A literary revision of ambient inteligence for the care of the elderly at smart homes

Revisión de la literatura sobre la inteligencia ambiental aplicada al cuidado del adulto mayor en hogares inteligentes

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Resumen

Introducción— Las personas tienen necesidades diversas y cambiantes a medida que envejecen y el número de personas que viven con alguna discapacidad está constantemente en aumento. Las casas inteligentes tienen un potencial único para proporcionar vida asistida, pero a menudo están diseñados para resolver un problema específico; por ejemplo, equipadas con reconocimiento de voz para personas ciegas o con pantallas inteligentes para personas sordomudas. Por esta razón se realiza una investigación con el fin de identificar esos componentes de la inteligencia ambiental aplicada en la domótica dirigida a la población del adulto mayor o pacientes que viven con alguna discapacidad física o mental. Se realizó una revisión de la literatura en tres (3) distintas bases de datos en el contexto internacional. La temática abordada es sobre la inteligencia ambiental aplicada en la domótica. Dirigido a una población en específico que es el adulto mayor o pacientes que viven con alguna discapacidad debido a la edad. En esta investigación Se identificaron los objetivos principales, factores importantes y la confiabilidad de esta tecnología aplicada en los hogares inteligentes teniendo en cuenta la población a la que va dirigida.

Palabras clave— Inteligencia Ambiental; hogares inteligentes; automatización del hogar; personas mayores; discapacidad

Abstract

Introduction— People have diverse and changing needs as they age, and the number of people living with a disability is constantly increasing. Smart homes have a unique potential to provide assisted living but are often designed to solve a specific problem; for example, equipped with voice recognition for blind people or with smart screens for deaf-mute people. For this reason, this research was carried out in order to identify those components of the ambient intelligence applied in home automation aimed at the elderly population or patients living with a physical or mental disability. A literature review was conducted in three (3) different databases in the international context. The topic to be addressed was ambient intelligence applied in home automation. This study aimed at a specific population: the elderly or patients who are living with a disability due to age. In this research, the main objectives, essential factors, and reliability of this technology applied in smart homes were identified considering its directed population.

Keywords— Ambient intelligence; smart homes; home automation; elderly; disability

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I. Introduction

The elderly prefer to live independently in their homes; in many cases, without anyone watching them. If an older person lives alone, it necessary to be monitored constantly. Because emergencies can arise at any time, independence and security are critical issues for older people. However, age brings with it certain diseases and complications; that is why the quality of life for the adult population becomes more complicated and less independent. Adults must eventually face situations that limit them when performing certain activities and risk situations such as falls, forgetfulness, sensory impairment, immobility, isolation, among others [1]. Some studies show that 90% of older people studied live independently in their homes. As time goes by, this population increases, and the shortage of care increases, in the same way, their work does [1]. Therefore, these two factors: The aging of the population and the need for follow-up within households, are the key issues that have motivated many studies on AAL (Ambient Assisting Living). AAL is based on Ambient Intelligence (AmI) and seeks to care for and monitor people by adapting to their environment and using new technologies [2], [3].

The importance of working with Information Technologies (IT) and their applications focused on life assisted by the environment [4] is to give people control and support the aging of the population in the future [5], [6]; provide peace of mind for family members, and nurses staff, who are responsible for assisting adults or patients living with a disability [2], [7]. This research and analysis are proposed to identify the components of ambient intelligence applied to the quality of life of adults with a disability or who wish to feel safe [8], [9], [10]. To clarify this issue, because as time passes, we are getting closer to a population of adults who need assistance in their homes, and there are technologies applied to assisted living in smart homes that will be able to provide solutions and support to these situations and patients, according to UC (USA) [11].

Over time, the older adult population increases, and it is expected that within 30 years, approximately 20 percent of the population will be over the age of 60; Environment-assisted living technology plays a challenging role in the solution of supporting the staff responsible for the care of the elderly and the tranquility of their family members, with the objective. In addition, to achieve the independent life of the adult [12], [13], [14].

