System Requirements & Hazard Analysis

Mechatronics & Software

Team 3 - SmartRead: Instant Translation with Wearable Device

Ding (Chris) Hao
Yimin (Jane) Pang
Yucheng Yao
Wenyu (Winnie) Yin
Taoming Yu
Xiang (Shawn) Zhang

Date	**Developers**	**Change**
Nov 24, 2024	Group 3	First version of the document

Table 1. Revision History

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Glossary

Term	**Definition**
Camera Module	A hardware component integrated into the system to capture visual data (e.g., images).
Display Device	A hardware component that is used to display translated text from the captured image (e.g. a mobile phone).
Tangible Text Entries	Physical or printed text visible to the camera and suitable for text recognition (e.g., street signs, menus). This would take into account the monitored variables *M_LIGHTING* and *M_DISTANCE*.
Lighting Condition	The level of ambient light, measured in lumens, affects the system's ability to capture and process images.
Standard Usage	Typical usage scenario where the user operates the device to translate text approximately once every 3 minutes on average.
Wearable Device	A general term that describes the physical component includes a camera module for image capturing, a microcontroller for data transmission, a battery for power supply, and a system frame for wearing.
Power Management	Power management in the microcontroller refers to how the device optimizes its power consumption based on its operational state, allowing efficient use of the battery to extend runtime.
User Guide	A document that provides detailed instructions on the system, including setup, usage, and maintenance procedures. It also includes critical safety guidelines, such as handling and disposal of batteries, to ensure user safety.

Table 2. Glossary

Purpose

This document aims to guide the development of SmartRead: Instant Translation with Wearable Device System by defining its system requirements and performing a detailed hazard analysis. It ensures that clear, measurable objectives regulate the design process and address key challenges such as functionality, safety and performance. This document is intended to act as a reference for ensuring consistency across the development process and providing a clear framework for system implementation. Furthermore, it aims to document the fundamental aspects of the system, ensuring alignment with standards and supporting the development of a reliable and effective solution designed to meet the project's goals.

Scope

This document outlines the requirements for the SmartRead: Instant Translation with Wearable Device System. In alignment with the 4-Variable System Model, the Monitored and Controlled Variable section lists the input and output variables of the system. A comprehensive Hazard Analysis is also included, identifying potential risks, with corresponding precautions and mitigation strategies documented in the Safety and Security Requirement section as extensions to the general requirements. The System Requirements section lists performance requirements and general requirements with noting likely to change and unlikely to change. Additionally, Undesired Event Handling is addressed to ensure a thorough and well-rounded specification.

Assumptions

1. For hazard analysis, it is assumed that text pieces are first extracted from the image using a machine learning model and then translated using any available API. This high-level workflow provides the necessary context for identifying and analyzing hazards specific to each stage. While this assumption references functional steps, it avoids specifying implementation details to maintain flexibility for design choices.

2. Users follow safety guidelines, including handling the device properly to avoid damage or misuse and operating it within the recommended environmental conditions.

3. The system operates in an environment from 0 ℃ to 45 ℃ [1], and the device does not support operations in extreme environmental conditions.

4. Handling malicious software/network attacks on the system is out of the scope of this project and, thus, not investigated.

5. Users will ensure a stable and reliable Wi-Fi connection to support the system's data transmission requirements, such as uploading captured images.

6. Users will only use the system to translate tangible text entries.

7. Throughout this document, it is assumed that the system will be operated under clear weather conditions.

Monitored & Controlled Variable

Monitored Variables

Variable Name	Unit	Description
M_BUTTON	Category: pressed, not pressed	The system will capture images when the button is pressed.
M_LIGHTING	Lumen	Represents the ambient lighting levels, which may affect image quality and text extraction accuracy.
M_DISTANCE	Meters	The distance between the camera module and the object being imaged
M_BATTERY_VOLTAGE	Voltage	Represents battery status.
M_TEMP	Celsius	Represents the operating temperature of hardware components.
M_DETECT_LANGUAGE	Category: English, French, Chinese, etc.	User's selection on which language they want the device to detect.
M_TRANSLATE_LANGUAGE	Category: English, French, Chinese, etc.	User's selection on which language they want the device to translate to.

Table 3. Monitored Variables

Controlled Variables

Variable Name	Unit	Explanation
C_CAPTURED_IMAGE	Pixels	The images captured by the camera module.
C_DETECTED_TEXT	Category: English, French, Chinese, etc.	Legible text extracted from the captured images that meet quality and accuracy thresholds.
C_TRANSLATED_TEXT	Category: English, French, Chinese, etc.	The translated text shown on the user interface is controlled to ensure readability and accuracy.
C_DEVICE_STATUS	Category: Idle, Regular	When the capture image button is not

	operation	pressed for a long time, the device will go idle mode to save the battery.
C_LED	Category: off, on, blinking	The LED light is used to represent battery status. LED is off when the battery is out, on when the battery does have electricity, and blinking when the battery is low.
C_WARNING	Category: send, not send	When the battery is low or dead, a warning will be sent to the application display.

Table 4. Controlled Variables

Constants with Nominal Values

The calculated variables for system parameters are based on theoretical data from datasheets and general assumptions. However, actual values may vary due to factors such as component tolerance, environmental conditions, voltage regulator inefficiency and variations in current draw during different operational states.

Constant	**Nominal value / Range**
CONST_MAX_TOTAL_WEIGHT	225 grams
CONST_LIGHTING_RANGE [2]	300 ~ 750 lux
CONST_MAX_POWER_CONSUMPTION	1.55 W
CONST_WIFI_SPEED_RANGE	802.11 b/g/n
CONST_MAX_MICROCONTROLLER_DIM	27 * 40.5 * 4.5 (± 0.2) mm
CONST_MIN_RESOLUTION [3]	40 × 30
CONST_MAX_RESOLUTION [3]	1600 × 1200
CONST_BATTERY_CAPACITY_RANGE [1]	1000 - 2000 mAh
CONST_BATTERY_DURABILITY_STD	5.8 ~ 10 hours
CONST_BATTERY_DURABILITY_IDLE	5.8 ~ 300 hours
CONST_MAX_OVERALL_TIME	2.8 seconds
CONST_MAX_IMAGE_CAPTURE_TIME	935 ms

CONST_MAX_PROCESSING_TIME	1.4 seconds
CONST_MAX_TRANSMISSION_TIME	32 ~ 436 ms
CONST_MAX_APPLICATION_STORAGE [4]	50 Mb
CONST_MIN_TRANSLATION_ACCURACY	78%

