STELLAR VISION V1 — USER MANUAL

Assistive Braille Input Device with AI Integration

Firmware Version: V3.2 – Use UserManual.Md file (Recomended)

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Device Overview

STELLAR VISION V1 is an assistive technology device designed for visually impaired users, featuring:

- **14-key Braille input system** via PCF8575 GPIO expander
- **6-dot Braille pattern recognition** with full character set
- **HID keyboard output** via DigiSpark (USB keyboard emulation)
- **AI integration** (Gemini AI for queries)
- **Notification system** via BLE (ChronosESP32)
- **Audio feedback system** with voice confirmations and mode announcements
- **SD card storage** for notes and files
- **OCR capabilities** (*B-DRIVE mode* for text extraction from images/PDFs)
- **Text-to-speech** for reading files aloud (300-character chunking)
- **One-hand gesture mode** via MPU6050 accelerometer
- **SOS Emergency Alert** via SMS (Twilio integration) with cooldown protection
- **OTA firmware updates** via WiFi
- **SD Upload Mode** with folder structure support
- **Audio Player** for WAV file playback
- **Alphabet audio feedback** for typed characters (toggle on/off)
- **Text auto-correction** system (15+ common typos)

- **Deep sleep mode** for power saving (30-second timeout)
- **Enhanced I2C/I2S conflict management** for stable operation

Button Layout

Input Keys (14 Total)

Pin	Function	Description
0–5	Braille Dots 1–6	Standard 6-dot Braille input
6	Ctrl Modifier	Toggle Ctrl key (for combos)
7	Backspace	Delete last character
8	Space (Left)	Space bar / Modifier / **SOS trigger (1.5s hold)**
9	Space (Right)	Space bar / Modifier / **SOS trigger (1.5s hold)**
10	Previous	Go back / Long press for gesture mode
14	Up	Navigate up in menus / **Long press (1s) toggles alphabet audio**
12	Select	Confirm / Enter mode
13	Down	Navigate down in menus

Getting Started

Initial Boot

1. Power on the device
2. Wait for initialization (vibration feedback)
3. Device enters **NORMAL MODE** by default
4. Serial output: *"Stellar Vision V1"*
5. Audio announcement plays

First-Time Setup

- **SD Card**: Insert before powering on for file storage
  - Create `/AudioFiles/` folder for audio player
  - Create `/Alphabets/` folder for letter pronunciation (optional: A.wav through Z.wav)
  - Create `/TACTI_VISION_WAV/` folder for system audio feedback
- **BLE Connection**: Pair with mobile device for notifications
- **HID Mode**: Connect DigiSpark for keyboard functionality
- **WiFi Configuration**: Update WiFi credentials in firmware for AI and OTA features
- **Twilio SMS**: Configure credentials for SOS emergency alerts

Power Management

- Device automatically enters **deep sleep** after **30 seconds** of inactivity (in applicable modes)
- **Power cycle device to wake** from deep sleep
- Deep sleep announcement plays before entering sleep mode

Operating Modes

1. NORMAL MODE

Entry: Device boots into this mode
Purpose: Idle state, ready to enter other modes

Actions:

- **Select (short press)** → Enter *PERKINS MODE*
- **Select (long press 1s)** → Open *MODE OPTIONS*

Power Management:

- Deep sleep enabled after 30 seconds of inactivity
- Power cycle to wake from deep sleep

2. PERKINS MODE

Entry: Short press SELECT from NORMAL MODE
Purpose: Braille typing with real-time HID keyboard output

Features:

- Type Braille patterns (dots 1–6)
- Characters appear on connected computer via HID
- **Space** → Add space character
- **Backspace** → Delete last character
- **Ctrl (toggle)** → Toggle Ctrl modifier on/off
- **Alphabet Audio** → Announces typed letters when enabled (toggle with UP long press)

Special Indicators

- **Pattern 60** (dots 3,4,5,6): Number mode indicator
- **Pattern 32** (dot 6): Capital mode indicator

Key Combinations

Combination	Function
Space + Backspace (hold 400ms)	Enter key
Space + Ctrl (hold 400ms)	Shift + Enter (newline)

Ctrl + Space (hold 400ms)	**Apply text correction**
Space LEFT or RIGHT (1.5s hold)	**Send SOS emergency SMS**
UP (long press 1s)	**Toggle alphabet audio feedback**
All 6 dots pressed	**Toggle alphabet audio (alternative)**

HID Keyboard:

- Automatically enabled when entering PERKINS MODE
- Requires DigiSpark connection
- Automatically disabled when leaving mode

Exit: Press PREVIOUS to return to MODE OPTIONS

3. MODE OPTIONS

Entry: Long press SELECT (1s) from any mode
Purpose: Navigate between device features

Available Modes:

1. NOTIFY
2. GEMINI AI
3. NOTE-MAKER
4. HID SHORTCUT
5. B-DRIVE
6. SD CARD
7. SD UPLOAD
8. SYSTEM UPDATE
9. AUDIO PLAYER

Navigation:

- **Up/Down:** Scroll through options (with audio announcements)
- **Select:** Choose highlighted option
- **Previous:** Return to PERKINS MODE

Deep Sleep: Disabled in this mode

4. NOTE-MAKER MODE

Entry: Select "NOTE-MAKER" from MODE OPTIONS
Purpose: Create and save text notes to SD card

Workflow

1. **Naming Phase**

    - Type desired filename (max 12 characters)
    - Double-tap SELECT (within 500ms) to confirm name
    - Double-tap SELECT again with no input for auto name (NOTE1.txt, NOTE2.txt…)
    - Names exceeding 12 characters will trigger error vibration
1. **Writing Phase**
    - Type note using Braille input
    - BACKSPACE → Correct errors
    - SPACE → Insert space
    - **Ctrl + Space (hold 400ms)** → Apply text correction
1. **Saving**
    - **Ctrl + Backspace (hold 400ms)** → Save and exit
    - Audio feedback confirms save
    - Returns to MODE OPTIONS

