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THEORETICAL MODEL FOR PROTOTYPING ASSISTIVE TECHNOLOGY AND HOME AUTOMATION WITH ARDUINO

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ABSTRACT

The general objective of this study was to propose a theoretical model that integrates accessible components of robotics and software to create a low-cost system, taking into account both the identification of criteria on home automation and accessibility, as well as the verification of opportunities and challenges related to prototyping itself - notably implying technical and economic feasibility with the respective budget design (carried out in October 2024) and the execution (with a term of 12 months). Thus, from a systematic review of the literature combined with the textual analysis technique, it was possible to carry out the first stage of the execution schedule, which is "Research and Planning", based on (n=24) works identified in the scientific literature. From which, by Similarity Analysis with the support of the Iramuteq software, five key topics were identified: (1) Person; (2) House; (3) Technology; (4) System; (5) Data - which allowed greater adherence of the theoretical model to prototyping, evidencing a critical view of the real application of the prototype. Future studies can benefit from the first stage of the execution schedule fulfilled, and use the remaining ten months for the allocation of resources under development. It is worth noting that the budget needs to be always updated. On the other hand, future theoretical studies can explore primary data with interviews and questionnaires among various stakeholders, including people with disabilities, in order to improve the prototype.

Keywords: Assistive technology, Home automation, Arduino, Motor disabilities, User interface.

INTRODUCTION

According to data from the Persons with Disabilities Module of the Continuous National Household Sample Survey (Continuous PNAD, 2022), the Brazilian population with disabilities was estimated at approximately 18.6 million people aged 2 years and over. This number reflects the significant portion of society that faces daily challenges arising

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from accessibility barriers. In the domestic sphere, accessibility plays a crucial role in ensuring independence and improving the quality of life of these people. However, many individuals face difficulties when using appliances and entertainment systems, negatively impacting their autonomy. While home automation technologies have the potential to mitigate these barriers, studies exploring practical, low-cost, and user-friendly solutions for people with disabilities are still scarce.

The existing literature broadly addresses the development of assistive technologies, but there is a specific gap in the integration of accessible robotics and software components into home automation systems aimed at users with disabilities. Everyday tasks, such as operating a television remote control, still pose significant obstacles due to the need for fine motor skills and precision (Cobra; Wataya, 2020). Given this, solutions that make these devices more accessible are essential to promote greater autonomy and inclusion.

Bersch (2017), Boot et al. (2018) and Smith et al. (2018) addressed the topic of assistive technologies for people with disabilities. This paper complements the existing literature by proposing a solution that utilizes simple robotics components such as servo motors, infrared emitters, microprocessors such as Arduino, and 3D printed parts, along with software programming. The proposal consists of creating a simplified operating interface, using a tablet to provide a friendly experience to the user with disabilities. This approach is distinguished by its simplicity, low cost and significant potential to improve the quality of life of these people. Therefore, the research problem is related to the need to create a theoretical model for prototyping assisted technology and home automation with Arduino. Consecutively, the work proposed a theoretical model that integrates accessible components of robotics and software to create a low-cost system, based on criteria on home automation and accessibility, with a focus on applicable proposals. Also, opportunities and challenges were identified regarding prototyping itself.

The exploratory and descriptive research was carried out in two stages, namely: (1) Literature scoping review carried out from the Web of Science - WoS (2024) scientific base on November 21, 2024 implies home automation and accessibility; (2) Application of Textual Analysis based on the Iramuteq software version 0.7 Alpha 2 to extract the categories useful for the creation of the theoretical model. The results may inspire future research aimed at product developments in the area of accessibility and home automation.

LITERATURE REVIEW

Disability is an inherent part of the human condition, temporarily or permanently affecting almost all people at some point in life. Aging aggravates functional difficulties,

requiring support from family and friends (World Health Organization - WHO, 2011). Historically, inclusion and support for persons with disabilities have been urgent moral and political issues, as defined by Sustainable Development Goal (SDG) 11, which promotes sustainable cities and communities, part of the United Nations Development Programme (UNDP, 2024). In addition to the economic impacts associated with residential adaptations and public policies, disability brings universal challenges, such as unemployment, social isolation, and psychological problems. The survey of the National Household Sample Survey - continuous PNAD (PNAD, 2022), reveals that people with disabilities have less access to education, work and income.

