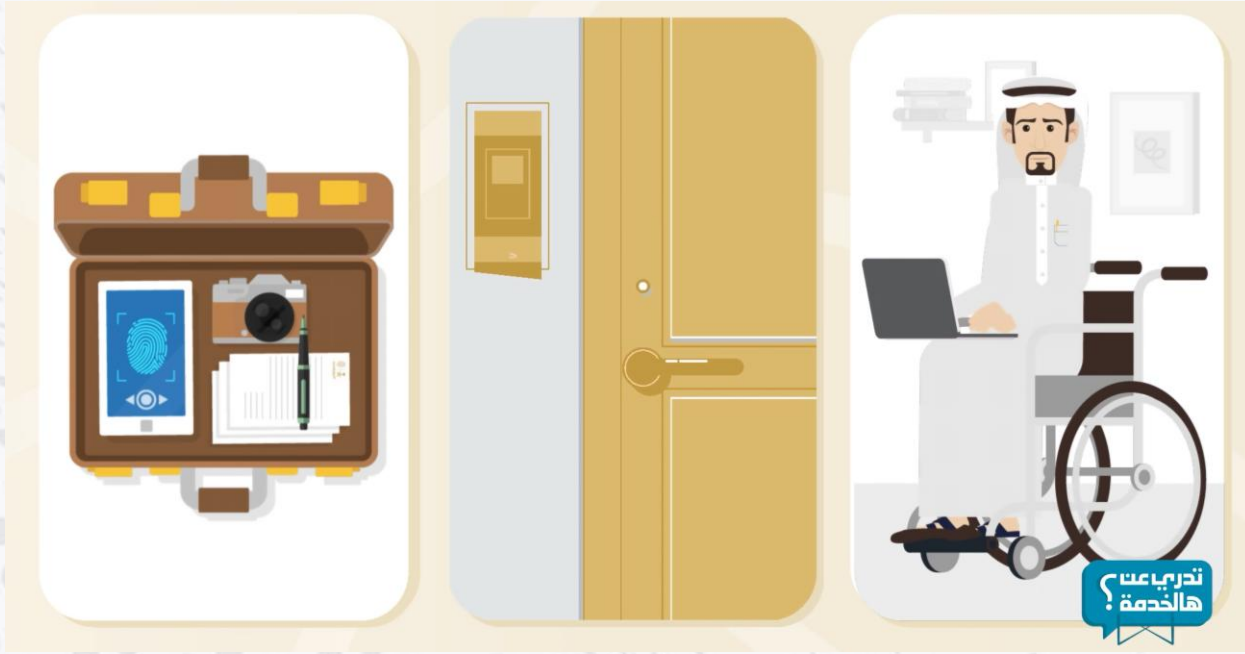




AI-Powered Arabic Sign Language Translation for Inclusive Public Services

OECD Call for Government Innovations 2026
Information Society and Digitalization

AI-Powered Arabic Sign Language Translation for Inclusive Public Services

Breaking communication barriers through real-time Two-Way AI Arabic Sign Language

Speech-to-sign and sign-to-speech translation happens instantly, enabling natural conversations between staff and visitors.

Deployed in service centers, call centers, and digital channels with virtual avatars, voice, and text interfaces.



Citizens who are deaf or hard of hearing can complete all civil transactions without needing a human interpreter.

A specialized language model trained on civil affairs procedures, forms, and regulations ensures accurate, compliant responses.

Background

Saudi Arabia is undergoing a significant transformation toward a fully digital and citizen-centric model of public service delivery, driven by the ambitions of Vision 2030. This transformation is anchored in a strong commitment to innovation, operational efficiency, and social inclusion, ensuring that government services are accessible, responsive, and aligned with the evolving needs of society. With a population exceeding 35 million people, the Kingdom is characterized by its diversity, which necessitates inclusive service models that accommodate individuals from different backgrounds, abilities, and circumstances.