Exit: PREVIOUS before saving → Discard note and return to MODE OPTIONS

5. SD CARD MODE

Entry: Select "SD CARD" from MODE OPTIONS
Purpose: Browse and read files on SD card

Navigation:

- **Up/Down:** Navigate file list (sorted alphabetically)
- **Select:** Display file content (printed to serial)
- **Ctrl + Backspace (hold 400ms):** Text-to-speech (TTS) of current file

TTS Features:

- Reads files in **300-character chunks** for natural pacing
- Detects sentence boundaries (periods, exclamation marks, questions, newlines)
- Announces conversion process with audio feedback
- Automatic cleanup of temporary files
- Success/failure vibration feedback

File Compatibility:
`.txt` (UTF-8 text)

Power Management: Deep sleep is **disabled** in this mode

Exit: Press PREVIOUS

6. GEMINI AI MODE

Entry: Select "GEMINI AI" from MODE OPTIONS
Purpose: Query Google Gemini AI and save responses

Workflow

1. **WiFi Connection:** Device auto-connects on mode entry
2. **Query Phase:** Type your question in Braille
3. **Send Query:** Ctrl + Backspace (hold 400ms)
    - Audio announcement: "Sending Query"
    - Response received announcement
1. **Save Response:**
    - Press SELECT to start naming process
    - Type filename (max 12 chars)
    - Double-tap SELECT to confirm
    - Double-tap SELECT with no input for default name (GEMINI1.txt, GEMINI2.txt…)
1. **Complete Save:** Ctrl + Backspace to finalize

Audio Feedback:

- WiFi connection status
- Query sending confirmation
- Response received notification

Requirements:

- WiFi connection (auto-connects on mode entry)
- Internet access
- Pre-configured Gemini API key

Text Correction: Available during query typing (Ctrl + Space)

Exit: PREVIOUS → Returns to MODE OPTIONS

7. B-DRIVE MODE

Entry: Select "B-DRIVE" from MODE OPTIONS
Purpose: Extract text from images/PDFs via OCR

Setup

1. Device announces local web server IP (port 80)
2. Connect device to same WiFi network
3. Access via browser at `http://[IP_ADDRESS]`

Web Interface Features

- Modern, responsive design with gradient background
- Drag-and-drop file upload
- Upload progress indicator
- Real-time status updates
- Support for multiple file types

Supported Formats

- **Images:** JPG, PNG (via OCR.space API)
- **PDFs:** Text extraction (client-side JavaScript processing)

Workflow

1. Upload file via web interface (drag-and-drop or browse)
2. **For Images:**
    - Sent to OCR.space API for processing
    - Device vibrates when OCR complete
1. **For PDFs:**
    - JavaScript extracts text directly in browser
    - Text sent to device automatically
1. **Extracted text displayed** on serial output
2. **Save Process:**
    - Press SELECT to start naming
    - Type filename (max 12 chars)
    - Double-tap SELECT to confirm name
    - Press Ctrl + Backspace to save

Audio Feedback:

- Mode entry announcement
- OCR completion notification
- Save confirmation

Requirements:

- WiFi connection + OCR.space API key
- SD card for file storage

Power Management: Deep sleep is **disabled** in this mode

Exit: PREVIOUS (stops web server and returns to MODE OPTIONS)

8. HID SHORTCUT MODE

Entry: Select "HID SHORTCUT" from MODE OPTIONS
Purpose: Execute predefined keyboard shortcuts on connected computer

Available Shortcuts

Shortcut	Action	Audio File
WIFI	Open WiFi settings	WIFI.wav
CHROME	Launch Chrome browser	CHROME.wav
GMAIL	Open Gmail	GMAIL.wav
CHATGPT	Open ChatGPT	CHATGPT.wav
PY COMPILER	Open Python IDE	PY_COMPILER.wav
LIBRARY	Open Library app	LIBRARY.wav

Navigation:

- **Up/Down:** Browse shortcuts (with audio announcements)
- **Select:** Execute highlighted shortcut

Execution:

- Success: Audio confirmation + vibration (0.3s)
- Failure: Error vibration (0.1s)

Requirements:

- DigiSpark HID connected and initialized
- Compatible operating system (Windows/Mac/Linux)

Exit: PREVIOUS → Returns to MODE OPTIONS

9. NOTIFY MODE

Entry: Select "NOTIFY" from MODE OPTIONS
Purpose: Receive and log smartphone notifications via BLE

Activation:

- First SELECT → Turn ON (vibration feedback + "NOTIFY is ON")
- Second SELECT → Turn OFF (vibration feedback + "NOTIFY is OFF")

Features:

- BLE connection via ChronosESP32
- Logs notifications to `/NOTIFY.txt`

- Ring buffer (8 messages maximum)
- Processes notifications from background

Log Format:

```
App: [app_name] [timestamp]

Msg: [title] [message]

---------------------
```

Behavior:

- Notifications received only when NOTIFY is ON
- Old `/NOTIFY.txt` cleared on each boot
- Automatic connection callbacks for device pairing

Connection Feedback:

- Vibration on mobile connection/disconnection
- Serial output for connection status

Exit: SELECT again to toggle OFF, or PREVIOUS to return to MODE OPTIONS

10. SD UPLOAD MODE

Entry: Select "SD UPLOAD" from MODE OPTIONS
Purpose: Upload files and folders wirelessly to SD card

Features

- Web-based file upload interface (port 8080)
- **Full folder structure support** with drag-and-drop
- Multiple file upload capability
- Browse, download, and delete files
- Directory tree visualization
- Real-time progress indicators

Setup

1. Device announces IP address on port 8080
2. Access `http://[IP_ADDRESS]:8080` in browser
3. Modern purple gradient interface loads

File Management

- **Upload Files:** Drag-and-drop or click to browse

- **Upload Folders:** Maintains complete directory structure
- **View Files:** List with file sizes and types
- **Download:** Click download button on any file
- **Delete:** Remove files remotely with confirmation
- **Create Directories:** Automatically created when uploading folders