According to Guzi de Moraes et al. (2021), assistive technology (AT) is defined as the application of organized knowledge and skills related to assistive products, including systems and services, which are designed and applied to improve quality of life and social inclusion. AT aims to increase the independence of individuals, promoting their well-being and playing a key role in maintaining and enhancing quality of life (Smith et al., 2018).

AT provides a number of significant benefits, such as increased independence, improved quality of life, social inclusion, and reduced care costs. It helps to overcome physical and functional limitations, allowing people to perform daily activities with greater autonomy. In addition, AT can ease the burden on caregivers, providing them with much-needed rest and improving their psychological well-being. However, the acceptance and continued use of AT resources depend on the adequacy of the devices to individual needs and adequate support during the adaptation process (Squires; Williams; Morrison, 2019).

Despite the significant demand for AT devices, intensified by global trends in population aging, several obstacles still persist in their implementation. Among the main challenges, the lack of funding and adequate public policies to support the dissemination and use of these devices stand out (Boot et al., 2018). According to Bersch (2017) in Brazil, AT resources are currently classified into twelve categories, according to their functional objectives: sport and leisure, aids for daily living, augmentative and alternative communication, computer accessibility resources, environmental control systems, architectural projects for accessibility, orthoses and prostheses, postural adequacy, mobility aids, aids for the qualification of visual ability, aids for people with hearing impairments and mobility in vehicles.

These devices, also known as Electronic Aids for Daily Living (AEDL) or Electronic Aids for Daily Living (EADL), make it easier for people with physical disabilities to operate electrical appliances in a given environment. By increasing independence, improving quality

of life, and promoting social inclusion, these technologies can also contribute to reducing care costs (Rojas; Ponce; Molina, 2022).

The construction of AT devices must consider not only functionality and accessibility, but also the integration of different technologies to maximize the independence of users (Reis, 2017). The inspiration to create the communication interface between the user with disabilities and the tablet comes from the pictogram method of the Aragonese Center for Augmentative and Alternative Communication. This tool was developed with the aim of making communication easier and more intuitive for people with disabilities.

Each pictogram has its meaning written above the image, making it easier for the user to understand. In addition, pictograms are divided into groups of the same category, which helps in the development of abstract thoughts from the generalization of concepts, making communication more agile and efficient. This organization promotes clearer and more direct interaction, significantly improving users' ability to express themselves (Aragonese Center for Augmentative and Alternative Communication, CACAA - 2024).

As for the electronics platform, it is desirable to adopt an open source platform that allows the creation of interactive hardware and software projects, such as Arduino. The platform consists of a development board that can be connected to a breadboard or protoboard, which are solderless development boards, and to other components, such as sensors, LEDs, and displays. Arduino programming is carried out in its own development environment, known as the Arduino IDE, where it is possible to write codes to control the components connected to the board. This ease of use makes Arduino a popular choice among enthusiasts, students, and professionals for rapid prototyping and electronic design development (Arduino, 2021).

There are several variants of Arduino boards on the market, each suitable for different types of projects. The Arduino Uno is popular for its simplicity and ease of use, ideal for beginners. The Arduino Mega 2560 offers more pins and memory, suitable for complex projects. The Arduino Nano is a compact version of the Uno, perfect for limited spaces. The Arduino Leonardo has native USB support, allowing the board to behave as an input device. The Arduino Due utilizes an ARM Cortex-M3 microcontroller, offering increased performance. The Arduino Micro combines the compactness of the Nano with the functionality of the Leonardo, while the Arduino Nano Every upgrades the original Nano with more memory and speed (Arduino, 2022).

This diversity of options makes it easy to experiment and develop interactive designs, allowing users to choose the most suitable board for their specific needs. Arduino's ability to function independently and with high accuracy stands out among the advantages

driving its widespread adoption in various areas, from education to industrial research and development (Arduino, 2021).

In summary, the literature highlights the crucial importance of assistive technology (AT) in promoting independence and improving the quality of life of people with disabilities. The integration of platforms such as Arduino, with its versatility and affordability, opens up new possibilities for the development of innovative and effective AT devices. The adoption of intuitive communication methods, such as pictograms, and the consideration of factors such as funding and public policies are essential to overcome the challenges in implementing these technologies. Thus, the present study seeks to contribute to this field by proposing an AT device that combines these approaches, offering practical and affordable solutions for daily needs. This literature review provides a necessary theoretical basis for the construction and justification of the proposed project, underlining the relevance and potential positive impact of this initiative.

