www.editada.org

International Journal of Combinatorial Optimization Problems and Informatics, 16(2), April 2025, 45-54. ISSN: 2007-1558. https://doi.org/10.61467/2007.1558.2025.v16i2.964

Integration of Alexa and Social IoT for Generation X: A study on the Optimization use of Smart Treadmill to improve physical health

Alberto Ochoa-Zezzatti[1,2], José Antonio De los santos[1], Maylin Hernandez[1], Ángel Ortiz[1], Joshuar Reyes[1], Miguel Garcia[1]

[1] UACJ, Universidad Autónoma de Ciudad Juárez.
[2] CADIT, Universidad Anahuac.
alberto.ochoa@uacj.mx

Abstract. The Internet of Things (IoT) is an emerging technology with a significant impact on social and technological domains, enabling interconnectivity between electronic devices for data transfer and storage via wireless networks, with minimal human intervention. The growing interest in technologies that enhance daily life, such as virtual assistants (Alexa, Siri), highlights their relevance in intuitively controlling connected devices. While popular among the current generations, there is a promising opportunity to improve the well-being of Generation X through IoT. This article explores how integrating voice commands and IoT capabilities can optimize the use of a treadmill by incorporating sensors to capture variables such as heart rate and oxygenation levels. The future implementation of an AI-powered virtual assistant aims to achieve maximum personalization, improve habits and quality of life, and provide economic advantages compared to traditional gyms.

Keywords: Internet of Things, Voice Assistants, Alexa, Smart Home, Generation X, Home Automation, Energy Efficiency.

Article Info
Received Dec 26, 2024
Accepted February 13, 2025

1 Introduction

As contemporary technology has become essential in the daily routine of the average person, it has brought with it a multitude of advantages. Among these are easier access to specialized information, the promotion of globalization among communities, and the simplification of daily tasks, which has led to a notable increase in productivity and efficiency. However, along with these positive aspects, there are distinctive characteristics that have drawn attention for their potential negative impact, such as technological dependency and the promotion of sedentary lifestyles (Universidad Anáhuac, 2019). It is widely known that most Mexicans lead sedentary lives. Only 39.8% of the population over 18 years of age engages in any type of physical activity, placing this percentage among the lowest recorded in Mexico since the start of censuses measuring this social variable. As seen in Figure 1, obtained from the National Institute of Statistics and Geography (INEGI), the results tend to decline over the years (Instituto Nacional de Estadística y Geografía, 2024).

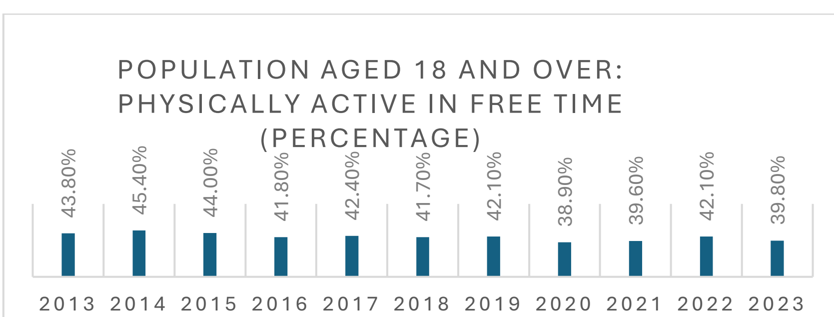

Fig. 1. Active population in Mexico 2023.

When evaluating physical activity more precisely, according to the level of sufficiency, it was found that 23.6% of the population aged 18 and older en-gages in physical activity at a sufficient level to obtain health benefits, while 15.3% does so insufficiently. The population that does not engage in any physi-cal activity reaches a worrying 60.2%, as indicated in Figure 2 (Instituto Nacional de Estadística y Geografía, 2024).

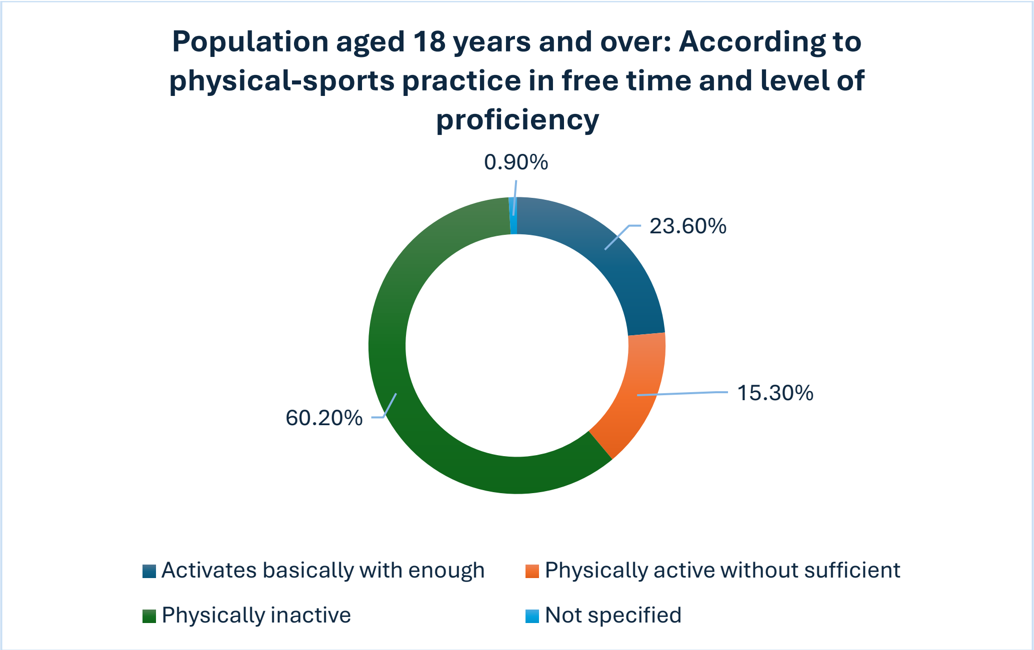

Fig. 2. Effectively active population in Mexico 2023.

