Scopus

Documents

David, D.[a] , Alamoodi, A.H.[a] , Albahri, O.S.[h] , Zaidan, B.B.[b] , Zaidan, A.A.[c] , Garfan, S.[a] , Ismail, A.R.[d] , Albahri, A.S.[e] , Alsinglawi, B.[f] , Malik, R.Q.[g]

Landscape of sign language research based on smartphone apps: coherent literature analysis, motivations, open challenges, recommendations and future directions for app assessment
(2023) *Universal Access in the Information Society*, .

[a] Department of Computing, Faculty of Arts, Computing and Creative Industry, Universiti Pendidikan Sultan Idris (UPSI), Perak, Malaysia

[b] Future Technology Research Center, National Yunlin University of Science and Technology, 123 University Road, Section 3, Yunlin, Douliou, 64002, Taiwan

[c] Faculty of Engineering and IT, The British University in Dubai, Dubai, United Arab Emirates

[d] Kulliyyah of Information and Communication Technology (KICT), International Islamic University Malaysia, Kuala Lumpur, Malaysia

[e] Iraqi Commission for Computers and Informatics (ICCI), Baghdad, Iraq

[f] School of Computer, Data and Mathematical Sciences, Western Sydney University, Sydney, Australia

[g] Medical Intrumentation Techniques Engineering Department, Al-Mustaqbal University College, Babylon, Iraq

[h] Computer Techniques Engineering Department, Mazaya University College, Thi-Qar, Nassiriya, Iraq

Abstract
Numerous nations have prioritised the inclusion of citizens with disabilities, such as hearing loss, in all aspects of social life. Sign language is used by this population, yet they still have trouble communicating with others. Many sign language apps are being created to help bridge the communication gap as a result of technology advances enabled by the widespread use of smartphones. These apps are widely used because they are accessible and inexpensive. The services and capabilities they offer and the quality of their content, however, differ greatly. Evaluation of the quality of the content provided by these applications is necessary if they are to have any kind of real effect. A thorough evaluation like this will inspire developers to work hard on new apps, which will lead to improved software development and experience overall. This research used a systematic literature review (SLR) method, which is recognised in gaining a broad understanding of the study whilst offering additional information for future investigations. SLR was adopted in this research for smartphone-based sign language apps to understand the area and main discussion aspects utilised in the assessment. These studies were reviewed on the basis of related work analysis, main issues, discussions and methodological aspects. Results revealed that the evaluation of sign language mobile apps is scarce. Thus, we proposed a future direction for the quality assessment of these apps. The findings will benefit normal-hearing and hearing-impaired users and open up a new area where researchers and developers could work together on sign language mobile apps. The results will help hearing and non-hearing users and will pave the way for future collaboration between academicians and app developers in the field of sign language technology. © 2023, The Author(s), under exclusive licence to Springer-Verlag GmbH Germany, part of Springer Nature.

Author Keywords
Assessment; Deaf people; Hearing impaired; Mobile app; Sign language; Smartphone

Index Keywords
Audition, Quality control, Software design; Assessment, Deaf peoples, Hearing impaired, Hearing loss, Literature analysis, Mobile app, Sign language, Smart phones, Smartphone apps, Systematic literature review; Smartphones

References

- O, W.H.
  (2021) *Deafness and Hearing Loss*,
  accessed 21 April

- Kaland, M., Salvatore, K.
  The psychology of hearing loss
  (2002) *ASHA Lead.*, 7 (5), pp. 4-15.

- Young, A.M., Ackerman, J.
  Reflections on validity and epistemology in a study of working relations between deaf and hearing professionals
  (2001) *Qual. Health Res.*, 11 (2), pp. 179-189.

- Jebali, M., Dakhli, A., Jemni, M.
  Vision-based continuous sign language recognition using multimodal sensor fusion
  (2021) *Evol. Syst*, pp. 1-14.

- Alamoodi, A.
  New extension of fuzzy-weighted zero-inconsistency and fuzzy decision by opinion score method based on cubic pythagorean fuzzy environment: A benchmarking case study of sign language recognition systems
  (2022) *Int. J. Fuzzy Syst.*, pp. 1-18.