METHODOLOGICAL PROCEDURE

As explained in the introductory section, the general objective of the work was to propose a theoretical model that integrates accessible components of robotics and software to create a low-cost system. To this end, the specific objectives were fulfilled: (a) to identify criteria on home automation and accessibility, focusing on applicable proposals; (b) to verify opportunities and challenges regarding prototyping.

In this sense, the present investigation was exploratory and descriptive, of a qualitative nature, was undertaken from a systematic literature review (RSL), conferring the scope. From the textual corpus it was possible to undertake the Textual Analysis (TA).

It should be explained that the systematic form ensures the accuracy, validity and reliability of the data, providing a robust structure for the analysis and interpretation of the results, thus promoting the generation of rigorous and well-founded scientific knowledge (Prodanov; Freitas, 2013). Also, according to Gil's (2022) classification, this research has an applied character, as it covers studies prepared with the purpose of solving problems identified within societies, being exploratory and descriptive, since the objective is to provide greater familiarity with the problem and describe the relationship between the research variables (Gil, 2022). Next, the data collection (3.1) and the processing of data (3.2) that support the creation of the theoretical and conceptual model are detailed.

DATA COLLECTION

In this study, secondary data collection was carried out by consulting the Web of Science (WoS) scientific database on November 21, 2024 and following the Prisma (2009) flowchart in an adapted way, that is: (a) Identification, (b) Selection; (c) Eligibility; (d) Inclusion. For the eligibility and inclusion stages, the support of artificial intelligence (AI) Rayyan (2024) was used. Chart 1 details the step-by-step data collection:

Table 1. Systematic Literature Review (RSL)

Steps	Description	Results
Identification	String 1 - assistive technology AND home automation; String 2 - assistive technology AND arduino.	String 1: n=222 String 2: n=71 Total: n = 293
Selection	Filters adopted: (1) Open Access; (2) Period (years 2019-2024); (3) Material Type: Items	String 1: n= 35 String 2: n= 8 Total: n=43
Eligibility	The support of Rayyan Artificial Intelligence was used in two rounds with two reviewers, the first with the blind on and the second with the blind on off.	Round 1: Excluded (n=17); included (n=22); maybe (n=04); conflict (n=01).
Inclusion		Round 2: Excluded (n=19); included (n=24);

Source: Prepared by the authors based on the adaptation of Prisma (2009) and use of Rayyan (2024)

The data processing with the support of the Iramuteq Textual Analysis software, version 0.7 Alpha 2, is detailed below.

DATA PROCESSING

From the textual corpus formed by n = 24 works, their abstracts were coded as follows: **** *abstract_n, where n is equivalent to the number of abstracts included for data processing, i.e. (n = 1 to 24).

The Iramuteq software version 0.7 Alpha 2 allows a series of analyses, however the Similarity Analysis was selected, which based on Graph Theory (Salviati, 2017) allowed to understand both the frequency of the terms and the co-occurrence from word communities by halos. It should be noted that the textual corpus was adjusted according to the Iramuteq manual (see Salviati, 2017) and the adverb term was adjusted to complement.

In addition, a cut-off was established for terms with a frequency equal to or greater than 10. These adjustments brought out the main themes of the analyzed textual corpus on home automation and accessibility from the perspective of the interface between assistive technology and specifically Arduino. This led both to the subsidy of the creation of the conceptual theoretical model, and to the discussion about opportunities and challenges in relation to prototyping.

