HS202 PROJECT REPORT

Smart Specs & Stick
For Visually Impaired

BY GROUP: 21

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DECLARATION

We hereby declare that the document titled **"Smart Spectacles and Smart Cane for Visually Impaired Individuals"**, which we have submitted, aims to address the challenges faced by visually impaired individuals in India. The project proposes affordable, AI-driven assistive technology solutions to enhance their mobility, independence, and social participation.

We affirm that the content of this report represents our original work, and appropriate references have been provided for ideas or words of others. We have made every effort to present our ideas in the clearest and most accessible manner possible. To the best of our knowledge, no incorrect information or sources have been used.

Therefore, we declare that our group has adhered to all principles of academic honesty and integrity.

ACKNOWLEDGEMENT

We would like to express our sincere gratitude to **Dr. Kamal Kumar Choudhary**, **Dr. Parwinder Singh**, and **Dr. Bhavesh Garg** for their exceptional guidance, support, and encouragement throughout this project. Their insights and feedback have greatly enhanced the quality of our work.

We would also like to extend our appreciation to **Ms. Divya Kumari**, our Teaching Assistant, for her consistent support, guidance, and helpful suggestions that were crucial in shaping our ideas and refining the project's direction.

INDIAN INSTITUTE OF TECHNOLOGY ROPAR

Project Report

Smart Devices for Visually Impaired Individuals

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Abstract—Millions of individuals in India are affected by visual impairment. While programs like ADIP and NPCBVI exist, meaningful support and inclusion often don't reach the blind individuals. This report explores key obstacles to assistive technology (AT) adoption, ranging from inefficient distribution systems and documentation barriers to high out-of-pocket costs and limited public awareness. In response, we propose 'Smart Spectacles': an affordable, AI-powered device designed for the Indian context. Equipped with features like real-time environmental sensing, SLAM-based navigation, and intuitive feedback, it aims to enhance mobility and independence. By addressing both technical and socio-economic challenges, this solution seeks integration with current aid systems to support broader inclusion of the visually impaired.

1. Definition of the problem

1.1. Problem Statement

This project aims to understand why visually challenged individuals in India continue to face barriers to independence and inclusion, despite existing assistive technologies and supportive policies. Inspired by the film Srikanth, which tells the story of visually impaired industrialist Srikanth Bolla and his fight for equal opportunity, the initiative proposes developing an interactive, affordable, scalable, and locally adaptable smart spectacle solution. This device would help India's 70 million visually impaired people—including about 5 million who are completely blind—navigate both public and home environments more safely and independently, thereby improving daily life and promoting autonomy

1.2. Methodology

In preparing this report, we focused on gathering information from trustworthy sources. This included official websites, published research papers, and online interviews. All the data mentioned in this project report is secondary data obtained from official websites and authentic sources. All sources have been cited wherever they are referenced.

1.3. Problem identification

1.3.1. Blindness in India

Mannava et al. [10] conducted a study assessing the financial burden of blindness in India, using certain economic assumptions. Their analysis estimated a substantial potential loss to the country's Gross National Income (GNI), reaching as high as INR 845 billion (approximately $38.4 billion). On a per-person basis, this equates to an average GNI reduction of about INR 170,624 (or $7,756) for each individual with blindness. The report also distinguishes the loss by age group, attributing INR 832 billion to adults and INR 13 billion to children.

1.3.2. The Government Handle

The government set up BIRAC as an autonomous body to support biotech startups focused on India-centric innovations. Similarly, the ADIP scheme aids visually impaired individuals by providing braille kits, adapted phones, low-vision aids, and mobility tools.