- Al-Samarraay, M.S.
  A new extension of FDOSM based on pythagorean fuzzy environment for evaluating and benchmarking sign language recognition systems
  (2022) *Neural Comput. Appl.*, 34 (6), pp. 4937-4955.

- Abualigah, L.M.Q.
  (2019) *Feature Selection and Enhanced Krill Herd Algorithm for Text Document Clustering*,
  Springer

- Alrubayi, A.H.
  A pattern recognition model for static gestures in malaysian sign language based on machine learning techniques
  (2021) *Comput. Electr. Eng.*, 95.

- Leite, D., Škrjanc, I., Gomide, F.
  An overview on evolving systems and learning from stream data
  (2020) *Evol. Syst*, pp. 1-18.

- Schliebs, S., Kasabov, N.
  Evolving spiking neural network—a survey
  (2013) *Evol. Syst.*, 4 (2), pp. 87-98.

- Abualigah, L.M., Khader, A.T.
  Unsupervised text feature selection technique based on hybrid particle swarm optimization algorithm with genetic operators for the text clustering
  (2017) *J. Supercomput.*, 73 (11), pp. 4773-4795.

- Dadiz, B.G., Abrasia, J.M.B., Jimenez, J.L.
  Go-Mo (Go-motion): An android mobile application detecting motion gestures for generating basic mobile phone commands utilizing KLT algorithm
  (2017) *2017 IEEE 2Nd International Conference on Signal and Image Processing (ICSIP)*, pp. 30-34.
  IEEE

- Alamoodi, A.
  A systematic review into the assessment of medical apps: Motivations, challenges, recommendations and methodological aspect
  (2020) *Health Technol*, pp. 1-17.

- Klímová, J.K.A.B.
  Use of smartphone applications in english language learning—a challenge for foreign language education
  (2019) *Educ. Sci.*,

- Nanaware, T., Sahasrabudhe, S., Ayer, N.
  Christo, R.:Fingerspelling-Indian Sign Language Training Tool
  (2018) *2018 IEEE 18Th International Conference on Advanced Learning Technologies (ICALT)*, pp. 330-334.
  IEEE

- Muzahidin, S., Rakun, E.
  Text-driven talking head using dynamic viseme and DFFD for SIBI
  (2020) *2020 7Th International Conference on Information Technology, Computer, and Electrical Engineering (ICITACEE)*, pp. 173-178.
  IEEE

- Villamarin, S.C.B., Morales, D.A.C., Reyes, C.A.Á., Sánchez, C.A.
  Application design sign language colombian for mobile devices VLSCApp (Voice Colombian sign language app) 1.0
  (2016) *2016 Technologies Applied to Electronics Teaching (TAEE)*, pp. 1-5.
  IEEE

- Mahesh, M., Jayaprakash, A., Geetha, M.
  Sign language translator for mobile platforms
  (2017) *2017 International Conference on Advances in Computing, Communications and Informatics (ICACCI)*, pp. 1176-1181.
  IEEE

- Perera, Y., Jayalath, N., Tissera, S., Bandara, O., Thelijjagoda, S.
  Intelligent mobile assistant for hearing impairers to interact with the society in Sinhala language
  (2017) *2017 11Th International Conference on Software, Knowledge, Information Management and Applications (SKIMA)*, pp. 1-7.
  IEEE

- Alamoodi, A.H.
  Sentiment analysis and its applications in fighting COVID-19 and infectious diseases: a systematic review
  (2021) *Expert Syst. Appl.*, 167.

- Shamseer, L.
  (2015) *Preferred Reporting Items for Systematic Review and Meta-Analysis Protocols (PRISMA-P) 2015: Elaboration and Explanation*, 349.