Table 5. Constants with Nominal Values

System Boundary Diagram

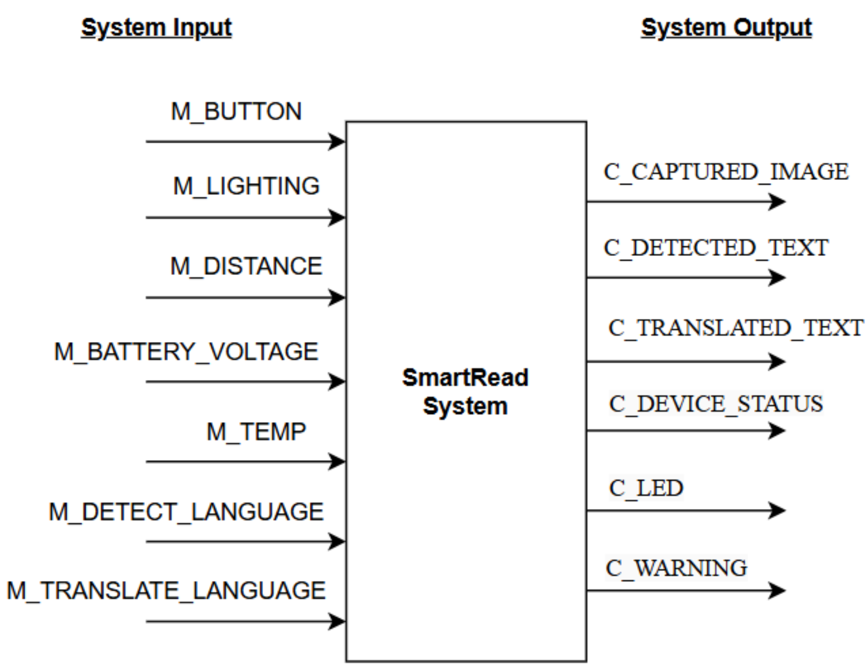

Fig 1. System Boundary Diagram

Behaviour Overview

Upon powering on, the SmartRead wearable translation device enters an idle low-power state, conserving energy while awaiting input. The device remains in this state until it receives the M_BUTTON input signal. Once the button is pressed, the device transitions to an active state, updating its monitored variables and coordinating its internal processes to generate the desired output.

Required Behavior

The SmartRead wearable translation device is designed to operate seamlessly upon user interaction. When the button is pressed, the device will process the content and deliver the translation result to the user's smartphone app within a reasonable time frame. This ensures an efficient and user-friendly experience without revealing the internal translation mechanisms.

Hazard Analysis

Hazard analysis is a critical process in the system design and development to ensure the safety, reliability, and usability of a product. For a wearable translation device, hazard analysis is essential to prevent hardware failures, software malfunctions, integration issues, and external threats. This process includes creating a fault tree analysis to visualize how failures propagate, identifying root causes through systematic breakdowns, and proposing detailed mitigation strategies to reduce risks by analyzing potential risks and failures that could impact the system, users, or environment. By thoroughly analyzing hazards, the project ensures a safer, more robust, and user-friendly system, aligning with our safety requirements and functional goals.

The system faces four major hazards that are critical to its design and functionality. It includes system failure, personal injury, privacy breaches, and environmental hazards. Each hazard is analyzed individually using a fault tree analysis to identify root causes, contributing factors, and potential mitigation strategies.

While hazard analysis and mitigation strategies aim to minimize risks, achieving 100% mitigation of all potential hazards is not feasible. Some risks may remain unaddressed due to technical, financial, or practical constraints. In such cases, it is important to label these limitations clearly through warnings, instructions or user manuals to alert users of potential dangers. In addition, not all mitigation can be fully implemented due to resource limitations or unforeseen challenges during the development process. Therefore, while efforts are made to reduce risks as much as possible, users should be aware of these risks and take corresponding precautions.

