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Implementation of a Mobile Application as a Tool for Recognition and Interpretation of Nonverbal Language to Improve Communication with Deaf-Mute People

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***Abstract*— In the present study, it was observed that a certain percentage of people with hearing and sound disabilities are not understood, as some non-disabled people do not know or master sign language, resulting in a lack of communication with deaf-mute people. Although it is true that nowadays communication and social inclusion is essential, it is for this reason that the mobile application for the recognition and interpretation of non-verbal language was implemented through the agile SCRUM methodology, it allows a better flexibility in developing the requirements established by the users, in addition, it adapts to the different changes in the development process of the mobile application based on the needs of the users. For the development of the application, a survey was made to citizens of a community, which helped to determine the contents of the mobile application, in which the information module is responsible for detailing information related to hand language and its application, on the other hand, there are the manual translation and consultation modules, which have the functions of translating hand movements, either by means of a camera or a keyboard, among others. As a result, several modules of the mobile application were developed and optimized to meet the needs of the surveyed users. The implementation of the mobile application provided communication and social inclusion facilities, since it allowed a better interaction between people without disabilities and deaf-mute people, generating knowledge about the meaning and execution of hand language.**

***Keywords*— Mobile Application, Communication, Sign Language, Non-verbal Language, Interpretation, Deaf Mutes.**

I. INTRODUCTION

Communication is essential between people, as it allows mutual understanding. Over time, technological innovations have been implemented in order to establish better communication between individuals, such as the case of translators, which allowed a better interaction between people from other countries, on the other hand, there are the deaf-mute people who have hearing impairment as well as sound impairment, which causes a limitation at the time of communication. According to [1], there are approximately 25,763 inhabitants in Peru who are unable to hear and speak. This causes a lack of understanding in the population, since not everyone knows the nonverbal language. On the other hand, according to [2], this represents 7.6% of people with disabilities.

In several places, the lack of understanding has become an obstacle to communication, causing exclusion, as in the case of the approach of some students to a community, because they all spoke through hand sign language, while the students did not understand sign language and therefore could not communicate with the community [3]. These problems happen often, and not only in communities, but in everyday life, all kinds of people can meet someone with a disability, whether hearing, sound or any other, this produces a problem of understanding, since they cannot understand what the person with a disability wants to say, communication is lost or they may choose to exclude that person. This problem is also caused by a lack of orientation.

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The English language is applied in different institutions with the purpose of being able to understand the way of speaking of other countries and to reach a good communication, but in the case of sign language, there are not many cases, the educational institutions that receive hearing impaired people have few tools that facilitate the learning of sign languages [4], in a traditional way, some institutions provide sign language interpretation for people with hearing difficulties, when requested and during the time they stay in the educational institution [5], This type of actions would facilitate the understanding of people with disabilities, on the other hand, on the technological side, applications that help the understanding of sign language are promoted for all types of people with disabilities.

In this research, we propose the development of a mobile application as a tool for recognition and interpretation of nonverbal language to improve social inclusion with deaf-mute people, in such a way that it helps to establish better communication, Since a certain number of people do not have the knowledge of non-verbal language, therefore, if they meet a person, whether deaf or mute, they would not know what to answer, that is why this mobile application will provide solutions and better interaction between people, providing understanding facilities by means of a camera that will allow to capture the movement of the deaf, mute or deaf-mute person, resulting in the translation of their movements, the application will also allow the interaction of an ordinary person with a deaf-mute person, by means of a keyboard or voice recognition, which will allow them to translate their words into various hand movements that will be understandable to deaf-mute persons.

The present work was elaborated by means of the Python programming language, which allowed the use of artificial intelligence to carry out one of the functionalities of the mobile application, as well as SQL server, which stores the necessary information for the application. The structure of the research work is made up of section II, in which the methodology used for the elaboration of the proposal will be mentioned in detail. In section III the case study will be used forming prototypes for its better understanding and the results generated will be evidenced. In section IV the results will be discussed and conclusions will be presented.

