Enhancing Human activity modeling through Spatio-temporal neural nets for applications in assistive robotics

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This study explores the potential of enhancing wearable robotics by analyzing walking activity data from a number of subjects. The research team employs sophisticated algorithms to recognize distinct human activities, aiming to bridge the gap between human motion and robotic assistance. By decoding patterns within walking data, the project seeks to contribute significantly to the development of more intuitive and responsive wearable robotic systems.

Activity Recognition Problem
In the realm of human activity recognition (HAR), the challenge lies in accurately identifying and classifying the type of activity being performed based on sensor data. This research focuses on a unique dataset collected from nine subjects performing four distinct activities: Slow Walking (SW), Fast Walking (FW), Normal Walking (W), and Running (RW). These activities were chosen to span a broad spectrum of human locomotion dynamics. The subjects walked on a treadmill while wearing a device embedded within the soles of their shoes, designed to measure the ground reaction forces (GRFs). These forces are pivotal in understanding the nuances of each activity, as they directly correlate with the biomechanical and physiological aspects of human movement.

Recognizing these activities with high accuracy is crucial for applications ranging from sports science to rehabilitation and beyond.

Knowledge Distillation
Knowledge distillation is used to transfer insights from complex, pre-trained networks to smaller, more efficient models. In this method, a smaller “student” model learns to replicate the “teacher” model’s output. The goal is to make the student model as effective as the larger model but with fewer computational demands. This is essential for use in devices with limited processing power, like wearable technology. By doing so, we ensure our models are both accurate and capable of real-time operation in such devices. Advantages include reduced model size and computational requirements, making the technology more accessible and practical for everyday applications.

Future Work
This research contributes to wearable human robotics, especially in developing assistive devices like exoskeletons and prosthetics. By accurately identifying walking activities and understanding ground reaction forces, we can improve these devices’ design and functionality. Integrating our activity recognition algorithms into wearable robotics enables these devices to assist movement more naturally and efficiently. This advancement helps in rehabilitation, helping people recover from injuries or overcome mobility impairments, ultimately enhancing their quality of life.

Neural Architecture for Insole Data Processing:
In this research, we use pre-trained ResNet models (e.g., ResNet-8, ResNet-20) for feature extraction and classification. ResNet’s design helps avoid the vanishing gradient problem, making it possible to use deeper networks. We adapt these models to our task of recognizing activities from 1D time series data of ground reaction forces. Since the original ResNet models are designed for 2D data (images), we modify the convolutional neural networks (CNNs) to process 1D data. This adaptation involves adjusting the input layer to accept 1D time series inputs, allowing the models to effectively learn from and classify our specific type of data. This strategy speeds up training and improves the models’ ability to generalize across different tasks by utilizing the complex features ResNet has learned from various datasets.

Knowledge Distillation

References

Grand Challenges Scholars Program
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