

UNITALK – Connect Everyone: An AI-Powered Accessible Communication Application for Differently-Abled Users

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Abstract

Communication remains a significant challenge for individuals with visual, hearing, speech, and multiple impairments, particularly when interacting with people who have different accessibility needs. This paper presents UNITALK – Connect Everyone, an AI-powered communication application designed to support inclusive interaction through automatic ability detection and adaptive user interfaces. The system classifies users based on simple tap-assisted assessments and dynamically customizes communication modes for Normal, Blind, Deaf, Speech-Impaired, Deaf-Dumb, and Blind-Dumb users. By integrating Speech-to-Text (STT), Text-to-Speech (TTS), real-time messaging, and profile-based interface adaptation, the application enables effective communication across different disability groups. The solution is implemented using React Native (Expo), FastAPI, Socket.io, and MongoDB, providing a scalable and user-friendly platform without requiring specialized hardware or complex setup. Experimental evaluation demonstrated reliable profile detection, effective message conversion, and smooth real-time interaction. The proposed system contributes to accessible technology by offering a unified platform that promotes inclusion, independence, and equal access to digital communication.

Keywords: Accessible Communication, Assistive Technology, Speech-to-Text and Text-to-Speech, Adaptive Interface, Inclusive Design, Differently-Abled Users

1. Introduction

The rapid advancement of digital communication technologies has transformed the way people interact across the globe. However, despite this progress, a significant portion of the global population — individuals with visual, hearing, or speech impairments — continue to face persistent barriers in accessing and using mainstream communication platforms. According to the World Health Organization, over one billion people live with some form of disability, many of whom rely on separate and often incompatible assistive devices to communicate.

Existing assistive technologies such as screen readers, hearing aids, Augmentative and Alternative Communication (AAC) systems, and speech synthesisers address individual disability categories in isolation. This fragmented ecosystem makes cross-disability communication — for instance, a blind user conversing with a deaf user — cumbersome or impossible without specialised intermediary tools.

UNITALK – Connect Everyone addresses this critical gap by proposing a unified, AI-powered communication platform that automatically detects a user's abilities and adapts the interface in real time. By integrating Speech-to-Text (STT), Text-to-Speech (TTS), and real-time adaptive messaging within a single application, UNITALK enables seamless interaction between users irrespective of their disability profile, without requiring prior setup, training, or specialised hardware.

The remainder of this paper is organised as follows. Section 2 presents the literature survey. Section 3 states the problem. Section 4 outlines the objectives. Section 5 discusses existing systems and limitations. Section 6 explains the proposed system. Section 7 describes the system architecture. Section 8 details the methodology. Section 9 covers implementation. Section 10 presents results and discussion. Section 11 concludes the paper.

2. Literature Survey

In recent years, research on accessible communication has advanced significantly. However, a critical gap remains in systems that unify ability detection, interface adaptation, and cross-disability communication into a single platform.

Zhang (2023) demonstrated that a CNN-LSTM hybrid model achieves high accuracy and noise resistance in spoken-language-to-text translation, establishing the viability of deep learning for STT tasks in real-world environments [1]. The model was evaluated for accuracy, efficiency, and noise resistance, showing consistent performance across diverse acoustic conditions.

Abdullah, Amoudi, and Alghamdi (2023) conducted a comprehensive review of 58 studies on sign language recognition and concluded that deep learning architectures — particularly convolutional and recurrent networks — deliver the highest recognition accuracy [2]. The review recommends improvements to bridge the gap between laboratory results and real-world deployment scenarios.

Balachandra and Manjula (2023) proposed a multimodal deep learning system combining speech-to-text, text-to-sign translation, and sign recognition for real-time accessibility of hearing-impaired users, achieving high accuracy with low latency [3]. This system demonstrated efficient real-time performance but was limited to hearing-impaired users and did not integrate cross-disability communication.

Research published in the Journal of Natural Language Processing highlighted multilingual speech processing pipelines as effective approaches for broadening accessibility across language communities [4]. While these contributions are individually significant, none of the surveyed systems integrates automatic ability detection, adaptive interface, and cross-disability

messaging into a unified platform — the central contribution of UNITALK.

