (bow, turn)	2
Total	18

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Figure 2. Android robots in the living-lab environments in Siegen University (1 and 2) and in Tohoku University (3 and 4)

2.1.2 Software

Figure 3 illustrates the overview of the system configuration to control an android robot. A software module to control an android is running on a PC (server) connected to the robot via USB cable. It receives motion and speech commands from external computers (clients) with a UDP socket interface. In the android sub-study, the robot is controlled based on the dialogue management system on e-VITA platform, or is tele-operated by human operator with Wizard-of-Oz interface.

In the former case, speech of the user is recorded by the microphone and sent to the cloud-based speech recognizer for speech recognition. Then the response of the robot (speech, facial expressions, and gestures) to the user is generated in the dialogue system on e-VITA platform and sent to the controller by way of e-VITA interface PC.

In the latter case, the android robot is controlled by way of Wizard-of-Oz interface displayed on a browser on a screen.Figure 5. Gatebox Device The interface is controlled by the researchers behind the participants and is designed to trigger different topics of conversation. It therefore has several buttons that include predefined questions and answers of the robot. Additionally, a text-to-speech field is available that allows the researchers to include short speech sequences. The interface also allows to control parts of the body movement of the robot, it enables us to make the robot express emotions like happiness or sadness or to nod its head or to bow its upper body towards the participants. The design

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of the interface can be easily changed depending on the experimental scenarios. Figure 4 shows an example of Wizard-of-Oz interface designed for demonstration.

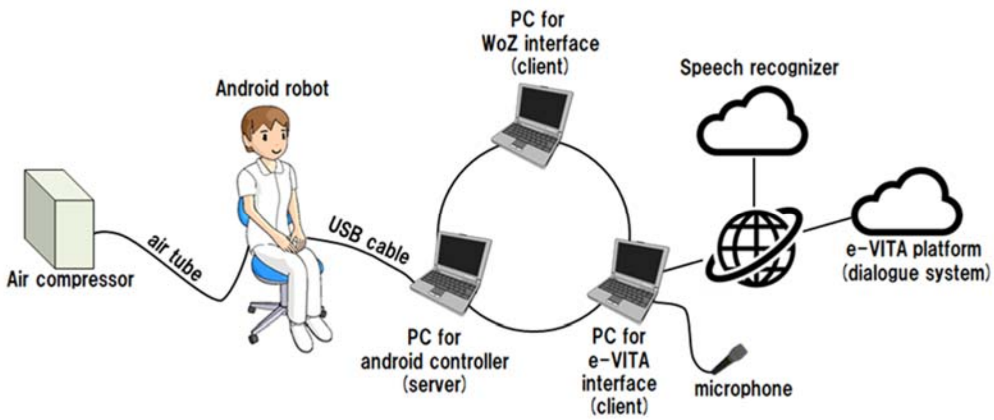

Figure 3. Android System overview

Figure 4. An example of Wizard-of-Oz interfaceFigure 5. Gatebox Device

2.2 Gatebox

The Gatebox is a communication device for interacting with virtual characters (see Figure 5). A virtual character can talk to end-users as affectionately as a real human, using projection technology and an array of sensors, such as worry, relax, snuggle up, and talk from the character. By creating a character app on the Gatebox platform, users can create a customer engagement solution. Gatebox creates a virtual character lifestyle. Professionals can create the app with virtual characters such as an administrative assistant, concierge, hotel clerk, attendant, sales assistant, receptionist, and sitter. Gatebox was founded in 2014 with the vision of "Living with Characters". The most recent Gatebox mass production model was introduced in October 2019. The Gatebox provides a virtual alternative to physically instantiated coaches in the e-VITA project (e.g., such as the NAO robot). The virtual, but visually present character inside the Gatebox takes on the role of a coach to encourage older adults to do certain activities. Thus, the device itself functions as a display for a fully virtual coach (seeFigure 5. Gatebox Device Figure 5).

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The character inside the Gatebox, like robots, provides a quasi-social relationship to the user, which is expected to support adherence to coaching content. When compared to existing coaching technologies such as wearables and mobile apps, the virtual coach relies on relational qualities rather than quantified experiences as a source of motivation. This can have both positive and negative consequences (for example, social bonding) (e.g., over trust, social pressure). Even though 3D characters are more common than robots, the Gatebox could provide a more familiar coach. Character animations could be used to demonstrate physical exercises or to enhance the expressiveness of the virtual coach. While the available character (i.e., Hikari) provides a very polished experience, the fittingness in other cultural areas should be investigated. The Gatebox includes an API for creating new characters.

2.2.1 Hardware

Figure 5. Gatebox Device

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Gatebox is equipped with a number of sensors, including a motion sensor, a heat sensor, a camera, and a microphone. The virtual character can detect whether people are approaching or moving away using the motion sensor. If you have your own computer vision APIs, you can use the Gatebox camera to create applications with personalized virtual characters. You can communicate with characters by connecting chatbots and AI to the server-side of the character app.

