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Secure and Assistive UPI Transaction System for Visually Impaired People

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Abstract

Android-based mobile application presents a digital payment solution specifically for visually impaired users. Conventional UPI apps pose a significant challenge due to their reliance on visual elements. This solution addresses by integrating assistive technology for more independent and secure transactions. The application features voice-guided navigation, which leads users through each step of the transaction via audio prompts. For secure access and quick payments, the solution has incorporated biometric authentication and a QR code scanner. This approach enhances the overall user experience while maintaining a high level of security, aligning with the principles of inclusive design in financial technology. Developed with Android Studio, the application utilizes key libraries such as ML Kit for QR code scanning and AndroidX Biometric for fingerprint authentication. The solution employed a modular development strategy, allowing each component to be independently tested for reliability and performance. Extensive unit, integration, and functionality tests demonstrate that the application meets the necessary usability and security standards for financial technology designed for users with visual impairments. This project contributes to accessible digital finance by enabling the visually impaired to perform UPI transactions autonomously. Future work involves adding support for regional languages and integrating AI-based voice recognition for more intuitive command input.

Introduction

UPI revolutionized the Indian world of money in 2016. It became such a big deal for virtual things because payments are instantaneous, they're simple, and so many people use it. Billions of those transactions are made each month, all across cities and villages as well.

Nevertheless, many populations are kept out. People with visual impairment or vision-related issues find it extremely difficult to access mainstream UPI-based systems. The majority of the applications concentrate on visual effects, demanding interaction with busy interfaces and little buttons for crucial information. The situation poses immense obstacles, robs them of autonomy and secrecy, and inhibits their ability to access digital banking in safety. In India itself, over 63 million citizens are subject to vision impairment, signaling the urgency of consideration of their needs while ushering in universal financial inclusion.

Research shows a lot of UPI tools don't follow

basic rules for accessibility. Lack of adequate screen reader support, improper UI parts, and insufficient sound feedback. This hinders big plans like Digital India. If payment systems stay out of reach, it just keeps people on the edges, making them depend on others for basic money moves.

Modern assistive technologies from advanced voice controls and text-to-speech to navigational gestures are becoming more robust. Integrating these could make payment applications safer and easier for everyone. This paper focuses on enhancing the accessibility of UPI applications, bridging the gap between innovative financial technology ideas and inclusive designs.

Literature Review

The literature survey conducted encompasses a wide range of studies exploring the challenges, evaluations, and solutions for achieving mobile accessibility for visually impaired users, with a significant focus on modern digital services like mobile payment and banking applications. Several studies have concentrated on evaluating existing platforms and proposing novel systems that leverage technology to bridge the digital divide.

For instance, researchers Singh, Kumar, & Sharma (2021) [1] proposed a usability inspection of leading UPI applications for visually impaired users, identifying specific design and interaction barriers. Similarly, another study by Rajput (2020)

[2] suggested a paradigm for recognizing and addressing the accessibility challenges in mobile UPI applications specifically for screen-reader users, detailing difficulties encountered during transactions. By focusing on fundamental usability and screen-reader compatibility, these studies aimed to improve the overall functional access to digital finance.

Furthermore, the literature addresses the importance of designing inclusive systems and specialized tools. A systematic review of accessible payment solutions was presented in a study by Çelik (2021) [4]. This review explored the global landscape of assistive technologies in finance, providing necessary context for region-specific challenges. Additionally, a study focused on the development of inclusive platforms by Bhowmik, Verma, & Das (2022) [3] explored the necessity of accessible-by-design mobile payment applications for Divyangjan, contributing to the framework for proactive accessibility.

Moreover, researchers Al-Shammari & Naser (2023) [10] investigated the factors influencing inclusive mobile banking applications, highlighting the critical role of both accessibility and trust for visually impaired users. Another study [6] emphasized the significance of transaction assistance by proposing "Pay Voice," a system for Point of Sale (PoS) recognition for visually impaired people, a key physical interaction challenge.

Additionally, researchers have investigated the broader context of mobile accessibility, evaluation, and specialized data interaction. A study by Weiss et al. (2018) [7] provided a comprehensive survey of mobile computing for the visually impaired, establishing the foundational issues and future research directions in the field. This context is essential for understanding general mobile usage. Furthermore, a study by Bhagat et al. (2024) [5] focused on the accessibility evaluation of major assistive mobile applications available for the visually impaired, offering a practical assessment of current tools.