- Abbas, A.A.Y.A.A.
  Role of gamification in engineering education: A systematic literature review
  (2021) *2021 IEEE Global Engineering Education Conference (EDUCON)*, pp. 210-213.
  https://doi.org/

- Garcia, M.G., San Luis, C.I., Samonte, M.J.
  C.:E-tutor for Filipino sign language
  (2016) *2016 11Th International Conference on Computer Science & Education (ICCSE)*, pp. 223-227.
  IEEE

- Khan, M.N.R., Sonet, H.H., Yasmin, F., Yesmin, S., Sarker, F., Mamun, K.A.
  'Bolte Chai'—An Android application for verbally challenged children
  (2017) *2017 4Th International Conference on Advances in Electrical Engineering (ICAEE)*, pp. 541-545.
  IEEE

- Pluempitiwiriyawej, C., Changsnit, P., Chevapatr, P., Ranong, S.
  N.:FING: Thai fingerspelling practice application
  (2017) *2017 6Th ICT International Student Project Conference (ICT-ISPC)*, pp. 1-4.
  IEEE

- Lena, P.H., Jimbara, W.R.
  Learning to read and identifies the level of hearing disability early age using a mobile learning application

(2017) *International Conference on Interactive Collaborative Learning*, pp. 355-362. Springer

- Sahid, A.F.B.M., Ismail, W.S.W., Abd Ghani, D.
  Malay sign language (MSL) for beginner using android application
  (2016) *2016 International Conference on Information and Communication Technology (ICICTM)*, pp. 189-193.
  IEEE

- Srithonratkul, B., Sintupetch, P., Saysaman, P., Pluempitiwiriyawej, C.
  Chauksuvanit, T.:New2Thai
  (2016) *2016 Fifth ICT International Student Project Conference (ICT-ISPC)*, pp. 137-140.
  IEEE

- Ridzky, D., Effendy, V., Junaedi, D.
  User interface modelling for SIBI (sistem isyarat bahasa indonesia/indonesian sign language system) learning applications using the user-centered design method
  (2019) *J. Phys. Conf. Ser.*,

- Hasanah, A., Kusumah, Y., Rahmi, K.
  Rounding-augmented reality book and smartphone for deaf students in achieving basic competence
  (2020) *J. Phys. Conf. Ser.*, 1521, p. 032064.

- Parvez, K.
  Measuring effectiveness of mobile application in learning basic mathematical concepts using Pakistan sign language
  (2019) *Sustainability*, 11, p. 30642019.

- Romero, R.L., Kates, F., Hart, M., Ojeda, A., Meirom, I., Hardy, S.
  Quality of deaf and hard-of-hearing mobile apps: evaluation using the mobile app rating scale (MARS) with additional criteria from a content expert
  (2019) *JMIR mHealth uHealth*, 7 (10).

- Sobhan, M., Chowdhury, M.Z., Ahsan, I., Mahmud, H., Hasan, M.K.
  A communication aid system for deaf and mute using vibrotactile and visual feedback
  (2019) *2019 International Seminar on Application for Technology of Information and Communication (Isemantic)*, pp. 184-190.
  IEEE

- Shahriar, R., Zaman, A., Ahmed, T., Khan, S.M., Maruf, H.
  A communication platform between bangla and sign language
  (2017) *2017 IEEE Region 10 Humanitarian Technology Conference (R10-HTC)*, pp. 1-4.
  IEEE

- Ku, Y.-J., Chen, M.-J., King, C.-T.
  A virtual sign language translator on smartphones
  (2019) *2019 Seventh International Symposium on Computing and Networking Workshops (CANDARW)*, pp. 445-449.
  IEEE

- Khan, M.N.R., Shahin, F.B., Sunny, F.I., Khan, M.R., Mashuk, A.E.H., Al Mamun, K.
  A.:An innovative and augmentative android application for enhancing mediated communication of verbally disabled people
  (2019) *2019 10Th International Conference on Computing, Communication and Networking Technologies (ICCCNT), Pp. 1–5, IEEE*,

- Abdallah, E.E., Fayyoumi, E.J.P.C.S.
  Assistive technology for deaf people based on android platform
  (2016) *Procedia Comput. Sci.*, 94, pp. 295-301.