This data is a major cause for concern, as a sedentary lifestyle is one of the leading risk factors for mortality, being associated with non-communicable chronic diseases such as diabetes, hypertension, osteoporosis, and cancer. Sedentary behavior is not only due to technological dependency but also to factors such as the lack of green spaces, pollution, economic issues in specific cases, and lack of time (Secretaría de Salud, 2015). Generation X especially faces problems like obesity and sedentary lifestyles due to the nature of their daily activities, predominantly in offices or jobs that limit mobility. Additionally, the time available for physical activity is often used to rest after a long workday (Genomawork, 2023). Therefore, in this document, a treadmill powered by the Internet of Things (IoT) will be developed to promote the physical well-being of people from these generations. This device will incorporate components such as AD8232 sensors for heart rate monitoring and the MAX30102 as an oximeter. All this data will be crucial, as thanks to a voice assistant powered by artificial intelligence, an exercise routine can be personalized according to the user's individual needs. Additionally, it will be justified that this treadmill will be more economical than a traditional gym subscription, and the possibility of integrating the detection of cardiac irregularities, such as cardiac arrest, will be explored, thus increasing user safety during exercise.

2 Objective of the research

The relevance of addressing this issue lies in the need to develop an intelligent system that integrates the collaboration of a virtual assistant (such as Alexa, Chat-GPT, among others) along with Internet of Things (IoT) capabilities in a treadmill, in order to optimize its use and promote healthy habits in Generation X. This approach is essential for personalizing exercise routines through artificial intelligence, tailoring them to the individual needs of users. This research also aims to justify the economic viability of this system compared to gym subscriptions. Ultimately, the goal is for this system to contribute to reducing sedentary lifestyles in Mexico, thereby improving the overall quality of life for the population.

3 Benefits to Generation X

The implementation of a smart treadmill supported by the Internet of Things (IoT) and virtual assistants offers several key benefits for Generation X, who often face specific challenges related to time, health, and the adoption of new technologies.

Adaptation to Busy Schedules: Generation X often manages strict schedules due to work and family commitments. This device allows them to exercise at home at the time that suits them best, eliminating the need to commute to a gym. Additionally, virtual assistants can schedule personalized workouts and send reminders, helping to smoothly integrate physical activity into their daily routine (Genomawork, 2023).

- **Personalized Health Monitoring:** Since people in this generation are at an age where health issues such as heart disease, hypertension, and diabetes are common, the smart treadmill becomes a crucial tool. The integrated sensors enable real-time monitoring of key indicators like heart rate and blood oxygen levels. These data allow for personalized exercise routines to improve the user's fitness without risking their health (Castellano et al., 2004).
- **Prevention of Chronic Diseases:** Sedentary behavior is a major risk factor for developing chronic diseases. Continuous use of the treadmill, along with automatic adjustments based on health data, not only promotes regular physical activity but also contributes to the prevention and control of conditions such as hypertension, high cholesterol, and obesity, which are prevalent in Generation X (Secretaría de Salud, 2015).
- **Technological Ease:** Although this generation did not grow up with the same exposure to technology as younger generations, the treadmill offers a user-friendly interface through voice commands with virtual assistants like Alexa. This removes technological barriers, allowing any user to interact with the device intuitively and personally, without needing advanced knowledge (Alejandro, 2022; Solectro, 2022).
- **Economic Savings:** By opting for a smart treadmill instead of a gym membership, users can achieve long-term economic benefits. While the initial investment may be significant, the savings on gym fees, transportation, and time justify this approach. Additionally, constant health monitoring can help avoid costly medical issues in the future, creating a positive impact on both the user's health and finances (Cristina, 2024; Javier, 2024).

3.1 Economic justification

The cost of a gym membership in Mexico varies depending on the type of establishment. For example, an annual subscription to premium gyms like Sport City can range from $8,000 to $15,000 MXN per year (Javier, 2024). These gyms offer additional services such as group classes, access to multiple locations, and personalized coaching, but they also represent a high cost for those who do not fully utilize these services. On the other hand, low-cost gyms like Smart Fit charge approximately $4,788 to $7,200 MXN annually (Cristina, 2024). Although more affordable, users must travel to the physical location of the gym, which may not be practical, especially for Generation X individuals with long workdays. In contrast, while the initial investment in a smart treadmill may seem high, it is amortized over time. For example, a treadmill equipped with sensors, IoT, and a virtual assistant could cost between $6,000 and $8,000 MXN, depending on the features included. However, this is a one-time investment. Unlike an annual gym membership, there would be no need to pay recurring fees, and the user can exercise at home without the additional costs of transportation or extra charges for specific services. Moreover, connected treadmills allow for personalized workout routines based on the user's needs, improving training efficiency without requiring constant personal trainer assistance. In the long term, this device can be more economical and convenient, especially for those who value the flexibility of exercising at home and avoiding gym commutes. This proposal promotes the efficient use of time and economic resources, making the smart treadmill a more cost-effective solution in the medium and long term compared to an annual membership to a traditional gym.

