ANALYSIS OF GAIT KINEMATICS

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Algorithm

1. Video capture with LEDs at Hip, Knee and Ankle joints respectively. Another LED at some **arbitrary** point on the foot to determine ankle angle.
2. A snapshot in the standing position for reference.
3. Video processing to get the joint trajectories.
4. A single step was isolated from the continuous trajectory to perform the simulation. The isolated step was such that it began with the right heel just touching the ground i.e. stance phase for right leg begins.
5. Inverse Kinematics to get the joint angles at every instant.
6. Assuming the gait is symmetric with respect to left and right foot, out of phase by half the step-time (say T_f), right heel was set as reference and forward kinematics was performed across 8 link (R – Heel-Ankle-Knee-Hip - L-Hip- Knee- Ankle- Heel) for half the time i.e. $T_f/2$.
   After that time, it is expected that left heel as just touched the ground and hence it is a better choice for being the reference. Hence, from this time onwards until the end of T_f, forward kinematics will be performed beginning from the left heel i.e. (L – Heel-Ankle-Knee-Hip - R-Hip- Knee- Ankle- Heel).

   The individual joint trajectories of these 8 points are expected to be continuous at the point where this transformation from right heel reference to left heel reference occurs so long as no additional constrains on the system are imposed.

Need For Additional Constrains

1. While writing the forward kinematics up from right heel to right hip and then going downwards from left hip to left toe, there is not guarantee to begin with that along the vertical axis, right heel will not cut the walking plane. This is because many additional degrees of freedom have been neglected. For eg. Frontal degrees of ankle, hip.
   However, it is not possible for any body part to cut the walking plane, this requires the first constrain i.e. if $Z_{toe} < 0$, $Z_{leg} = Z_{leg} - Z_{toe}$. This essentially means that if the toe of any leg (left leg in case just discussed) at any time during the gait intersects the walking plane then that leg is shifted upwards in the model to ensure that toe only touches the ground and not go inside it.
2. **Foot –** In the walking model, the foot is also shown .The constrain of not cutting the walking plane was also imposed on Z_{toe}. This complicates the simulation, the foot which was initially modelled at 15 cm of length would

cut the walking plane too often, this elevated at least one of the legs almost at all times.

Note –

The convention for the joint angles is shown below –

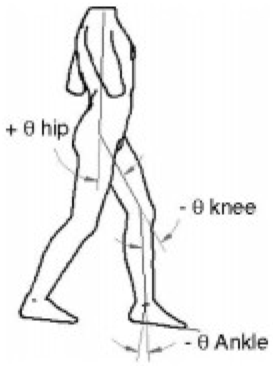
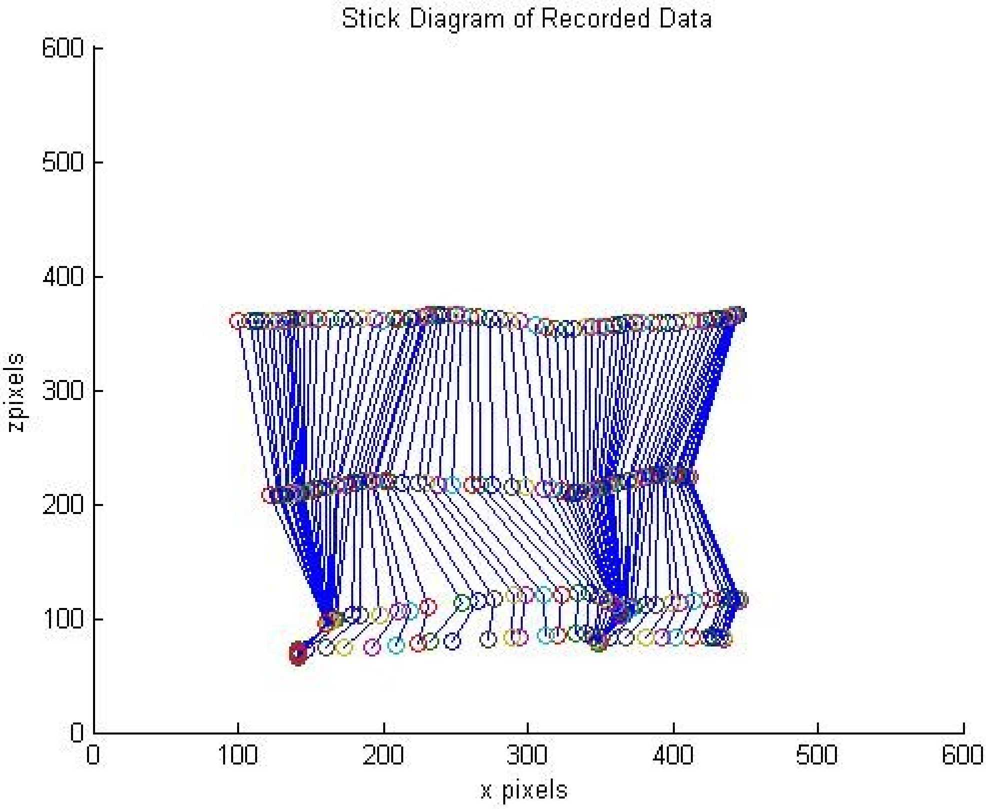