Hazard #1: System Failure

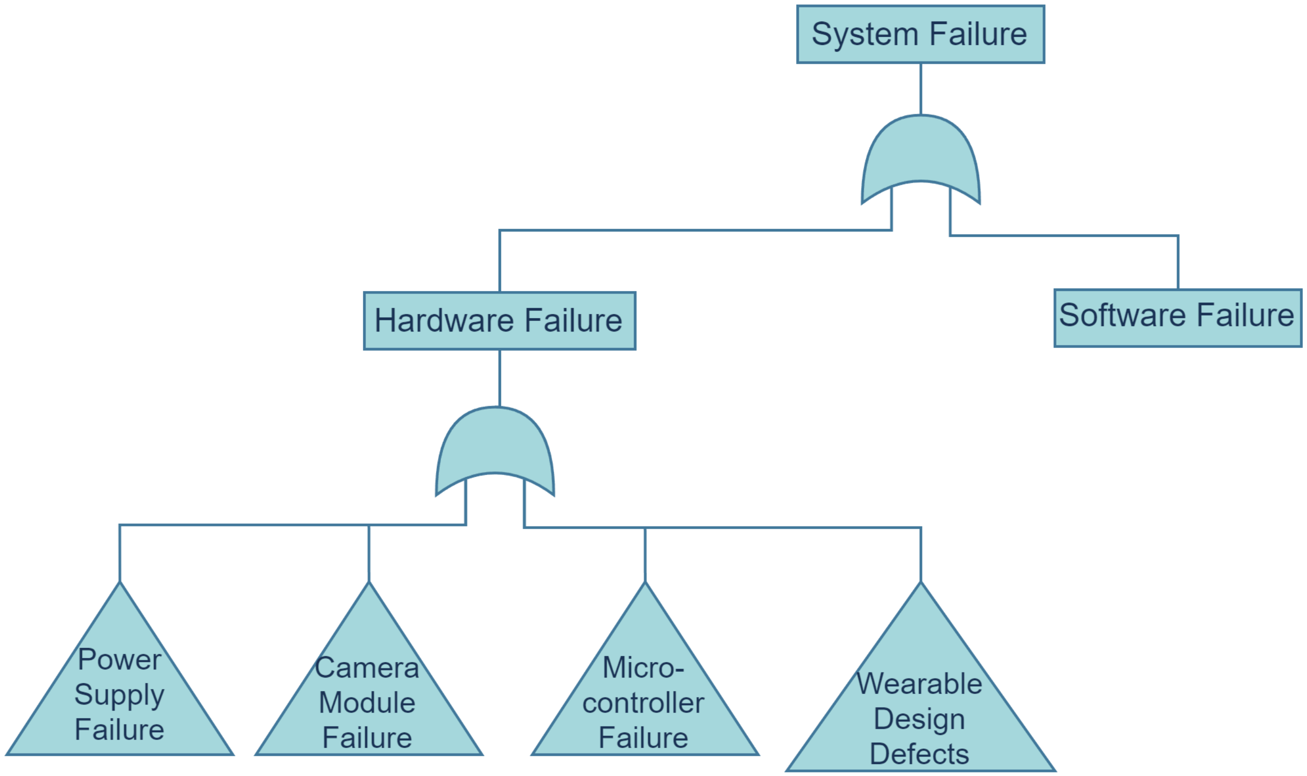

Fig 2. Fault Tree - System Failure

Hardware Failure

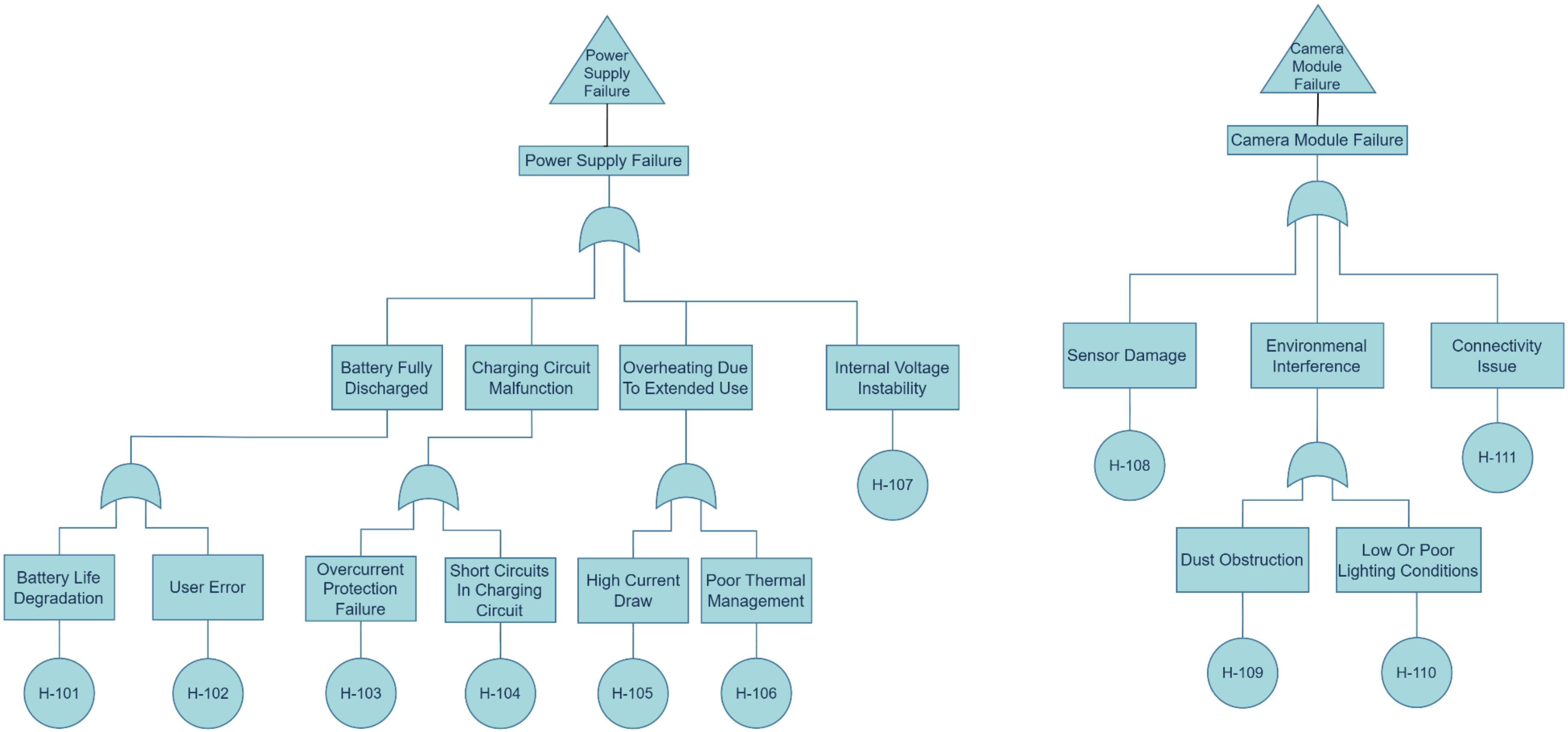

Fig 3. Fault Tree - Power Supply Failure & Camera Module Failure

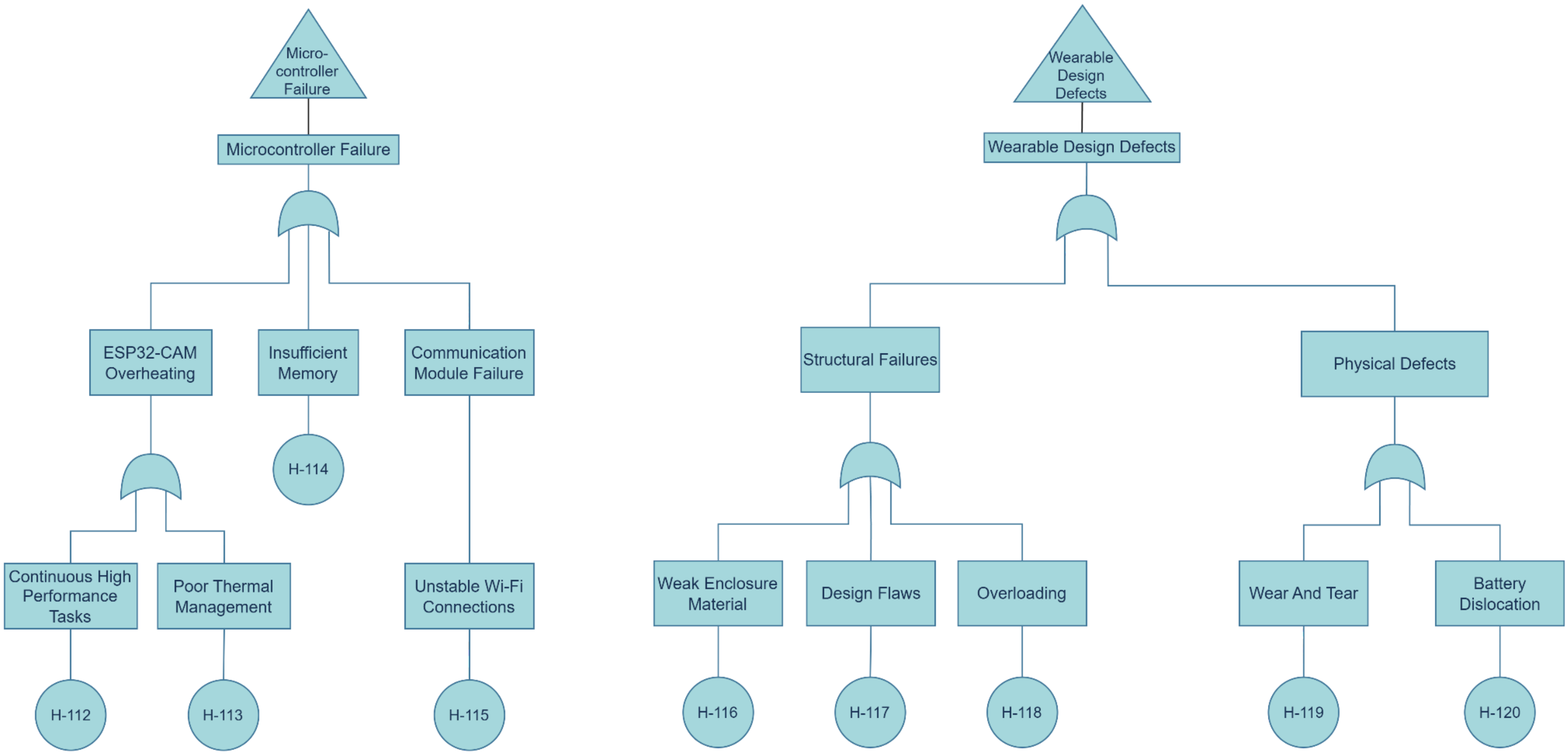

Fig 4. Fault Tree - Mirco-controller Failure & Wearable Design Defects

Hazard Cause	Hazard ID	Description	Potential Mitigation
Battery Life Degradation	H-101	Repeated charge-discharge cycles reduce lifespan.	Alert users with low battery warnings and reminders for regular charging.
User Error	H-102, H-212	Users forget to recharge or allow deep discharge.	Add a battery level indicator (LED or app-based).
Overcurrent Protection Failure	H-103	Overcurrent damages the battery or other components.	Regularly inspect charging components for faults.
Short Circuits In Charging Circuit	H-104	Faulty wiring or damaged components cause short circuits.	Use insulated wiring and ensure proper connections during assembly.
High Current Draw	H-105	Excessive power consumption from high-performance tasks leads to overheating.	Implement dynamic power management to reduce current draw during idle.
Poor Thermal Management	H-106, H-113	Inadequate heat dissipation increases device temperature.	Design enclosures with proper ventilation for passive cooling.
Internal Voltage Instability	H-107	Fluctuations from the power source disrupt performance.	Add voltage regulator to stabilize supply.
Sensor Damage	H-108	Shock or impact during usage.	Add a protective lens cover or coating. Use shock absorbing mounts for the camera.
Dust Obstruction	H-109	Exposure to dusty or dirty environments.	Seal the camera module. Include a lens-cleaning alert or routine maintenance schedule.
