

DESIGN FOR LIFE • COURSE PROJECT

EchoSense

Biomimetic Haptic Wearable

Feel your surroundings beyond sight and sound.

Submitted by

Aravind K T

Roll No. 240169 • B.Tech Electrical Engineering, IIT Kanpur

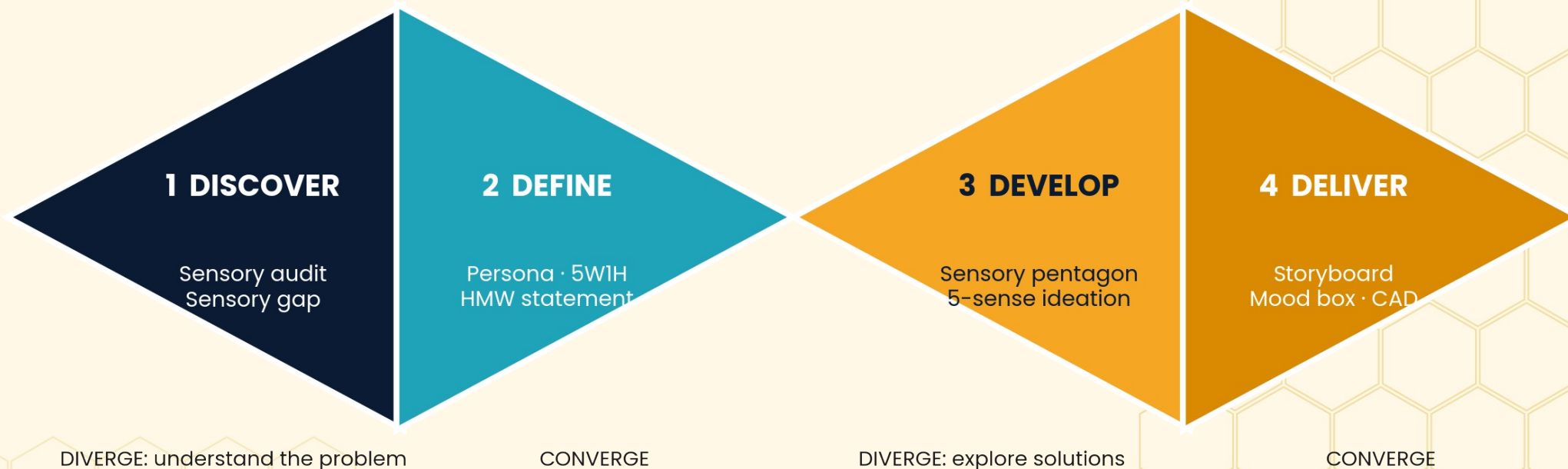
Presentation: 12 November 2026 (Thursday)



ROADMAP

The Design Journey

A double-diamond process: diverge to understand, converge to define, diverge to explore, converge to deliver.

**DISCOVER**

Sensory audit of a busy street, sensitivities and the Sensory Gap.

Slides 4 – 6

DEFINE

Persona, the 5W1H and the sensory problem statement + HMW.

Slides 7 – 8

DEVELOP

Sensory pentagon, five-sense ideation and the bat-inspired concept.

Slides 9 – 12

DELIVER

Storyboard, mood box, harmony test, CAD, live website.

Slides 13 – 20

IDENTIFY THE OPPORTUNITY

A Flawed Experience and an Unmet Need

2.2 billion

people worldwide live with a
near or distance vision
impairment

WHO, World Report on Vision (2019)

A flawed existing experience

- **Deprivation:** no preview of the path, signage, faces or traffic lights.
- **Overload:** hearing must track traffic, crowds and voice-navigation at once.
- **Friction:** a white cane senses the ground about one cane-length ahead and misses head-height hazards such as signboards, branches and vehicle mirrors.