4 Development

The development of the integration between Alexa and Social IoT for optimizing treadmill use among Generation X focuses on the seamless interaction between users and smart devices. By utilizing voice commands, this research aims to enhance the experience of treadmill users, specifically targeting the technological engagement of Generation X, a demographic known for being less familiar with cutting-edge technology than younger generations. Alexa, when integrated with IoT, allows for effortless control of the treadmill and other smart devices in the user's environment, fostering a more intuitive exercise routine. Sensors embedded in the treadmill monitor users' performance and health metrics in real-time, while Alexa's AI-driven capabilities offer personalized workout routines, track progress, and provide motivation based on the individual's preferences. This interconnection exemplifies the future of fitness, where the treadmill becomes an intelligent and interactive part of the smart home ecosystem. In addition to improving the user experience, the integration of IoT with voice assistants like Alexa highlights the potential economic and health benefits for Generation X. With customized workout plans and real-time feedback, users can avoid the costs associated with gym memberships, while still maintaining a personalized fitness routine in the comfort of their homes. This approach not only enhances accessibility to fitness for those with busier lifestyles but also ensures continuous improvement in health monitoring. The treadmill's adaptive features, coupled with Alexa's integration, support a more sustainable fitness journey, ensuring that users can remain engaged and motivated in their routines. As the research progresses, the primary focus is to refine this technology to be user-friendly, cost-effective, and sustainable for long-term health benefits.

4.1 Conceptual diagram

Figure 4 provides an overview of the system designed to optimize the user experience of the smart treadmill, specifically targeting Generation X. This system integrates a series of advanced sensors that allow continuous monitoring of key health variables, such as heart rate and blood oxygen levels. These data are stored and processed in real time through a central monitoring system, enabling the immediate personalization of exercise routines. One of the key features of the system is the inclusion of a virtual assistant, in this case, Amazon Alexa, which acts as the brain behind personalization. Using artificial intelligence algorithms, Alexa analyzes the user's health data to dynamically and automatically adjust the intensity and duration of exercise sessions. This continuous interaction ensures that routines are both safe and effective, adapting not only to the user's immediate needs but also to their long-term health goals. Finally, the economic and long-term benefits offered by the smart treadmill are highlighted when compared to traditional gym memberships. As illustrated, the user-centered design and the use of cloud-based data provide a comprehensive and connected approach to personal well-being, ensuring tangible health improvements over time.

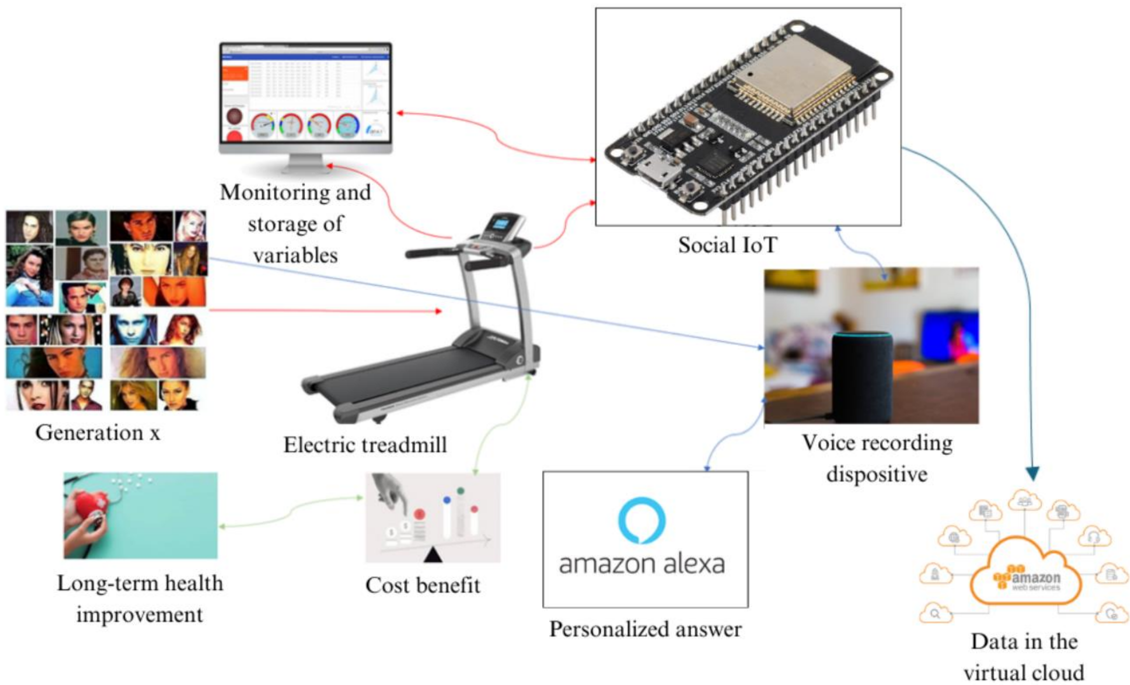

Fig. 3. Conceptual diagram of the treadmill.

