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TITLE

METHOD AND SYSTEM FOR POSTURAL STABILITY ASSESSMENT

CROSS-REFERENCE TO RELATED APPLICATIONS AND PRIORITY

10 [0001] The present application claims priority to Indian complete specification (Title: METHOD AND SYSTEM FOR POSTURAL STABILITY ASSESSMENT) Application No. (201721024012), filed in India on July 7th, 2017.

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TECHNICAL FIELD

[0002] The disclosure herein generally relate to health monitoring and assessment systems, and, more particularly, to perform postural stability assessment of a user and quantify the assessed postural stability.

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BACKGROUND

[0003] Postural instability is one of the prominent symptom associated with geriatric population and in many patients with neurological disorders like Stroke, Dementia, Parkinson's disease (PD), etc. Postural instability is also the major precursor of fall and about 35% of geriatric population fall each year, making fall prediction a significantly impacting parameter for geriatric health monitoring. Post stroke rehabilitation treatment reveals that about 83% of stroke patients suffers from postural instability leading to high fall risk.

25 [0004] Measurement or quantification of stability is required to estimate severity of stroke, define treatment plan and monitoring progress of rehabilitation programs. Postural instability is one of the cardinal signs of PD. The instability leads to progressive reduction in both static and dynamic balance, resulting in recurrent falls.

30 [0005] In view of the problems associated with postural instability and fall in a large population with neurological disorder and the total

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5 geriatric population, many postural stability assessment systems have
been introduced to the market. Most of these postural stability
assessment systems are capable of performing the postural stability,
however, require manual intervention at different stages of the
assessment. Further, the existing systems require service of a trained
10 person to operate the systems and a medically qualified person to
interpret outputs. Further, the existing systems in the area of stability
assessment work in a static manner by providing a pre-defined
questionnaire to the user and by collecting and analyzing user response
to the questionnaire.

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SUMMARY

[0006] Embodiments of the present disclosure present
technological improvements as solutions to one or more of the above-
20 mentioned technical problems recognized by the inventors in conventional
systems. For example, in one embodiment, a postural stability
assessment system is provided. The system includes a processor; and a
memory module comprising a plurality of instructions, the plurality of
instructions configured to cause the processor to monitor an action being
25 performed by a user and collecting at least one input pertaining to the
action being performed by the user, by an Input/Output (I/O) module of
the postural stability assessment system. Further, a SLS duration
measurement module of the postural stability assessment system
determines a value corresponding to Single Limb Stance (SLS) duration
30 of the user, based on the at least one input. A body joint vibration
determination module of the postural stability assessment system then
determines a value corresponding to body joint vibration of the user,
based on the at least one input. Further, a sway area determination
module of the postural stability assessment system determines a value
35 corresponding to body sway area of the user, based on the at least one

5 input. A stability index generation module of the postural stability
assessment system then determines the SLS duration, the body joint
vibration, and the body sway area, of the user as falling under at least one
respective category, and further generates a postural stability index score
for the user, based on the determined at least one category of the SLS
10 duration, the body joint vibration, and the body sway area. A stability
assessment module of the postural stability assessment system then
assesses postural stability of the user, based on the postural stability
index score.

[0007] In another aspect, a processor-implemented method for
15 postural stability assessment of a user is provided. In this method, in
order to perform the postural stability assessment, initially at least one
input pertaining to a Single Limb Stance (SLS) duration, body joint
vibration, and body sway area, of a user being monitored for postural
stability assessment, are collected, via one or more hardware processors,
20 by a postural stability assessment system. Further, the postural stability
assessment system determines the SLS duration, the body joint vibration,
and the body sway area, of the user as falling under at least one
respective category, via the one or more hardware processors. Further, a
postural stability index score is generated for the user, based on the
25 determined at least one category of the SLS duration, the body joint
vibration, and the body sway area, via the one or more hardware
processors, by the postural stability assessment system. Further, postural
stability of the user is assessed based on the postural stability index
score, by the postural stability assessment system.

30 [0008] It is to be understood that both the foregoing general
description and the following detailed description are exemplary and
explanatory only and are not restrictive of the invention, as claimed.

BRIEF DESCRIPTION OF THE DRAWINGS

[0009] The accompanying drawings, which are incorporated in and
10 constitute a part of this disclosure, illustrate exemplary embodiments and,
together with the description, serve to explain the disclosed principles:

[0010] FIG. 1 illustrates a block diagram of a postural stability
assessment system for performing postural stability assessment of a user,
according to some embodiments of the present disclosure.