An unmet need

- **Today's aids are audio or visual:** phone navigation speaks into the same ears already busy with traffic.
- **The skin is almost unused:** the body's largest sense organ is rarely a navigation channel.
- **The opportunity:** a silent, hands-free, always-on answer to “what is near me, and how near?”

Design brief: *turn the space around a visually impaired pedestrian into something they can feel, without taking over their eyes or ears.*

01 · DISCOVER

Empathy & Sensory Ethnography

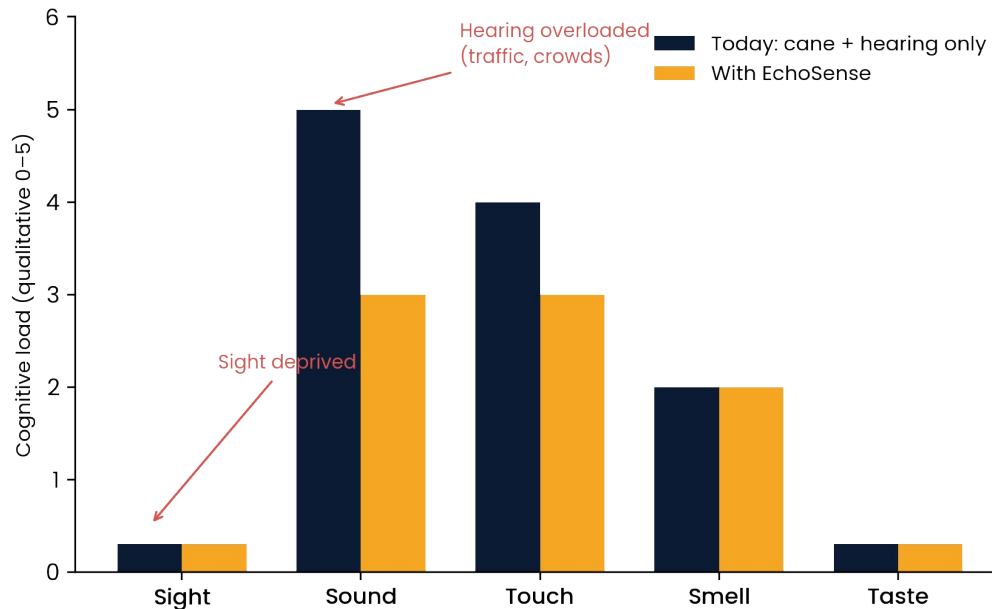
Sensory audit: a visually impaired pedestrian walking a busy urban street.

Sense	What the pedestrian experiences	Status
Sight	Absent or severely limited. No preview of the path ahead, signage, faces, kerbs or traffic lights.	DEPRIVED
Sound	A constant stream of horns, engines, footsteps, shop music and announcements, used to locate traffic and obstacles. Also needed for conversation and phone navigation.	OVERLOADED
Touch	Cane-tip vibration and surface texture, tactile paving, hands on rails, bumps from crowds. Reach is limited to ground level, about one cane-length.	HEAVILY USED, LIMITED REACH
Smell	Bakeries, exhaust, rain and flowers act as informal landmarks, helpful but unreliable.	SUPPORTING CUE
Taste	Effectively irrelevant while moving through a street.	NOT USED

01 · DISCOVER

Identifying the Sensory Gap

Which senses are being ignored, and which are overworked?



Qualitative audit rating (0-5), illustrative of the sensory audit on the previous slide.

The gap in one sentence

Nothing today carries **how far away an obstacle is** beyond cane reach without also occupying hearing.

- **Sight is removed** so the brain compensates by over-using hearing.
- **Hearing is double-booked** with traffic safety and navigation prompts.
- **Touch is narrow:** only a point (the cane tip), not a field.
- **Skin is a free channel:** forearm and wrist are sensitive, always available and silent.

Gap: a silent, wide-field sense of proximity.

01 · DISCOVER

Mapping Sensitivities

What drains energy, what comforts, and what that means for the design.