Within this national context, the Ministry of Interior plays a central role in enabling secure and reliable public services. Through the Civil Affairs Agency, it is responsible for delivering some of the most critical government functions, including civil registration, identity management, and the issuance of official documents. These services represent the foundation upon which citizens access a wide range of public and private sector services, making their reliability, security, and accessibility essential to everyday life.

Given the scale and importance of these services, Civil Affairs operates within a highly complex and dynamic environment. It must ensure consistent service delivery across multiple channels while maintaining the highest standards of data protection, operational continuity, and user experience. This requires continuous modernization of its systems and processes to meet increasing demand and rising expectations from citizens.

As part of this evolution, Civil Affairs is actively adopting advanced digital technologies to enhance service delivery. This includes rethinking traditional service models, streamlining processes, and leveraging intelligent solutions to improve efficiency and accessibility. The focus extends beyond digitization to achieving true inclusivity, ensuring that all segments of society—including individuals with specific accessibility needs—can independently and seamlessly access essential government services.

Through this ongoing transformation, the Kingdom is not only improving service quality but also setting a benchmark for innovative, inclusive, and future-ready public service delivery.



Overview



Despite this progress, a critical gap remained in ensuring equitable access to public services for the special needs community. Historically, accessing government services required physical visits, manual procedures, and direct communication with service agents. For deaf individuals, this created a significant barrier due to the severe shortage of qualified Arabic sign language interpreters, often forcing them to rely on others to complete personal transactions, limiting their independence and privacy.



To address this challenge, a novel Two-Way AI-Powered Arabic Sign Language Translation solution was introduced. This system enables real-time communication between deaf individuals and government service agents without the need for human interpreters.



Using advanced computer vision and natural language processing, the solution translates sign language gestures into readable text and converts spoken language into a lifelike signing avatar. Deployed on portable devices, the solution ensures seamless, instant, and accessible communication in public service environments. This innovation transforms how inclusive services are delivered, enabling deaf citizens to independently access government services with dignity, speed, and accuracy.

Description

01



The solution is built on advanced artificial intelligence technologies, combining computer vision and natural language processing to enable real-time, two-way translation between Arabic sign language and spoken language. It captures visual input through device cameras and processes spoken language through speech recognition, creating a unified system capable of understanding and translating both forms of communication simultaneously. This ensures that interactions are not only instantaneous but also context-aware and linguistically accurate.

02

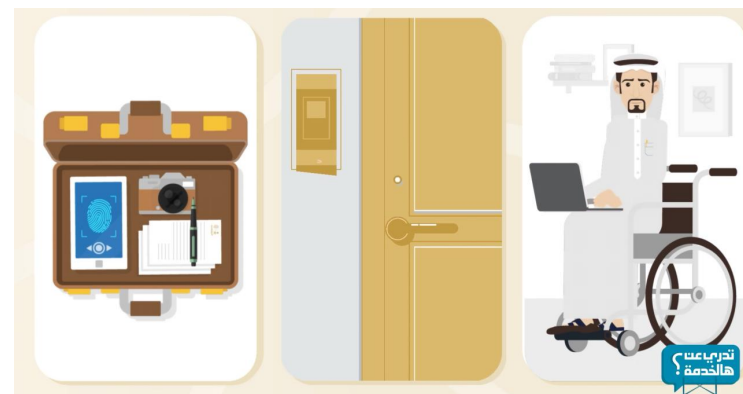


At the core of the solution is an intelligent translation engine that interprets sign language gestures—including hand movements, body posture, and facial expressions and converts them into structured, readable text. In parallel, spoken Arabic is analyzed and transformed into a realistic 3D signing avatar that reflects the meaning, tone, and intent of the message. This dual transformation enables a natural communication loop that closely mimics human interaction, bridging the gap between visual and spoken languages.