15 [0011] FIG. 2 is a flow diagram depicting steps involved in the
process of performing postural stability assessment, using the postural
stability assessment system, according to some embodiments of the
present disclosure.

[0012] FIG. 3 is a flow diagram depicting steps involved in the
20 process of identifying membership function for SLS duration, body joint
vibrations, and body sway area of a user being monitored, using the
postural stability assessment system, according to some embodiments of
the present disclosure.

[0013] FIG. 4 is a flow diagram depicting steps involved in the
25 process of dynamically determining range of membership functions of
SLS duration, body joint vibrations, and body sway area of a user, using
the postural stability assessment system, according to some
embodiments of the present disclosure.

DETAILED DESCRIPTION OF EMBODIMENTS

[0014] Exemplary embodiments are described with reference to the accompanying drawings. In the figures, the left-most digit(s) of a reference number identifies the figure in which the reference number first appears. Wherever convenient, the same reference numbers are used throughout the drawings to refer to the same or like parts. While examples and features of disclosed principles are described herein, modifications, adaptations, and other implementations are possible without departing from the spirit and scope of the disclosed embodiments. It is intended that the following detailed description be considered as exemplary only, with the true scope and spirit being indicated by the following claims.

[0015] Referring now to the drawings, and more particularly to FIG. 1 through 4, where similar reference characters denote corresponding features consistently throughout the figures, there are shown preferred embodiments and these embodiments are described in the context of the following exemplary system and/or method.

[0016] FIG. 1 illustrates a block diagram of a postural stability assessment system for performing postural stability assessment of a user, according to some embodiments of the present disclosure. The postural stability assessment system 100 includes an Input/Output (I/O) module 101, a Single Limb Stance (SLS) duration measurement module 102, a body joint vibration measurement module 103, a sway area determination module 104, a stability index generation module 105, and a stability assessment module 106.

[0017] The I/O module 101 is configured to provide at least a channel with appropriate communication protocol support, for facilitating communication between the postural stability assessment system 100 and at least one external entity. The 'external entity' herein can be a user or an external system. For example, using a suitable interface provided by

5 the I/O module 101, one or more users may interact with the postural stability assessment system 100. In another example, an external system can connect and communicate with the postural stability assessment system 100, for data transfer and/or any such action. The I/O module 101 can be further configured to provide suitable communication channel for
10 communication between the components of the postural stability assessment system 100. The I/O module 101 is further configured to provide suitable options for monitoring action(s) being performed by one or more users, and collect one or more inputs with respect to one or more actions being performed by the user. The I/O module 101 is further
15 configured to collect one or more inputs required for the postural stability assessment, by monitoring the user. For example, the I/O module 101 can use a Kinect[®] system that is internally or externally associated (or connected) with the postural stability assessment system 100, so as to monitor user action(s) and collect the required input(s). For example, for
20 the purpose of postural stability data assessment, the I/O module 101 can be configured to monitor and record spatio-temporal information of twenty five joints of each user being monitored. The I/O module 101 can be further configured to perform necessary pre-processing of the data collected as input, so as to condition the data for further processing,
25 wherein conditioning of the data refers to preparing the data suitable for further processing (for example, by performing actions such as but not limited to removal of noise content, conversion of the data to appropriate format and so on).

[0018] The SLS measurement module 102 is configured to collect
30 the user specific input data from the I/O module 101, process the collected data, and determine SLS time duration for the user. Here, the SLS time duration indicates the time period for which the user being monitored performed the action(s) as required by standard SLS test. For example, SLS time duration is determined by monitoring variation in lifted
35 leg's ankle coordinates. For example, when Kinect[®] is used for monitoring

5 and data collection, skeleton joints obtained from Kinect® are represented by 3D world co-ordinates (x, y, z) where 'x' represents left/right variation, 'y' represents up/down variation w.r.t ground and 'z' represents to/from variation of subject w.r.t Kinect®. Changes in the lifted leg's ankle y-coordinate (say, left leg is lifted) 'YAnkleLeft' can give meaningful
10 information about the precise timing when a subject lifts leg (here, left-leg) above the ground. Similarly right leg's movement also can be tracked.

