Development of a Machine Learning Powered Foot Gesture Recognition System

Including Sensor Selection, Test Setup Development, Feature Engineering, and Model Training and Evaluation

Graduate Candidates

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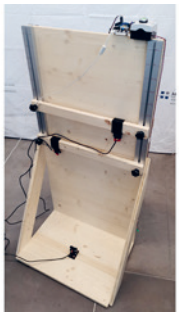
Introduction: The aim of this thesis was the development of a foot gesture recognition system. The project involved selecting a suitable gesture, choosing an appropriate sensor, and designing a test setup for data acquisition and system evaluation. The gesture detection process relies on a machine learning model that classifies input based on engineered features.

Approach: After extensive research on various sensor types, we identified two radar sensors and a Time-of-Flight(ToF)-based multi-zone infrared sensor as the most promising options for this task. To facilitate experimentation, a wooden test setup was constructed in the wood workshop. Custom fixtures were designed and 3D-printed to allow flexible mounting and positioning of the sensors. The sensor data was then collected and analyzed to develop meaningful features capable of capturing sufficient information for gesture recognition.

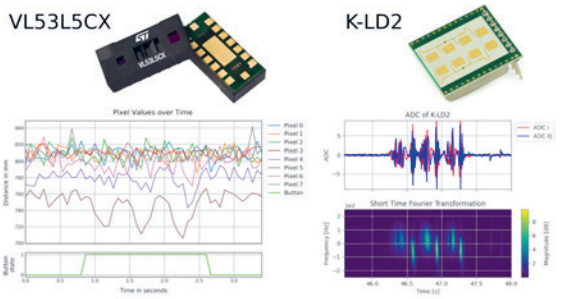
Result: Multiple features were tested and analyzed for all three sensor types. To evaluate their performance, various machine learning models were trained using different features and assessed using cross-validation techniques and several classification scores. The Random Forest and Support Vector Classifiers emerged as the most promising models, achieving accuracy scores exceeding 90% for all sensor types, even when accounting for uneven class labels.

Although incorrect classifications still occur in practical scenarios, this thesis successfully demonstrates the feasibility of classifying foot gestures using relatively simple sensors.

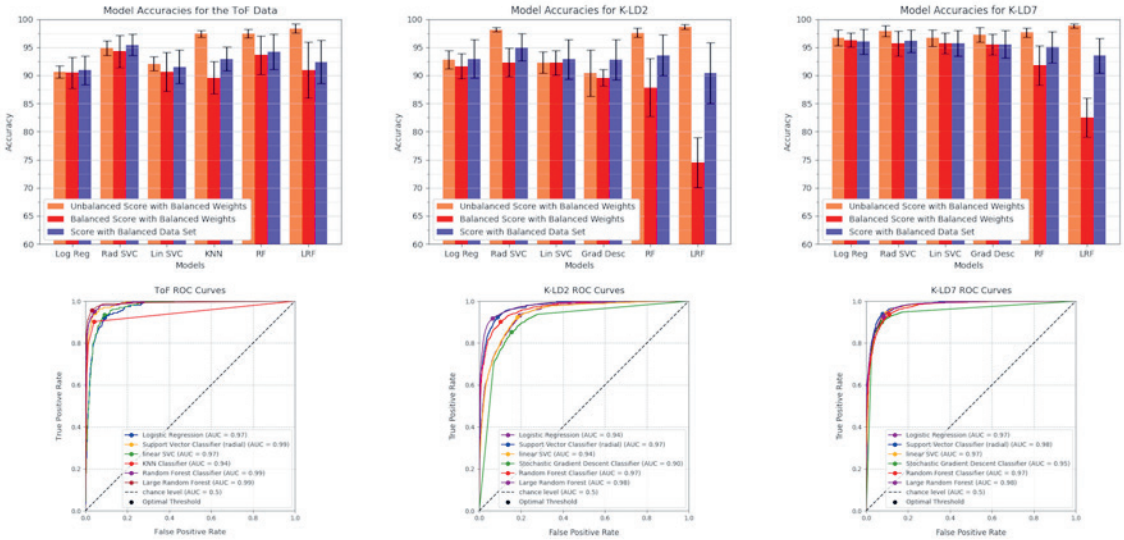
Test setup developed for this project and used for recording sensor data and evaluating classification models.
Own presentment



The utilized VL53L5CX ToF sensor (left) and K-LD2 radar sensor (right), with data plots of a performed gesture.
Own presentment including sensor images from STM and RFbeam



Model accuracies (top) and ROC curves (bottom) for the ToF, K-LD2, and K-LD7 sensors (from left to right).
Own presentment



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Subject Area
Artificial Intelligence