03



By enabling direct communication between deaf individuals and service providers, the solution removes the need for human interpreters and eliminates reliance on third-party assistance. This results in faster service delivery, improved accuracy, and a significantly enhanced user experience. More importantly, it empowers users with full independence, privacy, and dignity, ensuring equal access to essential public services and setting a new standard for inclusive digital service delivery.



Objectives

Enable Real-Time AI Communication

01

Provide accurate, real-time two-way translation between Arabic sign language and spoken language using advanced artificial intelligence.

Enhance Inclusive Public Service Experience

03

Ensure seamless, natural interaction between deaf individuals and service agents, improving accessibility and user experience.

Eliminate Dependency on Human Interpreters

02

Allow deaf citizens to communicate independently without relying on sign language interpreters or third-party assistance.

Ensure Secure and Privacy-Compliant Communication

04

Protect sensitive user data through secure processing, anonymization, and compliance with national data protection standards.



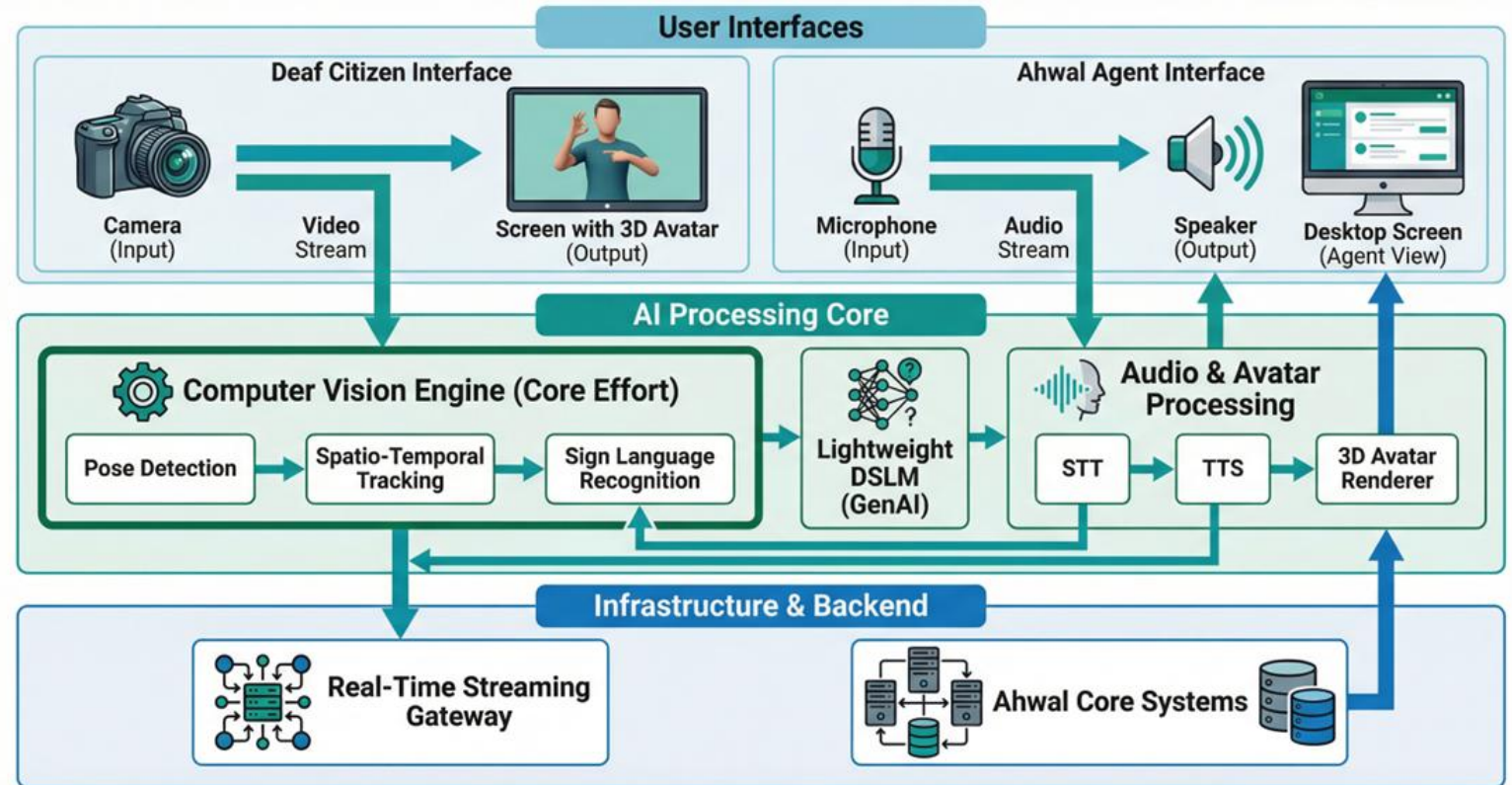
High-Level Architecture

The solution is built on a modular, AI-driven architecture that enables real-time, two-way communication between Arabic sign language and spoken language.

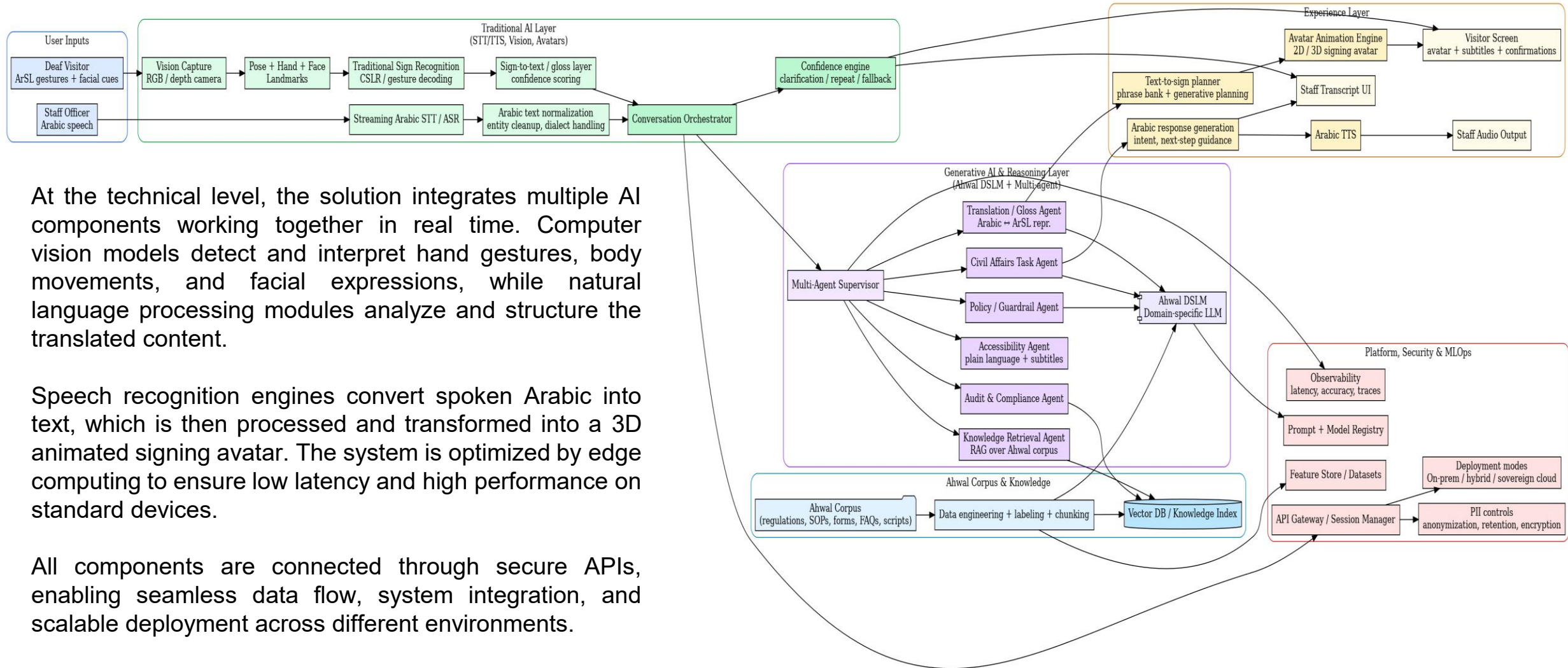
At a high level, the system consists of five main layers: data acquisition, AI processing, integration services, and user interaction interfaces.

