

SYSTEM AND METHOD TO DETECT FATIGUE CONDITION

TECHNICAL FIELD

The present disclosure relates generally to data processing and more specifically, systems and methods for detection of fatigue condition in humans.

5 BACKGROUND

Generally, users, such as humans perform one or more physical activities to keep the body fit and healthy. The physical activities include but not limited to walking, jogging, running, exercising or involving in an indoor/outdoor sport. The users take adequate amount of food which is further consumed during such physical activities and day today activities. The users
10 may come across one or more physical and mental conditions while performing such physical activities, which may have a considerable effect on performance. Further, these physical and mental conditions can be directly related to the physical and mental wellbeing of the user.

Typically, the conditions that a user may come across includes, fatigue, stress, anxiety, depression, sleeplessness, obesity and so forth. These conditions directly impact on the
15 performance of the user in physical activities. While performing the physical activities, the entire body including heart, muscles, lungs and the like are purposefully trained. Out of which, fatigue is one of interrelated condition which involves both mind and body. Fatigue is a feeling of constant tiredness or weakness which may be physical, mental or a combination of both. Fatigue is also a symptom, caused by a combination of lifestyle, social,
20 psychological and general wellbeing issues rather than an underlying medical condition.

Notably, fatigue may cause chronic tiredness or sleepiness, headache, dizziness, sore or aching muscles, muscle weakness, slowed reflexes and responses, impaired decision-making and judgement, moodiness, such as irritability, impaired hand-to-eye coordination, appetite loss, reduced immune system function, blurry vision, short-term memory problems, poor
25 concentration, hallucinations, reduced ability to pay attention to the situation, low motivation and the like. Thus, fatigue may seriously impact safety of the users and lead to increase in accidents. A user who is experiencing fatigue may not be able to react or communicate effectively, thereby causing a threat to its life or others.

In a prior art solution, disclosed is a utility model that relates to a kind of wearable muscular fatigue detection devices, specifically include adjustable frequency signal source, signal regulation and control unit, phase discriminator, input electrode, receiving electrode, differential amplifier circuit, filter circuit, shaping reduction unit, microprocessor and display module. The utility model structure simply minimizes, and acquisition mode is non-invasive, harmless and easy to operate.

Therefore, in light of the foregoing discussion, there exists a need to overcome various problems associated with conventional methods to detect fatigue condition in a user.

SUMMARY

The present disclosure seeks to provide a system to detect fatigue condition in a user. The present disclosure also seeks to provide a method to detect fatigue condition in a user.

According to an aspect, an embodiment of the present disclosure provides a system to detect fatigue condition, the system comprising:

- a wearable unit, when in operation, is configured to generate a first data, wherein the first data comprises a plurality of parameters associated with a user;
- an electronic device communicatively coupled to the wearable unit, wherein the electronic device is configured to:
 - analyze each parameter of the plurality of parameters in the first data;
 - detect a deviation in a value of at least one of the parameters of the plurality of parameters from a predefined range of each parameter; and
 - alert the user of detected abrupt deviation in the value of at least one of the parameters, indicative of a level of fatigue;
- a first communication network communicatively coupled to the electronic device through the wearable unit, wherein the first communication network is configured to receive a second data from the electronic device, and wherein the second data comprises a partially processed first data and a Global Positioning System (GPS) value associated with the GPS location of the user;
- a server communicatively coupled to the first communication network, wherein the server is configured to:
 - analyse the second data received from the first communication network;

- invoke a critical status associated with the user, if the level of fatigue exceeds a threshold limit; and
 - generate an alert notification for at least one care personnel based on the critical status of the user; and
- 5 - a database communicatively coupled to the server, wherein the database is configured to store at least one of: the first data, the second data, contact information of the at least one care personnel.

Optionally, the electronic device analyses each parameter of the plurality of parameters in the first data and detect the deviation by identifying an increase or a decrease in the value of at
10 least one of the parameters from the predefined range of the parameter.

Optionally, the plurality of parameters of the first data includes at least one of: a heart rate exertion of the user, a pace and steps of the user,

Optionally, the electronic device is configured to determine the pace of the user by calculation of an average length of stride of the user and a number of steps covered by the
15 user in a specific time period.

Optionally, the database is further configured to store a profile of the user, and wherein the profile of the user comprises at least one of: a wearable unit identifier (ID), a name of the user, an age of the user, a location of the user, a height of the user, a weight of the user a mobile number, an emergency contact number and a blood group.

20 Optionally, the electronic device is configured to determine the heart rate exertion of the user by using an average heart rate of the user and the age of the user.

Optionally, the server compares the second data with the threshold limit for determination of the critical status of the user and provide the GPS value associated with the user to the at least one care personnel based on the determined critical status of the user.

25 Optionally, the server is further configured to monitor a plurality of users, and wherein the monitoring of each user of the plurality of users is based on at least one of: an age, a health history, a type of activity performed by a user at a moment of monitoring, a level of fatigue, a heart rate, a location of each user.

