

BeaconCare



A technology-enhanced system that empowers independent hospital visits for visually impaired people.

Project Source

When investigating the adverse circumstances faced by visually impaired people, I came across their health status. Visually impaired individuals reported poor self-rated health and a higher number of hospital admissions. As I dug deeper into the sources, I realized a serious problem: visually impaired people in China are unable to visit hospitals independently. This inability prevents them from receiving proper treatment when necessary and is largely due to the complicated treatment process in Chinese hospitals.

How can the opportunity for independent hospital visits be offered to the visually impaired population?

My answer is technology. This highly advanced tool has been changing the world, and it should be used to help the vulnerable and shed light on problems that were previously overlooked.

Project goals

Enable visually impaired users to independently complete the full care journey in China's Tier-3/Tier-2 hospitals:

registration → arrival → indoor navigation → consultation → payment → pharmacy/admission → exit → follow-up.
Integrate voice-guided indoor navigation + smart cane obstacle avoidance + hospital systems into a single, unified experience.

Literature → Requirements

Key findings (from the provided sources)

Core bottlenecks: scarcity of assistive devices and fragmented care pathways (data silos).

Abroad: mature HIS; self-service iterates on usability/ease-of-use to enhance patient experience.

Research cues: embed human factors; anticipate care difficulties in advance; use empirical evaluation of user capability and satisfaction for continuous improvement.

China: late start; weak top-level planning; poor interoperability; non-uniform smart guidance systems.

Three modes for blind patients: telemedicine, self-care (minor ailments), assisted care (in-person escort).

Survey signal: 53% have used self-service machines; 82% are willing to try self-service and want improvements (your data).

Derived requirements

MUST: Voice-first + haptics as backup; single-button + voice for key actions; offline core (cached maps, ID verification, SOS); bone-conduction compatible; one-tap access to a human agent. Integrate with HIS/LIS/PACS/queuing/insurance and payment systems; comply with real-name and security standards; unified guidance paradigm across hospitals/devices.

SHOULD: Explainable guidance (“why this route,” steps remaining, upcoming turns); mapless prompts (landmarks, step counts, auditory beacons). Human-factors calibration (height, stride, grip, assistive device) → personalized navigation and haptic patterns.

COULD: Context awareness (peaks, crowding, construction, elevator outages) with auto re-routing and slower pacing; multimodal redundancy (audio + haptics + physical markers).

Comparison between China and foreign countries

Dimensions	foreign	domestic	Implications for system design
Medical Informationization	Sound system and high interface standardization	Insufficient interconnection and many stovepipe systems	Adopting mid-table docking, designing pluggable adaptation layer and data cache
self service	Iteration focused on usability/ease of use	Different forms and inconsistent experiences	Unified interaction paradigm (voice vocabulary, vibration grammar, confirmation process)
Human Factors Engineering	Standards/guidelines are relatively mature	Insufficient methodological penetration	Introducing human factors and usability assessments (SUS/UMUX-Lite/NASA-TLX) throughout the entire process
Intelligent medical guidance	Combined with indoor positioning/situational awareness	Multiple dependent static terminals	Mobile terminal as the main terminal + terminal as the auxiliary terminal, dynamic traffic conditions and congestion prediction

Positioning and interface strategies of three medical treatment models

model	Applicable Scenarios	Capability Boundary	System Support
Telemedicine	Follow-up visits, chronic diseases, mild illnesses	No complex inspection	Online consultation, electronic prescription, drug logistics, follow-up reminder, emergency offline transfer
Self-service medical treatment	Self-diagnosis/medication/payment/order collection for minor illnesses	Limited devices and scenarios	Voice + single-key process, number collection → waiting → payment → medication collection link is opened
Assistance with medical treatment	First visit/multiple examinations/high risk	Requires human accompaniment	One-click agent intervention, volunteer/guide call, and path sharing with accompanying persons

Challenges → Solutions (Online + Offline, concise)

Challenge-solution mapping

Independent visits = high difficulty/anxiety → route preview + step-by-step guidance + mental load scoring with adaptive pacing.

Unclear condition / weak communication → “visit goal” cards (symptoms → department → notes) + in-waiting digital Q&A/reminders.

Many nodes / disordered info → workflow engine (state machine: registration → waiting → exams → payment → pharmacy → admission → discharge → follow-up) + single overview screen.