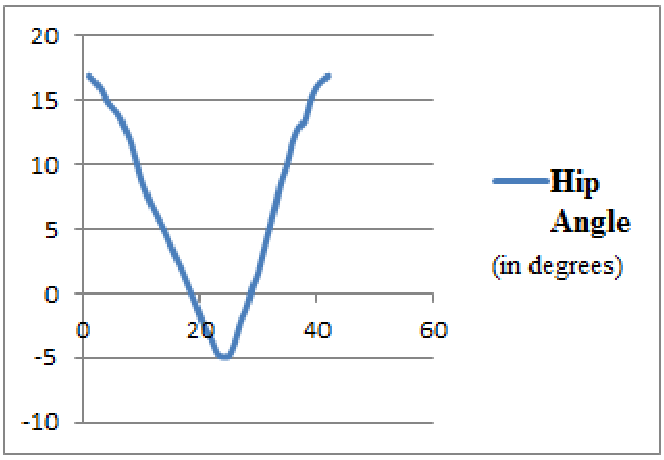
Fig. 5. Angle and torque sign conventions. Each joint angle is measured as the positive counterclockwise displacement of the distal link from the proximal link (zero in the standing position).

Observations –

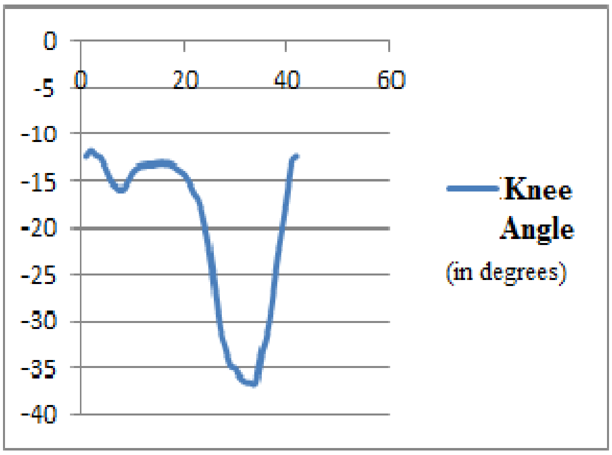
1. The stick diagram obtained from the video(full length) is as follows



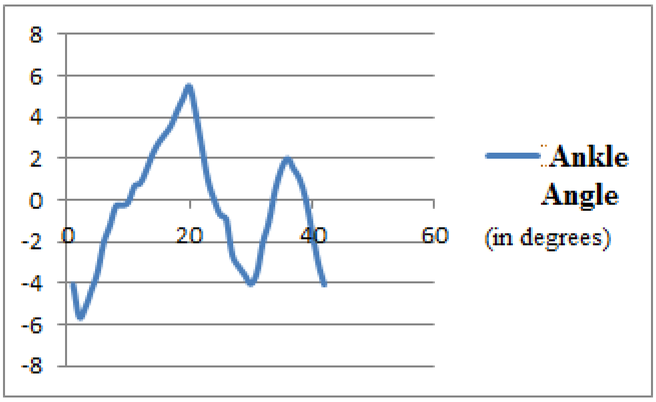
2. After isolating a single step, the raw variation of joint angles wrt to the number of frames is as follows –



Frames



Frames



Frames