II. Literature Review

Regarding the project, it is not the first time that the implementation of mobile applications, or web applications or research in a traditional way has been chosen to improve communication, whether with deaf people or with people of other languages.

According to the author [6], he informs us that there are mobile applications that help the understanding of any language, also known as translators that serve to teach that language and thus promote better communication, an example of this would be the development of a mobile application called VocabGame that is elaborated through help guidelines, it was implemented through surveys, the application was developed with the purpose of encouraging the learning of English to native Arab students, as a result the students managed to learn the language, achieving better performance and understanding.

On the other hand, the author [7] informs us that in certain communities far from the city, they speak through sign language, and their form of communication cannot be understood, that is why a mobile application was implemented through a own methodology, which was called Kinesika, through this mobile application several users who do not have knowledge of the language of hands, were able to recognize these languages with the help of various modules provided by the application. This application helps people with hearing or sound disabilities, to be able to communicate with people who do not have disabilities.

In addition, the lack of understanding with deaf and dumb people, causes limitations and understanding between people, through its own methodology, a mobile application was established, which allows to reduce the communicative limitation with deaf and dumb people using Creative, the application has an interactive camera that allows the recognition of signs, as a result, the application allows a better interaction with people with these disabilities [8].

In short, different authors contributed with the implementation of different applications aimed at improving communication, either with people of different languages, or with people with hearing and hearing disabilities, each author mentioned a functionality in his section, but with the same purpose, complying with what is required by users through various technologies.

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However, the form of communication through the Internet will be a trend in future development, so it is worth mentioning that in the established project it is possible to make improvements, such as the creation of new sections on its platforms, highlighting new points using new technologies. current trend, since new implementations would generate a greater impact and interest on the part of users.

III. Methodology

In this section, the chip used in the mobile application was detailed as well as the methodology implemented for the mobile application, in this case SCRUM was applied.

The chip that was used is the NPU, which means Neural Processing Unit, the chip is responsible for internally interfering with activities related to artificial intelligence. Functioning is trying to similar the different functions of a brain. Unlike GPU and CPU, NPU solves various calculations that vary according to the user. Which could be high resolution photographs, movement prediction, among others. With the advancement of technology, these chips are often implemented by default in mobile devices, which facilitates application development.

On the other hand, for the development of the project, the agile SCRUM methodology was implemented, because it provides flexibility to control and transform the requirements requested by the user into software [9]. The project is divided into sprints of 1 to 3 weeks, in which the results of the software deliverables are shown [10]. The SCRUM methodology has multiple processes that are divided into 5 phases:

A. Home

Scrum is characterized by having 3 roles, the ScrumMaster is the one who guides and helps the group to learn and apply the methodology correctly [11]. The Product Owner manages the product backlog based on customer requirements [12]. The Development Team converts the Backlog into software, which will be delivered in each sprint, the team can be made up of up to 9 members, depending on the magnitude of the project [13].

B. Planning and Estimation

In this phase it is used; the elaboration of the requirements, as well as the development of the user stories, epics and tasks, as well as the functionalities of the product, and the establishment of the delivery of advances [14].

Once identified, what is mentioned is estimated and the team commits to carry out each task, in this phase the sprint backlog is also used, also known as iteration.

C. Implementation

In this phase, the team discusses in meetings and the groups that will carry out the project are optimized, in this phase it is used; the creation of the deliverables, the refinement of the prioritized backlog, the software prototypes, according to the requested requirements [15]. Finally, a refinement is made to the prioritized backlog of the product.

D. Review and retrospective

When the sprint is completed, a review is made, where the Product owner and the development team review the sprint, in this phase the elaborated sprint is also demonstrated, the project owner reviews what was done, and analyzes the backlog; on the other hand, the development team mentions the problems that were found and what solution was given [16].

E. Launch

In the last phase, two processes are carried out, in which the deliverables are sent, which are accepted by the clients, complying with the various acceptance criteria, in addition, at the end of the project, a general retrospective of the project is carried out as a group; In this phase, emphasis is placed on sending the deliverables accepted by the client, as well as on the identification, documentation and lessons learned during the project [17].