Overall approach: Online platform + Offline navigation

Online (pre-visit / cross-hospital)

Real-name account; insurance/payment binding.

Smart triage (voice Q&A → department suggestion, time estimate).

Booking, payments, test results, follow-up plans.

E-prescriptions & medication delivery.

Calm module: route preview, noise exposure alerts, stair density hints.

Offline (on-site / in-hospital)

Positioning & guidance: multi-source (BLE beacons/UWB/visual landmarks/tactile QR); mapless prompts (steps + direction + landmarks).

Assistive gear: smart cane (obstacle/stairs/door/elevator alerts), bone-conduction headset, phone app (offline pack).

Access & ticketing: NFC/QR touchless; unified ticket/result pickup; queue sync to personal device.

Fallbacks: auto re-routing for closures/elevator outages; one-tap human/volunteer assistance.

End-to-end user journey (engineered to match your flow)

At home (online)

Login / Onboarding: Name + ID/ Passport + phone (first-time real-name verification) → create an electronic patient record; optional link to e-medical insurance.

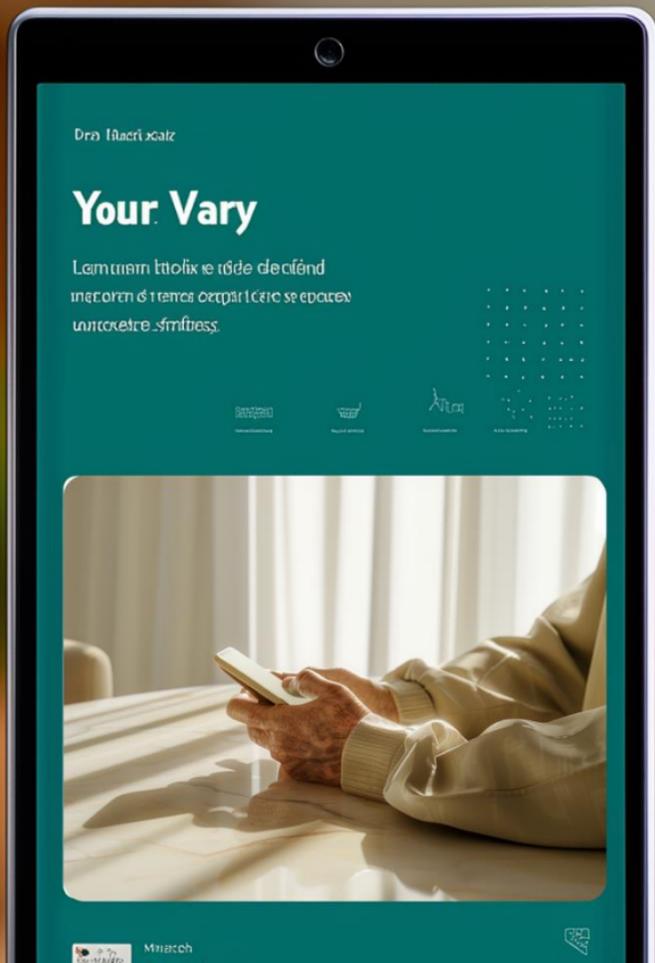
Choose appointment type:

By department (Internal Medicine / Surgery / Specialty), or

Symptom triage (voice Q&A → smart routing).

Need help: In-app hotline or voice call to an agent.

After booking: Voice + haptic confirmation; pre-download arrival route (entrance, security, elevators, clinic zone).



At the hospital (offline)

Entrance geofence & greeting: App auto-announces “Arrived at XX Hospital East Gate; walk 8 m to pick up the smart cane.”

Smart cane pickup: Cabinet lights up / voice indicates slot “12”; insert your own cane into an empty slot, then take the smart cane.

BLE auto-pairing: Cane pairs with phone and marks user “on-site.”

Navigation to clinic: Camera guidance + indoor positioning (UWB / BLE beacons / visual SLAM); app voice + cane haptics for direction.

Obstacle avoidance: IR / ultrasonic / micro-LiDAR sensing; handle haptics —continuous vibration for obstacle ahead at 1.5 m, short pulses for lateral alerts.

Dynamic risks: Crowds, carts, construction → real-time re-routing with voice prompts.

Waiting & calling: Auto check-in at the zone; sync with hospital queue/ number-calling system; voice alert and safe fast-track guidance when called.

Consultation & payment

Entering the room: Voice prompt “Arrived at Dr. XX’s office”; stop steadily.