Upload Process

1. **Single Files:**
    - Select or drag files to upload area
    - Progress bar shows upload status
    - Success/error status displayed
1. **Folder Upload:**
    - Select entire folder (maintains structure)
    - Creates all subdirectories automatically
    - Uploads all files preserving paths
    - Progress indicator for batch upload

Audio Feedback:

- Mode entry announcement
- File upload completion sound
- Ready to receive notification

Requirements:

- WiFi connection
- SD card with sufficient space

Power Management: Deep sleep is **disabled** in this mode

Exit: PREVIOUS (stops server, returns to MODE OPTIONS)

11. SYSTEM UPDATE MODE

Entry: Select "SYSTEM UPDATE" from MODE OPTIONS
Purpose: Check for and install firmware updates via OTA (Over-The-Air)

Workflow

1. **Update Check:**
    - Device connects to GitHub repository
    - Compares current firmware (V3.2) with latest version
    - Audio announcement: "Firmware Check"
1. **No Update Available:**
    - Message: "You're running the latest version"

    - Audio: "Latest Version"
    - Returns to MODE OPTIONS after 2 seconds
1. **Update Available:**
    - Announces new version number
    - Audio: "Firmware Available"
    - Displays: "Press SELECT to update" or "Press PREVIOUS to skip"
    - **15-second timeout** for user confirmation
1. **Installation Process:**
    - Audio: "Downloading"
    - Progress indicators via vibration
    - ⚠ **CRITICAL: DO NOT POWER OFF** during update
    - Automatic verification of downloaded firmware
    - Success audio: "Update Success"
    - **Device reboots automatically** after successful update
1. **Update Cancellation:**
    - Press PREVIOUS before timeout
    - Returns to MODE OPTIONS

Safety Features:

- HTTPS secure download
- Firmware integrity verification
- Automatic rollback on failure
- Timeout protection

Update Source:

- Repository: `github.com/MAATHES-THILAK-K/Stellar_Vision_V1`
- Update info: `Firmware/latest.json`

Power Management: Deep sleep is **disabled** in this mode

Exit: PREVIOUS (cancels update and returns to MODE OPTIONS)

12. AUDIO PLAYER MODE

Entry: Select "AUDIO PLAYER" from MODE OPTIONS
Purpose: Play WAV audio files from SD card

Setup

- Place `.wav` files in `/AudioFiles/` folder on SD card
- Files automatically sorted alphabetically
- Recommended format: 22kHz 16-bit mono WAV

Controls

Button	Function	Behavior
UP	Previous track	Stops current playback, moves to previous file
DOWN	Next track	Stops current playback, moves to next file
SELECT	Play/Stop	Toggle playback of current track
PREVIOUS	Exit mode	Stops playback and returns to MODE OPTIONS

Playback Features

- Audio feedback for track changes
- File list announced on mode entry
- Current track displayed on serial output
- Smooth transitions between tracks
- Automatic cleanup after playback

File Management

- If `/AudioFiles/` folder doesn't exist, it's created automatically
- Supports standard WAV format
- No playlist saving (plays files in alphabetical order)

Requirements:

- SD card with `/AudioFiles/` folder
- WAV audio files (other formats not supported)

Audio Feedback:

- Mode entry: "Selected"
- Initialization: "Audio Init"
- Playback stopped: "Playback Stopped"

Power Management: Deep sleep is **disabled** in this mode

Exit: PREVIOUS (stops any active playback and returns to MODE OPTIONS)

Navigation Guide

Global Button Combinations

Combination	Function	Hold Duration
Ctrl + Backspace	Save / Send / TTS	400ms
Space + Backspace	Enter	400ms
Space + Ctrl	Shift + Enter	400ms

Ctrl + Space	**Apply text correction**	**400ms**
Space LEFT (hold)	**SOS Emergency SMS**	**1500ms**
Space RIGHT (hold)	**SOS Emergency SMS**	**1500ms**
SELECT (long press)	Open MODE OPTIONS	1000ms
PREVIOUS (long press)	Toggle ONE-HAND MODE	1000ms
UP (long press)	**Toggle alphabet audio**	**1000ms**
All 6 dots pressed	**Toggle alphabet audio**	**Instant**

Mode Transitions

```
NORMAL MODE

↓ (SELECT short press)

PERKINS MODE

↓ (SELECT long press 1s)

MODE OPTIONS

↓ (SELECT on option)

[Selected Mode]

↓ (PREVIOUS)

MODE OPTIONS

↓ (PREVIOUS)

PERKINS MODE
```

Deep Sleep Behavior

Modes with Deep Sleep Enabled (30s timeout):

- NORMAL MODE
- PERKINS MODE

Modes with Deep Sleep Disabled:

- MODE OPTIONS
- B-DRIVE MODE
- SD UPLOAD MODE
- SD NAVIGATION MODE
- SYSTEM UPDATE MODE
- AUDIO PLAYER MODE

- BOOT MODE

Advanced Features

ONE-HAND GESTURE MODE

Activation: Long press PREVIOUS (1000ms) from PERKINS, NORMAL, or MODE OPTIONS
Purpose: Control device via MPU6050 accelerometer tilts

Tilt Actions

Tilt Direction	Action	Debounce
Right	SELECT	450ms
Left	PREVIOUS	450ms
Up	UP navigation	450ms
Down	DOWN navigation	450ms

Calibration

Uses pre-configured offsets for accurate tilt detection:

- **Acceleration X:** 0.88
- **Acceleration Y:** -0.20
- **Acceleration Z:** -10.03
- **Tilt Threshold:** 3.0

Disable: Long press PREVIOUS again

Audio: "One Hand Mode" announcement on activation

SOS Emergency Alert System

Activation: Long press **either SPACE button** for **1.5 seconds**
Provider: Twilio SMS API

Features

- Sends emergency SMS to pre-configured number
- Includes device status and uptime
- **30-second cooldown** between alerts (prevents spam)
- Audio announcement: `/TACTI_VISION_WAV/SOS.wav`
- Works from any mode