What drains energy

- Sudden horns and overlapping crowd noise
- Wind and rain masking useful sounds
- Voice prompts talking over street sounds
- Constant, unchanging vibration (the body tunes it out)
- Hot, rough or sticky materials on skin

What comforts

- Soft, breathable fabrics against the skin
- Smooth, rounded edges the hand can find
- Predictable patterns that repeat reliably
- Silence when nothing is wrong
- Gear that stays put on a moving arm

So the design must...

- Stay silent: no beeps or voice
- Use vibration that varies in rate and strength
- Rest at zero when the path is clear
- Use neoprene and rounded hex shapes
- Sit on the wrist or forearm, hands-free

Sensitivities are derived from the sensory audit and published accounts of urban navigation; they are to be confirmed through short interviews with visually impaired users.

02 · DEFINE · IDENTIFY THE OPPORTUNITY

Who, What, Where, When, Why & How

WHO

Persona: Asha, 27, a visually impaired postgraduate student who walks and takes public transport daily in a crowded Indian city. Independent, tech-comfortable, tired of relying on strangers.

WHAT

She cannot sense obstacles and their distance early enough. The cane reaches only the ground, a short way ahead, so she spends every step listening hard.

WHERE

Busy footpaths, crossings, bus stops and markets: noisy, uneven, unpredictable and shared with vehicles and hawkers.

WHEN

Every commute: at peak hours, at dusk and in rain, when sound is masked by traffic or weather.

WHY

Independence, safety and dignity. Fear of collisions reduces confidence and mobility, and constant listening is mentally exhausting.

HOW (today)

White cane, a sighted guide or kind strangers, memorised routes and voice-navigation apps, which compete with hearing.

02 · DEFINE

The Sensory Problem Statement

Written with the course formula, around human emotion and sensory interaction.

PROBLEM STATEMENT

Visually impaired urban pedestrians need a way to **detect obstacles and judge their distance early in crowded, noisy city streets**, but are held back by **sensory deprivation of sight and an overloaded sense of hearing** that is already busy tracking traffic.

HOW MIGHT WE...

translate the space around a visually impaired pedestrian into silent, intuitive touch cues **so that they can walk confidently and independently without relying on their eyes or ears?**

Persona

Visually impaired urban pedestrians

Goal

Detect obstacles and distance early

Context

Crowded, noisy city streets

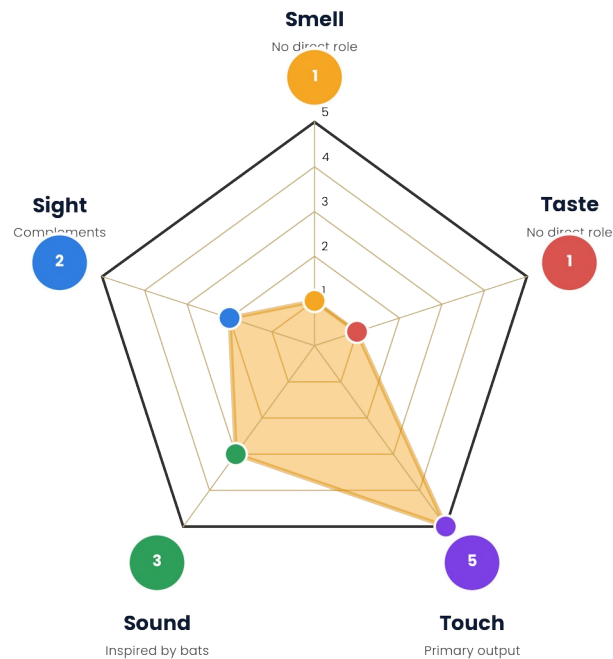
Friction

Sight deprived, hearing overloaded

03 · DEVELOP

The Sensory Pentagon: From Sight to Touch and Sound

EchoSense rebalances the senses. Touch becomes the primary channel.



TOUCH 5/5 *Primary output*

Distance becomes vibration on the skin of the wrist: gentle when far, urgent when near.

