D25.5 Product development progress

Clark

smart CLinic Assistant Robot for CGA

- Date: July 26, 2017
- Summary: Resume of technical status of CLARC solution for automatizing CGA testing

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Summary

This document describes the CLARC solution for July 2017.

1 Introduction

We will draw a picture of the status of the CLARC proposal for the end of July 2017. The next description follows up the one employed for defining the KPIs.

○ *System Architecture - Integration*

We are currently able to deploy a quasi-complete framework needed to deal with the CGA scenario. Figure 1 provides a picture of this framework. In the figure, it will be only needed to close the CDMS – CGAmed link. Thus, CLARC is composed of several modules, running either on the robot or on external PCs, including the clinician's PC. A total of three computers support the architecture, two of them are part of the robot and are used to control it and to interact with patients (see the Software architecture item). The third computer is placed outside the robot and supports the database system and the system-clinician interface. All the functionalities that we integrate within the CGAmed (see Figure 1). In fact, the CGAmed is currently running on an external server.

From a conceptual point of view the system can be divided into three main components: the Robot, the Cognitive Architecture and the CGAmed software. The robot is a mobile platform, based on the MetraLabs SCITOS G3, and equipped with extra sensors to be able to seamlessly perform and record tests and interact with patients and relatives. The cognitive architecture, running on-board the robot, provides it with the needed 'intelligence' to perform all required tasks. CGAmed supports the interface of the clinician both with the robot (to configure for example the tests to be performed) and with the generated data (patient profile, recorded sessions, tests marks, etc.). Connection of the robot and the CGAmed is done in two ways. The main link connects the High Level Executive of the robot's cognitive architecture to the CGAmed Control module. The later commands the former to switch on the remaining robot modules and transfers the information about the tests to be performed. All the configuration information and the results of the session travel through this connection. Although it is not shown in the figure, there is also a second direct link between the Session Recorder module of the robot and the database.