Sign language input is captured through device cameras and processed using computer vision models, while spoken language is handled through speech recognition and natural language processing.

The system then generates outputs in both formats, converting gestures into text and speech into a realistic signing avatar. This architecture ensures seamless, real-time interaction between deaf users and service agents across public service environments.



Low-Level Architecture



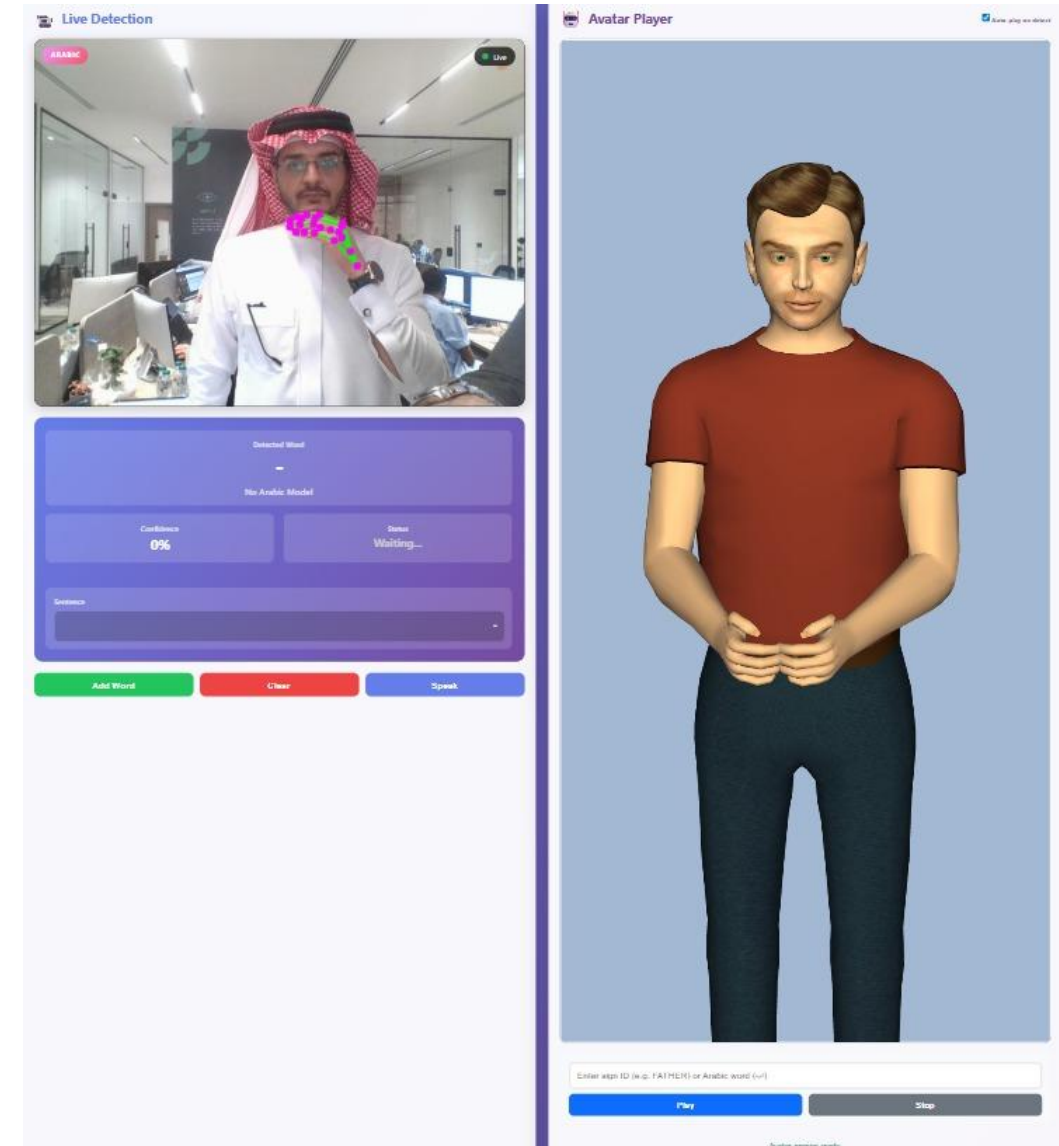
Initial Prototype

The initial prototype was developed as a proof of concept to validate the feasibility of real-time, two-way Arabic sign language translation using artificial intelligence.

At this stage, the focus was on building a functional model capable of recognizing basic sign language gestures and converting them into readable text, while simultaneously transforming spoken Arabic into a simplified signing avatar. This early version enabled controlled testing of core technologies, including computer vision, natural language processing, and avatar generation.

The prototype played a critical role in identifying technical challenges, refining model accuracy, and validating real-time performance under practical conditions. Insights gained from this phase directly informed the evolution of the full solution, ensuring scalability, reliability, and user-centered design.

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Alignment with Sustainable Development Goals (SDGs)

Q1



SDG 9 Industry The solution demonstrates advanced digital innovation by deploying AI-powered sign language translation using computer vision and natural language processing on accessible devices, enabling scalable and resilient service infrastructure.

Q2



SDG 10 Reduced The solution directly reduces inequality by eliminating communication barriers for deaf individuals, ensuring equal access to public services without reliance on interpreters.

Q3



SDG 11 Sustainable By enabling digital-first service interactions and reducing dependency on physical visits, the solution contributes to more efficient and accessible urban service delivery.

Q4