According to another aspect, an embodiment of the present disclosure provides a method for detecting fatigue condition, the method comprises:

- generating a first data, wherein the first data comprises a plurality of parameters associated with a user;
- 5 - analysing each parameter of the plurality of parameters in the first data;
- detecting a deviation in a value of at least one of the parameters of the plurality of parameters from a predefined range of each parameter;
- alerting the user of detected abrupt deviation in the value of at least one of the parameters, indicative of a level of fatigue;
- 10 - receiving a second data, wherein the second data comprises a partially processed first data and a Global Positioning System (GPS) value associated with the GPS location of the user;
- analysing the second data;
- invoking a critical status associated with the user, if the level of fatigue exceeds a threshold limit;
- 15 - generating an alert notification for at least one care personnel based on the critical status of the user; and
- storing at least one of: the first data, the second data, contact information of the at least one care personnel.

Optionally, the method further comprising monitoring each user of a plurality of users based
20 on at least one of: an age, a health history, a type of activity performed by a user at a moment of monitoring, a level of fatigue, a heart rate, a location of each user.

It will be appreciated that features of the present disclosure are susceptible to being combined in various combinations without departing from the scope of the present disclosure as defined by the appended claims.

25 **DESCRIPTION OF THE DRAWINGS**

The summary above, as well as the following detailed description of illustrative embodiments, is better understood when read in conjunction with the appended drawings. For the purpose of illustrating the present disclosure, exemplary constructions of the disclosure are shown in the drawings. However, the present disclosure is not limited to
30 specific methods and instrumentalities disclosed herein. Moreover, those in the art will

understand that the drawings are not to scale. Wherever possible, like elements have been indicated by identical numbers.

Embodiments of the present disclosure will now be described, by way of example only, with reference to the following diagrams wherein:

5 **FIG. 1** is a schematic diagram of a system to detect fatigue condition, in accordance with an embodiment of the present disclosure;

FIG. 2 is a block diagram of a wearable unit and an electronic device in communication, in accordance with an embodiment of the present disclosure;

FIG. 3 is a schematic diagram of exemplary system to detect fatigue condition, in accordance
10 with an embodiment of the present disclosure;

FIG. 4 is a flowchart illustrating the steps of a method to determine a pace of the user, in accordance with an embodiment of the present disclosure;

FIG. 5 is a flowchart illustrating the steps of a method to determine a heart rate exertion of a user, in accordance with an embodiment of the present disclosure;

15 **FIG. 6** is a flowchart illustrating the steps of a first method to determine a level of fatigue, in accordance with an embodiment of the present disclosure;

FIG. 7 is a flowchart illustrating the steps of a second method to determine a level of fatigue, in accordance with an embodiment of the present disclosure;

FIG. 8 is a flowchart illustrating the steps of a third method to determine a level of fatigue, in
20 accordance with an embodiment of the present disclosure;

FIG. 9 is a flowchart illustrating the steps of an exemplary method to detect fatigue condition, in accordance with an embodiment of the present disclosure;

FIG. 10 is an example fatigue detection module or ECG module or wearable unit in an aspect of the present invention;

25 **FIG. 11A and 11B** illustrates another example wearable unit with belt strap embedded in a T-shirt;

FIG. 12A, 12B and 12C, illustrates different views of belt strap; and

FIG. 13A through 13F illustrates various components of ECG module and belt strap in an embodiment of the present invention.

In the accompanying drawings, an underlined number is employed to represent an item over
5 which the underlined number is positioned or an item to which the underlined number is
adjacent. A non-underlined number relates to an item identified by a line linking the non-
underlined number to the item. When a number is non-underlined and accompanied by an
associated arrow, the non-underlined number is used to identify a general item at which the
arrow is pointing.

10 **DETAILED DESCRIPTION**

In overview, embodiments of the present disclosure are concerned with systems and methods
to detect fatigue condition in users.

According to an aspect, an embodiment of the present disclosure provides a system to detect
fatigue condition, the system comprising:

- 15 - a wearable unit, when in operation, is configured to generate a first data, wherein the first
data comprises a plurality of parameters associated with a user;
- an electronic device communicatively coupled to the wearable unit, wherein the electronic
device is configured to:
 - analyse each parameter of the plurality of parameters in the first data;
 - 20 - detect a deviation in a value of at least one of the parameters of the plurality of
parameters from a predefined range of each parameter; and
 - alert the user of detected abrupt deviation in the value of at least one of the
parameters, indicative of a level of fatigue;
- a first communication network communicatively coupled to the electronic device, wherein
25 the first communication network is configured to receive a second data from the electronic
device, and wherein the second data comprises a partially processed first data and a Global
Positioning System (GPS) value associated with the GPS location of the user;
- a server communicatively coupled to the first communication network, wherein the server is
configured to:
30 - analyse the second data received from the first communication network;

- invoke a critical status associated with the user, if the level of fatigue exceeds a threshold limit; and
 - generate an alert notification for at least one care personnel based on the critical status of the user; and
- 5 - a database communicatively coupled to the server, wherein the database is configured to store at least one of: the first data, the second data, contact information of the at least one care personnel.