On the data front, the National Sample Survey (NSS) remains the

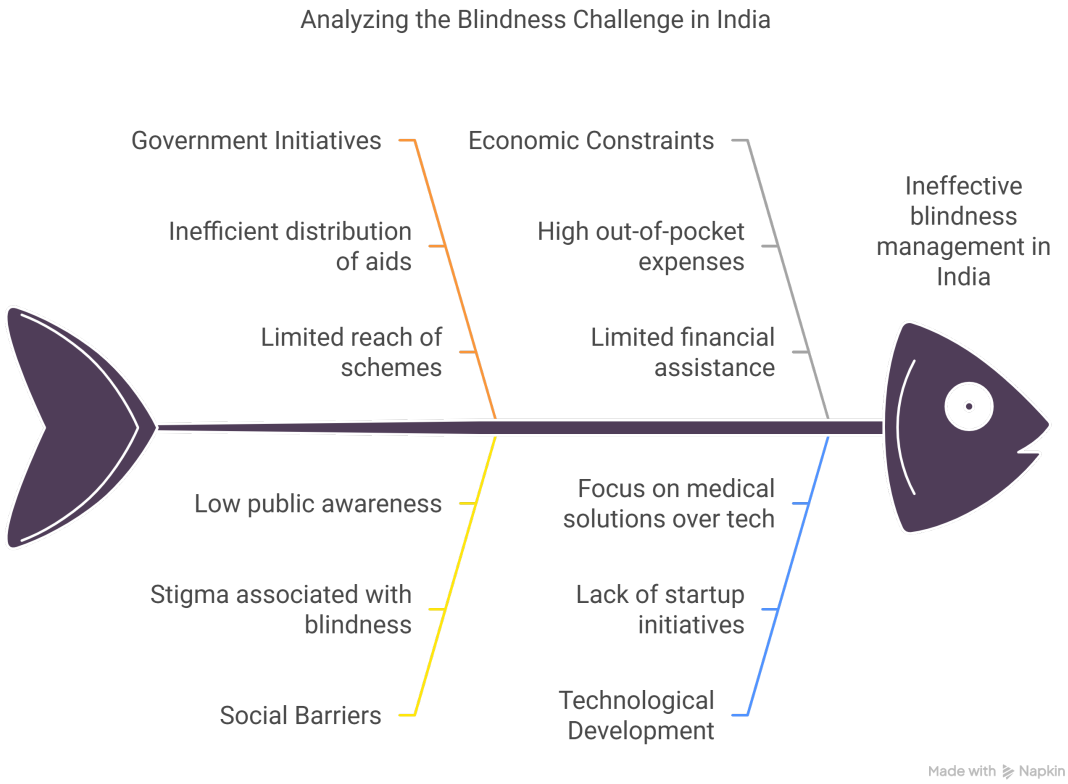

Figure 1. Fishbone diagram depicting the various barriers to ineffective implementation of measures for blind individuals.

main source of national-level insights into how persons with disabilities access assistive technologies (AT) and devices (AD). The 76th round, conducted in 2018, exposed several structural gaps contributing to this lack of accessibility. [11]:

- Eligibility for benefits under the ADIP program hinges on two key criteria: individuals must have a documented disability of 40% or more and report a monthly income under INR 30,000. However, securing the required certification remains a major barrier. Data from the National Sample Survey (NSS) shows that only 28.8% of people with disabilities possess this official documentation.
- Survey results indicated that less than a third (31.5%) of those identified as needing a specific aid were both recommended one and managed to acquire it. A disparity exists between urban (37.1% acquisition rate) and rural (29.8% acquisition rate) populations. Furthermore, approximately 14.3% of survey participants reported inability to acquire necessary devices, pointing primarily to affordability issues, unavailability, or other non-specified obstacles, as shown in Figure 2.

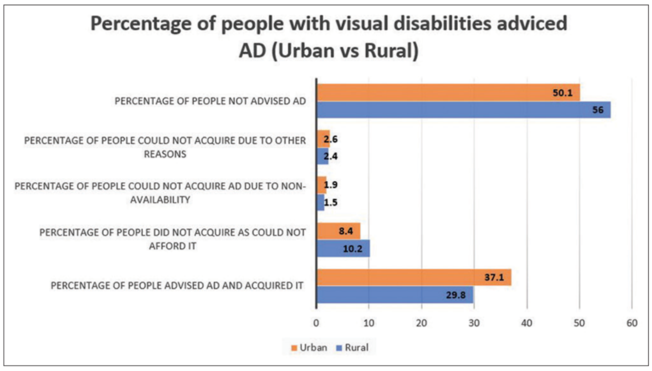

Figure 2. Percentage of people with visual disabilities advised AT/AD [11]

- According to Sivakumar *et al.* [6], vision-related assistive technologies often encounter barriers to adoption, primarily due to social stigma and limited public awareness of their advantages. These factors likely influence the infrequent recommendation of such devices, despite their potential to significantly improve users' quality of life.
- Most users, particularly in urban areas (91.4%), reported paying for these tools out-of-pocket. Rural users were slightly less likely to self-fund but still represented a large proportion (85.8%). In contrast, financial assistance from government or non-governmental organizations contributed only marginally to the purchase of these devices[11].