SOUND 3/5 *Inspired by bats*

Ultrasonic pulses (40 kHz) sense the space but are inaudible, so hearing stays free.

SIGHT 2/5 *Complements*

Not required. Users with partial vision may still combine it; a status LED reassures sighted bystanders.

SMELL 1/5 · TASTE 1/5 *No direct role*

Deliberately untouched, so natural smell cues remain clean landmarks.

03 · DEVELOP

Sensory Ideation & Brainstorming

The core idea run systematically through all five senses.



Sense	Sensory input / stimulus	Emotional / functional purpose
Touch	Vibration patterns on the wrist: pulse (far) to buzz (near).	Primary channel; turns distance into an intuitive felt proximity and builds confidence.
Sound	Silent 40 kHz ultrasonic pulses. No beeps.	Scans space invisibly; the user's hearing stays free for traffic and people.
Sight	Bypassed. Optional dim status LED only.	Never depends on vision; shows bystanders the device is on.
Smell	None; odour-neutral materials.	Keeps natural smell landmarks uncontaminated.
Taste	None; skin-safe, non-toxic materials.	Not applicable beyond safe, comfortable contact.

03 · DEVELOP

Biomimicry: From Echolocation to Haptics

Nature's solution to seeing without light, translated to the skin.



1 · NATURE

Bats emit ultrasonic calls and listen for echoes to navigate in darkness.



2 · SENSE

An ultrasonic sensor sends pulses and times the returning echo.



3 · TRANSLATE

Distance is converted into vibration patterns on the skin.



4 · FEEL

The user feels layout and proximity without eyes or ears.

The echo equation

$$d = (v \times t) / 2$$

$v \approx 343$ m/s (sound, 20 °C). An echo after 5.8 ms means an obstacle about 1 m away.

Second inspiration: *Apis mellifera*

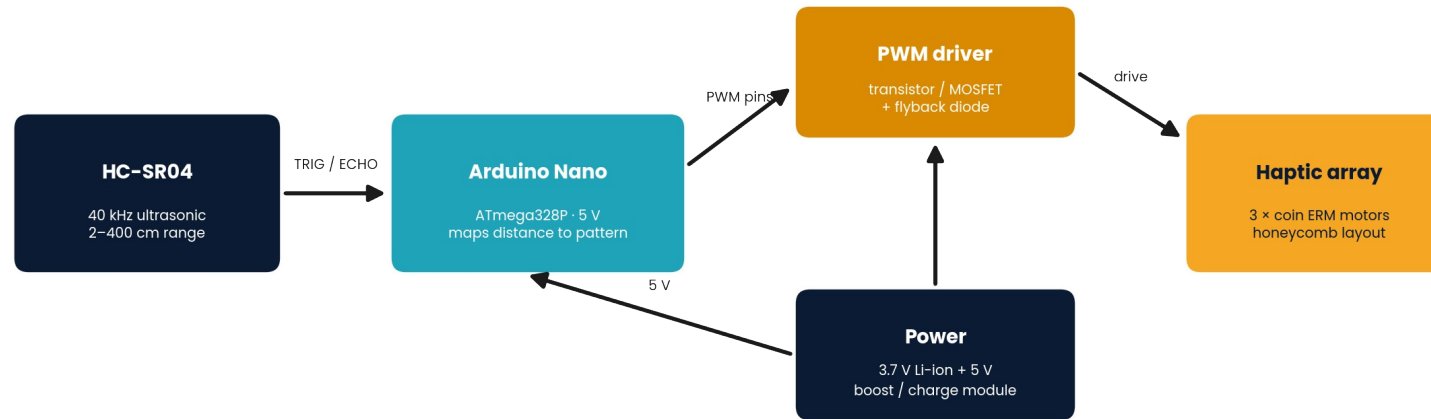
The honeybee's hexagon is the most space-efficient tiling. EchoSense borrows it for the shell texture and the honeycomb layout of its haptic motors, so cues stay distinct on a small patch of skin.