Ambiental intelligence can be broadly defined as the computer discipline that uses information technology and its applications to improve the quality of life and patient independence through interconnected systems that can detect, anticipate, adapt, predict, and respond to patient behavior and needs. These results can be seen in the works of UC (USA) [11], NTU (UK) and SHU (UK) [15] and OsloMet (NO) and UIO (NO). [16].

II. Methodology

Design: A systematic review of research articles in indexed journals on the use of ambient intelligence for home automation was conducted.

Search strategy: First, a search was carried out in the IEEE, SCOPUS, and WEB OF SCIENCE databases of documents published by different universities, journals, and professional associations in the international context on ambient intelligence for home automation.

Inclusion and exclusion criteria: The literature search included all kinds of documents contributed by different universities, journals, and professional associations in the international context on ambient intelligence for home automation. Regarding systematic reviews and scientific studies on environmental intelligence for homes, automation was mainly used as an inclusion criterion, emphasizing care for the elderly and people living with disabilities in smart homes. The main criteria for inclusion were that the articles should include information about the elderly or people living with some pathology or dementia and were excluded all those articles that refer to ambient intelligence but focus only on saving energy and care for elderly patients that were not from the last five years.

Data extraction: After searching the three different databases (Fig. 1; Fig. 2; Fig. 3), a sample of 130 articles with the inclusion criterion was obtained. Although 102 were excluded, which were not relevant for this review. Finally, four systematic reviews were selected, and twenty-four original studies.

To proceed with the selection, the abstracts and the complete articles review to decide whether or not the information they contained was related to our objective.

Data analysis: The information analyzed was structured based on the problem question distributed in two derivatives. One dedicated to the most important behaviors and activities that can be monitored and controlled through ambient intelligence. Moreover, dedicated to the objectives of ambient intelligence implemented in home automation focused on the elderly.

From the set of results, information was extracted from different groups of variables. Environmental Intelligence Factors: Sensors, Actuators, and Devices; AI Techniques: software, Environmental Intelligence Objectives; Behaviors and Activities: Ethics and Reliability.

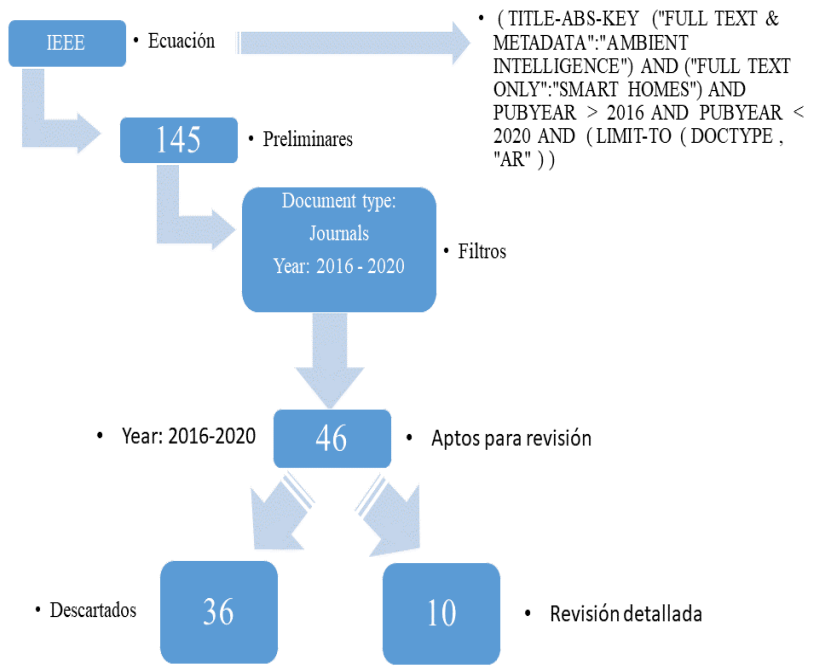

Fig. 1. Article selection process in the IEEE database.
Source: Authors.

