

Bridging Communication Gaps Among Individuals with Sensory Impairments Using Integrated Assistive Technologies

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Abstract

Communication is a critical part of life, and effective communication between two or more people can sometimes be challenging due to a person's inability to communicate because of a disability such as vision loss, hearing loss, or speech loss. In the case of individuals with disabilities, they are usually given time to send out messages and receive messages, meaning they need tools that only help them with one area of communication at a time. This paper introduces a new way to communicate with the help of artificial intelligence (AI) and the Internet of Things (IoT) for individuals who have sensory impairments in order to communicate better with each other and to find a way to create a "bridge" for persons with disabilities to understand each other. For example, the system would allow an individual to see gestures, and convert those gestures to text, return the text to the person that made the gesture in the form of speech or Braille, and provide a way to assist an individual with a sensory impairment to move about safely by identifying obstacles in the way and indicating how far away the obstacle is from the person. The system uses various tools, such as MediaPipe, to track the movement of the hands and other tools to convert the gesture to text and vice versa, and communicates the information to individuals around them. This new communication system can be made available to many users and is an affordable way for individuals to better communicate with one another. As such, this new technology applies to day-to-day activities to assist persons with sensory impairments to live more independently and be more involved in their communities by providing access to technology that has previously been unavailable to them. The proposed new Communication System for Individuals with Sensory Impairments is a work in progress and will likely take time to complete.

Keywords: Assistive technology, gesture recognition, speech processing, YOLO, Braille, AI, IoT

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INTRODUCTION

Living requires communication, which allows for the exchange of ideas and creating connections with others; however, people who are deaf, blind, or experience challenges with speaking find difficulties in communicating because they lack a means of contacting others; for example, someone who cannot speak has to use sign language to convey their message and a blind person cannot understand sign language as they cannot see it, conversely a deaf person misses out on verbal communication from one person to another and the same would apply to a blind person missing out on someone attempting to show or explain something to them, therefore making conversation among

individuals with disabilities especially difficult.

In recent times there has been significant advances made within the fields of Artificial Intelligence, The Internet of Things and Machine Learning which aid in developing systems designed to assist individuals with disabilities; some examples include: Computer vision enables computers to "see" things Natural Language Processing (enables computers to "understand what people are saying", and Speech Recognition translates spoken words into text instantaneously.

PROBLEM STATEMENT

Overall, communication facilitates the way in which people are able to interact and communicate. A person who is unable to hear, see or articulate (communicate) has great difficulty communicating their thoughts and feelings out loud. A person who cannot articulate may be able to communicate through signed language; however, a person who cannot hear will not have the capability to understand signed language. Thus it is often difficult for people with disabilities to communicate with each other and to communicate with non-disabled individuals [1–5].

The types of assistive technologies designed to assist persons with disabilities (such as systems that translate signed language for deaf people or systems that convert spoken language into printed text for hard-of-hearing individuals) will typically provide support for only one type of disability. There is no standard for defining the communication process for these two groups; therefore persons with disabilities (different types of disabilities) are not able to receive real-time assistance when communicating. Because of this, people with disabilities continually rely on other family members, friends or both for help with communication; they are not as independent as they otherwise could be.

Blind people have a hard time finding their way around because they can't see the physical obstacles that could be in their way. Besides needing help to communicate, blind people have a hard time moving from one place to another safely because they don't know what is there [6–10].

RESEARCH QUESTION

How can integrated assistive technologies enable real-time communication among individuals with sensory impairments?

OBJECTIVES

The primary aim of this research was to build an integrated communication platform that enables individuals with various disabilities to communicate with each other in an immediate fashion.