[0019] The body joint vibration determination module 103 is configured to collect the user specific input data collected by the I/O module 101, process the collected data, and determine values that
15 represent one or more types of body joint vibrations while the user was performing one or more specific actions as required for the postural stability assessment. For example, while the user is standing on single limb as part of SLS exercise, the user oscillates in order to maintain the balance. Body joint, especially hip joint contributes maximally to correct
20 the effect of instability to maintain the posture. Acceleration of hip joint center in x, y, z direction is analyzed for estimating body joint vibration. Mean frequencies of the hip joint center were calculated using appropriate techniques such as Fourier transform and the relative frequency variation between each segments of SLS (i.e., double stance, single stance
25 followed by double stance), gives a vibration index.

[0020] The sway area determination module 104 is configured to assess body sway from the collected input data, and determine sway of Center of Mass (CoM). Any suitable technique (for example, Statically Equivalent Serial Chain (SESC)) can be used by the sway area
30 determination module 104 for determining the CoM. SESC model locates the CoM of any linkage by means of a serial chain and the links in the chain are defined by their geometric configuration and mass distribution. Shoulder center and hip center are considered as the start and end point of the serial chain respectively. Midpoint of this chain is estimated to be
35 the body CoM, and projection of the estimated CoM is equivalent to body

5 sway. The sway area can be calculated using any suitable algorithm. For
example, a convex hull algorithm can be used. In the convex hull method
triangulation of the point sets is calculated first. The points of interest are
the x and z coordinates of estimated CoM. These coordinates $(x_1; z_1) \dots (x_n; z_n)$ of the polygon are arranged in a determinant, and cross product of
10 the determinant generates the sway area.

[0021] The stability index generation module 105 is configured to
collect information pertaining to the determined SLS time duration, body
joint vibration, and sway area, and process them together to generate a
postural stability index score, wherein the postural stability index score
15 represents level of postural stability of the user, and can further indicate
any potential health risks. The stability index generation module 105
processes information pertaining to the SLS time duration, body joint
vibration, and sway area, based on certain pre-defined rules. During this
process, the stability index generation module 105 compares determined
20 values of the SLS time duration, body joint vibration, and sway area with
corresponding membership function ranges, and accordingly determines
one membership function each that suits the determined value of each
parameter. Here, 'membership function' refers to of classifications each of
SLS time duration, body joint vibration, and sway area under different
25 categories (wherein each category is defined in terms of range of values).
Given below is an example classification:

SLS duration: Poor: 8 to 25 sec, Average: 20 to 40 sec, Good: 35 – 85
sec, Excellent: 80 to 120 sec.

Body (Hip) Joint vibration: Poor: 0 to 5, Average: 5 to 15, Good: 15 to
30 35, Excellent: 30 to 50.

CoM sway area: Poor: 16 to 25; Average: 8 to 16; Good: 4 to 8;
Excellent: 0 to 4.

[0022] In an embodiment, the stability index generation module 105
dynamically determines the ranges for a person being analyzed. The
35 stability index generation module 105 may consider the parameters such

5 as but not limited to age of the user, geographical location of the user and
so on, that has impact on physical health of a user, in order to dynamically
determine the ranges, and compare values corresponding to such
features with a learning model that specifies criteria for selecting the
ranges. By comparing the value of each parameter with corresponding
10 membership function ranges, the stability index generation module 105
determines the matching membership functions for the user. The means,
each of SLS duration, body joint vibration, and sway area is classified as
one of GOOD, BAD, AVERAGE, EXCELLENT. In another embodiment,
the stability index generation module 105 dynamically determines the
15 range of membership functions for a user, based on one or more diseases
the user has. For example, ranges of membership functions for all users
suffering from stroke. Similarly, for all users suffering from another
particular disease, the range would be a different set of values. In this
scenario, information pertaining to one or more diseases a user is
20 suffering from, is collected as one of the inputs, by the stability index
generation module 105, through the I/O module 101, for the purpose of
determining the range of membership functions for the user. Similarly
Neurological balance disorders like stroke, dementia etc., musculoskeletal
balance disorders like arthritis and geriatric care These membership
25 functions are then combined with rules to generate the postural stability
score. In an embodiment, any suitable technique (for example, Fuzzy
logic) can be used to combine the membership functions and the rules. A
few examples of the rules used are:

- 30 ➤ Rule 1: IF SLS duration is EXCELLENT; AND vibration
index is GOOD; AND sway area is GOOD; THEN stability is
EXCELLENT (score-75 to 100)
- Rule 2: IF SLS duration is Good; AND vibration index is
Average; AND sway area is GOOD; THEN stability is Good
35 (score-50 to 75)

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- Rule 3: IF SLS duration is AVERAGE; AND vibration index is GOOD; AND sway area is AVERAGE; THEN stability is AVERAGE (score-25 to 50)

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- Rule 4: IF SLS duration is POOR; AND vibration index is POOR; AND sway area is AVERAGE; THEN stability is POOR (score-0 to 25)

[0023] Using the combination of membership functions and the rule, the postural stability index score for the user is determined. Value of the postural stability index score, as determined, is then provided as input to the stability assessment module 106. The stability assessment module 106 can be configured to interpret the postural stability index score received as input, and generate appropriate suggestions/recommendations which are then provided as output to the user. In an embodiment, the interpretation of the postural stability index score is performed by the stability assessment module 106, on the basis of information that is statically or dynamically configured. For example, if the value of the postural stability index score is 20, then the stability is POOR, and the user may be recommended appropriate medical checkup and the like.

[0024] The memory module 107 can be configured to store any data that is associated with the postural stability assessment. In an embodiment, the information pertaining to membership functions of different parameters for a user or for a particular population, statically or dynamically decided, is stored in the memory module 107. Similarly all rules that are to be used for performing the postural stability assessment also are stored in the memory module 107. Further, all information (inputs, outputs and so on) pertaining to postural stability assessment performed for each user may also be stored in the database, as history data, for reference purpose. The learning model also is stored in the

5 memory module 107. The memory module 107 may be volatile or non-volatile, as per requirements.

[0025] FIG. 2 is a flow diagram depicting steps involved in the process of performing postural stability assessment, using the postural stability assessment system, according to some embodiments of the present disclosure. By monitoring a user for whom the posture stability assessment is to be performed, while the user is performing specific (manual) actions that are required for the postural stability assessment (SLS test for instance) required inputs are collected which can be further used for the assessment.

15 [0026] The input(s) thus collected is then processed by the postural stability assessment system 100 to determine (202) values that represent SLS duration, body joint vibration, and body sway area, for the user. The identified values are further processed by the postural stability assessment system 100 to identify (204) these values as belonging to (or matching) specific membership functions. The postural stability assessment system 100 further generates (206) a postural stability index score for the user, based on the identified membership functions and at least one rule. The postural stability assessment system 100 further assesses postural stability of the user, based on the generated postural stability index score. Various actions in Fig. 2 can be performed in the same order or in a different order. Further, or one or more of the actions in method 200 can be omitted.

[0027] FIG. 3 is a flow diagram depicting steps involved in the process of identifying membership function for SLS duration, body joint vibrations, and body sway area of a user being monitored, using the postural stability assessment system, according to some embodiments of the present disclosure. The postural stability assessment system 100 determines values of SLS duration, body joint vibration, and CoM of body sway area (302, 306, and 310 respectively), by processing the real-time inputs collected (301) by monitoring the user. The values thus determined

5 are then compared (304, 308, 312 respectively) with respective membership function ranges, wherein the ranges of membership function of each of the SLS duration, the body joint vibration, and the CoM of body sway area are dynamically determined for the user, by the postural stability assessment system 100. By means of the comparison, the postural stability assessment system 100 identifies (314) membership function that matches each of the SLS duration, the body joint vibration, and the CoM of body sway area, for the user. Various actions in Fig. 3 can be performed in the same order or in a different order. Further, or one or more of the actions in method 300 can be omitted.

15 [0028] FIG. 4 is a flow diagram depicting steps involved in the process of dynamically determining range of membership functions of SLS duration, body joint vibrations, and body sway area of a user, using the postural stability assessment system, according to some embodiments of the present disclosure. The postural stability assessment system 100 collects (402) user specific parameters such as but not limited to age of the user, geographical location of the user and so on, as inputs for dynamically determining ranges of membership functions for the user. These values are then compared (404) with a learning model that specifies criteria for selecting the ranges. Once a matching criteria is found, the ranges of membership functions mapped against that particular criteria are selected as the ranges of membership functions for the user. Various actions in Fig. 4 can be performed in the same order or in a different order. Further, or one or more of the actions in method 400 can be omitted.