03 · DEVELOP

System Architecture (Conceptual)

Echo in, touch out: a small, low-cost, Arduino-based design.

Conceptual system architecture – echo in, touch out



Top view: forward-facing sensor and three honeycomb-arranged motors.

SENSE

HC-SR04 ultrasonic module: 40 kHz, 2–400 cm range, roughly 15° beam, 5 V.

THINK

Arduino Nano times the echo pulse, smooths readings and picks a vibration zone.

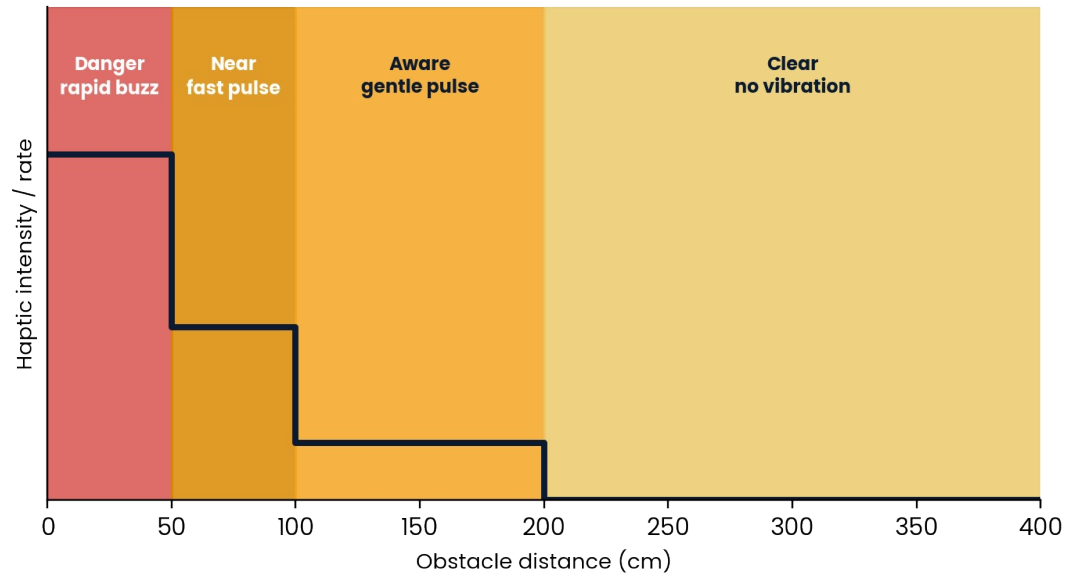
FEEL

Coin ERM motors driven by PWM through a transistor with a flyback diode; strength set by duty cycle.

04 • DELIVER

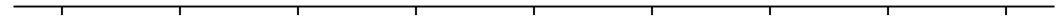
The Tactile Language

Distance zones map to distinct vibration patterns in both rate and intensity.



Closer obstacle, stronger and faster vibration.

1 Clear path – silence



2 Pole at 1.5 m – gentle pulse



3 Crowd at 0.8 m – faster pulse



4 Kerb/obstacle < 0.5 m – continuous buzz



time (s)

Illustrative vibration waveforms for the four storyboard stages.

Design rule: silence when clear, gentle pulse when aware, faster pulse when near, continuous buzz when urgent. Mappings are monotonic, so closer always feels stronger, and the rest-at-zero state prevents habituation.

04 · DELIVER

Sensory Storyboard: Four Steps in the City

What every sense experiences at each stage of the journey.