SDG 16 Peace The solution promotes inclusive and accessible public institutions by ensuring that all citizens, regardless of communication limitations, can independently access government services.

Impact (economic, social, environmental)

Social



01

Quantitative The AI-powered sign language translation system enables real-time communication with a conversational latency of 1–3 seconds, significantly improving service efficiency and accessibility. The solution has contributed to high user satisfaction levels, reflecting its effectiveness in delivering clear, fast, and reliable interactions for deaf citizens.

Qualitative The solution removes one of the most critical barriers faced by deaf individuals: the inability to communicate directly with service providers. By eliminating reliance on interpreters or third parties, it empowers users with full independence, privacy, and dignity. This transformation enhances social inclusion and ensures equal access to essential public services for all citizens.

Impact (economic, social, environmental)

Economic Impact



02

Quantitative Deploying AI-powered translation reduces reliance on costly human interpreters, creating a more sustainable and cost-efficient service model.

Qualitative The solution optimizes existing digital infrastructure by transforming standard devices into intelligent communication tools, improving efficiency while minimizing operational costs.

Impact (economic, social, environmental)

Environmental Impact



03

Quantitative The adoption of AI-powered sign language translation reduces the need for repeated physical visits to government service centers, contributing to a measurable decrease in transportation-related emissions. Additionally, the solution operates within a fully digital environment, eliminating reliance on paper-based processes and significantly reducing material consumption.

Qualitative The solution supports more sustainable service delivery by minimizing unnecessary travel and reducing dependency on physical documentation. By enabling efficient, remote-ready interactions and digital processing, it contributes to lowering the overall environmental footprint of public service operations while aligning with long-term sustainability goals.