Another study [8] explored the highly specialized issue of making interactive charts accessible in Android applications, aiming to "unblind the charts." This work addresses the often- overlooked challenge of complex data consumption. Moreover, a study [9] focused on the use of interactive mobile applications for navigation assistance for blind users, which, while not financial, utilizes core human-computer interaction principles vital for designing accessible interfaces across all domains.

Lastly, researchers have addressed the ongoing challenge of making complex information digestible. A study [5] (re- mentioning Bhagat et al. for emphasis on evaluation) focused on the accessibility evaluation of available assistive applications. Furthermore, a study [10] (re-mentioning Al- Shammari & Naser) proposed a focus on inclusive mobile banking to enhance trust and accessibility. These evaluations and proposals collectively highlight the critical need for continuous assessment and refinement of existing technologies.

Overall, these studies collectively highlight the importance of user-centric evaluation and data-driven design in improving accessibility to essential digital services. By leveraging systematic reviews, usability inspections, and novel technical proposals, researchers aim to equip visually impaired users with the functional tools required to engage equally with mobile payment and banking systems, thereby promoting digital inclusion.

Problem statement

India's going all out to promote digital finance, with UPI all over the place. But, blind people are excluded from the mainstream payments apps. It

is not the fault of some imagined tech bug. This denies them financial independence, keeps them unprotected, and isolates them from daily social activities.

Most UPI apps build everything around what you see. Users flip through screens, pick from dropdowns, confirm with visual pop-ups. For someone who's blind, screen readers help a bit. But it's messy. Errors pop up all the time. Transactions fail or just don't finish. And authentication? Entering a PIN on screen is a nightmare. They end up needing someone with sight to help. That kills privacy. Security goes right out the window.

Assistive technology access is really limited as well. Screen readers only give limited information. They miss the overall picture of these convoluted finance configurations. No context is derived whatsoever. And non-visual feedback is little to none. No beeps through sound, no use of vibration, no touch feedback. Those don't exist. Users can't even be certain that the transaction even went through.

QR code scanning is huge in UPI. But blind users can't line up their phone visually. So, they have to type in UPI IDs or phone numbers by hand. It's slow. Not practical at all.

All that adds up to real problems. Financial exclusion hurts. They become dependent upon someone for every transaction. Password sharing is risky. Privacy is impaired. Economic participation diminishes through inaccessibility of payments. And the frustration builds from repeated technology failure. It takes its toll. We need voice-based alternative of UPI today. An easily accessible one. It must allow blind people to handle their finances by themselves. Make it inclusive. Make it secure. That is the future.

Audio Feedback and Guidance

A text-to-speech engine gives voice feedback right away for each part of the process. It covers things like confirming the transaction, saying the amount you entered, spelling out beneficiary details, and even those authentication prompts that pop up. Basically, this setup cuts down on mistakes a lot. It helps users feel sure about handling transactions on their own.

Proposed Approach

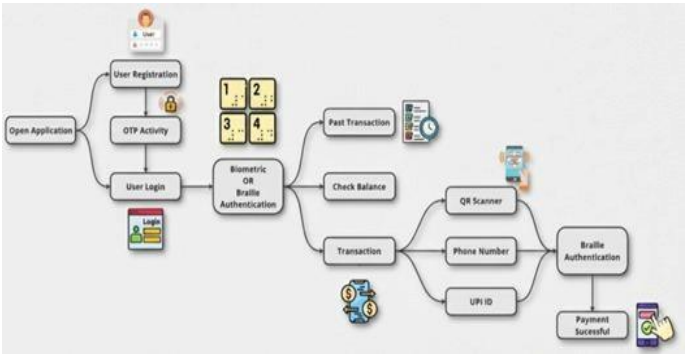

Fig 1: Flow of the proposed approach for UPI application

The proposed solution is a voice-based UPI application specifically designed for visually impaired users, focusing on accessibility, security, and usability. Unlike conventional UPI apps that rely heavily on visual navigation, this approach leverages speech recognition, text-to-speech (TTS), and gesture-based controls to enable seamless interaction without visual dependency.

The system architecture is built around five core modules:

1. Voice Command Interface

Users talk to the app like they're just chatting. They say stuff for entering phone numbers, or picking out how much money to send, or choosing who gets it. The speech recognition side of things uses Google Speech API or Vosk to handle all that voice stuff. It works pretty well, even when there's a bunch of noise around making it tricky. Basically, It picks up what you're saying without too many mix-ups.

Fig 2: Various types of authentication for UPI application

So instead of just punching in a PIN on those old numeric keypads, the app goes with this multi-modal authentication thing. It mixes it up a bit. Like voice-based PIN entry where prompts get randomized every time. That cuts down on eavesdropping risks. And then there's the optional biometrics too. Fingerprint or face recognition, whatever you pick. Adds that extra layer of security.

