Future Home 4.0 for People with Major Neurodegenerative Disorders, Finding the Contradictions

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Abstract
With the aging of the population, old people increasingly wish to stay at home before entering to a retirement home. There are several reasons such as: the cost of entry, the impersonal side and the lack of solicitation as well isolation and lack of identity are the elements that could delay the entry into the retirement home.
In this research, we would like to focus on persons with major neurodegenerative disorders who would like to stay at home as long as possible. These disorders are more and more present with aging of population, which lead us to reflect on the future home 4.0 by permitting residents to live their activities of daily living (ADL).
New technologies and connected objects could be the potential solutions for designing the future home. During this study, we will identify the contradictions that could be existed among different solution's concepts based on functional criteria. These criteria are proposed in parameters according to the TRIZ method in order to propose principles of solution's concepts.

Keywords.
Usage, Multi-user, Contradiction, Design, Neurodegenerative disorders.

1 Introduction

In the next ten years, the sociological face of French society will have changed because of ageing the population. People over 60 years old will represent a third of the population in 2040. People will live longer, but, with the emergence of new diseases, such as major neurodegenerative disorders, such as Alzheimer, Parkinson, Lewy bodies Corps, dementia vascular... [1], these pathologies differ from others as mobility difficulties or other physical disabilities.
The Neurological pathologies will have an effect on people staying at home, on their level of autonomy, as well, on their ability to continue the activities of daily living [2]. People affected by this pathology have also an impact on the healthcare assistant, that make him/her exhausted, tired and depressed.

The aim of this research is how to care these fragile people at home by identifying the contradictions and complementarity between their needs and their hops. Hence, the interest of this research is to adapt the home to this new situation. We will focus in this research on the future home 4.0 [3], particularly on the needs and functional study.

2 Research approach

Our approach in this research will be using a mix of the methods SWOT, User Experience and functional analysis. Each method will be satisfied and answered to the needs of our case.

The SWOT (Strengths, Weaknesses, Opportunities and Threats) method permit us to analyze and diagnostic the current situation of resident by Strengths, Weaknesses, Opportunities and Threats. The factors which are important role in her/his environment both interior and exterior of home. The objective of user experience is multiple. It can be user experience for a resident life style at home, healthcare assistance, nurses or other person who help the resident. We will discuss for all type of users in this paper. For example, the resident need to participate and to perform their daily activities.

She/he should use specific product, system, or services immediately in an easier way in our case. This products, system or service must be ergonomic and applicable immediately. The functional analysis method allows us to do study of needs for the new home 4.0. [4], that we used it based on TRIZ approaches. Figure 1 show the relations and needs in our methodological approach.