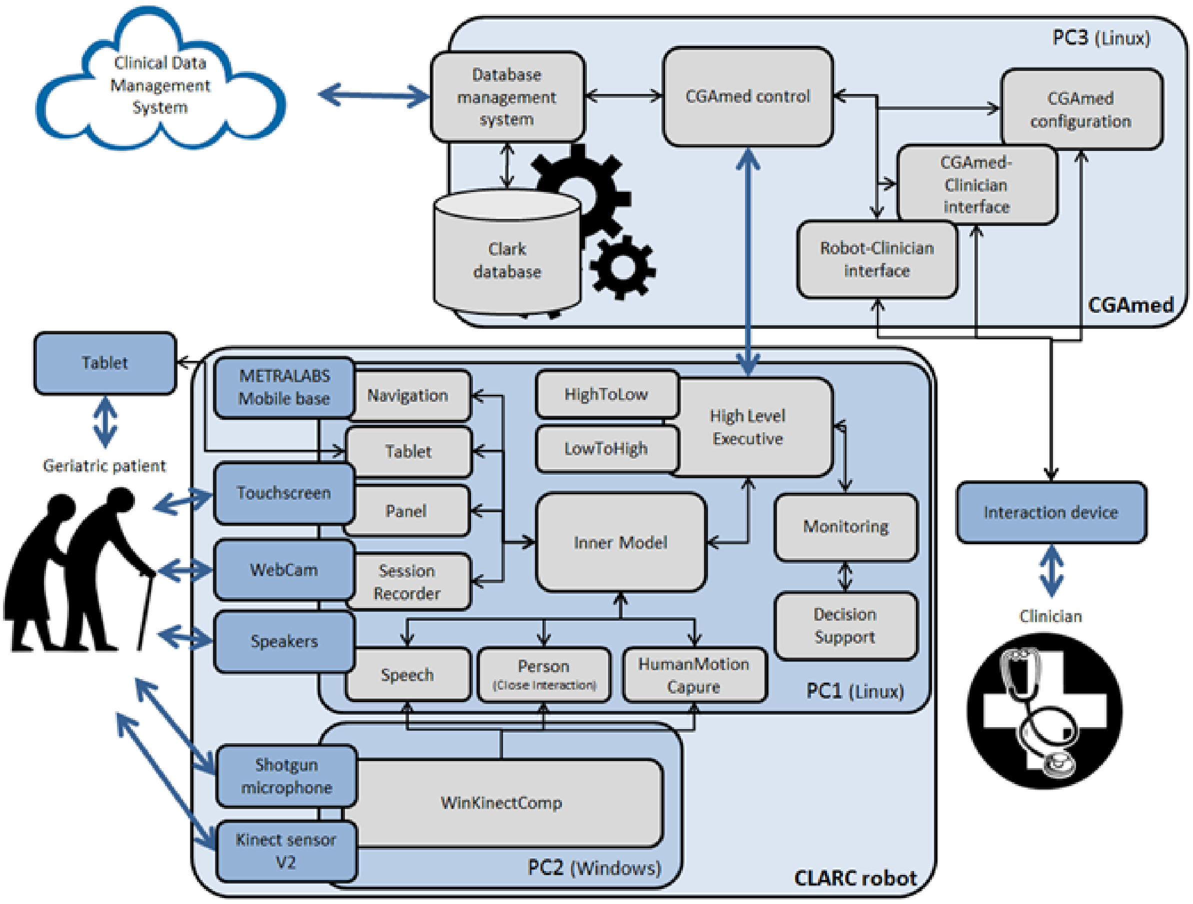


Figure 1. *Global view of the CLARC framework*

○ *Cognitive architecture*

*T*he robot is endowed with a software architecture whose core is an inner representation of the outer world, shared and updated by all modules on the architecture. Surrounding this representation, the architecture includes a deliberative planner, the PELEA module (UC3M) and several mid-level, task-related modules (see Figure 1). All modules interact among them using the inner representation, i.e. there is not a hard hierarchical organization, such as the one appearing in other hybrid software architectures. In this way, the architecture allows the robot to deal with the current situation following the reaching of a specific goal (e.g. the sequence of a Barthel test, driven by the PELEA module) but also reacting to external, unexpected events (e.g. the abnormal behavior of the patient to a question) (Voilmy et al, 2017). Furthermore, the architecture is open to solve other behaviors that were not initially considered, for which it only needs to encode this new behavior (e.g. a questionnaire-based or motion-based test) into the high-level domain of the PELEA module and to be endowed with the mid-level modules (task-based modules) in charge of dealing with the specific needs of this new behavior. Once the architecture was deployed, our team was able to endow each test (Barthel, MMSE…) within the architecture in less than one month.

The current software architecture within the CLARC robot includes the modules drawn in Figure 2: (a) the PELEA module, a deliberative architecture able to plan, monitor and learn high-level courses of action; (b) the Person module, in charge of detecting people in the surroundings of the robot and tracking their faces; (c) a Speech module, who allows the robot to speech specific sentences and to recognize speech; (d) the HumanMotionCapture module, whose aim is to track the full motion of the person in front of the robot; (e) the Panel module, which manages the Touchscreen; (f) the Tablet module, responsible of managing an external tablet; (g) the Session Recording module, which allows the robot to record specific parts of the session; (h) the WinKinectComp module, in charge of collecting and managing all data obtained from a Kinect v2 sensor and a shotgun microphone; and (i) the Navigation module, which runs using Myra middleware from Metralabs. Each module is composed by several software components, and is connected to the inner representation through a specific component, the so-called agent. These agents are able 'to read' the inner representation for determining the actuation of the whole module, and also to update this representation with the information captured from the sensor they manage (when this is the case).

