Mobility Scooter Safety Assessment Motion Data Processing and Mobile App Development

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Overview

Numerous safety concerns arise with mobility scooter riding, especially for older adults or patients with certain disabilities. These concerns emphasize the need for comprehensive solutions to ensure safety of riders. There are three components in this work:

1) Mobile App Development: This app aims to mitigate these safety concerns through a user-friendly mobile application. This app can record the user driving session and give feedback to the user.

2) Segmentation: Aims to utilize image segmentation to analyze the movements of drivers when riding mobility scooters.

3) Multimodal Learning: Aims to process both pose estimation and motion sensor data for safety prediction through models such as LSTM and Transformers.

Methodology

Mobile develop environment: We used Android Studio and Kotlin for development environment.
This application includes:

1. Easy to deploy and accessible design**(Figure 1)**
2. High performance of behavior analysis
3. Secure user data

Segmentation: Used Segment Anything and YOLOv8 for video processing. NVIDIA Jetson Orin Nano was used to test its capabilities of running the models in real-time.

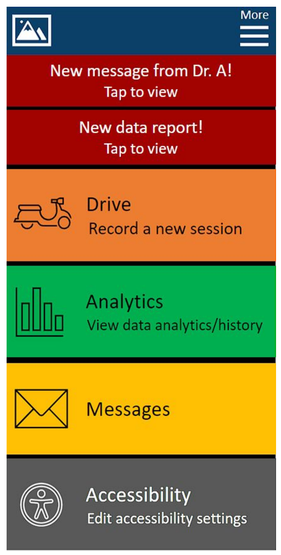

Figure 1. Mobile App Design

Multimodal Learning: Used PyTorch and Python libraries such as Pandas and NumPy to experiment with training deep learning models on pose estimation data
Progress:

1. Data preprocessing to filter out unstable frames and create dataset of 4 minute samples from pose data
2. Basic LSTM-based autoencoder for time series anomaly detection and initial embeddings **(Figure 2)**

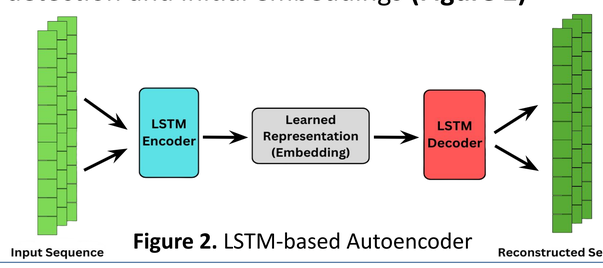

Figure 2. LSTM-based Autoencoder

System Workflow

- **System overview (Figure 3)**

Video Capture: Ends and stores in the database.
Processing: Video analyzed for key movement metrics.
Pose Estimation: Fast and accurate pose tracking.
Stability Check: Instant posture stability rating and respond.

- **Efficiency evaluation**

We made efficiency evaluation to make sure we can find the bottleneck of the application **(Figure 3).**

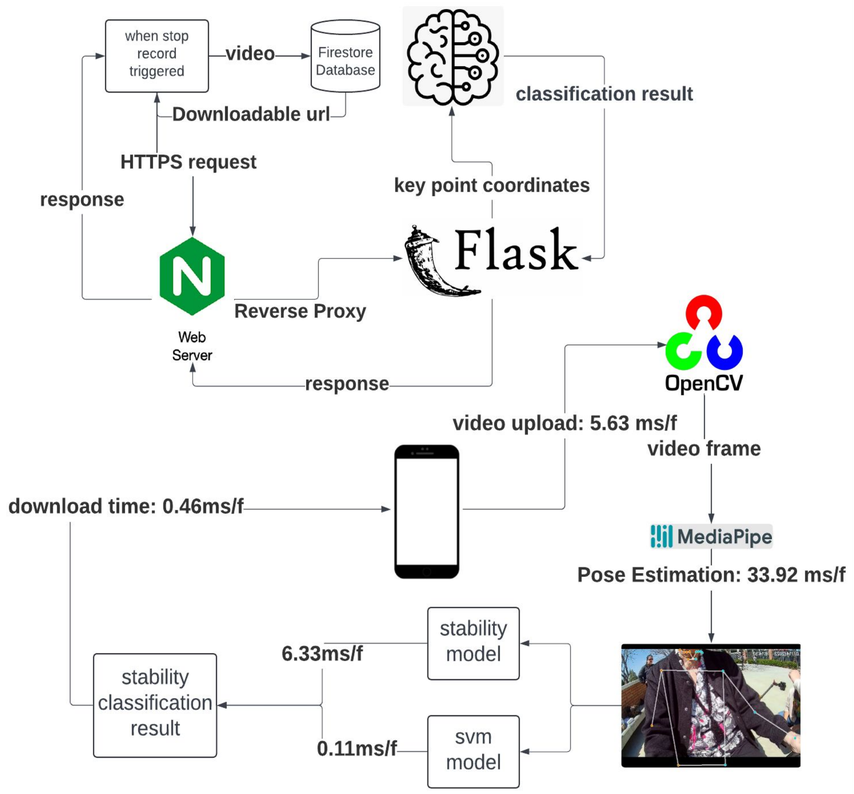

Figure 3. System workflow and efficiency evaluation

Future Work

Mobile App Development:

- Improve the efficiency for the pose estimation.
- Finish the mobile app other key function like chatting system.
- Optimize the cloud end, may apply a distribution system to improve the efficiency.

Segmentation

- Integrate with pose estimation into a single real-time application
- Analyze numerical data of masks

Multimodal Learning:

- Process motion sensor data to create embeddings and combine with pose estimation embeddings for multimodal learning
- Experiment with transformer models after testing LSTM-based autoencoders

Segmentation

One method of video processing that is being researched is segmentation. By utilizing open-source image segmentation models such as Segment Anything, a cut-out (mask) of the driver's body can be made. **(Figure 4)** Segment Anything is capable of taking in bounding boxes as a prompt, so to ensure that just the driver's body gets segmented, a bounding box is inputted for each frame. This bounding box is constructed using YOLOv8, an object detection model. This is useful for removing the background of videos for privacy purposes. The numerical data from the masks may potentially be useful for analyzing the safety of the driver by the shape of their body, but this method needs to be further developed.

Figure 4. Before and after segmentation

The NVIDIA Jetson Orin Nano is being tested for its capabilities of running real-time machine learning applications. **(Figure 5)** With current optimizations, it is capable of running video segmentation at roughly 9 FPS.

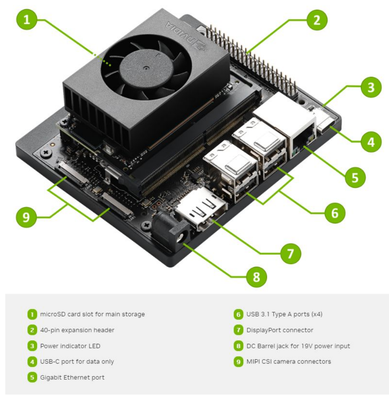

Figure 5. NVIDIA Jetson Orin Nano [4]

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