According to another aspect, an embodiment of the present disclosure provides a method for detecting fatigue condition, the method comprises:

- 10 - generating a first data, wherein the first data comprises a plurality of parameters associated with a user;
- analysing each parameter of the plurality of parameters in the first data;
 - detecting a deviation in a value of at least one of the parameters of the plurality of parameters from a predefined range of each parameter;
- 15 - alerting the user of detected abrupt deviation in the value of at least one of the parameters, indicative of a level of fatigue;
- receiving a second data, wherein the second data comprises a partially processed first data and a Global Positioning System (GPS) value associated with the GPS location of the user;
 - analysing the second data;
- 20 - invoking a critical status associated with the user, if the level of fatigue exceeds a threshold limit;
- generating an alert notification for at least one care personnel based on the critical status of the user; and
 - storing at least one of: the first data, the second data, contact information of the at least one
- 25 care personnel.

The fatigue in a user is due to chronic tiredness or sleepiness, headache, dizziness, sore or aching muscles, muscle weakness, slowed reflexes and responses, impaired decision-making and judgement, moodiness, such as irritability, impaired hand-to-eye coordination, appetite loss, reduced immune system function, blurry vision, short-term memory problems, poor

30 concentration, hallucinations, reduced ability to pay attention to the situation at hand, low

motivation etc. Some of the above symptoms can be identified by a heart rate, blood pressure and amount of breathing.

Further, to address the above symptoms of fatigue in a person, it is crucial to analyse the heart rate and detect a fatigue condition in a person, especially while performing physical activities, since the heart rate may be volatile and considerable rate of change in fatigue may be observed. The following invention describe a method to analyse the heart rate in a particular manner and formulate an algorithm to detect the fatigue condition in a user.

Referring to FIG. 1, there is shown a system **100** for detection of fatigue condition, in accordance with an embodiment of the present disclosure. The figure is shown comprising components that include a wearable unit (or vest) **110**, an electronic device **120** such as a mobile device, a first communication network **130**, a server **140** and a database **150**. The following paragraphs describe the above components in detail. The wearable unit **110**, when in operation, is configured to generate a first data. The first data comprises a plurality of parameters associated with the user. The wearable or vest **110** which is worn by the user is connected to the electronic device **120**, through a second communication network (not shown), for example, Bluetooth or BLE. The wearable unit **110** covers the chest portion wherein which consists of one or more sensors to primarily monitor the heart rate and other activities of the user. The sensors include heart rate monitoring sensor, an accelerometer or pedometer, and a gyroscope. In an embodiment, one or more similar type of sensors is used to accurately detect any movement, and appropriately capture and record the variation during the activities. The heart rate monitoring sensor records the heart rate of the user, during any activity such as walking, running, jogging and so forth. In another embodiment, the wearable unit **110** transmits the first data from one or more sensors to the electronic device **120** for further processing. The first data includes heart rate, accelerometer data and gyroscope data. The electronic device **120** communicatively coupled to the wearable unit is configured to analyse each parameter of the plurality of parameters in the first data. Optionally, the plurality of parameters of the first data includes at least one of: a heart rate exertion of the user, a pace of the user, the GPS location of the user. The plurality of parameters includes, a heart rate, blood pressure and breathing pattern of a person, and the like. Moreover, the electronic device **120** detects a deviation in a value of at least one of the parameters of the plurality of parameters from a predefined range of each parameter. The predefined range of

each parameter may be standard range of parameters in accordance with medical norms. For example, a predefined range for heart rate of a person may be 60 to 100 beats per minute. Furthermore, the electronic device **120** alert the user in reference to the detected abrupt deviation in the value of at least one of the said parameters, indicative of a level of fatigue.

- 5 The electronic device **120** is configured with an application to receive and read the first data from the wearable unit **110**. The mobile application process and analyse the first data with one or more algorithms and methods to find any change in pattern.

The heart rate of the user is typically analysed to determine average heart rate and number of beats per minute. The heart rate may vary person to person, and activity to activity. The
10 variation in heart rate is due to one or more internal or external parameters that include, stress, fatigue, anxiety, walking, jogging, running, or any physical activity or mental state of the user. Further, heart rate sensor is used to identify any abrupt variation in the heart rate and further helps to alert the user or share the information with the network through the electronic device **120**, immediately.

- 15 In an embodiment, the algorithms of subject invention are primarily capable of identifying pace of user, determine heart rate exertion and fatigue in a user, while performing any activity. Any abrupt value in fatigue level is immediately identified and user is alerted to pause or stop the ongoing task.

