SmartBath: A New Bathing Concept for Disabled People

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Abstract Nowadays, the development of equipment for the elderly care is of great importance due to the increased number of elderlies. The requirements and failures of the existing elderly-care devices were studied in order to identify the most important needs of the bathing activity and then a new concept is proposed 'SmartBath'. The SmartBath is a new assistive technology to improve autonomy, quality, safety, comfort and hygiene of bathing for elderly or bedridden. The bathing is a daily activity that requires physical effort, dedication and time to perform from the caregiver. This new concept integrates an automatic control of the bathing temperature, water flow-rate and light intensity. This concept can be operated directly or remotely into the system using mobile devices.

Keywords Well-being · Assistive technology · Elderlies · Assistive bath · Medical devices

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P. Garrido et al. (eds.), *CONTROLO 2016*, Lecture Notes
in Electrical Engineering 402, DOI 10.1007/978-3-319-43671-5_39

1 Introduction

Based on the statistics [1], there is an increase in the number of aging population, which draws more attention to the development of medical devices for elderlies or disabled persons.

In this context, the healthcare should include services to promote better conditions for elderly groups and should comprise a complex system that integrates both process and the product [2, 3].

The entire development process was focused on the security and comfort for the bedridden or the disabled through medical devices that allow more independence. There is a wide range of equipment existing in the market, but they are usually used with the help of caregivers to perform daily care. Assistive technology is an alternative to solve and prevent problems such as the risk of falling, pressure sores areas, lack of mobility and cleaning [3, 4].

Particularly in the bath area, it is important to consider that not only elderly people have difficulties in bathing, and it is believed that about 5 % of the population needs help performing this task [4].

There are devices designed to help in different areas of care including bath, such as wheelchairs, support belts, smart environments, transfer chairs, among others [4, 6].

For a society to have good living conditions it requires some technologies that are comfortable and safe for the user [5, 6].

The highlight of this problem, the bath area, is conducted to the home in care given. Therefore, the device should be designed to integrate the care provided by caregivers (family or professionals) which however, will be given to only one person to perform the activities and required efforts with the bedridden [7–10].

This work is a product development process that seeks to transmit a new concept for care in the home and in the bath area. Therefore, conceptualize an intelligent bath to assist elderly people and/or their physical limitations in trying to improve the quality of life for both the user and the caregiver. It requires that the needs and limitations, due to lack of autonomy of users, are taken into account. This concept allows it to be handled by just one person, it is lightweight, portable, and easy to use, it promotes independence and good hygiene conditions.

The SmartBath development process described in this article is divided into five sections that explain its way of working, besides the introduction there is the related work; new approach of medical device; proposed control system and the final remarks of the work.

2 Related Work

Devices for assisting bath of older people and people with physical limitations are already commercialized. Among the existing devices some examples are presented below.

The Essence™ Apollo, Fig. 1 [11], aims to provide the care in assistive life, allowing easy and safe bathing experience for bedridden and caregivers. It has a lateral face structure which engages in various environments to allow an easy installation. The seat material is of glass fiber and it has a water drain system and removable side panels for convenient access of the flow components. The product has a safety system that closes the access door to the interior of the system. The product performs automatic cleaning and disinfection. This system promotes safety, comfort and hygiene of the user. The system disadvantage lies in the difficulty to transfer the bedridden into the system.

Another system that allows assisted baths is the Parker Bath® [12]. This is a safe solution; its structure has side access to the users. The shape gives caregivers contact with the patient to perform cleaning. The system includes a soap dispenser for cleaning and disinfection of the structure of the system. The structure should be fixed in the care facility. However, if the care facility does not have enough space, the installation is not possible.

The bath structure Bolero®, shown in Fig. 2, is a mobile device that collects the bedridden person from bed and transports them to the bath. It has a lift to adjust the required height, a lifting capacity of 136 kg and wheels with brakes. This product is efficient because it transmits comfort, security, mobility and hygiene. However, it has no support to be used without the elevator.