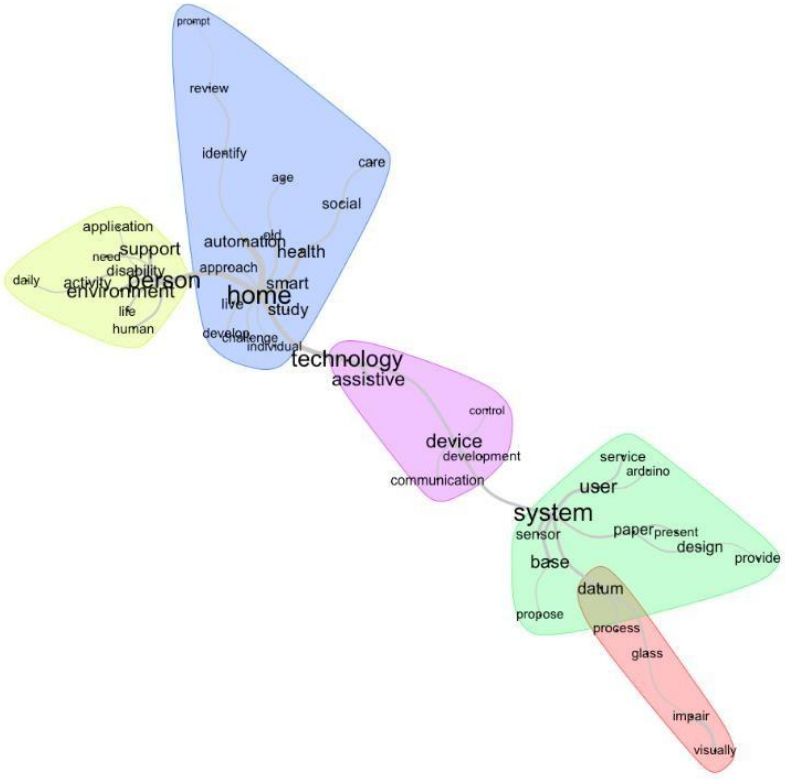
RESULTS & DISCUSSIONS

The results and discussions are aligned with the understanding of criteria on home automation and accessibility from the perspective of the relationship between assisted technology and home automation, in addition to the specificity related to Arduino (subsection 4.1). After fulfilling this specific objective, the proposition of the theoretical model is presented (subsection 4.2), and finally the opportunities and challenges of prototyping from a theoretical and practical point of view are scrutinized.

HOME AUTOMATION AND ACCESSIBILITY

To list the criteria based on the systematic review of the literature undertaken, the support of the Iramuteq v. 0.7 Alpha 2 software was used to produce a similarity analysis (Figure 1) that allowed the identification of the main themes by more frequent terms, equal to or greater than 10, for example: home/casa (f=60), system/sistema (f=46); person (f=45); technology (f=42); user (f=32), device (f=28), automation/automation (f=28); assisted (f=26); environment (f=26); support (f=25); smart (f=23); health (f=23); base/base (f=22); datum/data (f=22).

Figure 1. Similarity Analysis



Source: Prepared by the authors using the Iramuteq software version 0.7 Alpha 2.

The five word communities in Figure 1 were formed respectively by key terms, namely: (1) person (f=45), (2) home (f=60), (3) technology (f=42), (4) system; (5) (f=46), datum/data (f=22). Therefore, the scientific evidence from the systematic review of the literature combined with the textual analysis was listed in Chart 2:

Table 2. Scientific evidence

Halos	Scientific evidence
1.Person /Person	The person needs support daily/daily in the environment.
2.Home / Casa	Home is linked, among other terms, to smart / intelligence and automation / automation. It is in line with: health / saúde e social care. In addition to the close relationship with develop/develop, challenge/challenges and individual/individual.
3.Technology / Technology	The term is linked to assistive/assistive, and then to device/equipment, and this unfolds into three perspectives: (a) communication; (b) control/control and (c) development/development
4.System/System	The term Arduino is directly linked to the terms user and system. On the other hand, the term sensor/sensor as a proposition is within the context of the system.
5.Datum / Data	Datum/data binds to glass/glasses and odd visually / impaired vision.

Source: Prepared by the authors, (2024).

Diego et al. (2020) dealt with the role of the smartphone in control for people who lose control of the upper limbs or are in rehabilitation, demonstrating the role that assisted technology has for developing countries, and its manufacture is low-cost. On the other hand, Kumar et al. (2024) underline the role of Arduino Nano microcontroller for visually impaired people to gain more autonomy, with auditory cues and using a global positioning system (GPS). However, rigorous tests are still needed, which demonstrates the relevance of theoretical models to start prototyping, ascertaining challenges and opportunities.

At first, the context of the home seems to be key to ensuring greater autonomy for people with disabilities, as it is the most frequent term in the textual corpus analyzed. In this sense, Wu et al. (2020) treated technology assisted with multiple sensors from a wireless network. On the line, the authors used Morse code translator and between human and machine and between humans, and the experimental test was favorable in relation to the quality of life regarding the control of household appliances. Therefore, in this research in line with the search for health, the challenging factor from an individual perspective was evident. This perspective of individuality was addressed by Cleland et al. (2024) demonstrating the relevance of the topic in the journal Disability and Rehabilitation: Assistive Technology.

