ASSISTIVE EQUIPMENT FOR MONITORING PEOPLE WITH ALZHEIMER

COSTACHE Iulia

Faculty: Industrial Engineering and Robotics, Specialization: Equipments for recovery therapies, Year of study: 2021-2022, e-mail: iulia.costache97@yahoo.com

Scientific supervisor: Prof.dr.eng. **Cristina MOHORA**

ABSTRACT: Alzheimer's disease is a progressive neurological disorder that causes a slow deterioration of memory, logical thinking, behavioral and social skills. Systems designed for cognitive degradation play a key role in structuring daily activities within the home. Automated healthcare devices allow people with Alzheimer's disease to live partially independent in their own homes for a longer period of time. The aim of this research is to develop an assistive patient monitoring unit in their own home, equipped with a drug dose distribution system and a caregiver alert system in case of refusal / failure of the pill dose.

KEYWORDS: Alzheimer's disease, assistive equipment, intelligent system, pill distribution, sensors.

1. General aspects

The increasing costs associated with specific aging healthcare services such as health monitoring, prevention of worsening health problems, rehabilitation services or palliative care, together with a lack of qualified staff in the field, have increased investments in the development of smart technology, supporting the current health needs of users, thus improving their quality of life and safety.

The aim is also to maintain a level of independence as high as possible in their own house, which can be seen in the avoidance of transfers to medical units or nursing homes, thus preserving the ability of older people to care for themselves and carry out activities in their homes.

Alzheimer's disease is a progressive degenerative disorder of the brain that occurs mainly among elderly people, producing an increasingly severe deterioration of the brain's cognition functions, with loss of the individual's intellectual abilities and social value of his or her personality, associated with behavioural disorders.

When a person's ability to perform daily activities is impaired, their independence becomes limited and they may require assistance from elderly care services. For example, patients may have trouble managing medication, maintaining a routine, scheduling daily and essential activities or getting help in case of an emergency. These difficulties can be a burden for both the patient and their family/caregiver.

The treatment of Alzheimer's disease consists of slowing down the progression and reducing or stopping the already existing symptoms of the disease. The sooner therapy begins, the longer it is possible to maintain cognitive brain function. Unfortunately, there are no medications that lead to a full recovery, however, some pills have been proposed, which aim to improve memory and intellectual capacity, as well as eliminate the symptoms that accompany the disease (depression, anxiety, hallucinations).

Assistive systems dedicated to cognitive impairment have a fundamental role to structure routines in the home. Automated medical assistive devices allow those diagnosed with Alzheimer's disease to live more in partial independence in their own homes. An assistive robot is an ideal technology for monitoring a person's physical and/or psychological condition, enhancing quality of life, ensuring safety and reducing potential cognitive or physical decline.

This paper focuses on modeling, designing and 3D printing an equipment to assist and suport people diagnosed with Alzheimer's disease.

2. Designing and modelling an assistive monitoring system for people with Alzheimer's disease

Patients diagnosed with Alzheimer's require a higher level of care compared to other age-specific diseases. In order to monitor these people, I have created a concept, where I have integrated technological mechanisms and systems, facilitating their self-care at home. The operational mechanical system is interconnected with accessories designed to provide a modern monitoring and assistance solution.

Figure 1 shows the system, modelled and animated in 3ds Max software for aided design.

Fig. 1 Isometric view of animation

The functions of the systems implemented in the animation allow:

- Constant communication with a healthcare professional/patient's family
- Permanent location of the patient
- Follow-up of the patient's vital functions
- Automatic movement of the robot in the home
- Delivery of water and pills at a predefined time
- Avoidance of possible obstacles encountered in the home
- Energy autonomy of the system
- Storage of medicines, water and glasses

The assistive robot in the presented concept is able to locate and track the patient in a restricted environment. It is equipped with mechanisms, sensors and systems developed for continuous monitoring, administration of the correct dose of medication and alerting the caregiver in case of rejected/missed dose of pills. Control of the system is handled by several digital processors that make possible the reception of information generated by environmental sensors. The robot is also equipped with proximity sensors for detecting and avoiding obstacles that may appear in its path. (see figure 2)

