Revista Internacional de Investigación e Innovación Tecnológica

Página principal: www.riiit.com.mx

A Systematic Literature Review of New Technologies for Translating Sign Language for Deaf People
Una Revisión Sistemática de Literatura de las Nuevas Tecnologías Destinadas a Traducir la Lengua de Signos para Personas Sordas

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Technological Innovation: Identification of the advantages of current sign language interpreting methods.
Industrial application area: Software Development, Digital Services Integration, Data Analysis.

Received: april 17th, 2024
Accepted: december 21th, 2024

Resumen

Actualmente, en todo el mundo hay más de 450 millones de personas que padecen discapacidades auditivas. Esta condición les provoca problemas sociales y psicológicos, ya que tienen problemas de aislamiento social y laboral, y un alto estrés que les resta calidad de vida. En este trabajo se realiza una revisión literaria de 104 investigaciones dedicadas a solucionar el problema de comunicación de las personas sordas, estás investigaciones han sido obtenidas empleando una metodología de desarrollo propio en combinación con el modelo PRISMA 2020 (*Preferred Reporting Items for Systematic reviews and Meta-Analyses*), desde la perspectiva de la implementación de dispositivos IoT (*Internet of Things*), el uso de servicios de computación en la nube y el desarrollo de bases de datos dedicadas como base de modelos de detección de señales basados en algoritmos de inteligencia artificial. Finalmente, se presenta un análisis sobre la influencia de los dispositivos IoT en la traducción de diversas lenguas de signos mediante la integración de diferentes sensores, el uso de herramientas de clasificación como las redes neuronales y el aprendizaje automático, por otro lado, la computación en la nube permite brindar soluciones que permiten la integración de modelos de alto rendimiento, los cuales están disponibles para diferentes tipos de plataformas. En las investigaciones analizadas es posible observar una influencia importante de diferentes técnicas de inteligencia artificial, en particular, el uso de redes neuronales convolucionales para la identificación de señas gestuales debido a su alta efectividad.

Palabras clave: Computación en la nube, Conjunto de datos, Internet de las cosas, Lengua de signos, Personas, mudas.

Abstract

Currently, there are more than 450 million people worldwide who suffer from hearing impairment. This condition causes them social and psychological problems, since they have problems of social and work isolation, as high stress that reduces their quality of life. This work is a literature review of 104 investigations dedicated to solving the communication problem of deaf people. These investigations have been obtained using a self-developed methodology in combination with the PRISMA 2020 model (Preferred Reporting Items for Systematic reviews and Meta-Analyses), from the perspective of the implementation of IoT (Internet of Things) devices, the use of cloud computing services and the development of dedicated databases as a basis for signal detection models based on artificial intelligence algorithms. Finally, an analysis is presented on the influence of IoT devices on the translation of various sign languages through the integration of different sensors, the use of classification tools such as neural networks and machine learning. On the other hand, cloud computing provides solutions that allow the integration of high-performance models, which are available for different types of platforms. In the analyzed research, it is possible to observe an important influence of different artificial intelligence techniques, particularly the use of convolutional neural networks for the identification of gestural signs due to their high effectiveness.

Keywords: Cloud computing, Dataset, Mute, People, Internet of things, Sign language.

1. Introduction

One of the sectors of the population worldwide that suffers most from restrictions on access to services, jobs, as well as the development of their social and cultural capabilities is the mute community (Admire and Ramirez, 2021), because the sense of hearing is essential to carry out a series of activities in daily life (Robinson and Henner, 2017). This community is made up of more than 450 million worldwide, due to their very condition, these people face occupational and social exclusion (Power, 2022; Vergara, 2019) and other problems that limit their quality of life (Matus et al., 2020). The human ear captures acoustic intensity levels between 0 dB (threshold) to 120-130 dB, which can be contaminated by the effects of artificial sources that weaken hearing (Walker et al., 2013), when a person has 'disabling' hearing, they have a hearing loss greater than 35 decibels (dB) in the ear with better hearing.

Mute people have their own language, which is sign language (SL), in each country there is a different SL, even between countries there are variants of the same SL, according to the World Federation of the Deaf (WFD) there are more than 300 sign languages (Power et al., 2020). An important characteristic of sign languages is that they evolve with respect to the local needs of each region and each country in the world. Of the diverse types of SL families, British, Spanish, French, German, Swedish Finnish, Indo-Pakistani, Kenyan and Arab families stand out. SL has the characteristic of taking elements in the expression of facial movements, through the hands, as well as the expression of written language (Manning et al., 2020). There are several problems to solved in communication with deaf-blind and non-disabled people, among them are two way real-time person-to-person physical communication and the integration of digital platforms (Ray, 2018; Gupta et al., 2020).

Considering the development of current technology with the development of devices that are part of the IoT (internet of things) universe, it is possible to integrate hardware that gets motion signals with different types of sensors to propose a reference framework and solve a problem as big as communication (Mehta et al., 2018). The IoT architecture is related to the Internet users, considering a layer that includes the network layer, which is related to routers for internet connection, and finally it has the sensing layer is related to devices such as sensors, actuators, and controllers. Among the most relevant hardware platforms that are related to the IoT are Arduino and Raspberry (Novillo-Vicuña et al., 2018; Ardiansah et al., 2020). On the other hand, with the development of cloud computing, it is possible to use services to assemble complex software architectures that allow interpreting from visual signals to a huge amount of data in a matter of seconds. Cloud computing allows devices with low computational performance to execute complex tasks to save on in-site equipment for people with limited resources. Cloud computing includes models of software-as -a-service (SaaS), platform as a service (PaaS), and infrastructure as a service (IaaS). All cloud computing models include a rigorous security scheme as data loss and misuse can be problematic if breached (Palos-Sanchez et al., 2017). Both cloud services and IoT devices present solutions to solve problems related to communication with mute people.