- Samonte, M.J.C., Gazmin, R.A., Soriano, J.D.S., Valencia, M.N.O.
  BridgeApp: An assistive mobile communication application for the deaf and mute
  (2019) *2019 International Conference on Information and Communication Technology Convergence (ICTC)*, pp. 1310-1315.
  IEEE

- Amrutha, C., Davis, N., Samrutha, K., Shilpa, N., Chunkath, J.J.P.T.
  Improving language acquisition in sensory deficit individuals with mobile application
  (2016) *Procedia Technol.*, 24, pp. 1068-1073.

- Olga, L., Valeriia, S., Volodymyr, P.
  The sign translator information system for tourist
  (2019) *2019 IEEE 14Th International Conference on Computer Sciences and Information Technologies (CSIT)*, 3, pp. 162-165.
  IEEE

- Dissanayake, P.J.W.I.S.M., Mudunkotuwa, M.A.S., Fernando, P.W.N.
  Utalk: Sri Lankan sign language converter mobile app using image processing and machine learning
  (2020) *2020 2Nd International Conference on Advancements in Computing (ICAC)*, 1.
  https://doi.org/

- Imran, A., Razzaq, A., Baig, I.A., Hussain, A., Shahid, S., Rehman, T.U.
  Dataset of Pakistan sign language and automatic recognition of hand configuration of Urdu alphabet through machine learning
  (2021) *Data Brief*, 36, p. 107021.

- Dahanayaka, D.T.D.M., Madhusanka, B.G.D.A., Atthanayake, I.U.
  A multi-modular approach for sign language and speech recognition for deaf-mute people
  (2021) *Eng. J. Instit. Eng.*,

- Kumar, P., Kaur, S.
  Sign language generation system based on Indian sign language grammar
  (2020) *J. ACM Trans. Asian Low-Resour. Lang. Inf. Proc.*, 19 (4), p. 1.

- Hartanto, R., Kartikasari, A.
  Android based real-time static Indonesian sign language recognition system prototype
  (2016) *2016 8Th International Conference on Information Technology and Electrical Engineering (ICITEE)*, pp. 1-6.
  IEEE

- Vintimilla, M.G., Alulema, D., Morocho, D., Proano, M., Encalada, F., Granizo, E.
  Development and implementation of an application that translates the alphabet and the numbers from 1 to 10 from sign language to text to help hearing impaired by Android mobile devices
  (2016) *2016 IEEE International Conference on Automatica (ICA-ACCA)*, pp. 1-5.
  IEEE

- Yousaf, K.
  A novel technique for speech recognition and visualization based mobile application to support two-way communication between deaf-mute and normal peoples
  (2018) *Wirel. Commun. Mob. Comput.*, 2018, p. 1013234.

- Sengupta, A., Mallick, T., Das, A.
  A cost effective design and implementation of arduino based sign language interpreter

(2019) *2019 Devices for Integrated Circuit (Devic)*, pp. 12-15.
IEEE

- Vachirapipop, M., Soymat, S., Tiraronnakul, W.
  Hnoohom, N.:An integration of Myo Armbands and an android-based mobile application for communication with hearing-impaired persons
  (2017) *2017 13Th International Conference on Signal-Image Technology & Internet-Based Systems (SITIS)*, pp. 413-417.
  IEEE

- Gul, A., Zehra, B., Shah, S., Javed, N., Saleem, M.I.
  Two-way smart communication system for deaf & dumb and normal people
  (2020) *2020 International Conference on Information Science and Communication Technology (ICISCT)*, pp. 1-4.
  IEEE

- Mahamud, M.S., Zishan, M.S.R.
  Watch IT: An assistive device for deaf and hearing impaired
  (2017) *2017 4Th International Conference on Advances in Electrical Engineering (ICAEE)*, pp. 556-560.
  IEEE

- Liu, Y., Jiang, F., Gowda, M.
  Finger gesture tracking for interactive applications: a pilot study with sign languages
  (2020) *Proc. ACM Interact. Mob. W. Ubiquitous Technol.*, 4 (3), pp. 1-21.