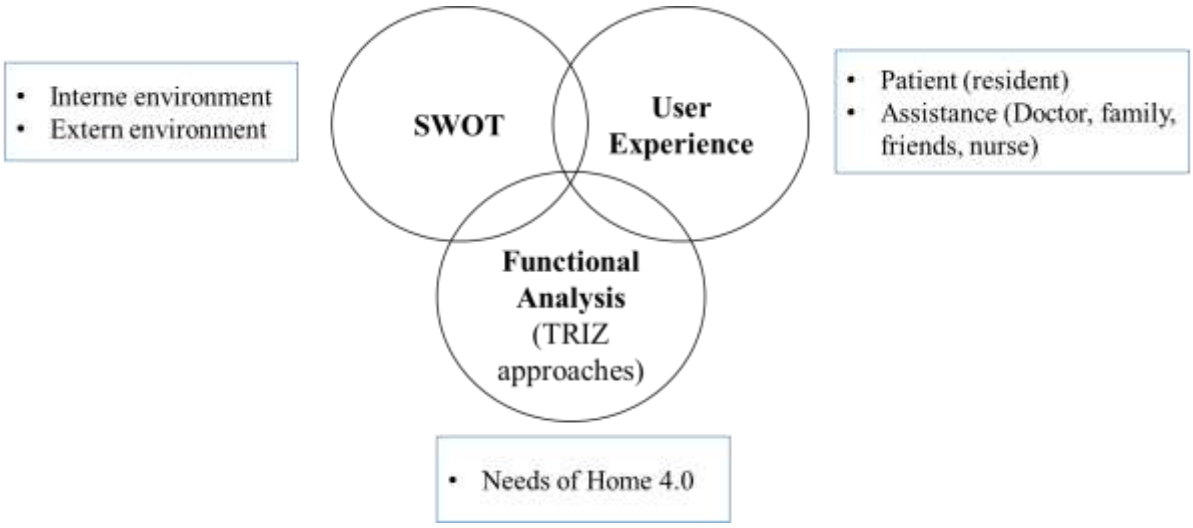


Fig1. Our methodological approach

3 Home 4.0

3.1 Current situation

In these days, the old French people wish to stay at home as long as possible. They prefer to delay the time of moving to retirement home, whether alone or rally around. Therefore, their family at home tries to innovate or have a long-term planning. They start to modify their house or apartment, such as rearranging the bathroom (on a level) or removing the access of rooms on the floor and preparing house on a level. Sometimes, they sell their house and by another. Therefore, they try to change their house to have more functional and comfortable for their old person. That means they anticipate rearranging the house depending disabilities of their old person. In the framework of this work, it is necessary to demonstrate the way of preparing home for the old person in order that he/she could stay at home as long as possible. It is about replacing the user, the future resident, at home as part of his/her needs and imagine the future home to be functional [5]. The future resident of home 4.0 could be different kind of users at home and the user or resident in this paper is mainly the old person how will live in home4.0 . The other users could be presented at Home 4.0 such as: a healthcare assistant, nurse, family doctor or neighbors.

3.2 The analyze of current home based on SWOT method

At first, we propose to perform analysis of strengths and weakness for the current home in order to reflect on the future home 4.0. These analyses are based on SWOT method. This assessment permits us to provide a better understanding of the resident's interests at home, about his/her strengths and limits and possibility to improve the house (table 1).

Strengths	**Weaknesses**
- Continue to have her/his habits and activities at home - Social bond with friends and neighbors - The resident is not disoriented - The budget is lower regarding the place - Keep his mark on the surrounding, neighbors, friends. - feel more comfortable in the apartment - The resident has self-confidence thanks to this autonomy - The resident could be always autonomous	- The resident is alone with an evolving pathology and with security risks - Less monitoring - Monitoring is not continuous - Isolation of the resident, anonymity - Non-regularity of needs - any alerts in case of problems (fall down, slips, or movements ...)
Opportunities	**Threats**

- Activities of daily living are not only stopped, but also are active by cognitive stimulation - The resident "EXIST" and has an identity - The effects of the disease could be delayed - Cost of retirement home could be still saved	- Retirements homes are growing ... - There is no financial ways to renovate or update the home - The resident is ALONE at home - there is no more help, in case of natural disaster or technical problem in the building

Table.1. Study of the current home from the SWOT grid

In SWOT method, Strengths, Weaknesses are about intern factors, in our case it is about the situation of resident at home. The Opportunities and Threats are about extern factor, so in our case exterior of resident's home, means environment factors which could have an effect on the resident.

3.3 The future home 4.0

The connected and automated objects will have main place in this new future home 4.0. The objective is not setting up a hyper connected environment, but to assess the autonomy of the resident and evaluate her/his needs as an actor for his/her daily activities [6]. The renovated home will not only be a place to live her/his end of life in a way just "cared", but also, to be able as an actor to manage his/her handicaps and degree of autonomy. Hence, the home should not just be a place to live, but, a place where cognitive stimulation or other forms of stimulation are part of daily activities.

The type of home that we would like to design for the resident consist in being able to stimulate activities of daily living (ADL) safely, in a way that the social bond is as well safeguard.

Actually, in this case, there is the expertise of user instead of customer's needs. That means, the resident of the home is no more a customer who expects a service for a payment, but, an expert user who knows his/her pathology through the healthcare assistant. The healthcare assistant changes his role; she/he has to no more suffer the effects of disease, but must anticipate its effects. The medical body does not only provide the care or a specific service, but also, they must accompany the resident in his activities of daily life [7-8].

4 User Experience UX

4.1 Definition of User Experience UX

In recent years, some authors have focused on the user experience, called "user experience (UX)" [9-10]. This refers to the experience of a person using a specific product, system or service. It's about making a product, a system easy to use, under-

standable immediately, ergonomic, logical, by integrating user experience into product design [11-12].
In this sense, design studies must be able to identify or consider different users according to the product's life cycle. It is not rare to note that the product in operation phase has several users. Designers must transform customer's/user's requirements into product performance. It should be noted that the requirements of the customer are not the same as those of user (it is the first level of contradiction). Subsequently, the designers will have to prioritize these users, in order to better understand the features of the product according to the type of user. The functional analysis makes it possible to answer it.

