ProGait: A Multi-Purpose Video Dataset and Benchmark for Transfemoral Prosthesis Users

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A. List of General Gait Category and Subcategories for Gait Deviation

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1	Rotational Deviations	37
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Table 1. Distribution of general gait categories. The hierarchical relationship between general gait categories and gait deviations can be found in the supplementary materials.

- **Rotational Deviations:** These involve abnormal inward or outward twisting of the prosthetic limb or foot during walking, often leading to inefficient movement, joint stress, and potential discomfort or skin issues. They disrupt the natural alignment and progression of the leg through the gait cycle.
  Subcategories:
  Medial whip
  Lateral whip
  Toe-in asymmetry
  Internally rotated foot
  Toe-out asymmetry
- **Step and Base of Support Deviations:** This category covers issues with the width of the walking path or how the feet are placed, often indicating problems with stability, balance, or confidence. Such deviations can result in an unsteady, energy-intensive, or overly rigid gait.
  Subcategories:
  Too narrow step width
  Too narrow base of support
  Too wide base of support
  Abducted gait
  Leaning pylon
- **Step Length and Timing Issues:** These are inconsistencies in the length or synchronized timing of individual steps, typically signaling imbalances, pain, or problems with prosthetic control. They lead to an asymmetrical and less efficient walking pattern.
  Subcategories:
  Asymmetric step length
  Terminal impact
  Early foot flat
- **Knee Instability and Malalignment:** This category describes issues where the prosthetic knee is unstable or improperly aligned, significantly impacting safety and function, especially for above-knee amputees. It can cause a feeling of insecurity, increase fall risk, and lead to abnormal loading.
  Subcategories:
  Insufficient knee flexion
  Hyperextended knee
  Knee varus asymmetry
  Excessive valgus
  Externally rotated knee
- **Prosthetic Length Issues:** These deviations occur when the prosthetic limb is not the correct length, forcing the user to adopt compensatory movements throughout the body. Even minor discrepancies can drastically affect gait mechanics, increasing energy expenditure and potential for secondary problems.
  Subcategories:
  Prosthesis too short
  Prosthesis too long
  Hip drop
- **Roll-Over and Clearance Issues:** This category addresses problems with the smooth weight transfer over

the prosthetic foot during stance or the ability of the prosthetic limb to clear the ground during swing. These issues greatly reduce walking fluidity and often trigger compensatory actions like hip hiking or circumduction.
Subcategories:
Incomplete roll-over
Insufficient toe clearance
Circumduction

- **Socket Fit and Stability:** These deviations are direct results of an ill-fitting or unstable prosthetic socket, which is crucial for comfort and function. Poor fit can cause pain, skin irritation, and instability, leading to compensatory movements and an inefficient gait.
Subcategories:
Socket too wide in ML
Lateral instability
- **Foot and Ankle Deviations:** This category includes abnormalities in the prosthetic foot and ankle's position or movement, affecting shock absorption, propulsion, and balance. Such issues often stem from incorrect component selection, alignment, or the user's compensatory habits.
Subcategories:
Incongruity of knee and ankle axes
Excessive plantar flexion
Excessive dorsiflexion
Pronated or everted foot
- **Normal Gait:** This describes an efficient, symmetrical, and coordinated walking pattern where muscles, joints, and the nervous system work in harmony for stability and propulsion. The goal for prosthetic users is often to achieve a gait as close to this natural, energy-minimizing pattern as possible.

B. Subject Diversity

The four subjects in our dataset are middle-aged/elderly above-knee amputees (with an average age of 61), represents a significant and specific sub-population within the amputee community - those who have lost their limbs due to vascular issues (e.g., diabetes-related complications leading to limb loss). This demographic constitutes a large portion of lower limb prosthesis users in the U.S. [1, 4, 5]. For this sub-population, safety and comfortable alignment are paramount, often prioritizing stability over high activity levels, especially with newly-fitted prostheses which are the focus of our data collection.

While the dataset is limited to four subjects due to the inherent challenges and costs associated with recruiting and testing this vulnerable population, commonly leading to small sample sizes in highly specialized prosthetics research [2, 3, 6], it's noteworthy that each subject presents highly diverse gait patterns and poses across various walking trials. This variability arises from the diverse prosthesis configurations, including differences in knee and ankle angles, pylon lengths, and knee mechanisms. These factors influence the subject's walking dynamics, ensuring diversity in video data samples. As a result, the dataset captures a broad spectrum of gait variations, which is crucial for training and evaluating vision models in real-world scenarios. The promising results achieved even with this small set of initial samples, on the other hand, underscores the potential of our methodology for future scaled-up studies, which will certainly aim to incorporate broader demographic and prosthetic diversity.