- Loke, P., Paranjpe, J., Bhabal, S., Kanere, K.
  Indian sign language converter system using an android app
  (2017) *2017 International Conference of Electronics, Communication and Aerospace Technology (ICECA)*, 2, pp. 436-439.
  IEEE

- Abou Haidar, G., Achkar, R., Salhab, D., Sayah, A., Jobran, F.
  Sign language translator using the back propagation algorithm of an MLP
  (2019) *2019 7Th International Conference on Future Internet of Things and Cloud Workshops (Ficloudw)*, pp. 31-35.
  IEEE

- Berger, A., Maly, F.
  Smart Google Glass Solution Used as Education Support Tool
  (2019) *2019 International Symposium on Educational Technology (ISET)*, pp. 265-267.
  IEEE

- Luangrungruang, T., Kokaew, U.
  Applying universal design for learning in augmented reality education guidance for hearing impaired student
  (2018) *2018 5Th International Conference on Advanced Informatics: Concept Theory and Applications (ICAICTA)*, pp. 250-255.
  IEEE

- Deb, S., Bhattacharya, P.J.P.C.S.
  "Augmented sign language modeling (ASLM) with interaction design on smartphone-an assistive learning and communication tool for inclusive classroom
  (2018) *Procedia Comput. Sci.*, 125, pp. 492-500.

- de Araujo, T.A.C., Oliveira, F.C., Costa, C.L.
  Creating job opportunities in computer assembly line for people with disabilities through augmented reality
  (2019) *2019 IEEE Frontiers in Education Conference (FIE)*, pp. 1-7.
  IEEE

- Joseph, M.H.
  SignAR: A sign language translator application with augmented reality using text and image recognition
  (2019) *2019 IEEE International Conference on Intelligent Techniques in Control, Optimization and Signal Processing (INCOS)*, pp. 1-5.
  IEEE

- Park, H., Lee, J.S., Ko, J.
  Achieving real-time sign language translation using a smartphone's true depth images
  (2020) *2020 International Conference on Communication Systems & Networks (COMSNETS)*, 7-11, pp. 622-625.
  https://doi.org/

- Baehaqi, M.N., Irzal, M., Indiyah, F.H.
  Morphological analysis of speech translation into indonesian sign language system (SIBI) on android platform
  (2019) *2019 International Conference on Advanced Computer Science and Information Systems (ICACSIS)*, pp. 205-210.
  IEEE

- Jin, C.M., Omar, Z., Jaward, M.H.
  A mobile application of American sign language translation via image processing algorithms
  (2016) *2016 IEEE Region 10 Symposium (TENSYMP)*, pp. 104-109.
  IEEE

- Liqing, G., Wenwen, L., Yong, S., Yanyan, W., Guoming, L.
  Research on portable sign language translation system based on embedded system
  (2018) *2018 3Rd International Conference on Smart City and Systems Engineering (ICSCSE*, pp. 636-639.
  IEEE

- Bhujbal, V.P., Warhade, K.
  Hand Sign Recognition Based Communication System for Speech Disable People
  (2018) *2018 Second International Conference on Intelligent Computing and Control Systems (ICICCS)*, pp. 348-352.
  IEEE

- Hussain, M.A., Ahsan, K., Iqbal, S., Nadeem, A.
  Supporting deafblind in congregational prayer using speech recognition and vibro-tactile stimuli
  (2019) *Int. J. Hum. Comput. Stud.*, 123, pp. 70-96.

- Neiva, D.H., Zanchettin, C.
  Gesture recognition: a review focusing on sign language in a mobile context
  (2018) *Expert Syst. Appl.*, 103, pp. 159-183.

- Abdulla, D., Abdulla, S., Manaf, R., Jarndal, A.H.
  Design and implementation of a sign-to-speech/text system for deaf and dumb people
  (2016) *2016 5Th International Conference on Electronic Devices, Systems and Applications (ICEDSA)*, pp. 1-4.
  IEEE

- Paudyal, P., Lee, J., Banerjee, A., Gupta, S.K.
  A comparison of techniques for sign language alphabet recognition using armband wearables
  (2019) *ACM Trans. Interact. Intell. Syst.*, 9 (2-3), pp. 1-26.

- Rao, G.A., Kishore, P.J.A.S.E.J.
  "Selfie video based continuous Indian sign language recognition system
  (2018) *Ain Shams Eng. J.*, 9 (4), pp. 1929-1939.

