TED UNIVERSITY

CMPE 491 – Senior Project I

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AKKE – Project Specifications Report

(SMART COMMAND AND CONTROL GLOVE)

Webpage: https://ilter-akke.github.io/website/

Name Surname Department

Abdullah ESİN (CMPE)

Berk ÇAKMAK (CMPE)

Ömer Efe DİKİCİ (CMPE)

Şevval KURTULMUŞ (EEE)

Supervisors: Ali BERKOL and Hüseyin Uğur YILDIZ

Jury Members: Hakkı Gökhan İLK and Mehmet Evren ÇOŞKUN

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1. Introduction

In modern defense and security operations, effective communication and coordination are critical for mission success and personnel safety. Traditional communication methods often fall short in environments where silence, speed, and confidentiality are essential.

To address these limitations, the AKKE project introduces an intelligent wearable system that enables users to transmit commands silently and efficiently through hand gestures. By integrating sensor-based data collection, gesture recognition, and wireless audio communication technologies, the system enhances operational performance while maintaining user safety and reliability.

The project is conducted within the CMPE 491 – Senior Project I course at TED University, through the joint efforts of Computer Engineering and Electrical–Electronics Engineering students. Thus, AKKE represents an interdisciplinary engineering project, combining hardware and software expertise to achieve a robust and integrated design.

In summary, AKKE merges human–machine interaction with secure communication technologies, offering an innovative, silent, and effective command-control solution for defense and security applications.

1.1 Description

AKKE is a wearable system that detects hand movements, interprets them as predefined commands, and transmits them wirelessly. The glove uses flex sensors to capture finger bending and IMU sensors (accelerometer and gyroscope) to detect hand orientation and motion. The collected data are processed by an ESP32-S3 microcontroller, which maps recognized gestures to corresponding audio commands.

Commands are transmitted through an audio module, and the system operates independently without requiring any external network connection, ensuring privacy and security during operation.

In conclusion, the AKKE system provides silent, fast, and secure command communication, offering an effective human–machine interaction solution for military and security applications.

1.2 Constraints

1.2.1 Economic

The project is limited by a specific budget for obtaining necessary components for the prototype, such as sensors (e.g., gyroscopes, accelerometers), microcontrollers, glove materials, and other electronic elements. Moreover, since a separate glove is to be designed for each soldier, the system must be developed with cost efficiency in mind to ensure feasibility for large-scale production.

1.2.2 Environmental

The smart glove is designed for military use, so it must be very durable. It must function in harsh environments with dust, moisture, and extreme temperatures. This requirement affects which materials we can select and how we protect the internal components.

1.2.3 Social

As the system is intended for military and security-oriented applications, data privacy, reliability, and responsible usage are crucial. The system should not endanger user privacy or violate confidentiality principles during operation.

1.2.4 Political

As a military application, the project may be subject to defense industry standards and regulations. This could entail additional procedures and permissions during the development and testing phases.

1.2.5 Health and Safety

The glove must be comfortable and ergonomic for personnel during long-term use. Materials should be selected to avoid skin irritation or allergic reactions. Device safety, including battery safety and electromagnetic compatibility, is crucial for the health and safety of the user.

1.2.6 Manufacturability

The hardware design should allow for easy assembly, maintenance, and reproducibility. If mass production is considered in future stages, component placement and wiring must be optimized for manufacturability and cost reduction.

1.2.7 Sustainability

Low power consumption and long battery life are critical for ensuring uninterrupted operations in the field. The ease of maintenance, repair, and updates will ensure the project is long-lasting and sustainable.

1.3 Professional and Ethical Issues

This section outlines the professional and ethical responsibilities considered during the development and deployment of the AKKE project. The project adheres to the principles of the ACM Code of Ethics [1], the IEEE/ACM Software Engineering Code of Ethics [2], the IEEE Code of Ethics [3], and the Stanford Encyclopedia of Philosophy's *Computer and Information Ethics* [4]. The main ethical principles include public welfare, avoidance of harm, honesty, privacy, fairness, responsibility, and sustainability.

1.3.1 Public Welfare and Safety

The AKKE system is designed to enhance safe and reliable communication between users. Therefore, public welfare and safety are top priorities throughout the project. Both hardware and software components will be tested to ensure safe operation, and fail-safe mechanisms will be implemented to minimize risks. In case of incorrect gesture recognition, the system will provide visual feedback to prevent false commands.

1.3.2 Privacy Data Protection

The AKKE project is committed to protecting data privacy and integrity as a fundamental principle. The system's internal communication infrastructure will be isolated from external wireless networks to prevent any unauthorized access or data leakage attempts. This ensures that external networks cannot intrude into or interfere with the system's data flow.

- Only the necessary sensor data required for system operation will be collected and processed.
- No personal or identifiable user data will be stored, transmitted, or shared with third parties.
- Network connections will be protected against unauthorized external access, minimizing the risk of privacy breaches and security threats.

This approach complies with IEEE Policy 9.25 (Information Disclosure Policy) and IEEE Policy 9.26 (Non-Discrimination and Civility Policy), ensuring adherence to ethical data management and responsible information handling standards.

