State Of Art on Ontologies for Improving the Living Conditions of Seniors: Positioning Towards Learning Systems For Seniors

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Abstract: - Older people are fragile people who need the support of other younger people and even help from new technologies to improve their living conditions. The issue of improving the living conditions of senior citizens through intelligent computer systems is discussed in this article. We present a state of the art on intelligent computer systems techniques, in particular ontologies for improving the living conditions of seniors, in order to highlight some shortcomings and take a position accordingly.

Key Words: —*Senior, Intelligent computer system, Ontologies, Improve living condition.*

I. INTRODUCTION

Old age is an inevitable and natural period of human life characterized by reduced body functions, loss of adult social role, changes in physical appearance and a gradual movement towards loss of ability. Several studies show that the world's population is aging more and more. Indeed, according to the United Nations (UN) surveys done in 2005, people aged 60 and over represented nearly 5% of the total population and will represent nearly 10% in 2060 [1]. In Africa, for example, the number of elderly people is increasing by around 2.6% per year: the number of people over 60 years of age has increased from around 12 million in 1950 to 53 million in 2005 and will reach, according to United Nations estimates, 200 million in 2050 [2]. According to the projections in 2050 [3], the growth of the proportion of people over 60 years old is given in Figure 1. In this figure we can see that, in the regions of Africa, the proportions of people over 60 years old will represent in 2050 14.9% of the population in Southern Africa, 6.4% of the population in Central Africa, 8.2% in East Africa, 6.9% in West Africa and 17.3% in North Africa.

Faced with such a trend towards aging, it is important to give special attention to this segment of the population, which represents the "old" also called seniors.

Manuscript revised June 24, 2021; accepted June 25, 2021.
Date of publication June 26, 2021.
This paper available online at www.ijprse.com
ISSN (Online): 2582-7898

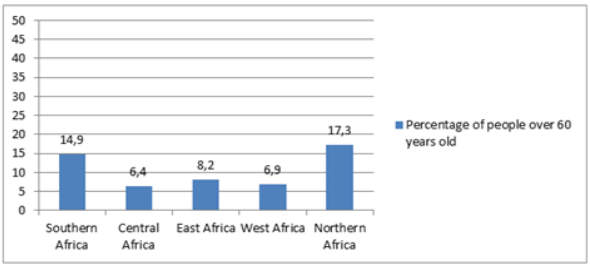

Fig.1. Percentage of over 60 years old in African regions as forecast in 2050 [3]

The issue of improving the living conditions of senior citizens through intelligent computer systems is increasingly addressed by researchers. Several proposed platforms [4] [5] [6], some developed applications [7] [8] [9] and others have even designed computers [10] [11].

Other researchers have used techniques such as Internet of things (IoT), Multi-agent System (MAS) and ontologies to provide systems for intelligent habitats [12] [13] [14] [15] [16] [17] and for health monitoring [18] [19] [20] [21] [22].

The objective of this work is to make a state of the art on ontologies designed to improve the living conditions of seniors, in order to highlight some shortcomings and take a position.

The rest of the document is presented as follows: section 2 presents the methodology used to achieve the objectives, section 3 presents an overview on ontologies, sections 4 presents the state of the art on ontologies designed to improve the living conditions of seniors; section 5 is devoted to the

discussion in relation to the state of the art, and the last section presents a conclusion of the work.

II. METHODOLOGY

In order to achieve the objectives, the main approach we followed is shown in Figure 2. Indeed, we have performed advanced searches in Google Scholar, Research Gate and many other scientific database using keywords and titles that have a connection with our topic such as: senior, elderly, old person, ontology, improve living condition, learning and so on, and we found several scientific articles, theses, conference papers and reports that deal with seniors in general, their living conditions and the technologies used to improve their conditions. Among these documents we applied a filter from 1990 to 2021, we analyzed the content and we selected more than 60 documents that have a direct link with our objectives. These documents constitute the main references of this work

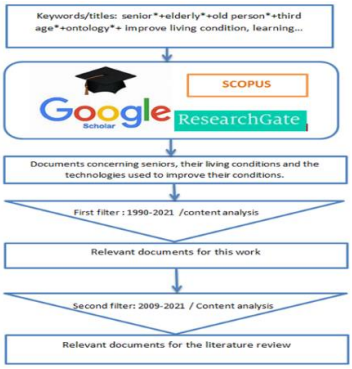

Fig.2. Approach followed to search for documents

To carry out the state-of-art parts on ontologies designed to improve the living conditions of seniors in this article, among the selected documents we have carried out a second filter by sorting and prioritizing the articles, conference papers and recent theses of the last twelve years (from 2009 to 2021) that fit most with our target.