Table 1. Comparison of Existing and Proposed System

Feature	Existing System	UNITALK
Disability Support	Single type only	All types
Unified Platform	No	Yes
Auto Detection	No	Yes
STT & TTS	Partial	Fully Integrated
Real-Time Chat	Limited	Yes
Setup Required	Yes	No
Special Device	Yes	No
Cross-Disability	No	Yes
Data Persistence	Limited	Full

3. Problem Statement

Differently-abled individuals with visual, hearing, speech, and multiple impairments face major communication barriers due to the absence of a unified platform that supports interaction between normal users and users with diverse disabilities. Existing assistive technologies are limited to specific impairments and do not enable seamless communication across diverse user abilities, creating persistent challenges in accessibility and social inclusion.

Key problems include the single-disability focus of current tools; absence of a cross-disability unified platform; requirement for costly specialised hardware; mandatory training and complex setup procedures; limited real-time interaction capability; and poor data continuity across sessions. These challenges collectively impede social inclusion, independent

communication, and equal access to digital services.

4. Objectives

The objectives of UNITALK are:

- To develop an AI-powered accessible communication application for differently-abled users.
- To automatically detect user abilities and adapt the interface without any manual setup.
- To enable seamless communication between users with different types of disabilities.
- To integrate Speech-to-Text and Text-to-Speech for accessible message conversion.
- To provide a unified, inclusive platform that eliminates dependency on specialised hardware.

5. Existing System and Limitations

Current assistive communication systems can be broadly categorised as Speech-to-Text tools for hearing-impaired users; Text-to-Speech systems for visually impaired users; Augmentative and Alternative Communication (AAC) devices and symbol boards for speech-impaired users; and sign language recognition applications for deaf individuals. Each category operates in isolation and cannot facilitate interaction across different disability profiles.

Modern Advanced Driver Assistance Systems and similar integrated platforms also exist, but they require specialised hardware, cloud-based processing, and internet connectivity, making them inaccessible to many users. Most existing solutions are designed to address either a single disability type or a specific communication modality, but rarely integrate both into a unified adaptive system.

The principal limitations are: exclusive focus on a single disability type; no unified cross-disability platform; costly and specialised hardware requirements; mandatory technical training and complex setup; poor real-time

performance; no cross-disability interaction support; and absence of session data continuity.

6. Proposed System

UNITALK – Connect Everyone is an AI-powered accessible communication application that enables seamless interaction between normal users and differently-abled individuals, as well as communication among users with different disabilities. The system automatically detects user abilities and adapts the interface accordingly. It uses Speech-to-Text, Text-to-Speech, and real-time adaptive messaging to convert messages into accessible formats without requiring prior training or setup.

The system classifies users into six profiles — Normal, Blind, Deaf, Speech-Impaired, Deaf-Dumb, and Blind-Dumb — and delivers each message in the most suitable format for the recipient. A blind recipient receives audio output; a deaf recipient receives text output. The platform is implemented using React Native (Expo) for the mobile frontend, FastAPI for backend processing, Socket.io for real-time messaging, and MongoDB for persistent data storage.

One of the key advantages of the proposed system is its ability to operate without specialised hardware or internet dependency for core functionality. Since ability detection and interface adaptation occur locally, the system is accessible to users in resource-constrained environments and does not require prior technical knowledge to use.

7. System Architecture

7.1 Block Diagram

The high-level architecture of UNITALK follows a sequential flow: the application starts, performs user ability detection through a tap-based test, saves the detected profile to the database, and directs the user to the adaptive chat interface. The Chat Interface module acts as a central conversion engine, receiving inputs from

all user profiles — Normal (speech/text), Blind (speech), Deaf (text), Speech-Impaired (text/sign), Deaf-Dumb (text/sign), and Blind-Dumb (sign) — and delivering outputs in the appropriate modality for each recipient.