Communication assist (opt-in):

Doctor’s side sees a “visually impaired” flag + tips. Patient may enable key-point recording/structured summary (per hospital policy and consent).

Orders & payment: Rx / lab / imaging sync to app; voice-guided insurance settlement + self-pay (WeChat / Alipay / UnionPay).

Pharmacy / tests / admission

Pharmacy: Voice navigation → queue → voice call → pickup confirmation; medicine bag supports large-print / voice labels.

Tests: Navigate to imaging/labs; queue integration + prep prompts (e.g., remove metal, lie down).

Admission (if needed): Navigate to admissions; bed assignment, ward route, door-plate voice confirmation.

Exit & follow-up

Leaving: Upon exiting, app asks to confirm checkout & cane return → cabinet pops your original cane slot → return the smart cane.

Follow-up & rehab: Receive 1–3 days of voice surveys (outcomes/adverse events/return visit needs); abnormalities auto-escalate to a human agent.

System Architecture (Product & Tech)

App & Mini Programs

Form factors: Native iOS/Android (full accessibility); WeChat/Alipay mini programs as lightweight entry points (booking, arrival alerts, payment, results).

Key capabilities: TTS/ASR (offline + online hybrid), voice wake, single-finger large-target gestures, haptic pattern library, camera guidance (OCR for room/elevator/department signage + directional arrows), offline map packs.

Accessibility: Dynamic type, high contrast, semantic labels, logical focus order, full screen-reader support (TalkBack/VoiceOver).

Cloud Backend

Services: User & visit records, booking & queuing, routing & positioning, smart cane device management, logs & alerts, content & voice-pack delivery.

Compliance: Domestic data centers, data minimization & tiered encryption, MLPS 2.0 / Tier-3 roadmap; sensitive data de-identification & audit trails.

API gateway: Bridges to hospital systems (see below).

Hospital Integrations

- Systems: HIS (registration/billing), LIS (labs), PACS (imaging), EMR (restricted/de-identified access), queue/number-calling, access gates/turnstiles.
- Interfaces: Hospital standards (HL7 v2 / FHIR pilots / in-house APIs); adapter layer to mask heterogeneity; message queues for async decoupling.

