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Tesis

Mobile Robot to Assist in Therapies for Children with Autism

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Abstract The increase in the autistic population and rapid technological advances have led to further research on robot-assisted rehabilitation for autism therapy as a practical system aimed at overcoming the distance between autistic patients and their therapists. In this investigation, an interactive mobile robot was developed whose main objective is to perform therapy for children with autism spectrum disorder (ASD) that meets certain qualities that will be chosen by the therapist, so that the robot will be able to give treatment in different approaches of language, speech, and coordination. This mobile robot offers the ease of being manipulated by a geomagnetic router (GRG) glove, RFID cards that allow the display of different expressions (emotions), and SD cards that can save voice recordings or songs according to the therapist.

Keywords Autism · Interactive mobile robot · GRG · RFID

1 Introduction

Currently, interactive mobile robots are still alien to the Peruvian market because the delay and lack of importance of new implementations for the treatment of children with autism spectrum disorder (ASD) in Peru, specifically in Huancayo, has prevented our country from implementing modern and updated technology in this field. Autism represents a challenge for medicine. It is an early onset of neuropsychological development disorder. It is one of the most serious alterations that affect behavior and communication with stereotyped patterns. Autism spectrum disorder (ASD) is a neurological and developmental condition that begins in childhood and

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lasts a lifetime. People with ASD present problems that concern difficulties to talk and a scattered vision when communicating with other people [1].

According to [2], the percentage of minors aged 3–11 years with a mental disability, specifically autism, is 0.076% of the current population of Peru. In the Junín region, out of 60 people diagnosed with ASD, 29 are minors aged 3–11 years [3]. This is increasing owing to various circumstances. It is worth noting that within this percentage, the majority of people are of low socioeconomic status, and consequently the various therapies that can be applied are ignored as they can not afford it. Although children with ASD need adequate care and education according to their condition, there has been no progress in projects that provide adequate treatment within the educational field. This research work aims to facilitate progress in the scientific, technological, and educational field with respect to autism therapy in the Junín region, specifically in Huancayo.

Robots can cooperate with humans to perform tasks. The image from science fiction that comes to mind, of humanoid robots or service robots working alongside humans, still invokes a certain sense of surprise and insecurity when performing a joint task. This perception is perhaps influenced by the image of the industrial robot working in manufacturing scenarios. The case of robots for medical applications is especially interesting owing to the aspect of human relations in health issues [4]. Robotics brings together various disciplines such as mechanics, electronics, computer science, artificial intelligence, control engineering, and physics. Other important areas are algebra, programmable automatons, animatronics, and state machines [5]. Medical robots are robots that operate in any of the following scenarios: a surgical environment, rehabilitation scenario, or domestic environment where assistance tasks are performed. The common characteristic that we find in these robots is that apart from collaborating to perform a certain task, these medical robots have a direct physical relationship with human beings, i.e., there is physical contact between the robot and a person. Obviously, this feature conditions the human-machine interface of these robots and makes them different from industrial robots [4].

In recent years, the psychological approach and engineering and robotics advances have been combined to offer an alternative in the treatment of children and adults with ASD, robot-assisted therapy [6]. In this sense, there are therapies given to children with autism from behavioral analysis when they interact with different toys [7]. Also, through therapies driven by mistrust and deception games, children with ASD learned complex social rules from a social robot [8]. The empirical evidence supports the potential use of specific robotic and technological agents for increasing motivation and socially relevant behaviors in some children with ASD [9]. The development of this type of robot-assisted therapies aims at improving basic services to children with ASD from the moment they are diagnosed and throughout their life cycle, with support services for families, allowing parents to live with the affected child as long as possible, without dismantling the family nucleus and thus achieving true integration into society [10].

This work pretends to explore to what extent does the prototype development of an interactive mobile robot for the treatment of children with moderate ASD at the school stage may contribute. The main objective of the research is to design a mobile robot that will help therapists in their sessions, specifically with speech, language, and music.

2 Function

The proposed prototype will fulfill the function of being the therapist's assistant because therapists will make improvements in the therapies for language, speech, and music [11].

Next, the therapies where the robot will assist are explained:

- Speech: The therapist is available for therapy with RFID cards because thanks to this the robot can change expressions in six opportunities. With the help of speech, the therapist can interact with the patient when they identify themselves and use expressions.
- Language: Here we propose a therapy that is simple for the patient because the robot has an SD card in which words selected by the therapist can be recorded to interact with the patient.
- Music: In this therapy, the robot has an SD card, where music selected by the therapist can be recorded.
- Coodination: It has a geo-drive control system in the form of geomagnetic router gloves (GRG) that can direct the robot to a specific point.