The above data, thus, highlights the gap between implemented government schemes and their impacts. However, a deeper analysis of the implemented government schemes should help in reasoning out the above gaps. Judging by the grants that government provide:

1 Under the collaborative initiative called the BIRAC–Social Alpha Quest for Assistive Technologies, 14 startups were awarded funding, with grants reaching up to INR 50 lakh per company. These ventures are dedicated to developing assistive solutions. Its 2024 annual report highlights that typical support per startup generally ranges from INR 30 lakh to INR 50 lakh.

2 As stated by Verma *et al.* [3], over INR 3,000 crore in funding has been allocated to blindness prevention programs, including those that cover cataract operations and corneal transplant procedures.

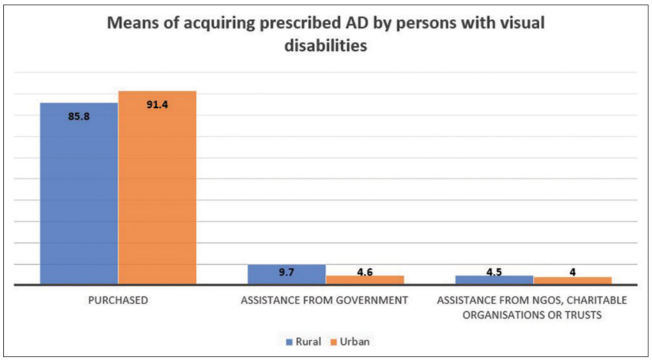

Figure 3. Means of acquiring AT/AD by persons with visual disabilities [11]

Overall, the data suggests that significant investment is being funneled into medical treatments for blindness, especially surgical interventions. While there's a growing movement to back startups focused on assistive technologies, the majority of disability-related funding still appears to prioritize clinical care. In contrast, financial support for tech-based assistive solutions remains relatively limited within the broader framework of disability assistance.

1.4. Current Developments in the Domain

1.4.1. Leading Products in the Market

Smart Glasses and AI-Powered Eyewear

1. Envision Glasses - AI-powered smart glasses that assist users by reading text aloud, recognizing faces, and identifying objects. Priced at approximately $3,500 for the professional edition, with read edition at $1,899 and home edition at $2,499 [15], [17].
2. Torchit Jyoti AI Smart Glasses - Made by Indian Startup Torchit, these glasses use cutting edge AI and computer vision techniques to help in object detection. Priced at around 20,000 rupees.
3. Ray-Ban Meta Smart Glasses - Developed in collaboration with Meta, these stylish glasses offer features like photo and video capture and integration with the "Be My Eyes" app. Starting at $299, they represent a more affordable option in the market[17].
4. Smart Vision Glasses - Another 'Make in India' product developed by OJAS Eye Hospital. Priced at around 45,000 rupees, these glasses have the additional feature of having support in regional languages in India.

Braille Devices and Readers

1. Annie - Developed by Thinkerbell Labs, an Indian Startup, it is the world's first self learning braille device.
2. Mantis Q40 QWERTY Keyboard and Braille Display - Hybrid device that combines a full QWERTY keyboard with a 40-cell refreshable Braille display[7].
3. Brailliant BI 40X Braille Display - Features 40 refreshable braille cells, Bluetooth and USB connectivity options, and supports multiple languages and braille codes[7].

Text-to-Speech and Reading Devices

1. LyriQ AI Assistive Text-to-Speech Reader - Transforms printed text into natural-sounding speech in real-time, with support for multiple languages and voices[7].

1.4.2. Availability of Assistive Technology: The Global Gap

What's Happening in Developed Countries?

In countries like the U.S., Australia, and across Europe, people with visual impairments have access to high-tech solutions:

- Smart glasses with AI, text-to-speech, and even augmented reality
- Strong government support through programs like:
  - NDIS in Australia
  - ATF in the U.S.
  - Collaborative initiatives across the EU

1.5. Need and significance of resolving the problem

1.5.1. India's Visual Impairment Landscape

According to the National Blindness and Visual Impairment Survey (2015–2019), India has actually made remarkable progress over the years.