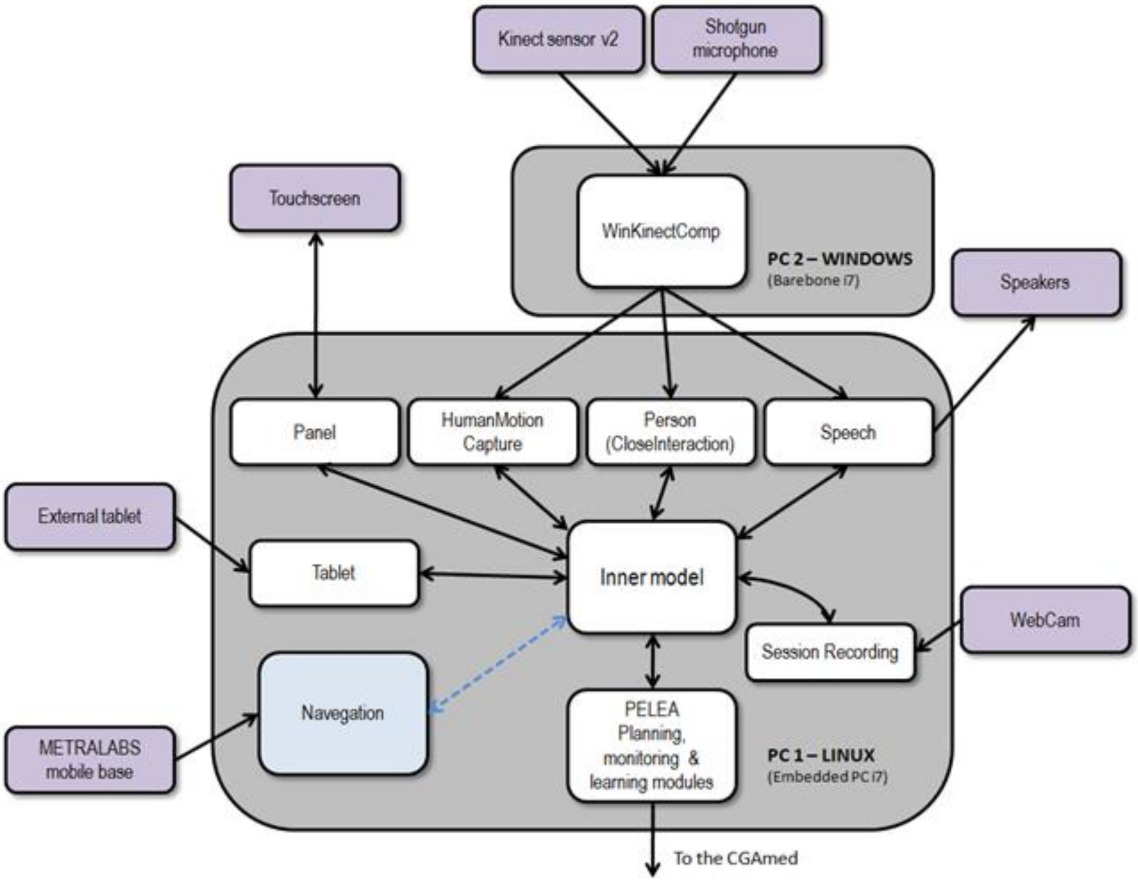


Figure 2. *The instantiation of the cognitive architecture within the CLARC robot*

It must be noted that, in this version, the WinKinectComp module is not connected to the inner representation, and it works as a complex sensor (i.e. providing data to other modules such as the Speech or the Person ones). Furthermore, the whole architecture is distributed in two computers. One of them runs this WinKinectComp module, which currently needs a large computational load, but that is able to provide the main perceptive channels of our robot. Figures 1 and 2 include the

Navigation module, connected to the mobile base and to the Inner model. This module was integrated after Phase I and our platform uses it for navigating and self-localizing. Thus, they are able to endow the robot with the ability of navigating within a previously mapped environment. This functionality has been used for designing a more complete Get Up & Go test.