3 Materials and Methods

This project involves systematic creation and development, and the documentation of the design activity can be used to manufacture the product. In terms of existing work, the method standardized by the German association of engineers VDI (Verein Deutscher Ingenieur), VDI2222, was developed [12]. This method can be easily used by designers with or without experience, in addition to seeking optimization in each of its stages, so that the solutions always aim to be the best. Next, a list of research requirements is prepared where the design is analyzed, which will make it easy to interact with the children with the objective of capturing the attention of children with ASD, so that they can learn to socialize through the SD cards (provided in the prototype) in which voice or songs will be transmitted according to the desired treatment. A child will be able to see the changes in the expressions of the robot using the RFID cards.

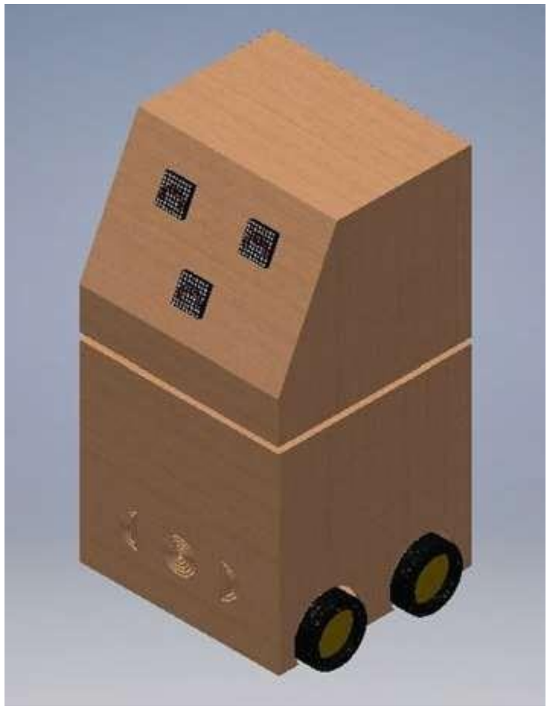


Fig. 1 Robot assembly–inventor

3.1 Design

It was achieved by separating the physical from the intangible, it was developed through steps, through which the designs of both software and hardware were obtained to finally assemble them together. The development was carried out using Inventor [13] and Proteus software [14] (Figs. 1, 2, and 3).

3.2 Materials

The materials used in this work were Arduino mega, accelerometer, L293D Driver, Bluetooth, RFID card reader, SD card reader, speakers, 8 × 8 matrixes, and MDF frame.

3.3 Software Development

It was based on being able to control the robot by two methods: by an application created for an application, by an accelerometer as well as the RFID cards or by algorithms with the programming of microcontrollers.