- Blindness affects about 0.36% of the population
- Severe visual impairment: 0.35%
- Moderate visual impairment: 1.84%
- Early visual impairment: 2.92%

Now, when we apply these percentages to India's 2017 population, it translates to:

- Around 4.8 million people who are blind
- 4.7 million with severe impairment
- 24.5 million with moderate impairment
- And nearly 39 million with early visual issues

Even though there's been a huge reduction since the 2010 WHO estimates—like a 47% drop in blindness—the overall numbers are still very high. And this means there's a growing need for assistive technologies to support these individuals.

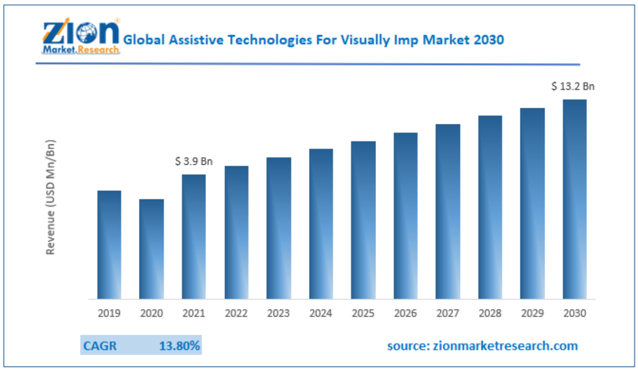

Figure 4. Global Market Overview and Growth Projections [13]

1.5.2. Significance

- **Promotes Inclusion:** Making environments and information accessible allows blind individuals to participate fully in education, work, and society.
- **Supports Well-being:** Reducing barriers helps prevent social isolation and improves mental health.
- **Economic Benefits:** Empowering blind people to work and contribute benefits the whole economy.
- **Fulfills Human Rights:** Ensuring accessibility is a basic human right and shows respect for everyone.
- **Encourages Innovation:** Solutions for the blind often lead to new technologies that help everyone.

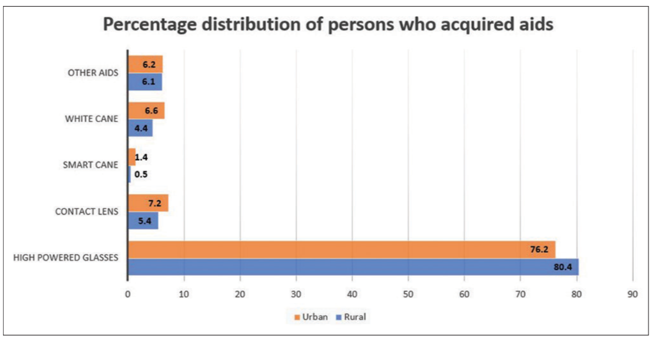

Figure 5. Distribution of people who acquired AT/AD [11]

2. Goals on minimizing the gap

Although assistive tools have progressed, individuals with blindness still grapple with substantial challenges to their independence, notably in orientation within physical spaces and perceiving their environment without sight.

While innovations like smart glasses and canes offer meaningful aid, many potential users still lack access. Notably, data referenced in Figure 5 shows that among those who do own assistive devices, smart glasses are the most commonly possessed.

Therefore, our solution aims to provide the following outcomes:

1 Help individuals gain assistance from government schemes. These government schemes would benefit individuals by providing them with funds to purchase assistive technology.
2 Provide cheap, affordable, and effective assistive device in the form of smart glasses optimized as per the Indian environment.

3. Tools and Techniques perceived to be effective

Most existing assistive technologies use basic sensors or vision-based detection, with few AI-powered smart glasses adapted to India's unpredictable road conditions and traffic chaos. The current tools have the following:

- **Ultrasonic Sensors:** These use ultrasonic frequency sound waves to detect nearby obstacles and are used in specs as well as sticks for blind people [12].
- **GPS Module:** Used for basic navigation from one point to another, but with not as much accuracy required for covered and congested ideas such as metros or markets [1].
- **Camera Sensor:** Useful for basic functions such as object detection.
- **Basic Vibration Motor and Audio Feedbacks:** These are used for alerting users of nearby objects but often lack context or directionality.