SMS Content

```
SOS TRIGGERED FROM STELLAR VISION
```

```
STATUS: Emergency

DEVICE: TACTI-WAVE

UPTIME: [hours]h [minutes]m [seconds]s

⚠ IMMEDIATE ASSISTANCE REQUIRED
```

Behavior

1. **First Trigger:**
    - WiFi auto-connects if needed
    - SMS sent immediately
    - Success vibration (0.5s)
    - Cooldown timer starts
1. **During Cooldown:**
    - Shows remaining time (in seconds)
    - Error vibration (0.1s)
    - Message: "Cooldown active"
1. **After Cooldown:**
    - Full functionality restored
    - New SMS can be sent

Requirements:

- WiFi connection (auto-connects if needed)
- Twilio account credentials configured
- Valid phone numbers in international format

Troubleshooting:

- 401 Error: Invalid credentials (check SID/Token)
- 400 Error: Invalid phone number format
- 500+ Error: Twilio server issue (retry)

Text Auto-Correction System

Activation: Ctrl + Space (hold 400ms)
Purpose: Correct common typing mistakes automatically

Supported Corrections (15 Total)

Typo	Correction	Typo	Correction
teh	the	heelp	help
pleese	please	cal	call

tnanks	thanks	fone	phone
mesage	message	reed	read
adio	audio	braile	braille
scren	screen	voise	voice
setings	settings	batery	battery
emergncy	emergenc y		

How It Works

1. Scans `currentWord` for known typos
2. Identifies word boundaries (space, punctuation, newlines)
3. Replaces typos with correct spellings
4. Maintains capitalization and punctuation
5. Counts and reports corrections made

Available In:

- PERKINS MODE
- NOTE-MAKER MODE
- GEMINI AI MODE (query typing)
- B-DRIVE MODE (naming phase)
- GEMINI MODE (naming phase)

Feedback:

- Vibration (0.2s) on successful correction
- Audio announcement: "Autocorrection"
- Serial output shows original and corrected text
- Correction count displayed

Process:

```
Original Text:

"pleese cal me if you need heelp with the setings"


Corrected Text:

"please call me if you need help with the settings"


[CORRECTION] Made 4 correction(s)
```

Alphabet Audio Feedback

Toggle Methods:

1. Long press UP (1000ms)
2. Press all 6 Braille dots simultaneously

Audio Source: `/Alphabets/A.wav` through `/Alphabets/Z.wav`

Features

- Announces each letter as you type
- Works with both lowercase and uppercase
- **Disabled by default** (to save processing time)
- Available in all typing modes (PERKINS, NOTE-MAKER, GEMINI AI, B-DRIVE naming)
- Plays after character is typed

File Requirements

- 26 files named: A.wav, B.wav, C.wav... Z.wav
- Located in `/Alphabets/` folder
- Recommended format: 22kHz 16-bit mono WAV
- Short duration (0.5-1 second recommended)

Audio Announcements:

- Enable: "Alpha_enab.wav" + vibration (0.3s)
- Disable: "Alpha_disable.wav" + vibration (0.2s)

Behavior:

- Automatically converts lowercase to uppercase for file lookup
- Silent if file missing (no error)
- Only triggers for letters A-Z

Audio Feedback System

Hardware: MAX98357A I2S amplifier

System Features

- Mode entry notifications
- Action confirmations
- Gesture mode announcements
- Alphabet pronunciation (when enabled)
- Deep sleep announcement
- SOS alert sound

- Update process feedback

I2C/I2S Conflict Prevention

Problem: ESP32C6 I2C and I2S share resources
Solution:

1. **Pre-Audio Preparation:**
    - Temporarily disables HID keyboard
    - Allows pending I2C transactions to complete (50ms delay)
1. **Post-Audio Cleanup:**
    - Stops I2S output completely
    - Ends I2C bus (Wire.end())
    - Waits 150ms for hardware reset
1. **I2C Reinit:**
    - Restarts I2C at 100kHz for stability
    - Re-tests PCF8575 connection
    - Checks DigiSpark availability
    - Re-enables HID if available
1. **Device Recovery:**
    - Automatic DigiSpark reconnection (with retry)
    - Error handling for failed reconnections
    - Status reporting via serial output

I2C Configuration:

- **Bus Speed:** 100kHz (reduced from 400kHz for multi-device stability)
- **Timeout:** 500ms per transaction
- **Devices:** PCF8575 (0x20), DigiSpark (0x23), MPU6050 (0x68)

Text-to-Speech (TTS)

Trigger: Ctrl + Backspace (in SD CARD MODE)
Provider: VoiceRSS API

Features

- Reads text aloud in **300-character chunks**
- Detects sentence boundaries for natural pausing
- Natural US English voice
- 22kHz 16-bit mono WAV output
- Error handling with visual/haptic feedback

Chunking Logic

1. Divides file into 300-character segments

2. Finds last sentence-ending punctuation (. ! ? or newline)
3. If found in second half of chunk, breaks there for natural pacing
4. Otherwise, breaks at 300-character mark

Process

1. Audio: "Converting TTS"
2. Calculates total chunks needed
3. Processes each chunk:
    - Fetches TTS from VoiceRSS
    - Saves to `/TTS_temp.wav`
    - Plays audio immediately
    - Deletes temp file
    - 300ms pause between chunks
1. Final vibration feedback (success or error)

Success/Failure:

- All chunks successful: Vibration (0.25s)
- Some failures: Error vibration (0.15s)
- Serial output shows success/failure count

Format: Temporary WAV files (`/TTS_temp.wav`) auto-deleted

Deep Sleep Mode

Activation: Automatic after **30 seconds** of inactivity
Wakeup: Power cycle device