The electronic device **120** further adds a GPS location value to the first data and prepares the
20 second data. The electronic device **120** (for example, a mobile device) transmits the second data to the server **140**, through a first communication network **130**. The first communication network **130** communicatively coupled to the server **140** configured to receive a second data from the electronic device **120**, Notably, the second data comprises a partially processed first data and a Global Positioning System (GPS) value associated with the GPS location of the
25 user. The first and second data which is being captured by the wearable unit **110** and electronic device **120** are transmitted to the server **140** for additional processing, wherein the server **140** is configured to analyse the second data received from the first communication network. The server **140** further invoke a critical status associated with the user, if the level of fatigue exceeds a threshold limit and generate an alert notification for at least one care
30 personnel based on the critical status of the user. The one or more adverse heart rate conditions of one or more users are shared in a safety network or groups or closed contacts or

hospitals for identification of adverse condition, monitoring of user and to provide timely assistance. Optionally, the server compares the second data with the threshold limit for determination of the critical status of the user and provide the GPS value associated with the user to the at least one care personnel based on the determined critical status of the user. The
5 threshold limit may be a minimum or a maximum value associated with each parameter, such that if any parameter of the user falls below the minimum value or rise above the maximum value generates a critical status, so the user may receive medical assistance. For example, if a heart rate of a person rises to 130 beats per minute, which is one of the indications of fatigue, the server invokes the critical status and alerts the user and at least one care personnel. The
10 server **140** manages all data in the network, process them in a particular manner with the help of one or more algorithms and ultimately analyse health data to invoke a critical status with alert notifications. The server **140** stores all such processed data in the database **150**. The database **150** maintains all data related to users, connected devices, emergency contact details in one or more tables. The database **150** is configured to store the first data, the second data,
15 contact information of the at least one care personnel.

Optionally, the database **150** is further configured to store a profile of the user, and wherein the profile of the user comprises at least one of: a wearable unit identifier (ID), a name of the user, an age of the user, a location of the user, a height of the user, a weight of the user, a mobile number, an emergency contact number and a blood group. The database **150** further
20 indexes the data for faster retrieval, and revert when requested by the server **140**. Optionally, the server is further configured to monitor a plurality of users, and wherein the monitoring of each user of the plurality of users is based on at least one of: an age, a health history, a type of activity performed by a user at a moment of monitoring, a level of fatigue, a heart rate, a location of each user.

25 Referring to FIG. 2, illustrated is a block diagram of a wearable unit **110** and an electronic device **120** in communication, in accordance with an embodiment of the present disclosure. The figure is shown comprising the components of wearable unit **110** and the electronic device **120**. As shown there, the components of wearable unit **110** include a micro controller unit **205**, a battery unit **210**, a second communication module **215** and sensor modules **220**.
30 The sensor modules further include, an accelerometer or a pedometer **225**, a gyroscope **230**, and a heart rate monitor (HRM) **235**. The components of electronic device **120** include, a first

communication module **255**, a GPS module **265** and primary controller unit **260**. The first communication module **255** of the electronic device **120** and the second communication module **215** of wearable unit **110** are connected through a second communication network (not shown). The first data from wearable unit **110** is transmitted through the second
5 communication network, to the electronic device **120**.

Referring to FIG. 3, shown is a schematic diagram of exemplary system to detect fatigue condition, in accordance with an embodiment of the present disclosure. As shown there, the server **140** is connected with one or more user groups through one or more network, including first communication networks. The one or more user groups may include, users
10 preparing for marathon in different range (5K, 10K, half marathon and a full marathon), users under coaching for one or more sport or sport related activities, or any activity. In an embodiment, the group of users may not be in a same place. The server **140** may also monitor the activities of every user in the network. The server **140** may also be configured to monitor a specific set of users based on their age, health history, type of activity, pace, fatigue level,
15 Heart rate, distance covered, location, regularity (in doing an activity) and so forth.

Referring to FIG. 4, shown is a flowchart **400** illustrating the steps of a method to determine a pace of the user, in accordance with an embodiment of the present disclosure. Optionally, the electronic device is configured to determine the pace of the user by calculation of an average length of stride of the user and number of steps covered by the user in a specific time period.
20 Herein, the electronic device is referred to as a mobile device. In step **410**, the server or mobile device monitor the movement of the user and count the steps of a first course or current activity through the wearable unit. The mobile device is also capable of recording the each and every activity with a start and end time. In an embodiment, each activity may have one or more courses. A course is a part of an activity wherein which the starting step count is
25 being recorded and continuously monitoring the activity of the user and ends when user stops the recording or pauses the recordation of step count over a period of time and distance. The wearable unit transmits the step data to mobile device. In step **420**, the mobile device is configured to determine the total number of steps taken by the user in a first course from first location to second location. In an embodiment, the mobile device also uses GPS data to
30 approximate the total steps between first and second location. In step **430**, the mobile device simultaneously identifies the stride length of the user, based on average step count and total

distance or from the current step values. In step **440**, the mobile device determines the pace of the user with average stride length and current step values. In an example, the pace of the user is determined as follows,

$$\text{PACE} = ((\text{Stride length} * \text{total number of steps}) / \text{total time taken}) / 60$$