The premise of assistive technology in the third halo appears as a centrality of the textual corpus analyzed, which is understandable, since the expectation is the prototyping of a new assistive technology. Giraud, Volanschi & Consel (2020) dealt with smart homes including a key aspect to this, the anticipation of behavior. In addition, the focus was on the

elderly and caregivers. Therefore, the systemic vision integrating machines and human beings is a key support for the prototyping of new devices/equipment.

Creating an assistive technology system that considers Arduinos and sensors must take into account the user/user. Kumar et al. (2024), for example, dealt with the specificities aimed at people with visual impairments, so their needs may be different from those of people with other types of disabilities. Low cost is essential for new prototypes, even more so in developing countries like Brazil. Busaeed et al. (2022) when dealing with LidSonic for people with visual impairments detail costs, such as the microcontroller board that cost less than eighty dollars. The fifth halo seems to be a specificity when treating datum/data from the perspective of glass/glasses and impaired vision. In this sense, it is necessary to explore other types of prototyping in order to meet various disabilities, such as motor disabilities.

The communities of words by halos (see Table 2) allow us to understand that a new theoretical model for prototyping home automation and accessibility must be in line with technological advances focused on people and behaviors, including the various stakeholders such as people with disabilities, caregivers, etc., for the sake of health and well-being. The new model should go beyond the challenges for people with visual impairments, although these should be considered. Finally, it is necessary to have a systemic vision in the development of new technologies assisted in homes, focusing on low cost to expand access based on the social and economic inclusion of the majority of people.

PROPOSITION OF A THEORETICAL MODEL

Fulfilling the general objective of the work, a theoretical model was proposed that integrates accessible components of robotics and software to create a low-cost system, as evidenced from the similarity analysis. In general terms, the theoretical prototype of home automation will be structured based on two main technological interfaces: (1) unlike Diego et al. (2020) who addressed smartphones, in the present model a tablet will be proposed. This will act as a user interface for direct communication with the person with disabilities; (2) the activation mechanism, responsible for interacting with and controlling electronic devices in the residential environment, including reflection on Wi-Fi networks (see Wu et al., 2020) and Bluetooth.

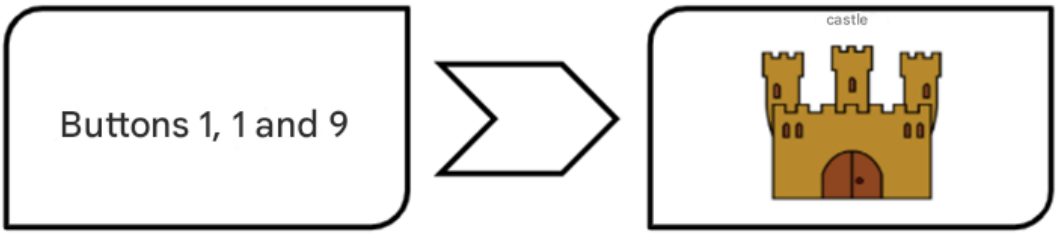
In line with the objectives of focusing on people and the relationship between people and machines (see Giraud, Volanschi & Consel, 2020) the tablet will be equipped with a personalized application. Therefore, it will be designed to offer an intuitive and user-friendly

interface, making it easy for the user to interact with the system. This application will allow the user to select and send control commands to various electronic devices as observed in the study by Wu et al. (2020).

The information and commands sent by the tablet will be transmitted via Bluetooth to an Arduino microcontroller, which will serve as the core of the system, processing the data received and performing the necessary actions. Arduino will be responsible for managing various integrated components, including servo motors to perform mechanical movements, infrared emitter to control devices that use this type of communication, and 3D printed parts to structure and support the system's hardware efficiently.

In methodological terms, the construction of the interface of the application on the tablet, will be used the pictogram method of the Aragonese Center for Augmentative and Alternative Communication (ARASAAC), which offers a solid basis for a user-friendly and accessible interface. The replacement of the usual remote control commands with pictograms, which will be converted into "activities", aims to facilitate communication and interaction for the user with disabilities. For example, to change channels, where it is usually necessary to press several buttons, the Disney Channel will be transformed into a pictogram easily associated with Disney like a castle (see Figure 2).