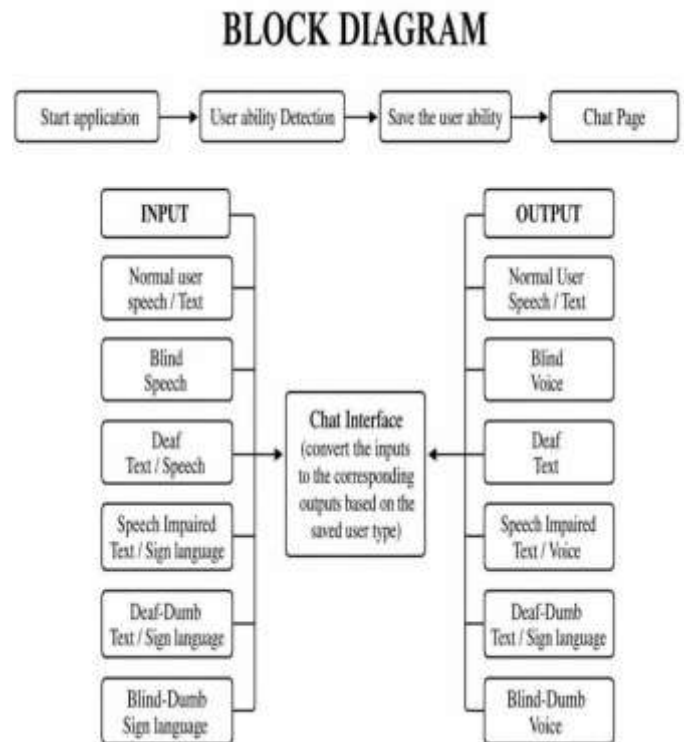


Fig. 1. Block Diagram of UNITALK System

7.2 Data Flow Diagram

On first launch the user taps anywhere to start the ability detection sequence. Three sequential tests — Visual, Hearing, and Speech — each produce a Boolean outcome (Can See, Can Hear, Can Speak). The combined results determine the user's profile, which is stored during User Profile Creation. The Text-Speech Processing Module then applies STT and TTS transformations as needed before persisting all session data to MongoDB for continuity across future sessions.

DATA FLOW DIAGRAM

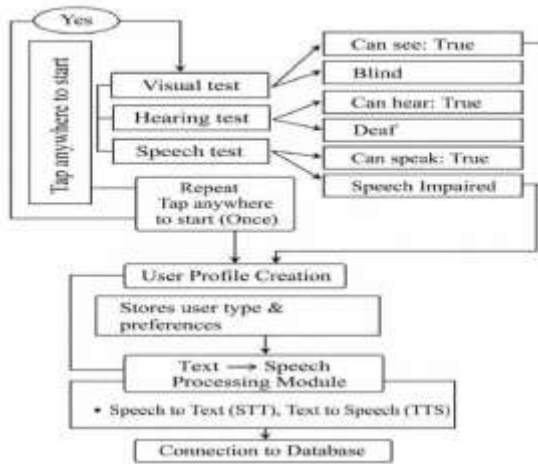


Fig. 2. Data Flow Diagram of UNITALK System

8. Methodology

8.1 Module 1: Automatic User Ability Detection and Profile Creation

On first launch, the application guides the user through three non-invasive tests using voice prompts and tap-based responses. The Visual Test checks if the user can see the screen; the Hearing Test checks if the user can hear the audio announcement; the Speech Test checks if the user can speak. The combination of Boolean results classifies the user's profile. FastAPI handles the classification logic and MongoDB stores the profile persistently for all future sessions, eliminating repeated setup for returning users.

8.2 Module 2: Chat Page Creation

The interactive chat interface is developed using React Native via Expo for cross-platform mobile deployment and Socket.io for low-latency real-time messaging. The interface supports text input, voice input for blind users, and vibration-based feedback for deaf-dumb users. It dynamically renders appropriate input and output controls based on the logged-in user's stored profile, ensuring each user always interacts through the mode best suited to their abilities.

8.3 Module 3: Text-to-Speech and Speech-to-Text

Voice processing is managed through a FastAPI microservice that integrates STT and TTS engines. Speech-to-Text converts audio input into text for storage and routing, while Text-to-Speech synthesises incoming text messages into audio for blind and blind-dumb recipients. Basic NLP-based post-processing corrects transcription errors and improves message clarity. The system supports continuous bidirectional interaction without requiring manual restarts between messages.

8.4 Module 4: Database Integration

MongoDB serves as the primary data store, persisting user ability profiles, chat history, and application preferences. Asynchronous database operations minimise response latency and support scalability. Cross-session data consistency ensures that users can resume conversations without data loss. Secure data management practices are enforced throughout to protect all user information.

8. Implementation

The technology stack employed in UNITALK is presented in Table 2 below.