Sleep Process

1. **Audio Announcement:** "Deepsleep.wav" plays first
2. **Delay:** 1000ms for audio completion
3. **Pre-Sleep Vibration:** 0.5s haptic feedback
4. **Vibration Complete:** 600ms delay ensures motor stops
5. **Resource Cleanup:**
    - Stops B-DRIVE server (if active)
    - Stops SD UPLOAD server (if active)
    - Disconnects BLE notifications (if active)
    - Cleans up audio resources
1. **Motor Safeguard:**
    - Vibration motor set to LOW
    - Pin reconfigured to INPUT_PULLDOWN (prevents floating)
1. **Enter Sleep:** `esp_deep_sleep_start()`

Exempt Modes (Sleep Disabled)

- **B-DRIVE MODE** (web server active)
- **SD UPLOAD MODE** (file transfer active)
- **SD NAVIGATION MODE** (user browsing files)
- **SYSTEM UPDATE MODE** (OTA in progress)
- **AUDIO PLAYER MODE** (audio playback)
- **MODE OPTIONS** (user navigating)
- **BOOT MODE** (initialization)
- **NORMAL MODE** (ready state)

Activity Timer:

- Reset on any button press
- Reset on any Braille input
- Reset on mode change
- 30-second countdown in applicable modes

Power Saving: Reduces battery consumption by ~90% during idle periods

Important: No wakeup source configured - requires physical power cycle

OTA Firmware Update System

Update Source: GitHub repository
Current Version: V3.2
Update Check: Automatic when entering SYSTEM UPDATE MODE

Update Process

1. **Version Check:**
    - Fetches `latest.json` from GitHub
    - Compares with current V3.2
    - HTTPS secure connection
1. **User Confirmation:**
    - Displays new version number
    - 15-second timeout for decision
    - SELECT confirms, PREVIOUS cancels
1. **Download:**
    - Audio: "Downloading"
    - Fetches `.bin` file from GitHub
    - Progress monitoring
    - Size verification
1. **Installation:**
    - Writes to flash memory

    - Integrity verification
    - Error handling with automatic abort
1. **Completion:**
    - Audio: "Update Success"
    - Vibration feedback (0.8s)
    - Automatic reboot (2-second delay)

Safety Features

- **DO NOT POWER OFF** warning
- Secure HTTPS download only
- Firmware signature verification
- Automatic rollback on failure
- No partial updates (all-or-nothing)

Update Info File (latest.json):

```
{
  "latest_version": "V3.3",
  "url": "https://github.com/.../firmware_v3.3.bin"
}
```

Timeout Handling:

- 15 seconds to confirm update
- Auto-cancels if no response
- Returns to MODE OPTIONS

Braille Character Set

Letters (Lowercase Default)

Pattern	Dots	Char	Pattern	Dots	Char
1	1	a	5	1,3	k
3	1,2	b	7	1,2,3	l
9	1,4	c	13	1,3,4	m
25	1,4,5	d	29	1,3,4,5	n
17	1,5	e	21	1,3,5	o
11	1,2,4	f	15	1,2,3,4	p
27	1,2,4,5	g	31	1,2,3,4,5	q
19	1,2,5	h	23	1,2,3,5	r
10	2,4	i	14	2,3,4	s
26	2,4,5	j	30	2,3,4,5	t

37	1,3,6	u	39	1,2,3,6	v
58	2,4,5,6	w	45	1,3,4,6	x
61	1,3,4,5,6	y	53	1,3,5,6	z

Numbers (Preceded by Pattern 60)

Pattern	After [NUM]	Number
1	1	1
3	1,2	2
9	1,4	3
25	1,4,5	4
17	1,5	5
11	1,2,4	6
27	1,2,4,5	7
19	1,2,5	8
10	2,4	9
26	2,4,5	0

Punctuation

Pattern	Dots	Symbol	Pattern	Dots	Symbol
2	2	,	34	2,5,6	.
6	2,3	;	38	2,3,5	!
18	1,2,5	:	36	2,6	?
20	3,6	-	44	5	"
8	3	'	48	4,6	=
42	1,2,6	(	50	3,4,5	)

Mode Indicators:

- Pattern 60 (3,4,5,6): Activates number mode for next character
- Pattern 32 (6): Activates capital mode for next character

SD Card File System

Format: FAT32
Organization:

```
/
├── NOTE1.txt, NOTE2.txt, ...     → User notes from NOTE-MAKER
├── GEMINI1.txt, GEMINI2.txt, ... → AI responses from GEMINI AI
├── Bdrive1.txt, Bdrive2.txt, ... → OCR outputs from B-DRIVE
├── NOTIFY.txt                     → BLE notifications (cleared on boot)
├── TTS_temp.wav                   → Temporary TTS file (auto-deleted)
```

```
│
├── /TACTI_VISION_WAV/            → System audio feedback
│   ├── StellarVision.wav         → Boot announcement
│   ├── PERKINS_MODE.wav          → Mode entry sounds
│   ├── MODES.wav
│   ├── SAVED.wav
│   ├── SELECTED.wav
│   ├── PREVIOUS.wav
│   ├── ONE_HAND_MODE.wav
│   ├── SOS.wav                   → Emergency alert sound
│   ├── Deepsleep.wav             → Sleep announcement
│   ├── Alpha_enab.wav            → Alphabet audio enabled
│   ├── Alpha_disable.wav         → Alphabet audio disabled
│   ├── Autocorrection.wav        → Text correction sound
│   ├── OCR_Completed.wav         → B-DRIVE OCR done
│   ├── File_Upload.wav           → SD upload success
│   ├── converting_TTS.wav        → TTS conversion start
│   ├── hold_save.wav             → Save instruction
│   ├── hold_query.wav            → Gemini query instruction
│   ├── Sending_Query.wav         → Gemini sending
│   ├── response_received.wav     → Gemini response ready
│   ├── Connecting_wifi.wav       → WiFi connecting
│   ├── wificonnected.wav         → WiFi success
│   ├── Firmware_check.wav        → OTA check start
│   ├── firmware_available.wav    → Update available
│   ├── Downloading.wav           → Firmware download
│   ├── update_sucess.wav         → Update complete
│   ├── latestversion.wav         → Already up to date
```

```
│   ├── READY_TO_RECEIVE.wav      → SD upload ready
│   ├── Audio_Init.wav            → Audio player init
│   ├── playbackstopped.wav       → Audio stopped
│   └── [other system sounds]
│
├── /AudioFiles/                  → User audio files (AUDIO PLAYER)
│   ├── song1.wav
│   ├── podcast.wav
│   └── ...
│
├── /Alphabets/                   → Letter pronunciation (optional)
│   ├── A.wav
│   ├── B.wav
│   ├── ...
│   └── Z.wav
│
└── /[user-created-folders]/      → SD UPLOAD folder structure
    └── [nested directories]
```