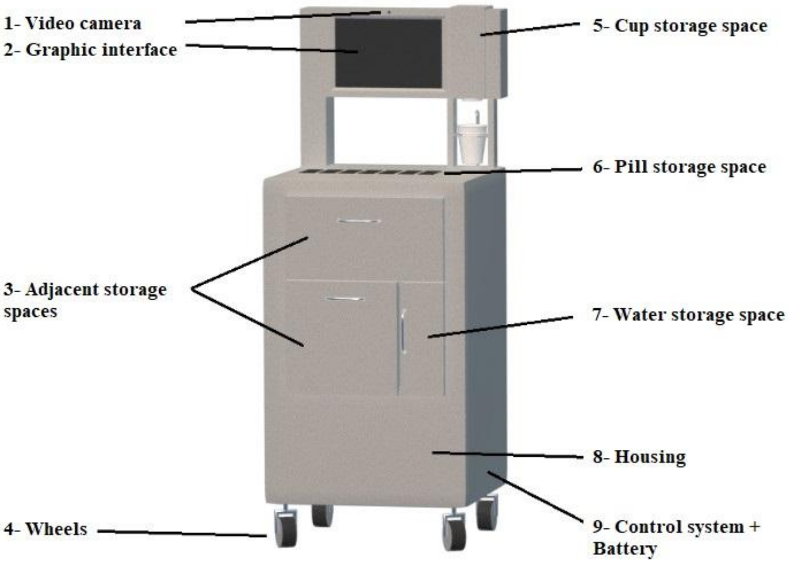


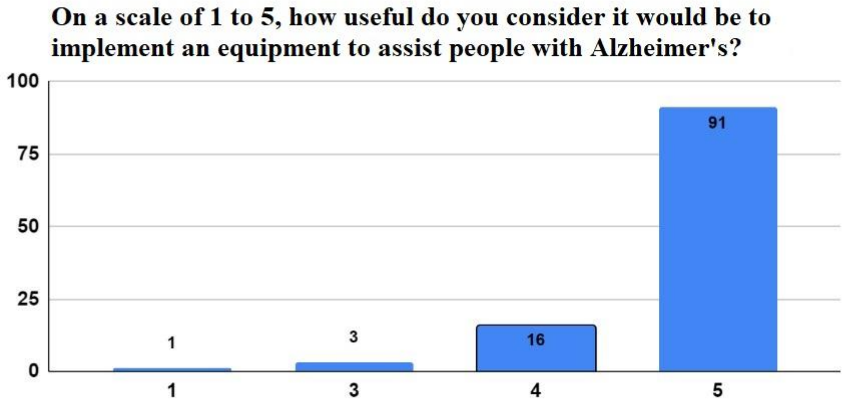
Fig. 2 Front view of mobile robot

3. Designing a questionnaire to evaluate the need for 3D modelling of a care and monitoring system for people diagnosed with Alzheimer's disease

The primary data collection method is a survey. The survey tool is the questionnaire. It was used on a random panel of 111 people. They were sent the questionnaire individually, digitally, in the form of a link. The questionnaire contains a short presentation, to explain to respondents the purpose of the questionnaire, and 11 questions, both open and closed (with multiple choice or scaled).

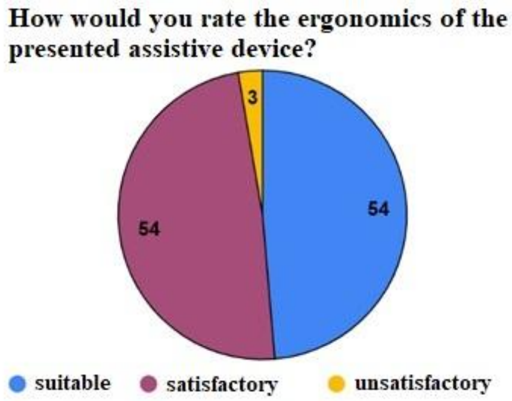
The research population is defined according to age and gender, resulting 60 male and 51 female respondents, ranging from 20 to 60 years.

The main objective of the questionnaire was to find out the degree of respondents' interest in the assistive design of assistive equipment for people diagnosed with Alzheimer's disease. Following the question in the figure below, 82% of respondents considered it necessary to implement such equipment in their homes.