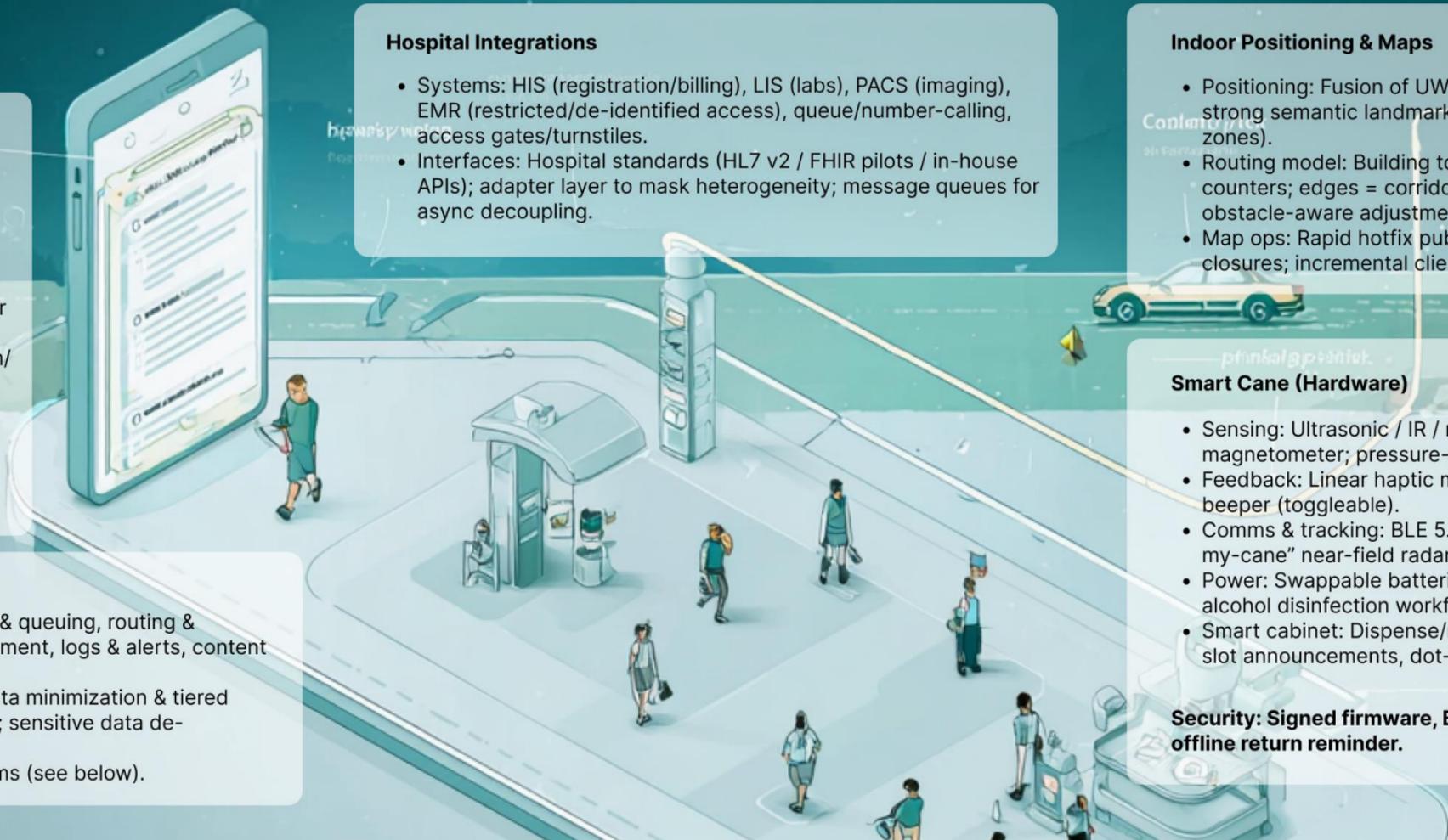
Indoor Positioning & Maps

- Positioning: Fusion of UWB + BLE beacons + visual odometry (VIO); strong semantic landmarks (elevators, escalators, restrooms, clinic zones).
- Routing model: Building topology graph (nodes = doors/elevators/counters; edges = corridors/passages); A* / Dijkstra with real-time obstacle-aware adjustments.
- Map ops: Rapid hotfix publishing for construction/temporary closures; incremental client updates.

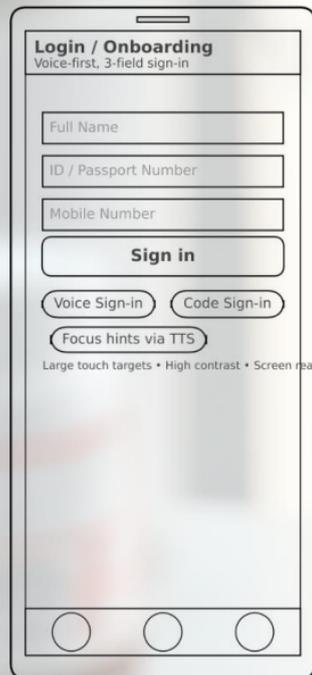
Smart Cane (Hardware)

- Sensing: Ultrasonic / IR / micro-LiDAR (triple redundancy); IMU/magnetometer; pressure-sensing tip.
- Feedback: Linear haptic motor (multi-spectrum patterns), small top beeper (toggleable).
- Comms & tracking: BLE 5.2; bidirectional heartbeat with app; "find-my-cane" near-field radar.
- Power: Swappable batteries / fast-charge dock; 8-12 h runtime; UV/alcohol disinfection workflow.
- Smart cabinet: Dispense/return, disinfection, asset tracking, voice slot announcements, dot-matrix/e-ink display.

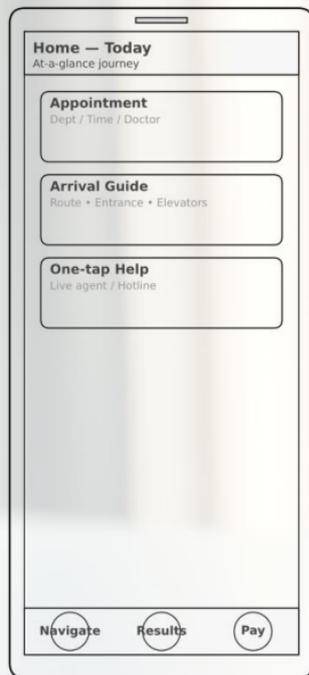
Security: Signed firmware, Bluetooth pairing allowlist, offline return reminder.