Specific Objectives

- Develop a way for sign language to be converted into text and/or voice output so that people who do not speak are able to use this as a form of communication.
- Construct a module that converts words into text in order for those who are hard of hearing to be able to communicate and understand what other people are saying.
- Develop a way for sign language to be converted into text and/or voice output so that people who do not speak are able to use this as a form of communication.
- Construct a module that converts words into text in order for those who are hard of hearing to be able to communicate and understand what other people are saying.
- Develop a way for individuals who cannot hear to be able to read text so that they are able to receive messages through the reading of printed text.
- Develop a device for generating Braille output using Arduino modules and various forms of assistance for people with vision challenges to read written communication.
- Create a system for people with disabilities to identify things in their way and receive spoken directions to aid them in traveling throughout the world around them.
- Build an integrated communication system that utilizes artificial intelligence and connected devices to provide comprehensive access to information and communication.

- Ensure that all elements of the communication system can be purchased at a reasonable cost, can be utilized by individuals with disabilities, and can function well in a variety of locations including schools, hospitals and public buildings.

LITERATURE REVIEW

The use of assistive technology to help people with disabilities communicate and perform everyday activities has received much more attention in recent years. Researchers have studied numerous ways to use computer vision, machine learning, deep learning, speech processing, and tactile systems. However, most existing solutions are either focused on only one type of disability or communication mode; therefore, few integrated solutions exist.

Sign language recognition is an important area of research. Significant contributions have been made by Zhang et al. [1] and Wang et al. [2] who demonstrate that use of deep learning models such as CNN-BiLSTM and spatial-temporal networks can accurately recognize gestures produced by individuals using sign language. Tao et al. [3] have shown that datasets used to train these models, as well as real-time processing capabilities, are critical components of successful sign language systems. Nehra et al. [11] demonstrate that a combination of computer vision techniques, specifically MediaPipe and LSTM, provides significant real-time performance improvements over previous models.

Newer deep learning models, including VGG16, ResNet50 [7], and YOLOv4 [9], have improved the speed and accuracy of gesture recognition. Zhang et al. [8] have shown further enhancements in recognition accuracy through the use of hierarchical models for gesture recognition. Use of smart gloves [6], which employ tactile-based sensory technology, can produce accurate gesture recognition results; however, the complexity of the required hardware is significantly greater than that required for use of cameras. The development of Braille-based systems specifically designed for visually impaired users has been shown to increase accessibility to text and video content by converting videos (Sridhar [5] and Verma [12]) and the creation of multilingual sign language systems [10].

RESEARCH GAP

Over the past few years, there have been a substantial number of developments in the area of assistive technology for people who have sensory related disabilities. The large majority of assistive devices and/or systems that do exist today are developed to accommodate a single group or category of disabled individuals, e.g.) gesture recognition for those who cannot speak, speech to text systems for people who are deaf/ hard of hearing, Braille based systems for blind individuals. Since these devices and/or systems operate as separate and independent devices and/or system, individuals with different disabilities are unable to properly communicate with each other when they do not have access to each other's device and/or system.

In addition to being unable to offer effective two-way communication to individuals with different disabilities, many of the existing assistive devices and/or assistive systems do not offer real-time two-way communications between multiple individuals using different assistive devices and/or systems and do not provide environmental awareness services to blind individuals, such as obstacle detection and navigation assistance, resulting in limited autonomy and safety for those individuals. Also, some of the existing assistive devices and/or systems are developed with very expensive hardware, such as smart gloves, resulting in their unavailability to the majority of individuals who would benefit from those devices or systems.

The previously mentioned deficiencies lead to the development of this research proposal for an integrated, low-cost assistive technology system based on AI and IoT, which will enable gesture recognition and speech processing for converting gestures to voice or text, speech to text or Braille, and object detection for providing voice instructions based on detected obstacles. Moreover, the integrated assistive technology system will provide individuals who have disabilities (whether visual, auditory or any combination of both) with real-time communication and navigation options that are affordable.

NOVELTY/CONTRIBUTION OF THE PROPOSED SYSTEM

The proposed system provides a way for people with multiple types of disabilities such as being mute, deaf, or blind, to communicate with each other through the use of different technologies. Currently, many assistive communication devices exist to address the needs of people who are mute, but not all disabilities are covered when it comes to assistive technology. This system provides a single source of multi-modal interactive communication for anyone who is using assistive devices to communicate.