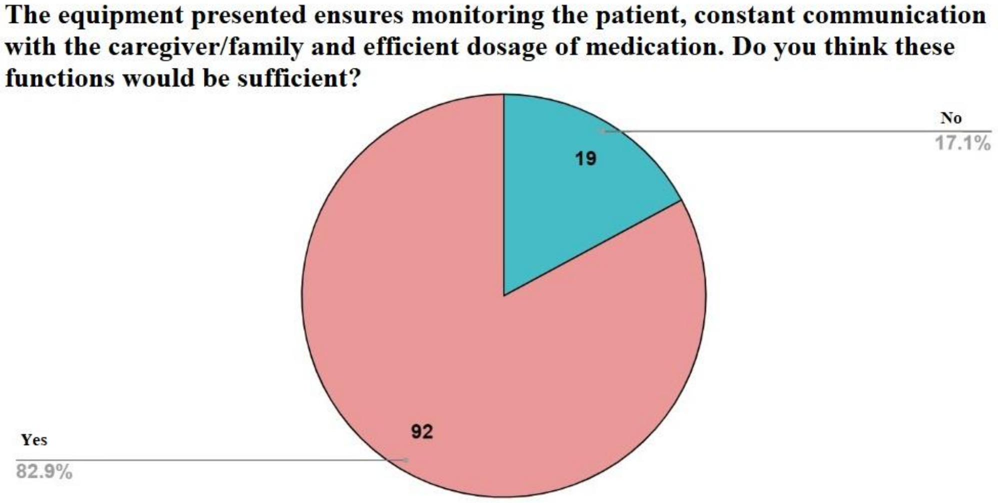


In the previous chapter, a concept that highlights the main functionalities of the desired system was designed and modelled in 3dsMax software. (see figure 1)

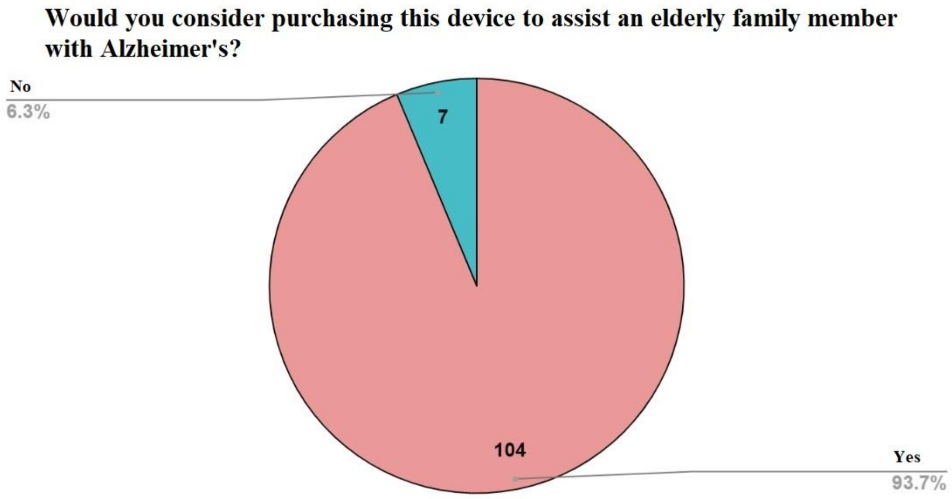
In the first diagram only 3 respondents considered the appearance of the modelled equipment to be unsatisfactory, while 108 considered that the equipment should not be modified.



The following diagram shows that 92 of the respondents are satisfied with the functions performed by the robot.



The study shows an increased awareness of the seriousness of this disease, so 93% of study participants would consider purchasing a device that assists Alzheimer's patients.



4. Design and 3D fabrication of assistive equipment

Computer-aided design (CAD) is using a software technology to design two-dimensional (2D) drawings and generate three-dimensional (3D) part models.

Computer Aided Manufacturing (CAM) is the process of making three-dimensional physical objects from a digital file by successively adding layers of material using a 3D printer.

3D printing technology differs from traditional methods of making objects because instead of removing excess material, it is deposited from the start in the desired shape, eliminating the need for further processing. 3D printing offers an excellent method for visualizing the geometry of the proposed model. Three-dimensional printable models can be created using dedicated 3D design software or by 3D scanning the actual model.

Aided design of the model (see figure 3) was achieved using the CATIA V5 framework, resulting in a geometric model that prefigures the final concept. The design of the assembly followed a technical approach, where the component parts were made to real scale and then assembled.