The main objective of this research is to analyze and discuss the information obtained from a systematic review of proposals for sign language translation for deaf people obtained through the PRISMA 2020 model (Page et al., 2021) in combination with a proposal developed for obtaining works that use IoT technology, cloud computing and data set. The following section presents the methodology followed to compile a collection of works dedicated to solving the problems that exist in the communication of deaf and mute people using IoT devices, cloud computing and database proposals aimed at the interpretation of different languages signs.

2. Methodology

The methodology proposed for this research aims to generate a search for current research for the interpretation of SLE using IoT devices, cloud computing and databases through the choice of keywords, specific questions that allow generating the search for relevant research in the context, in addition the PRISMA 2020 model has been used to give greater solidity to this research. Figure 1 shows the phases of the proposed methodology.

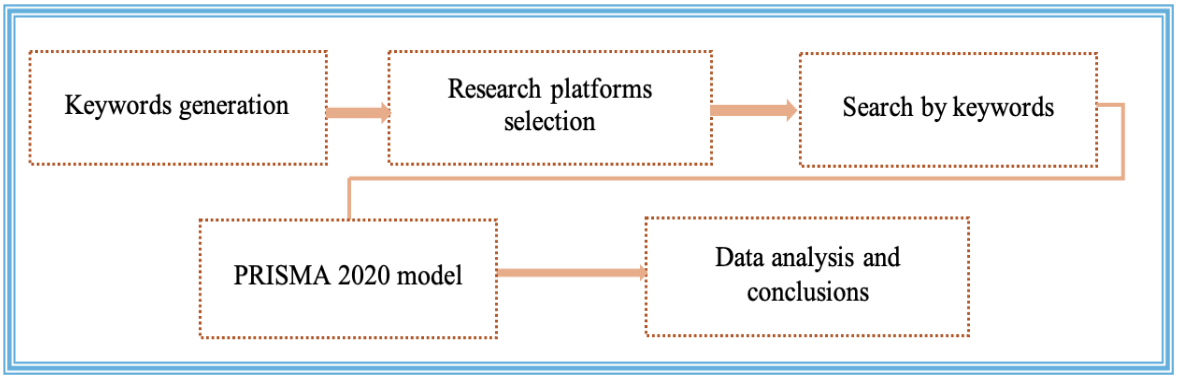


Figure 1. Workflow methodology.

-Keyword generation. Key terms referring to deaf people and SL are defined, considering the detection mechanism and context, such as cloud computing, IoT, the dataset related to mute people.

- Selection of research platforms. A search is carried out in the databases in which the execution of jobs related to the translation of SL will be carried out. The search engines IEEE Xplore, Wiley, Scopus, Springer, and Google Academics will be consulted, and research papers from 2015 to 2023 should be filtered.

- Search by keyword. The key terms referring to IoT, deaf and mute people, cloud services, and reference datasets, should be applied in the database search engines mentioned above. To carry out the search for the research work, a combination of values has been made as shown in Table 1, in the first instance the word O1 "IoT" is placed followed by the set C1 "mute people" and then the set C2 "sign language" or "hand gesture", for the other categories O2 = "cloud computing, O3 = "internet services" is used in combination with C1 and C2 in combination, finally the process is repeated with O4 = "dataset", O5 = "database" and O6 = "lexicon".

PRISMA 2020 Model. The PRISMA 2020 model uses the selection of research based on indexing of the research obtained if it is found in journals indexed in Scopus or WoS, relevant works whose journals are indexed in Latindex, EBSCO or similar are also considered. Book chapters and conferences are considered if they are published by publishers such as IEEE, Springer, ACM, among others, and the definition of categories allows the works to have been filtered, the categories are generated based on whether the main topic is IoT, cloud computing or datasets dedicated to solving problems related to the translation of SL into other types of languages.

- Data analysis and conclusions. According to the data collected, an analysis is generated for each category, considering advantages and disadvantages of the proposals, future challenges, as well as a proposal that covers solutions according to the areas of opportunity found, as can be seen in Table 2.

Table 1. Combination of words to search for research.

Option	Complement 1	Complement 2
Pile	Mute people	Sign language/hand gestures
Cloud Computing	Mute people	Sign language/hand gestures
Internet Services	Mute people	Sign language/hand gestures
Dataset	Mute people	Sign language/hand gestures
Database	Mute people	Sign language/hand gestures
Lexicon	Mute people	Sign language/hand gestures

Table 2. Biases in obtaining research dedicated to the interpretation of MS.

Biases	Description
Bias Computational technology	Computational technology used for the detection and translation of SLs.
Bias precision	Percentage of accuracy greater than 85% obtained in the proposal.
Bias SL recognition	Number of signs that the proposal can recognize.
Impact bias in the scientific community	It includes research that has been cited more than 39 times by the scientific community.

The research questions on which this work is based are in the following Table 3 to generate the directions that conduct this investigation.

Table 3. Questions used for the execution of the research.

Criteria	Question
Limit the information obtained in search to narrow the results to IoT, cloud computing and specialized datasets.	What current technologies and methods are highly relevant from the perspective of IoT, cloud computing and specialized datasets to solving the communication problem of deaf and mute people?
	What is new research focusing on to address the problems of mute people?
To select the research papers, the following questions have been applied.	Is the research found in a journal indexed in WoS, Scopus or at least in Latindex or EBSCO? If the work is from the period 2016-2019, does it have at least more than 5 citations?
For research from international conferences or book chapters, the following question was asked.	Are the investigation works published in prestigious publishers such as IEEE, Springer, ACM or equivalent?