30 [0029] The written description describes the subject matter herein to enable any person skilled in the art to make and use the embodiments. The scope of the subject matter embodiments is defined by the claims and may include other modifications that occur to those skilled in the art. Such other modifications are intended to be within the scope of the claims if they have similar elements that do not differ from the literal language of

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5 the claims or if they include equivalent elements with insubstantial differences from the literal language of the claims.

[0030] The embodiments of present disclosure herein addresses unresolved problem of postural stability assessment. The embodiment, thus provides mechanism for postural stability assessment based on SLS
10 duration, body joint vibrations, and body sway area of a user, providing a system thereof.

[0031] It is to be understood that the scope of the protection is extended to such a program and in addition to a computer-readable means having a message therein; such computer-readable storage
15 means contain program-code means for implementation of one or more steps of the method, when the program runs on a server or mobile device or any suitable programmable device. The hardware device can be any kind of device which can be programmed including e.g. any kind of computer like a server or a personal computer, or the like, or any
20 combination thereof. The device may also include means which could be e.g. hardware means like e.g. an application-specific integrated circuit (ASIC), a field-programmable gate array (FPGA), or a combination of hardware and software means, e.g. an ASIC and an FPGA, or at least one microprocessor and at least one memory with software modules
25 located therein. Thus, the means can include both hardware means and software means. The method embodiments described herein could be implemented in hardware and software. The device may also include software means. Alternatively, the embodiments may be implemented on different hardware devices, e.g. using a plurality of CPUs.

30 [0032] The embodiments herein can comprise hardware and software elements. The embodiments that are implemented in software include but are not limited to, firmware, resident software, microcode, etc. The functions performed by various modules described herein may be implemented in other modules or combinations of other modules. For the
35 purposes of this description, a computer-usable or computer readable

5 medium can be any apparatus that can comprise, store, communicate, propagate, or transport the program for use by or in connection with the instruction execution system, apparatus, or device.

[0033] The illustrated steps are set out to explain the exemplary embodiments shown, and it should be anticipated that ongoing
10 technological development will change the manner in which particular functions are performed. These examples are presented herein for purposes of illustration, and not limitation. Further, the boundaries of the functional building blocks have been arbitrarily defined herein for the convenience of the description. Alternative boundaries can be defined so
15 long as the specified functions and relationships thereof are appropriately performed. Alternatives (including equivalents, extensions, variations, deviations, etc., of those described herein) will be apparent to persons skilled in the relevant art(s) based on the teachings contained herein. Such alternatives fall within the scope and spirit of the disclosed
20 embodiments. Also, the words “comprising,” “having,” “containing,” and “including,” and other similar forms are intended to be equivalent in meaning and be open ended in that an item or items following any one of these words is not meant to be an exhaustive listing of such item or items, or meant to be limited to only the listed item or items. It must also be
25 noted that as used herein and in the appended claims, the singular forms “a,” “an,” and “the” include plural references unless the context clearly dictates otherwise.

[0034] Furthermore, one or more computer-readable storage media may be utilized in implementing embodiments consistent with the
30 present disclosure. A computer-readable storage medium refers to any type of physical memory on which information or data readable by a processor may be stored. Thus, a computer-readable storage medium may store instructions for execution by one or more processors, including instructions for causing the processor(s) to perform steps or stages
35 consistent with the embodiments described herein. The term “computer-

- 5 readable medium” should be understood to include tangible items and
exclude carrier waves and transient signals, i.e., be non-transitory.
Examples include random access memory (RAM), read-only memory
(ROM), volatile memory, nonvolatile memory, hard drives, CD ROMs,
DVDs, flash drives, disks, and any other known physical storage media.
- 10 [0035] It is intended that the disclosure and examples be
considered as exemplary only, with a true scope and spirit of disclosed
embodiments being indicated by the following claims.

CLAIMS

1. A processor-implemented method for postural stability assessment of a user, said method comprising:
 - 10 collecting at least one input pertaining to a Single Limb Stance (SLS) duration, body joint vibration, and body sway area, of a user being monitored for postural stability assessment, via one or more hardware processors, by a postural stability assessment system;
 - 15 determining the SLS duration, the body joint vibration, and the body sway area, of said user as falling under at least one respective category, via the one or more hardware processors, by the postural stability assessment system;
 - 20 generating a postural stability index score for said user, based on said determined at least one category of the SLS duration, the body joint vibration, and the body sway area, via the one or more hardware processors, by the postural stability assessment system; and
 - 25 assessing postural stability of said user, based on said postural stability index score, by the postural stability assessment system.
2. The method as claimed in claim 1, wherein determining the SLS duration, the body joint vibration, and the body sway area, of said user as falling under the at least one respective category comprises of comparing values of the SLS duration, the body joint vibration, and the body sway area, collected in real-time, with range of corresponding membership functions, via the one or more hardware processors, by the postural stability assessment system.