Low Or Poor Lighting Conditions	H-110, H-202	Insufficient ambient light affects image capture.	Integrate an adaptive image sensor with auto-brightness and exposure control. Provide optional external lighting or flash support.

Connectivity Issue	H-111	Loose or faulty connections between the camera and microcontroller disrupt signals.	Ensure proper physical connections with robust connectors for camera interfaces.
Continuous High-Performance Tasks	H-112	The use of high-power components leads to overheating and performance issues.	Monitor the real-time temperature using built-in sensors in ESP32 and implement a safe shutdown when overheating.
Insufficient Memory	H-114	Lack of sufficient RAM or flash memory causes crashes or slow performance.	Use optimized memory allocation in firmware.
Unstable Wi-Fi Connections	H-115	Signal interference or weak Wi-Fi signals.	Use dual-band Wi-Fi (2.4 GHz and 5 GHz) to minimize interference.
Weak Enclosure Material	H-116	Brittle or low-strength materials lead to structural failure under stress or impact.	Use durable materials like polycarbonate for enclosures. Conduct impact and stress testing during the design phase.
Design Flaws	H-117	Poor design choices lead to hardware inefficiencies, structural weakness, or overheating issues.	Perform thorough design reviews. Use CAD simulations for structural and test prototypes under real-world conditions.
Overloading	H-118	Exceeding design load limits causes physical deformation or device failure.	Define operational load limits, use reinforced materials, and test under extreme conditions.
Wear And Tear	H-119	Gradual degradation of components due to extended use.	Apply protective coatings such as scratch resistance material)
Battery Dislocation	H-120	Battery shifts or disconnects due to shock or improper fastening.	Secure the battery with brackets, latches or shock-absorbing pads to prevent dislocation.