Quick Reference Card

Mode Access

Action	Result	Hold Time
SELECT (short)	PERKINS MODE	< 1s
SELECT (long)	MODE OPTIONS	1s
PREVIOUS (long)	ONE-HAND MODE	1s
UP (long)	**Toggle Alphabet Audio**	**1s**

Common Actions

Function	Input	Hold Time

Type	Dots 1–6	-
Space	Pin 8 or 9	-
Delete	Pin 7	-
Enter	Space + Backspace	400ms
Shift + Enter	Space + Ctrl	400ms
Save/Send/TTS	Ctrl + Backspace	400ms
Correct Text	**Ctrl + Space**	**400ms**
SOS Alert	**Space (either)**	**1500ms**
Go Back	Pin 10	< 1s
Navigate	UP/DOWN	-
Confirm	SELECT	< 1s

Emergency Procedures

Situation	Action	Notes
Emergency	**Hold either Space 1.5s**	**30s cooldown between alerts**
Device Frozen	Power cycle	Wakes from deep sleep
Update Firmware	MODE OPTIONS → SYSTEM UPDATE	V3.2 → latest
Reset Audio	Power cycle	Reinits I2C/I2S

Technical Specifications

Hardware

Component	Specification	Address/Pin
MCU	ESP32C6 (dual-core, 160MHz)	-
GPIO Expander	PCF8575 (16-bit I/O)	I2C 0x20
HID Interface	DigiSpark ATtiny85	I2C 0x23
IMU	MPU6050 (6-axis)	I2C 0x68
BLE	ChronosESP32	Built-in
Audio	MAX98357A I2S amplifier	I2S
Storage	SD card (FAT32, SPI)	SPI
Power	5V USB / Battery	-
Vibration Motor	DC motor	GPIO 2

Pin Configuration

Function	GPIO Pin	Protocol
I2C SDA	0	I2C (100kHz)
I2C SCL	1	I2C (100kHz)
Vibration Motor	2	Digital Out

SD CS	5	SPI
I2S BCLK	12	I2S
I2S LRC (WS)	13	I2S
I2S DIN (SD)	15	I2S
SD MISO	21	SPI
SD MOSI	22	SPI
SD SCK	23	SPI

Software

Feature	Details
Firmware Version	**V3.2**
I2C Bus Speed	100kHz (multi-device stability)
I2C Timeout	500ms per transaction
Deep Sleep Timeout	30 seconds
Braille Input Delay	150ms character recognition
Button Debounce	50ms
Combo Hold Duration	400ms
Long Press Duration	1000ms
SOS Trigger Time	**1500ms**
SOS Cooldown	**30 seconds**
TTS Chunk Size	300 characters

Power Management

Mode	Deep Sleep	Timeout
NORMAL	Enabled	30s
PERKINS	Enabled	30s
MODE OPTIONS	Disabled	N/A
B-DRIVE	Disabled	N/A
SD UPLOAD	Disabled	N/A
SD NAVIGATION	Disabled	N/A
SYSTEM UPDATE	Disabled	N/A
AUDIO PLAYER	Disabled	N/A

Network Features

Service	Port	Protocol
B-DRIVE Web Server	80	HTTP
SD Upload Server	8080	HTTP
OTA Updates	443	HTTPS
Twilio SMS	443	HTTPS
VoiceRSS TTS	80/443	HTTP/HTTPS
OCR.space API	443	HTTPS
Gemini AI API	443	HTTPS

Troubleshooting

Device Issues

Device Not Responding

Symptoms: No vibration, no audio, buttons not working
Solutions:

1. Power cycle the device
2. Check battery/USB power connection
3. Verify SD card is properly inserted
4. Wait 30 seconds (may be in deep sleep)

HID Keyboard Not Working

Symptoms: Typing in PERKINS MODE doesn't appear on computer
Checks:

- DigiSpark connected? (check USB connection)
- Serial shows " DigiSpark found"? (if not, reconnect USB)
- Correct USB port? (try different port)
- Driver installed? (DigiSpark requires drivers on first use)

Fix:

1. Exit to MODE OPTIONS
2. Re-enter PERKINS MODE (reinitializes HID)
3. If still failing, power cycle device

Audio Not Playing

Symptoms: Silent operation, no mode announcements
Checks:

- SD card inserted and readable?
- `/TACTI_VISION_WAV/` folder exists?
- WAV files present? (check file list)
- Speaker/amplifier connected?

I2C/I2S Conflict:

- Audio temporarily disables I2C devices
- Automatic recovery after playback
- If frozen after audio, power cycle

Vibration Motor Stuck

Symptoms: Vibration continues indefinitely
Solution:

- Power cycle device immediately
- Motor safeguard should prevent this in V3.2

Mode-Specific Issues

GEMINI AI Not Responding

Symptoms: No response after query, timeout errors
Checks:

- WiFi connected? (check serial output)
- Internet access working?
- API key valid? (check firmware config)
- Query too long? (try shorter query)

Fix:

1. Exit mode (PREVIOUS)
2. Check WiFi signal strength
3. Re-enter GEMINI AI MODE
4. Try simple test query: "hello"

B-DRIVE OCR Failing

Symptoms: "No text detected" or timeout
Checks:

- WiFi connected?
- OCR.space API key valid?
- Image quality good? (clear text, good lighting)
- File size < 1MB?