Fig. 2 A complete circuit in proteus

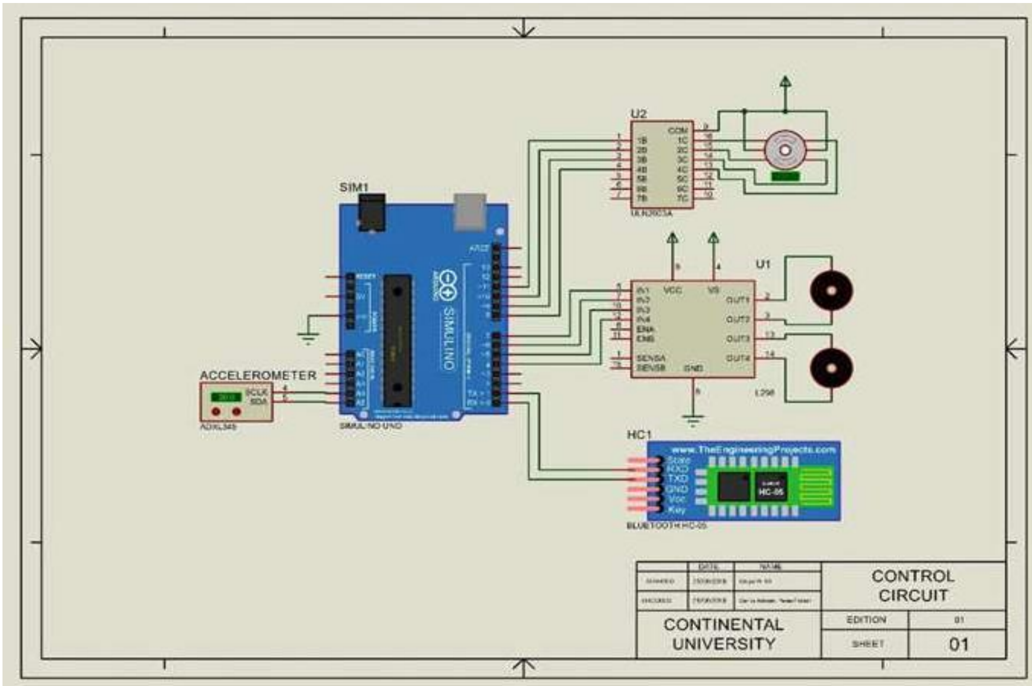
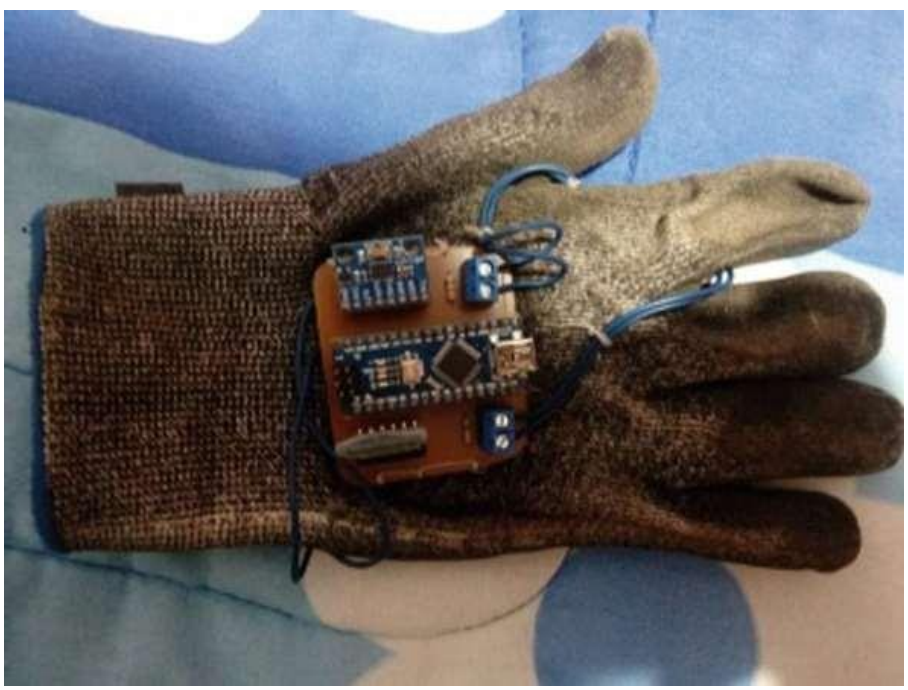


Fig. 3 Geomagnetic router glove (GRG)



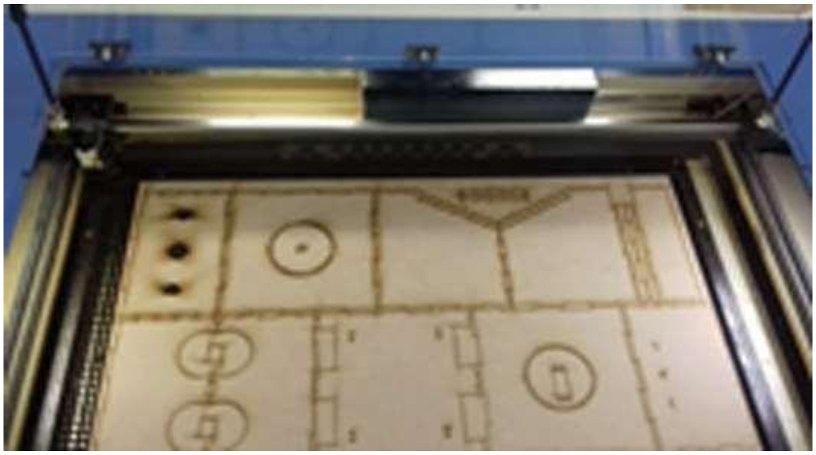


Fig. 4 Laser cutting of the robot design

3.4 Hardware Development

Hardware was manufactured using easily accessible materials and efficient manipulation. The operation was executed with the AutoCAD program and laser cutting (Fig. 4).

3.5 Flowchart

This part explains the robot process and its working (Fig. 5).