Figure 2 shows the application of the PRISMA 2020 model. The process begins with the capture of the data obtained from the databases in which the research work has been obtained according to the keywords, then the criteria in Table 2 are applied for filtering and the number of investigations is counted according to whether articles come from journals, conferences or book chapters. In the final process are obtained 104 investigations about SL models.

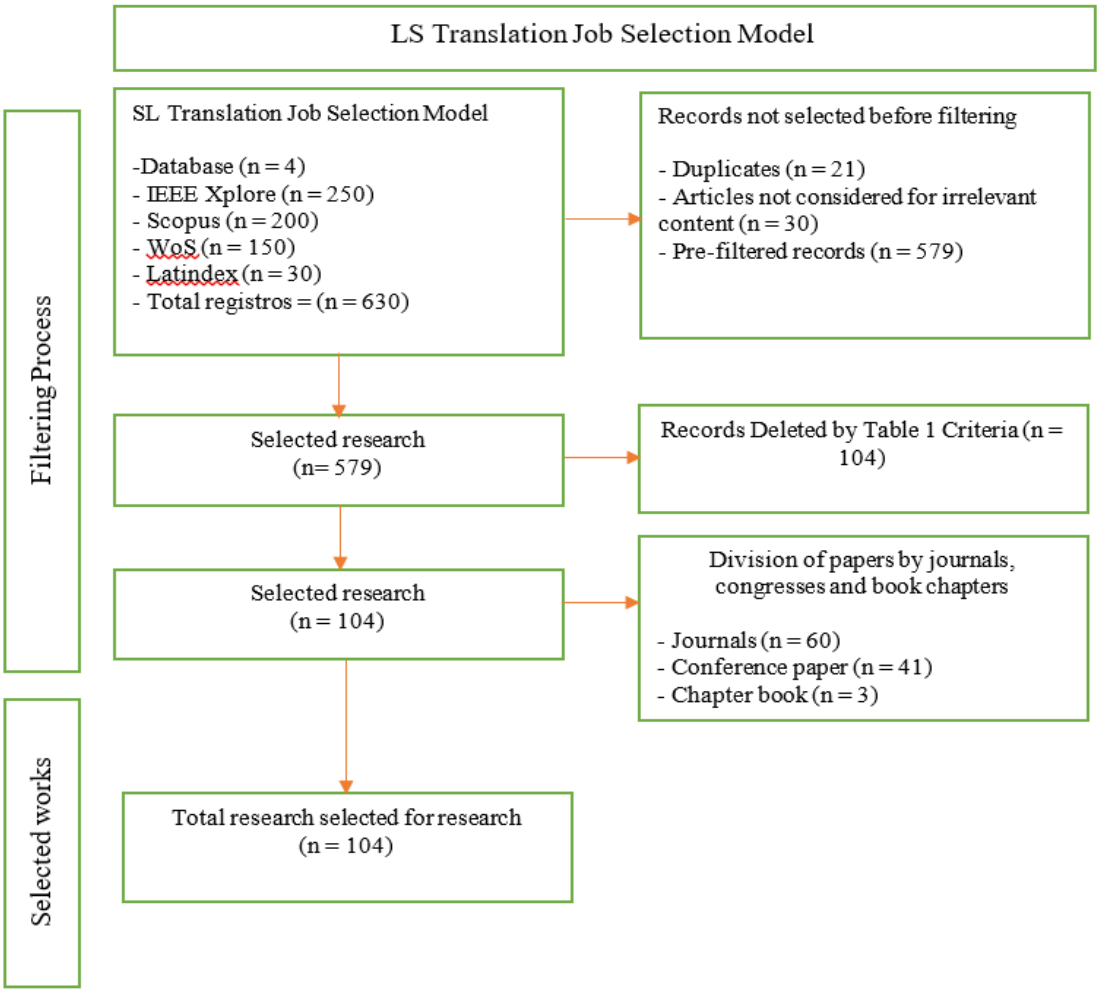
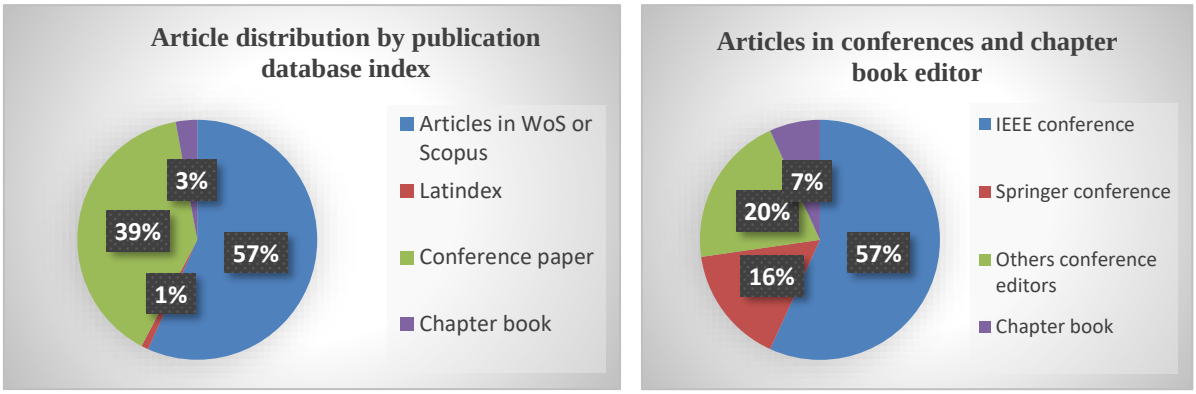


Figure 2. Flowchart for the selection of sign language translation research based on PRISMA 2020.