- Chuan, N.K., Sivaji, A., Loo, F.A., Ahmad, W.F.W., Nathan, S.S.
  Evaluating 'Gesture Interaction'requirements of mobile applications for deaf users: Discovering the needs of the hearing-impiared in using touchscreen gestures
  (2017) *2017 IEEE Conference on Open Systems (ICOS)*, pp. 90-95.
  IEEE

- Eryiğit, C., Köse, H., Kelepir, M., Eryiğit, G.J.K.-B.S.
  "Building machine-readable knowledge representations for Turkish sign language generation
  (2016) *Knowl. -Based Syst.*, 108, pp. 179-194.

- Ayadi, K., Elhadj, Y.O., Ferchichi, A.
  Prototype for learning and teaching arabic sign language using 3D animations
  (2018) *2018 International Conference on Intelligent Autonomous Systems (Icoias)*, pp. 51-57.
  IEEE

- Sachdeva, H., Misra, A., Chauhan, K., Dave, M.
  Morse-Comm: Mobile application environment for visually-impaired and neuro-muscular disabled people using morse code conversion
  (2020) *2020 7Th International Conference on Signal Processing and Integrated Networks (SPIN)*, pp. 809-813.
  IEEE

- Rizwan, S.B., Khan, M.S.Z., Imran, M.
  American sign language translation via smart wearable glove technology
  (2019) *2019 International Symposium on Recent Advances in Electrical Engineering (RAEE)*, 4, pp. 1-6.
  IEEE

- Amarasinghe, A., Wijesuriya, V.B.
  Stimme: A Chat Application for Communicating with Hearing Impaired Persons
  (2019) *2019 14Th Conference on Industrial and Information Systems (ICIIS)*, pp. 458-463.
  IEEE

- Bhuvan, M.S., Rao, D.V., Jain, S., Ashwin, T.S., Guddetti, R.M.R., Kulgod, S.P.
  Detection and analysis model for grammatical facial expressions in sign language
  (2016) *2016 IEEE Region 10 Symposium (TENSYMP)*, pp. 155-160.
  IEEE

- Rastgoo, R., Kiani, K., Escalera, S.
  Sign language recognition: a deep survey
  (2021) *Expert Syst. Appl.*, 164, p. 113794.

- Zanzarukiya, A., Jethwa, B., Panchasara, M., Parekh, R.
  Assistive hand gesture glove for hearing and speech impaired
  (2020) *2020 4Th International Conference on Trends in Electronics and Informatics (ICOEI)(48184)*, pp. 837-841.
  IEEE

- Tiku, K., Maloo, J., Ramesh, A., Indra, R.
  Real-time Conversion of Sign Language to Text and Speech
  (2020) *2020 Second International Conference on Inventive Research in Computing Applications (ICIRCA)*, pp. 346-351.
  IEEE

- Kanakri, W., Lo'ai, A.T., Alharbi, A.
  Dos and Donts Integrated System Based on GPS and Cloud Technologies for Pilgrims
  (2017) *2017 IEEE 14Th International Conference on Mobile Ad Hoc and Sensor Systems (MASS)*, pp. 622-627.
  IEEE

- Paudyal, P., Lee, J., Banerjee, A., Gupta, S.K.
  Dyfav: Dynamic feature selection and voting for real-time recognition of fingerspelled alphabet using wearables
  (2017) *Proceedings of the 22Nd International Conference on Intelligent User Interfaces*, pp. 457-467.

- El-Gayyar, M.M., Ibrahim, A.S., Wahed, M.J.E.I.J.
  Translation from Arabic speech to Arabic sign language based on cloud computing
  (2016) *Egypt. Inform. J.*, 17 (3), pp. 295-303.

- Nath, G.G., Arun, C.
  Real time sign language interpreter
  (2017) *2017 IEEE International Conference on Electrical, Instrumentation and Communication Engineering (ICEICE)*, pp. 1-5.
  IEEE

Correspondence Address
Alamoodi A.H.; Department of Computing, Perak, Malaysia; email: Alamoodi@fskik.upsi.edu.my