Fix:

1. Verify image is readable (not upside-down)
2. Try different image format (JPG recommended)
3. Reduce file size if large
4. Check API quota (OCR.space limits)

SD UPLOAD Not Accessible

Symptoms: Cannot access web interface
Checks:

- WiFi connected on computer and device?
- Same network? (check IP address)
- Port 8080 open? (firewall settings)
- Browser shows correct URL: `http://[IP]:8080`?

Fix:

1. Note IP address announced by device
2. Disable firewall temporarily
3. Try different browser
4. Re-enter SD UPLOAD MODE

TTS Not Speaking

Symptoms: Silent file reading, conversion fails
Checks:

- WiFi connected?
- VoiceRSS API key valid?
- File format supported? (only .txt)
- File not empty?

Fix:

1. Check file content (SELECT to print)
2. Verify internet connection
3. Try smaller file (<10KB for testing)
4. Check VoiceRSS API quota

AUDIO PLAYER No Files

Symptoms: "No .wav files found"
Checks:

- `/AudioFiles/` folder exists?
- Files are .wav format? (not .mp3, .ogg, etc.)
- File names correct? (case-sensitive)
- SD card readable?

Fix:

1. Create `/AudioFiles/` folder if missing
2. Add .wav files (22kHz 16-bit mono recommended)
3. Re-enter AUDIO PLAYER MODE
4. Check file list on serial output

OTA Update Issues

Update Check Fails

Symptoms: "Failed to fetch update info"
Checks:

- WiFi connected?
- GitHub accessible? (check internet)
- Timeout (15s for connection)?

Fix:

1. Exit and re-enter SYSTEM UPDATE MODE
2. Check WiFi signal strength
3. Try later (GitHub may be down)

Update Download Fails

Symptoms: Error during firmware download
Checks:

- WiFi stable? (don't move device)
- Sufficient space? (unlikely)
- Power stable? (don't disconnect USB)

Fix:

- **DO NOT power off during update**
- Wait for automatic retry
- If fails 3 times, exit and try later

Device Won't Boot After Update

Symptoms: No response after reboot
Solution:

- Power cycle 2-3 times
- Check for continuous reboot loop
- May need to reflash firmware via USB (rare)

Deep Sleep Issues

Device Sleeps Too Quickly

Symptoms: Enters sleep during use
Cause: 30-second timeout in certain modes
Solution:

- Keep interacting with device (any button press resets timer)
- Only NORMAL and PERKINS modes have sleep timeout

Can't Wake from Sleep

Symptoms: Device unresponsive after sleep
Solution:

- **Power cycle required** (no button wake)
- Disconnect and reconnect USB power
- Or press physical reset button if available

Didn't Sleep When Expected

Cause: Currently in exempt mode
Modes Without Sleep:

- MODE OPTIONS (navigating)
- B-DRIVE (server running)
- SD UPLOAD (server running)
- All active modes

Notification Issues

BLE Not Connecting

Symptoms: No notifications from phone
Checks:

- ChronosESP32 app installed on phone?
- Bluetooth enabled on phone?
- NOTIFY mode turned ON? (check serial)
- Paired correctly?

Fix:

1. Toggle NOTIFY OFF then ON
2. Restart ChronosESP32 app
3. Re-pair Bluetooth on phone
4. Power cycle device

Notifications Not Logging

Symptoms: NOTIFY.txt empty or missing
Checks:

- SD card working?
- NOTIFY mode ON? (must be enabled)

- Ring buffer full? (8-message limit)
- `/NOTIFY.txt` cleared on boot (normal behavior)

General Performance

Sluggish Response

Causes:

- SD card slow/corrupted
- WiFi interference
- Too many devices on I2C bus

Solutions:

1. Use faster SD card (Class 10 recommended)
2. Reduce WiFi distance to router
3. Power cycle to reset I2C bus
4. Check for loose connections

Random Reboots

Causes:

- Power supply insufficient
- SD card issues
- Memory overflow (rare)

Solutions:

1. Use quality USB power adapter (5V 2A minimum)
2. Check SD card health
3. Reflash firmware if persistent

Support and Resources

API Keys (Pre-configured in Firmware)

- **Gemini AI:** Google Generative AI API
- **VoiceRSS:** Text-to-speech API
- **OCR.space:** Image text extraction
- **Twilio:** SMS emergency alerts

⚠ **Security Note:** API keys are hardcoded in firmware. For production, use environment variables or secure storage.

Firmware Updates

- **Repository:** `github.com/MAATHES-THILAK-K/Stellar_Vision_V1`
- **Update Info:** `Firmware/latest.json`
- **Current Version:** V3.2
- **Update Method:** OTA (Over-The-Air) via SYSTEM UPDATE MODE

Required SD Card Structure

```
/TACTI_VISION_WAV/       → System audio (required)

/AudioFiles/             → User audio (optional)

/Alphabets/              → Letter sounds (optional)
```

Calibration Values (MPU6050)

Located in firmware for gesture mode:

- ACCEL_X_OFFSET: 0.88
- ACCEL_Y_OFFSET: -0.20
- ACCEL_Z_OFFSET: -10.03
- GYRO offsets: minimal (<0.1)

Note: Calibrate for your specific MPU6050 for best gesture accuracy.

WiFi Configuration

Update in firmware before uploading:

```
const char* gemini_ssid = "YOUR_SSID";

const char* gemini_password = "YOUR_PASSWORD";
```

Twilio SMS Configuration

Update in firmware for SOS feature:

```
const char* twilio_account_sid = "ACxxxxx";

const char* twilio_auth_token = "your_token";

const char* twilio_from_number = "+1234567890";

const char* twilio_to_number = "+0987654321";
```

Serial Monitoring

- **Baud Rate:** 115200
- **Provides:**
  - Boot messages
  - Mode transitions
  - Error diagnostics
  - Button press feedback
  - Braille input display
  - Network status
  - File operations

About the Author

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Contact & Project Links

- **GitHub:** github.com/MAATHES-THILAK-K
- **Project Repository:** Stellar_Vision_V1
- **Firmware Releases:** Check repository for latest versions

Interests & Aspirations

- Embedded Systems Design
- Robotics & Automation
- Assistive Technology Development
- Human-Computer Interaction
- Accessibility Engineering

Development Philosophy

"Vibe Coding — Leveraging AI as a collaborative tool to accelerate innovation and create meaningful accessibility solutions."