The research works in this review are presented in the following distribution according to how they are indexed in the databases of WoS or Scopus, Latindex, and other indexing and abstraction engines, which appear in Figure 3 a). According to the data collected in this research, 59 articles are indexed in the Web of Science (WoS) and Scopus (57%), while 1 article is found in Latindex, and 3 in chapter book (3%), the other 41 articles were published in conferences that were stored in the databases IEEE, Springer, ACM, among other publishers (39%). On the other hand, Figure 3 b) shows the distribution of research that is published by important publishers such as IEEE, Springer, ACM, as well as book chapters, of which 25 are registered in IEEE (57%), 7 in Springer (16%), 4 in ACM, 3 in IOP, and 2 in Wiley (20%), while the 3 book chapters are published by Springer and Wiley (7%).



a) Distribution of articles according to the database where they are indexed.

b) Distribution of research published in conference papers and book chapters.

Figure 3. Article distribution by database index and article distribution in conferences

Figure 4 shows the amount of research distributed by classification, where a greater amount of research based on IoT is observed, with 50 selected articles, followed by research related to cloud computing, with 27 articles, and finally related research with datasets, with 27 selected articles. The following is a detailed state of the art dedicated to showing the attention to communication problems in deaf and mute people, based on topics such as IoT, cloud computing and datasets dedicated to generating sign language translation models.

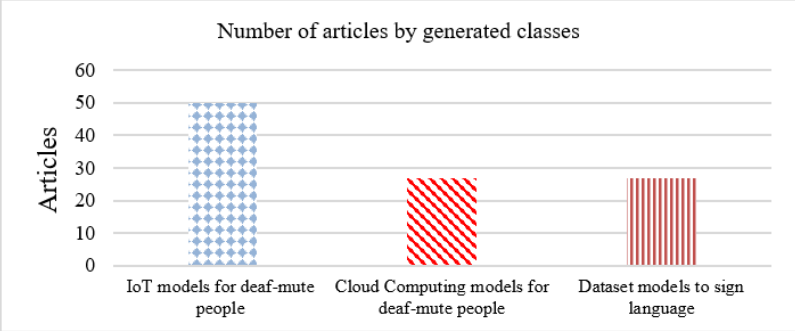


Figure 4. Articles number per class.

2.1. Bias analysis

The bias analysis that has been carried out in the research carried out for the interpretation of sign language, as can be seen, considered the biases that allowed a detection percentage greater than 85% in

the accuracy of the signs, then the number of signs that the software that can detect and finally the detection technology is analyzed. According to what is observed in Table 4, Sosa-Jiménez through the analysis of 3D sensors was able to obtain an accuracy of 90% on average for 430 signs, while Brenland's work presents an accuracy of 99% for 320 signs, using a CNN, it is important to mention that more than 90% of the detection methods used in the works obtained in the table have used AI techniques to obtain the best In addition, the use of large datasets of images or videos to obtain the best SL interpretation results is notorious.

Table 4. Works included in the bias analysis performed.

Author	Bias Computational technology	Bias precision	Bias SL recognition
Sosa-Jiménez et al. (2022)	3D sensors	90%	430
Breland et al. (2021)	CNN	99 %	320
Martínez- Sánchez et al. (2023)	DL	99%	100
Wadhawan and Kumar (2020)	CNN	99%	100
Ahmed et al. (2021)	Electronic signal	99%	75
Wen et al. (2021)	DL	87%	70
Basnin et al. (2021)	CNN-LSTM	89%	44
Vo et al. (2019)	DL	86%	31
Kasapbaşi et al. (2021)	CNN	99%	26
Morfín-Chávez et al. (2023)	ML MediaPipe	95%	21
Rezende et al. (2021)	DL	93.3%	20
Saggio et al. (2020)	CNN	99%	10

Table 5 presents the research with the highest number of citations, as can be seen, the topics they cover are related to IoT as can be seen in Wu et al. (2016), Wen et al. (2021) and Kumar et al. (2017), recognition based on deep learning supported by dedicated SL databases, Sincan and Keles (2020) Rastgoo et al. (2020), which indicates that the potential that can be achieved for the translation of SL into different languages, as well as the growing importance of developing highly complex databases related to SL, which allow reducing translation errors with respect to current proposals. On the other hand, cloud computing technology in this area is little exploited, since urban environments with high connectivity to wireless networks to access this technology can contribute significantly to solving the most challenging problems of SL. The researchers are related to the application of deep learning The research that are related to the application of deep learning are Mekruksavanich and Jitpattanakul (2022), Bird et al. (2020), Kumar et al. (2017), in addition to the use of large data sets for the recognition of SL like can see in Sehyr et al., 2021, Latif et al. (2021), Duarte et al., (2021), Rastgoo et al. (2020) and Wadhawan and Kumar (2020).

Table 5. Most cited investigation works in translation SL

Author	Propose	Number cites
Wu et al. (2016)	Wearables integrate with EGM sensors	258
Wen et al. (2021)	Smart glove	217
Wadhawan et al. (2020)	Deep learning auto dataset	197
Kumar et al. (2017)	Sensor SL recognition	183
Sincan & Keles (2020)	Dataset	132
Rastgoo et al. (2020)	Multiview hand skeleton	129

Duarte et al. (2021)	Dataset ASL in CVF	126
Sehyr et al. (2021)	Dataset	85
Zhang et al. (2019)	Device MyoSign	65
Bird et al. (2020)	Leap motion ASL	64
Khomami and S. Shamekhi (2021)	IMU with EMG sensors	51
Kim et al. (2017)	Lexicon	47
El-Gayyar et al. (2016)	Cloud computing	47
Zhao et al. (2019)	Wearable with CNN integrated	44
Mekruksavanich & Jitpattanakul (2022)	Activity CNN	40

Nowadays, various models based in advanced technology have been developed to help people with hearing and speech disabilities to perform better in their work environments, as well as to stablish better contact in society. The following investigations present solutions for people with hearing and speech disabilities through IoT devices, cloud computing services for translation of different SLs, as well as tools that help to carry out diverse types of activities like specialized data bases in SL.