5 Referring to FIG. 5, shown is a flowchart **500** depicting steps of a method to determine a heart rate exertion of a user, in accordance with an embodiment of the present disclosure. Optionally, the electronic device is configured to determine the heart rate exertion of the user by using an average heart rate of the user and the age of the user. In step **505**, the server or mobile device identifies the profile of the user when the user wears the wearable (or wearable
10 unit) and pairs with the mobile device. The profile of the user is created at least with wearable device ID, name, age, location, height, weight, total number of steps to be covered in a day by user, mobile number, blood group, emergency contact number etc. If user profile is already available, the mobile device is capable of retrieving the total steps taken by user over a period of time, heart rate values at various occasions, stride length, total distance covered,
15 fatigue level of the user etc, from the database. In step **510**, the wearable configured with the heart rate sensor which records heart rate of user every second and transmits the same to the mobile device in equal interval, for example, every 5 minutes. In step **515**, the mobile device identifies the average heart value per minute of the user. In step **520**, the mobile device determines the heart exertion rate in reference to user's age. In one example, heart rate
20 exertion is determined as follows,

$$\text{HEART RATE EXERTION} = ((\text{average heart rate exertion})) / (220 - \text{age of the user})$$

In step **525**, the mobile device compares and checks the heart exertion rate with that of default set of rates configured with respect to age and past performances of the user. When the heart exertion rate is less than 0.8, then the control is transferred to step **530**, otherwise,
25 the control is transferred to **535**. In step **530**, the mobile device assigns the heart rate exertion value as '1'. In step **535**, the mobile device again checks exertion rate, when exertion rate is between 0.8 and 0.9, the control is transferred to step **540**, otherwise, the control is transferred to step **545**. In step **540**, the mobile device assigns the heart rate exertion value as '2'. In step **545**, the mobile device again checks exertion rate, and finds when exertion rate is
30 more than 0.9, the control is transferred to step **550**, otherwise, the control is transferred to

step **555**. In step **550**, the mobile device assigns the heart rate exertion value as '3'. In step **555**, the mobile device cannot determine the heart rate exertion value and the control is transferred to step **520**, and again the process continues till exertion rate is determined.

Referring to FIG. 6, shown is a flowchart **600** illustrating the steps of a first method to
5 determine a level of fatigue, in accordance with an embodiment of the present disclosure. In
step **605**, the mobile device monitors the pace and heart rate value of the user through the
wearable. In step **610**, the mobile device checks whether the heart rate value is monitored for
at least 300 seconds. If the heart rate is being monitored more than 300 seconds, then the
control is transferred to step **615**, otherwise the control is transferred to step **605**. In an
10 embodiment, the mobile device frequently monitors the heart rate value of user. In step **615**,
the primary controller unit in the mobile device (through a mobile application) may obtain
last three computed heart rate exertion values which are being represented by $v[0]$, $v[1]$ and
 $v[2]$.

In step **620**, the primary controller unit checks the condition of the current exertion values of
15 the user. When the exertion values $v[0]=1$ & $v[1]=2$ & $v[2]=2$, then the control is transferred
to step **625**, otherwise the control is transferred to step **630**. In step **625**, the primary
controller unit identifies and assigns a fatigue level 0.4 for the subject exertion. In step **630**,
when the primary controller unit checks the current exertion values with $v[0]=1$ & $v[1]=2$ &
 $v[2]=3$, then the control is transferred to step **635**, otherwise the control is transferred to step
20 **640**. In step **635**, the primary controller unit identifies and assigns a fatigue level 0.5 for the
subject exertion. In step **640**, when the primary controller unit further checks the current
exertion values with $v[0]=1$ & $v[1]=3$ & $v[2]=3$, then the control is transferred to step **645**,
otherwise the control is transferred to step **650**. In step **645**, the primary controller unit
identifies and assigns a fatigue level 0.6 for the subject exertion. In step **650**, when the
25 primary controller unit further checks the current exertion values with $v[0]=2$ & $v[1]=3$ &
 $v[2]=3$, then the control is transferred to step **655**, otherwise the control is transferred to step
660. In step **655**, the primary controller unit identifies and assigns a fatigue level 0.65 for the
subject exertion. In step **660**, when the primary controller unit further checks the current
exertion values with $v[0]=3$ & $v[1]=3$ & $v[2]=3$, then the control is transferred to step **665**,
30 otherwise the control is transferred to step **670**. In step **665**, the primary controller unit
identifies and assigns a fatigue level 0.75 for the subject exertion. In step **670**, the primary

controller unit cannot determine the heart rate exertion value and the control is transferred to step **615** and further the primary controller unit is configured to determine the fatigue level from the last three exertion values.

Referring to FIG. 7, illustrated is a flowchart **700** illustrating the steps of a second method to
5 determine a level of fatigue, in accordance with an embodiment of the present disclosure. In step **705**, the mobile device monitors the pace and heart rate value of the user through the wearable, beyond 300 seconds. In step **710**, the primary controller unit of mobile device checks the current pace value of the user. The last three pace values per second are identified and analysed. The last pace value (first value) is `paceval[0]`, second pace value is identified as
10 `paceval[1]` and third pace value is identified as `paceval[2]`. When the pace values (`paceval[0]` > `paceval[2]`) & (`paceval[1]` > `paceval[2]`), then the control is transferred to step **715**, otherwise the control is transferred to step **705**.