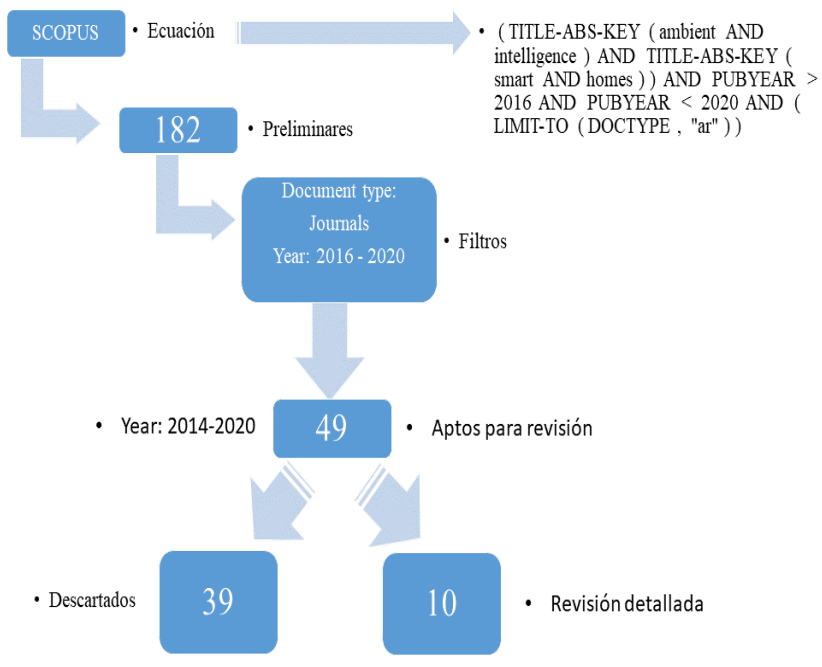

Fig. 2. Article selection process in the Scopus database.
Source: authors.

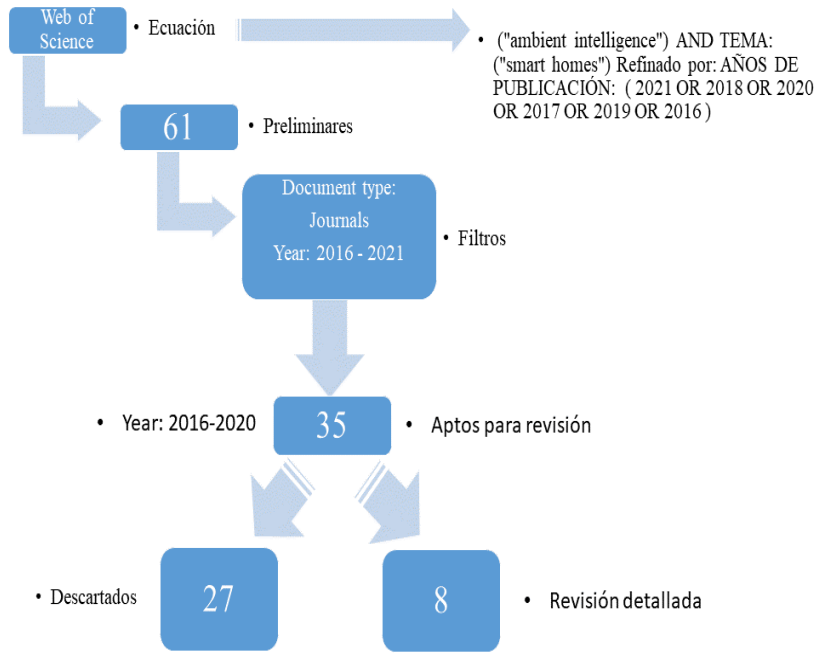

Fig. 3. Article selection process in the Web of Science database.
Source: Authors.

III. Results

There are a variety of (theoretical and practical) solutions and models that have been proposed in research articles and indexed journals that attempt to address the safety and risk control requirements of older people; Some of the models and technologies identified in the documents found show interesting strategies [1], [15].

Home Monitoring: Sensors have been developed to measure the ambient variables of the home, such as temperature, lighting, humidity, movement, pressure, and sound. The data collected from these sensors can be analyzed to determine whether risks such as a rapid increase in temperature or low humidity have occurred [1], [9].