2.2. IoT analysis models for mute people

The data processing that IoT devices can perform allows them to be combined with different types of hardware to solve problems such as the translation of different types of SL because these allow develop sign translation applications using smartphones and electronic gloves (Salem et al., 2019; Koppuravuri et al., 2020; Adeyanju et al., 2023; Zuhri and Adilah, 2020; Illahi et al., 2021; Adem et al., 2020). IoT devices can perform activities such as voice recognition and sound emission using gloves allows signal-based communication (Amin et al., 2020; Ji et al., 2023; Ahmed et al., 2021; Patwary et al., 2022; Ahmed et al., 2021) to generate two-way communication between people with disabilities and without hearing impairment. In general, IoT models allow sign interpretation using diverse type sensors (Saggio et al., 2020; Wijayawickrama et al., 2020; Salvi et al., 2021).

Among the platforms most used for SL interpretation are open architectures such as Arduino (Khomami and Shamekhi, 2021; Zafar et al., 2023; Karmel et al., 2018; Sengupta, et al., 2019; Bedi et al., 2022; Priiyadharshini et al., 2021), while Raspberry platform (Ullah et al., 2023; Chen et al., 2020; Khan et al., 2019; Lu et al., 2023; Cerna et al., 2023; Jain et al., 2020; Vasanth et al., 2019) occupies an important participation for the translation of the SL. The combination of hardware such as gloves and wearables are highly widespread in SL translation (Liu et al., 2023; Wu et al., 2016; Zhao et al., 2019; Zhang et al., 2019; DelPreto et al. 2022; Wen et al., 2021; Lee and Lee, 2017; Nimmalapudi et al., 2022; Alzubaidi et al., 2023; Deng et al., 2020; Sruthi and Lijiya, 2019) because it allows an exact interpretation of the movements of the fingers and hands, although it requires highly training response process.

On the other hand, there are various developments that handle using artificial intelligence (AI) using convolutional neural networks (CNN) (Siddineni and Manikandan, 2022; Lee et al., 2020; Balaha et al., 2023; Dias et al., 2021; Sharma et al., 2020) to interpret the movements of deaf and mute people. The use of virtual reality glasses is one of the recent applications, because they incorporate a series of sensors, cameras and powerful graphic processing units that allow them to handle recognition models based on machine learning and CNN (Hasdak et al., 2018; Rahim et al., 2023; Mekruksavanich and Jitpattanakul, 2022; Nikita et al., 2022; Guo et al., 2023; Jin et al., 2023). Table 6 shows the works with the greatest impact and the novelty it represents in the solution of the SL translation.

Table 6. Relevant IoT works for sing language recognition.

Author	Description	SL type
Salem et al. (2019)	This proposal presents an electronic glove with 5 flexible sensors and an accelerometer to detect the position of the hand, which are controlled by an Arduino Nano using an Android application, the gestures are translated into text and audio.	ArASL
Ahmed et al. (2021)	This development presents an electronic glove with 17 sensors and 65 channels capable of recognizing 75 gestures with 99%, 96% and 94% accuracy to recognize numbers, letters, and words, respectively. The sensors are controlled by an Arduino Mega 2650.	Malayan Sign Language (MaSL)
Saggio et al. (2020)	Its main development is based on a glove with flexible and inertial sensors to record hand and arm movements, the signals are interpreted by k-neighbor algorithms and CNN. The control and sending of data are through ZigBee, while CNN will run on a PC with an Intel i7-7700 processor. Detection is close to 100%.	Italian Sign Language (ILS)
Wen et al. (2021)	The development is an electronic glove with the ability to recognize 50 words and 50 sentences controlled by an Arduino Mega 2560. The inputs are analyzed using deep learning. The learning module allows you to recombine words with 86.6% success. Information can be presented visually, text and audio to enable two-way communication.	American (ASL)
Lee et al. (2017)	A glove is presented that consists of 5 flexible sensors, 2 pressure sensors and 1 inertial movement sensor to interpret hand movements. The data is sent by Bluetooth to be later analyzed by an SVM (Support Vector Machine) on Android, with 98% accuracy.	ASL
Sharma et al. (2020)	This investigation is an electronic glove to translate hand movements that interpret 24 signs into voice. Training is based on neural networks.	ASL
Hasdak et al (2018)	The device developed is a glove to translate voice into Morse code and the Morse code is made by the fingers to emit text and voice.	MaSL
Guo et al. (2023)	The main basis of this work is the implementation of a Smart glass, which can communicate to 911 so that the disabled person and the operator communicate by translating signs and voice. The translation of the SL is through ML.	ASL
Jin et al. (2023)	The proposal is based on an end-to-end system based on markers, so that Smart glass can interpret 80 words and 4 sentences.	ASL

The proposals that use IoT devices previously presented have the advantage of adapting various electronic devices to offer a range of solutions that adapt to the needs of disabled people, allowing them to incorporate themselves with certain advantages in their routine activities. It is important to point out that most of the proposals are based on static models that are based on a translation of signs to text and voice or from voice and text to SL, but no clear effort is shown to propose systems that allow incorporating added information to their knowledge bases.

2.3. Cloud Computing analysis models for mute people

Cloud computing technology allows the development of various models for the implementation of translation applications and the ability to communicate with people with hearing and speech disabilities. It is an area that is under-exploited, because the integration of IoT devices, as well as desktop computers for people with hearing disabilities, are not common commercially, but various investigations have been developed for the combination of these devices with the computing power offered by cloud services.