In step **715**, the primary controller unit further checks for the condition, if ((`paceval [2]` - `paceval[0]`) >15) & ((`paceval[2]` > `paceval[0]`) <25), then the control is transferred to step
15 **720**, otherwise the control is transferred to step **710**. In step **720**, the primary controller unit checks the result of step **715** with that of identified current heart rate exertion values. When, current exertion values with `v[0]=1` & `v[1]=3` & `v[2]=3`, then the control is transferred to step **725**, otherwise the control is transferred to step **730**. Further, in step **725**, the primary controller unit identifies and assigns a fatigue level 0.65 for the subject exertion. In step **730**,
20 the primary controller unit checks current exertion values with `v[0]=2` & `v[1]=3` & `v[2]=3`, then the control is transferred to step **735**, otherwise the control is transferred to step **740**. In step **735**, the primary controller unit identifies and assigns a fatigue level 0.7 for the subject exertion. In step **740**, the primary controller unit checks current exertion values with `v[0]=3` & `v[1]=3` & `v[2]=3`, then the control is transferred to step **745**, otherwise the control is
25 transferred to step **740**. In step **745**, the primary controller unit identifies and assigns a fatigue level 0.8 for the subject exertion. In step **750**, the primary controller unit cannot determine the heart rate exertion value and fatigue level and the control is transferred to step **705** and the primary controller unit monitors the pace and heart rate value beyond 300 seconds.

Referring to FIG. 8, shown is a flowchart **800** illustrating the steps of a third method to
30 determine a level of fatigue, in accordance with an embodiment of the present disclosure. In step **805**, the mobile device monitors the pace and heart rate value of the user through the

wearable, beyond 300 seconds. In step **810**, the primary controller unit of mobile device checks the current pace value of the user. The last three pace values per second are identified and analyzed. The last pace value (first value) is paceval[0], second pace value is identified as paceval[1] and third pace value is identified as paceval[2]. When the pace values

5 (paceval[0] > paceval[2]) & (paceval[1] > paceval[2]), then the control is transferred to step **815**, otherwise the control is transferred to step **805**. In step **815**, the primary controller unit further checks for the condition, if $((\text{paceval}[2] - \text{paceval}[0]) / \text{paceval}[2]) * 100$ is greater than 25), then the control is transferred to step **820**, otherwise the control is transferred to step **810**. In step **820**, the primary controller unit checks the result of step **815** with that of

10 identified current heart rate exertion values. When, current exertion values with v[0]=1 & v[1]=3 & v[2]=3, then the control is transferred to step **825**, otherwise the control is transferred to step **830**. Further, in step **825**, the primary controller unit identifies and assigns a fatigue level 0.75 for the subject exertion. In step **830**, the primary controller unit again checks current exertion values with v[0]=2 & v[1]=3 & v[2]=3, then the control is transferred

15 to step **835**, otherwise the control is transferred to step **845**. In step **835**, the primary controller unit identifies and assigns a fatigue level 0.8 for the subject exertion and user is moderately critical. In step **840**, the primary controller unit, immediately alert the user with the increased fatigue level and also notify the other users in a network. In step **845**, the primary controller unit checks current exertion values with v[0]=3 & v[1]=3 & v[2]=3, then

20 the control is transferred to step **850**, otherwise the control is transferred to step **860**. In step **850**, the primary controller unit immediately alert the user with the extreme fatigue level and critical, advise the user to take a rest and further notify the other users in a network to provide a medical assistance to the subject user. In step **860**, the primary controller unit cannot determine the heart rate exertion value and fatigue level and the control is transferred to step

25 **805**, and the primary controller unit monitors the pace and heart rate value beyond 300 seconds.

The present disclosure provides a method to detect fatigue condition. Referring to FIG.9, there is shown a method **900** to detect fatigue condition, in accordance with an embodiment of the present disclosure. At a step **902**, the method comprises generating a first data, wherein

30 the first data comprises a plurality of parameters associated with a user. At a step **904**, the method comprises analysing each parameter of the plurality of parameters in the first data. At a step **906**, the method comprises detecting a deviation in a value of at least one of the

parameters of the plurality of parameters from a predefined range of each parameter. At a step **908**, the method comprises alerting the user of detected abrupt deviation in the value of at least one of the parameters, indicative of a level of fatigue. At a step **910**, the method comprises receiving a second data, wherein the second data comprises a partially processed first data and a Global Positioning System (GPS) value associated with the GPS location of the user. At a step **912**, the method comprises analysing the second data. At a step **914**, the method comprises invoking a critical status associated with the user, if the level of fatigue exceeds a threshold limit. At a step **916**, the method comprises generating an alert notification for at least one care personnel based on the critical status of the user. At a step **918**, the method comprises storing at least one of: the first data, the second data, contact information of the at least one care personnel.

