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Using health monitor data to detect macro and micro habits with a behavioral model

Abstract

A method for communicating activity-related notifications to a user includes: receiving a record of activity events of a particular activity type performed by the user over a period of time; selecting a first time-based filter from a set of time-based filters; identifying a cluster of activity events in the record of activity events filtered according to the first time-based filter; identifying an early bound and a late bound on start times of activity events of the particular activity type from the cluster; communicating a notification of a first type to the user at a first time within a threshold time of the early bound on a day fulfilling the first time-based filter; and communicating a notification of a second type to the user at a second time within a threshold time of the late bound on a day fulfilling the first time-based filter.

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Parent Case Text

CROSS-REFERENCE TO RELATED APPLICATIONS

This application claims the benefit of U.S. Provisional Application No. 61/916,708, filed on 16 Dec. 2013, and U.S. Provisional Application No. 61/935,987, filed on 5 Feb. 2014, both of which are incorporated in their entireties by this reference.

The application is related to U.S. Provisional Application No. 61/827,920, filed on 28 May 2013, U.S. Provisional Application No. 61/916,701, filed on 16 Dec. 2013, U.S. patent application Ser. No. 14/048,956, filed on 8 Oct. 2013, U.S. patent application Ser. No. 14/315,195, filed on 25 Jun. 2014, and U.S. patent application Ser. No. 14/315,195, filed on 25 Jun. 2014, which are incorporated in their entireties by this reference.

Claims

We claim:

1. A method for communicating activity-related notifications to a user, the method comprising: receiving, at a remote computer system from a wireless communication transceiver module of a mobile computing device, a record of activity events of a particular activity type performed by the user over a period of time, the record specifying a start time and a duration of each activity event in the record of activity events, wherein receiving the record of activity events comprises collecting location data sampled at a location sensor of the mobile computing device comprising the location sensor, a display, and the wireless communication transceiver module, wherein the location data comprises a location coincident performance of each activity event by the user; selecting, at the remote computer system, a first time-based filter from a set of time-based filters for the record; identifying, at the remote computer system, a cluster of activity events in the record of activity events filtered according to the first time-based filter, wherein identifying the cluster of activity events in the record of activity events comprises: obtaining a set of computer-implemented rules defining activity event subgrouping as a function of activity event start time, activity event duration, and coincident location, wherein the set of computer-implemented rules are operable to improve the remote computing system in relation to behavioral pattern prediction, and selecting a subgroup of activity events according to the set of computer-implemented rules and corresponding to: composite start times and durations falling within a core composite distance threshold of a composite start time and a duration of at least one other activity event within the subgroup of activity events, and locations, from the location data sampled at the location sensor,

within a threshold distance of a location corresponding to at least one other activity event within the subgroup of activity events; and predicting, at the remote computer system, representation of a behavioral pattern of the user in the subgroup based on identification of the cluster; identifying, at the remote computer system, an early bound on start times of activity events of the particular activity type from the cluster of activity events; identifying, at the remote computer system, a late bound on start times of activity events of the particular activity type from the cluster of activity events; at a first time succeeding the period of time, communicating a notification of a first type to the user for presentation at the display of the mobile computing device, the first time within a threshold time of the early bound on a day fulfilling the first time-based filter; and at a second time succeeding the period of time, communicating a notification of a second type to the user for presentation at the display of the mobile computing device, the second time within a threshold time of the late bound on a day fulfilling the first time-based filter.

2. The method of claim 1, wherein receiving the record of activity events comprises collecting a first set of action data of the user from a wearable device worn by the user during the period of time, collecting a second set of action data of the user from a mobile computing device associated with the user during the period of time, fusing the first set of action data and the second set of action data into discrete activity events performed by the user during the period of time, and filtering the discrete activity events by the particular activity type to assemble the record of activity events.

3. The method of claim 1, wherein receiving the record of activity events comprises retrieving, from a database, a record of walking events performed by the user over a sequence of days, the record specifying a start time and a duration of each walking event in the record of walking events; wherein selecting the first time-based filter from the set of time-based filters comprises selecting the first time-based filter specifying a minimum duration of a walking event and a particular subset of weekdays; and wherein identifying the cluster of activity events in the record of activity events comprises discarding walking events, in the record of walking events, of duration less than the minimum duration and occurring on days outside the particular subset of weekdays.