IV. Case Study

In this section the case study was applied since it allows the development of the agile methodology in the proposed software. The mobile application provides an improvement in communication with deaf-mute people, and also helps to improve understanding with people who have these disabilities through different modules.

One of the main actions of the mobile application is the recognition and interpretation of the movement of the hand signals, by means of the NPU chip, which is implemented in the cell phones. The motion detection is done through the camera, once the movement is captured, it is analyzed by the chip that hosts multiple recognition algorithms and machine learning, then a comparison is made with the server that hosts the movements, as a result shows the translation issued. As shown in the schematic diagram of the process in Fig. 1.

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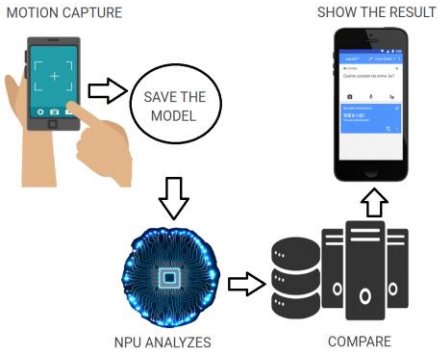

Fig. 1. Schematic diagram of the motion query process in the cell phone

A. Applying the SCRUM agile Methodology

1) Home: The Product owner established a survey to 30 citizens of a community, in which their needs were determined, as well as the functions that were granted to the mobile application for sign recognition and interpretation. The results of the community survey can be seen in Fig. 2.

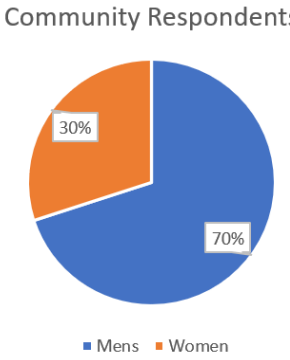

Fig. 2. Results of a survey of the population of a community

2) Planning: Once the Product owner relected the needs of the surveyed users, he established several user stories, as shown in Table I. These were developed by the scrum team in a certain time frame.

TABLE I.
MODULES AND USER STORIES

Modules	UH	User Stories
Information Module	H1	I as a user want the system to have information related to hand movements in order to have knowledge about the meaning of non-verbal language.
	H2	I as a user want the system to have a dictionary to learn more about nonverbal language.
Translation Consulting Module	H3	I as a user want the system to show me a camera to detect hand movement.
	H4	I as a user want the system to translate the movements captured by the camera.
	H5	I as administrator want the system to allow saving new transactions.
Manual Translation Module	H6	As an administrator, I want the system to have a didactic keyboard for the hearing and speech impaired.
	H7	I as an administrator want the system to have a didactic keyboard and to display a hand sign avatar for people without disabilities.

3) Implementation: Once the time needed to use each module was determined, we proceeded with the implementation of each one of them:

a) *Translation Consultation Module:* To establish motion detection, the camera captures the model taken and assigns various points to it, which are then compared. As shown in Fig. 3. Motion detection by the camera is done by means of three features, an infrared light camera, a dot projector and an IR illumination, which allows a three-dimensional recognition of the hand movement captured by the camera. By means of the IR illuminator, movements in areas that are not so bright can be recognized, invisible detections are established by the spot projector and the infrared light is responsible for capturing the movement.

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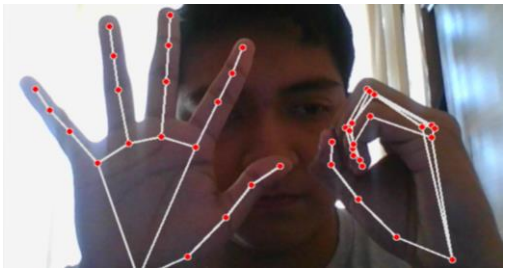