- 5 3. The method as claimed in claim 2, wherein the range of membership functions corresponding to the SLS duration, the body joint vibration, and the body sway area are dynamically determined for the user.
- 10 4. The method as claimed in claim 3, wherein dynamically determining the range of membership functions comprise of:
collecting at least one input pertaining to the user;
comparing the at least one input with a learning model; and
determining ranges membership functions of the SLS duration, the body joint vibration, and the body sway area,
15 that matches the collected input.
5. A postural stability assessment system, said system comprising:
a processor; and
a memory module comprising a plurality of instructions, said plurality of instructions configured to cause the processor to:
20 monitor an action being performed by a user and collecting at least one input pertaining to the action being performed by the user, by an Input/Output (I/O) module of the postural stability assessment system;
determine a value corresponding to Single Limb Stance (SLS) duration of the user, based on the at least one input, by a SLS duration measurement module of the postural stability assessment system;
25 determine a value corresponding to body joint vibration of the user, based on the at least one input, by a body joint vibration determination module of the postural stability assessment system;
30 determine a value corresponding to body sway area of the user, based on the at least one input, by a sway area determination module of the postural stability assessment system;
35

5 determine the SLS duration, the body joint vibration,
and the body sway area, of said user as falling under
at least one respective category, by a stability index
generation module of the postural stability
assessment system;

10 generate a postural stability index score for said user,
based on said determined at least one category of
the SLS duration, the body joint vibration, and the
body sway area, by a stability index generation
module; and

15 assess postural stability of said user, based on said
postural stability index score, by a stability
assessment module of the postural stability
assessment system.

20 6. The postural stability assessment system as claimed in claim 5,
wherein the stability index generation module is configured to
determine the SLS duration, the body joint vibration, and the body
sway area, of said user, as falling under the at least one respective
category by comparing values of the SLS duration, the body joint
vibration, and the body sway area, collected in real-time, with

25 range of corresponding membership functions.

30 7. The postural stability assessment system as claimed in claim 5,
wherein the stability index generation module is configured to
dynamically determine the range of membership functions
corresponding to the SLS duration, the body joint vibration, and the
body sway area, by:

35 collecting at least one input pertaining to the user, using the
I/O module;
comparing the at least one input with a learning model; and
determining ranges membership functions of the SLS
duration, the body joint vibration, and the body sway area,

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that matches the collected input.

- 5 8. One or more non-transitory machine readable information storage
 mediums comprising one or more instructions which when
 executed by one or more hardware processors causes:
- collecting at least one input pertaining to a Single Limb
 Stance (SLS) duration, body joint vibration, and body sway
10 area, of a user being monitored for postural stability
 assessment, via one or more hardware processors;
 determining the SLS duration, the body joint vibration, and
 the body sway area, of said user as falling under at least
 one respective category, via the one or more hardware
15 processors;
 generating a postural stability index score for said user,
 based on said determined at least one category of the SLS
 duration, the body joint vibration, and the body sway area,
 via the one or more hardware processors; and
20 assessing postural stability of said user, based on said
 postural stability index score, via the one or more hardware
 processors.
9. The one or more non-transitory machine readable information
 storage mediums of claim 8, wherein the one or more instructions
25 which when executed by the one or more hardware processors, for
 determining the SLS duration, the body joint vibration, and the
 body sway area, of said user as falling under the at least one
 respective category, further cause comparing values of the SLS
 duration, the body joint vibration, and the body sway area,
30 collected in real-time, with range of corresponding membership
 functions.
10. The one or more non-transitory machine readable information
 storage mediums of claim 9, wherein the one or more instructions
 which when executed by the one or more hardware processors
35 cause dynamic determination of the range of membership functions

5 by:

collecting at least one input pertaining to the user;

comparing the at least one input with a learning model; and

determining ranges membership functions of the SLS

duration, the body joint vibration, and the body sway area,

10 that matches the collected input.