○ *Human-Machine Interfaces*

The interfaces that the CLARC system maintains with end-users are shown in Figure 3. Apart from the M2M interaction provided by the CGAmed-CDMS interface, we can identify three interfaces:

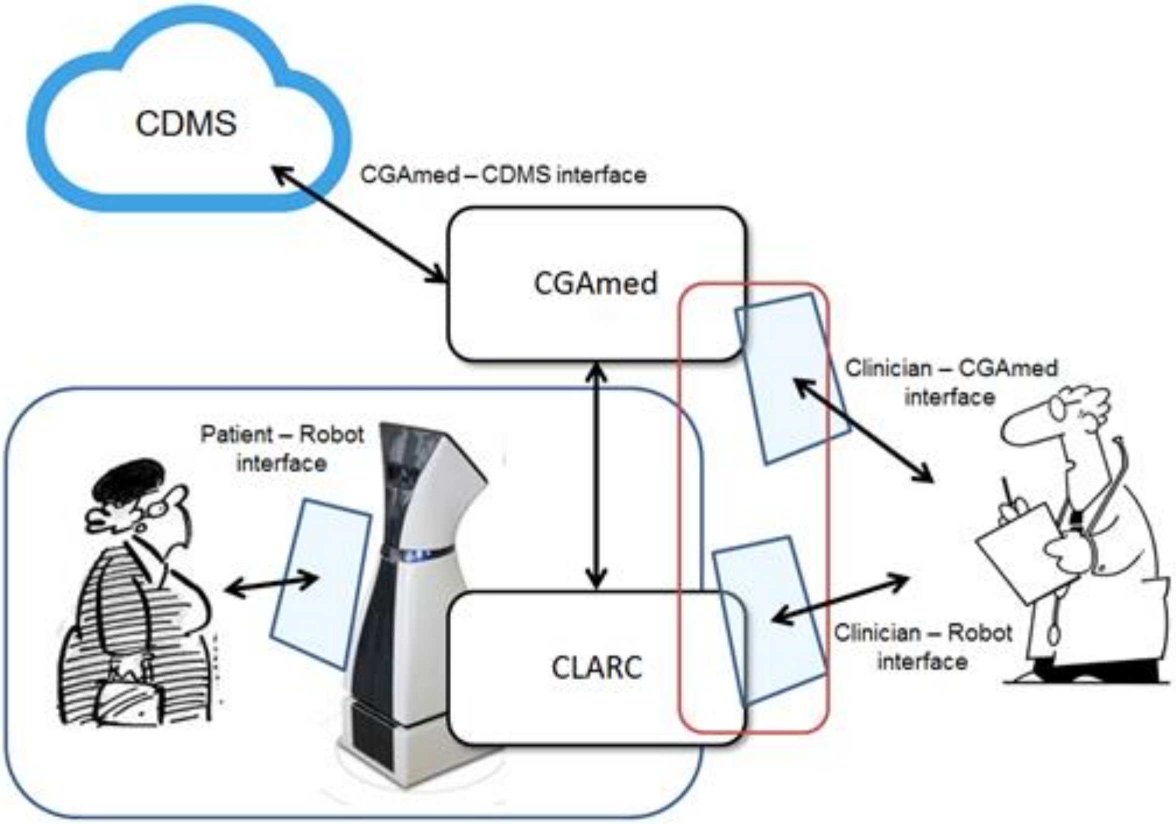


Figure 3. *Human-computer interfaces within the CLARC framework*

- The **Patient-Robot interface** allows the robot to interact with the patients or relatives during the CGA tests execution. The interface uses verbal and text channels for interaction. Thus, the CLARC prototype is currently able to run the Barthel, MMSE and Get up & go tests in English and Spanish languages, and the Barthel and Get up & go tests in French. The selection of one language implies to change the Automatic Speech Recognition (ASR) module (we are using the Microsoft Speech Platform SDK) and the Text-to-Speech (TTS) module (we can currently use Festival or the Microsoft Speech Synthesis API, which provides a more natural voice). When the language changes, we must also change the specific Grammar that the speech module uploads for the ASR of each question on the Barthel and MMSE tests. Briefly, each language option implies to use a specific txt file containing sentences (Speech module), a specific set of graphical panels (Panel (touch-screen) module), and a specific set of grammars for the ASR module. It also implies to change the language option on the ASR and TTS modules. Language change is automatically done for each patient following the information about language preferences stored in the database (Clark database, see Figure 1). The Deliberative module receives this information from the CGAmed server before launching the test, and publishes it in the inner model of CLARC. These data allow all modules to configure themselves to use the desired language. Furthermore, the robot is equipped with a touch-screen on its torso that allows augmenting the interaction with the patient or relative. Each time the robot speaks, a message is also displayed on the touch screen. A collection of graphical panels have been designed to address this interaction following the general guidelines provided by experts on accessibility from the UC3M team and, from January 2017, the opinions and suggestions from end-users. One of the objectives of the first focus group celebrated on Troyes (January 2017) was to redesign all these interfaces. Figure 4 shows one example of the previous (a) and current (b) view of one of the panels (Lan Hing Ting et al, 2017).