Figure 2. Conversion of commands to pictograms.



Scheme: Prepared by the author, (2024) Pictogram source: ARASAAC, (2024)

As underlined, the programming of the application will be focused on the development of an intuitive interface, which will allow the selection of commands through simple touches, such as controlling functions for changing the channel or adjusting the volume. Communication between the tablet and the Arduino microcontroller will take place via Bluetooth, ensuring efficient and reliable data transmission. The development will follow accessibility best practices, ensuring that all features are fully usable by people with motor limitations. It should be noted that ARASAAC provides an Application Programming Interface (API) for programmers, providing greater ease in the development of custom software. When selecting any icon, the system emits an auditory and tactile response, with vibration, in order to facilitate interaction and meet the needs of people with disabilities.

Figure 3 presents an example of the main screen of the application (app), since this theoretical prototype needs to be validated according to its usability. The application will be focused on the control of various equipment that uses infrared in communication, such as televisions, cable TV receivers and air conditioners, that is, household appliances as seen in the study by Wu et al. (2020). The main interface of the application will simulate the control of these devices, providing the user with an intuitive and accessible way to manage multiple electronic equipment through pictograms, as evidenced in Figure 3.

Figure 3. Example of the app's splash screen.

Editing: Prepared by the author, (2024) Pictogram source: ARASAAC, (2024) Tablet model source: OPENAI, (2024)

It is noteworthy that in Figure 3, the function will be configured according to the routine of the person with disabilities, and there may be only one page with functions or several, as necessary. As observed by the scientific literature consulted, more specific issues need to be addressed individually, requiring the application to have an intuitive and simple customization interface, that is, focused on the person (person, halo 1 of Figure 1). This will allow caregivers to configure and adjust the app's functions with ease, meeting the specific needs of each user in an efficient manner, as seen in Squires' research; Williams; Morrison (2019) and de Giraud, Volanschi & Consel (2020). Below are listed challenges

and opportunities of this prototyping based on the debate on technical, economic and time feasibility.

CHALLENGES AND OPPORTUNITIES

Seeking an adherence of the theoretical model to reality based on the scientific literature consulted, it was evident that the challenges and opportunities regarding prototyping were related to two main dimensions: (a) Technical Feasibility (4.3.1); (b) Economic and Term Feasibility (4.3.2.).

Technique

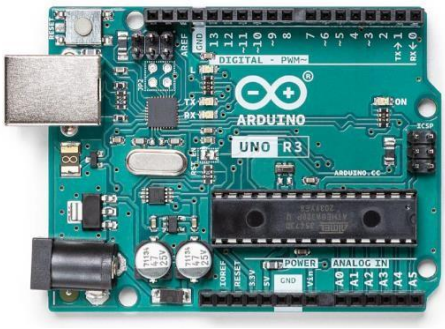
In summary, the technical dimension is related to the proposal of a mechanism of interaction with electronics via infrared. To ensure autonomy and ease of use for people with motor disabilities, it is essential to develop an efficient mechanism of interaction with home electronic devices that use infrared communication. This mechanism will allow the user to control equipment such as televisions, cable TV receivers and air conditioning in an intuitive and accessible way. On this point, Wu et al. (2020) was inspiring for the debate on this technical feasibility. The implementation of this mechanism will be carried out using the Arduino platform. It should be noted that Arduino is an open-source platform that allows the creation of interactive hardware and software projects, consisting of a development board equipped with a programmable microcontroller. Several studies have used Arduino, such as that of Kumar et al. (2024) who focused on a different aspect of motor disability, which is visual.

The choice of Arduino is due to its ease of use, low cost, and extensive support community, making it easy to prototype and develop custom solutions. Low cost is something discussed prominently in the scientific literature, see Busaeed et al. (2022). In the context of this project, the Arduino will receive commands from the application on the tablet via Bluetooth and send infrared signals to the electronic devices, ensuring a harmonious integration between software and hardware. The simplicity and versatility of the Arduino, characteristics that make it ideal for fast and efficient prototype development.