4. The method of claim 3, wherein selecting the first time-based filter comprises selecting the first time-based filter from the set of time-based filters comprising a filter specifying a single weekday, a filter specifying a combination of two weekdays, a filter specifying a combination of three weekdays, a filter specifying a combination of four weekdays, a filter specifying a combination of five weekdays, a filter specifying a single weekend day, and a filter specifying a combination of weekend days.

5. The method of claim 1, wherein identifying the cluster of activity events in the record of activity events comprises: identifying activity events in the subgroup as core points; selecting a second subgroup of activity events, in the record of activity events, corresponding to composite start times and durations exceeding the core composite distance threshold and falling within a density-reachable threshold distance of a composite start time and duration of an activity event within the subgroup of activity events; identifying activity events in the second subgroup as density-reachable points; calculating a centroid of core points and density-reachable points in the subgroup and the second subgroup; calculating a maximum distance and a minimums distance between the centroid and the core points and between the centroid and the density-reachable points; and predicting representation of a minimum of two behavioral patterns in the subgroup and the second subgroup in response to a difference between the maximum distance and the minimum distance exceeding a threshold.

6. The method of claim 1, further comprising, from the cluster of activity events, identifying a particular geographic location associated with the activity events of the particular activity type; further comprising setting a threshold distance from the particular geographic location for activity events of the particular activity type for the user; wherein communicating the notification of the first type to the user comprises communicating the notification of the first type through a mobile computing device associated with the user based on presence of the computing device within the threshold distance of the particular geographic location on a day fulfilling the first time-based filter.

7. The method of claim 1, wherein identifying the cluster of activity events in the record of activity events comprises identifying a subgroup of activity events, in the record of activity events, corresponding to start times falling within a threshold time from a start time of at least one other activity event within the subgroup of activity events.

8. The method of claim 1, further comprising identifying a user behavioral pattern for the particular activity type based on the subgroup of activity events comprising a number of activity events exceeding a threshold number of events.

9. The method of claim 8, wherein identifying the user behavioral pattern of the particular activity type comprises characterizing the subgroup of activity events as one of a pre-habit behavior and a habit based on the number of activity events in the subgroup of activity events; and wherein communicating the notification of the first type to the user comprises generating the notification of the first type based on a characterization of the subgroup of activity events as one of a pre-habit behavior and a habit.

10. The method of claim 1, wherein communicating the notification of the first type to the user comprises extrapolating, from the cluster, a quantitative datum corresponding to the particular activity type and presenting a form of the quantitative datum through a mobile computing device associated with the user.

11. The method of claim 10, wherein extrapolating the quantitative datum from the cluster comprises calculating a probability of initiation of an activity of the particular activity type, by the user, between the early bound and the late bound on a current date and predicting a duration of the activity of the particular activity type based on the cluster of activity events; and wherein presenting the form of the quantitative datum comprises rendering the probability of initiation of the activity and the duration of the activity within in a notification on a display of the mobile computing device in response to instance of a time within a threshold time of the early bound on a day fulfilling the first time-based filter.

12. The method of claim 10, wherein communicating the notification of the second type to the user comprises, in response to an absence of a detected activity of the particular activity type between the early bound and the late bound on a day fulfilling the first time-based filter, presenting to the user, through the mobile computing device, a prompt to provide feedback for the absence of a detected activity of the particular activity type.

13. The method of claim 12, further comprising: receiving feedback for the absence from the user through the mobile computing device; selecting an alternative time-based filter from the set of time-based filters based on the feedback; identifying a second cluster of activity events in the record of activity events filtered according to the alternative time-based filter; identifying an alternative early bound on start times of activity events of the particular activity type from the second cluster of activity events; identifying an alternative late bound on start times of activity events of the particular activity type from the alternative cluster of activity events; at a third time succeeding the period of time, communicating a notification of the first type to the user, the third time within a threshold time of the alternative early bound on a day fulfilling the alternative time-based filter; and at a fourth time succeeding the period of time, communicating a notification of the second type to the user, the fourth time within a threshold time of the alternative late bound on a day fulfilling the alternative time-based filter.