1.3.3 Fairness, Neutrality, and Accuracy

The machine learning models used in AKKE are designed to ensure fair and consistent performance for all users, regardless of physical or demographic differences. For instance, differences in hand strength between male and female users will not cause inconsistency in the system's performance. The system will be tested on various user groups (e.g. different hand sizes, gender, age) to reduce any potential issues that may affect accuracy or usability. In simple terms, the system should perform reliably and impartially, regardless of who operates it.

Furthermore, the system’s capabilities and limitations will be communicated honestly and transparently, without exaggeration or misleading claims. This approach aligns with the IEEE/ACM principles of honesty, accuracy, and fair communication.

1.3.4 Professional Responsibility and Competence

All project team members will perform tasks within their area of expertise and follow professional standards in all stages of the project.

- Project outputs will be reviewed through peer review processes.
- Traceability will be maintained for code, documentation, and testing activities.
- Ethical decisions and potential conflicts of interest will be clearly disclosed.

This framework is consistent with the IEEE/ACM Code of Ethics, emphasizing professional judgment, independence, and integrity.

1.3.5 Misuse and Unauthorized Access Risk

The AKKE system is designed for use only by authorized personnel within defined operational roles.

To prevent misuse or unauthorized operation:

- Command sets will be limited and controlled to maintain operational safety.
- User authentication and role-based access control will be implemented to ensure that only authorized individuals can operate the system.

These measures comply with the IEEE Ethics and Member Conduct guidelines.
In summary, the system will only be accessible to individuals who are authorized and trained, operating under defined ethical and safety standards.

1.3.6 Legal, Organizational, and Compliance Aspects

The project will comply with all applicable legal regulations, including data protection, electromagnetic compatibility, and occupational safety. The principles of transparency, accountability, non-discrimination, and information security, as emphasized in IEEE governing documents, will be maintained. If human participants are involved in testing, their informed consent will be obtained, and all ethical board approvals will be secured prior to experimentation.

2. Requirements

2.1. FUNCTIONAL REQUIREMENTS

2.1.1 Sensor and Data Collection

- **REQ-F-001:** The system must have flex sensors to detect finger bending
- **REQ-F-002:** The system must have motion sensors (IMU/accelerometer/gyroscope) to detect hand orientation and movement
- **REQ-F-003:** All sensor data must be collected in real-time without interruption
- **REQ-F-004:** The system must read data from sensors

2.1.2 Gesture Recognition

- **REQ-F-005:** The system must recognize at least 5 different hand gestures
- **REQ-F-006:** Recognition accuracy must be at least 75-80%

2.1.3 Audio Communication

- **REQ-F-009:** The system must store audio command files on SD card
- **REQ-F-010:** The system must play audio files based on recognized gestures
- **REQ-F-011:** The system must broadcast audio via RF Module
- **REQ-F-012:** Multiple receivers (radios) must receive broadcasts simultaneously

2.1.4 Command Processing

- **REQ-F-013:** The system must convert sensor data to gesture recognition
- **REQ-F-014:** The system must map gestures to specific audio commands
- **REQ-F-015:** Commands must be transmitted without requiring line-of-sight
- **REQ-F-016:** The system must work silently (no speech required)

2.2. NON-FUNCTIONAL REQUIREMENTS

2.2.1 Performance

- **REQ-NF-001:** Gesture recognition response time must be under 1 seconds
- **REQ-NF-002:** The system must process multiple sensor inputs simultaneously

2.2.2 Hardware Components

- **REQ-NF-003:** Microcontroller: ESP32-S3, responsible for sensor data processing and gesture recognition
- **REQ-NF-004:** Audio module: DFPlayer Mini, used for audio playback and command transmission.
- **REQ-NF-005:** Radio transmitter: FM-based transmission module for wireless audio communication.
- **REQ-NF-006:** Storage: MicroSD card.

- **REQ-NF-007:** Power Supply: Lithium battery or adapter.
- **REQ-NF-008:** Antenna: For RF transmission.

2.2.3 Sensor Specifications

- **REQ-NF-009: Flex sensors:** Must detect finger bending from 0° to 180°
- **REQ-NF-010: IMU sensors:** Must provide 3-axis acceleration and 3-axis gyroscope data
- **REQ-NF-011:** Sensor sampling rate must be sufficient for real-time gesture detection
- **REQ-NF-012:** Sensors must be flexible and comfortable to wear

2.2.4 Reliability

- **REQ-NF-013:** The system must work in harsh military environments
- **REQ-NF-014:** The system must support a minimum communication range of 10 meters
- **REQ-NF-015:** The system must handle sensor noise and interference

2.2.5 Usability

- **REQ-NF-016:** The glove must be easy to put on and take off
- **REQ-NF-017:** System setup and calibration must be simple

2.2.6 Maintainability

- **REQ-NF-018:** Battery must be rechargeable or replaceable

3. References

[1] ACM, “ACM Code of Ethics and Professional Conduct.” Available: https://www.acm.org/code-of-ethics

[2] IEEE Computer Society, “Software Engineering Code of Ethics and Professional Practice,” Oct. 27, 2025. Available: https://www.computer.org/education/code-of-ethics

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[4] T. W. Bynum, “Computer and Information Ethics,” *Stanford Encyclopedia of Philosophy*, Oct. 26, 2015 (archived version). Available: https://plato.stanford.edu/archives/fall2017/entries/ethics-computer/

[5] Anthropic, *Claude* [Web application], 2025. Available: https://claude.ai/

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