Monitoring people: Portable sensors or Body Sensor Networks (BSN) can be very accurate by recording biomechanical and physiological data, such as blood pressure and heart rate [2], [17].

The devices and sensors mentioned in Table 1 can be found implemented in different designs of smart homes for the care of the elderly. Their implementation is made to procure support in different predictive software of user actions and supply quick responses to any adverse events. Providing, in this way, safety and reliability to the occupants of the home. These devices have different designs, and they mainly depend on the application, and the approach wanted and can be modified by the patient's data privacy.

Table 1.
Types of sensors and devices.

Devices	Structure	Application
The 4 in 1 Multi-sensor by Aeotec	It comprises four different sensors: temperature sensor, motion sensor, lighting sensor, and humidity sensor.	The multi-sensor will report to the controller to which it is linked.
Accelerometers	It is made by attaching a mass to a dynamometer whose axis is in the same direction as the acceleration to be measured.	They are electromechanical devices that detect acceleration forces, whether static or dynamic.
Body Sensor Network (BSN)	It has physiological sensors and bio-kinetic sensors.	The BSN can be highly accurate by recording biomechanical and physiological data such as blood pressure and heart rate.
Gyroscope	Its design consists of a freely rotating disc, called a rotor, mounted on a rotating shaft in a larger, stable wheel center.	Gyroscopes are available to measure rotational velocity in one, two, or three directions.
Raspberry pi	In all its versions, it includes a Broadcom processor, RAM, GPU, USB ports, HDMI, Ethernet (the first model did not have it), 40 GPIO pins (since the Raspberry Pi 2), and a camera connector.	It is often used as a controller or centering basis for decision-making.
sensor INRIA-Nancy	Pressure sensors	They measure the load forces exerted on the floor that can be used [18].

Source: Authors [18].

There are numerous AI techniques and amount of information that could be found in the research articles. For example, in Table 2, Most of them are intended to learn from people's behavior and thus make the best decisions when presented with an activity involving an emergency. Most of the articles found that the amount of data generated by the patients and obtained by the sensors is enough to make the system learn by itself with machine learning techniques. Although other techniques allow an assertive analysis as a system based on rules and another with and statistical level, those do not qualify as an artificial intelligence technique.

Table 2.
Techniques of ambient intelligence.

No.	Technics IA	Functions
1	Computer vision	Allows object detection.
2	Automatic learning	It is a type of artificial intelligence (AI) that provides. In addition, the ability to learn without being explicitly programmed [17].
3	The artificial intelligence of reasoning	It is responsible for solving everyday problems automatically by imitating human behavior [19].
4	Pattern detection	It is intended to extract information from physical or abstract objects, allowing to establish properties between sets of such objects.
5	Decision-making	It is responsible for taking the best solution to any event presented to it.
6	Rule-based system	This system works by applying rules, comparing results, and applying the new rules based on the situation taken.

Source: Authors [19].

Software plays a vital role in the creation of a Domotic environment applied to ambient intelligence. Since it is responsible for taking all the data provided by the different devices and sensors, some of it counts to integrate artificial intelligence techniques to make functional environments considering its applicability and design. Table 3 summarize the software used in domotic ambient.

Table 3.
Software used in domotic ambient.

No.	Software	Functioning
1	RapidMiner	It is a computer program developed for data analysis and mining. In addition, it is used for rapid prototyping and enterprise applications.
2	MReasoner	It is a unified computational implementation of the mental model theory of thought and reasoning.
3	Middleware	It is software that sits between an operating system and the applications running on it. It works as a hidden translation layer to enable communication and data management in distributed applications.
4	MDMS	This Advanced Measurement Infrastructure (AMI) is a scalable software that provides data analysis services (smart meters) and OS / Firmware; Intrusive Load Monitoring (ILM) [20].
5	HAR monitoring system	It is done by implementing a HAR (Human Activity Recognition) system to identify activities that are carried out daily.

Source: Authors [20].