4.2 Different users UX

Analyzing a need means translating the product into "Customer specifications" and/or "User's specifications". The "client as user" reasons in solutions rather than needs. When there are multiple users, we talk about multi-users. The functional analysis approach is a response to this search for users' needs. In our study for designing the future home, we are looking for different types of users as showed in table 2.

User type	(UX_i)	User-Experience	Activities
Resident at home (different users)	UX_1	cooker	Culinary activities, washings dishes, setting the table ...
	UX_2	Gardener	Gardening, Planting, Watering…
	UX_3	Cleaning agent	Setting the table, clearing the table, washing dishes …
Healthcare assistant	UX_4	Nursing	Toilet, hygiene…
Nurse and/or doctor	UX_5	Medical follow-up, taking medicine	Manage medicine, perform care
Neighbors and/or Friends	UX_6	Conviviality, social bond,	Sharing moments, tea, outing…
Relationship, family	UX_7	Legal guardian, guardianship ...	Guarantor against institutions
Care staff	UX_8	Speech therapist, Physiotherapist ...	Bridging or stimulating the resident's lack of autonomy

Table 2. The different users at home.

5 Functional analysis for home 4.0

5.1 Study of Needs

A study of need is required in order to know exactly the needs for this new home 4.0. We propose to use the tools of study needs for functional analysis proposed by

the firm APTE. There are some questions raise in order to define the goal or objective of this future home 4.0.

- Who does it help?
- What is used for?
- Who is it acting on?
- What does it work on?

At last, for what purpose or objective? We present in table 3 a synthetic result of study of needs for future home 4.0 by using the tool of cabinet APTE.

Who does it help?	People with major neurodegenerative disorders (MND)
What is used for?	Make their life easy and safe
Who is it acting on?	Multi-user (patient, caregiver, etc.)
What does it work on?	Daily life activities' simulation
For what purpose or objective?	Allow people with MND to stay in their adapted home (future 4.0) to their pathology as long as possible
Why this need exists? (purpose, reason)	Many people will be getting old with this pathology and wish to stay at home as long as possible. The retirement homes are limited and do not completely respond to this new pathology
What could make it disappear? or evolve it?	A remedy, medicine ... cure these pathologies of memory disorders
What is the risk of disappear?	Nowadays, there is no any positive sign that appears as a solution to fight against these pathologies

Table 3. Study of the need for the future home4.0

5.2 Functional analysis

We made our analysis form two levels: outside environment search and Service and constraints functions. The results of our analysis from outside environment search is presented in table 4.

Mi	**Type of outside environment**	**Description of outside environment**
M_1	Kitchen equipment	Set of utensils for cooking ...
M_2	Gardening equipment	Bins, flowerpots, utensils, watering can, seeds ...
M_3	Mobility system	Staircase, walker, wheelchair, cane
M_4	Home resident	Person with MND, early stages (pathology)
M_5	Help team and accompanied *	Healthcare assistant, Living Assistant Gerontology
M_6	Security ways	Alarm, keys, Digi code…
M_7	Nurse, doctor, parents ...	Medical corps specialized in home care
M_8	Speech therapist, Kenseisha. **	Specialists in effects of pathology
M_9	Hygiene equipment, maintenance	Sponge, broom, washing machine, brush, products
M_{10}	Entertainment system	TV, games, books, armchair

** accompaniment (Healthcare assistant, Living Assistant ...)*

***physiotherapist*

Table 4. *outside environment search*

In Service functions and constraints functions levels, the results are presented in the table 5:

F_i	Description of functions	Criteria C_j	Level N_k	Flex. Fl..
F_1	The home 4.0 must allow resident to be mobile thanks to the mobility system	Mobility Type of material	100% Base	Fl.2
F_2	The home 4.0 must allow resident to dispose kitchen equipment for doing culinary activities safely	Type of material Type of activities	Autonomes	Fl.3
F_3	The home 4.0 must allow resident to welcome help team such as, doctor, nurse, physiotherapist, neighbors, parents ... in good conditions.	Type of help Type of reception	Pathology Access Intervention	Fl.3
F_4	The home 4.0 must allow resident to practice gardening activities safely	Type of activity Type of security	Autonomous 100%	Fl.3
F_5	The home 4.0 must integrate home security systems of resident	systems Level	100%	Fl.1
F_6	Home 4.0 must be adapted to receive health personnel in order to provide personalized care to resident	Type of access Type of care	Free Autonomous	Fl.1
F_7	Home 4.0 must allow resident to continue the maintenance and hygiene activities of her/his home	Type of activities Maintenance level	Phase 1 to 5 (illness)	Fl.3
F_8	Home 4.0 must have an entertainment system for the resident based on his degree of independence	Type of autonomy Entertainment type	Phase 1 to 5 (according autonomous)	Fl.3