4 Results

From the fabrication and testing process, an interactive mobile robot with two degrees of freedom was obtained with dimensions of 23 cm × 23 cm and a height of 48 cm. The total weight of the robot was 2 kg, and the rotation range of the head was from 9° to 180°. The human-machine interface was developed using open-source software and hardware technology that allows cost reduction in the manufacturing of therapeutic robots without degrading their quality. In this case, the software system was built in Arduino. The hardware was implemented with technological components that were compatible with everything that was used. The performance of the interactive robot was evaluated at each stage of the child's cognitive development. The obtained data show that the signals coming from the controller and the commands given by the Arduino do not have communication delay because they are working at the speed of milliseconds. To improve the robot–patient interaction, audio (voice) and music player were incorporated into the robot to listen to and observe the patient's reactions

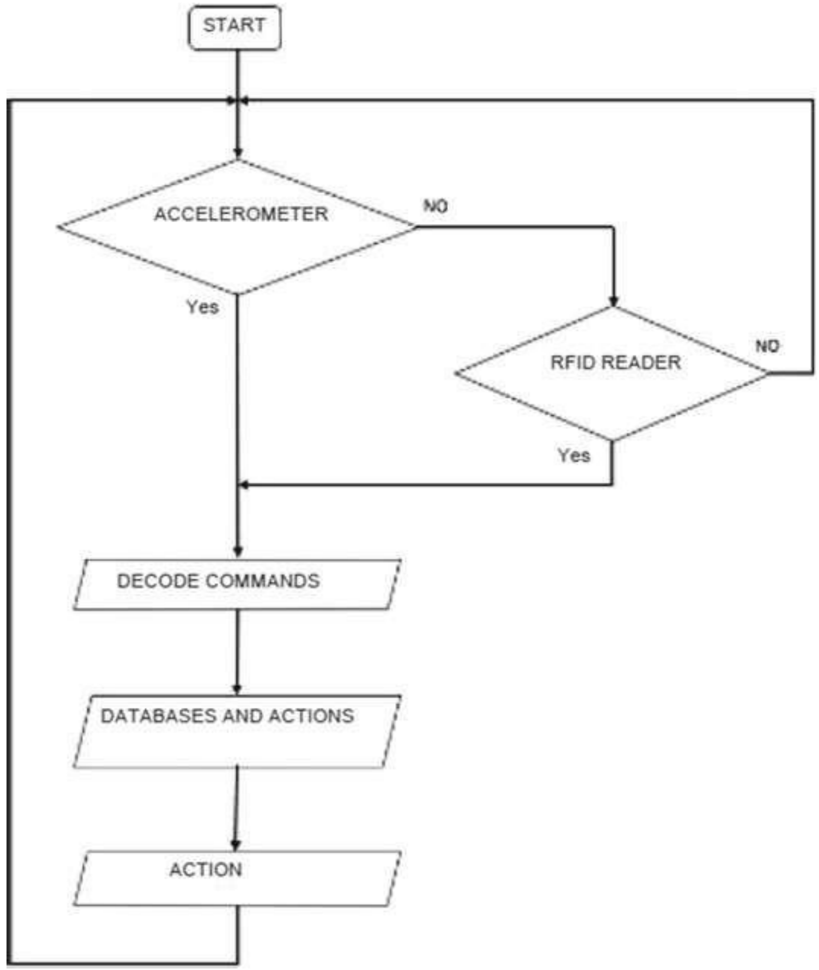


Fig. 5 Flowchart of robot operation

in real-time. It also had an accelerometer installed, which was part of the robot and was placed in the hand of the patient or therapist to observe the robot movement and the obtained interaction. In addition, there was an option of the specialist starting a conversation with the patient to evaluate the degree of attention and understanding that the patient had through the robot. In conclusion, this development has allowed the generation of knowledge about therapeutic social robotics. It has facilitated a new field of application of interactive robots. In this way, the research in this area can take advantage of it and served to implement new ideas in future projects where may be implemented.

5 Development Cost

It is known that the robot mentioned as the background is in charge of examining children with and without ASD who learned to socialize with a social robot through games of mistrust and deception. The cost of this robot for academic use is EUR 5.79,000; within Peru, the cost is PEN 21.83,971. Therefore, it is very expensive, especially in Huancayo. Thus, the robot proposed in this research, which works as a therapist assistant with the objective of treating children with ASD, offers ease of acquisition, as its components are very easy to find in the Peruvian market. Moreover, its maintenance can easily be understood by users, and its cost for academic use in Peru is PEN 2000 (Tables 1, 2, and 3).