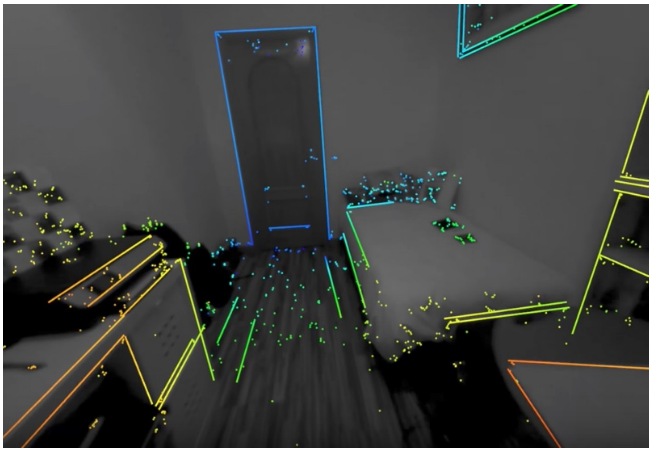

Figure 6. SLAM visualization developed by using a cheap camera sensor and an IMU.

Our proposed solution enhances this approach by the integration of more advanced and context-aware technologies:

- **Stereo Camera Modules:** Instead of using just one we can use two cameras (on each side of the specs) that can mimic human vision and estimate the 3d structure and depth of the environment [18].
- **SLAM (Simultaneous Localization and Mapping):** A technique used in autonomous systems, allowing real-time mapping and localization even in surroundings unfamiliar to us [4].
- **Edge AI Processing:** Lightweight tasks use neural networks that can run directly on microcontrollers, reducing cloud dependency and providing faster responses [8].

- **Microphone**: With microphone a user can interact, such as ask spec to read something or guide them somewhere, and along with that the user can control volume or give feedback to the specs which will help the model inside the specs to improve on its own as per their user requirements.
- **IMU Sensor**: To keep in check the movements done by the user, and we can have a location and motion of other objects concerning the user's reference.
- **Haptic motors:** Small vibration sensors near ear which vibrate by whose direction and intensity person can get an intuition on obstacle direction and rate of approaching or distance [9].
- **Smart Stick Add-on:** Equipped with its sensors, it detects terrain-based hazards like potholes, steps, or slopes, and sends vibration or audio alerts accordingly [5].

4. Detailed Work Plan

4.1. Technology Intervention

Our intervention adapts autonomous driving technologies like SLAM and navigation tools for smart specs to assist the visually impaired. Instead of controlling a vehicle, our system provides real-time audio and haptic feedback to guide users safely, much like how autonomous vehicles inform drivers about their surroundings and navigation decisions [2].

Most AI-powered smart glasses are developed abroad and lack training on Indian-specific data, making them less effective in local conditions. By collecting training data from Indian roads and observing how guides assist blind individuals with actions like stopping, turning, or climbing stairs, our system can better mimic the real-world instincts of human helpers and provide more relevant assistance. [16].

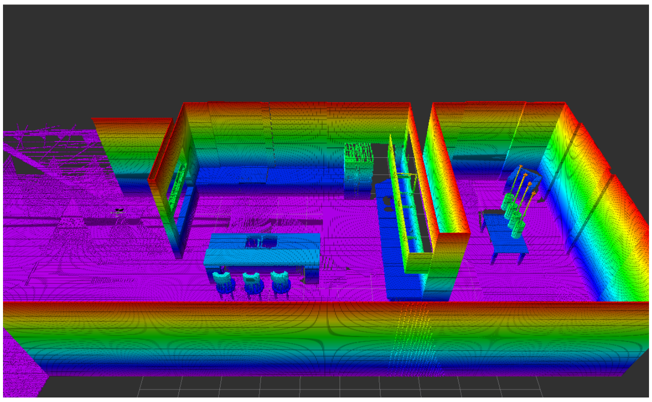

Figure 7. Map saved on micro controller[14].

We propose an indoor navigation system for blind users that uses IoT and AI-driven mapping. By capturing smartphone footage of the home, we generate a digital map, process it with edge detection and feature extraction, and upload it to smart specs.

Using SLAM and autonomous navigation, the glasses can:

- Detect the user's current position indoors.
- Guide users to rooms or objects with audio and haptic cues
- Warn about and update temporary obstacles like moved furniture

This system enables reliable, autonomous daily navigation in familiar spaces without needing constant cloud connectivity or live AI processing

4.2. Approximate Pricing for Prototype Development

The following is a rough estimation of the prototype costs for two assistive products: the Smart Specs and the Smart Stick. If components like PCBs are self-manufactured, the overall costs can be significantly reduced.