III. BACKGROUND ON ONTOLOGIES

In this section, it is a question of defining the notion of ontology, presenting the different types of ontologies and its methodologies and design tools.

A. Definitions

The term "ontology", borrowed from philosophy, designates the part of metaphysics, which applies to being as being, independently of its determinations.

In artificial intelligence, several definitions of the concept of ontology have been proposed. Indeed, in 1993, Gruber [23] defined ontology as an "explicit specification of a conceptualization". The latter has become the most commonly used in the literature and in particular in artificial intelligence. Ontology is defined there as the elaboration of an abstract model of a real world domain by identifying and classifying the relevant concepts describing this domain [24]. Formalization consists in making this conceptualization exploitable by computer systems [25].

In the same logic as Gruber, for Guarino and Giaretti (1995) an ontology is a logical theory, which offers an explicit and partial view of a conceptualization: "an ontology is a specification partially accounting for a conceptualization" [24].

Finally, we can think of an ontology as a structured set of terms and concepts representing the meaning of an information field, whether through the metadata of a namespace, or the elements of a knowledge domain. Ontology itself constitutes a data model representative of a set of concepts in a domain, as well as the relationships between these concepts.

The primary objective of an ontology is to model a body of knowledge in a given domain, which can be real or imaginary. Ontology can serve the purposes of communication (human and organizational), interoperability (machine and systems), and systems engineering.

B. Types Of Ontologies

There are several types of ontologies [26]:

Domain Ontologies:

Reflect the vocabulary of a specific domain through concepts and relationships that model the main activities, theories and basic principles of the domain in question. They can be reused for several applications concerning the field for which they were created because they have been designed as independently as possible of the type of manipulations, which will be carried out on this knowledge.

Applicative Ontologies:

[27] are the most specific ontologies; they contain the knowledge required for a particular application and are not reusable. They can also include a domain ontology.

Generic Ontologies or High-Level Ontologies:

They express valid conceptualizations in different domains of relatively general value such as notions of objects, property, value, state, or even concepts of time, space of 'events. They are

intended to be used in various situations, and to serve a large community of users.

Representation Ontologies:

which groups together the concepts used to formalize knowledge. Among the representational ontologies, we find ontologies that will describe the notions used in all ontologies to specify knowledge, such as substances, concepts, relationships, etc.

C. Methodologies and Tools for Developing Ontologies

Several Researchers Have Proposed Methodologies For Developing Ontologies. We can cite lenat and guha [28], who published in 1990 the general stages and some interesting points on the development of the cyc method; bernaras and his teams [29] who proposed kactus [30] in 1996 (method of constructing an ontology in the field of electrical networks); the natural language group information sciences institute (isi) which proposed sensus [31] in 1997; york sure and his team from the karlsruhe institute of technology who proposed the on-to-knowledge methodology [32] in 2001.

Regarding ontology design tools, they are classified into 2 main categories: tools dependent on the representation formalism (ontolingua [33], ontosaurus [31], webonto [34], oiled,) and tools independent of the representation formalism (protégé [35], ode and webode [36], ontoedit [37]).

IV. State Of The Art On The Ontologies Related To Seniors

Many researchers have proposed ontologies aimed at improving the living conditions of seniors.

Indeed, in 2009 Juan A. Botia Blaya and his team [38] proposed an "Approach based on ontology for the detection of domestic problems for independent elderly people". This detection is done using a network of sensors and an intelligent processing unit in a single and small processor. This type of non-intrusive system encourages older adults to increase their perception of independence and security at home.

In 2010, Farah Arab [39], proposed ontologies for the design and evaluation of training aids for aging subjects. The first objective of his work was to contribute to the knowledge of the problems of activity limitations and restrictions on participation in society encountered by aging people. The second objective consisted in preserving the capacity and the power to act of these people during the home activities of daily life. And, the third objective aimed to enrich the model of the subject taken into account in the design. Thus, in her work, she proposes an Ontology of the capable subject, an Ontology of the resource system and an Ontology of the activity of the senior.