14. The method of claim 1, further comprising: receiving a second record of activity events of the particular activity type performed by the user over a second period of time succeeding the period of time, the second record specifying a start time and a duration of each activity event in the second record of activity events; selecting a second time-based filter from a set of time-based filters for the record and the second record; identifying a second cluster of activity events in a combination of the record of activity events and the second record of activity events filtered according to the second time-based filter, the second cluster comprising at least one activity event of the cluster; identifying an alternative early bound on start times of activity events of the particular activity type from the second cluster of activity events; identifying an alternative late bound on start times of activity events of the particular activity type from the second cluster of activity events; at a third time succeeding the second period of time, communicating a notification of the first type to the user, the third time within a threshold time of the alternative early bound on a day fulfilling the second time-based filter; and at a fourth time succeeding the second period of time, communicating a notification of the second type to the user, the fourth time within a threshold time of the alternative late bound on a day fulfilling the second time-based filter.

15. The method of claim 1: wherein receiving the record of activity events comprises receiving the record further specifying a second activity event preceding each activity event in the record of activity events by a

corresponding lead time; wherein identifying the cluster of activity events in the record of activity events comprises identifying a subgroup of activity events, in the record, preceded by second activities of a second activity type corresponding to lead times less than a maximum lead time specified in the first time-based filter, the second activity type distinct from the first activity type; and wherein communicating the notification of the first type to the user comprises communicating the notification of the first type to the user in response to detecting an activity of the second type prior to the early bound on a day fulfilling the first time-based filter.

16. The method of claim 1, wherein receiving the record of activity events comprises collecting motion data sampled at an inertial sensor of the mobile computing device, wherein the motion data describes user motion coincident the performance of each activity event by the user, wherein the location data and the motion data are operable to improve the remote computer system in relation to activity type prediction, and the method further comprising: classifying, at the remote computer system, the particular activity type performed by the user based on the location data and the motion data, wherein predicting representation of the behavioral pattern comprises predicting representation of the behavioral pattern based on classification of the particular activity type and the identification of the cluster.

17. A method for communicating activity-related notifications to a user, the method comprising: receiving, at a remote computer system from a wireless communication transceiver module of a mobile computing device, a record of activity events of a particular activity type performed by the user over a period of time, the record specifying a time of each activity event in the record of activity events, wherein receiving the record of activity events comprises collecting location data sampled at a location sensor of the mobile computing device comprising the location sensor, a display, and the wireless communication transceiver module, wherein the location data comprises a location coincident performance of each activity event by the user; selecting, at the remote computer system, a first time-based filter from a set of time-based filters for the record; identifying, at the remote computer system, a cluster of activity events in the record of activity events filtered according to the first time-based filter, wherein identifying the cluster of activity events in the record of activity events comprises: obtaining a set of computer-implemented rules defining activity event subgrouping as a function of activity event start time, activity event duration, and coincident location, wherein the set of computer-implemented rules are operable to improve the remote computing system in relation to behavioral pattern prediction, and selecting a subgroup of activity events according to the set of computer-implemented rules and corresponding to: composite start times and durations falling within a core composite distance threshold of a composite start time and a duration of at least one other activity event within the subgroup of activity events, and locations, from the location data sampled at the location sensor, within a threshold distance of a location corresponding to at least one other activity event within the subgroup of activity events; and predicting, at the remote computer system, representation of a behavioral pattern of the user in the subgroup based on identification of the cluster; identifying, at the remote computer system, an early bound on times of activity events of the particular activity type from the cluster of activity events; identifying, at the remote computer system, a late bound on times of activity events of the particular activity type from the cluster of activity events; extrapolating, from the cluster, a quantitative datum corresponding to the particular activity type and the first time-based filter; at a first time succeeding the period of time, presenting a form of the quantitative datum through the display of the mobile computing device associated with the user, the first time within a threshold time of the early bound on a day fulfilling the first time-based filter; and at a second time succeeding the period of time, in response to an absence of a detected activity of the particular activity type between the early bound and the late bound on a day fulfilling the first time-based filter, presenting to the user a prompt to provide feedback for the absence of a detected activity of the particular activity type, the second time within a threshold time of the late bound on a day fulfilling the first time-based filter.