Considering the three presented equipment, the Essense Applo® has a functional drawback as it is not easy to transfer the bedridden into the system. The Parker Bath® has the aim to promote the bath care, but it does not allow to be used without the elevator. The Bolero® proved to be the most complete system but caregivers are not comfortable to provide care for a longer time using this equipment.

Table 1 presents the functional features of the commercial equipment presented.

By the performed analysis, it is possible to verify that the presented devices partially achieve the design requirements. From this, it is proposed a new approach of a medical device to afford better conditions of shower in bedridden people. The

Fig. 1 Apollo Essence™ equipment for bathing [11]

Fig. 2 Bolero® bathing mobile device [13]

Table 1 Functional features from the analyses of equipment

Equipment	Requirements
Essense Applo®	Fixed structure Installation needs bathroom changes Transportation needs more than one caregivers
The Parker Bath®	Mobile device Lift and easy to use Not comfortable for a long time Does not support use without elevator
The Bolero®	Mobile device Heavy structure Not easy to clean the back and waist area Not comfortable for a long time

aims to overcome the limitations of the referred systems, which could significantly improve the action of bath of elderly and/or bedridden people.

3 New Approach of Medical Device

Following the needs of the requirements to take care of bedridden people a new approach has been developed considering the concepts of Ambient Assisted Living (AAL). Basically it is designed to provide to a better quality of life in daily situations which will demand a lot of effort from to caregivers. The mechatronic system was projected to control all its integrated parts. The SmartBath (SB) provides to

older people a secure shower. This part has an integrated SmartBath Controller (SBC) to monitor and control system with the specifications of bath operation [14, 15] The two parts of the integrated system are connected through the contact of the base of the SB to the SCB, by a central plate fixed to the structure of the SCB [15] (Fig. 3). The system supervises, among other functions, the water flow rate, the water temperature and the light intensity.

The SmartBath (SB) is a design concept with a light and flexible surface which promotes an easy transportation. This approach was idealized with a washable material, specifically polyester. The system weight is around 30 kg. The SB integrates some technologies, such as motion detector to certify the correct adjustment of the person inside of the equipment [14.

Figure 4 presents the usage sequence of the SB. In the first step, transportation is executed by the caregiver, basically, the equipment must be picked and placed at the desired location. The second step, is to position the device on the horizontal plane. In the third step, the caregiver pulls the carry handle, thus extending all parts of the structure. In the fourth step, with the structure opened, the caregiver needs to organize the SB to start using it. By the fifth step, the door is opened to adapt the elder inside of the equipment. The sixth step, to finish this process, requires checking the position of the elder inside the equipment and, with the caregiver on the outside of the SB, the bath process starts.

The equipment has some functional parts. The structure is mobile, on the top it has a specific part, a grip specific for the product to be carried by hand. There is a side door to enter and exit the equipment. A retractable structure is considered to allow the door manual close and opening (Fig. 4-Open Door (5)) [15]. The system shows when it is prepared to begin. The structure is fixed by attaching rubbers between the frames and applying pressure. When the weight decreases, the pressure also reduces and the system can be removed for transportation. The showers have tuning capability with an extension of up to 1.50 m. The user is capable of moving his/her arms being able to control the bath (Fig. 5).

Table 2 presents the specific project parameters.

Moreover, the project should take into account the human factor requirements allowing the user to remain seated and that his limbs can move in order to perform a clean task. It intends to improve the performance of the equipment and to minimize

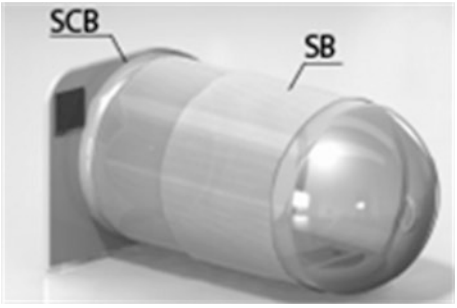

Fig. 3 SmartBath concept compose of two parts [15]