2.2.2 Overview of system architecture to make AI character

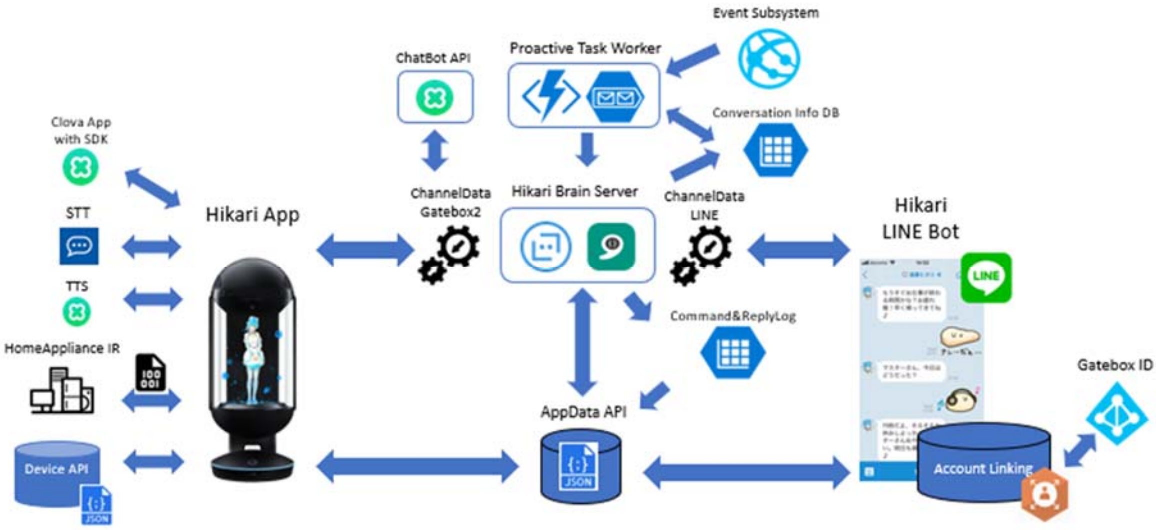

Figure 6. Gatebox System Overview

Figure 6 provides an overview of the current Gatebox system. While the Gatebox already has its own STT, TTS, and backend for the Hikari Character (Hikari Brain Server). It can also be used by a Line Chatbot to supplement communication with the character. It is necessary to investigate whether and how existing components can be used in e-VITA. The software components may need to be tweaked in order to work with the e-VITA architecture. The STT and NLP in e-VITA must support multiple domains in multiple languages (Germany, Italy, French, Japanese). The backend must also utilize e-VITA coaching content (e.g., knowledge graphs). Wizard-of-Oz solutions can be utilized as a starting point to investigate various Gatebox contents (e.g., via Gatebox Video). "AZUMA Hikari" is an AI created by Gatebox Inc. She is referred to as a family and has human-like communication skills. A set of sensors in the Gatebox, APIs for utilizing them, and other cloud and AI services are used to achieve "Hikari."

"AZUMA Hikari" is an AI created by Gatebox Inc. She is referred to as a family and has human-like communication skills. A set of sensors in the Gatebox, APIs for utilizing them, and other cloud and AI services are used to achieve "Hikari." Particularly, the following services are active while the user converses with "Hikari" and gets her responses: the main program determines actions, a chatbot determines the contents of responses, STT is used to realize conversations, an AI engine analyzes the content of discussions, a chatbot determines the contents of responses, and a completely new and original TTS synthesized voice creates an appealing voice.

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Figure 7. Gatebox Illustration - Living with someone instead of human beings

In addition to the Hikari character for the Japanese target group, two more characters have been designed for European users for the first wave. The first roll-out concentrated on user-robot interaction rather than user-Character interaction. For the second wave, ten characters were presented to all participants who had either used the Gatebox or wished to have one to express their feelings about various characters. Two Character out of ten which had more rate by the user has been chosen to be develop for the second roll-out phase.

2.3 NAO 5&6

Nao is a humanoid robot developed by Aldebaran robotics (see Figure 8). It is commonly used in many social robot applications to enable spoken interaction with animated gesturing. The mass production of Nao began in 2009 by Aldebaran and continued by Softbank in 2015. In the last decade, from 2010 to 2020, Nao has been globally researched as a humanoid robot in various fields of application (Amirova, et al. 2021). The use of humanoid robots in elderly care and healthcare is a popular narrative. Gesturing and speech are considered powerful tools for healthcare advocacy. The added value is often seen in tailoring to personalized needs, efficiency, and interconnectedness. NAO represents the typified socially assistive robot in that its assistive function (e.g., coaching) is amplified by social bonding. In e-VITA the social element is used in combination with a directed coaching service and takes on a complementary role to human coaches.

NAO is 58 cm in height and weighs 5.6 kg. It has a human shaped body that can simulate human activities, such as walking, sitting, and laying down on the ground. To enable such humanlike movements the robot has extremities with 25 degrees of freedom, of which 5 for each leg, 1 for the waist, 4 for each arm, 1 for each hand, and 2 for the head (SoftBank Robotics 2022). There are a total of seven touch sensors on the robot's body for some interaction and four sonar sensors to detect the object in front of it. At the head of the robot, two cameras and speakers plus four microphones are located. This voice interaction on the robots enables itself to communicate with humans in 20 different languages. Verbal and non-verbal communication are among the most studied interactions with users. However, the expressivity is limited to body posture and acoustic utterances. NAO can also recognize

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human emotions through speech cues and facial expressions. However, the human-likeness tends to raise expectations that cannot be fulfilled by the actual experience (Jokinen and Wilcock 2017).

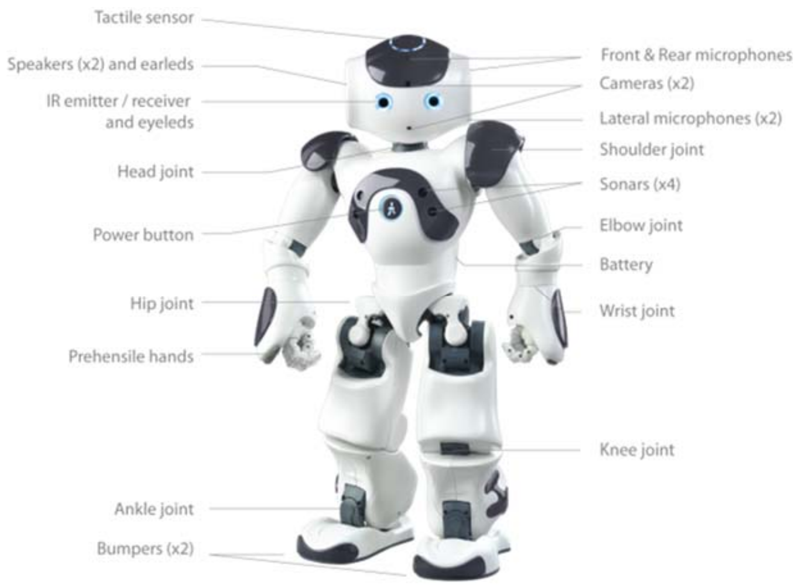

Figure 8. Nao Robot Schematics

2.3.1 Hardware

The coaching devices in e-VITA need to process voice data to engage in dialogue with the user. ASR and all subsequent processes depend highly on the quality of voice data. Therefore, coaching devices should be equipped with a microphone that can capture the end-users voice even in domestic settings. The NAO robot comes equipped with four omnidirectional microphones located at the head of the robot (see Figure 9). NAO has four microphones enable the robot to localize the source of sound based on the time-delayed arrival of sound waves.