Cloud computing has made it possible to develop applications for automatic recognition of SL (Glasser, 2019), as well as serving patients with hearing and speech disabilities (Xia et al., 2017), helping learning in classrooms (Vinoth, and Nirmala, 2017) and achieving real-time translations (da Rosa Tavares and Victória Barbosa, 2021; Patil and Prajapat, 2017; El-Gayyar et al., 2016; de Oliveira Neta and Kofuji, 2016; Pasupuleti et al., 2021, Battistoni et al., 2020; Karumanchi et al., 2022; Hashim et al., 2019; Silva et al., 2017). Although cloud computing is a technology that is not very widespread in this sector, it is possible to extend it to expand learning models in distant SL (Bird et al., 2020), as well as integrate services with complex

hardware such as robots and different IoT devices (Di Nuovo et al., 2019; Kumar et al., 2017; Zhou et al., 2017, Shumilov and Philippovich, 2016, Russo et al., 2018; Gullapalli et al., 2020; Kumar, 2022; Zhao, et al., 2023). It is important to note that cloud computing for SL can be applied to pattern recognition based on CAPTCHA (Completely Automated Public Turing Test to Tell Humans Apart) codes, helping people with disabilities understand them.

Other research, as observed in (Adhikari et al., 2023; Vasudevan and Vivek, 2015; Kim et al., 2017; Chen 2016; Abduljabbar et al., 2023; Zhang and Zhang, 2018), cloud computing allows developing connections between physical devices and models trained using neural networks to generate platforms that reduce the cost of SL. Table 7 presents the most relevant works of this research that uses cloud computing to address the communication problems of deaf and mute people.

Table 7. Relevant cloud computing works for sing language recognition.

Author	Description	SL type
Glasser (2019)	It includes a study based on improving the speech of models for virtual assistants that allow the integration of people with hearing problems.	ASL
El-Gayyar et al. (2016)	This research consists of a framework based on mobile devices to communicate with deaf and mute people through an avatar that allows translation of the Egyptian SL relying on cloud computing.	Arabic Sign Language (ArSL)
Hashim et al. (2019)	It is a development based on cloud computing for the learning of deaf people in Iraq through an interactive platform.	Iraqi Sign Language (IrSL)
Bird et al. (2020)	The authors propose a comprehensive training of 18 gestures from the British Sign Language (BSL) CNN algorithm, perfected artificial neural networks, as well as a Leap Motion model, with 94% accuracy, allowing transfer learning to translate models such as ASL. Model training can be done on local machines or in the cloud.	BSL
Shumilov and A. Philippovich (2016)	This proposal is based on the generation in a cloud based CAPTCH service, which generates hand gestures to be characters.	Machine application hand gestures
Gullapalli et al. (2020)	A comparative is presented to recognize gestures using a CNN and visual recognizer based on a Watson model, with 97%.	Indian Sign Language (ISL)
Zhao et al. (2023)	The research proposes a SL recognition CNN to run on Smart glasses.	Indonesian Sign Language (IndoSL)

The main advantages of this technology are that the gesture recognition models and other elements of the environment can be processed by cloud services, while the physical device used by users is in charge of displaying the information, as well as the data acquisition and processing of minor tasks, allowing the costs of final devices to be lowered, something that is of utmost importance, taking into account the economic gap in this sector of the population.

2.3. Dataset analysis models to sign language

Currently, various efforts have been developed to generate research on the creation of databases that allow better results in the interpretation of different types of SL (Basnin et al., 2021; Yirtici and Yurtkan, 2022; Chen and Gong, 2020; Aloysius et al., 2020; Sharma and Kumar, 2021; Sánchez et al., 2023; Moryossef, et al., 2020). One of the biggest problems faced by projects that present SL translation systems for some written to spoken language is that they have relatively small data sets, although several investigations have focused on generating datasets of a

size in the order of thousands of samples to increase the precision of their results (Mejía-Pérez et al., 2022; Sosa-Jiménez et al., 2022; Trujillo-Romero et al., 2023), to achieve precision score greater than 98%. MediaPipe training models based on experimental data sets (Rios-Figueroa et al., 2022; Morfín-Chávez et al., 2023) and can obtain 100% and 98% accuracy results in laboratory environments for the Mexican Sign Language (MSL). Some important advances in the construction of datasets can be observed in Martínez-Sánchez et al. (2020) by integrating the lexicon of 100 gestures and 5000 videos from three participants with different grammatical elements; the reported accuracy is 99%.

The recurring SL in database generation is ASL (Sehyr et al., 2021) because it is highly widespread. Some large-scale databases can be seen in Latif et al. (2019), which is reference of Arabic signs (ArSL), while Kim et al. (2017) collection of continuous fingerspelling videos, the authors used the random treatment of segmental conditionals (semi-Markov) with deep neural networks. Other research dedicated to developing databases for SL translation projects can be seen in (Vo et al., 2019; Rezende et al., 2021; Ordaz-Hernández et al., 2023; González-Rodríguez et al., 2024; Kasapbaşi et al., 2022; Breland et al., 2021; Duarte et al., 2021; Sincan and Keles, 2020; Rastgoo et al., 2020; Wadhawan and Kumar, 2020; Ramadhani et al., 2018). It is worth noting that for the generation of recognition models based on these datasets are based on neural networks, the main AI method to achieve the recognition of the movements of the hands and other parts of the body. Table 8 shows a summary of research dedicated to building databases for the SL translation project.

Table 8. Most important dataset proposes.