Fig. 3. Hand movement detection

Once the model is captured, a clarification of the captured model is established as well as a comparison of the image captured by the camera with the images stored by means of algorithms. For this purpose, reference was taken from the author [18], which shows the process of capturing the model of the hand, as shown in the code fragment of Fig. 4.

```
#START CAMERA
cap = cv2.VideoCapture(0)
with mp_hands.Hands(
    min_detection_confidence=0.5,
    min_tracking_confidence=0.5) as hands:
  while cap.isOpened():
    #CHECK INPUT
    success, image = cap.read()
    if not success:
      print("Ignoring empty camera frame.")
      continue
    #CONVERT IMAGE TO RGB
    image = cv2.cvtColor(cv2.flip(image, 1), cv2.COLOR_BGR2RGB)
    image.flags.writeable = False
    results = hands.process(image)
    #DRAW DETECTION POINTS
    image.flags.writeable = True
    image = cv2.cvtColor(image, cv2.COLOR_RGB2BGR)
    if results.multi_hand_landmarks:
      for hand_landmarks in results.multi_hand_landmarks:
        #print("HAND LANDMARKS: ", hand_landmarks)
        mp_drawing.draw_landmarks(
            image, hand_landmarks, mp_hands.HAND_CONNECTIONS)
    cv2.imshow('MediaPipe Hands', image)
    if cv2.waitKey(5) & 0xFF == 27:
      break
cap.release()
```

Fig. 4. Hand Motion Capture Algorithm

The query process starts by capturing the model that originates through the camera, after performing the recognition process, compares it with existing models and displays the requested translation as a result. A brief summary of the process is shown in Fig. 5.

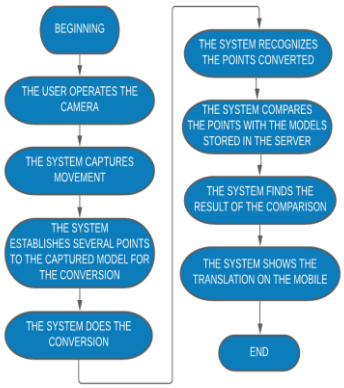

Fig. 5. Translation Query Module Flowchart

b) Manual Translation Module: The application allows the user to interact with people with disabilities by means of a didactic keyboard which has several symbols with or hand signals for each letter, which will allow a better interaction with deaf-mute people.

The person enters the message to be translated into sign language, the system compares the written message with the data stored in the server by means of various algorithms, at the end it displays a small avatar with the required translation. The process can be visualized in the diagram in Fig. 6.

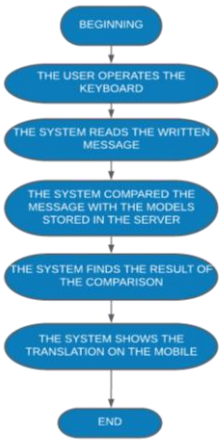

Fig. 6. Manual translation module flowchart

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a) Information Module: The application has a dictionary which allows the user to learn more about sign language, for this the user selects the topic of interest, and the system displays information related to it, in which is included its translation into hand signs.

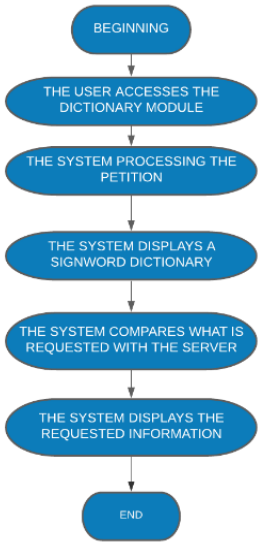

Fig. 7. Information module flowchart

V. Results And Discussions

This section shows the results based on the implementation of the various modules of the mobile application, as well as a brief commentary on similar works.

A. Regarding implementation

The established modules were implemented by means of sprints, which resulted in several prototypes.

1) Sprint 1 prototypes: User stories 3 and 4 of Table I were taken into account. The first prototype shows the capture of the movement of hands by means of the camera, in the second prototype the requested translation is displayed by the camera. The prototypes show the function of the assigned sprint, as shown in Fig8.

2) Sprint 2 prototypes: User stories 6 and 7 shown in Table I were developed. In the first prototype a didactic keyboard is displayed for people without disabilities, in the second prototype an avatar is displayed that performs the hand signals according to the requested translation. The prototypes show the function of the assigned sprint, as can be seen in Fig9.