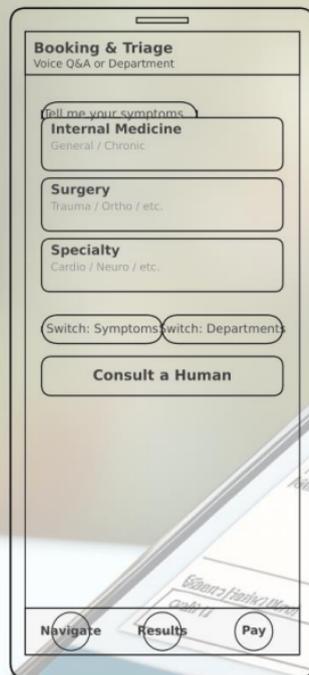
Key Screens (Mid-Fidelity Wireframes, concise)



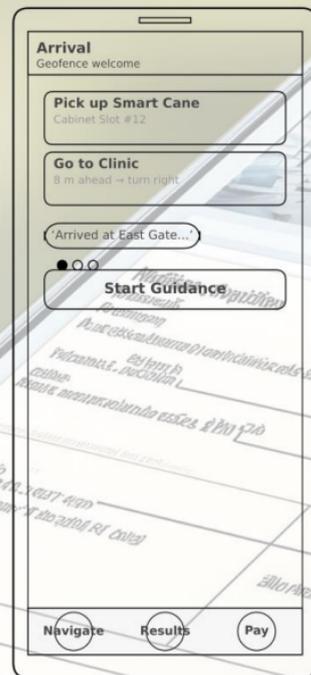
Login / Onboarding
Extra-large buttons; voice focus hints; only 3 fields; "Voice sign-in / Code sign-in."



Home (Today)
Cards for Appointment / Arrival Guide / One-tap Help; bottom bar with only 3 primary actions: Navigate · Results · Pay.



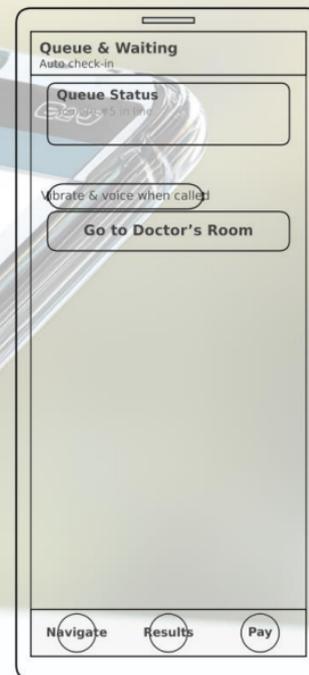
Booking & Triage
Voice Q&A selection; top toggle Departments / Symptoms; bottom Contact Human Agent.



Arrival Welcome
Auto popup on arrival; options Pick up Smart Cane → Go to Clinic; voice countdown with distance.



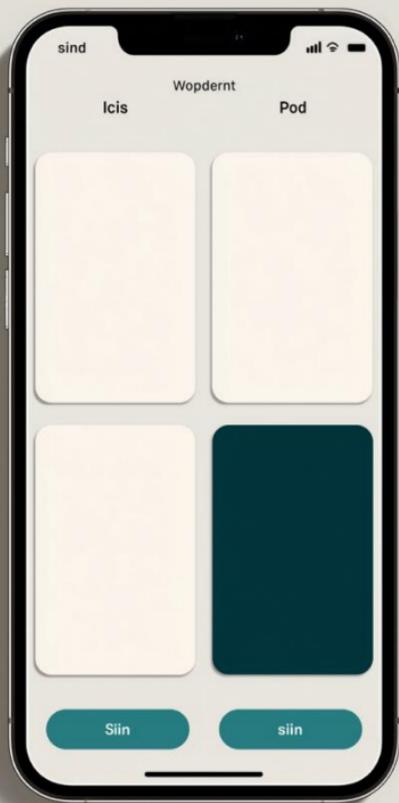
Indoor Navigation
Full-screen voice card; three states Forward / Turn / Arrive; large Pause / Help buttons.



Queue & Waiting
Shows current queue position; vibration + voice when called; Go to Doctor's Room one-tap navigation.



Payment & Settlement
Merged Insurance + Self-pay bill; Pay Now one-tap; failure → guided fallback.