Author	Corresponding SL	SL type
Basnin et al. (2021)	In this proposal, the CNN and Long short-term memory (LSTM) classification models are used, based on a database of 13,400 images, obtaining an accuracy of 88.5%.	Bangla Sign Language (BanSL)
Ríos-Figueroa et al. (2022)	A data set of 21 letters is used in conjunction with 3D sensors to analyze the movements of the MLS.	MSL
Morfín-Chávez et al. (2023)	This investigation consists of a database construction of 21 letters, coming from 10 test subjects, training a MediaPipe model, with an F1 0.98.	MSL
Martínez-Sánchez et al. (2023)	It makes up a database called MX-ITESO-100 composed of 100 gestures stored in 5000 MSL videos. The accuracy achieved in the training tests was 99%.	MSL
Sehyr et al. (2021)	It stands for a study of the ASL-LEX 2.0 database, on the phonological characteristics of this database.	ASL
Latif et al. (2019)	The authors built a database called ArSL2018, which consists of 54,049 images referring to the Arabic sign language and was made up of 40 participants.	ArSL
Kim et al. (2017)	This research consists of a set of labeled ASL data, the model created was created with deep neural networks using random fields, obtaining 92% accuracy in letter recognition.	ASL
Vo et al. (2019)	The generated database is based on Vietnamese sign language (VSL), composed of 23 letters, 3 signs and 5 tones, the stored data is represented in videos. The samples taken used a data collection augmentation. In the training stage they obtained 86.6% accuracy	VSL
Rezende et al. (2021)	It presents a validation of the Libras public database, which corresponds to the Brazilian sign language (BrSL), to which an analysis is applied based on sign selection, characteristics of a signaler, recording acquisition sensors and data structure, based on deep analysis approaches. The proposed model achieved an average accuracy of 93.3%	BrSL

Kasapbaşi et al. (2021)	It is a study based on the generation of a data set for ASL recognition, the researchers generated a CNN-based recognition model with 99.4% accuracy.	ASL
Breland et al. (2021)	Its investigation consists of a recognition system based on a database of 3,200 thermal images of digit-based gestures. The system training is based on deep neural networks with an accuracy of 99.5%. The greatest contribution is that the system is implemented in Raspberry Pi, without focus variations of a conventional camera.	General digits
Duarte et al. (2021)	This research presents a large dataset for ASL called How2Sing of a multimodal and Multiview type, which brings together videos with a total duration of 80 hours (about 3 and a half days). Its main feature is that it holds 3D components.	ASL
Sincan and Keles (2020)	It is a database of 38,336 videos, corresponding to 226 signs of the Turkish language, the samples were recorded with a Kinect v2. Training was carried out with CNN and LSTM networks, achieving 95% accuracy in the best case.	Turkish Sign Language (TSL)
Rastgoo et al. (2020)	It presents a set of large-scale signs called RKS-Persian sign, consisting of 10,000 RGB videos referring to 100 Persian signs. The generated model is based on LSTM model and 3DCNN convolutional networks.	Persian Sign Language (PSL)
Wadhawan and Kumar (2020)	It is a study based on a database of 35 thousand InSL images with RGB and grayscale images, with the evaluation of 50 CNN models. The detections results obtained are greater than 99.7%	Indian Sign Language (InSL)

3. Discussion

The research process of SL recognition models using IoT devices, cloud computing and datasets using the proposed methodology in combination with PRISMA 2020 has allowed us to understand the current direction of SL translation. According to the information obtained, it is possible to see that there is a large amount of research that takes different approaches when looking for the SL translation, when using IoT and cloud computing services. Due to the wide spectrum of solutions that can be applied with IoT it is possible to classify the different applications by the type of output this produces.

- Translation of text and voice into SL through images or avatars.
- Translation of SL to text and speech.

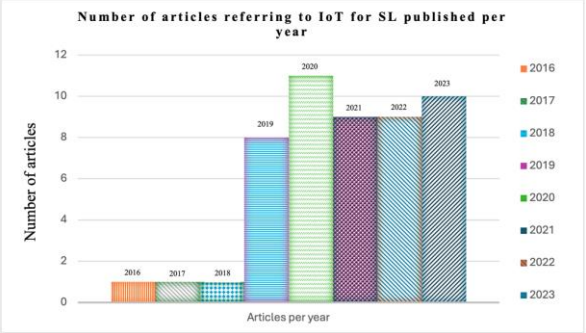
Among the most common proposals can be seen the use of voice-to-text and text-to-speech translators, those with greater complexity can display images related to SL, as well as the use of vibration systems to alert users when a conversation or risk situation may arise. The use of communication networks allows the sending of data with various equipment, through Wi-Fi, Bluetooth, as well as internet connection for data processing. With the versatility offered by open hardware platforms such as Arduino and Raspberry it is possible to implement different technological solutions among which stand out.

- Development of electronic gloves.
- Deploying speakers with microphones.
- Development of electronic solutions in combination with mobile devices.

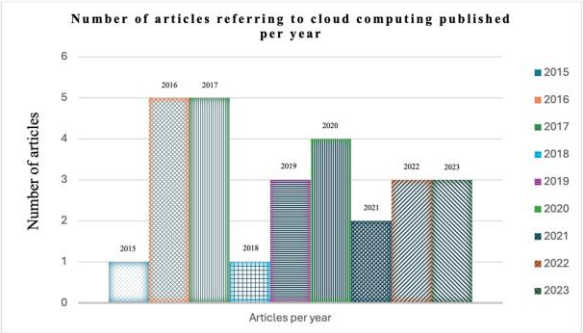
Of the earlier implementations, the ones that present the most complexity, are those that allow to capture movements through mobile devices in combination with the sensors controlled by the IoT to reduce the degree of invasion presented by using this type of devices with mute people.