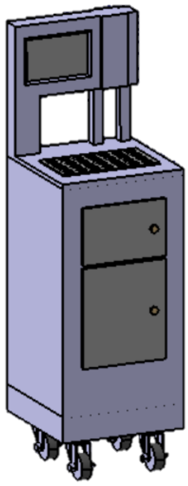


Fig. 3 Isometric view of the 3D model designed

The actual dimensional characteristics of the equipment are shown in Table 1:

Tabel 1. Technical specifications of the robot

Length	500 mm
Width	500 mm
Height of pill dispenser	1000 mm
Total height of equipment	1500 mm

The additive manufacturing technology used in the work is FDM (Fused Deposition Modeling), thermoplastic extrusion molding, which is the most commonly used manufacturing technique due to its simplicity and applicability. This manufacturing method has the great advantage of low cost, both in terms of materials used for printing and supplies. The main disadvantages of FDM technology, encountered in designs with complex geometry, are high printing time and inappropriate bonding of some layers.

A FDM 3D printer uses a continuous filament, which is fed through a gear mechanism into a heater that melts it. The molten filament is then ejected from the nozzle and deposited on the printing table in the desired geometry. After each layer, the printing table (or nozzle) is moved vertically and the next layer is added until the object is completely printed according to the CAD file.

The previously designed 3D model has been converted and saved in a .stl file because it must be processed in a slicer software application that divides the model into cross-sections called layers. The slicer software dedicated to the printer used generates a series of commands corresponding to the parameters of the printing process and the three-dimensional displacements (on the X, Y and Z axes).

The commands are transformed into G-code, the programming language used in computer-aided manufacturing to control 3D printers. To achieve the desired model shape, the 3D printer follows the commands in the G-code and successively deposits layers of material corresponding to the virtual cross-sections of the CAD model.

For additive manufacturing the dimensions of the equipment were scaled 1:100 and are shown in the figure below (see figure 4).

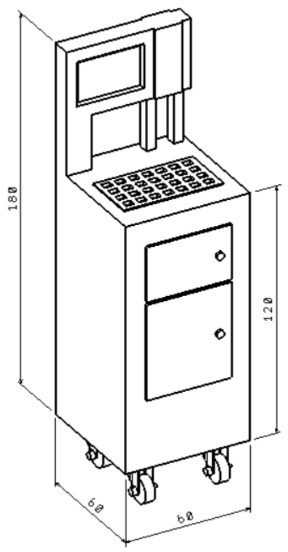


Fig. 4. Scaled equipment

The geometry of the 3D model, in .stl format, was reviewed using the Meshmixer program, then imported into the Cura slicer software. The model was conventionally oriented (see Figure 5), fixed on the printing table and the process parameters were chosen (material used, FDM printer, print type).

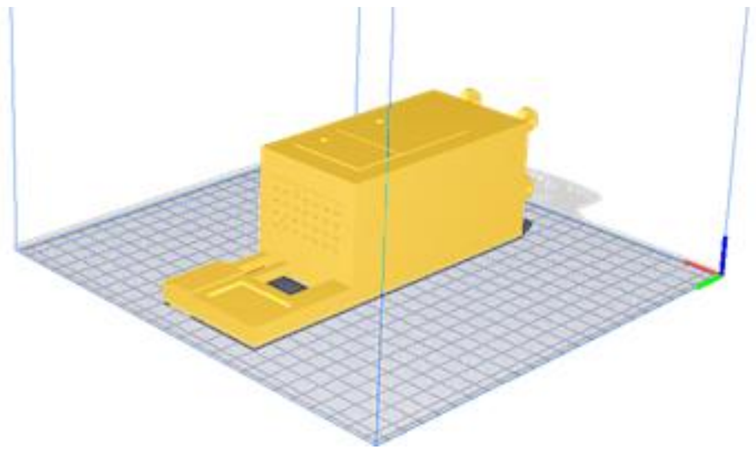


Fig. 5. Isometric view of the equipment before 3D printing

The process parameters set are shown in Table 2**:**

Tabel 2. 3D printing parameters

3D Printer	TwoTrees CoreXY SP-5
Material	PLA filament
Profile	Normal - 0,15 mm
Degree of filling inside the part	30%
Support	Yes

Assisted printing of the model was carried out using the TwoTrees desktop 3D printer model CoreXY SP-5 (see figure 6), ideal for prototyping and production of low-volume parts.