	1 · Walking, path clear	2 · Detect, pole at ~1.5 m	3 · Navigate, crowd at ~0.8 m	4 · Avoid, kerb at <0.5 m
Touch (primary)	Band is silent. Cane taps pavement texture.	One soft pulse per second, like a calm heartbeat.	Faster pulses, about three per second, ramping up as the gap closes.	Continuous rapid buzz: an unmistakable “stop”, then silence once the user turns away.
Sound	Traffic and footsteps. Ultrasonic scan is inaudible.	Unchanged; ears free for a horn.	Crowd noise unaffected; no beeps.	Unchanged; ears stay on traffic.
Sight	Not used.	Not used.	Not used.	Not used.
Smell / Taste	Bakery and exhaust remain natural landmarks.	Unchanged.	Unchanged.	Unchanged.
Emotion	Calm, aware	Alert, curious	Careful, in control	Safe, relieved

04 · DELIVER

The Mood Box: Prototyping the Experience

Low-fidelity physical swatches, a sound playlist and a live vibration demo for class.

Material swatch	Where used	Sense and purpose
Breathable neoprene (3 mm)	Wrist strap	Soft, flexible, skin-friendly; holds motors firmly.
Textured 3D-printed shell (PLA/PETG)	Casing	Honeycomb texture, findable by touch; rounded hex corners.
Thin silicone / fabric liner	Under motors	Spreads vibration evenly, avoids a sharp sting.
Hook-and-loop closure	Strap end	Adjustable fit found by feel in one move.

Sound & demo

- **Street playlist:** traffic, horns, footsteps, crowd chatter at moderate volume.
- **Silence track:** to show that ultrasonic sensing adds no sound.
- **Live demo:** coin motor + Arduino on a classmate's wrist, eyes closed, while a hand moves toward the sensor.
- **Scent:** none, deliberately.

04 · DELIVER

Test for Sensory Harmony

All inputs must tell the same story. Each risk of cognitive dissonance and how the design resolves it.

Check	The story the senses must tell	Dissonance risk	Design resolution
Sound ↔ Touch	Calm street, calm device	A beeping or buzzing device while the path is clear would feel alarming.	Silent ultrasonic sensing; band rests at zero when clear.
Touch ↔ Distance	Closer means stronger	A strong buzz for a far object feels wrong and erodes trust.	Monotonic mapping across four zones.
Material ↔ Function	Gentle guide, not a warning	A hard, sharp casing would feel hostile on the skin.	Neoprene strap, silicone liner, rounded hex shell.
Sight ↔ Touch	Quiet confidence	A bright flashing LED contradicts soft pulses.	Dim, steady status LED only.

Class trial protocol: with eyes closed, a participant feels five random distances and names each as clear, aware, near or danger. Target: at least 8 of 10 correct without training.

04 · DELIVER

Digital Twin: Concept, CAD & Build

Concept renders of the final EchoSense band: assembled, exploded, shell and strap.

EchoSense

Biomimetic Haptic Wearable

Feel Your Surroundings
Beyond Sight and Sound

Smell
(No direct role)
1/5

Taste
(No direct role)
1/5

Touch
(Primary output)
5/5

Sound
(Inspired by bats)
3/5

Sight
(Complements)
2/5

1. Nature's Inspiration

Bats use ultrasonic echolocation to navigate and detect obstacles in their environment.

2. Sensing the Surroundings

Ultrasonic sensors scan the environment and measure distance to objects.

3. Tactile Translation

Proximity data is converted into dynamic haptic vibrations on the skin.

4. Feel the Environment

User physically feels the layout and proximity of obstacles, without relying on eyes or ears.

Concept overview and sensory pentagon.

HAPTIC WRIST DEVICE

FEEL · INTERACT · EXPERIENCE

Advanced ultrasonic haptic technology designed for intuitive, discreet and immersive interaction.

- Ultrasonic Haptic Feedback (Non-contact, silent)
- Durable Polymer Shell (Showerproof, Scratch-resistant)
- Lightweight & Comfortable (All day wear)
- Sweat & Water Resistant (IP66)
- Long Battery Life (Up to 48 hours)

01 · ASSEMBLED Product sheet: views, materials, dimensions

WEARABLE HAPTIC DEVICE

EXPLODED VIEW

02 · EXPLODED Shell, HC-SR04, Nano, 3 motors, strap

03 · SHELL

Honeycomb texture, sensor cut-outs, swatches

04 · STRAP

Adjustable neoprene band worn on the wrist

FEEL · INTERACT · EXPERIENCE

More than a device. It's a feeling.