C. Additional Video Samples

In this appendix, we provide additional video samples and visualized annotations in all scenarios and views. This provides a comprehensive view of the whole dataset, and shows the diversity of scenes, poses and gaits in ProGait dataset.

References

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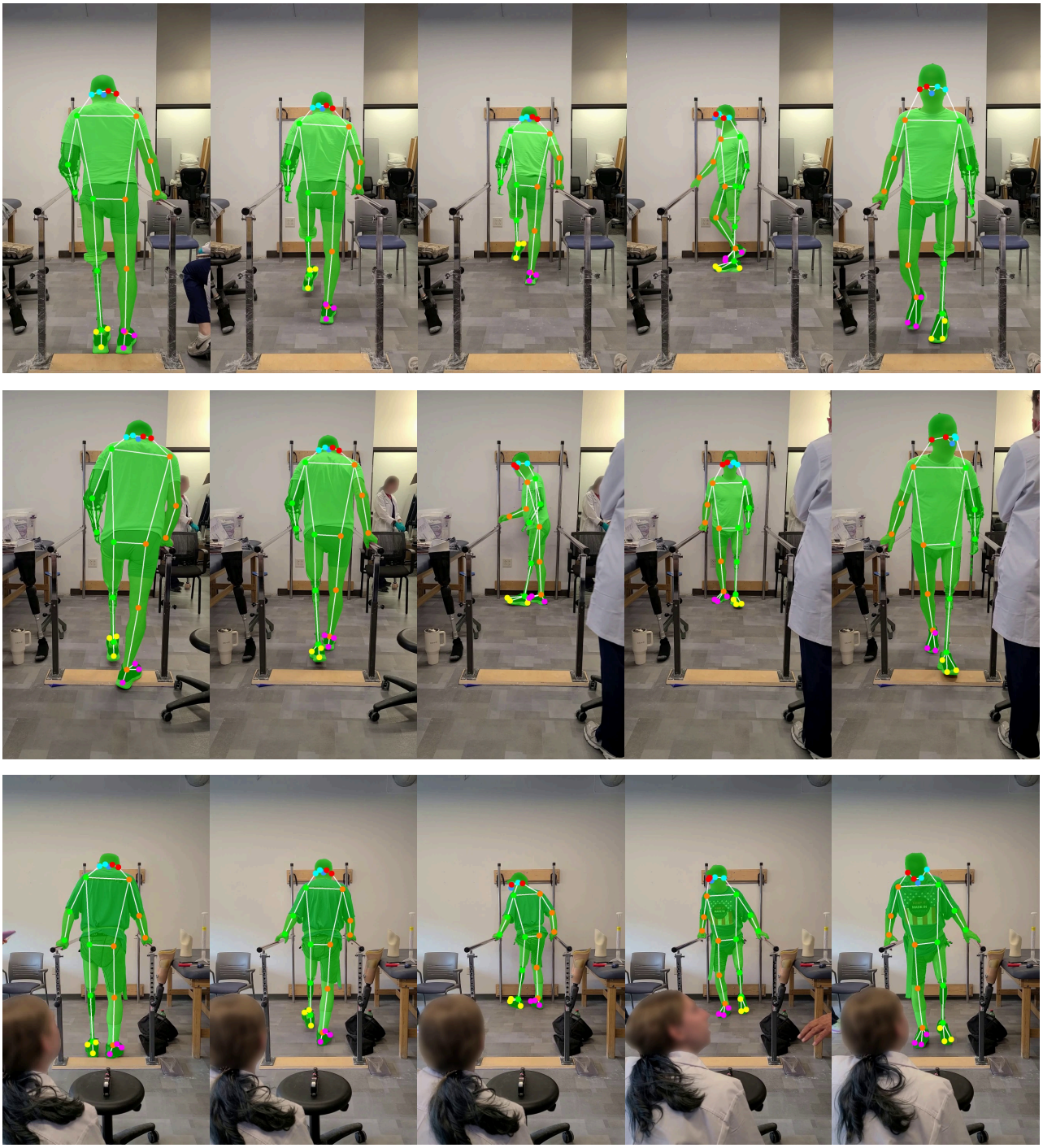

Figure 1. Videos and corresponding annotations captured at **frontal** view **inside** the parallel bar. Sequence 1 & 2 shows Subject 1 walking with a simple mechanical knee vs. a hydraulic knee. Sequence 3 shows Subject 2 walking with another model of hydraulic knee.