In the same sense, in 2015 Fatiha Latfi [40] proposed a "meta-model based on ontologies for an intelligent habitat dedicated to people with loss of cognitive autonomy". Her meta model, inspired by the advantages of modularity, consists of eight ontologies by means of which she describes the aspects which, in her view, complement each other and make it possible to consider the whole of the Smart Homes system and Telehealth. Thus, it describes the structural and material dimension through the ontologies of housing and equipment. The human and behavioral aspect is described using the ontologies of the person and behavior. Finally, the decision-making part is taken care of by the ontologies of the task, decision, software applications and that of the events.

In 2015, Qin Ni and his colleagues [41] in an article entitled "The Elderly's Independent Living in Smart Homes: A Characterization of Activities and Sensing Infrastructure Survey to Facilitate Services Development" first propose a classification of the main activities taken into account in smart home scenarios that target independent living for the elderly, as well as their characterization and formalized contextual representation; second, they classify sensors and data processing methods that are suitable for detecting the above activities. Their goal is to help researchers and developers in these low-level technical aspects that are fundamental to the success of a complete application.

Nachabe et al. [42] in 2016 offered ontosmart, an ontology-based tele-health system for home care of the elderly. Indeed, the authors proposed flexible independent sensors and scenarios sensitive to the context and distributed based on standardized ontologies of e-health and a multi-agent architecture. This is to ensure the safety of patients and inform their relatives and medical staff of their status.

In 2017, Marjan Alirezaie and his team [43] propose in an article a framework called E-care @ home, composed of an IoT infrastructure (Internet of Things), which provides information with a meaning shared without ambiguity between IoT devices, end users, loved ones, health and care professionals and organizations. They focused on integrating measures collected from heterogeneous sources using ontologies to allow a semantic interpretation of events and an awareness of the context. E-care @ home was also developed to help seniors who live alone in smart homes. It is made up of 10 interrelated ontologies.

In an article published in 2018 under the theme “An Ontology-Driven Elderly People Home Mobilization Approach”, Karagiorgou Sophia and his team [44] proposes a semantic interoperability agent which exploits the monitoring of mobility and spatio-temporal characteristics for extract human profiling and encourages mobilization at home. The agent exploits an extensive ontology which facilitates the collection of evidence of the effects on the movement control of the elderly. To assess the proposed semantic interoperability agent, data on human mobility were collected and analyzed according to daily activities, their duration and their mobility patterns.

Sheik Mohammad Mostakim Fattah and Ilyoung Chong [45] proposed in 2018 a semantic modeling technique for the composition of manual and semi-automated services. Their objective was to provide a framework to enable the composition of web services using a semantic ontology for the creation of life support services for the elderly in a smart home environment based on the Web of Objects (WoO).

In 2018, Rahma Dandan and her colleagues [46] set up an ontology for the description of the activities of the elderly. Indeed, in their work they present the approach used to model the activity and the conception of the ontology of the activity for the elderly which they called OAFE (Ontology of Activities For Elderly). They present the knowledge-based approach as being the most effective for representing activity, managing sensor data and reasoning on modeled knowledge. Using knowledge engineering methods, they were able to model the concept of activity by considering the variables used in defining the profile of the elderly. To design and evaluate the OAFE, they relied on scenarios and competency questions as a means of determining ontology specifications. Their ontology makes it possible to reason to establish personalized, targeted and incentive suggestions for the elderly.

In 2019, Yasemin Afacan and Elif Surer [47] start from the fact that the inaccessibility of buildings is a common problem that presents obstacles for older people with different motor skills and therefore an inclusive design process, where older people and designers are working together, is necessary to overcome this obstacle. Thus, they propose a user-oriented model (i) to define a presentation of knowledge for designers; (ii) to support them in the development of accessible housing and (iii) to accommodate exemplary housing attributes for activities of daily living. The ontology of this model was first constructed by collecting information about the user regarding the four subdomains of motor skills namely strength, balance, locomotion and endurance.

Nora Shoaip & al. in 2020 [48] designed a complete decision support system based on a fuzzy ontology for the diagnosis of Alzheimer's disease. This is a comprehensive semantic knowledge base for the development of a fuzzy ontology-based clinical decision support system for the diagnosis of Alzheimer's disease. The proposed disease diagnostic ontology serves as a central component of the decision support system, which provides representation, annotation and access to aspects related to the study and diagnosis of Alzheimer's disease. This ontology is based on the essential principles of Open Biomedical Ontology (OBO) and follows the principles of Basic Formal Ontology (BFO) and Ontology for General Medical Sciences (OGMS). The proposed ontology focuses on representing patient characteristics, complications, medications, diagnostic examination tests and key aspects of their periodic visits in a standard way.