4.2.1. Smart Specs (Approx. Rs. 14,000)

- Microcontroller / Edge AI board (Raspberry Pi 4 / Jetson Nano) – Rs. 6,000
- Stereo Camera Module (basic Arducam or 2x OV5647) – Rs. 3,000
- Microphone Module (MAX9814 or KY-038) – Rs. 250
- IMU Sensor (MPU6050) – Rs. 200
- Ultrasonic Sensor (HC-SR04) – Rs. 250
- Haptic Motors (2 units) – Rs. 600
- Audio Output (small speaker or bone conduction) – Rs. 1,200
- Battery + Charging Circuit – Rs. 1,000
- Mounting Frame / Casing (3D printed or lightweight) – Rs. 1,500

4.2.2. Smart Stick (Approx. Rs. 3,800)

- Microcontroller (ESP32 / Arduino Nano) – Rs. 400
- Ultrasonic Sensors (2x for obstacle detection) – Rs. 300
- IR Sensor / Terrain Sensor (e.g., Sharp GP2Y0A21YK) – Rs. 600
- Vibration Motor (haptic feedback in handle) – Rs. 300
- Audio Feedback Module (buzzer or small speaker) – Rs. 400
- Battery + Charging Module (Li-ion + TP4056) – Rs. 800
- Stick Body + Grip + Mounting (PVC + handle build) – Rs. 1,000

Total Estimated Cost: Rs. 18,000 (for both Smart Specs and Smart Stick, upper-bound estimation)

4.3. Government Intervention

As highlighted in Section 1, several government initiatives can be leveraged to promote assistive technology adoption:

1 Assist individuals in obtaining disability certificates to access government benefits.
2 Support beneficiaries in availing financial aid under the ADIP scheme.
3 Seek funding from disability-focused startup programs like Attvaran and EMPOWER.
4 Collaborate with NAB to fund and distribute devices through government-linked NGOs.

Engaging with networks like the Blind People's Association, Vision-Aid, and national programs such as NPCBVI will enable effective deployment, training, and integration into public health strategies, boosting accessibility and user independence.

5. Novelty

5.1. Technology

Our smart-specs-stick solution features AI tailored to the Indian environment, addressing gaps in international assistive wearables. It uses two cameras for 3D depth perception, mimicking human vision, and incorporates autonomous technologies from self-driving cars. The device also offers an IoT-based indoor mapping feature, allowing caretakers to record and store a home walkthrough for quick, user-friendly navigation.

In addition to technology, we leverage government schemes to make our solution affordable for those in need. We help blind individuals obtain disability certificates to access benefits and provide them with assistive technology to improve their lives.

5.2. Sustainability

We will use a modular design, making each component—such as the camera, battery, sensors, and frame—individually replaceable. If a part fails or becomes outdated, it can be swapped out without replacing the entire device, reducing electronic waste and supporting long-term usability. Caretakers will be able to repair the device themselves using provided guides.

This approach lowers user costs and supports environmental sustainability by minimizing full replacements and using recyclable or biodegradable materials where possible in the casing and supporting parts

6. Approaches to Implementation

Taking inspiration from Indian innovators like SHG Technologies and Vision-Aid, we're designing smart spectacles that cost less than Rs. 25,000—making them far more affordable than imported options and within reach for many more people. Powered by AI, machine learning, and computer vision, these glasses will help users navigate obstacles, recognize faces, and read both printed and handwritten text with ease. The device will also recognize Indian currency, enabling users to manage tasks independently. Real-time audio feedback will assist in navigation, object recognition, and reading, while an emergency button will notify family members of the user's location and surroundings, especially useful in crowded public spaces. We aim to partner with NGOs and government bodies to distribute the devices and conduct training programs across rural and urban regions. The product will be lightweight, include Braille-coded keys, and support offline usage to suit areas with low internet access. Regular updates and user feedback will help us continuously improve the device.

