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(54) **SYSTEM AND METHOD FOR THREE DIMENSIONAL CALIBRATION OF FORCE PLATES**

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See application file for complete search history.

(56) **References Cited**

**U.S. PATENT DOCUMENTS**

5,355,715 A 10/1994 Rausche et al.  
5,814,740 A \* 9/1998 Cook ..... G01L 5/164  
73/862.637

(Continued)

**OTHER PUBLICATIONS**

Bartel et al., Force Measurement Services at NIST—Equipment, Procedures, and Uncertainty, NCSL Workshop and Symposium, 1997.\*

(Continued)

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(57) **ABSTRACT**

A method for calibrating a force platform includes, providing a force platform and applying an  $n \times m$  grid on a top surface of the force platform via a computing device. Next, applying  $p$  known loads on each of the  $n \times m$  grid points of the top surface along a Z-axis being perpendicular to the X and Y axes and along the X and Y axes. Next, taking multipoint measurements at each grid point and for each applied known load along the X, Y and Z axes and generating six measured output signals, exact position coordinates and applied known load magnitude for each grid point. Next, assembling an array of  $n \times m \times p$  of six equations with six unknown for each grid point and applied known load and then solving the assembled equations and deriving a position and load specific calibration matrix for each grid point.

**17 Claims, 17 Drawing Sheets**

