

PROJECT RESULTS & PERFORMANCE

=== OVERALL RESULTS ===

Total files tested: 90
Overall accuracy: 92.2% (83/90 correct)
Overall valid rate: 95.6% (86/90 valid)

Detailed Analysis:

- **SNAP:** 90.0% accuracy (27/30), 90.0% valid (27/30)
- **CLAP:** 96.7% accuracy (29/30), 100.0% valid (30/30)
- **KNOCK:** 90.0% accuracy (27/30), 96.7% valid (29/30)

Error Analysis:

- **SNAP misclassified as:** rejected_long: 3 times
- **CLAP misclassified as:** snap: 1 time
- **KNOCK misclassified as:** clap: 2 times, rejected_long: 1 time

FUTURE DEVELOPMENTS

HARDWARE ENHANCEMENTS

- **Portable GameBoy-like Unit:** Battery-powered with integrated display for standalone play
- **Wireless Communication:** Wi-Fi and Bluetooth connectivity for remote control and multiplayer options
- **Enhanced Audio Hardware:** Multiple microphones with beam-forming for better noise rejection
- **Custom PCB Design:** Miniaturized circuit with optimized components for better performance

SOFTWARE IMPROVEMENTS

- **Advanced ML Models:** Implementing neural networks for improved sound classification accuracy
- **Adaptive Learning:** System that learns from user patterns to improve personalized recognition
- **Expanded Sound Palette:** Support for more sound types beyond snap, clap, and knock

CHALLENGES & SOLUTIONS

TECHNICAL CHALLENGES

- **User Variability:** Differences in how users produce claps, snaps, and knocks affected the system's consistency
- **Environmental Noise:** Capturing distinct sounds in noisy environments while maintaining high accuracy
- **Feature Extraction:** Developing features resilient to variations in user intensity, timing, and gesture patterns
- **Real-time Processing:** Balancing computational complexity with the need for immediate feedback

SOLUTIONS IMPLEMENTED

- **Hybrid Classification:** Combined energy thresholds with feature-based methods for more robust classification
- **High-pass Filtering:** Reduced low-frequency noise and improved signal quality
- **Feature Normalization:** Enhanced system resilience to variations in sound intensity
- **Training Data Diversity:** Collected samples from multiple users to improve generalization
- **User Calibration:** Optional session-specific thresholds to adapt to individual users

CONCLUSIONS & IMPACT

PROJECT ACHIEVEMENTS

- Created a fully functional sound-based Simon Says game with >92% classification accuracy
- Developed a hybrid sound classification algorithm optimized for real-time performance
- Successfully integrated MATLAB signal processing with ESP32 microcontroller hardware
- Demonstrated practical application of audio feature extraction and classification
- Built an intuitive, responsive game interface with visual feedback

BROADER IMPACT & APPLICATIONS

- **Accessibility:** Potential applications for motor-impaired users who can produce sounds but have limited physical movement
- **Education:** Demonstrates principles of signal processing and machine learning in an engaging format
- **HCI Research:** Platform for exploring sound-based human-computer interaction
- **Entertainment:** Novel gaming concept that engages players in a unique way