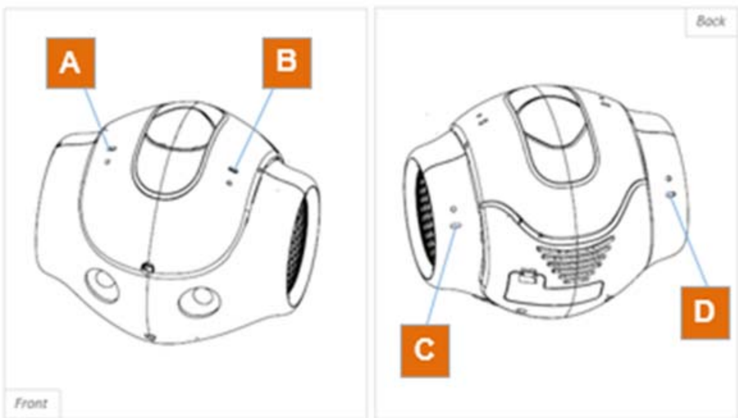

Figure 9. Location of NAO Microphones

In addition, NAO comes equipped with two identical video cameras that provide a resolution of up to 2560x1920 at one frame per second (fps) or 640x480 at 30 fps (see Figure 10).

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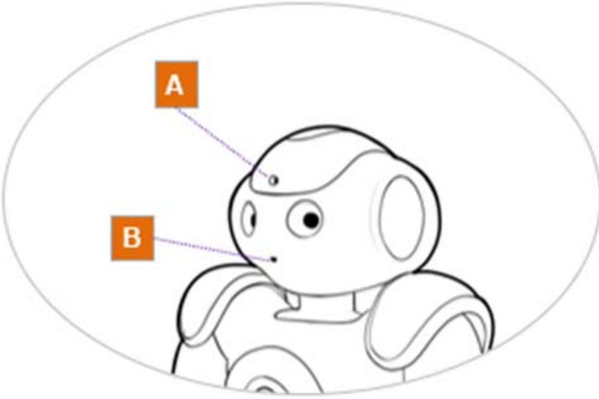
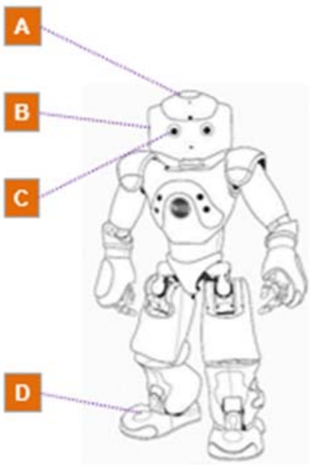


Figure 10. NAO camera location

The audio and video streams of cameras and microphones need to be processed to produce an appropriate response for the robot. In the e-VITA architecture, audio/video streams are collected by the Media Manager (see Deliverable 7.1). For example, the recorded speech from the NAO microphones can be used to recognize the emotions of the user who interacts with the device.
Apart from speech, NAO has two important possibilities to express itself non-verbally (see Figure 11). There are LEDs located on the head of the device that underlines its expression. For example, the eyes can light up in RGB colors. Next to the lights, movement is an important means of expressivity for the NAO robot. Given its bipedal and human-like shape, it can mimic human postures that are associated with emotional expression.



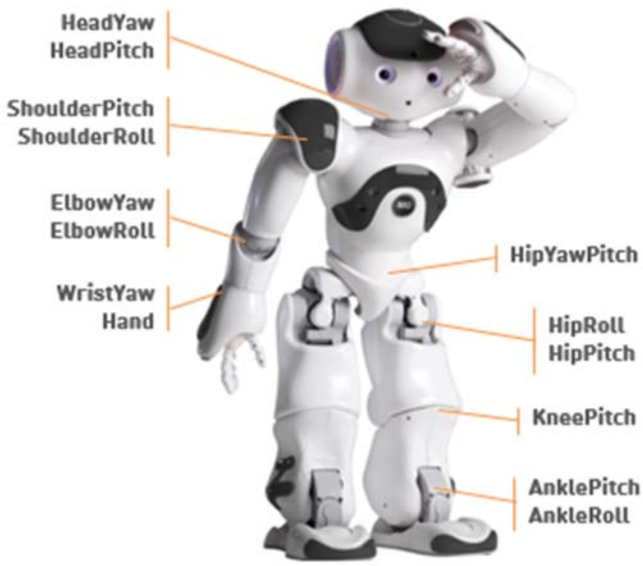


Figure 11. NAO expressive possibilities a) LEDs b) Actuators

Overall, NAO is a well-researched robot. It is commercially available but instead targeted at researchers than consumers. Consequently, it is frequently used in labs but rarely in domestic environments. Therefore, the reliability of hardware and software components in uncontrolled settings is an important challenge for the e-VITA project.

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2.3.2 Software

NAO's pre-installed basic channel program provides basic awareness and brief dialog topics. In addition, it has a middleware framework which is called NAOqi. NAOqi allows users to access sensors and resources and sends commands and functions to control the robot via SDK in parallel and sequentially. The NAOqi executes by an object on the robot called broker. This broker has a list of modules which has a list of methods of itself. This broker has two main tasks to enable users to access a module's methods and allows users to find and call them outside of the process.

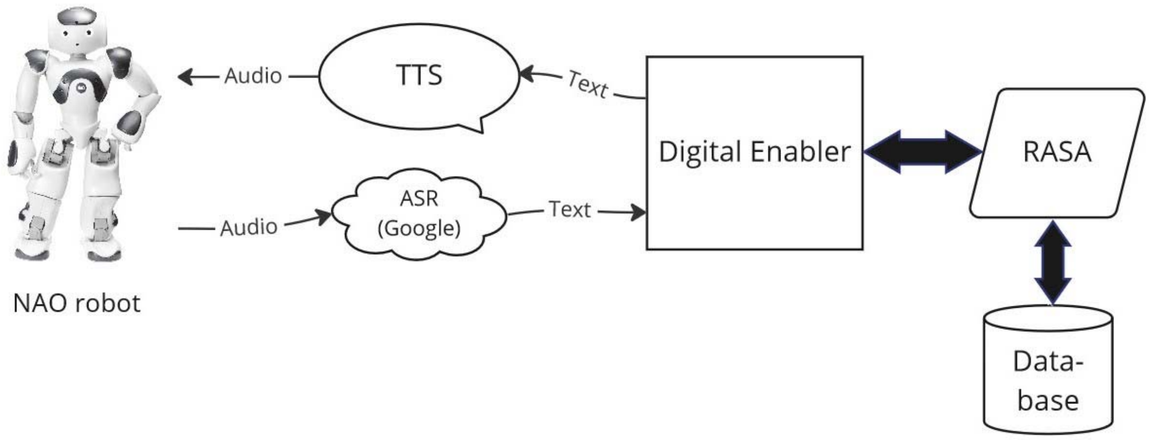

Figure 12. System architecture for the dialogue model integration

E-VITA architecture aims to enable NAO to act autonomously in the users' homes. Since the first wave, the devices have run on the e-VITA architecture, using respective TTS and ASR solutions and the dedicated content (Figure 12). Since then, several features have been added to the NAO. Due to the need for more feedback from the device, a new feature was added to the Nao in which the robot repeats what it understood from users. Emotion detection was one of the features added to the Digital-Enabler framework. NAO sends the audio file to the server, and AI on the server side detects the user's emotion for further reaction. The latest development for the NAO is the notification system. NAO regularly checks in the Digital Enabler framework for any update related to the user. When the update exists, the NAO device reads the message and informs the user. With that, the NAO robot increases users' awareness regarding their well-being, recommended activities, and exercises.