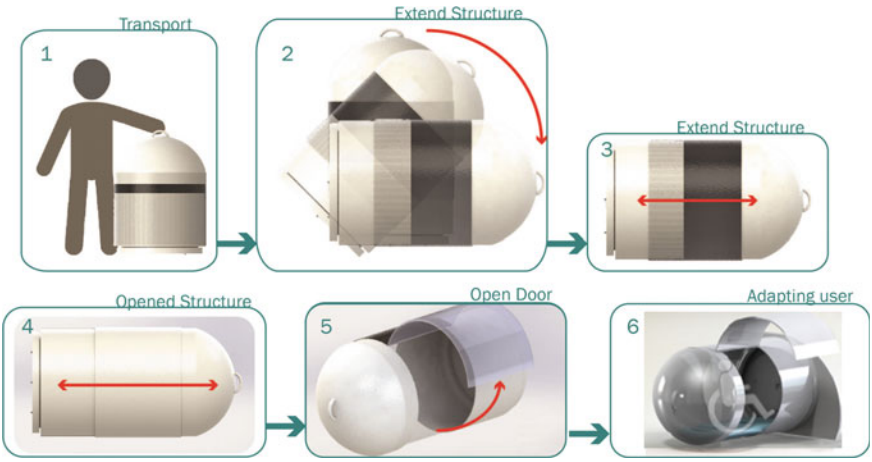

Fig. 4 The functioning steps of SB by caregiver

Fig. 5 Closed structure [14]

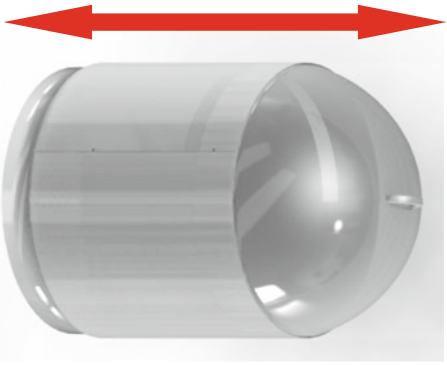

Table 2 Project Requirements

Requirements	Parameters
Average weight	120 kg—Maximum weight allowed to borne by structure [16]
Water temperature	From 0 to 40 °C [17]
General dimensions	1500 mm length, 770 mm width and 770 mm high
Volume of the reservoirs of water	Considered to be sufficient for 25 L of tank volume [18]

the risks related to the movement of bedridden between different environments. The user remains in his wheelchair to take a bath inside the SmartBath. Figure 6 represents a simulation of usage. Caregivers use the side door to put the elder inside

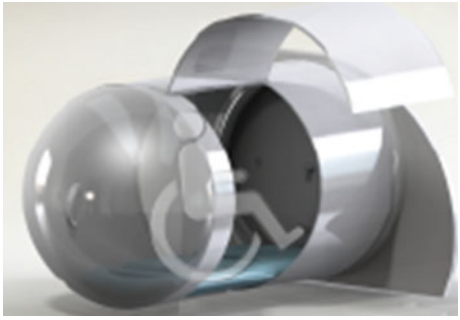

Fig. 6 Simulation of the usage

and then exit the SB. Only one person can enter the equipment as the person needs to stay seated to be able to bath.

Parallel to this bath system design it is being developed a water supply system. This is a modular system responsible for supplying the water for the bath and drain the used water. This will facilitate and make possible the versatility of the bath system.

4 Proposed Control System

The SmartBath (SB) can be installed inside any bathroom without compromising the aesthetics and performance. The design considers the usage in any environment with drainage for the evacuation of water. The temperature and flow rate are individually controlled unlike any other shower system, allowing a personal configuration.

For safety reasons, the device is designed with the possibility of mechanical use, not being restricted by possible electronic failure.

The interface used in the structure of the SmartBath controller (SCB) is used for control and monitoring of the bath operation (Fig. 7).

The main user of this equipment is the caregiver (a member of the family or a health technician). The primary control function is the ON/OFF button, followed by the desired water temperature (0–40 °C), light intensity (0–100 lx) and shower flow (water on/rinse off). The water flow can be controlled, as well as the rinsing function when the user is managing the bath. In general, the bath activity takes between 15 and 20 min, it has an alarm that indicates to the caregiver when entering the last 5 min.