4.2 Signal discretization

Sampling, also known as "Signal Discretization," is the first step in the process of converting an analog signal (continuous time and amplitude) into a digital signal (discrete time and amplitude). According to Barco (2013), this process involves taking samples at defined intervals from the continuous signal, converting it into a digital version that can be interpreted by electronic systems without losing critical information. The need to convert an analog signal to digital has an essential justification, especially for its role in the integration and functionality of modern electronic systems that we use in our daily lives and various industries. Devices such as cell phones and computers are capable of capturing analog signals, but processing them directly is a complex task due to the continuous nature of these signals (Ogata, 1996). Analog signals have an infinite number of possible values within a given range, which can make processing computationally intensive for digital systems (Alan & Alan, 1997). Signal discretization emerges as a solution to this problem. This process involves taking samples at defined intervals from the continuous signal, converting it into a digital version that can be interpreted by electronic systems without losing critical information. This facilitates signal processing, allowing devices to perform their functions more efficiently and accurately (Antony, 2023).

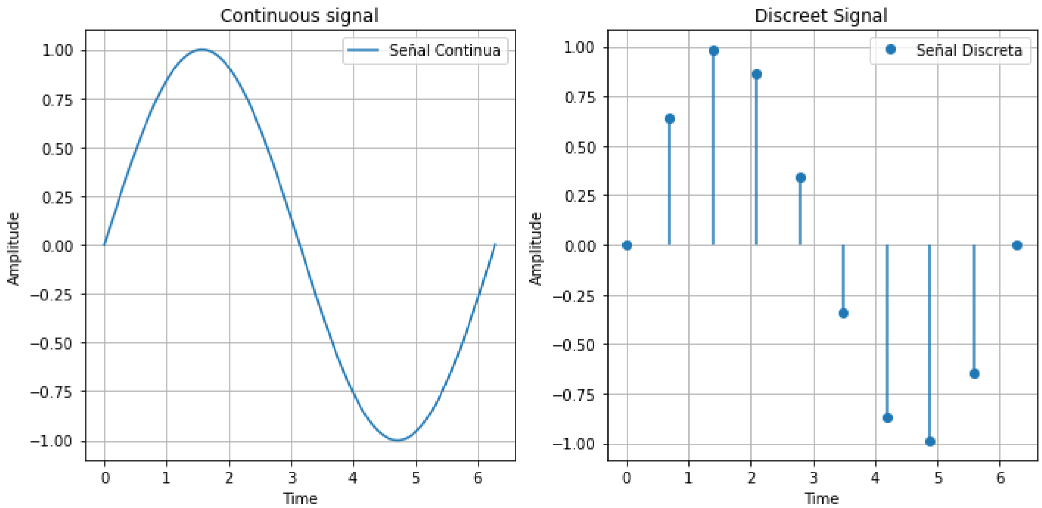

Fig. 4. Comparison between a continuous signal and a discrete signal.

Once we have a discretized signal, the next step is quantization, which is the process by which the continuous values of a sinusoidal wave are converted into a series of discrete decimal numeric values corresponding to the different levels or voltage variations contained in the original analog signal (Ingrid, 2013; Jimmy et al., 2008). This allows us to assign corresponding values in the decimal number system, paving the way for conversion to binary.

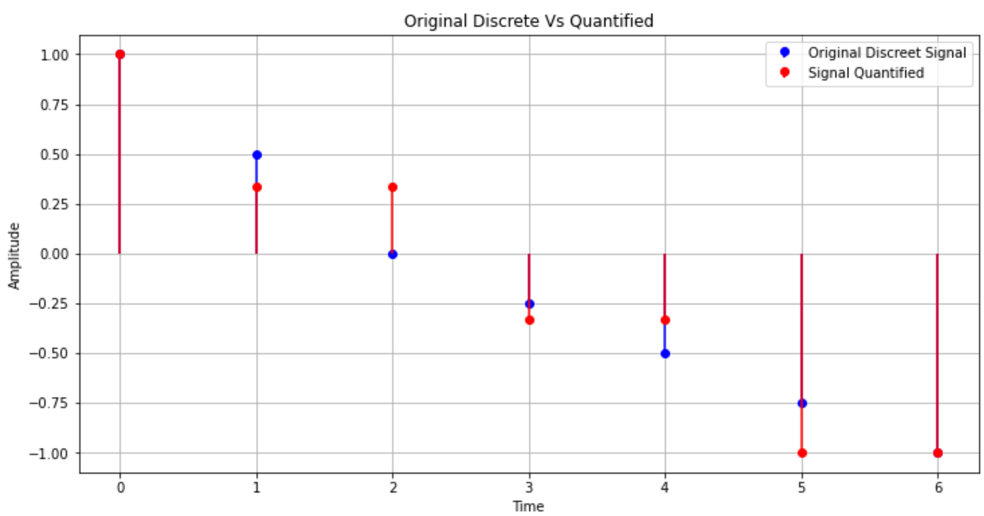

Fig. 5. Quantization of a signal.

A clear example of this would be an electrocardiogram (ECG). Sensors like the AD8232 capture the mechanical signals produced by cardiac activity and convert them into electrical signals. These electrical signals, which are still analog, represent the continuous behavior of the heart over time. However, for them to be processed by electronic systems, these signals must be digitized. The process of converting an analog signal to digital involves several steps: first, the sensor detects the analog signal, and then an analog-to-digital converter (ADC) samples this continuous signal at predefined time intervals. These samples are quantified and converted into a sequence of digital data that can be stored, analyzed, and used for decision-making, such as customizing exercise routines or detecting cardiac irregularities in real-time (Marcovecchio & Pacagnini, 2013).

This is highly relevant to understand for our system, as we are working with a very small voltage range, and disturbances within our signals are constant. Understanding these processes helps us as developers implement filters, reducing reading errors and opening new possibilities.