2. Accessible Payment Processing

The app has an audio-guided module for scanning QR payments. It uses vibrations or tones which helps line up the camera correctly, making it easier if you're not staring at the screen. Or, could go with NFC tap-to-pay instead. And then there's voice entry for UPI IDs too. No need to mess with visual codes at all.

3. Braille Keyboard Integration Module

To make things more accessible, Braille Keyboard Integration module was added. It handles secure text and PIN entry pretty well. Visually impaired users can input sensitive stuff using that tactile method. They do it confidently, without needing help from someone who can see. The system mixes Braille input right in with voice and gesture navigation. That way, it supports multi-modal interaction. It fits various user preferences and accessibility needs.

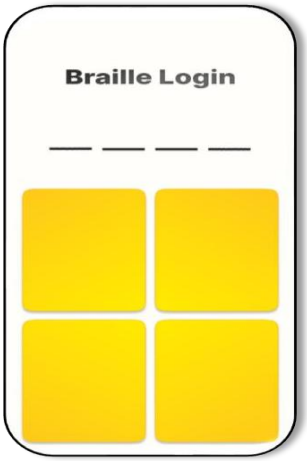

Fig 3: Braille Keypad

It cuts down on visual hassles. The backend runs on Node.js with REST APIs hooked up to the existing UPI setup for all that interoperability stuff. Using MS SQL to handle data securely, and JWT takes care of authentication to keep sessions safe.

This whole approach makes sure the app follows accessibility rules like WCAG 2.1 and RBI guidelines for digital banking. It lets visually impaired users join in on financial stuff independently, inclusively, and without security worries.

Excepted outcome

The proposed voice-based UPI app is expected to significantly improve the availability, ease of use, and independence of users with visual disabilities. Through the exchange of complicated visual interfaces with intuitive voice-based commands, gesture- based navigation, and real-time audio-based output, the app is purposed to ensure an accessible payment system under which those blind or of limited sight can transact successfully by themselves.

Major expected outcomes are:

1. Enhanced Accessibility

The citizens can use the entire UPI-based payment flow registrations, transfer of money, bill payments, and QR- based payments without visual dependency.

Screen-reader friendliness, complemented by internal audio queues, ensures that everything in the user interface is understandable.

2. Better Security & Privacy

Multi-modal authentication (voice PIN + biometrics) reduces the use of sighted assistance, protecting user confidentiality and securing the confidentiality of the transaction.

Secure voice-based input prevents the need to share PINs or credentials with others, minimizing fraud risks.

3. User Confidence and Independence

Customers with impairment of sight will not be reliant upon shopkeepers or relatives for making payments digitally.

Real-time audio confirmations of transaction details (amount, recipient, success/failure) provide assurance and reduce transaction errors.

4. Inclusion in Digital Economy

Making the UPI platforms directly accessible to blind users is fully in line with financial inclusion missions such as Digital India and Accessible India Campaign.

Greater usage can allow citizens with visual impairment to participate more actively in cashless activity, e-commerce, and government subsidies.

5. Scalability and Adaptability

The design of the system can be extended to various regional languages for wider coverage.

The architecture can be integrated with various banking and e-wallet platforms, hence developing a single access layer to all financial programs.

As a whole, the desired result is a secure, cheap, and accessible digital payment product that enables blind people to transact financially on

their own behalf, yet simultaneously establishes a standard for future accessible financial technology products.

Conclusion

The android application project turned out to be pretty valuable. It mixed up technical stuff with real social impact. Digital payments are exploding in India these days. But accessibility is still a huge issue for visually impaired folks. Our goal was to fix that. We built an Android UPI payment app that's secure and easy to use for people with visual disabilities.

The app connected UPI features to an MS SQL database. That made transactions reliable and data safely stored. Included voice support. Easier navigation as well. Larger buttons also helped. And screen readers worked fine with it. All of it made users more autonomous. Things came easily to people. Security received additional emphasis. Employed encryption and authentication to secure financial transfers.

During development, we acquired hands-on experience. Android Studio was the focal point. Java programming was involved. Integrating the database and API handling completed it. But it was not all tech. Inclusive design came through from the project. Team collaboration was important. Troubleshooting was as well. We addressed challenging areas such as accessibility edits and UPI configuration. That supported learning. It immersed us in real-world development work.

This android UPI app goes beyond tech fixes. It's a move toward financial inclusion. Visually impaired people can join the digital economy with confidence.

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