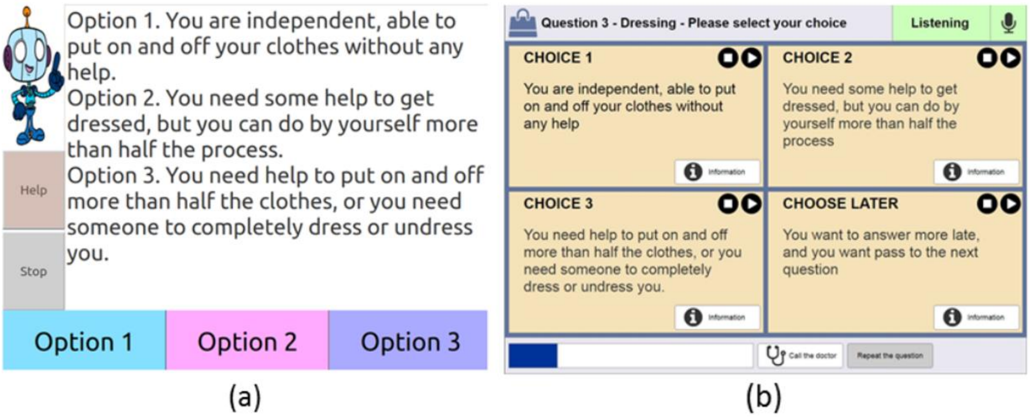


Figure 4. *The Patient-robot interface*

These panels depend on the specific question under evaluation on the test. Multi-language is supported as mentioned on the previous item. In the MMSE test, as a general rule the robot tries twice to recognize the answer of the patient using voice. If it is not able to recognize it, the touch screen is activated allowing the patient to introduce the answer using virtual buttons or a virtual keyboard. In questions where the patient is asked to draw or to write on the screen, a tablet is provided for the patient's convenience. In the Barthel test, the speech recognition and the touch screen are simultaneously activated, allowing the patient to answer questions using voice or virtual buttons. These behaviors can be easily changed by modifying the PDDL encoding of the test (PELEA module).

- The **Clinician-Robot interface** allows the healthcare expert to interact with the robot and define configuration aspects which are local to the robot (e.g. the capturing of the map of the rooms). It will be the interface for visualizing the sessions online and receiving notifications or alerts. It shares a web service with the **Clinician-CGAmed interface**, which allows the expert to visualize recorded sessions, analyze the scores (and edit them if needed) and define the agenda of the robot. These interfaces for configuration, evaluation and data management can be run on the touch-screen on the robot, but the more natural interface will be the monitor of the PC on the physician's room, a smartphone or a tablet. Both interfaces have been designed and changed according to the needs and suggestions of the physicians of the Hospital Universitario Virgen del Rocío (SAS). Interfaces are programmed as web services that could be easily updated for supporting multi-language requirement (they currently use English language). It has not been changed from Phase I as this has not been required by the end-users (focus groups at Troyes and Seville, and meetings with doctors and care centre managers).