3) Sprint 3 prototype: User stories 1, 2 and 5 that are in Table I were applied. In the first prototype a hand movements information module was applied, in the second prototype a dictionary with information is displayed Detailed on topics of the language of hands and in the third prototype a module is shown to add new translations. The prototypes show the function of the assigned sprint, as can be seen in Fig10.

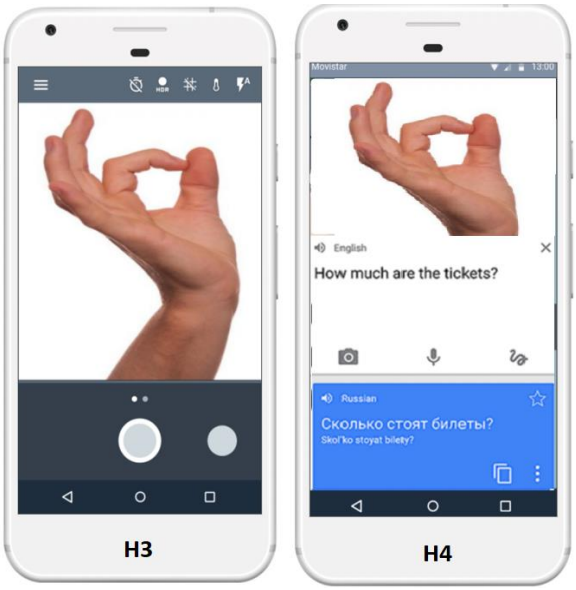

Fig. 8. Prototypes of the 1st sprint

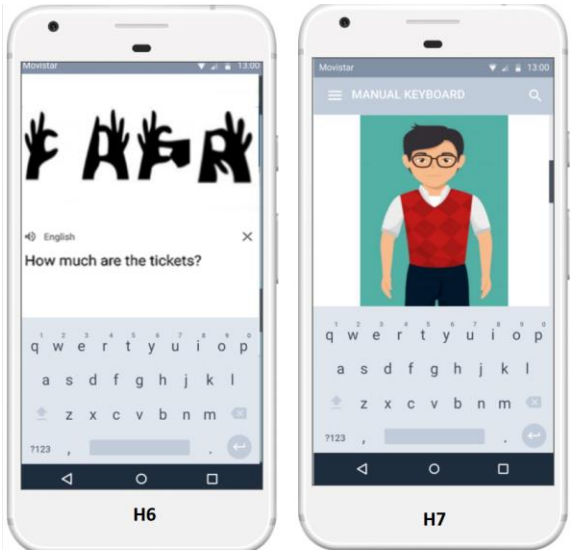

Fig. 9. Prototypes of the 2nd sprint

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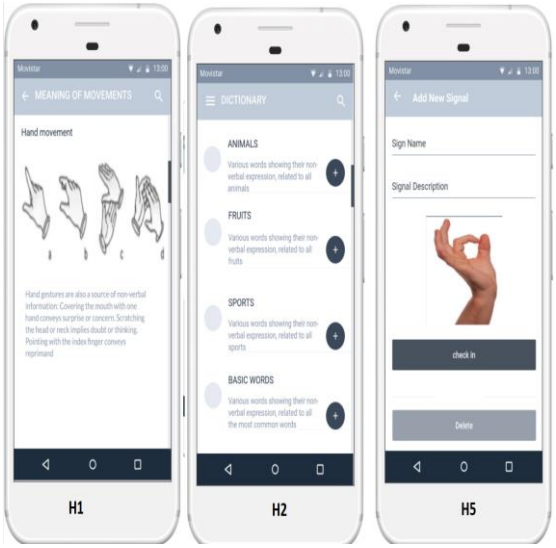

Fig. 10. Prototypes of the 3rd sprint

4) *Burn Up Diagram:* In order to evaluate the degree of elaboration that the non-verbal language recognition and interpretation mobile application had, the burn-up diagram was carried out, where the objective was to establish the amount of work from the beginning of the project to its completion, on the vertical axis are the history points established by the surveyed users of fig. 2 and on the horizontal axis are the time in which it was used the software. as shown in Fig11.