Acknowledgments

- **ChronosESP32** library for BLE notifications
- **VoiceRSS** for text-to-speech API
- **OCR.space** for optical character recognition
- **Google Gemini** for AI integration
- **Twilio** for SMS emergency alerts
- Open-source community for Arduino libraries

STELLAR VISION V1 – Making Technology Accessible

Firmware Version: V3.2
Last Updated: December 2024
Developed by: MAATHEs THILAK K

Appendix A: Audio File List

Required System Audio Files

All files should be in `/TACTI_VISION_WAV/` folder:

Filename	Purpose	When Played
StellarVision.wav	Boot greeting	Device startup
PERKINS_MODE.wav	Mode entry	Entering Perkins mode
MODES.wav	Mode list	Opening mode options
SAVED.wav	Save confirm	File saved successfully
SELECTED.wav	Selection confirm	Item selected
PREVIOUS.wav	Back action	Going back/canceling
ONE_HAND_MODE.wav	Gesture mode	Gesture mode activated
SOS.wav	Emergency alert	SOS triggered
Deepsleep.wav	Sleep warning	Before entering sleep
Alpha_enab.wav	Feature enabled	Alphabet audio ON
Alpha_disable.wav	Feature disabled	Alphabet audio OFF
Autocorrection.wav	Text correction	Correction applied
OCR_Completed.wav	OCR done	B-DRIVE extraction complete
File_Upload.wav	Upload success	SD file uploaded
converting_TTS.wav	TTS start	Beginning text-to-speech
hold_save.wav	Instruction	Note-maker ready
hold_query.wav	Instruction	Gemini query ready
Sending_Query.wav	Network action	Sending to Gemini
response_received.wav	AI response	Gemini reply ready
Connecting_wifi.wav	Network status	WiFi connecting
wificonnected.wav	Network success	WiFi connected
Firmware_check.wav	Update process	Checking for updates
firmware_available.wav	Update alert	New version found
Downloading.wav	Download status	Firmware downloading
update_sucess.wav	Update complete	Update successful
latestversion.wav	Version status	Already up to date
READY_TO_RECEIVE.wav	Server ready	SD upload server started
Audio_Init.wav	Player init	Audio player started
playbackstopped.wav	Playback stop	Audio stopped
NOTIFY.wav	Mode name	Notify option

GEMINI_AI.wav	Mode name	Gemini AI option
NOTE_MAKER.wav	Mode name	Note maker option
HID_SHORTCUT.wav	Mode name	HID shortcut option
B_DRIVE.wav	Mode name	B-Drive option
SD_MODE.wav	Mode name	SD card option
SD_UPLOAD.wav	Mode name	SD upload option
SYSTEM_UPDATE.wav	Mode name	System update option
AUDIO_PLAYER.wav	Mode name	Audio player option
WIFI.wav	Shortcut name	WiFi shortcut
CHROME.wav	Shortcut name	Chrome shortcut
GMAIL.wav	Shortcut name	Gmail shortcut
CHATGPT.wav	Shortcut name	ChatGPT shortcut
PY_COMPILER.wav	Shortcut name	Python compiler shortcut
LIBRARY.wav	Shortcut name	Library shortcut
num.wav	Mode indicator	Number mode activated
caps.wav	Mode indicator	Capital mode activated

Recommended Format: 22kHz, 16-bit, Mono, WAV

Appendix B: Version History

V3.2 (Current - December 2024)

Major Features:

- Enhanced I2C/I2S conflict management
- SOS emergency SMS with 30-second cooldown
- Alphabet audio toggle (UP long press or all 6 dots)
- Text auto-correction (15 common typos)
- SD Upload with folder structure support
- TTS chunking (300 characters with sentence detection)
- Deep sleep safeguards (motor protection)
- OTA update with timeout and confirmation

Improvements:

- Stable multi-device I2C (100kHz)
- HID keyboard auto-reconnection
- DigiSpark recovery after audio
- Vibration motor safeguards
- Enhanced error handling

Bug Fixes:

- Fixed I2C freeze after I2S audio

- Resolved vibration motor sleep issues
- Corrected SOS false triggers
- Fixed folder upload structure preservation

V1.0 (Original - November 2024)

Initial Release:

- Basic Braille input
- PERKINS mode HID output
- NOTE-MAKER functionality
- SD card navigation
- GEMINI AI integration
- B-DRIVE OCR
- NOTIFY BLE notifications
- Audio feedback system
- Gesture mode
- Deep sleep

Appendix C: Hardware Assembly Notes

I2C Bus Configuration

Devices on Bus:

1. PCF8575 (0x20) - GPIO expander for 14 buttons
2. DigiSpark (0x23) - HID keyboard interface
3. MPU6050 (0x68) - Accelerometer for gestures

Critical Settings:

- Bus speed: 100kHz (NOT 400kHz)
- Timeout: 500ms
- Pull-up resistors: 4.7kΩ recommended

Power Requirements

- **Minimum:** 5V 1A
- **Recommended:** 5V 2A (for stable operation)
- **Peak current:** ~800mA (during WiFi + audio + vibration)

SD Card Compatibility

- **Format:** FAT32 only
- **Capacity:** Up to 32GB tested
- **Speed Class:** Class 10 or higher recommended

- **Brands tested:** SanDisk, Samsung, Kingston,Amazon Basics

Audio Amplifier

- **Model:** MAX98357A I2S
- **Gain:** Set to 0.9 in software (adjustable)
- **Speaker:** 4-8Ω, 3W recommended
- **Volume:** Controlled by software gain setting

End of User Manual

For latest updates, visit the GitHub repository.
For support, check serial output for diagnostic messages.
For emergency assistance, use the SOS feature (1.5s Space hold).