Hajar Khallouki & al. [49] recently proposed in 2020 a complete ontological model for the recognition of well-being activities in the smart home. Their approach takes into account different aspects of the well-being context such as the patient's profile, the object used to carry out the activity, the time of the performance of the activity, its location, etc. The authors start from the fact that most research in the field of “smart home for the elderly” has focused on the recognition of activities (e.g. eating, sleeping, watching television, etc.) which can be defined as l " identification of a sequence of actions (eg using a microwave, going to bed, etc.).

Also in 2020, Jorge Gómez Montalvo's team [50] is offering OPAIEH (Ontology-based Platform for Activity Identification of the Elderly at Home), an ontology-based platform for identifying the activities of elderly people at home. Identifying activities is a key part of helping older people living alone. The platform includes the ontological model, which allows a new characterization of the activity, a network of sensors, a client device and a web server to perform the recognition of the different activities that the elderly do inside their home. In addition, the platform generates a set of graphs that show different statistics and user behaviors. In order to carry out an experimental test on OPAIEH, a case study was developed as a proof of concept on the use of ontologies for the activity recognition task.

In 2020, Martin Kodys [51] proposes a semantic reasoning, for an intelligent assistance platform, oriented to well-being and digital health.

The table below presents a summary of these ontologies presented.

Table.1. Summary of the study on ontologies related to senior domain

Designation	**Year**	**Goals**	**Field**				**Tools**	**Learning context**	
			Health	**Social**	**Smart home**	**Learning**		**Reusable ontology?**	**Reusable classes**
Botia & *al.*[38]	2009	*Detection of senior household problems*	*No*	*No*	*Yes*	*No*	*Sensor network*	*No*	//
Farah Arab [39]	2010	*Design and evaluation of empowering aids for seniors*	*Yes*	*Yes*	*Yes*	*No*		*Yes*	*Ontology of the capable subject;* *Ontology of senior citizens' activities*
Fatiha Latfi [40]	2015	*Detection of senior household problems*	*Yes*	*No*	*Yes*	*No*	*Sensors*	*Yes*	*Ontology of the person;* *Behavior ontology*
Qin Ni & *al.* [41]	2015	*Detection of senior household problems*	*No*	*No*	*Yes*	*No*	*Sensors*	*Yes*	*Classification of activities*
Nachabe & *al.* [42]	2016	*Home care for seniors*	*Yes*	*No*	*Yes*	*No*	*Agents and Sensors*	*Yes*	*E-health ontology*
Alirezaie & *al.* [43]	2017	*Help seniors who live alone*	*Yes*	*No*	*Yes*	*No*	*IoT*	*No*	//
Karagiorgou et *al.* [44]	2018	*Movement control of seniors*	*No*	*No*	*Yes*	*No*	*Agent*	*No*	//
S. M. Fattah & Ilyoung Chong [45]	2018	*Creation of life support services for seniors*	*No*	*No*	*Yes*	*No*	*WoO*	*No*	//
Rahma Dandan & *al.* [46]	2018	*Description of senior citizens' activities*	*No*	*No*	*Yes*	*No*	*Sensors*	*Yes*	//
Yasemin Afacan & Elif Surer [47]	2019	*Facilitate access to buildings*	*No*	*Yes*	*Yes*	*No*		*No*	//
Nora Shoaip & *al.* [48]	2020	*Diagnosis of Alzheimer's disease*	*Yes*	*No*	*No*	*No*	*Fuzzy logic*	*Yes*	*Ontologie du diagnostic de la maladie*
Hajar Khallouki & *al.* [49]	2020	*Recognition of wellness activities*	*Yes*	*No*	*Yes*	*No*		*Yes*	*Recognition ontology of well-being activities*
Jorge Gómez Montalvo & *al.* [50]	2020	*Identification of senior activities*	*No*	*No*	*Yes*	*No*	*Sensor network*	*Yes*	*Activity identification ontologies*
Martin Kodys [51]	2020	*Assistance focused on well-being and digital health*	*Yes*	*No*	*Yes*	*No*		*No*	//

V. Analysis, Discussion And Positioning

The analysis of Table 1 on ontologies dedicated to improving the living conditions of senior citizens is summarized in Figure 3.