It should be noted that the Arduino Uno is widely compatible with a variety of modules and components, including Bluetooth modules and infrared emitters, essential for the communication and control of electronic devices, which leads to this choice, unlike the work of Diego et al. (2020) who dealt with the smartphone or Wu et al. (2020) who dealt with the wi-fi network. In addition, it offers a sufficient number of digital pins and Pulse Width Modulation (PWM) or Pulse Width Modulation (MLP) pins to control the required

servo motors. A decisive factor for this choice is the existence of a robust support community and the abundance of resources and libraries available make it easy to troubleshoot and implement additional functionality. As mentioned, the affordable cost of the Arduino Uno makes it a cost-effective and practical option for assistive technology projects (see Figure 4):

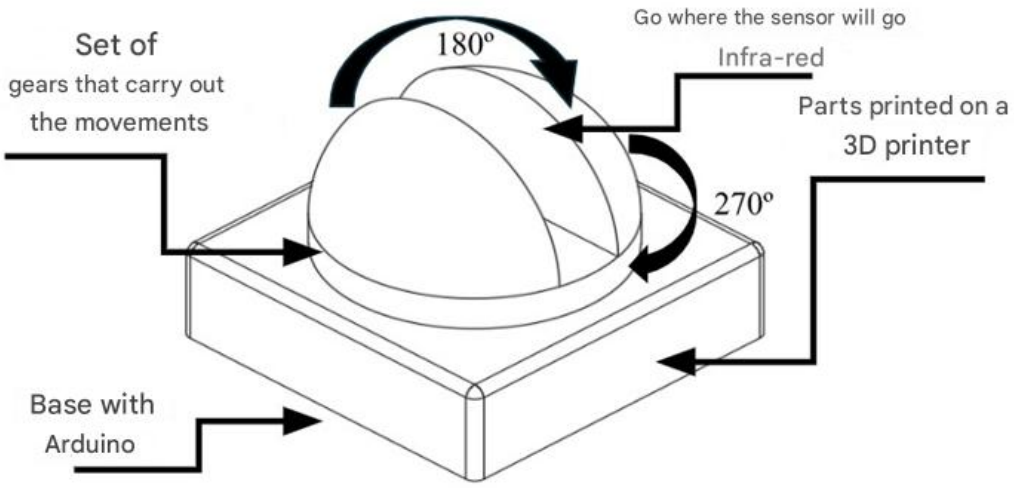
Figure 4. Arduino Uno



Source: ARDUINO, (2022)

Once the programming platform has been defined inspired by the conceptual theoretical debate derived from the systematic review of the scientific literature, it is important to understand how the mechanism will work in practice. According to the technical specifications adopted, the Arduino Uno will receive the Bluetooth signal through a specific module and, after processing it, will send infrared commands to electronics. To ensure that the emitter reaches devices in different directions, a set of servo motors will be used to move it effectively. according to the Theoretical Model of the Prototype in Figure 5:

Figure 5. Theoretical Model of the Prototype



Source: Prepared by the authors, (2024)

In line, for this purpose, a set of gears with cogwheel will be built, moved by servomotors, which will allow a movement of 270º on the axis itself and 180º of amplitude (see Figure 5). This will ensure that the infrared emitter reaches as many positions as possible, similar to the mechanism used in IP cameras. Next, based on Figure 5, the feasibility of the economic dimension is discussed in more detail.

Economic Dimension

To ensure the feasibility and successful implementation of the project, it is essential to conduct a detailed analysis of the costs and time required. This analysis includes: (a) hardware (Arduino Uno, Bluetooth and IR modules, servo motors, electronic components, and 3D printed parts); (b) software (application development and Arduino programming) and other resources needed for construction and testing. The time required for each phase of the project is estimated, from initial research to implementation and validation. In this sense, Table 1 presents the expected costs, providing a clear view of the necessary investments, including labor based on a scientific initiation (CI) scholarship holder with a scholarship value of R$2,200.00 because it is a possibility of spinoff, that is, derivation from the academic world to the world of work. Table 1 details the expected costs for the project, considering the month of October 2024 as a reference for the survey:

Table 1. Projected costs for the project.