The most critical behaviors and activities that can be monitored and controlled through ambient intelligence in a domotic environment for elderly patients can be seen in Table 4. These are the data that the software most considers in the course of the day to day to provide an exemplary assisted life. The main idea is to provide independence to the elder, so in the end, all that these devices can provide is an alarm signal to stakeholders, as well as some entities such as police or health system facilities [21], [22], [23].

Table 4.
Behaviors and activities.

No.	Behaviors and activities
1	Amount of sleep
2	Eating
3	Performance of personal grooming
4	Monitoring of vital signs
5	Fitness
6	Forgetfulness of names

Source: Authors.

The subject's behaviors can help to identify emergencies depending on where and when they are performed [24], [25], [26] because it is known that not all people carry out their activities at the same time or in the same way. Due to this, several articles explain the different interfaces where the user's routines can modify the variables depending on their schedule and the way they tend to perform certain activities [27], [28].

IV. Smart home design

After concluding the literature review, we designed a model that explain how works a Smart Home, implementing Ambient Intelligence concepts and technology. The model is presented in Fig. 4.

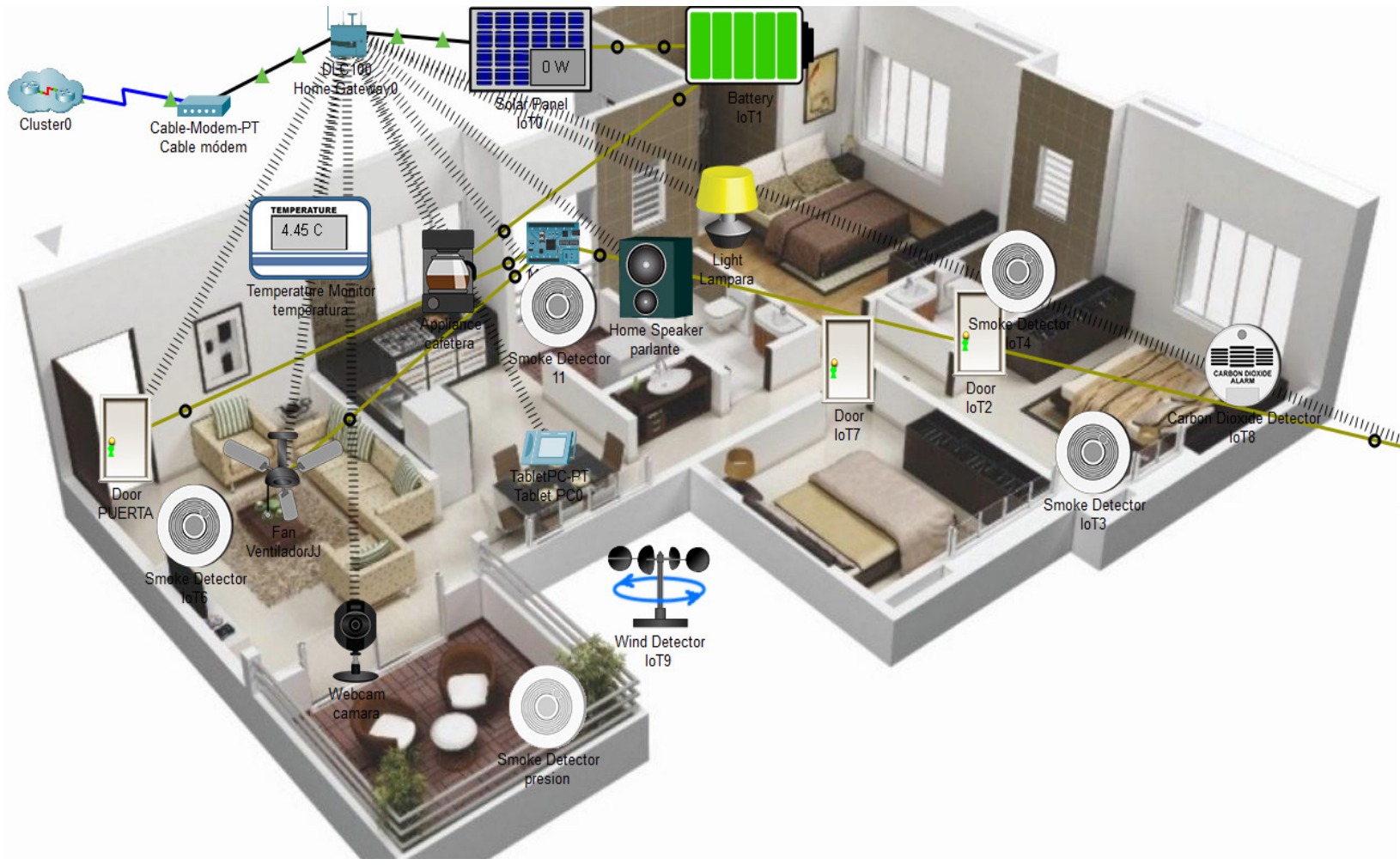

Fig. 4. Model of a Smart Home using ambient intelligence technology.
Source: Authors.

This project was designed with the CISCO Packet Tracer Tool [29]. It also used Internet of Things (IoT) devices, which have become a common term worldwide, both at work and at home. In a literal sense, it could refer to anything connected to the internet to implement a smart home with greater security and care towards the elderly population.

Every "thing" in the term "Internet of Things" refers to a device. Many devices can be connected from cameras, scales, sensors, and home management systems to cardiac monitoring implants, automobiles, etc., even monitoring sensors. Where we manage to use this design, the interconnection opportunities are unlimited. The devices that can use such as:

- *Ambient sensor* = Measures different variables such as temperature or humidity, variables that could allow an air conditioner to be turned on or off.
- 2*G module.* = Integrates 2G communication with which you can have a connection in several places in the world.
- *Battery* = Device capable of storing intelligent energy with charge measurement remaining.
- *Presence detector* = Element that reacts to certain energy sources, like the heat of the human body.
- *GPS module* = The satellite geolocation element can be replaced by positioning telephony antennas when such precision is not needed.