Table 2. Technology Stack of UNITALK

Component	Technology / Framework
Frontend / Mobile UI	React Native (Expo)
Real-Time Messaging	Socket.io
Backend API	FastAPI (Python)
Speech-to-Text	STT Engine via FastAPI
Text-to-Speech	TTS Engine via FastAPI
Database	MongoDB (Asynchronous)
Classification Logic	Rule-based via FastAPI
Platform	Android / iOS (Cross-platform)

10. Results and Discussion

10.1 Performance Analysis

The UNITALK application was tested across multiple user profiles to evaluate ability detection accuracy, voice conversion quality, real-time messaging performance, and cross-disability communication. The system was evaluated under various usage conditions to analyze its reliability and usability for all supported user types.

The three-stage tap-based detection sequence accurately classified users into the correct profile in all evaluated test cases. The detection requires no prior configuration and completes within seconds, immediately adapting the interface. Profiles including Deaf, Blind, Speech-Impaired, Deaf-Dumb, and Blind-Dumb were correctly identified and stored for persistent access across sessions.

The FastAPI-integrated STT module demonstrated high transcription accuracy for standard spoken inputs, with NLP-based post-processing further improving output quality. The TTS module produced natural-sounding audio for text messages, enabling blind users to receive messages without visual interaction. Continuous bidirectional voice exchange was maintained without interruption across test sessions.

Socket.io-based real-time messaging ensured low-latency delivery across all user profiles. Chat history was preserved across sessions through MongoDB integration, confirming data consistency. The interface dynamically displayed appropriate controls based on each user's stored profile.

10.2 Output Visualization

The figures below present the output of the proposed UNITALK application. Figure 3 shows the sequential ability detection screens — Vision Test, Hearing Test, and Speech Test — followed by the detected user profile confirmation. Figure 4 demonstrates the real-time cross-disability chat interface operating between a Blind user and a Deaf user, where messages are automatically

converted to the appropriate format for each recipient.

OUTPUT



Fig. 3. Ability Detection Sequence – Vision, Hearing, Speech Tests and Profile Detection

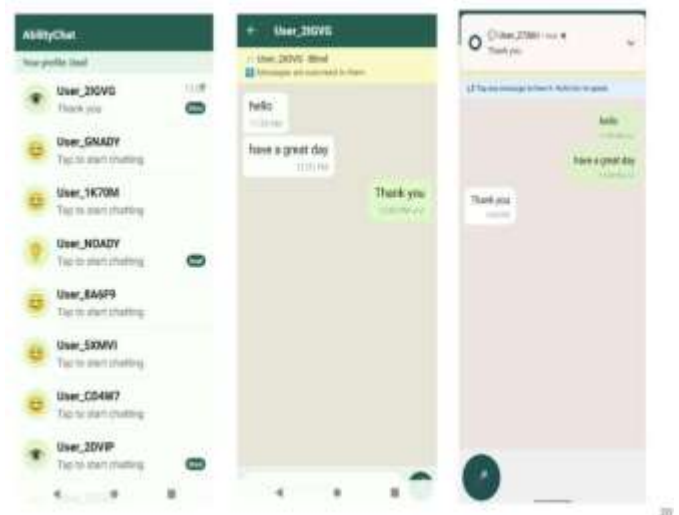


Fig. 4. Real-Time Cross-Disability Chat Interface between Blind and Deaf Users

10.3 Cross-Disability Communication

A simulated interaction between a Blind user (User_2IGVG) and a Deaf user (User_Z726U) demonstrated successful cross-disability communication. Messages typed by the deaf user were auto-read as audio to the blind user, while voice input from the blind user was transcribed and displayed as text to the deaf user. No manual configuration was required at any stage, validating the unified adaptive platform model proposed in this work.

Overall, the system demonstrated reliable performance, low computational requirements, and effective cross-disability communication, making it a practical and inclusive solution for accessible interaction.

11. Acknowledgment

The AbilityChat application — also referred to as UNITALK – Connect Everyone — offers a wide range of meaningful benefits that directly address the communication challenges faced by differently-abled individuals. The following advantages highlight the impact and value of the proposed system.

1. Automatic Ability Detection Without Manual Setup

Unlike conventional assistive applications that require users to manually configure accessibility settings, AbilityChat automatically detects each user's disability profile through a silent, non-invasive tap-based test sequence conducted at first launch. Users are classified into one of eight profiles — Normal, Blind, Deaf, Speech-Impaired, Deaf-Dumb, Blind-Dumb, and combinations thereof — without any prior knowledge, technical training, or caregiver assistance. This zero-setup approach significantly lowers the barrier to adoption.