Figure 5 shows the distribution by year of published research works for SL translation using IoT devices, cloud computing as well as development of databases holding SL information. In Figure 5 a) the researches consulted is mainly concentrated in the period 2016-2023, while the research reported regarding cloud computing has its greatest concentration in periods ranging from 2016-2017 and 2019-2022, Figure 5 b) finally, the research aimed at testing models

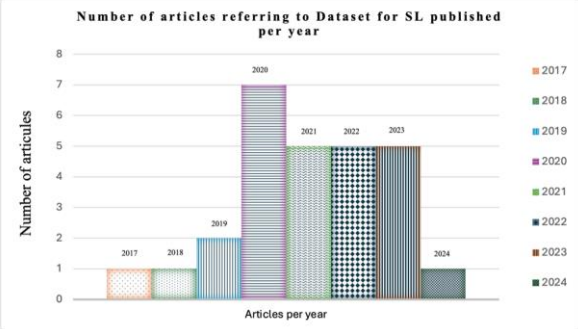
using experimental or public datasets has a greater volume in the 2020-2023 period, Figure 5 c), while the research analyzed in 2024 has a low participation due to the fact that it is the beginning of the year. This trend presented shows the importance of IoT devices in addressing translation tasks, and the growing need to create extensive SL databases that allow them to be used by different algorithms that improve the interpretation of SL in different environments.



a) SL IoT investigation from 2016 to 2023



b) SL cloud computing investigation from 2015 to 2023



c) SL dataset investigation from 2017 to 2023

Figure 5. Investigation works distribution per year.

IoT-based proposals have the versatility to implement devices such as LCD screens, speakers, Mekruksavanich and Jitpattanakul (2022), as well as being associated with neural networks, Silva et al. (2017). An important part is that the sensors applied to mute people can interpret the signs that are being made in Patil and Prajapat (2017), although this model has the limitation of not learning new gestures. On the other hand, with the current development of cloud services allow combining the acquisition of information from IoT devices, as well as smartphones, to develop the translation of the gestures made by a mute person to be able to set up communication with other people. One of the biggest advantages of SL translation models is that they allow CNN and other powerful AI algorithms to be applied to classify the movements of individuals without a secondary device receiving the processing load, Di Nuovo et al. (2019), Kumar et al. (2017), Zhou et al. (2020) and Shumilov and Philippovich (2016).

In general, it can be said that the greatest challenge in the interpretation of the SL focuses on generating accessible computing tools and models for disabled people, both in terms of ease of use and from an economic perspective, it being important to take advantage of the potential of the cloud services. Cloud computing allows to reduce data processing costs, as well as the correct integration of IoT hardware with desktop computers and smartphones, the latter also have a relevant role, because current

processing capabilities allow them to integrate models lightweight CNNs for sign detection. The challenges to be faced for future SL recognition proposals are diverse, due to the complexity that exists in interpreting movements in various environments. Among the most important challenges are the following.

- Sign interpretation in environments with light noise.
- Effective two-way communication.
- Help with integration with digital platforms.
- Standardized training models.
- Availability of Wi-Fi networks and cellular networks.

It is important to note that current SL translation models, whether implemented on IoT devices or on platforms based on cloud services, have the characteristic that their knowledge base is static, which represents an important limitation when it is necessary to use these systems in environments that require a constant update of new signs in order to achieve dynamic communication both with other people and with virtual personal assistants.

Models based on computer vision that require the acquisition of signs outdoors face noisy environments, where the proposed models must consider these variations when interpreting people's signals. Another challenge can be seen in two-way communication because a controlled communication channel is needed that certifies the correct sending of information between the person with a disability and the person without a disability. The research cited in this document focuses on small spaces, such as an office or studio, but excludes open spaces. In the third challenge, slow progress is being made in the development of the integration of text or voice translation tools into SL into digital platforms, as well as in the use of native controls for digital assistants. Finally, in most countries that are lagging in their educational systems, they face the problem of not having standardized databases dedicated to the development of SL recognition models based on computer vision or AI, which conditions the operation of these models is appropriate in space with adequate lighting in closed spaces. This last point is one of the most critical, because it is a very widespread limitation in developing countries, where Internet access continues to be limited, presents instability, causing limitations in access to computing service platforms in the cloud, in addition, the use of mobile data is expensive for countries where there are few options in choosing cellular companies.

4. Conclusions

According to the works collected in this research, 48% corresponds to research dedicated to performing SL translation using IoT devices, while 26% corresponds to research oriented to the use of cloud computing technology, and the remaining 26% corresponds to the generation or use of databases for SL interpretation projects, from the above it can be interpreted that there is a clear tendency to use electronic devices to help people perform sign language translations, on the other hand there is a tendency to use cloud services to support SL interpretation tasks, as well as the use of recognition systems based on CNN and ML, which use sets of images or videos as a training base to obtain better results in various environments, due to the potential achieved by neural networks and ML for the recognition of shapes, which is essential in the interpretation of SL.

The current development of IoT devices has allowed the implementation of advanced devices such as wearables capable of interpreting the hand movements of mute people so that the movements are translated into text and voice in conversations with people who do not know any SL, as well as interpreting voice and text in SL through avatars, to establish bidirectional communication. Currently, a relevant

importance has been given to the generation of extensive databases whose information refers to movements of different signs that represent words or phrases to generate translation models of a certain SL, this has allowed very advanced CNN models that support the translation of spoken and written language to SL, to be implemented in a wide range of devices. Cloud services have allowed the incorporation of a series of dedicated solutions that incorporate translation models of different SL, being accessible from IoT devices and computing equipment, reducing the computational processing effort in host devices, although this technology with great potential still needs to be exploited for the development of tools that help people with hearing and visual disabilities. Based on the information analyzed, we can anticipate that new models of sign language translation will be based on developing dynamic platforms based on cloud services to generate recognition models that use CNNs capable of running on various devices to translate gestures generated by mutes, to establish communication with other people, as well as with personal assistants.

Future work

Based on the data obtained during the elaboration of this research, the development of computer vision software is proposed with the capacity to perform a translation of sign language through cloud services, as well as having the capacity to learn new signs through the acquisition of images or videos captured from digital cameras on desktop computers or smartphones.

Acknowledgments

We appreciate the support offered by CONAHCYT to carry out this research, through registration number 445998.

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