Innovation Methodology

Empathize The innovation journey began with a deep exploration of the challenges faced by deaf individuals in accessing public services. This stage focused on understanding real user pain points, communication barriers, and accessibility limitations. Insights were informed and validated through academic collaboration, ensuring that the solution is grounded in real-world needs and reflects a comprehensive understanding of user behavior, expectations, and constraints.

Define Based on the insights gathered, the problem was clearly defined and reframed. Instead of expecting deaf users to adapt to complex service environments, the challenge was rearticulated as the need to redesign services around the user. This shift established a strong user-centered problem statement focused on eliminating communication barriers and enabling direct, independent interaction.

Ideate + Process At this stage, multiple solution approaches were explored through structured ideation and iterative innovation cycles. The process involved continuous brainstorming, refinement, and evaluation to identify the most effective approach for real-time communication. This ensured that the final concept is not only innovative, but also practical, scalable, and aligned with operational realities.

Prototype + Test The solution was translated into a functional prototype using a hybrid AI approach that combines advanced neural networks with adaptive fallback mechanisms. This stage focused on validating the feasibility of real-time translation, ensuring accuracy, and optimizing system performance. Continuous testing and iterative refinement allowed the solution to evolve based on practical feedback, ensuring readiness for deployment in real-world environments.

Innovation

The Civil Affairs Agency launched the AI-Powered Arabic Sign Language Translation initiative to solve a persistent public-service barrier: deaf citizens often could not communicate independently with frontline staff when accessing essential civil services such as identity registration, family records, and official documentation. In practice, this meant many users had to rely on family members, written notes, or the limited availability of interpreters, which reduced privacy, slowed transactions, and undermined equal access to government services. The innovation turns this challenge into an opportunity to embed accessibility directly into service delivery, making inclusion a built-in feature of public infrastructure rather than a special accommodation.

The innovation is a real-time, two-way AI communication system that translates spoken Arabic into Arabic Sign Language through a signing avatar, and interprets sign language input into readable text or speech for staff. It combines speech recognition, natural language processing, computer vision, sign recognition, avatar rendering, and secure integration into a unified service experience designed for public-service environments. Its objectives are to enable direct communication, reduce dependency on human interpreters, improve speed and service quality, protect privacy, and ensure that deaf citizens can complete their transactions with dignity and independence.

What makes the project innovative is not only the technology itself, but how it reframes accessibility in government. Instead of treating accessibility as an external support service, the initiative integrates AI-powered communication directly into routine public interactions. It also follows a practical innovation path: beginning with a controlled prototype, validating feasibility in a constrained service domain, and then evolving toward a scalable architecture that can expand vocabulary, improve contextual understanding, and support broader deployment. This phased approach responds realistically to the scarcity of Arabic Sign Language datasets and the linguistic complexity of sign language, while still delivering an implemented and operationally relevant solution.

The primary beneficiaries are deaf and hard-of-hearing citizens, who gain more independent, private, and dignified access to essential government services. Civil Affairs staff also benefit through clearer communication, fewer misunderstandings, and a more efficient service process, while the institution benefits from a scalable and more inclusive service model aligned with digital transformation goals. Looking ahead, the innovation is envisioned as an institutional capability embedded across Civil Affairs channels and progressively extended to other public sectors such as healthcare, courts, and social services. With modular architecture, standard-device deployment, and future enhancements in continuous sign understanding, expressive avatars, and domain-specific language intelligence, the project has the potential to become a broader national and regional model for inclusive digital government.



Sustainability



Maximizing Financial Efficiency

The solution operates on standard portable devices without the need for specialized hardware, significantly reducing deployment and maintenance costs while ensuring long-term financial sustainability.



Pioneering Sustainable AI Architecture

The translation engine combines advanced neural networks with optimized edge processing to deliver real-time performance while minimizing reliance on high-cost cloud infrastructure.