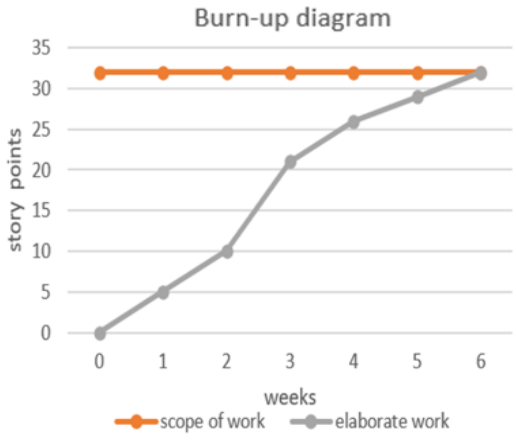

Fig. 11. Burn up diagram

B. Referring to other research

With the passage of time, mobile translators became a technological option to improve communication and facilitate mutual understanding between people, on the other hand, technology was advancing, and new technological devices were developed, as in the case of the implementation of a mobile application as a tool for the recognition and interpretation of non-verbal language, this application helps to establish better communication with deaf-mute people, this allows them to engage in conversation with better fluency, by means of diverse learning methods which allow them to generate knowledge of sign language, as well as the translation of messages by means of didactic keyboards. In comparison to the author's research [3], which mentions a mobile application that translates sign language through various modules, such as interactive keyboards with signs drawn on the keyboards and translation through voice recognition, which aims to eliminate communication gaps.

The application has a finding that is very helpful, such as the real-time recognition of hand movements of deaf-mute people through the cell phone camera by means of artificial vision and as a result translates what is captured by the camera, making communication and understanding more feasible for deaf-mute people, as well as their social inclusion. On the other hand, as time goes by, new technologies are being discovered, therefore, the application should be improved, to automate processes according to user needs, such as more learning modules and adaptation of the application to all mobile device systems.

VI. Conclusions

In summary, assistance was provided to people with hearing and sound disabilities to enable them to communicate with people who do not understand sign language, through the implementation of a mobile application as a tool for the recognition and interpretation of non-verbal language. Following the processes of the application which allowed people without disabilities to learn about nonverbal language, as well as other options that were very helpful to learn more about sign language, the most frequently used words, as well as the elaboration of a hand signal, among others, were used.

On the other hand, for a better interaction, sign translation was applied by means of a camera, which captures the movements of deaf and dumb people, this was a great help for people with disabilities, since through this module they can communicate without having the obstacle of not being understood. We also implemented the translation through the keyboard, which was helpful to translate words that people without disabilities want to express to deaf and dumb people.

The mobile application was developed through the agile SCRUM methodology, which allowed to meet the requirements established by the community. By means of this methodology it was possible to establish several changes to the project when the client believed it convenient, in addition to carrying out a great communication with all members and stakeholders, this communication contributed to the development of various points necessary for the project.

On the other hand, for future deliveries of work related to the topic, it is recommended to investigate in more detail about the branches of artificial intelligence and the use that can be given to provide solutions to problems that may arise in the community, as well as the implementation of new modules for the mobile application. Although it is true that there are multiple methodologies, as a group we should select the one that best suits the project.

REFERENCES

[1] INEI, "Resultados definitivos de los Censos Nacionales 2017." 2017.

[2] Defensoria del Pueblo, "Debe facilitarse el aprendizaje de la lengua de señas peruana y promover la identidad lingüística y cultural de las personas sordas," 2020. https://www.defensoria.gob.pe/defensoria-del-pueblo-debe-facilitarse-el-aprendizaje-de-la-lengua-de-senas-peruana-y-promover-la-identidad-linguistica-y-cultural-de-las-personas-sordas/.

[3] UPC, "Kinesika: app que elimina barreras de comunicación," 2020. https://noticias.upc.edu.pe/2020/09/27/kinesika-app-elimina-barreras-comunicacion/.