7. Challenges in making and implementation of smart spectacles

7.1. Implementation and Support Barriers

7.1.1. Lack of Training and Technical Knowledge

A critical barrier to effective implementation is the lack of proper training for both users and support personnel:

- Teachers and support staff often lack the necessary training to help visually impaired individuals use these technologies effectively.
- Many educators don't receive adequate courses on assistive technology usage and implementation.
- Limited availability of technical support for troubleshooting and maintenance.
- Insufficient training resources for users to learn the full capabilities of the devices.

7.1.2. Integration with Educational and Work Environments

Smart glasses face challenges in seamlessly integrating into various environments:

- Difficulty in adapting classroom materials and activities to work with smart glasses.
- Workplace environments may not be configured to support the use of these technologies.
- Online learning platforms often lack proper accessibility features for smart glass integration.
- Limited job-oriented applications designed specifically for smart glasses.

7.2. Social and Practical Barriers

7.2.1. User Adoption and Attitudes

User attitudes and behaviors can significantly impact the adoption of smart glasses.

- Some visually impaired individuals show resistance to learning new technologies.
- Concerns about appearance and social stigma associated with wearing distinctive assistive devices.
- Preference for familiar aids like white canes or guide dogs.

The development of smart glasses for the blind represents a promising frontier in assistive technology, but overcoming these various constraints requires coordinated efforts across technical development, economic policy, education, and social support systems.

8. Student Expertise

1. **Aman Mittal** : Proficient in computer hardware and embedded programming. Will play a major role in the planning of making the devices.
2. **Devansh Arora**: Understands the working and implementation of AI in real-world scenarios. Part of ongoing research on computer vision-based tasks.
3. **Abhay Singh**: Is well versed in market research and trend analysis. Understands the ongoing market demands and developments.
4. **Hritik Agarwal**: Has understanding of software techniques and algorithmic solutions. Commands the development of special software based features for the spectacles.

9. Expected Outcome

Smart spectacles with AI and sensors help blind individuals navigate safely in crowded or unfamiliar Indian environments.

- **Key features:** Obstacle detection, object/facial recognition, and navigation assistance—important for inconsistent Indian infrastructure.
- **Multilingual support:** Devices can read printed/handwritten text in major Indian languages (Hindi, Tamil, Telugu, Malayalam, Kannada, Marathi, Gujarati).
- **Educational and professional aid:** Enables independent study and access to documents, improving opportunities.
- **Accident prevention:** Real-time alerts reduce risks—over 88% of blind people in India have faced accidents.
- **Daily assistance:** Helps with shopping, reading signs, using public transport, and more via audio cues and directions.
- **Promotes inclusion:** Supports independent travel, digital access, and participation in education, work, and community.
- **Supports national initiatives:** Aligns with Digital India and Accessible India Campaign goals.
- **Local innovation:** Indian startups focus on affordability and local language support; collaborations help distribute devices in rural areas.
- **Improves quality of life:** Boosts independence, self-esteem, and reduces social isolation for blind individuals and their families.

10. Suggested Utilization

The process starts by helping users access government schemes for financial support to invest in AT/ADs, if eligible. With this assistance, the user can purchase our product. Once the product arrives, a manual is provided for the caretaker to understand its operation. For any questions, they can reach out to our customer care team. The caretaker records details about the house in the specs, and once set up, the user simply wears the specs and states their destination. The specs then guide the user, learning from their feedback to improve the experience. Additionally, the stick's sensors detect hazards like slippery surfaces or stairs, alerting the user with haptic or audio feedback, helping them move around confidently and safely.

11. Conclusion

Our novel smart spectacles and cane offer an innovative, affordable, and user-friendly solution for blind and visually impaired people in India. With features like real-time object detection, multilingual text reading, facial recognition, and GPS navigation, these devices empower users to navigate daily life more safely and independently. By supporting national inclusion efforts, our technology has the potential to significantly improve the quality of life for visually impaired individuals across the country.

12. Contributions

1. **Aman Mittal**: Worked on proposing novel technologies with reliable cost ranges. Analyzed sustainable solutions to the presented problem.
2. **Devansh Arora**: Researched on understanding the problems and solutions from the government's end. Also contributed to suggesting AI-based solutions.
3. **Abhay Singh**: Analyzed market trends and current status of available assistive technologies. Foresighted the possible outcomes of the product.
4. **Hritik Agarwal**: Made the framework for the implementation of the idea. Also, critically analyzed the ideas to find gaps in suggested strategies.

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