Advanced ultrasonic haptic technology designed for intuitive, discreet and immersive interaction.

- Ultrasonic Haptic Feedback (Non-contact, silent)
- Durable Polymer Shell (Showerproof, Scratch-resistant)
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04 · DELIVER

Live Website & GitHub Repository

A public GitHub Pages site acts as the digital portfolio for the design.



Scan to open the live site

kt2141.github.io/ EchoSense-Biomimetic-
Design

Repository: EchoSense-Biomimetic-Design

- **index.html:** dark-mode, amber honeycomb landing page (problem, biomimetic solution, renders, design process).
- **README.md:** overview, Sensory Gap problem statement, biomimetic inspiration, system architecture, digital twin.
- **firmware/:** Arduino Nano sketch in C++ mapping distance to PWM haptic patterns.
- **assets/ and cad/:** diagrams, Fusion 360 renders and prototype photos.

Designer portfolio: sites.google.com/view/aravind-k-t-iitk · github.com/kt2141

ABOUT THE DESIGNER

Aravind K T: Building on Prior Work

Electrical engineering foundations meet human-centred, socially driven design.

Aravind K T

Roll No. 240169

B.Tech, Electrical Engineering (2024–28)

Indian Institute of Technology Kanpur

aravindkt24@iitk.ac.in

sites.google.com/view/aravind-k-t-iitk

github.com/kt2141

Directly relevant work

- **H.A.W.K. (Aug–Nov 2025):** Arduino-based autonomous tracking robot using ultrasonic, IR and UV sensing with servo and DC motor control. The same sensing know-how now serves people.
- **BlueBridge Civic Nexus:** civic-tech model that turns citizen complaints into visible action, framed around SDG 11, 16 and 9.

Skills brought to EchoSense

- Embedded C and Python; circuit design
- Sensor integration and motor control
- Grassroots, user-first problem framing
- Policy and stakeholder communication
- SDG-driven impact thinking

IMPACT & NEXT STEPS

Why It Matters and What Comes Next

Aligned with the UN SDGs

- **SDG 3 • Good health & well-being:** safer, less stressful mobility.
- **SDG 9 • Industry, innovation & infrastructure:** low-cost assistive hardware.
- **SDG 10 • Reduced inequalities:** independence for people with visual impairment.
- **SDG 11 • Sustainable cities:** streets that work for every body.

Roadmap

- **Now:** concept, CAD digital twin and low-fidelity mood box.
- **Next:** working Arduino Nano prototype and bench-testing of the distance zones.
- **Then:** user testing with visually impaired participants; refine patterns and comfort.
- **Later:** multi-sensor sweep, head-height detection, waterproofing, rechargeable battery and cost reduction.

EchoSense lets people feel their surroundings, beyond sight and sound.

REFERENCES & CREDITS

References

- World Health Organization (2019). World report on vision. Geneva: WHO.
- Griffin, D. R. (1958). Listening in the Dark: The Acoustic Orientation of Bats and Men. Yale University Press.
- HC-SR04 ultrasonic ranging module datasheet (40 kHz, 2–400 cm).
- Arduino Nano (ATmega328P) technical documentation, arduino.cc.
- Autodesk Fusion 360 for CAD modelling and rendering of the digital twin.
- Design for Life: Course Project Process Guidelines (Discover, Define, Develop, Deliver).

Concept infographic and illustrative diagrams were created for this project. Sensory ratings are qualitative design judgements, not measurements.

Thank you

EchoSense

Feel your surroundings beyond sight and sound.



Aravind K T • Roll No. 240169 • IIT Kanpur

aravindkt24@iitk.ac.in • github.com/kt2141 • sites.google.com/view/aravind-k-t-iitk