Table 1 Cost of materials

Item	Description	Quantity	Unit	Unit cost	Total cost
1	Accelerometer	1	PEN	15.00	15.00
2	Driver module	1	PEN	20.00	20.00
3	Arduino mega	1	PEN	60.00	60.00
4	Lithium battery	8	PEN	5.00	40.00
5	RFID card	6	PEN	5.00	30.00
6	Servomotor	1	PEN	25.00	25.00
7	RFID reader	1	PEN	15.00	15.00
8	SD card	1	PEN	4.00	4.00
9	Matrix 8 * 8	3	PEN	16.00	48.00
10	Gearmotor	4	PEN	6.00	24.00
			Subtotal	PEN	281.00

Table 2 Mechanical part cost

Item	Description	Quantity	Unit	Unit cost	Total cost
1	Chassis	1	Und	30	30
2	Bolts	50	Und	15	15
3	Nuts	50	Und	15	15
4	Brackets	4	Und	5	20
			Subtotal	PEN	80.00

Table 3 Total cost

Item	Description	Quantity	Unit	Subtotal
1	Purchase of electronic part materials	1	Todo	281
2	Purchase of mechanical part materials	1	Todo	80
3	Services	1	Todo	700
		Total	PEN	1061.00

6 Conclusion

In this study, we demonstrate the feasibility of manufacturing a mobile robot that makes facial changes, music, and simple and interactive movement. Contributing mainly to therapies as an assistant in the process of improvement in the patient. It exhibits movements that can attract the attention of children being able to move easily and without irregularities. The movement of the head gives realism to its expressions with the design and construction of the interactive mobile robot for the treatment of children with ASD were performed with two degrees of freedom where you can easily interact with the user through the glove where you place the accelerometer, and you can observe the movement of the robot, it is also able to interact with the user by the voice recorded on the SD card, responding with sounds and gestures images by the RFID card. Therefore, the interactive mobile robot is suitable for such treatments.

As future work, we will improve the design of the mechanism to enlarge the arms of the prototype and, also accompany and measure qualitatively the improvements in therapy.

References

1. Medlineplus.gov.: Trastorno del espectro autista: MedlinePlus en español. Available at https://medlineplus.gov/spanish/autismspectrumdisorder.html. Accessed 12 Feb 2020 (2020)
2. Zhang, Y., et al.: ¿Could social robots facilitate children with autism spectrum disorders in learning distrust and deception? 2019. China: s.n. **7**, S0747-5632-(19)30148-7 (2019)
3. Discapacidad, Observatorio Nacional de: Conadis. https://www.conadisperu.gob.pe/observatorio/estadisticas/inscripciones-en-el-registro-nacional-de-la-persona-con-discapacidad-julio-2019/. Accessed 2 July 2019 (2019)
4. Opensurg, Consorcio. Robotica Medica. Elche: Cyted. 978-84-15413-12-7 (2013)
5. Sánchez Martín, F.M., Milán Rodríguez, F., Salvador Bayarri, J., Palou Redota J., Rodriguez Escovar, F.: Esquena Fernández S, Villavicencio Mavrich H. Historia de la Robótica: de Arquitas de Tarento al Robot Da Vinci (Parte I). Actas Urol Esp. **31**(2), 69–76 (2007)
6. Pennisi, P., et al.: Autism and social robotics: a systematic review. Autism Res. **9**(2), 165–183 (2015). https://doi.org/10.1002/aur.1527
7. Yaser, A.A., et al.: Robotic Trains as an Educational and Therapeutic Tool for Autism Spectrum Disorder Intervention. W. Lepuschitz, Italy (2019)
8. Provenzi L.: Interaction with social robots: Improving gaze toward face but not necessarily joint attention in children with autism spectrum disorder. IRCCS Eugenio Medea, Italia. https://doi.org/10.3389/fpsyg.2019.01503
9. Kumazaki, H., et al.: Brief Report: Evaluating the Utility of Varied Technological Agents to Elicit Social Attention from Children with Autism Spectrum Disorders, p. 2018. Springer, Japan (2018)
10. Anys, 40: Autismo. Autismo. https://www.autismo.com.es/autismo/tratamientos-del-autismo.html. Accessed 20 May 2019 (1976–2019)
11. Asociación Americana del Habla, L. y. Autismo Diario. Retrieved from https://autismodiario.org/2017/04/17/desarrollo-la-comunicacion-autismo-traves-la-musica-juego/. Accessed 17 Apr 2019
12. VDI: A systematic approach to the design of technical systems and products. Guideline 2222 (1986)

13. Autodesk: Inventor 2019 [Software]. Retrieved from https://latinoamerica.autodesk.com/products/inventor/overview (2019)
14. LabCenter. (s.f.).: Proteus 8.7 [Software]. Retrieved from https://www.labcenter.com/