Figure 2. Videos and corresponding annotations captured at **sagittal** view **inside** the parallel bar. Subjects 1, 3, and 4 are shown walking with various prosthetic knee types: mechanical, hydraulic, and mechanical, respectively.

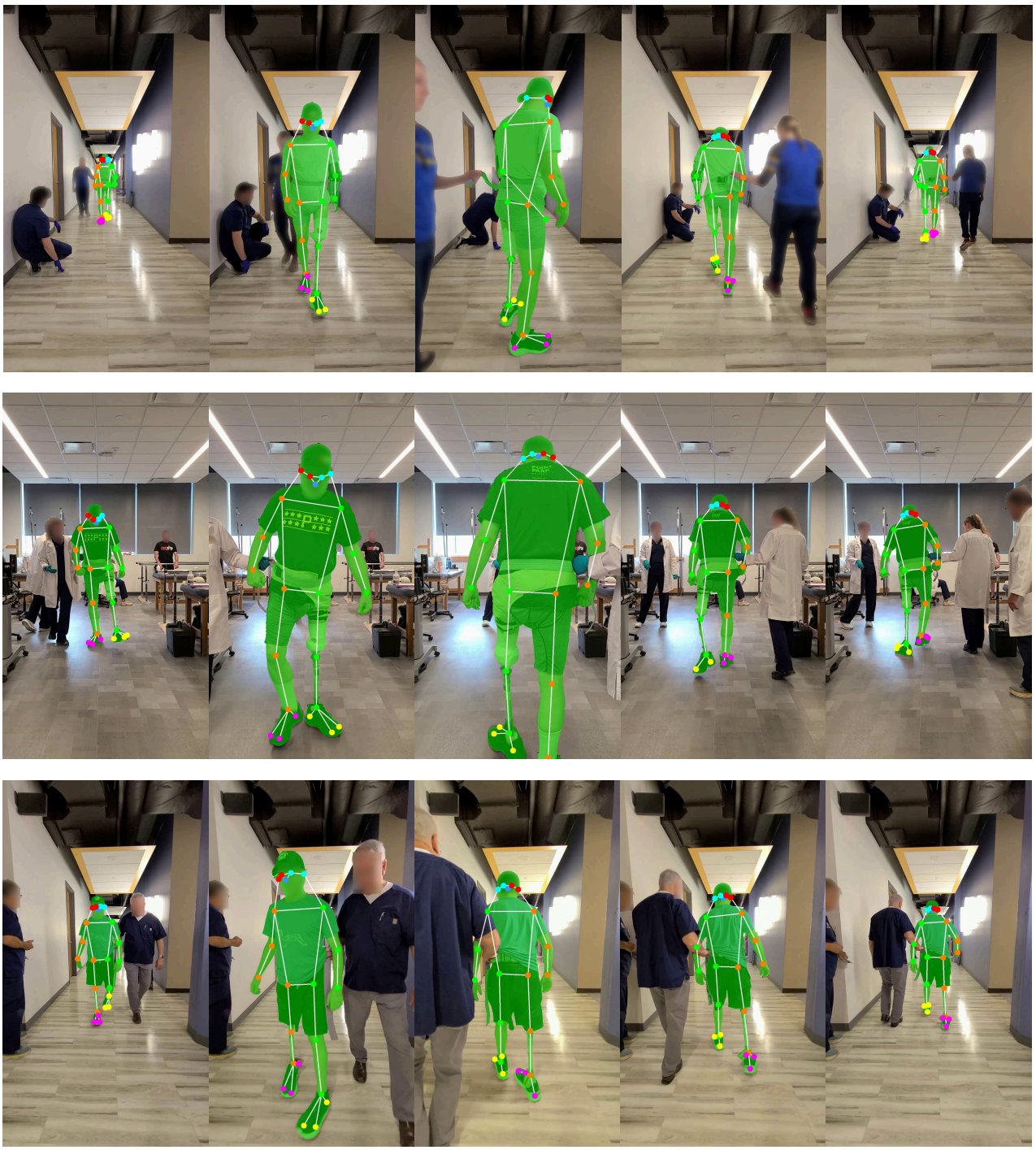

Figure 3. Videos and corresponding annotations captured at **frontal** view **outside** the parallel bar. Subject 1, 2, and 3 walking alongside the hallway with mechanical knees, accompanied by the healthcare staff.

Figure 4. Videos and corresponding annotations captured at **sagittal** view **outside** the parallel bar. Subjects 1, 2, and 4 walking alongside the hallway with mechanical knees, accompanied by the healthcare staff.