Table 6. Hardware Hazards

Software Failure

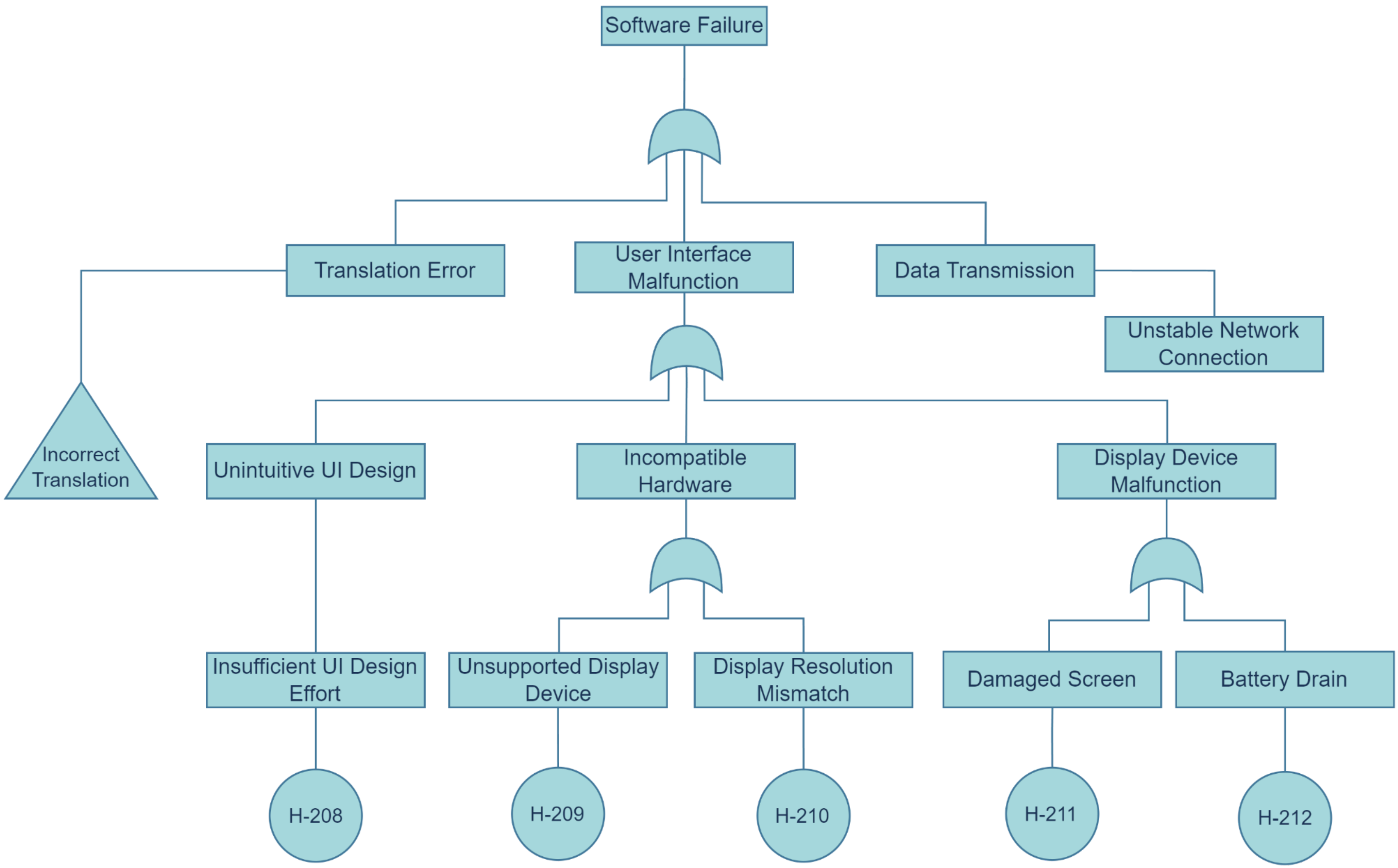

Fig 5. Fault Tree - Software Failure

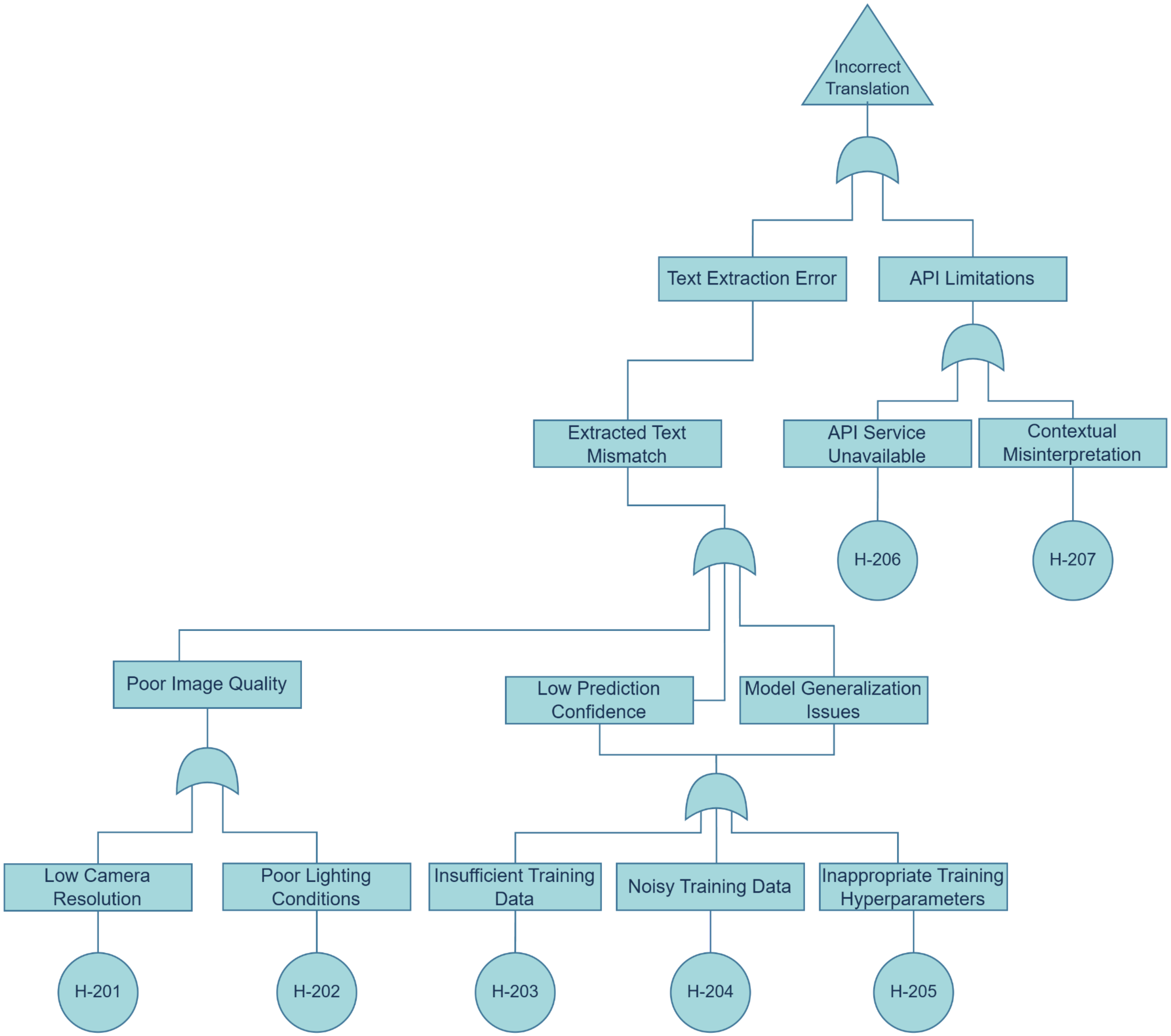

Fig 6. Fault Tree - Incorrect Translation

Hazard Cause	Hazard ID	Description	Potential Mitigation
Low Camera Resolution	H-201	The camera module captures images with insufficient clarity for text extraction.	Adopt image preprocessing techniques (e.g. denoising, edge enhancement) to enhance image quality.
Insufficient Training Data	H-203	Training datasets are too small or lack diversity, leading to poor machine learning performance.	Augment the dataset with various samples to improve model generalization.
Noisy Training Data	H-204	Data contains errors, irrelevant features, or poorly labelled samples.	Perform data preprocessing and ensure accurate labelling in datasets.
Inappropriate Training Hyperparameters	H-205	Model hyperparameters are not optimized, leading to underfitting or overfitting.	Optimize hyperparameter configurations with appropriate techniques.
API Service Unavailable	H-206	The translation API is down or unreachable.	Implement a fallback mechanism (e.g. cached translation).
Contextual Misinterpretation	H-207	Translation results do not match the context of the original text.	*OUT OF SCOPE*
Insufficient UI Design Effort	H-208	The user interface is unintuitive or difficult to navigate, reducing usability.	Follow usability principles like Norman's and Gestalt's Principles
Unsupported Display Device	H-209	The software is incompatible with certain smartphones or display devices.	Test compatibility across a variety of devices and ensure adaptive display support.
Display Resolution Mismatch	H-210	The software's resolution settings do not align with the device's display capabilities.	Design UI that supports dynamic resolution scaling.
Damage Screen	H-211	Physical damage to the display screen.	*OUT OF SCOPE*