- *Warning device* = These elements have three-colour LED light (red, green, and blue) and a bell to report various incidents.
- *Position detector* = Has an accelerometer and clinometer to determine the position of a body in space.
- *Smart plug* = It has a rheostat, relay, and ammeter, along with its battery that can feed the whole device.

The current IoT architecture involves machines, sensors, among other devices that connect to the internet to send and receive information from the cloud, to then be processed. In turn, these current devices can disable or activate some relays [30]:

- *Cloud gateways* = This allows storing information in the cloud in a practical way.
- *Real-time data processors* = Updates input data with very short latency, measured in milliseconds or seconds.
- *Databases* = Is a database used to save data for its subsequent use quickly.
- *Big Data Waterhouse* = Are structured, semi-structured, and unstructured data that can be extracted for information.
- *Machine Learning* = Is based on techniques that allow computers to learn without the need to be programmed.
- *Data analysis* = Allows us to take an extensive topic and understand it better by dividing it and using several pieces to better understand it.

V. Conclusions

There is a great need to integrate technology into homes or workplaces to assist in having a more independent life in our old age eventually. However, improving these spaces requires adaptable, flexible, and time-changing systems to meet the needs of people in that environment.

One of the risks for older adults living alone is the potential danger of their home environment. The risks identified in research articles in indexed journals include injuries in the home, risks to the home environment, and adverse medical events that may occur at any time. The technology applied in the home automation and assisted by the environment (ambient intelligence) bets a solution to the problem that presents the population of the elderly in the future and the provision of life quality for these patients in the best way, by supporting staff who aid and reassuring family members.

Some of the most critical limitations in ambient intelligence applications are the limited technological capacity for applying action systems to people. That is, systems capable of physically helping a person, such as robots or automated systems for moving around the home.

On the other hand, in the studies carried out, action systems for treating risks, such as fires or evacuation systems for potentially toxic gases, have not been contemplated. However, despite being generally commercial systems, usefulness is undeniable. In this way, the application of intelligent systems for home security must also be considered to have a comprehensive approach.

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