Fig. 6. 3D Printer used

The main technical features of the printer used are shown in the following table (see Table 3):

Tabel 3. Printer technical specifications

Number of nozzles	1
Nozzle diameter	0,4 mm
Print size	300*300*330 mm
Printing accuracy	±0,1-0,2 mm
Layer thickness	0,1 – 0,4 mm
Recommended speed	60 mm/s
Printing speed	max 200 mm/s

The material used for printing the prototype is polylactic acid (PLA), which is the most common material used in 3D printing with desktop printers due to its affordability and high mechanical properties (biodegradability, thermoplasticity, etc.). The specifications of the used material are shown below (see Table 4):

Tabel 4. PLA filament technical specifications

Material	Polylactic acid
Colour	Yellow
Transparency	Opaque
Tolerance	±0,05
Filament diameter	1,75 mm
Temperature of heated bed	50-60°
Temperature of the print head	200-235°

Figure 7 shows the model prepared for 3D printing and Table 5 shows the main specifications of the additive manufacturing process (see Table 5).

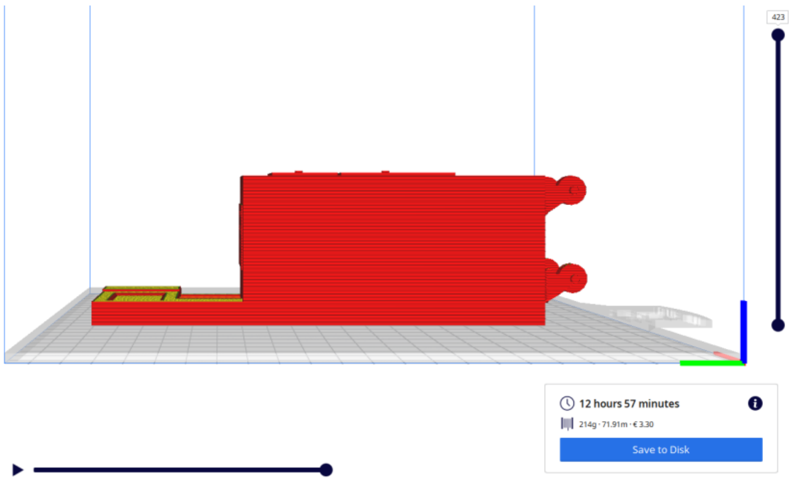


Fig. 7. Model prepared for 3D printing

Tabel 5. Main printing specifications

Manufacturing time	12h & 57min
Filament consumption	214 g / 72 m
Cost of filament consumption	3,3 €

Research conclusions

As people get older, they have to take daily medications, and cognitive decline can lead to undesirable events (failure to take the prescribed dose of medication). After a period of time following the outbreak of Alzheimer's disease, the patient becomes dependent on additional assistance, requiring hospitalisation in a dedicated care home. At the same time, a lack of qualified staff is noted, so in this work we have developed an assistive equipment dedicated to people with Alzheimer's, which ensures the independence of the beneficiary in his own home, his permanent monitoring, and the maintenance of a familiar environment.

In order to discover the need for the proposed equipment, as well as its possible improvements, I developed a questionnaire-type descriptive research on a sample of 111 people.

The proposed device was modelled using 3dsMax software, its technical concept was designed in Catia V5 software, and additive manufacturing was realized in Cura software application.

In the future, the design of the equipment is also pursued from a functional point of view, carrying out the simulation of the mechanisms incorporated in the equipment.

Bibliography

[1].Shaheen E Lakhan, , MD, PhD, MEd, MS, FAAN (2022), Alzheimer Disease
[2].Arshia Khan, Yumna Anwar, Paul Craig și Rana Imtiaz (2021), Robotic Assistive Technology Augmenting Dementia Care: Technology Design and Preliminary Acceptability
[3].Kazi Shahrukh Omar, Afia Anjum și alții (2019), An Intelligent Assistive Tool for Alzheimer's Patient
[4]. Mrityunjaya D H1, Kartik J Uttarkar2, Teja B3 și Kotresh Hiremath (2016), Automatic Pill Dispenser
[5]. Diaa Salama Abdul Minaam și Mohamed Abd-Elfattah (2018), Smart drugs:Improving healthcare using Smart Pill Box for Medicine Reminder and Monitoring System
[6].Anderson WL și Wiener JM (2015), The impact of assistive technologies on formal and informal home care