Referring to FIG. 10, shown is an example fatigue detection module or ECG module or wearable unit **1000** in an aspect of the present invention. The ECG module **1000** has a flexible belt like structure providing a snug fit to the abdomen (chest or heart portion) of the user. In an embodiment, the belt strap and ECG module are enclosed in a vest and which is further knitted within a T-shirt. Thus, a smart t-shirt is made which is capable of detecting a heart rate of user. In another embodiment, the rear side of belt which touches the skin of user has a two or more electrodes to detect heart signal and the module detecting and transmitting the heart rate.

Referring to FIG. 11A and 11B, shown is another example wearable unit or ECG module with belt strap **1120** embedded in a T-shirt **1110**. The figures also show respective front and back portion of T-shirt **1110**. In an embodiment, the belt strap **1120** having the ECG module is particularly placed or positioned at the chest portion or upper abdomen of the user to sense and monitor the heart rate and heart rate exertion of the user in real-time.

FIG. 12A, 12B and 12C, illustrates different views of belt strap **1120**. In an embodiment, the ECG module **1210** has two main components namely, a module and an ECG base. The ECG base is knitted or sewed on the belt strap **1120**. In another embodiment, the module is coupled with the ECG base. In yet another embodiment, the module is detachable from the ECG base, and which firmly sits within the slot provided in ECG base, when attached, with the help of the sliding mechanism constructed on the ECG base and back side of the module. The ECG base supports the vertical insertion and removal of module from the ECG base.

FIG. 12B illustrates the example belt strap **1120** and ECG module **1210** in an embodiment of the present invention, wherein the two ends of belt strap **1120** are attached and weaved together at **1220** to form an elastic belt like structure. This elastic nature of belt strap **1120** further provides a snug fit to the user. FIG. 12C illustrates the example belt strap **1120**,
5 wherein, the ends of belt strap **1120** are attached together through a button mechanism, or hook mechanism or any adhesion technique to keep belt strap snug fit for the user.

FIG. 13A through 13F illustrates various components of ECG module **1210** and belt strap **1120** in an embodiment of the present invention. FIG. 13A illustrates the position and arrangement of ECG base **1310**, on the first side (or front side) of the belt strap **1120**. In an
10 embodiment, the ECG base **1310** is made of ABS and PU material and is attached to the belt strap **1120** through a pair of nickel-plated rivets. Whereas, on the second side (or rear side) of the belt strap **1120**, the nickel-plated rivets are attached to the pair of nickel-plated washers and electrodes. In an embodiment, the pair of electrodes are arranged above the belt strap surface. In another embodiment, these pair of electrodes are supported by two more
15 electrodes to absorb better heart readings and to receive improved signal quality at the nickel-plated rivets. The pair of electrodes in combination of nickel-plated washers are directly in contact with the skin of user and further transmits the heart rate signals to the ECG base and ECG module.

FIG. 13B and 13C is the rear side of belt strap **1120** illustrating the position and placement of
20 pair of electrodes **1330**, nickel-plated washers **1340**, and a first sensor layer **1350**. In an embodiment, the first sensor layer **1350** and pair of electrodes **1330** are arranged on the belt strap **1120** one above the another. In other words, a first sensor layer **1350** is placed between the pair of electrodes **1330** and the belt strap **1120** to improve the quality of signal. The nickel-plated washers **1340** are used to transmit the electrical signals, which are captured by
25 the pair of electrodes **1330**, to the module, through nickel-plated rivets. In an embodiment, one or more sensor layers may be placed between the pair of electrodes **1330** and belt strap **1120** to improve the signal quality. In an embodiment, the nickel-plated washers **1340** and rivets are made up of stainless steel and copper respectively. In another embodiment, the pair of electrodes **1330** are primarily made up of carbon or conductive carbon/rubber
30 combination. In yet another embodiment, the electrodes **1330** becomes conductive and transmit electrical signals, when comes in contact with water or saline or sweat or gel. In yet

another embodiment, the belt strap **1120** is combination of is spandex fabric and cotton material. In yet another embodiment, the module is made up of ABS and PC material.

FIG. 13D is an ECG base **1310** in an embodiment of the present invention. The figure also shows the position and arrangement of nickel-plated rivets (**1360** and **1370**) which are capable of transmitting the electrical signals from the pair of electrodes **1330** to the module. FIG. 13E and 13F is an example front side and rear side view of the module in an embodiment of the present invention. In one aspect, the module comprises a controller unit, a power supply unit, a pair of signal units, a pair of pins and a communication module. Further, the communication module, pair of signal units and power supply unit are connected to the controller unit. In an embodiment, the pair of pins (ex: pogo pins) are internally connected with the pair of signal units. When the module is placed in the ECG base, the nickel-plated rivets and a pair of pins comes to direct contact and electrical signals generated from pair of electrodes are transmitted to the pair of signal units of the module, for processing. The signals at signal units are further transferred to the controller unit. The controller unit receives the signals from the pair of signal units, process, integrate and prepare the heart signals for transmission. The power supply unit provides electrical supply to the controller unit, communication module and other components of module. In an embodiment, the power supply unit is a rechargeable battery and a port is provided in the module to increase the battery level time to time. The communication module transmits the data processed by the controller unit to the mobile device. And, the mobile application configured in the mobile device is capable of analysing the heart rate value exertion rate, fatigue condition of user. FIG. 13F is an example rear side view of the module, illustrating the position and arrangement of pogo pins in an embodiment of the present invention. These pogo pins (**1380** and **1390**) are used to transmit the electrical signals from nickel-plated rivets to the pair of signal units.