2.4 Google Nest

Task 4.4 was responsible for the final selection of the 4th device for the POC study. After brainstorming with the content group, it was decided to proceed with a smart speaker as the 4th coaching device, so market research was carried out. After analyzing costs, device characteristics, connectivity, API availability, type of vocal assistant, the choice fell on the use of the Google Nest Hub 2nd generation (device with screen) and Google Nest Mini 2nd generation (without screen). Regarding the privacy aspects, Google is explicitly following the role of Data Processor of the GDPR.

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Figure 13. Google devices to integrate within e-VITA platform

Table 3. Google Nest Mini Technical Specifications

Google Nest Mini - Technical Specifications	
Dimensions & weight	Dimensions Diameter: 98 mm (3.85") Height: 42 mm (1.65") Power cable: 1.5 m Weight Device: 177-183 g
Connectivity	802.11b/g/n/ac (2.4 GHz/5 GHz) Wi-Fi Bluetooth® 5.0 Chromecast built-in
Power and ports	Power 15 W power adaptor Ports DC power jack

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Speakers and mics	**Speakers** Google Assistant built-in 360-degree sound with 40 mm driver **Mics** 3 far-field microphones Voice Match technology
Sensors	Capacitive touch controls 3 far-field microphones
Processor	Quad-core 64-bit ARM CPU 1.4 GHz High-performance ML hardware engine
Supported operating systems for the Google Home app	Android • iOS

Table 4. Google Nest Hub Technical Specifications

Google Nest Hub - Technical Specifications	
Dimensions & weight	**Dimensions** Height: 120.4 mm (4.7 in) Width: 177.4 mm (7 in) Depth: 69.5 mm (2.7 in) Power cable: 1.5 m (59 in) **Weight** 558 g (19.68 oz)
Display	7-inch touchscreen (1024 x 600)
Connectivity	Wi-Fi · Bluetooth ·Thread
Power & ports	**Ports** DC power jack **Power** 15 W power adaptor
Speakers and mics	**Speaker**

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	Full-range speaker with 43.5 mm (1.7 in) driver Mics 3 far-field microphones Mic off switch
Technology	Google Assistant built in Voice Match technology Ultrasound sensing
Sensors	Soli sensor for Motion Sense Ambient EQ light sensor Temperature sensor
Processor	ARM CPU with ML hardware engine
Languages	Language support

Google Nest Mini and Google Nest Hub are Google devices whose integration will be available in the next release of the e-VITA platform. They are devices with which the user can interact with voice commands. The interaction that takes place is between the user and the Google Assistant integrated within the device. The current integration provides the forwarding of requests made by the user to Rasa, the Dialogue Manager of e-VITA.

This integration is achieved through an extension based on the Google Assistant SDK by implementing a new Google Assistant action and also with a specific REST API within the e-VITA Manager component. The user, after starting a communication with the Google Assistant, will be asked to log in the e-VITA platform with his own e-VITA credentials and then he will be able to interact with Rasa Dialogue Manager of the e-VITA platform by making a vocal request and receiving the response.

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3 Newly Developed Devices

3.1 DarumaTO

DarumaTO (Daruma Theomorphic Operator) (see Figure 14) is a series of prototypes of robots resembling a Daruma (達磨) doll. With its familiar appearance to older generations of Japan and China, DarumaTO is intended to serve as a social robot that provides company and monitors health of elderly people - a critical need in ageing societies.

Among its peculiar functionalities, it can print omikuji, a fortune-telling typically available in Shinto shrines. DarumaTO interfaces with e-VITA coaching system, and it will integrate its functionalities in the future. The current version 4 was made in two versions: the 1 DoF DarumaTO-4, nicknamed MARUBO (マルボ), and the static DarumaTO-4W, nicknamed WABO (ワボ).

Figure 14. DarumaTO-4W and DarumaTO-4

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3.1.1 Specification

Table 5. Specification of DarumaTO-4

Name	DarumaTO-4 (Daruma Theomorphic Operator v4)「MARUBO」
Manufacturer	LAB22 (Shibaura Institute of Technology); Waseda University
Height	32 cm
Width	19.8 cm
Depth	19.5 cm
Weight	2.540 kg
Power	82.5W (approx.)
Current	14A
Voltage	100V-250V AC

Table 6. Specification of DarumaTO-4W

Name	DarumaTO-4W (Daruma Theomorphic Operator v4W)「WABO」
Manufacturer	LAB22 (Shibaura Institute of Technology); Waseda University
Height	26 cm
Width	19.8 cm
Depth	19.5 cm
Weight	2.210 kg
Power	80W
Current	14A
Voltage	100V-250V AC

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3.1.2 Hardware

DarumaTO is a multimodal system, composed of a variety of devices. All of them are standard components that are commonly used on Amazon, and available in both European and Japanese market.

Table 7. Hardware components

	Computer The computer is a Jetson Nano B01. All electronical parts are connected to its pins. Regulatory and compliance documents are available at this link: https://developer.nvidia.com/embedded/dlc/jetson-nano-regulatory-compliance-docs
	Storage Model: SDSQUA4-064G-EPK Brand: SanDisk
 	Wireless and Bluetooth The Jetson needs a wireless and Bluetooth module in order to connect. Additional antennas are needed to reinforce the signal. Model: 8265 8265NGW Brand: Intel Model ASIN: B08BK86WSL Brand: LTDparts

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Display

A 7 inches touch screen is used for showing facial expressions and getting user input through touch.