Table 7. Software Failure

Hazard #2: Privacy Breach

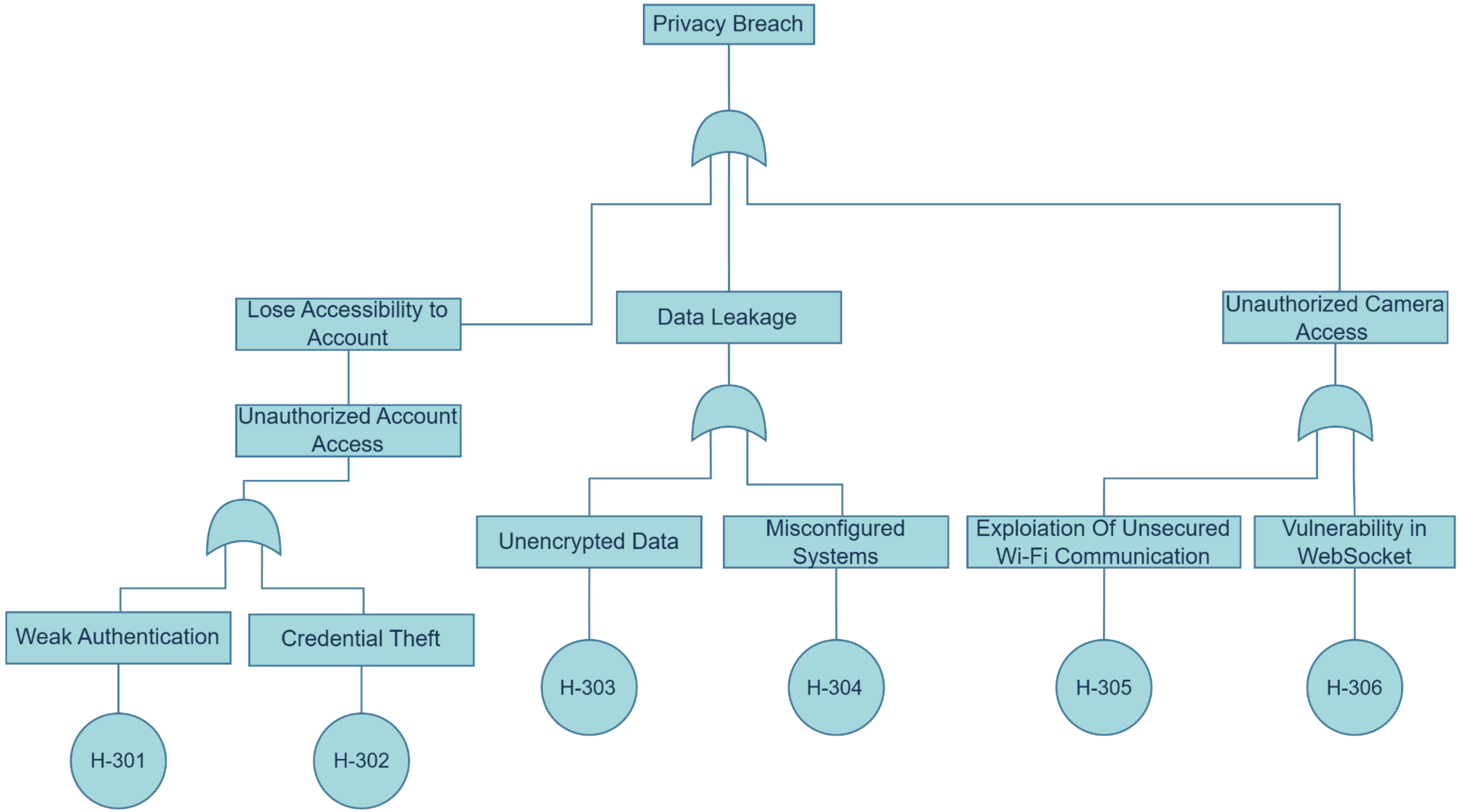

Fig 7. Fault Tree - Privacy Breach

Hazard Cause	Hazard ID	Description	Potential Mitigation
Weak Authentication	H-301	Inadequate authentication mechanisms allow unauthorized access.	Implement multi-factor authentication (MFA) and enforce strong password policies.
Credential Theft	H-302	Malicious access to user credentials through phishing, malware, etc.	
Unencrypted Data	H-303	Sensitive data is transmitted or stored without encryption, making it vulnerable to attacks.	Use HTTPS protocol for all communications and encrypt data with proper protocols.
Misconfigured Systems	H-304	Incorrect configuration of system components (e.g. firewall) exposes sensitive data to unauthorized access.	*OUT OF SCOPE*
Exploitation of Unsecured Wi-Fi Communication	H-305	Data intercepted on open Wi-Fi networks.	*OUT OF SCOPE*
Vulnerability in WebSocket	H-306	Security flaws in WebSocket communication.	*OUT OF SCOPE*

Table 8. Privacy Breach

Hazard #3: Environment Impact

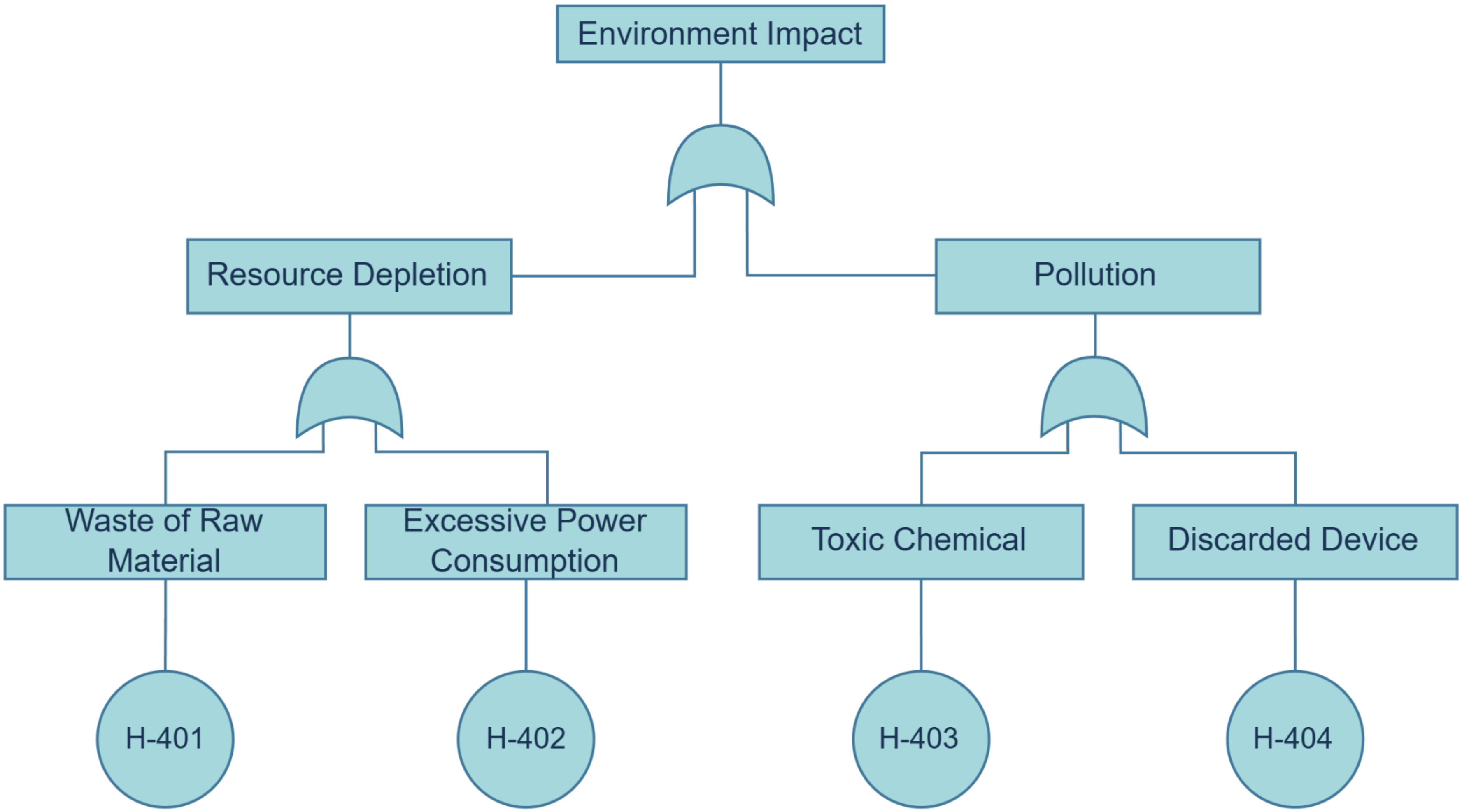

Fig 8. Fault Tree - Environment Impact

Hazard Cause	Hazard ID	Description	Potential Mitigation
Waste of Raw Material	H-401	Excessive or inefficient use of raw materials in designing the wearable device.	Use recyclable and sustainable materials and minimize material usage by design.
Excessive Power Consumption	H-402, H-105	High energy usage during device operation.	Implement dynamic power management to reduce energy use (idle mode).
Toxic Chemical	H-403	Environmental contamination caused by hazardous materials used for the wearable.	Prioritize non-toxic and environmentally friendly materials.
Discarded Device	H-404	Improper disposal of the wearable device.	*OUT OF SCOPE*