○ *Automated Guided Vehicle (AGV) Platform*

The CLARC prototype is built over the SCITOS platform from MetraLabs. It is endowed with MIRA[1] and CogniDrive[2], a software system that enables vehicles to navigate to arbitrary goal points in an environment. The localization module uses existing environmental structures, so additional sensors or markers are not required. MetraLabs has tested the person following skill in other projects using this same framework. After Phase I the robot is able to map an environment in an off-line manner and then uses this map for navigating to a specific goal and for self-localizing within this environment. The SCITOS platform avoids static and dynamic obstacles and, thanks to CogniDrive, offers the user the possibility for configuring all parameters (e.g. safety distances). This software is currently integrated with the rest of the architecture using a bridge MIRA-RoboComp, developed by researchers from Metralabs and UMA teams.

○ *Hardware (Power, Control Electronics, Sensors, Transducers and Chassis)*

The locomotion of the SCITOS G3 platform is based on a differential drive system consisting of two powered wheels and a caster wheel for stability. This enables the robot to rotate on the spot and drive at speeds of up to 1 m/s, if necessary. The platform contains a 40Ah lithium battery which allows for up to 18 hours of autonomous operation, and can be recharged fully within 4 hours. A safety bumper socket sensor around the outer perimeter of the robot's shell is used to prevent the

[1] *http://www.mira-project.org/joomla-mira/*
[2] *http://www.metralabs.com/en/research*

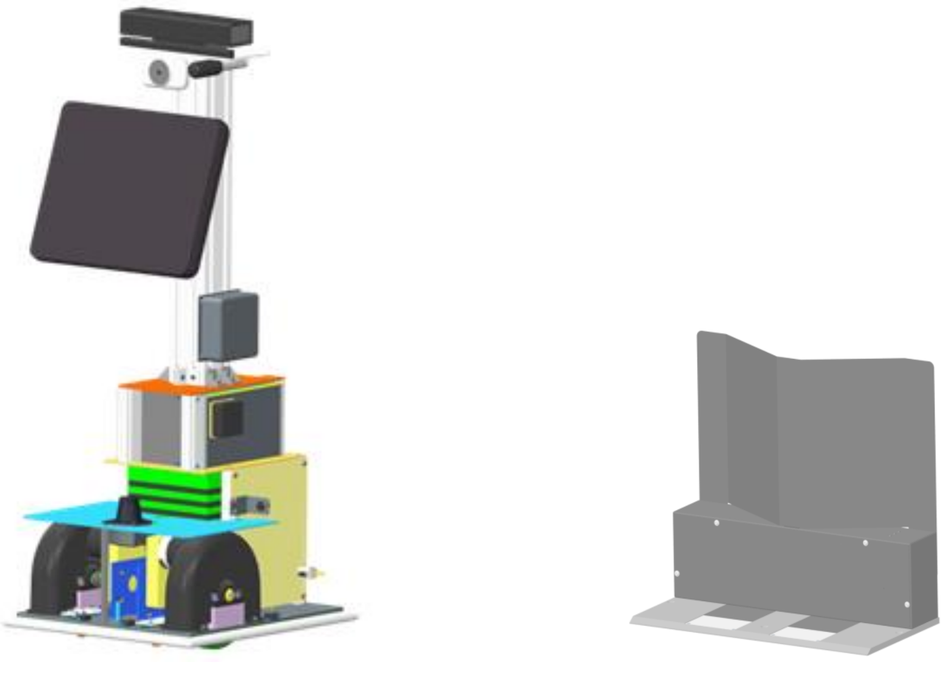
robot from exerting force against animate or inanimate objects. The platform is fitted with a LIDAR sensor for localization, navigation and obstacle avoidance.