Manufacturer: EVICIV

ASIN: B08V54V4NN

Size: 16.4 x 10.1 x 0.9 cm

Weight: 208.65 g

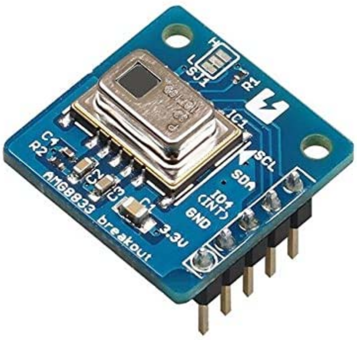
Voltage: 5V

Power: 10W

</td></tr>
<tr><td></td><td>

USB storage

A 3D printed omamori contains a USB memory which contains user private information

</td></tr>
<tr><td>
</td><td>

Sensor

A thermography AMG8833 sensor detects through infrared any human presence and user input (equivalent functionality to a button)

Operating Voltage: 3.3 V ± 0.3 V

Board profile: 2cm x 2cm

</td></tr>
<tr><td></td><td>

Microphone

Model: MIC0001

Brand: iGOKU

-Sensitivity: -30dB±3dB

-Polar Pattern: Omnidirectional

-Impedance: ≤2.2KΩ

</td></tr>
</table>

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The project has received funding from the European Union H2020 Programme under grant agreement n° 101016453. The Japanese consortium received funding by the Japanese Ministry of Internal Affairs and Communication (MIC).

	Speakers Model: MS-P08UWH Brand: ELECOM -Speaker Unit:50mm frenzy -Practical Maximum Output:4W(2W+2W) -Impedance:4Ω -Frequency characteristics:180Hz-20kHz -Connection cable:133cm -Input plug:3.5mm
	Printer Phomemo, a small heat label printer, is at the bottom of the device. -Package Dimensions: 3.86 x 3.78 x 2.52 inches -Item Weight: 12 ounces -ASIN-B086JXFR87 -Batteries: 1 Lithium Polymer batteries required. (included)
	Motor (MARUBO only) One TowerPro servomotor is used for one degree of freedom (yaw) Model: MG90S Modulation: Analog Torque: 4.8V: 2.20 kg-cm 6.0V: 2.50 kg-cm Speed: 4.8V: 0.11 sec/60° 6.0V: 0.10 sec/60° Weight: 14.0 g Gear Type: Metal Rotation/Support: Dual Bearings

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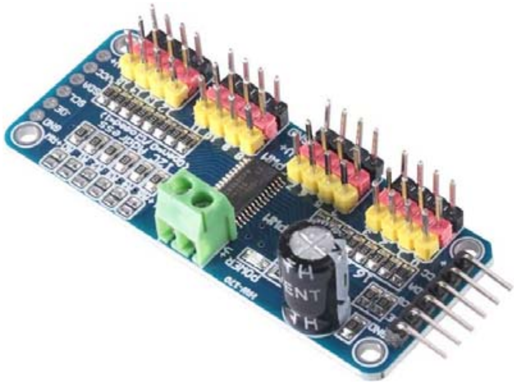
	Rotational Range: 180° Pulse Cycle: 20 ms Pulse Width: 400-2400 µs
	Motor driver (MARUBO only) Model: ACEIRMC PCA9685 Voltage: DC 5-10V power supply Communication Interface: IIC 16-Way Steering Control Size: 25 x 61 mm
	3D printed parts The shell and the inner parts are 3D printed in PLA filaments. -Tangential Diametre: 1.75mm -Length: 325M (1KG) -Melting Point: 245C±15 (°C) Daruma-TO4 (MARUBO) base is made of nylon.
	Fan One 5V DC brushless fan is applied at the Jetson Nano and pulls out air on the back of the device. -Size: 1.97in (L)×1.97in (W)×0.39in(H) -Rated Voltage: 5V -Speed: 4500RPM -Airflow: 9.5CFM

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	-Noise: 24dBA -Bearings: Sleeve Bearings -Connectors: USB
	Power supply Manufacturer: EVICIV Model: HDD28-01 Power: 15.0 W Output: 5.0V 3.0A
	Power hub Model: LC-101 ASIN: B098KWTQBH - Input: AC 100V 50/60Hz 0.8A - Output: AC Outlet, 1400W Max5 Ports, - Total Output 8.4A Max 50W Single USB Port, - 5V/2.4A Max Single USB Output, - QC3.0 (3.6-5V/3A 6.6-9V/2A 9-12V/1.5A) - USB-C Port (PD3.0) Output: 5V/3A 9V/2.22A 12V/1.67A

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3.1.3 Components and Connections

The main difference among the two versions is that MARUBO has 1 active DoF (yaw) and 1 passive DoF (pitch), whereas WABO is a simplified version, having only 1 passive spherical DoF at the bottom, which allows it to have a "wobbling" movement. The sensor on WABO is placed on the top right, while on MARUBO it is placed at the bottom center.