4.3 Main components of the system

Health Monitoring Sensors:

- **MAX30102:** This optical sensor employs photoplethysmography (PPG) technology to measure heart rate (BPM) and blood oxygenation (SpO2). Through LEDs and a photodetector, it captures variations in light reflected by blood flow, providing accurate indicators of cardiovascular and respiratory health (Castellano et al., 2004; Ll. Luis, 2020).
- **AD8232:** Electrocardiogram (ECG) sensor designed to monitor the electrical activity of the heart. It is essential for detailed analysis of heart rhythm and the identification of possible abnormalities in the heart's electrical signals (Nilda et al., 2018).

Processor and Communication:

- **ESP32:** Microcontroller that manages the input from sensors. It functions as a node in an IoT network, responsible for data collection, control logic execution, and communication with other devices in the system.

User Interface:

- **Oled Display:** Provides real-time visualization of vital metrics such as heart rate and blood oxygenation. It offers a clear and accessible interface for user interaction.
- **Alexa:** Integrated via Amazon Web Services (AWS), this voice assistant facilitates interaction by providing personalized feedback and alerts about anomalies based on collected health data.

Connectivity and Remote Monitoring:

- **AWS (Amazon Web Services):** This cloud platform receives, processes, and stores the data collected by the system. Integration with AWS not only enables long-term data storage but also facilitates advanced analysis and the personalization of exercise routines through Alexa.

4.4 Connecting the main components of the system

The following table details the distribution and specific allocation of the main components in our smart treadmill system. This table organizes each component according to its location and function within the system, providing a clear over-view of how each element contributes to the overall integration and efficiency of the project.

Table 1. Component connections.

COMPONENT	COMPONENT PIN	PIN DESCRIPTION	PIN ON ESP32
MAX30102	SDA	I2C Serial Data	GPIO 21
	SCL	I2C Serial Clock	GPIO 22
	INT	Interrupt (not used in current code)	Not connected
AD8232	OUT	ECG Signal Output	GPIO 34
	LO+	Electrode disconnection detection (positive)	Not used in current code
	LO-	Electrode disconnection detection (negative)	Not used in current code
	GND	Ground	GND
	VCC	Power supply	3.3V
DISPLAY OLED	SDA	I2CSerialData	GPIO 21
	SCL	I2C Serial Clock	GPIO 22
	VCC	Power supply	3.3V
	GND	Ground	GND

4.5 Connecting the main components of the system

The prototype integrates a real-time communication flow designed to monitor the user's health parameters and offer personalized responses through interaction with Alexa. This process begins with the collection of health data via sensors connected to an ESP32 microcontroller. The monitored parameters include heart rate and oxygen levels, which are sent in real-time to the Amazon Web Services (AWS) platform using the MQTT protocol (Alejandro, 2022; Solectro, 2022). Once in the cloud, the data is published to a specific AWS IoT topic, making the information accessible to other cloud services. The user can interact with the system through voice commands to Alexa, such as "Alexa, how are my heart parameters?" This request triggers an Alexa skill, which in turn triggers an AWS Lambda function designed to retrieve the user's most recent data from AWS IoT. The Lambda function processes the received information and generates a personalized response based on the user's current health status. This response is then transmitted back to the Alexa skill, which communicates the information to the user through an Alexa device, providing details such as "Your current heart rate is 150 beats per minute, and your oxygen level is 90%." This system enables constant monitoring and delivers direct, tailored feedback to the user, optimizing the experience during physical activities and promoting greater health awareness.

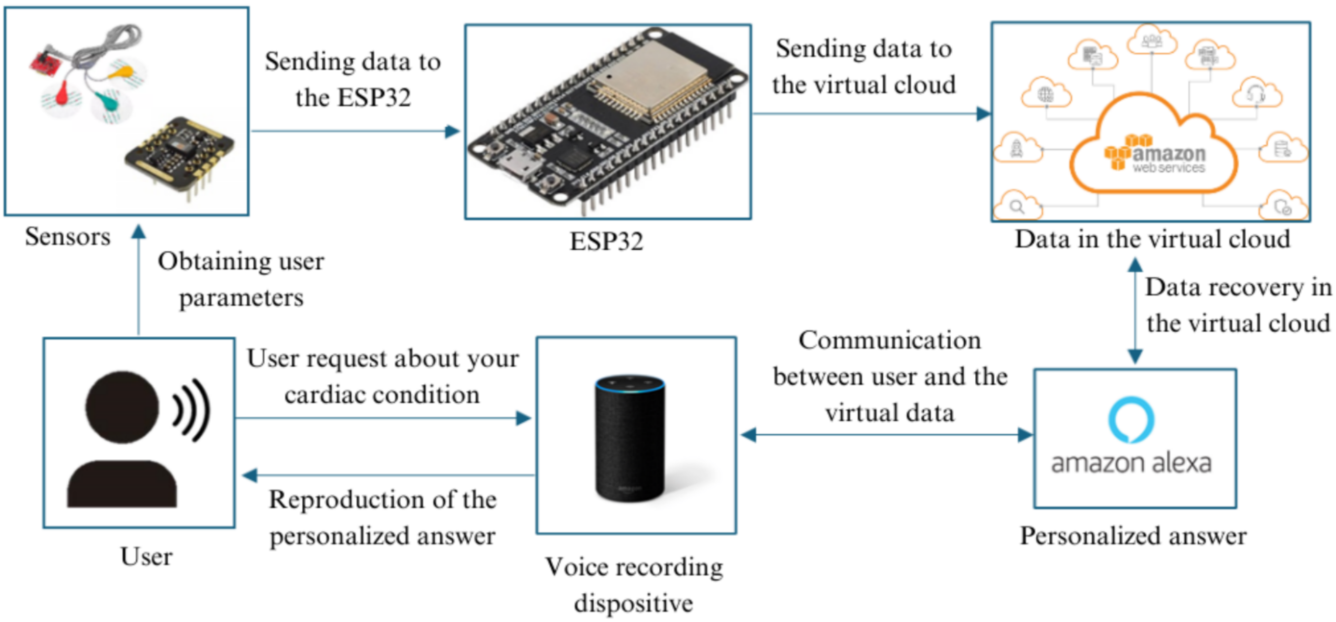

Fig. 6. Communication between devices.

