Approximation Technique for Prosthetic Design Using Numerical Foot Profiling

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INTRODUCTION

Foot inspection can be done on a model skeleton. A photograph or a radiograph, on the other hand, is the medium for live foot inspection. But, do engineers need to examine radiographs or to go through autopsies to study foot biomechanics? Presently, there is no standard method for prosthetic foot design.

There are, however, methods for prosthetic foot selection. For example, clinical teams select prosthetic feet by ranking the biomechanical parameter —the spring efficiency [1]. But there are times the prescribed foot is based on intuition [2]. It is argued that the current analytical technique for calculating spring efficiency has two flaws: i) prosthetic feet with a bendable flexible keel are analyzed the same way as those with an articulated ankle and a rigid foot, ii) there is no accounting for the energy losses in the viscoelastic cosmetic material surrounding the keel which can be found in a silicon rubber cosmesis [1].

This work proposes a model that allow engineers to visualize foot structure from synthetic images created from proper profiling of bones and joints. The advantage of this model is that the engineers do not need to comprehend radiograph images or undergo autopsies to understand the skeleton mechanics. In fact, this model allow computer analysis because the stored information is digital. The objective of this work is to model foot structure in the form of numerical profile and to estimate prosthetic foot design based on justified information from the profile.

II. METHOD

A. Kinematic Structure

Kinematic structure is an abstract representation of a mechanical structure. It contains the essential information about which link (L) connects to which other links by what types of joint, J . Figure 1 shows the proposed kinematic structure that represents human foot. For example, ${}_1L$ connects ${}_2L$ and ${}_3L$. The link ${}_1L$ represents talus bone. The object shape identifies the type of link.

The legend displays the meaning of the object shapes found in the figure. For example, link ${}_1L$ is a quaternary. There are three different types of links: quaternary, ternary, and binary. A quaternary link has four joints, the ternary has three, and the binary has two. A circle represents a revolute single-axis joint. The two shaded circles are the joints that connect the foot to fibula and tibula. These points are insignificant in this study.

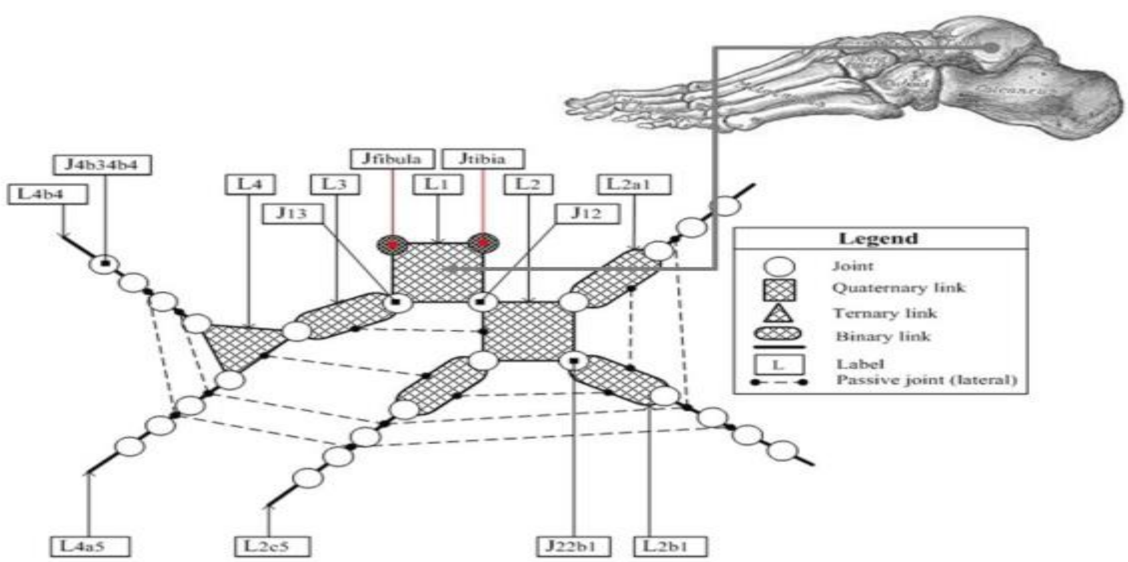

Fig. 1 The proposed human foot kinematic structure is shown above. The legend explains the object symbols that represent the components in foot. The skeleton figure has ${}_1L$ represents talus bone

B. Graph

A network of vertices is a graph. In general, a graph contains vertices and edges. In Fig. 2, the circles represent vertices V , the connecting lines as edges E , and the concentric circle is the root—talus (v_1). They are the conversion of links and joints in Fig. 1. A link is equivalent to a vertex and a joint to an edge. The labels designate locations of vertices and edges. For example, v_{21a} preceeds v_2 . The edge e_{22a1} links v_2 and v_{21a} .

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http://link.springer.com/chapter/10.1007/978-3-642-21729-6_180