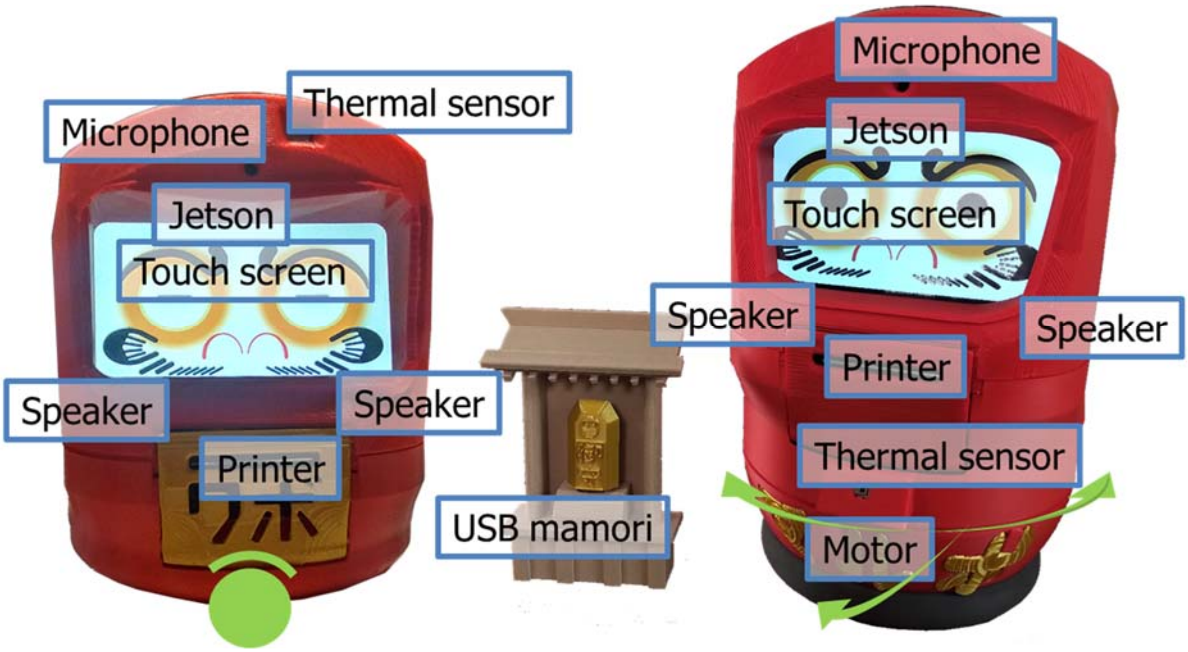

Figure 15. Components of DarumaTO-4 and DarumaTO-4W

3.1.3.1 Connections Diagram

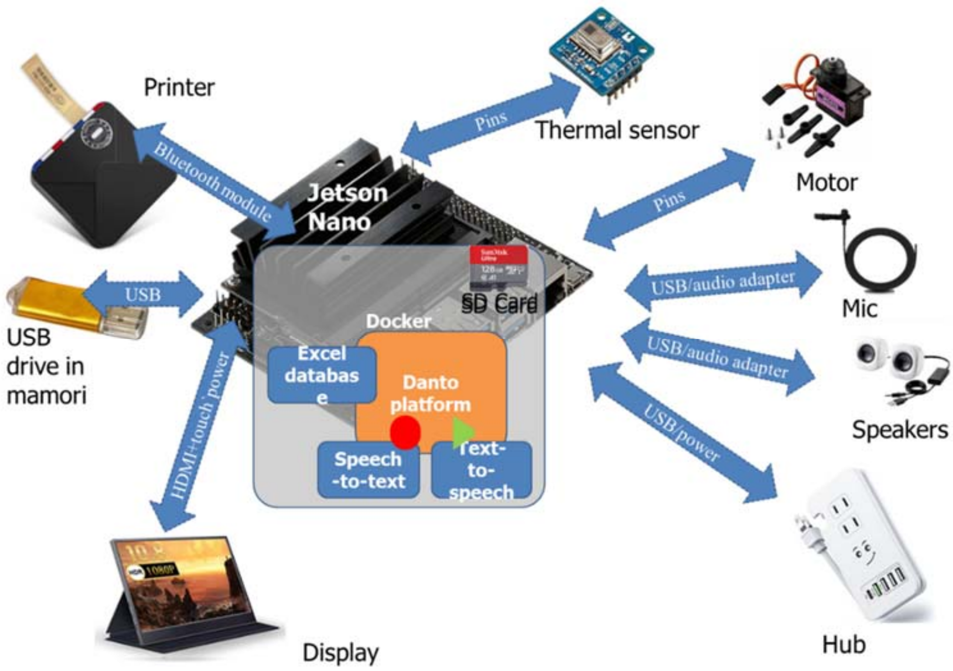

Figure 16. Connections diagram of DarumaTO

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3.1.3.2 Electric diagram

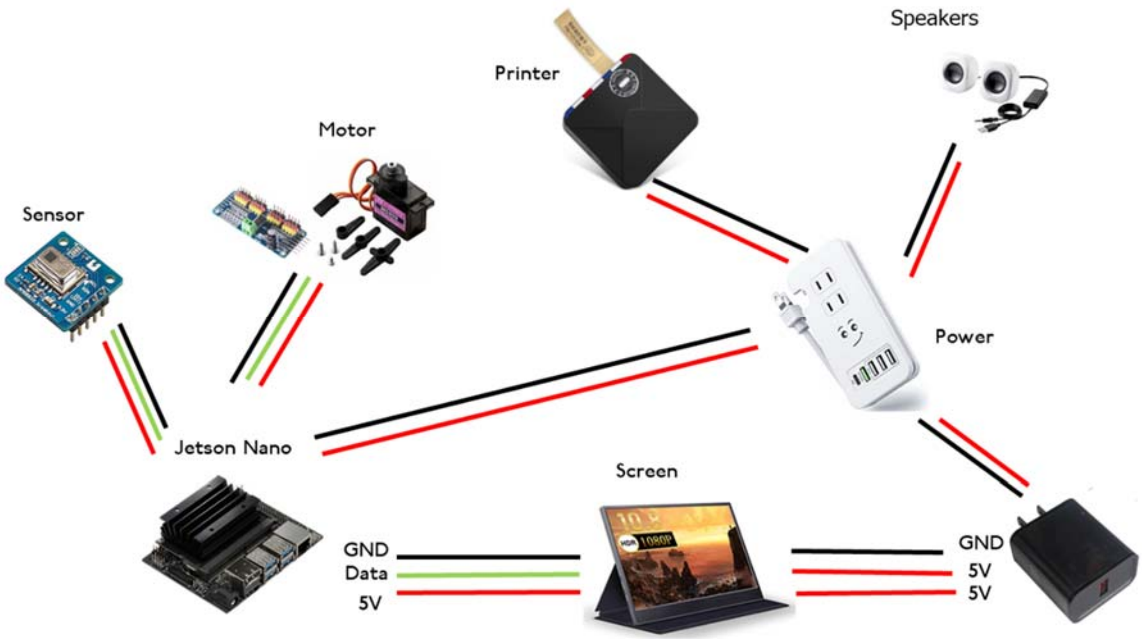

Figure 17. Electric diagram of DarumaTO

3.1.4 Software updates

The whole software platform, Danto, has been refactored in order to be compatible with RASA and simpler to use as a Finite State Machine. Before Wave 2, modifications at the code will be operated in order to comply with the requirements of functionality of the e-ViTA system. The trigger-action system coming from the Digital Enabler will be integrated for CelesTE to respond to active triggering. Moreover, the recorded sound will be stored and sent to the Digital Enabler in order to have emotional recognition performed.

3.2 CelesTE

CelesTE (*Celestial Theomorphic devicE*) (see Figure 18) is a small social robot with the appearance of an interactive statue of an angel on the top of a column. It is a redevelopment of SanTO, the first Catholic robot ever created, which was developed since 2017 in the Pontifical Catholic University of Peru by Dr. Gabriele Trovato.

Like SanTO, CelesTE incorporates elements of sacred art, being inspired by neoclassical architecture and including the golden ratio, in order to convey the feeling of a sacred object, thus matching form with functionality and hiding the robotic appearance.

The intended main function of CelesTE is to be a “guardian angel”, especially thought for elderly people. It can be a prayer companion, and contains a vast amount of teachings, including the whole Bible. Its AI is capable of keeping a short conversation, in which the user may ask and receive an answer about a sensitive topic (such as happiness, death, faith, etc.). It can also printout a selection of contents.