5 Results

In this first prototype, significant progress was made, such as obtaining key biometric parameters, including oxygen saturation (SpO2), beats per minute (BPM), and basic sampling of an electrocardiogram (ECG). Additionally, the interconnectivity between these sensors and the virtual assistant Alexa was successfully established, allowing Alexa not only to monitor but also to report in real-time on the user's various health variables. This advancement represents an important step toward the personalization of health monitoring through the integration of IoT and intelligent voice assistants

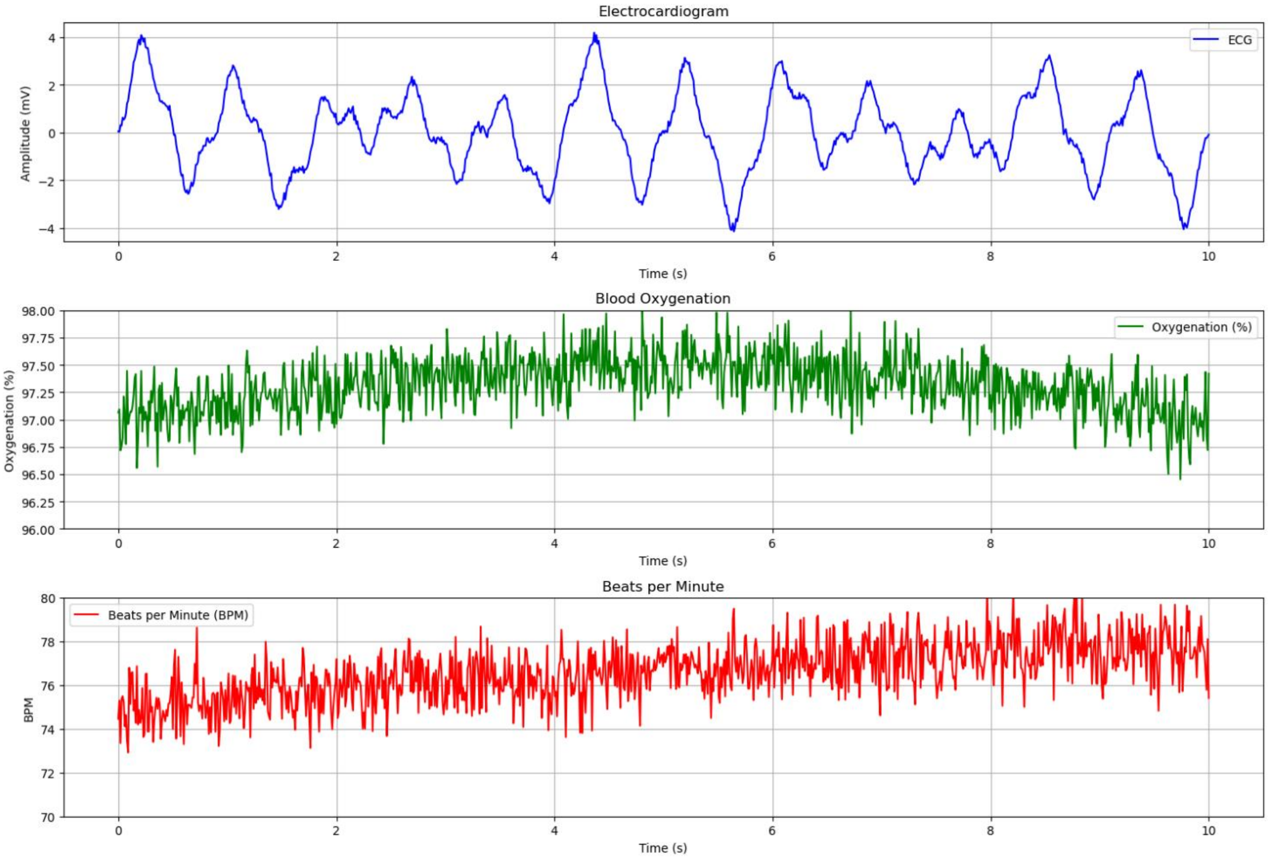

Fig. 7. View of the electrocardiogram.

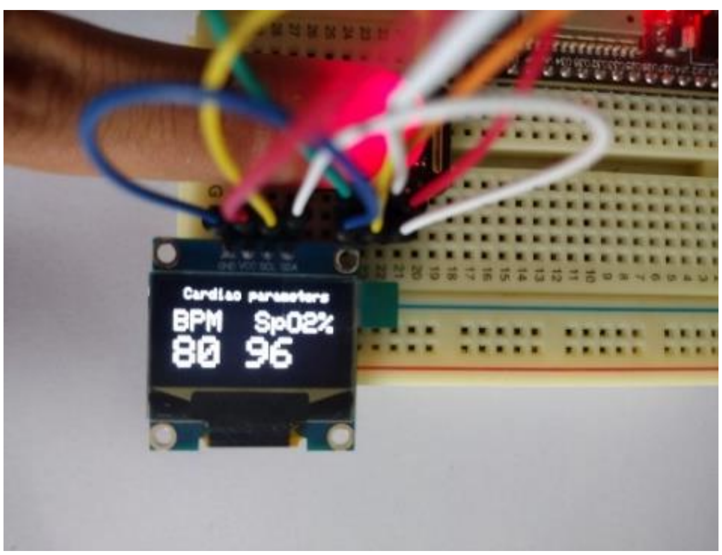

Fig. 8. Oximeter functioning

5.1 Prototype reaction levels

A reaction level system is also integrated, which serves as a prelude to the final functionality of the prototype, aimed at managing the user's physical conditions in an automated and progressive manner. As shown in Figure 9, this system is broken down into four steps.