Table 9. Environment Impact

Hazard #4: Personal Injury

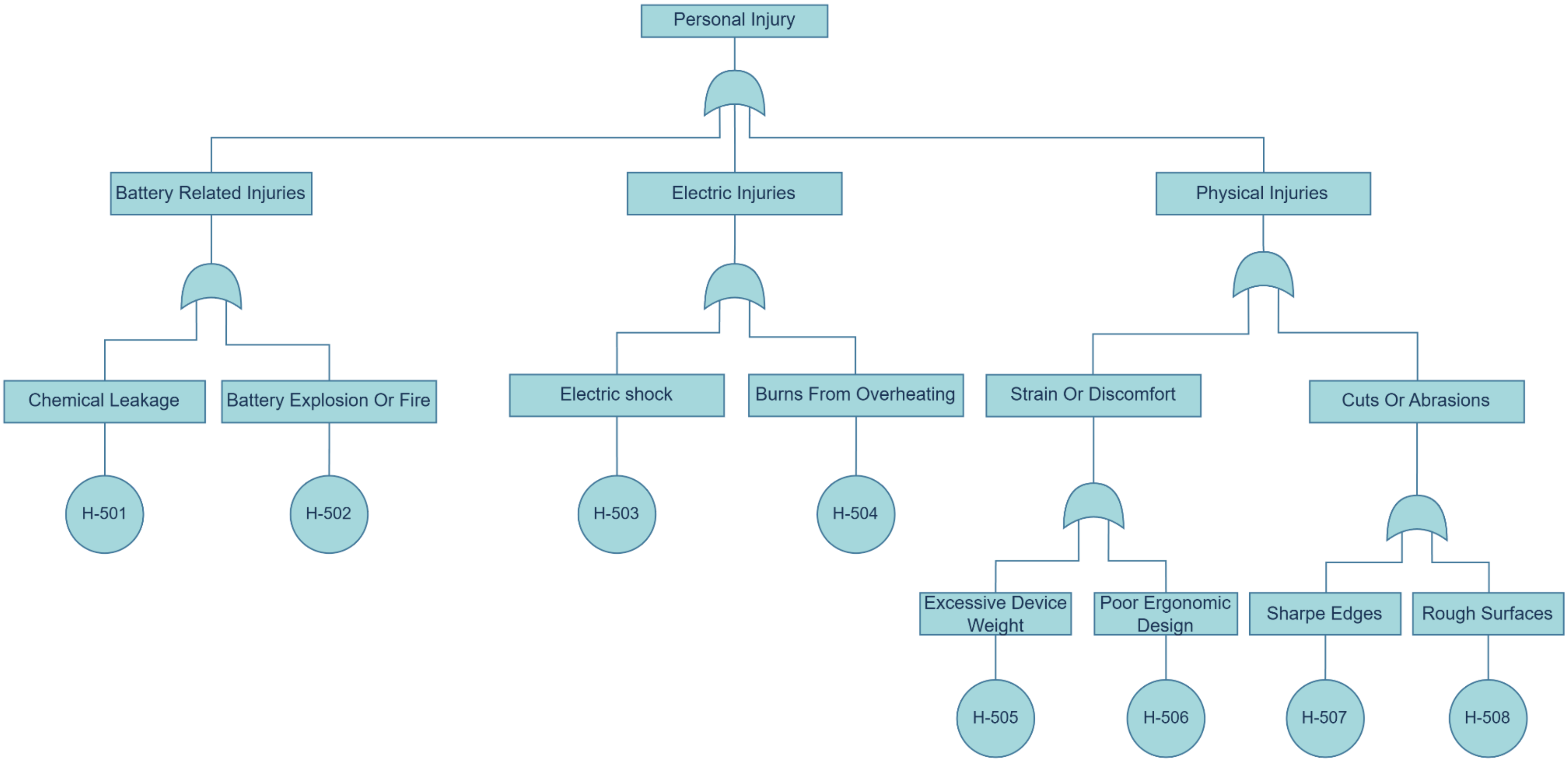

Fig 9. Fault Tree - Personal Injury

Hazard Cause	**Hazard ID**	**Description**	**Potential Mitigation**
Chemical Leakage	H-501	Leakage of harmful chemicals from a damaged or defective battery.	Use high-quality, sealed batteries. Conduct regular inspections and provide clear battery disposal guidelines.
Battery Explosion Or Fire	H-502	Overcharging or short circuits cause the battery to overheat, resulting in fire or explosion.	Use batteries with thermal management and overcharge protection. Include short circuit prevention circuitry.
Electric Shock	H-503	Faulty wiring or exposed live components result in user exposure to electric shock.	Use proper insulation on wires, ensure secure connections, and design the system with waterproof castings.
Burns From Overheating	H-504, H-106	Prolonged contact with overheated surfaces causes burns to users.	Design efficient cooling mechanisms and implement temperature monitoring with auto-shutdown.
Excessive Device Weight	H-505	Excessive weight of the wearable device causes physical strain to users.	Optimize the design to reduce weight and adopt lightweight materials.
Poor Ergonomic Design	H-506	An uncomfortable design causes strain or repetitive use injuries.	Perform ergonomic testing during design phases.
Sharp Edges	H-507	Sharp edges and rough surfaces of the wearable cause discomfort during operation.	Conduct physical safety testing and adopt a skin-safe and smooth design.
Rough Surfaces	H-508		

Table 10. Personal Injury

Safety and Security Requirements

Requirement No.	Description	Related Hazard(s)
Human Safety Requirements		
HSR-1	The system shall use batteries that comply with safety standards to prevent chemical leakage.	H-501
HSR-2	The system shall prevent overcharging, overheating, or explosions.	H-502
HSR-3	The system should ensure safe operation to prevent short circuits.	H-502
HSR-4	The system should ensure proper insulation to prevent electric shocks.	H-503
HSR-5	The system should protect live components from liquid exposure.	H-503
HSR-6	The system should control and dissipate heat during operation.	H-504, H-106
HSR-7	The wearable device's surfaces, corners and edges shall be smooth to prevent direct injury to users.	H-507, H-508
HSR-8	The User Guide should provide instructions on safety inspections and disposal of batteries	H-501
Environmental Safety Requirements		
ESR-1	The wearable device shall minimize material usage to reduce environmental impact.	H-401
ESR-2	The wearable device shall use materials that are recyclable and sourced sustainably.	H-401
ESR-3	The wearable device should lower power consumption during low-usage states	H-402, H-105
ESR-4	The wearable device should be built with materials that comply with environmental safety standards to avoid hazardous substances.	H-403

ESR-5	The User Guide should label materials to enable safe disposal and recycling.	H-404
Data Security Requirements		
DSR-1	The system should restrict unauthorized or malicious access.	H-301
DSR-2	The system should protect user credentials and secure all transmitted data.	H-302, H-303

