MARey: A Package of Motion Analysis Routines for Three Dimensional Segmental and Joint Dynamics in MATLAB

P.R. Cavanagh1-5, K. A. Christina1,2, C.E. Milner1, N. Okita1, S. J. Piazza1,6, and J. S. Higginson1

1The Center for Locomotion Studies, Penn State University, University Park, PA, USA
Departments of 2Kinesiology, 3Biobehavioral Health, 4Medicine, and 5Orthopaedics & Rehabilitation, 6Mechanical and Nuclear Engineering, Penn State University, University Park and Hershey, PA, USA
Email: celos@psu.edu Web: www.celos.psu.edu

Introduction

MATLAB (Mathworks Inc. Natick, MA, USA) has become a popular computer language in many fields of science including biomechanics. Although MATLAB routines have been written for the kinematic analysis of human motion (Reinschmidt et al., 1997) there is presently no publicly available package which performs both kinematic and kinetic calculations in three dimensions. The present work was designed to address this need.

Methods

The program requires the three dimensional (3D) trajectories of marker clusters attached to segments of interest as input in text format. These trajectories can be derived from any motion analysis system, although custom preprocessing routines are available to convert VICON .c3d files into the correct format. Currently configured segments include head, trunk, and pelvis as well as the thigh, shank, and foot on one side of the body. A pointing technique (Cappozzo et al., 1995) is used to identify anatomical points of interest and to define any required additional points. An optimization routine similar to that described by Leardini et al. (1999) is implemented for the location of the hip joint center. The package can be used as a stand-alone kinematics program, or extended to include ground reaction forces and subject specific anthropometric data for kinetic analysis. A variety of user selectable options, available from on-screen dialog boxes, allow such features as 3D wire frame plots of segmental motion, graphical and disk output of segmental and joint angles, and trajectories of points of interest. If ground reaction forces and subject anthropometric data are provided, a full three-dimensional inverse dynamic analysis of lower extremity motion can be performed, including calculation of joint moments and powers at the hip, knee, and ankle.

Results & Discussion

Typical graphical outputs from the program illustrating stair descent by a healthy elderly subject are shown in Figure 1.

Figure 1: Sample output from the MARey program
No knowledge of MATLAB programming is required to use the MARey package which runs under MATLAB 5.3 with the signal processing toolbox. However, the routines, which use a 4 x 4 matrix approach to calculation, are available for user modification. The package is Freeware and the M-files and user manuals can be downloaded from www.celos.psu.edu/downloads/MARey. CD-ROMs are also available. There is no formal technical support for the package but the authors will attempt to correct any errors that may be found by users.

References
Reinschmidt C. et al., 1997 http://isb.ri.ccf.org/isb/software/kinemat/

Acknowledgements
This work was supported in part by NIH grant R01 AG140703