	BUDGET		**COST**	
ITEM	**SPECIFICATION**	**QUANTITY**	**UNITARY**	**TOTAL**
1	Electronics	1 unit	R$5,000.00/Unit	R$5.000,00
2	Filament Expenses	3 Kg	R$300,00/kg	R$900,00
3	3D Printing Hours	165 Hours	R$2.50/Hour	R$412,50
4	Hours of Electronics	130 Hours	R$13.75/Hour	R$1.787,50
7	Hours of Modeling	320 Hours	R$13.75/Hour	R$4.400,00
6	Assembly Hours	320 Hours	R$13.75/Hour	R$4.400,00
8	Research and Planning Hours	240 Hours	R$13.75/Hour	R$3.300,00
5	Programming Hours	480 Hours	R$13.75/Hour	R$6.600,00
9	Hours of Testing	240 Hours	R$13.75/Hour	R$3.300,00
			Total Expected Costs:	**R$30.103,00**

Source: Prepared by the authors, (2024)

With an approximate total of thirty thousand reais in October 2024, to ensure economic viability, it becomes relevant to explain the allocation of the resource in time, detailing an execution schedule. Thus, in the organized and efficient execution of the project, a detailed schedule was prepared in Chart 3, which covers all stages from the initial research including this systematic review of the literature to the implementation and final validation of the product.

Table 3. Planned execution schedule

EXECUTION SCHEDULE													
Item	**Activity**	**Period(month)**											
		1	2	3	4	5	6	7	8	9	10	11	12
1	Research and Planning												
2	Parametric modeling												
3	Programming												
4	3D Printing												
5	Electronics												
6	Assembly and testing												
7	Corrections and final delivery												

Source: Prepared by the authors, (2024)

Based on Chart 3, it is evident that the approximate resource of thirty thousand reais would be allocated within one year in order to continue what is being started in October 2024 with the research and planning materialized in this article. Therefore, this article already fulfills an important stage in terms of time optimization for the execution of this project, and future interested parties can subtract at least two months, carrying out the project from here in less than a year.

FINAL CONSIDERATIONS

According to the general objective of the research, which was to propose a theoretical model that integrates accessible components of robotics and software to create a low-cost system, a theoretical model was proposed that integrates accessible components of robotics and software to create a low-cost system. In an auxiliary way, criteria on home automation and accessibility were identified, focusing on applicable proposals; and, it verified opportunities and challenges regarding prototyping.

The systematic review of the literature combined with Textual Analysis allowed, based on scientific evidence measured with the textual corpus formed by (n=24) works, to understand prominent topics such as: (1) person; (2) home/house; (3) technology; (4) System/system; (5) datum/data extract relevant clues to understand both the relevance of assistive technology in promoting independence and improving the quality of life of these

individuals allowing the creation of a conceptual theoretical model, as well as the debate of challenges and opportunities, including technical and economic feasibility of the prototype.

Although still in the proposition phase, based on the systematic review of the literature and textual analysis, it has been shown that the implementation of an intuitive interface based on pictograms, combined with an infrared control system, has shown promise in facilitating the interaction of users with domestic electronic devices.

In practical terms, aiming to carry out the project in twelve months with an estimated budget of approximately thirty thousand reais in October 2024, it is clear that the dependence on low-cost components, such as those used in the Arduino Uno and its associated modules, in addition to the use of 3D printing are challenging in the medium and long term. This is because, while these components are affordable and widely available, they may not offer the durability and robustness needed for prolonged and intensive use, especially in home environments where reliability is essential. Therefore, it is emphasized that a limitation of the prototype is the need for maintenance and replacement of parts, which would be inconvenient for end users. Another limitation refers to the integration of infrared-based devices, since it requires direct line of sight for effective communication, which may not be feasible in all home settings, but it becomes a more relevant low-cost option than others identified in the scientific literature.

Thus, future studies can be concerned with deepening the incorporation of technological improvements, such as the use of more advanced sensors and higher quality components, in addition to the integration of new forms of interaction, such as voice commands and gesture control, for which new systematic reviews of the literature are suggested.

In terms of primary data, the expansion of the research may consider questionnaires and interviews, duly approved by the Ethics Committee, to investigate with the various stakeholders, including the disabled themselves, about usability and the social and economic impact of these technologies. It is noteworthy that this expansion of the present research can contribute to the development of public policies aimed at promoting digital inclusion and accessibility.

In summary, this article not only offers a potentially practical and low-cost solution with a theoretical prototype model from a systematic review of the literature for home automation with arduino, but also opens paths to discuss future innovations in the area of assistive technology, contributing to a more inclusive future.

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