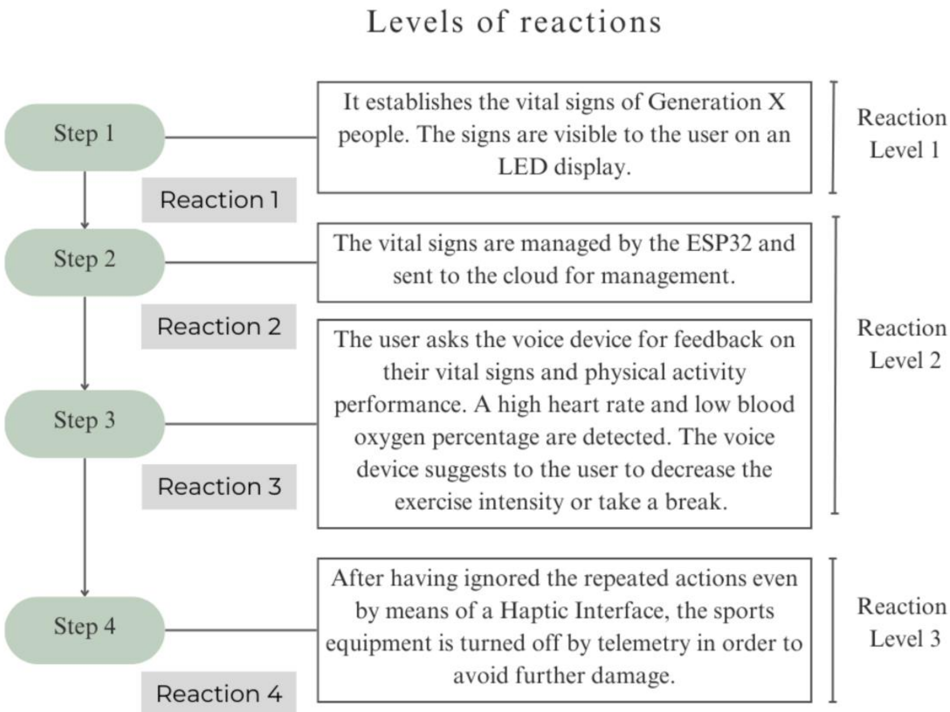

Fig. 9. Prototype reaction levels.

This structure allows the system to be proactive, ensuring the user's safety during exercise and optimizing their experience based on their real-time physical conditions.

6 Conclusion

In this work, we have developed an innovative system specifically designed to improve the quality of life of Generation X. This system facilitates physical activity from the comfort of home, directly addressing the issue of sedentary behavior prevalent in this demographic group due to their demanding daily routines. Our prototype promotes a more active lifestyle and aims to mitigate the risk of chronic diseases associated with sedentary habits. The implementation of this system represents a significant step toward proactive health support, offering a practical solution that adapts to the time and space limitations often faced by individuals of this generation. Additionally, in cases where chronic diseases are already present, the system is designed to act preventively and therapeutically in the future, adjusting the recommended activities to the specific needs of each user. Looking to the future, this prototype has the potential to serve as a catalyst for positive changes, not only for Generation X but also as a model for future interventions aimed at other demographic groups. By integrating technology into people's daily routines, we are paving the way for healthier and more active aging.

7 Future research

For future iterations, the complete implementation of the automation proposed in this document is anticipated. The goal is to develop Alexa's ability to adjust users' routines based on their current states. Additionally, users will be able to modify their own routines through direct voice commands. On the technical side, advanced mathematical models are planned for the development of digital filters. This implementation will enable the system to detect cardiac anomalies, thus contributing to the prevention of critical incidents such as cardiac arrest (the system would call emergency services if necessary). The analysis of discretized signals mentioned earlier will serve as the foundation for these developments. Lastly, the sensing of various physiological and environmental parameters will be explored to enhance the user experience. This will include monitoring hydration levels, sleep hours, and other key aspects related to the user's safety and well-being. These improvements aim not only to increase the system's functionality but also to enhance its ability to provide personalized and proactive support to users, as shown in Figure 10.

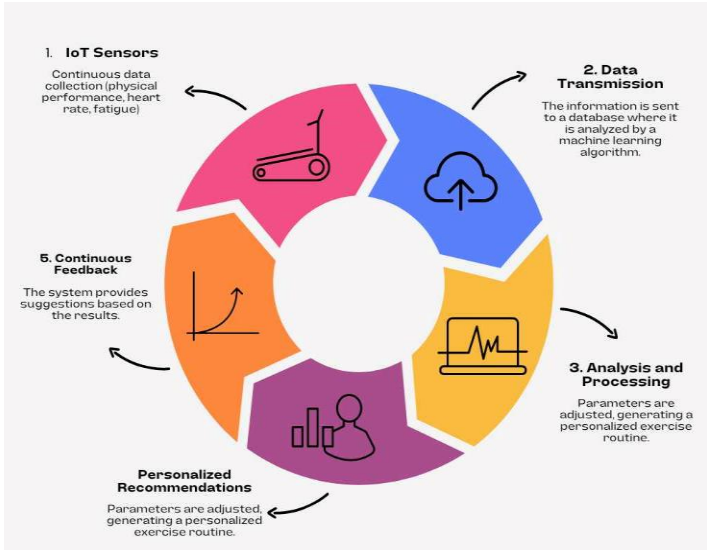

Fig. 10. Demonstrative diagram of functioning.