Table 11. Safety & Security Requirements

System Requirements

Requirement No.	Description	Likelihood of Change
	Performance Requirements	
R-1	The system shall support small-volume translation, specifically for text entries containing 50 words or fewer.	Likely to change word processing capacity if finding a good way to identify more words.
R-2	The system shall display the final translated text within *CONST_MAX_OVERALL_TIME* seconds starting from receiving a button press input (*M_BUTTON*) from the user.	Unlikely to change process time with current technology.
R-3	The system shall be able to identify selected language text from the object, enabling reliable translation with an overall accuracy of at least *CONST_MIN_TRANSLATION_ACCURACY* under CONST_LIGHTING_RANGE.	Unlikely to change the reliability of text identification and translation accuracy with current technology.
R-4	The system should have a battery that provides a minimum of *CONST_BATTERY_DURABILITY_STD* hours of active use under standard usage conditions or *CONST_BATTERY_DURABILITY_IDLE* hours on standby.	Likely to change the battery life data after actual experimentation.
	General System Requirements	
R-5	The system shall be able to do English-French translation.	Likely to change if getting a good language translation package (e.g. DocLayNet) that supports translation between more languages [5].
R-6	The wearable device component of the system shall be resizable or	Unlikely to change since one of the project goals is to deliver a wearable device suitable for the

	elastic to fit most users and not cause users any discomfort.	majority.
R-7	The system shall inform users about the device's status and promptly notify them of any changes in these conditions in a clear and straightforward manner.	Unlikely to change since it is important to let the user know the device status.
R-8	The system should ensure that the hardware storage utilized for application deployment does not exceed CONST_MAX_APPLICATION_STORAGE for static data, excluding temporary cache memory for images and text.	Likely to change application storage constraints if new necessary features are needed.
R-9	The wearable device shall weigh no more than *CONST_MAX_TOTAL_WEIGHT* grams to minimize physical strain.	Unlikely to change the weight constraint to avoid physical strain.
R-10	The system should allow users to save translated phrases for later access and provide a method to view the stored phrases at any time.	Likely to change. This may be hard to implement and this will not be done.
R-11	The system shall recognize text in formal fonts like Arial and Calibi.	Likely to expand to support more fonts, such as handwritten and Font Art, based on the technologies used in text analysis.

Table 12. System Requirements

Undesired Event Handling

Event #1: The user's device for the UI is suddenly shut down during processing.

If the display device shuts down unexpectedly, the user will lose the current translation process and need to restart the device. Once rebooted, the user can re-capture the image by pressing the shutter to initiate translation again as another try.

Event #2: The user attempts to capture images repetitively.

The system has an input frequency input limitation to prevent high-frequency pressing. Users' repetitive input is legal overall.

Event #3: The camera module runs out of battery during device usage.

Users will have access to the camera's battery status as R-7 mentioned. However, if the user disregards the low battery warning and continues to use the device until it powers off, the shutter functionality will become unavailable, preventing any further image capture. Additionally, if a translation process is already initiated on the server, it will be finished, and the result will be sent back to users.

Event #4: The connection between the wearable device and the user's interface device is cut off.

If the connection between the wearable device and the display device is interrupted, the user will lose access to translation results. The user must re-establish the connection between the devices and retry the translation process by capturing the image again on a second try.

Event #5: The server is offline during or before processing.

If the server goes offline, translation functionality will be temporarily unavailable. The shutter can still be used to capture images, but users will have to wait for the server to come back up before processing and retrieving the translation results. The system shall notify users when the connection is interrupted.

Event #6: The lens becomes dirty or obstructed.

If the camera lens is smudged, dusty, or obstructed, the image quality will be degraded, leading to failed or inaccurate translations. Users will need to clean the lens or remove any obstructions.

References

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Appendix A - Constant Calculation

For maximum total weight, below is the calculation

Assume there are only four components for the hardware system.

- Microcontroller module and camera module [6]
    - Around 15 grams
- Battery module
    - Around 40 - 60 grams [1]
- System frame
    - 30 ~ 150 grams, depending on the material.

Maximum weight = $15 + 60 + 150 = 225$ grams.

For transmission time, below is the calculation [6]

Assume a 2MP image is compressed to approximately 300 KB.

- Data transfer rate [6]
    - Wifi 802.11 b: Up to 11 Mbps (Theoretical max)
    - Wifi 802.11 g: Up to 54 Mbps (Theoretical max)
    - Wifi 802.11 n: Up to 150 Mbps (Theoretical max)
- Convert image size to bits
    - $300\,KB = 300 \times 8 = 2400\,Kb$
- Calculate effective data rate (real-world application)
    - For Wi-Fi 802.11 g (assuming 50% efficiency)
    - Effective rate 54 $Mbps \times 0.5 = 27\,Mbps$
- Transmission time (T) given by
    - $T = \frac{Data\ size}{Effective\ rate}$
    - For 802.11 b (5.5 Mbps effective)
        - $T = \frac{2400}{5.5} \approx 0.436\ seconds\ (436\ ms)$
    - For 802.11 n (75 Mbps effective)
        - $T = \frac{2400}{75} \approx 0.032\ seconds\ (32\ ms)$ System Boundary Diagram

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For maximum power consumption and battery durability, below is the calculation [1] [6]

Assume 90% efficiency after using a voltage regulator.

$Power = Voltage \times Current$

$Runtime = \frac{Battery\ Capacity}{Current\ Draw} \times Efficiency$

- Turn off the flash lamp mode
  - $Power = 180mA \times 5V = 0.9\,W$
  - $Runtime = \frac{2000}{180} \times 0.9 = 10\ hours$
- Turn on the flash lamp (max brightness) mode
  - $Power = 310mA \times 5V = 1.55\,W$
  - $Runtime = \frac{2000}{310} \times 0.9 = 5.8\ hours$
- Deep sleep
  - $Power = 6mA \times 5V = 0.03W$
  - $Runtime = \frac{2000}{6} \times 0.9 = 300\ hours$
- Modern sleep
  - $Power = 20mA \times 5V = 0.1W$
  - $Runtime = \frac{2000}{20} \times 0.9 = 90\ hours$
- Light sleep
  - $Power = 6.7mA \times 5V = 0.0335W$
  - $Runtime = \frac{2000}{6.7} \times 0.9 = 268.7\ hours$

For minimum translation accuracy, below is the calculation

General Accuracy = Text Extraction Accuracy × Translation Accuracy [7] [8]

= 95% × 82.5%

= 78%

This means that 78% of the text the user intends to translate will be translated accurately.

For minimum image processing time, below is the calculation

Assume there are two steps for image processing.

- Text Extraction

- Around 1.2 seconds
- Text Translation
    - Around 0.2 seconds

Minimum Image Processing Time = $1.2 + 0.2 = 1.4$ seconds

For maximum image capture time, below is the calculation

- Image capture time includes button debouncing, camera initialization and image capture time.
- The standard debounce times for hardware buttons range from 10 to 50 ms [9], depending on the switch type and the desired stability.
- Camera initialization often takes 100 ~ 300 ms depending on resolution and setup.
- Image capture time often takes 200 to 500 ms depending on the image resolution and compression method.
- We can also multiple the time by 1.1 for real-time delay and additional latency that might happen.
- $Max\ time = (50 + 300 + 500) * 1.1 = 935\ ms$

For maximum overall time, below is the calculation

- Assume the maximum overall time is the combination between button pressed, image taken, image processing time, as well as transmission time.
- $Max\ time = 935 + 1400 + 436 \approx 2.77$ seconds