Real Time EMG-Based Hand Gesture Recognition using SVM

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Background

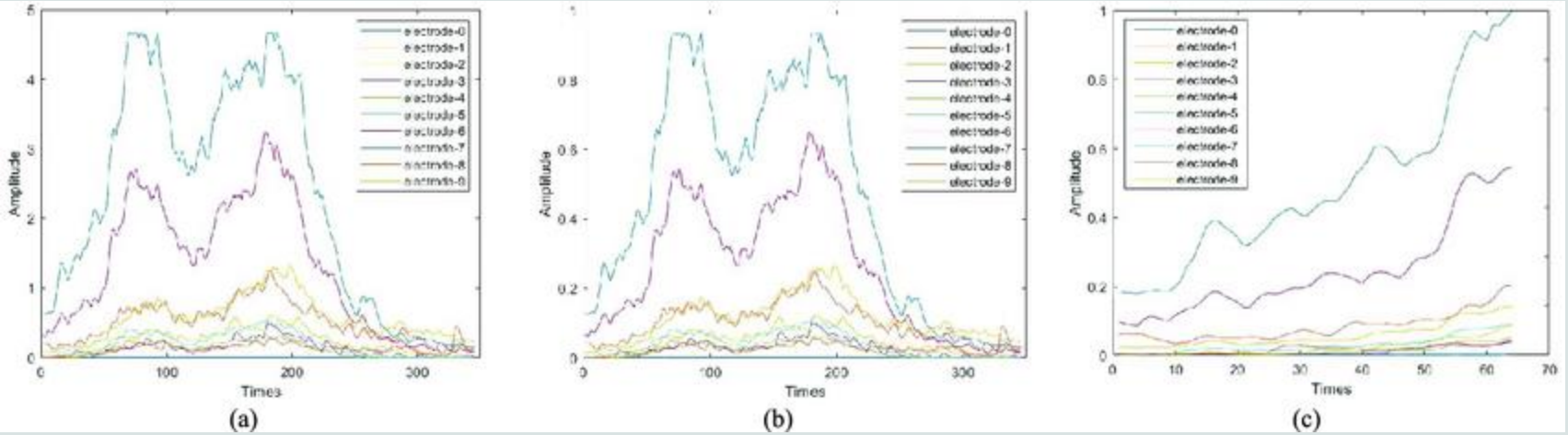
- **Electromyography:** EMG measures the electrical signals produced when muscles contract. Surface EMG uses electrodes on the skin to capture these signals
- **Why Prosthetics Need EMG:** Prosthetic hands aim to restore function after limb loss. A key challenge is making control intuitive. Buttons or joysticks feel unnatural; EMG allows the user to move the prosthetic simply by thinking about moving their muscles.
- **ML's Role:** Raw EMG is noisy, variable between people, and hard to interpret directly. ML models can map EMG patterns → hand gestures (open, fist, pinch). Once classified, these gestures can be translated into prosthetic movements.

Objective/Goals

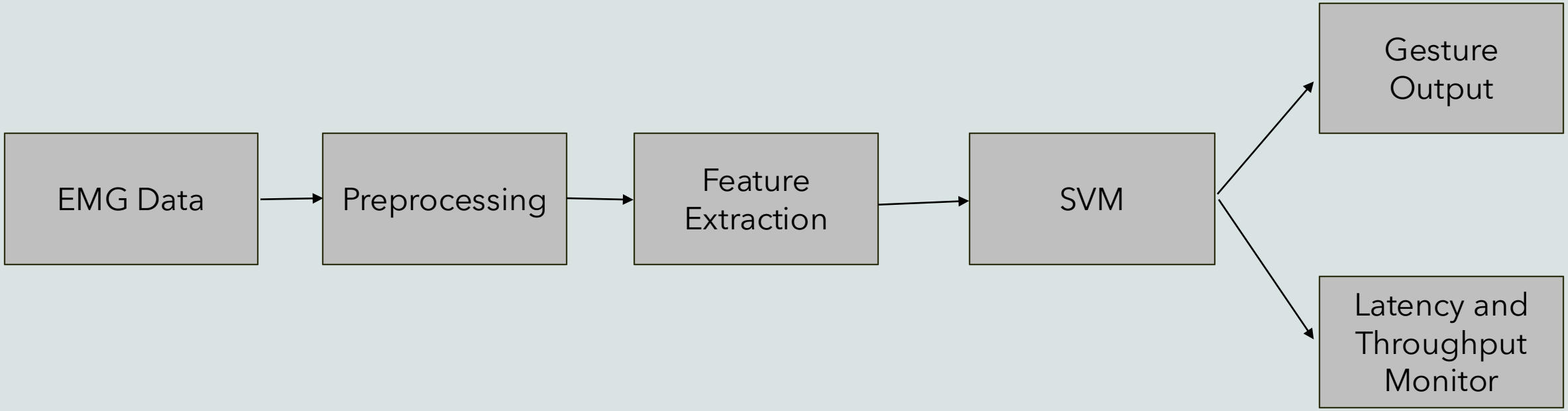
- Develop a preprocessing pipeline for EMG signals, including filtering and segmentation.
- Extract discriminative features (RMS, Mean Absolute Value, Waveform Length) for gesture classification.
- Train and evaluate an SVM classifier for multi-class gesture recognition.
- Implement a realtime simulation environment to output predictions via a text/GUI interface.
- Analyze system-level performance by measuring latency and throughput, with the aim of achieving low-latency inference suitable for assistive technologies.

Data

- NinaPro = *Non-Invasive Adaptive Hand Prosthetics Database*
- Large-scale EMG dataset collected from healthy subjects and amputees.
- Includes multiple hand gestures
- EMG recorded with surface electrodes at multiple channels.



Design



The pipeline begins with EMG data, which is preprocessed and transformed into features such as RMS and waveform length. These features are passed to an SVM classifier that outputs predicted hand gestures. The predictions are displayed through a simple text/GUI interface, while a latency and throughput monitor evaluates realtime performance. Feedback from the monitor can guide adjustments to preprocessing or feature extraction, creating a loop that balances accuracy with system responsiveness.

Importance

- **Bridging Biomedicine and Machine Learning:** Demonstrates how classical ML techniques like SVM can be applied to physiological signals for real-world applications.
- **Prosthetic Control Feasibility:** Highlights how EMG-based gesture recognition can enable intuitive control of prosthetic hands, improving patient independence and quality of life.