For safety reasons, the system has a motion sensor implemented to ensure the correct position when the use is within the shower environment, as well as it is prepared to stop the operation at any time, if necessary.

In Fig. 6, the side door enables a better view for the caregiver during the bath, since the material used is transparent. The door can be handled both electronic or manually. The control part of the SCB is connected to the SmartBath and is removable and easy to transport. The designed control panel can be seen in Fig. 8.

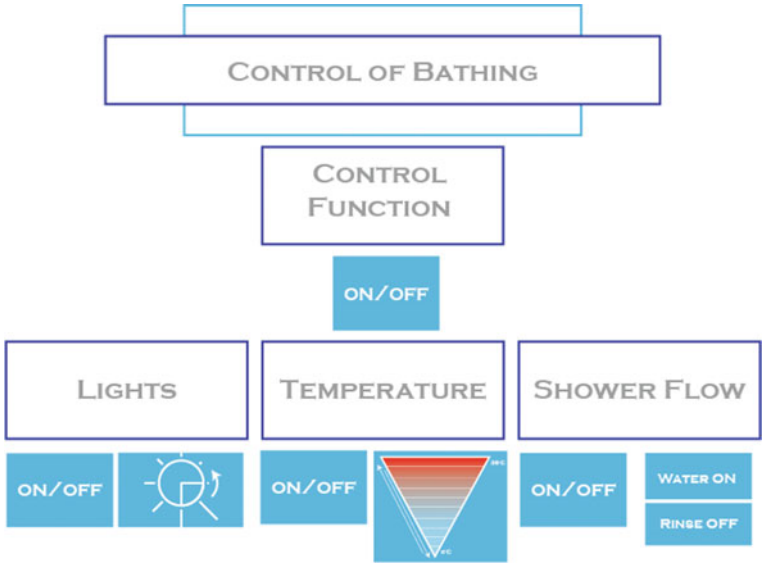

Fig. 7 System control panel

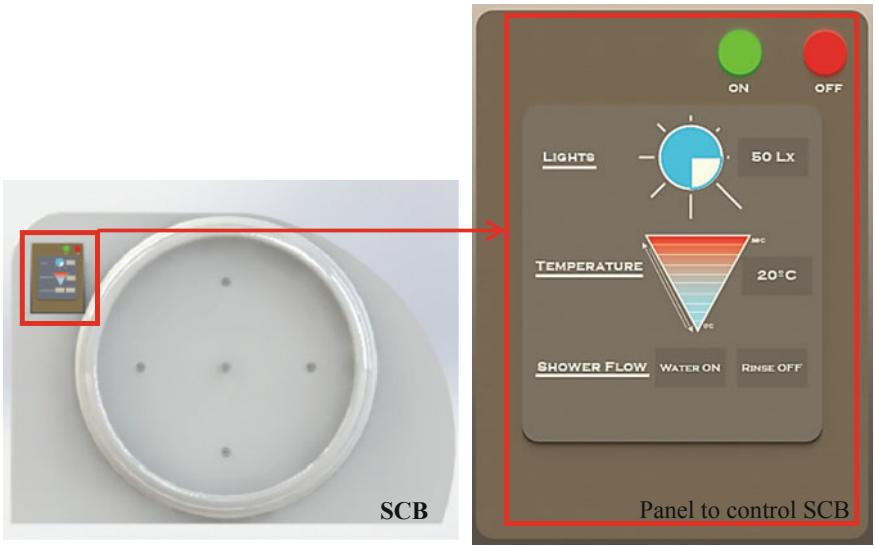

Fig. 8 The SmartBath (SCB) control panel

Once the system starts operating the functionalities can be activated by the caregiver and, following a sequence of options, which must be followed in the sequence described first, to connect the control functions for all the following

options to be enabled. This option was implemented to ensure that the device will not be activated without the user's permission, thus avoiding future errors in operation.

Therefore, after activating the control functions, the lights should be turned ON and set in a range between 0 and 100 lx, then turn ON the temperature option and set the desired temperature between 0 and 40 °C and finally enable the water flow ON and select the options of water or rinse.