Reliable and Secure Operations

The system is designed to ensure high availability, secure data processing, and continuous service delivery, with regular updates that enhance performance without disrupting operations.



Continuous Learning and Improvement

The AI models continuously improve through real-world usage data, enabling higher accuracy and better adaptation to diverse sign language patterns over time.



Sustainable Impact Through Inclusion

By enabling independent communication, the solution creates lasting social impact, supporting equal access to public services and promoting long-term digital inclusion.

Replicability

Engineering Modular Architecture

The core system relies entirely on flexible software and standard hardware like everyday mobile tablets and desktop cameras. This eliminates the need for expensive proprietary equipment and ensures seamless replication across diverse environments.

Designing Adaptable Artificial Intelligence

The fundamental computer vision and speech recognition engines are built to be highly modular. We can rapidly update the gesture translation models with new service vocabularies or adjust them to comprehend unique regional dialects.

Scaling Through Agile Methodology

Flexible deployment models including both cloud and on-premise options guarantee rapid geographic expansion. Our strict agile project management ensures the platform adapts instantly to new operational requirements without system downtime.

Enabling Cross Sector Integration

This universal blueprint for digital inclusion easily extends beyond civil affairs into vital sectors like public healthcare and the judicial system. Private industries such as banking and telecommunications can seamlessly integrate these AI-powered service channels to serve their own vulnerable customers.

Pioneering Regional Accessibility

The solution can be replicated across different countries and sectors, enabling broader adoption of AI-powered sign language translation and advancing digital inclusion at scale.

Challenges

Developing a real time Two Way AI Arabic Sign Language system Developing a real-time two-way AI Arabic sign language system presented significant technical and linguistic challenges. The most critical obstacle was the absolute scarcity of comprehensive and standardized training datasets for Arabic Sign Language. Unlike spoken languages sign languages possess immense regional variations and distinct dialects across the Arab world making universal recognition incredibly difficult.

The team faced massive hurdles in raw dataset creation which required capturing diverse signers under various physical conditions and camera angles. Following the capture phase the intricate process of manual annotation proved highly resource intensive. Mapping the precise spatial and temporal dynamics of hand shapes body poses and facial movements requires specialized linguistic expertise. Overcoming these regional variations and data gaps required implementing a sophisticated hybrid strategy. This approach successfully combined core word level signs with letter level fingerspelling fallbacks to ensure immediate usability.

Additionally ensuring the generative 3D avatar and computer vision models operated seamlessly on portable tablets on portable devices in real-world environments demanded intense edge computing optimization. The development team had to balance complex neural network processing with strict latency requirements. Achieving a conversational response time of just one to three seconds was critical to ensure fluid communication especially in remote locations that might experience fluctuating network connectivity during field agent visits.

Future Perspectives

Enhancing Sign Language Understanding

The system will evolve from recognizing isolated gestures to achieving full continuous sign language comprehension. This advancement will enable the interpretation of complete sentences and dynamic signing sequences rather than individual signs, allowing for more natural, fluid, and context-aware communication. By improving temporal and contextual modeling, the system will better understand the relationship between gestures, resulting in higher accuracy and more meaningful interactions.

Advancing Expressive 3D Avatars

Future upgrades will enhance the realism of the 3D signing avatar by incorporating detailed facial expressions and non-manual signals, such as eye movement, head positioning, and emotional cues. These elements are essential components of sign language, as they convey tone, intent, and grammatical structure. Improving these features will ensure that the generated output is not only accurate, but also expressive and closer to natural human communication.

Expanding Vocabulary and Context Awareness

The solution will continuously expand its vocabulary base and contextual understanding to support a wider range of real-world scenarios and service interactions. This includes adapting to different dialects, domain-specific terminology, and evolving language patterns. By enhancing contextual awareness, the system will be able to interpret meaning more precisely and handle complex conversations, making it more robust, scalable, and adaptable across various environments.

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