18. The method of claim 17, further comprising: receiving feedback for the absence from the user through the mobile computing device; selecting an alternative time-based filter from the set of time-based filters based on the feedback; identifying a second cluster of activity events in the record of activity events filtered according to the alternative time-based filter; identifying an alternative early bound on times of activity events of the particular activity type from the second cluster of activity events; and identifying an alternative late bound on times of activity events of the particular activity type from the alternative cluster of activity events.

19. The method of claim 17, wherein identifying the cluster of activity events in the record of activity events

comprises identifying a minimum number of activity events, in the record of activity events, corresponding to start times falling within a range of start times specified in the first time-based filter for a particular weekday.

20. The method of claim 17, wherein receiving the record of activity events of the particular activity type comprises receiving the record of activity events of the particular activity type comprising one of walking, exercising, eating, driving, working, and sleeping, the record further specifying a duration of each activity event in the record of activity events.

Description

TECHNICAL FIELD

This invention relates generally to the field of digital health and more specifically to a new and useful method for communicating activity-related notifications in the field of digital health.

BRIEF DESCRIPTION OF THE FIGURES

FIG. 1 is a flowchart representation of a method;

FIG. 2 is a flowchart representation of one variation of the method;

FIG. 3 is a flowchart representation of one variation of the method;

FIG. 4 is a flowchart representation of one variation of the method;

FIGS. 5A and 5B are flowchart representations of variations of the method;

FIG. 6 is a flowchart representation of one variation of the method; and

FIG. 7 is a flowchart representation of one variation of the method.

DESCRIPTION OF THE EMBODIMENTS

The following description of embodiments of the invention is not intended to limit the invention to these embodiments, but rather to enable any person skilled in the art to make and use this invention.

1. Method

As shown in FIG. 1, a method for communicating activity-related notifications includes: detecting a pattern of a behavior by a user during a first time period in Block S110; classifying a strength of the behavioral pattern in Block S120; detecting a deviation from the behavior during a second time period of duration less than the first time period in Block S130; in response to a deviation from the behavior during the second time period, arming a recommendation for delivery to the user in Block S140; selecting the recommendation from a set of recommendations based on the strength of the behavioral pattern and a direction of the deviation from the behavior in Block S150; and presenting the recommendation to the user in response to a trigger corresponding to the behavioral pattern in Block S160.

As shown in FIGS. 4, 5A, and 5B, one variation of the method for communicating activity-related notifications to a user includes: receiving a record of activity events of a particular activity type performed by the user over a period of time in Block S102, the record specifying a start time and a duration of each activity event in the record of activity events; selecting a first time-based filter from a set of time-based filters for the record in Block S110; identifying a cluster of activity events in the record of activity events filtered according to the first time-based filter in Block S110; identifying an early bound on start times of activity events of the particular activity type from the cluster of activity events in Block S140; identifying a late bound on start times of activity events of the particular activity type from the cluster of activity events in

Block S140; at a first time succeeding the period of time, communicating a notification of a first type to the user in Block S160, the first time within a threshold time of the early bound on a day fulfilling the first time-based filter; and at a second time succeeding the period of time, communicating a notification of a second type to the user in Block S160, the second time within a threshold time of the late bound on a day fulfilling the first time-based filter.

As shown in FIG. 6, a similar variation of the method includes: receiving a record of activity events of a particular activity type performed by the user over a period of time in Block S102, the record specifying a time of each activity event in the record of activity events; selecting a first time-based filter from a set of time-based filters for the record in Block S110; identifying a cluster of activity events in the record of activity events filtered according to the first time-based filter in Block S110; identifying an early bound on times of activity events of the particular activity type from the cluster of activity events in Block S140; identifying a late bound on times of activity events of the particular activity type from the cluster of activity events in Block S140; extrapolating, from the cluster, a quantitative datum corresponding to the particular activity type and the first time-based filter in Block S150; at a first time succeeding the period of time, presenting a form of the quantitative datum through a mobile computing device associated with the user in Block S160, the first time within a threshold time of the early bound on a day fulfilling the first time-based filter; and at a second time succeeding the period of time, in response to an absence of a detected activity of the particular activity type between the early bound and the late bound on a day fulfilling the first time-based filter, presenting to the user a prompt to provide feedback for the absence of a detected activity of the particular activity type in Block S160, the second time within a threshold time of the late bound on a day fulfilling the first time-based filter.