The major contribution of this research is the creation of an integrated communication device that will allow users to communicate in real-time with each other, regardless of what types of disabilities they have. The communication device utilises AI (artificial intelligence) based gesture recognition and speech-processing technologies to allow for rapid and effective communication without the need for an interpreter. The device also includes an obstacle detection module that will help visually impaired users navigate through their environments by providing directions through the use of voice commands and distance measurements (Figure 1).

The integrated communication device will be low-cost and scalable due to its ability to function with almost any common device such as a web camera or microphone, thus making it very easy to implement the device in schools, hospitals, or public locations. The device also includes a Braille output module that will allow people with severe vision impairment to receive tactile feedback from the device. The integrated communication device has the potential to serve as a foundational component for a gamified learning platform that will provide children with an interactive way to learn how to communicate in sign language.

This research provides solutions to many of the issues associated with the current assistive communication devices that fail to provide adequate solutions for individuals who have multiple disabilities.

In addition, this new system is designed to provide greater inclusivity and accessibility in a world where people communicate independently and have less dependency on People to help them communicate.

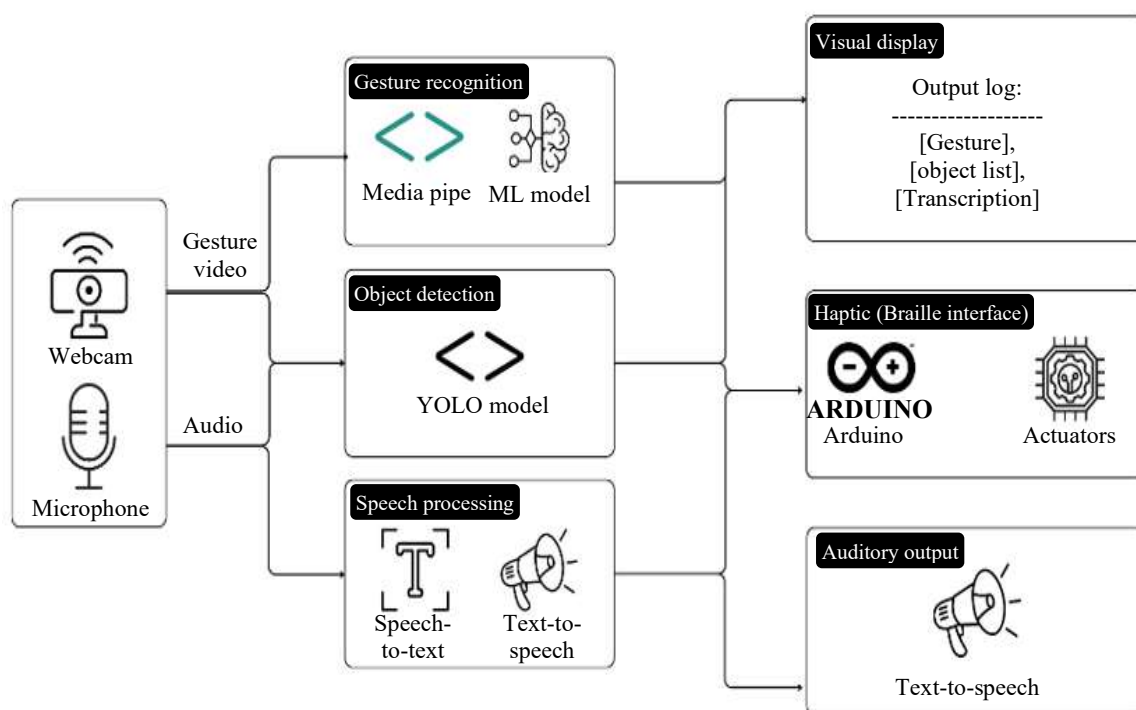


Figure 1. System architecture diagram.