Table 5. Service functions' list or future home constraints

5.3 Interaction of functional criteria

In the table 6, we privilege the functions and criteria related to safety according to the different users.

Functions	Participant	Criteria	C_i
F_1 Mobility Assistance	Resident (without activity)	Degree of autonomy and Walking equipment	C_1
F_2 safety	Resident (without activity)	Fonct. degree of Autonomy	C_2
F_3 Reception of health staff, friends, healthcare assistants, parents	Healthcare assistant, helper	Resident Hygiene Access	C_3
	Physiotherapist, speech therapist	Adequate equipment, local,	C_4
	Doctor, Nurse	Access, secure medicine ...	C_5
	Friends, parents	Access, service, conviviality	C_6
F_2 Cooking activities	Resident	Dexterity, security	C_7
	Assistant	Memory, procedure ...	C_8
F_4 Garden activities	Resident	Dexterity, time ...	C_9

		Products choice	C_{10}
F_7 Maintenance activities	Resident	Products safety	C_{11}
		handling	C_{12}
F_8 Relaxation activities	Resident	Comfort	C_{13}
	Resident	Freedom of movement	C_{14}
		Motivation of activity	C_{15}

Table 6. Criteria's Functions and safety according to the type of user

6 Discussion

Based on different criteria, we will seek the opposition criteria or complementary criteria, in order to find a solution, as presented in table 7. For examples, we present criteria that are complementary or in opposition one to another and we propose recommendations in terms of solutions. These recommendations can have a positive impact on the choice of solutions. For exemple :

From the criteria resulting from the functional analysis, the question is converting them into parameters in order to emerge contradictions among them, and find the principles of solutions' Concepts.
The criterion C2 (Function F2) is "Degree of autonomy". The degree of autonomy is specified: either total or less use of right hand or left hand (depends on the person is right-handed or left-handed). The criterion C7 is "level of dexterity" of resident to carry out certain cooking activities that require the use of both hands. A contradiction is:

- Either, to increase the degree of autonomy for criterion C2 by asking resident to work in groups of two people,
- Or, to decrease the C7 criterion by looking for an ergonomic device that comes to replace the deficient hand.

Opposition criteria	**Comments**
$C_2 – C_7$	Secure resident during cooking activities (knives, electrics...). Secure devices for people with MND. Make the resident autonomous with a minimum of safety whereas the safety in the kitchen must be increased
$C_7 – C_{11}$	Safety systems for cooking as well, maintaining furniture, there are not the same level of protection on the floors or other parts of home. The kitchen must be secured regarding the movement of residents, while, it is forbidden for maintenance
Complementary criteria	**Comments**
$C_9 – C_7$	About these two activities (garden and kitchen), we use cutting or slicing objects... in the same manipulations.

	Only the base changes. Electrical tools are also dangerous and must be secured.
$C_{11} – C_2$	In general, the resident must be safe in his basic daily activities such as arrangement and storage activities, maintenance ... The use of dangerous products must be controlled, monitored ... both in terms of arrangement and manipulation level.
$C_2 – C_{13}$ et C_{14}	safety depends on the disability of the resident and his pathology. This security is done in agreement with the resident without risky activities (cooking, gardening, maintenance ...)

Table 7. the opposition criteria or complementary criteria

7 Conclusion

In this paper, we wanted to discuss innovative research support such as the study of the future home in the medico-social sector. This support is topical because of the aging of the population and the response that society will have to provide.
In answer our research problem we used a mix of three methods SWOT, User experience and functional analysis.It is this framework we also used the functional analysis and the beginning of the TRIZ approach. This work is a beginning of reflection and deserves to be followed-up in subsequent studies. In the future work we work on how to transform the functional criteria into TRIZ parameters in order to look for principles of solutions.

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