CelesTE interfaces with e-ViTA coaching system, and it will integrate its functionalities in the future.

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Figure 18. CelesTE

3.2.1 Specification

Table 8. Specification of CelesTE

Name	CelesTE R3 (Celestial Theomorphic Device Revision 3)
Manufacturer	LAB22 (Shibaura Institute of Technology); Waseda University
Height	54 cm
Width	21.4 cm
Depth	26.45 cm
Power	70W
Current	14A
Voltage	100V-250V AC

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3.2.2 Hardware

CelesTE is a multimodal system, composed of a variety of devices. All of them are standard components that are commonly used on Amazon, and available in both European and Japanese market.

Table 9. Hardware components

	Computer The computer is a Jetson Nano B01. All electronical parts are connected to its pins. Regulatory and compliance documents are available at this link: https://developer.nvidia.com/embedded/dlc/jetson-nano-regulatory-compliance-docs
	Storage Model: SDSQUA4-064G-EPK Brand: SanDisk
 	Wireless and Bluetooth The Jetson needs a wireless and Bluetooth module in order to connect. Additional antennas are needed to reinforce the signal. Model: 8265 8265NGW Brand: Intel Model ASIN: B08BK86WSL Brand: LTDparts

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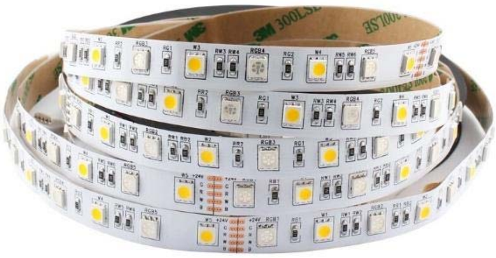	Lights Model: WS2812B Brand: Worldsemi Co.,Limited A LED strip illuminate the aureole and the wings of the angel. -Power Supply Voltage(VDD): +3.5~+5.3V -Input Voltage: -0.5~VDD+0.5 -Operation junction Temperature: -25~+80°C -Storage temperature range: -40~+105°C
 	USB storage A 3D printed candle contains a LED and a USB memory which contains user private information Model: 1122 Brand: サムコス Model: USB EL-08 Brand: Nanpoku

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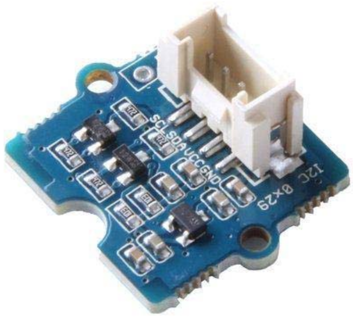	Sensor Model: VL53L0X Brand: Grove A Time-of-Flight VL53L0X laser sensor is used to detect human presence and user input (equivalent functionality to a button) -Supply Voltage:3.3V/5V -Interface:I2C -Measure Distance: Max 2m -Accuracy:<±,3%
	Microphone Model: MIC0001 Brand: iGOKU -Sensitivity:-30dB±3dB -Polar Pattern: Omnidirectional -Impedance:≤2.2KΩ
	Speakers Model: MS-P08UWH Brand: ELECOM -Speaker Unit:50mm frenzy -Practical Maximum Output:4W(2W+2W) -Impedance:4Ω

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	-Frequency characteristics:180Hz-20kHz -Connection cable:133cm -Input plug:3.5mm
	Printer Phomemo: M02S Brand: Phomemo Phomemo, a small heat label printer, is at the bottom of the device
	3D printed parts The figure and the pedestal are 3D printed in PLA (marble, white, and black) and PETG (marble) filaments. Model: MarblePLA-01 Brand: TINMORRY Model: PETG17521082109B Brand: QC Pass Model: REP-MPLA-1.75MM-1KG-WHITE Brand: RepRapper Model: PM70820 Brand: PolyTerra

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	Fan Two 5V DC brushless fan are applied: one on the back of the device to pull out hot air, one directly at the Jetson Nano. Model: ASIN: B08D3GMKT9 Brand: GeekPi -Connectors: USB
	Power supply Model: HDD28-01 Brand: Aifulo
	Power hub Model: GB118G MagicCube Brand: GreenBlue - 3500 W - 16 A - max voltage: 250 V

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3.2.3 Components and Connections