[4] A. Juárez Torres, "Interacción didáctica y lenguaje no verbal," Interconectando Saberes, no. 7, 2019, doi: 10.25009/is.v0i7.2572.

[5] M. C. S.-G. y A. P. C. Ariana Castillo Alzuguren, "Autodeterminación, emociones y exclusión en un blog de personas sordas: mirada cualitativa," Rev. Bras. Enferm. REBEn, vol. 72, no. 4, pp. 1153–1160, 2019, doi: https://doi.org/10.1590/0034-7167-2018-0573.

[6] M. M. Elaish, N. A. Ghani, L. Shuib, and A. Al-Haiqi, "Development of a Mobile Game Application to Boost Students' Motivation in Learning English Vocabulary," IEEE Access, vol. 7, pp. 13326–13337, 2019, doi: 10.1109/ACCESS.2019.2891504.

[7] Elcomercio, "La aplicación peruana que traduce la lengua de señas y puedes bajarte gratis al celular ahora mismo," 2021. https://elcomercio.pe/somos/historias/kinesica-aplicacion-sordos-traduce-lengua-de-senas-android-christian-martinez-peru-noticia/?ref=ecr.

[8] L. P. Pichón Pacheco, S. P. Romero Martínez, E. Leal Narváez, N. Leal, and C. Henriquez Miranda, "Aplicación integrada a la tecnología Kinect para el reconocimiento e interpretación de la Lengua de Señas Colombianas," Escenarios, vol. 14, no. 2, p. 7, 2016, doi: 10.15665/esc.v14i2.928.

[9] F. Hayat, A. U. Rehman, K. S. Arif, K. Wahab, and M. Abbas, "The Influence of Agile Methodology (Scrum) on Software Project Management," Proc. - 20th IEEE/ACIS Int. Conf. Softw. Eng. Artif. Intell. Netw. Parallel/Distributed Comput. SNPD 2019, pp. 145–149, 2019, doi: 10.1109/SNPD.2019.8935813.

[10] A. Srivastava, S. Bhardwaj, and S. Saraswat, "SCRUM model for agile methodology," Proceeding - IEEE Int. Conf. Comput. Commun. Autom. ICCCA 2017, vol. 2017-Janua, pp. 864–869, 2017, doi: 10.1109/CCAA.2017.8229928.

[11] P. Deemer, G. Benefield, C. Larman, and and B. Vodde, Básica De Scrum (the Scrum Primer), vol. 1.1. 2009.

[12] A. Alhazmi and S. Huang, "A Decision Support System for Sprint Planning in Scrum Practice," Conf. Proc. - IEEE SOUTHEASTCON, vol. 2018-April, pp. 1–9, 2018, doi: 10.1109/SECON.2018.8479063.

[13] E. Bahit, Scrum & Extreme Programming Para Programadores. Buenos Aires, Argentina, 2012.

[14] J. Palacio, Flexibilidad con Scrum: Principios de diseño e implantación de campos de Scrum, Octubre –. 2007.

[15] V. Gomero-Fanny, A. R. Bengy, and L. Andrade-Arenas, "Prototype of Web System for Organizations Dedicated to e-Commerce under the SCRUM Methodology," Int. J. Adv. Comput. Sci. Appl., vol. 12, no. 1, pp. 437–444, 2021, doi: 10.14569/IJACSA.2021.0120152.

[16] A. Ramos-Romero, B. Garcia-Yataco, and L. Andrade-Arenas, "Mobile Application Design with IoT for Environmental Pollution Awareness," Int. J. Adv. Comput. Sci. Appl., vol. 12, no. 1, pp. 566–572, 2021, doi: 10.14569/IJACSA.2021.0120165.

[17] SCRUM study, A Guide to the Scrum Body Of Knowledge (SBOKTMGuide), Tercera., vol. 44, no. 8. SCRUMstudyTM, 2017.

[18] antonioam82, "DETECTOR DE MANOS EN PYTHON, CON 'opencv' Y 'mediapipe,'" 2021. https://github.com/antonioam82/hand-deteccion.git.