References

Alan, V., & Alan, S. (1997). *Señales y sistemas* (2a ed.). Pearson.

Alejandro, L. (2022). Usando Amazon Lex y Alexa para controlar un coche de carreras en el AWS Summit Madrid 2022. *If Geek Then*. https://ifgeekthen.nttdata.com/s/post/usando-amazon-lex-y-alexa-para-controlar-un-coche-de-carreras-en-el-aws-summit-m-MCJSD5IYZR4NBYNI536QPHNKRQH4?language=es

Antony, G. (2023). Discretización de señales analógicas. *Panamá Hitek*. https://panamahitek.com/discretizacion-de-senales-analogicas/

Barco, R. (2013). Discretización de señales. *Laboratorio de Comunicaciones y Redes, UNS*. http://lcr.uns.edu.ar/fvc/NotasDeAplicacion/FVC-RodrigoBarco.pdf

Castellano, C., Pérez de Juan, M. A., & Attie, F. (2004). *Electrocardiografía clínica* (2a ed.). Elsevier.

Cristina, O. (2024). Smart Fit se lleva más de 20% de las membresías en gimnasios en México. *Milenio*. https://www.milenio.com/negocios/smart-fit-tiene-mas-de-20-por-ciento-de-las-membresias-gimnasios

Darinka, R. (2024). México sedentario: Solo el 39% de la población hace ejercicio con regularidad. *El País*. https://elpais.com/mexico/2024-01-26/mexico-sedentario-solo-39-de-la-poblacion-hace-ejercicio-con-regularidad.html?event_log=regonetap

Genomawork. (2023). Cómo es la Generación X en el trabajo: ¿Los tienes identificados? *Genomawork Blog*. https://www.genoma.work/post/como-es-la-generacion-x-en-el-trabajo-habilidades-caracteristicas

Ingrid, D. (2013). Diferentes tipos de señales y ejemplos. *Apuntes de Análisis de Sistemas*. https://apuntes-de-analisis-de-sistemas.webnode.es/news/diferentes-tipos-de-senales-y-ejemplos/

Instituto Nacional de Estadística y Geografía (INEGI). (2024). Módulo de práctica deportiva y ejercicio físico (MOPRADEF) 2023. Comunicado de prensa número 31/24. https://www.inegi.org.mx/contenidos/saladeprensa/boletines/2024/MOPRADEF/MOPRADEF2023.pdf

Javier, T. (2024). Cuánto cuesta la anualidad en Sport City: Precios actualizados. *Unives*. https://unives.com.mx/cuanto-cuesta-la-anualidad-en-sport-city-precios-actualizados/?expand_article=1

Jimmy, C., Hugo, C., & José, C. (2008). Fundamentos y aplicaciones del muestreo en señales ubicadas en las bandas altas del espectro. *Scientia et Technica*, *XIV*(39), 37-38.

Ll. Luis. (2020). Pulsímetro y oxímetro con Arduino y MAX30102. *Luis Llamas*. https://www.luisllamas.es/pulsimetro-y-oximetro-con-arduino-y-max30102/

Marcovecchio, A. M., & Pacagnini, A. M. J. (2013). Cuantificación e insuficiencia argumentativa: Construcciones con "para" de contraexpectativa. *Círculo de Lingüística Aplicada a la Comunicación*, *55*. https://repositorio.uca.edu.ar/handle/123456789/16984

Nilda, F., Rodrigo, V., & Juan, H. (2018). Registro de la actividad electromiográfica con AD8232. *Boletín de Ciencia y Tecnología*, *69*. https://www.boletin.upiita.ipn.mx/index.php/ciencia/791-cyt-numero-69/1601-registro-de-la-actividad-electromiografica-con-ad8232

Ogata, K. (1996). *Sistemas de control en tiempo discreto* (2a ed., pp. 1-7). Prentice Hall.

Secretaría de Salud. (2015). ¿Qué es el sedentarismo? https://www.gob.mx/salud/es/articulos/que-es-sedentarismo#:~:text=El%20sedentarismo%20ocurre%20por%20diversos,al%20televisor%20o%20a%20la%20computadora

Solectro. (2022). ¿Qué es MQTT? El protocolo de comunicación IoT. *Solectro Blog*. https://solectroshop.com/es/blog/que-es-mqtt-el-protocolo-de-comunicacion-para-iot-n117?srsltid=AfmBOooLADne13jnzGbUuZaM_cqgGepslf9t1ohUplrMpNO2tHTgzl8K

Universidad Anáhuac. (2019). La influencia de la tecnología en nuestra vida cotidiana. https://www.anahuac.mx/generacion-anahuac/la-influencia-de-la-tecnologia-en-nuestra-vida-cotidiana

Vicente, G. (2015). Muestreo de señales. *Universidad de Almería*. https://w3.ual.es/~vruiz/Docencia/Apuntes/Signals/Sampling/index.html