The water supply system holds about 25 L [14, 15, 18] to support home environments. The shower is built-in the structure itself, at the top, its water supply is electronically controlled but in case of error automatically turns to manual override. The water control collects all the water already used and eliminates domestic sewer routes. The functions of the SB and SCB in this device provides the caregiver greater confidence that the bath is finally a pleasure, not an obligation, and through its use can have a higher quality of life.

5 Final Remarks

In this paper it was presented the design of a device to give bath to bedridden elderly people that can be operated by a single person (caregiver). The system integrates functions such as, the automatic control of bath temperature, water flow-rate and light intensity. It is capable of being operated directly by the SmartBath controller (SBC) and it is designed to optimize the care in the daily life of the bedridden elderly people. Moreover, it includes safety procedures allowing reducing possible errors, as well as physical efforts to caregivers.

It will be possible consider as future work a severe redesign. This project still has some shortcomings to be a final concept and an idealization of what would be best for the use of the caregivers in the bath task.

Acknowledgments This work has been supported by COMPETE: POCI-01-0145-FEDER-007043 and FCT – Fundação para a Ciência e Tecnologia within the Project Scope: UID/CEC/00319/2013.

References

1. Gallagher, A., Murphy, E., Fennell, A.: Ageing, Vision Impairment and Digital Inclusion in Ireland, pp. 1–7 (2014)
2. Després, C.L., Ramadier, T.: When mobility makes sense: a qualitative and longitudinal study of the daily mobility of the elderly. J. Environ. Psychol. **31**(1), 52–61 (2011)
3. Started, G.: Selecting the Right Bathing Systems for Your Facility, vol. 1, no. 1 (2005)
4. Brummel-Smith, K., Dangiolo, M.: Assistive Technologies in the Home: Clinic Geriatric Medical, vol. 25(1), pp. 61–77. Elsevier, Amsterdam (2014)
5. José, F., Cláudio, L.: Paulo Hartung Anselmo Tozi secretário de estado da saúde gerente de regulação assistencial, pp. 1–180 (2008)

6. Pinto, C.: Validação do Índice de Barthel numa amostra de idosos não institucionalizados. **25**, 59–66 (2007)
7. Mohamed, Z., Capi, G.: Development of a new mobile humanoid robot for assisting elderly people. Procedia Eng. **41**(Iris), 345–351 (2012)
8. MIT House_n Research Group. http://architecture.mit.edu/house_n/documents/2006
9. Friedewald, M., Punie, Y., Alahuhta, P., Heinonen, S.: Perspectives of ambient intelligence in the home environment. Telemat. Inf. **22**(3), 221–238 (2005)
10. Park, H.K., Hong, H.S., Kwon, H.J., Chung, M.J.: A nursing robot system for the elderly and the disabled. Int. J. Human-Friendly Welf. Robot. Syst. **2**(4), 11–16 (2001)
11. Apollo Essence™. http://apollobath.com/bathing-systems/essence-7000 (2015)
12. Parker Bath®. http://www.arjohuntleigh.pt (2015)
13. Bolero®. http://www.arjohuntleigh.pt (2015)
14. Bezerra, K., Machado, J., Carvalho, V., Soares, F., Silva, B., Matos, D., Leão, C.P.: System for assistance on bath of bedridden elderly people. In: ASME International Mechanical Engineering Congress and Exposition, Proceedings (2014)
15. Bezerra, K., Machado, J.M., Silva, B., Carvalho, V., Soares, F., Matos, D.: Mechatronic system for assistance on bath of bedridden elderly people. In: IEEE 4th Portuguese Meeting on Bioengineering, pp. 1–4 (2015)
16. Lima, R.F.: Adaptação ergonómica e antropométrica: Universidade do Minho (2012)
17. Ordem Arquitetos. Decreto-Lei n.º 163/2006 de 8 de Agosto. Diário da República (2006)
18. Smas-sintra Tecnirede. http://www.smas-sintra.pt/index.php?option=com_content&task=view&id=76 (2015)