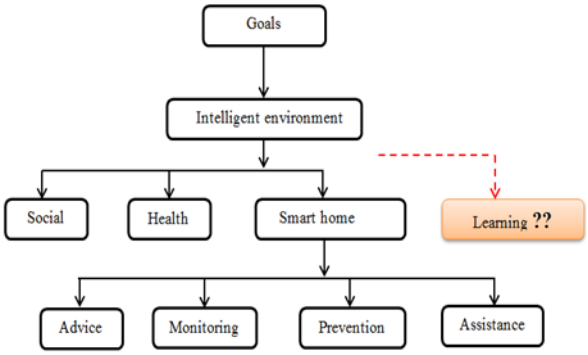

Fig.3. Organization chart showing the axes of the objectives scanned by ontologies for seniors

After analyzing, it emerges that the existing ontologies for seniors up to now are much more oriented in the areas of health, the design of smart homes and in the social aspect, in particular for surveillance, prevention and assistance, to help these seniors. This work has not placed an emphasis on the learning for the seniors. We can see that much remains to be done regarding ontologies for the design of intelligent learning systems for seniors. However, there are also among these presented ontologies several classes that could be reusable for the ontologies of learning systems. Indeed, the ontologies of the activities of seniors, the ontologies of the behavior of seniors, the ontologies of the capable subject and the ontologies of health can be reusable for the ontologies of learning systems for seniors insofar as, "knowing the psychology of the learner and his environment influences learning [52]". So if the learning system has an idea about seniors and their daily activities, then it can offer them learning that fits with these activities and their needs.

A. Importance of Learning for Seniors

However, studies show that the pursuit of knowledge (learning) is beneficial for everyone insofar as it allows everyone to achieve a better standard of living, both physically and in terms of mental and social [53]. Learning is recognized as the factor that keeps the human mind active and flexible. Learning is an element of personal growth that should be encouraged throughout life [53]. It is therefore important to address the issue of learning in the third age.

In addition, seniors have learning needs and interests. Indeed, the work of Nathalie Aubin and her team has made it possible to develop six categories of needs which are inspired by the theories of needs of Maslow (1954) and Lumsden (1985) [53]. This work shows that older people have much more interest in learning activities related to their health and well-being, as well as in activities that target computers and new technologies.

We can therefore say that senior citizens need learning to improve their living conditions.

B. Use of Ontologies for Designing Senior Learning Systems

Ontologies have a proven track record in the design of intelligent learning systems. We can cite as an example the work of Al-Samarrie Hosam and his colleagues in 2010 [54] which proposes "the design and development of an exceptional representation based on domain ontology and multi-agent systems for e-learning purposes". In 2011, Bremgartner and Magalhães Netto [55] proposed "An adaptive strategy to help students in e-Learning systems using competency-based ontology and agents". In 2015, Antonello Comi and his colleagues [56] proposed an algorithm, called E-Learning Ontology Enrichment (ELOE), to derive a global representation of the personal ontologies of different agents present in an e-Learning. In 2016, Jaroslav Melesk and Eugenijus Kurilovas [57] use the Semantic Web and ontologies for a personalized intelligent multi-agent learning system for engineering courses. Very recently in 2021 Hanaa El Fazazi and his team [58] proposed a design of an adaptive online learning system based on the multi-agent approach, ontologies and reinforcement learning. Several other works point in the same direction [59],[60],[61].

But however, all of these learning systems are not also designed for senior; their ontologies are not modeled for seniors. Rather, these systems are intended for other categories of the population.

Indeed, the existing apprenticeship systems have not taken into account the specific characteristics of older people, their particular needs and learning interests. This is demonstrated in their modeling and ontologies that are not senior user-centric.

It would therefore be important for researchers to propose intelligent learning systems for seniors that take into account their specificities (disabilities...) their learning needs and interests in order to improve their living conditions.

VI. Conclusion And Future Work

To conclude, in this article we have reviewed ontologies designed to improve the living conditions of senior citizens and we have summarized this work. What emerges from the results of this synthesis is that this work did not put an emphasis on the learning of the elderly. They are rather oriented in the areas of health, smart homes and the social aspect, for surveillance, prevention and assistance to the elderly.

To this end, we suggest that researchers explore the field of learning in the third age by using ontologies, which is also very beneficial in improving the living conditions of seniors.

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