APP Voice Assistance

Goals & Tone

Minimize cognitive load and maximize safety throughout the care journey.

Calm, clear, jargon-free; "action first, then context." All prompts are interruptible (barge-in).

Interaction Stack (on device first)

Wake (hotword/button) + VAD → ASR (offline hotwords + online fallback) → NLU/FSM (safety overrides) → TTS(local first) → playback & sync with haptics/earcons → safety channel (emergency stop).
Logs are event/intent only (privacy-preserving).

Prompt Style Rules

Short sentences (1-2 s). Relative direction + distance; confirm completion.

Three verbosity levels: Concise / Standard / Detailed (auto-concise during navigation).

Haptics & Earcons

Direction nudge = short pulse; Emergency obstacle = continuous strong; Arrival/Called = double tap.

Earcons: confirm = short "ding"; warn = low "thump"; listening = soft "beep." Stagger 150-250 ms before/after TTS.

Adaptive Controls

Speech rate/volume auto-adjust to ambient dB; user can say "faster/slower/repeat."

Distance in meters or steps. Dialect hotword packs; pinyin accepted. Night mode softens earcons.

Key Flows (examples)

Navigation: "Forward 6 meters, turn right." (short pulse) → "Arrived at Room 3, door 0.5 m on your right." (double tap)

Dynamic obstacle: "Person 1 meter ahead—please wait." (continuous strong) → "Path clear—continue."

Queue/call: "You're #5 in line." → "You're called—go to Room 3." (double tap)

Payment: "Total 126 CNY; insurance 98, self-pay 28. Proceed to pay?"

Performance Targets

Latency (command→speech): ≤ 500 ms local (≤ 1200 ms cloud fallback).

ASR intent accuracy: ≥ 97% quiet / ≥ 92% at 70-80 dB.

False wake ≤ 0.5/hour; missed wake ≤ 5%. TTS intelligibility ≥ 80/100 (subjective).

The Smart Cane

1. The smart cane is designed to be made mainly using aluminum tubing for the following reasons:
 - (1) Hollow tubes make it easy to run wires for the infrared sensor, haptic feedback system, and speaker.
 - (2) It is strong yet lightweight.
 - (3) It is easy to work with, as it can be cut, drilled, and mounted for electronics.
 - (4) It is cost-effective, affordable for both prototyping and scaling.
2. Among multiple cane designs, the T-shaped structure offers the best ergonomic support.
3. All smart canes are placed in racks along the hospital walls on both sides of the main entrance. When the patient arrives, the app instructs them to stop through voice assistance and announces a serial number (1-20) corresponding to a smart cane. Using the braille numbers at the top of the racks, the patient locates and retrieves the assigned smart cane, placing their own cane into the empty slot.

Inside the hospital, the smart cane provides warnings of obstacles. It incorporates an infrared sensor, a haptic feedback system, and a speaker:

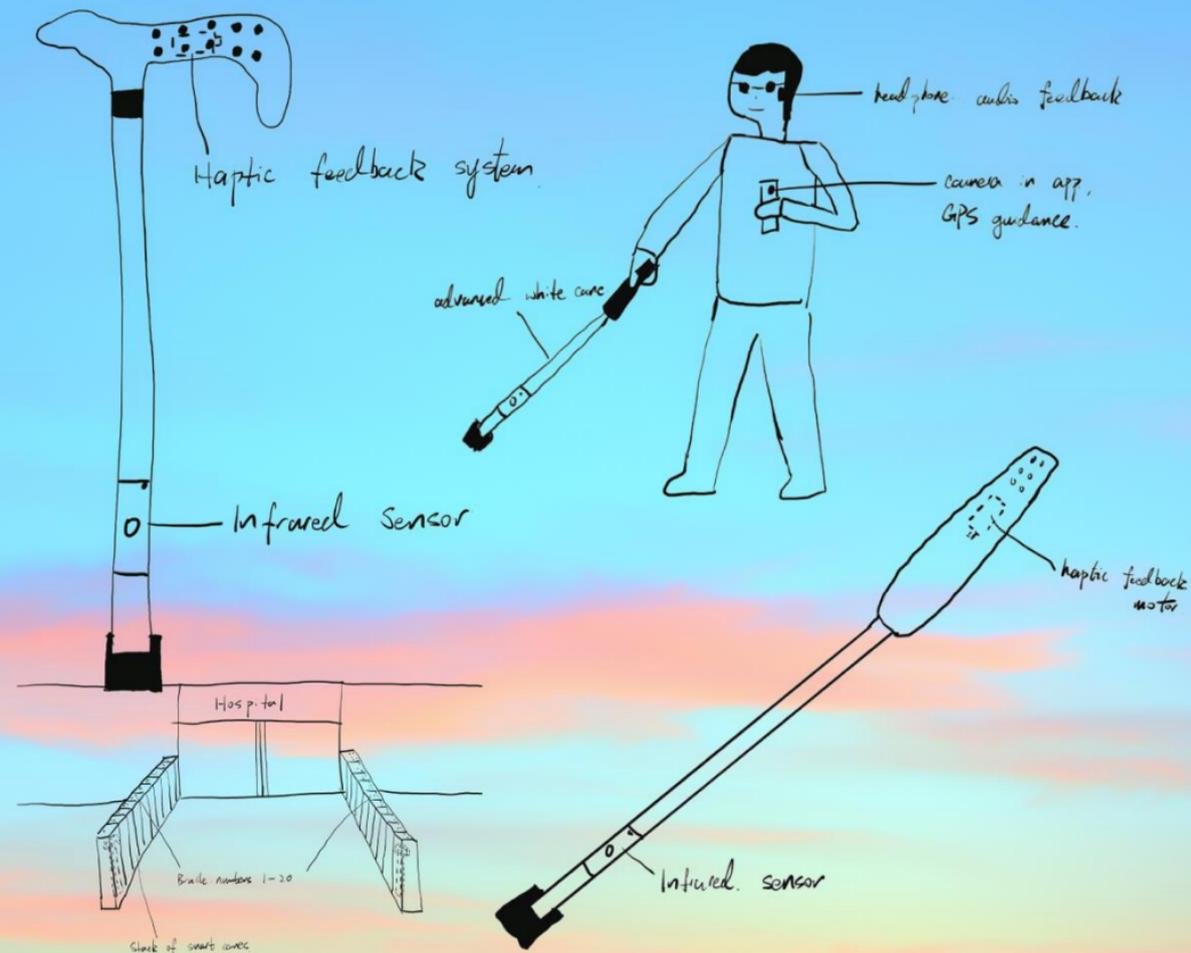
1. The infrared sensor detects any object within one meter and sends signals to the haptic feedback system, which then produces a vibration to prompt the patient to stop.
2. To alert others nearby, the infrared sensor will also activate the speaker on the smart cane. The speaker will announce "Be careful" to help prevent collisions with the visually impaired patient.

The smart cane works together with the app to guide the patient throughout the hospital.

When exiting, the patient confirms departure through the app's voice assistance. The assigned slot opens, allowing the patient to retrieve their personal cane and return the smart cane.

The traditional white cane is made of a long tube of aluminum, fiberglass, or carbon fiber with a handle on one end and a tip on the other. The handle may have a wrist loop or a small crook for storage. The body of the cane is covered with white/red paint or reflective tape for visibility. Some canes have a few inches of red at the tip to indicate the user has both vision and hearing loss. A white cane should be strong, durable, and lightweight to prevent fatigue and withstand normal wear and tear during travel, and its parts should be replaceable.

https://www.who.int/docs/default-source/assistive-technology-2/aps/vision/aps24-white-canes-oc-use.pdf?sfvrsn=5993e0dc_2



Future Work

My project grew out of dozens of conversations with visually impaired people in China, all of whom told me the same thing: going to the hospital alone is simply impossible. That insight pushed me to imagine a voice-first smartphone app and a network of “smart canes” that would allow them to register, navigate, consult, and pay without sighted assistance.

Next, I plan to:

Deepen the research.

Review HCI and assistive-tech literature on voice interaction, indoor positioning and ethical AI.

Study best-practice guidelines for accessibility, data privacy and human-subject protection.

Prototype the solution.

Build a minimal viable app with speech I/O and AI-based landmark recognition.

Integrate it with a sensor-rich cane that provides haptic feedback.

Pilot and iterate.

Conduct a small-scale trial with real users, measure task-completion, safety and satisfaction, then refine the design.

Scale responsibly.

Establish clear consent flows, data-minimization policies, and an open-source audit trail.

Empowering a community I have long cared about reminds me why technology exists in the first place: to serve people who need it most.

The End