JOINT REPRESENTATION OF HUMAN WALKING THROUGH THE DIRECT KINEMATICS

Ing. Esperanza Camargo, Ing. Lely Luengas, Ing. Yamid Garzón
Distrital University, Colombia.

Abstract. This paper shows the representation of human walking from the angles formed in each of the lower extremity joints and the length of each segment during each of the subphases of gait, for hip (flexion, extension , abduction and adduction, medial rotation and lateral rotation), knee (flexion and extension) and ankle (dorsiflexion, plantar flexion, pronation and supination) [1]. To determine the spatial location of each joint is modeled from the Denavit-Hartenberg parameters with the help of MATLAB.

Keywords. Gait, joint, walking, kinematics analysis, MATLAB.

Introduction. Although there are various methods of gait analysis as the kinetic and kinematic, kinematic analysis of gait is an essential tool which facilitates the diagnosis, treatment, monitoring and implementation of rehabilitation methods. This analysis is based in the description and quantification of the variation in the displacements of the body segments and the centers of rotation of joints.[2] The result is a virtual representation of clinical or joints. In general, the whole process records, processes and quantifies the movement of the patient in a clinical setting.
The lower limbs of human body are prolongations of the gluteal region at the foot and are connected to the bottom of the trunk. The three main joints are the hip, knee and ankle.[3]

Methods

For the present analysis were studied, six degrees of freedom on three joints, these are central to the process of bipedal locomotion and their ranges of motion are shown in Table 1.

Articulación	Función	Rango
Cadera	Extensión - Flexión	-30 ~ 120
	Aducción - Abducción	-20 ~ 45
	Rotación Interna - Externa	-15 ~ 60
Rodilla	Extensión - Flexión	0 ~ 120
Tobillo	Flexión Plantar – Dorsal	-40 ~ 20
	Supinación - Pronación	-35 ~ 15

Tabla 1 Rangos Articulares

We developed an application to power the system with anthropometric data, to set the length of the segments of the lower limbs [4]. The mathematical model of the links, was performed using the Denavit-Hartenberg parameters in denavit2 function () developed in MATLAB as show in Figure 1 [5]. The variables were:
Femur length.
Length of the tibia
Length of the pelvis
Ankle
Foot length

Parametros de Denavid-Hartemberg

Pierna derecha

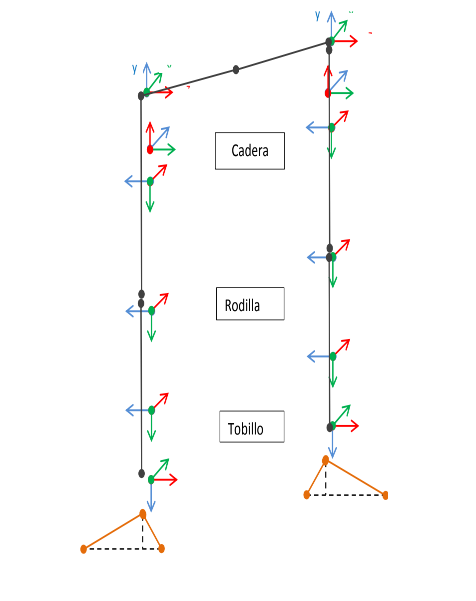
PD=[pi/2	-LDPelvis/2	0	-TD(1)	0;
-pi/2	0	0	TD(2)-pi/2	0;
-pi/2	0	0	-TD(3)+pi/2	0;
0	LDFemur	0	TD(4)	0;
0	LDTibia	0	TD(5)	0;
pi/2	0	0	TD(6)	0];

Pierna Izquierda

PI=[pi/2	LIPelvis/2	0	TI(1)	0;
-pi/2	0	0	-TI(2)-pi/2	0;
-pi/2	0	0	-TI(3)+pi/2	0;
0	LIFemur	0	TI(4)	0;
0	LITibia	0	TI(5)	0;
pi/2	0	0	-TI(6)	0];

Once removed position in x, y and z of each joint, modeling proceeds with each of them and later his cinematic assembly, for which different functions were implemented in MatLab, denavit2 (), geoeslnsbotv2 (), invcacin (), cineslab (). Once the transformation matrices obtained homogeneous kinematic assembly is performed from two substrings kinematics for each leg by cineslab functions (), invcacin (), which aim to build the drive train and the second aims to do calculate the inverse of the links for further assembly.

Denavid-Hartemberg Parameters



Right Leg				
$\frac{\pi}{2}$	$\frac{-LDPelvis}{2}$	0	-TD(1)	0
$\frac{-\pi}{2}$	0	0	TD(2)-$\frac{\pi}{2}$	0
$\frac{-\pi}{2}$	0	0	-TD(3)+$\frac{\pi}{2}$	0
0	LDFemur	0	TD(4)	0
0	LDtibia	0	TD(5)	0
$\frac{\pi}{2}$	0	0	TD(6)	0
Left leg				
$\frac{\pi}{2}$	$\frac{LIPelvis}{2}$	0	TI(1)	0
$\frac{-\pi}{2}$	0	0	-TI(2)$\frac{-\pi}{2}$	0
$\frac{-\pi}{2}$	0	0	-TI(3)+$\frac{\pi}{2}$	0
0	LIFemur	0	TI(4)	0
0	Ltibia	0	TI(5)	0
$\frac{\pi}{2}$	0	0	-TI(6)	0

Fig. 1 Denavid-Hartemberg Parameters

Results

Once parameters are entered as MTPD MTPI and which contain homogeneous transformation matrices of each of left and right legs, respectively, in addition to this the variable 'if' which indicates that the origin of kinematic assembly is in the left leg in relation to the real world, i.e. the floor.

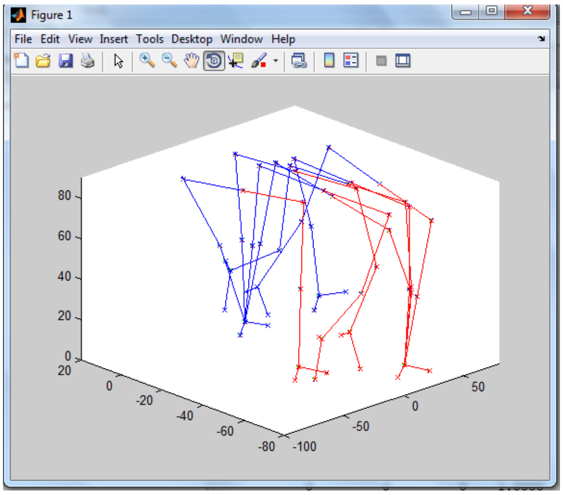


Fig. 2. Modeling of human walking in the 3 planes from the kinematics

In the figure 2 shows the kinematic assembly based on the two powertrains one red and one blue for the right leg and left leg, this can be seen each of the subphases of gait and to identify the position of the foot.

The feet were taken as a new joint through a triangle format the junction with the ankle, the point formed between the heel and ankle and the point formed between the toes and ankle, through foot plot function ().

Discussion.

The developed model is valid and can be used from the actual measurement of the angles. However, it should establish the position of the foot during each subphase.

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