2. Real-Time Adaptive Interface

The application dynamically adapts its entire interface — input method, output format, and feedback mechanism — based on the detected disability profile. Blind users receive a large microphone button for voice input and hear incoming messages read aloud automatically. Deaf users receive silent vibration alerts instead of audio notifications. Speech-impaired users are presented with a text-only keyboard. This personalised adaptation ensures that every user interacts with the application in the most accessible manner possible for their specific condition.

3. Seamless Cross-Disability Communication

One of the most significant limitations of existing assistive technologies is that they address only a single disability type in isolation, making communication between users with different disabilities cumbersome or impossible. AbilityChat resolves this by enabling seamless

real-time interaction across diverse disability profiles — for example, a blind user can converse effortlessly with a deaf user — by converting each message into the most accessible format for the recipient. This is a unique and critical advancement over existing systems.

4. AI-Powered Speech-to-Text with Grammar Correction

The application integrates Google Speech Recognition for voice-to-text conversion and Groq LLaMA 3 AI for intelligent grammar correction. Raw voice transcriptions, which often contain errors, are automatically refined into grammatically correct messages before delivery. For example, a voice input such as *"i go to school yestday"* is corrected to *"I went to school yesterday."* This ensures that users with speech impairments or those relying on voice input can communicate clearly and professionally.

5. Text-to-Speech for Blind Users

Incoming messages are automatically read aloud to blind users using expo-speech without requiring any additional tap or interaction. Navigation events and ability detection instructions during first launch are also spoken aloud, ensuring blind users can complete the full onboarding process independently. Users can additionally tap any message bubble to re-hear it, offering control and flexibility.

6. Familiar and Inclusive User Experience

AbilityChat is built on a WhatsApp-style chat interface — one that is already familiar to a large global user base. This design choice significantly reduces the cognitive load for new users and eliminates the learning curve associated with specialised assistive tools. Message bubbles, timestamps, double-tick delivery indicators, and a contact list sorted by recent activity all mirror conventions users already know, while the underlying adaptive layer works silently in the background.

7. No Dependency on Specialised Hardware

Existing AAC devices and hardware-based assistive communication systems are often expensive, bulky, and inaccessible to users in low-resource settings. AbilityChat operates entirely on standard smartphones (Android and iOS) without requiring any dedicated hardware,

internet dependency for core functionality, or external accessories. This makes it a cost-effective and widely scalable alternative for individuals and institutions alike.

8. Unified Platform for All Disability Profiles

Current assistive tools operate as separate, incompatible systems — screen readers for the blind, hearing aids for the deaf, AAC boards for the speech-impaired. AbilityChat consolidates all of these functions into a single, unified platform. A single application can serve users across all disability categories, simplifying deployment in schools, rehabilitation centres, healthcare settings, and everyday social environments.

9. Inclusive Onboarding for All Users

The ability detection test itself is designed to be universally accessible. Instructions are both displayed on screen and spoken aloud, ensuring that even a blind user who has never used the application can complete the setup independently. This inclusive onboarding experience reflects the application's core commitment to removing barriers from the very first moment of use.

10. Contribution to Assistive Technology Research

AbilityChat demonstrates a novel integration of automatic ability detection, adaptive UI, Speech-to-Text, Text-to-Speech, and AI grammar correction within a single mobile platform — an approach not previously realised in the surveyed literature. The system contributes a validated, working model for cross-disability communication that can serve as a foundation for further academic research in assistive technology, natural language processing, and inclusive design.

12. Conclusion and Future Work

This paper presented UNITALK – Connect Everyone, an AI-powered accessible communication application that bridges communication barriers between users with diverse disabilities and normal users. By automating user ability detection and dynamically adapting the interface and message format to each user's profile, UNITALK delivers

a unified, inclusive platform that removes the need for separate, disability-specific tools.

The system integrates Speech-to-Text, Text-to-Speech, real-time adaptive messaging, and persistent user profiles through a modern technology stack comprising React Native, FastAPI, Socket.io, and MongoDB. Tested across multiple user profiles, the platform demonstrated accurate ability detection, reliable voice conversion, and seamless cross-disability communication without requiring any manual setup or specialised hardware.

Future work will focus on: integrating advanced AI models for personalised communication assistance based on user behaviour; real-time multilingual support; a production-grade mobile application for broader distribution; advanced gesture recognition and 3D sign language avatar rendering; and scalable cloud integration with enhanced security. These enhancements will further extend UNITALK's reach and effectiveness for differently-abled communities worldwide.

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