To allow autonomous recharging, the robot interfaces with external autonomous charging stations (ACS) as pictured in Figure 5b. One or more charging stations can be placed in the environment to provide power to the robot either in short intervals during operational hours, or continuously while waiting overnight for the next assignment. The electrical current is conducted using carbon sliding contacts on the underside of the robot. Robot and ACS negotiate the charging process using very small currents; charging will only begin once the robot has authenticated itself and has reached the final charging positioning.

All hardware is in compliance with German technical inspection agency TÜV regulations and has been certified safe for use in public environments.

○ *Physical Appearance (Form factor/ Footprint)*

The SCITOS G3 platform is extended with an extensive human-machine-interface, consisting of a Microsoft Kinect V2 sensor, a shotgun microphone, a touch screen and speakers for multi-modal human-robot interaction, as well as a webcam for recording the sessions and a IP camera for visualizing the sessions online (see Figure 1). The system is also provided with an external tablet which the patient use to answer some questions of the MMSE test. Figure 4 shows a prototypical adaption of the SCITOS G3 platform for the CLARC use case.



(a) *(b)*

Figure 5. *(a) The internal structure of the CLARC robot, and (b) the charging station*

During the last months, the UTT and Metralabs teams have worked on the design of an external chassis for the robot platform. The new design is expected to be available for September 2017. Figure 6 shows some initial pictures from Sean Scott (Metralabs). The design has emerged from the interaction of engineers from Metralabs and UMA, and end-users, in several co-design sessions driven by the researchers from UTT (Lan Hing Ting et al, 2017). Figure 6 shows the last proposal from Metralabs, which was reviewed by the experts from UTT, SAS and UC3M.

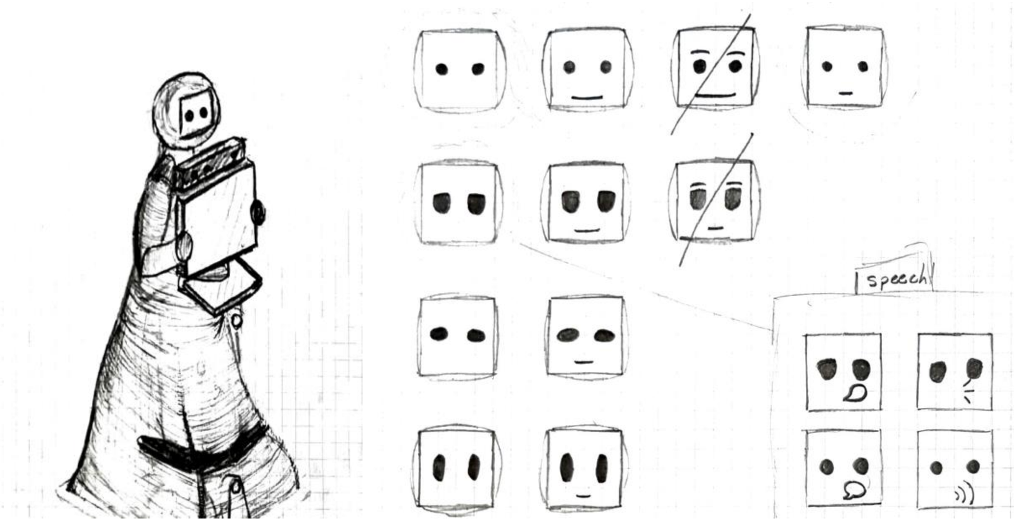


Figure 6. *Designing the external aspect of the CLARC robot*

References

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(Lan Hing Ting et al, 2017) Lan Hing Ting K, Voilmy D, Iglesias A, Pulido JC, García J, Romero-Garcés A, Bandera JP, Marfil R, Dueñas A (2017) *Integrating the users in the design of a robot for making comprehensive geriatric assesments (CGA) for elderly people in care centers*. 26th IEEE Int. Symp. Robot and Human Interactive Communication, Lisbon, Portugal