2018 Asia and Pacific Mathematical Contest in Modeling

Problem A

Real-time training model for elderly people balance ability

Falls are common in the elderly population. Falls may cause many complications in elderly people because they generally have poor rehabilitation ability, so the side effects can be so debilitating as to accelerate body failure. In addition, the fear from falls may impair the ability to move and constrict the scope of mobility, therefore worsening the quality of life significantly. Consequently, it is of great realistic importance to make a balance ability assessment for elderly people with a view to assisting them in mobility status, correcting postures and preventing accidental falls.

There is not a catch-all definition of balance for the present. Balance, in medical science, has two meanings. One is a state of static balance when the human body is maintained in a posture of stability. The other is a state of dynamic balance when the body, in motion or subject to an external force, adjusts itself to maintain a posture automatically. In mechanics, balance occurs when the resultant force on an object is zero. Balance, or stability, of the body is correlated to the position of its center of gravity and the area of the bearing surface. The body is maintained in balance if the line of gravity falls within the bearing surface, or else unbalance occurs.

A research institute made a random sampling test by deploying 42 monitoring points on the body of the elderly subjects. See the layout of the points indicated as follows the following pictures.

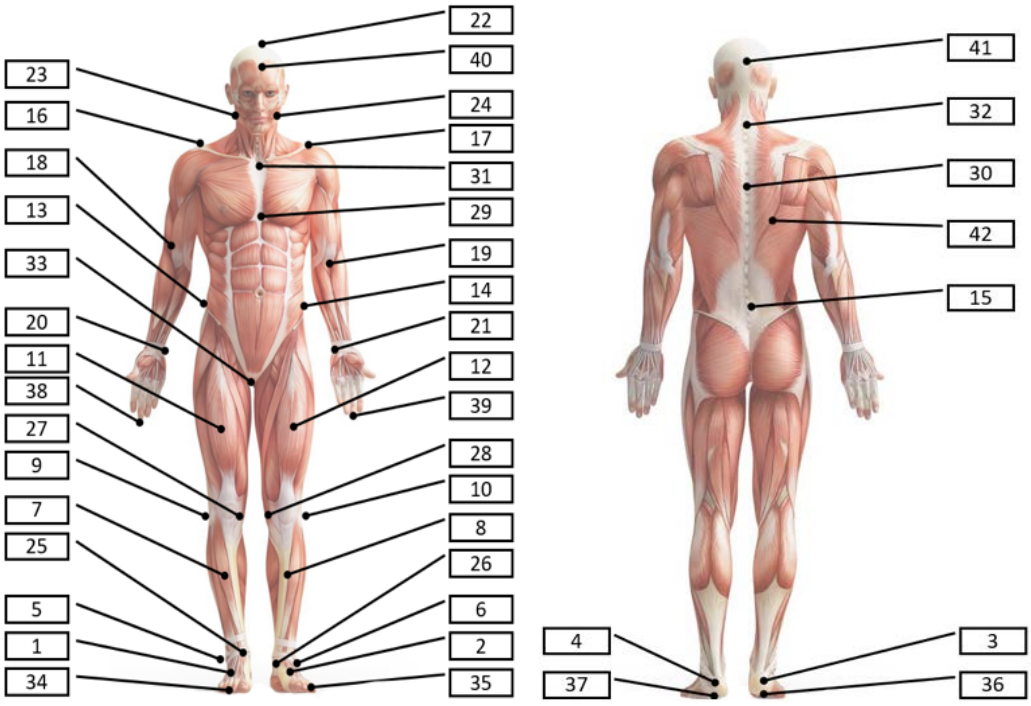

Fig. 1: The layout of the monitoring points

Complete the following tasks based on the experiment data in the annexes:

Question 1: Analyze the balance features of elderly people based on the data in Annex 2. Build a feature extraction model based on an analysis of steps, the center of gravity and motion. A system consisting of the 42 monitoring points is applied to the extraction of 25 body balance features in order for a comprehensive body balance assessment for elderly people.

Question 2: Build a balance risk assessment system based on 25 indicators to assess the balance ability of elderly people. Give advice accordingly.

Question 3: Make an analog computation and a comparative analysis of the body balance force based on the actual data provided. Give effectual advice to elderly people with weak balance ability.

Annex Description:

Annex 1: Basic Data of Elderly People (format: .xlsx) contains the basic data of all the elderly subjects.

Annex 2: Annex 2 contains the calibrated raw data of each subject in free walk state. There are three full gaits (file suffix: .trc) and can be open with Excel.

The first column is frame sequence and the second column is time. Beginning from the third column, every three columns stands for the coordinates of motion of a monitoring point (x, y, z). There are 42 monitoring points in all.