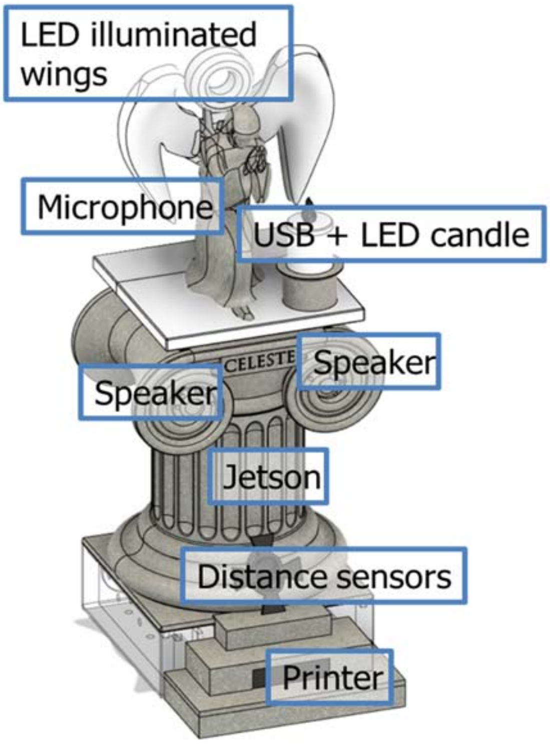

Figure 19. Components of CelesTE

3.2.3.1 Connections diagram

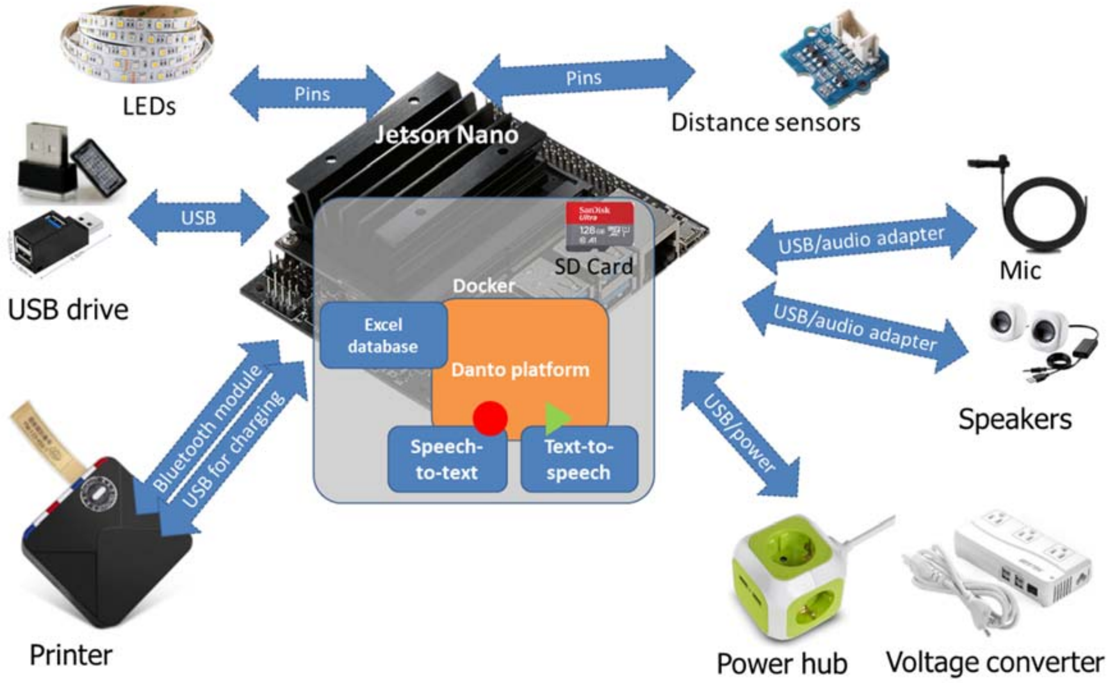

Figure 20. Connection diagram of CelesTE

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3.2.3.2 Electric diagram

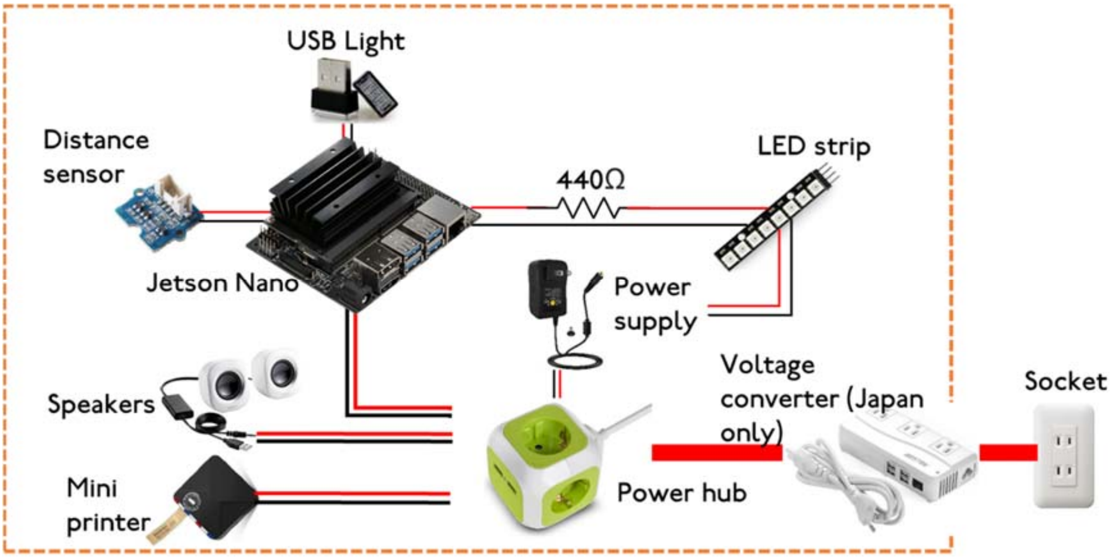

Figure 21. Electric diagram of CelesTE

3.2.3.3 Electric diagram (LEDs)

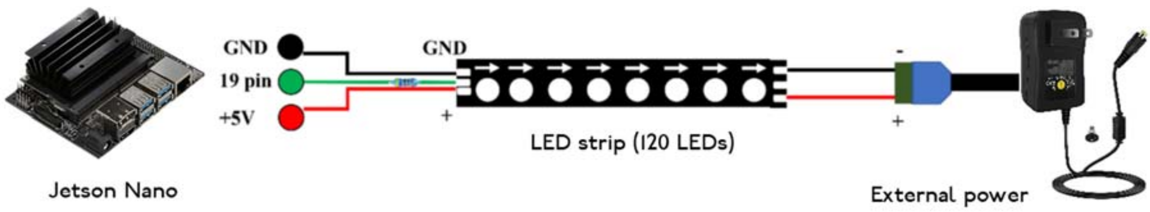

Figure 22. Electric diagram (LEDs) of CelesTE

3.2.4 Software updates

The whole software platform, Danto, has been refactored in order to be compatible with RASA and simpler to use as a Finite State Machine. Before Wave 2, modifications at the code will be operated in order to comply with the requirements of funcionality of the e-ViTA system. The trigger-action system coming from the Digital Enabler will be integrated for CelesTE to respond to active triggering. Moreover, the recorded sound will be stored and sent to the Digital Enabler in order to have emotional recognition performed.

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4 Conclusions

This deliverable presents six different types of coaching devices: android robots, NAO robots, Gatebox devices, the Google Nest (Mini and Hub), Daruma-TO-4, and CelesTE. These devices have been prepared (or newly developed) to be used in the e-VITA project. Furthermore, in our Living Labs, the first insights about the end-users' perceptions of the devices have been gained (see Deliverables 6.5 and 6.2). Finally, in Deliverable 7.1, the first version of the e-VITA platform architecture has been presented.

While the hardware components of the devices are mostly similar, they vary slightly in specs. In addition, the overall appearance and aesthetic of the devices vary significantly. In the first living lab testing, Daruma-TO was only used in Japan, while CelesTE has been explored in Europe. Other devices, such as Gatebox and the NAO robot primarily used regardless of cultural region. At the time being, the Android robot can still only be used in Wizard-of-Oz studies in the different living labs in Europe and Japan.

During the feasibility study wave 1 of the project (see Deliverable 8.2), the devices were used autonomously in the home of older adults. Additionally, this period offered more insights into the fit between content and devices.

Based on the feedback loop and the collective feedback of wave 1 (see Deliverable 8.2), the devices have been further improved as part of our reusability analysis in M19 (Deliverable 6.12). After the re-designing phase, the devices will be explored and evaluated further in the upcoming proof of concept study wave 2 from M30-M36 of the project.

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