Optionally, the method further comprising monitoring each user of a plurality of users based on at least one of: an age, a health history, a type of activity performed by a user at a moment of monitoring, a level of fatigue, a heart rate, a location of each user.

Modifications to embodiments of the invention described in the foregoing are possible without departing from the scope of the invention as defined by the accompanying claims. Expressions such as “including”, “comprising”, “incorporating”, “consisting of”, “have”, “is”

used to describe and claim the present invention are intended to be construed in a non-exclusive manner, namely allowing for items, components or elements not explicitly described also to be present. Reference to the singular is also to be construed to relate to the plural. Numerals included within parentheses in the accompanying claims are intended to
5 assist understanding of the claims and should not be construed in any way to limit subject matter claimed by these claims.

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CLAIMS

We claim:

1. A system to detect fatigue condition, the system comprising:
 - 5 - a wearable unit, when in operation, is configured to generate a first data, wherein the first data comprises a plurality of parameters associated with a user;
 - an electronic device communicatively coupled to the wearable unit, wherein the electronic device is configured to:
 - analyse each parameter of the plurality of parameters in the first data;
 - 10 - detect a deviation in a value of at least one of the parameters of the plurality of parameters from a predefined range of each parameter; and
 - alert the user of detected abrupt deviation in the value of at least one of the parameters, indicative of a level of fatigue;
 - a first communication network communicatively coupled to the electronic device
15 through a wearable unit, wherein the first communication network is configured to receive a second data from the electronic device, and wherein the second data comprises a partially processed first data and a Global Positioning System (GPS) value associated with the GPS location of the user;
 - a server communicatively coupled to the first communication network, wherein the
20 server is configured to:
 - analyse the second data received from the first communication network;
 - invoke a critical status associated with the user, if the level of fatigue exceeds a threshold limit; and
 - generate an alert notification for at least one care personnel based on the critical
25 status of the user; and
 - a database communicatively coupled to the server, wherein the database is configured to store at least one of: the first data, the second data, contact information of the at least one care personnel.
- 30 2. The system as claimed in claim 1 wherein the electronic device analyses each parameter of the plurality of parameters in the first data and detect the deviation by

identifying an increase or a decrease in the value of at least one of the parameters from the predefined range of the parameter.

3. The system as claimed in claim 1, wherein the plurality of parameters of the first data
5 includes at least one of: a heart rate exertion of the user, a pace and steps of the user.

4. The system as claimed in claim 3, wherein the electronic device is configured to
determine the pace of the user by calculation of an average length of stride of the user and a
number of steps covered by the user in a specific time period.

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5. The system as claimed in claim 3, wherein the database is further configured to store a
profile of the user, and wherein the profile of the user comprises at least one of: a wearable
unit identifier (ID), a name of the user, an age of the user, a location of the user, a height of
the user, a weight of the user a mobile number of the user, an emergency contact number and
15 a blood group of user.

6. The system as claimed in claim 5, wherein the electronic device is configured to
determine the heart rate exertion of the user by using an average heart rate of the user and the
age of the user.

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7. The system as claimed in claim 1, wherein the server compares the second data with
the threshold limit for determination of the critical status of the user and provide the GPS
value associated with the user to the at least one care personnel based on the determined
critical status of the user.

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8. The system as claimed in claim 1, wherein the server is further configured to monitor
a plurality of users, and wherein the monitoring of each user of the plurality of users is based
on at least one of: an age, a health history, a type of activity performed by a user at a moment
of monitoring, a level of fatigue, a heart rate, a location of each user.

9. A method for detecting fatigue condition, the method comprises:

- generating a first data, wherein the first data comprises a plurality of parameters associated with a user;
- 5 - analysing each parameter of the plurality of parameters in the first data;
- detecting a deviation in a value of at least one of the parameters of the plurality of parameters from a predefined range of each parameter;
- alerting the user of detected abrupt deviation in the value of at least one of the parameters, indicative of a level of fatigue;
- 10 - receiving a second data, wherein the second data comprises a partially processed first data and a Global Positioning System (GPS) value associated with the GPS location of the user;
- analysing the second data;
- invoking a critical status associated with the user, if the level of fatigue exceeds a
- 15 threshold limit;
- generating an alert notification for at least one care personnel based on the critical status of the user; and
- storing at least one of: the first data, the second data, contact information of the at least one care personnel.

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10. The method as claimed in claim 9, the method further comprising monitoring each user of a plurality of users based on at least one of: an age, a health history, a type of activity performed by a user at a moment of monitoring, a level of fatigue, a heart rate, a location of each user.