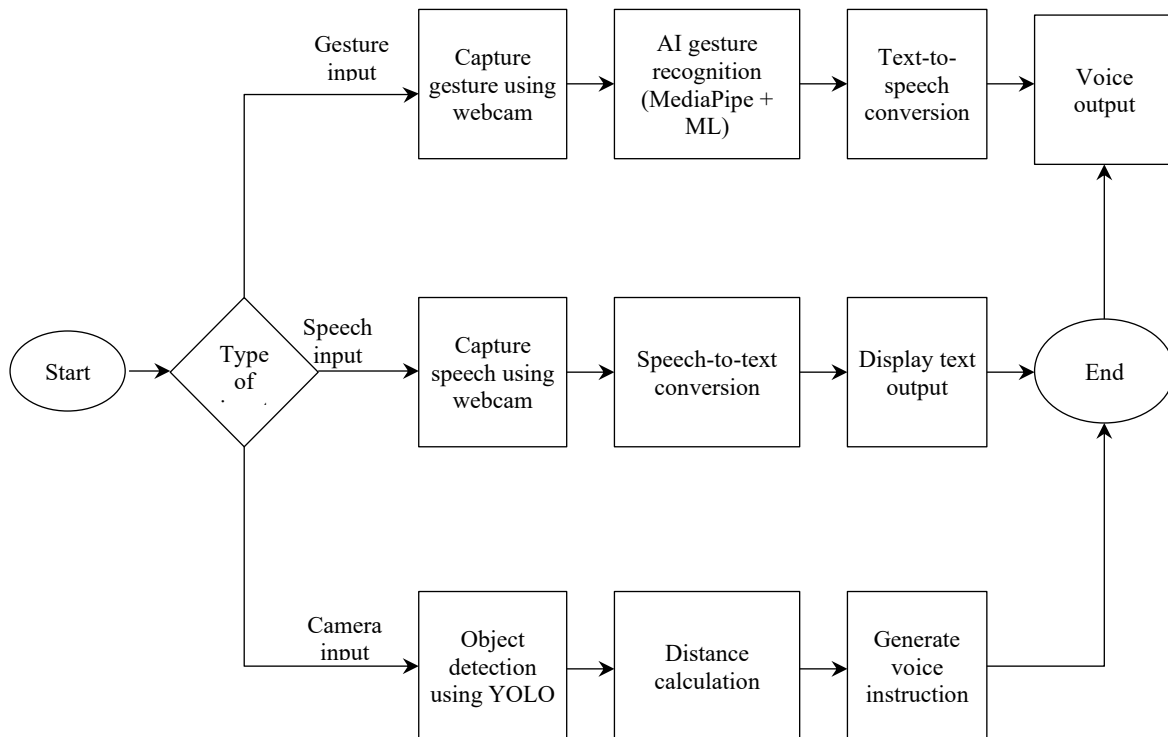


Figure 2. System flowchart.

This new communication system will also improve upon the efficiency of the way people with sensory disabilities communicate and give those individuals greater social confidence and interaction through the combination of all of these technologies into one system.

AI and IoT and the ability to scale and add future technology such as wearables, real-time translation and smart navigational systems will provide this communication system with many additional or enhanced features down the road. By doing so, the research being done today will create intelligent, economical, and suitable solutions for addressing the issues faced by people with disabilities as we look to the future (Figure 2).

CONCLUSIONS

This paper presents research involving an integrative assistive communication system designed for individuals with sensory impairments. The overall outcome is a successfully implemented system that uses gesture recognition, speech-to-text conversion, text-to-speech conversion, Braille, and real-time obstacle detection to foster seamless communication between mute, deaf, and visually impaired people. This research therefore proposes a complete answer to the failure of current single-modal assistive communications systems.

Artificial intelligence and IoT-based technologies allow fast processing and real-time operation; the gesture recognition system allows mute people to communicate; the speech-to-text conversion system allows visually impaired individuals to communicate with the deaf; and the Braille output system makes this proposed system remarkably easy to use. In addition, the obstacle detection system allows users to safely navigate through their environment. The integration of all of these systems allows for real-time voice notifications and distance measurements of objects for users.

As such, the proposed system is feasible, affordable, and can be implemented in schools, hospitals.

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