2. Applications

Generally, the method functions to detect a behavioral pattern of a user over a first period of time, to correlate the behavioral pattern of the user with a trigger, to identify a deviation from the behavioral pattern by the user within a second period of time succeeding (and/or shorter than) the first period of time, and to deliver a notification (e.g., a prompt, a recommendation) to based on the trigger in response to deviation from the behavioral pattern. The method can therefore be implemented within a habit-building program--such as within a wellness program executing on a wellness platform described in U.S. patent application Ser. No. 14/048,956--to select and deliver content to a user to support the user in building a positive behavioral pattern, sustaining a positive behavioral pattern (or "macro habit"), and/or weakening a negative behavioral pattern. In particular, the method can function to select a particular type of prompt to deliver to the user, to automatically construct the prompt, to determine when to deliver the prompt to the user based on an user behavioral pattern identified from user data collected over a period of time, based on a deviation from the behavioral pattern within a subsequent (e.g., short) period of time, and based on an identified trigger (e.g., time, location, weekday) corresponding to the behavioral pattern.

In one example, various Blocks of the method are implemented within a native wellness platform application executing on (or in conjunction with) a smartphone associated with a user, and the user interfaces with the smartphone to enter a goal of `walking continuously over a period of ten minutes per day` into the native wellness platform application. In this example, Block S110 analyzes user motion data collected from the smartphone and/or from a wearable device worn by the user (e.g., a `smart` wristband) over a two-week period (or "interval") to identify user walking patterns, such as based on or related to locations coincident a walking event, daily start times for walking events, durations of walking events, and/or other events or actions performed by the user before and/or after walking events, such as shown in FIGS. 1 and 2. In this example, Block S110 can implement a pattern engine to determine that, `on average, the user completes one continuous nine-minute walk every weekday` or that, `on average, the user completes one continuous nine-minute walk around every weekday starting within six minutes of 1:15 PM.` Block S130 can subsequently detect a deviation away from the detected behavioral pattern, such as to determine that `the user did not complete a nine-minute walk today` or `the user did not initiate a nine-minute walk between 1:09 PM and 1:21 PM today.` Based on such detected deviation from the detected behavioral pattern, Block S140 can arm a notification engine (e.g., a recommendation engine) to respond to the detected absence of the anticipated event, and Block S150 can implement the notification engine to select an appropriate prompt or other or directive for the user to guide the user back toward habitually fulfilling the (positive) behavioral pattern of walking after lunch. Block S160 can thus deliver the selected prompt to the user at a time substantially likely to elicit a response from the user.

In one implementation, Block S150 selects a prompt of a first type prompting the user to complete a walking event, and Block S160 delivers the prompt of the first type to the user immediately prior to anticipation of the user beginning a walking event on a subsequent weekday, such as at 1:08 PM on the subsequent weekday for the user who regularly walks around 1:15 (.+-.6 minutes) each weekday. In another implementation, Block S150 selects a prompt of a second type asking the user to provide feedback for omitting the action from his daily routine, and Block S160 delivers the prompt of the second type to the user immediately upon determination that the user deviated from the predicted behavior, such as at 1:22 PM in the foregoing example.

The method can therefore populate messages relevant to a user and manage timely delivery of such messages to the user. The method can further support development and reinforcement of sub-habits (e.g., minor or "small" habits) to guide the user in developing larger, more involved habits out of multiple sub-habits over time. As in the foregoing example, the method can initially support the user in completing a ten-minute walk each weekday in order to guide the user in developing a more involved habit of completing multiple ten-minute walks each day or of completing one thirty-minute walk each weekday. However, the method can handle any other suitable behavioral pattern and/or habit, such as walking, running, eating well, sleeping, etc. and on any other timescale, such as hourly, daily, weekly, monthly, annually, etc., such as shown in FIG. 2.

As described in U.S. patent application Ser. No. 14/048,956, a native wellness platform executing on a mobile electronic device carried by the user (e.g., on a smartphone, tablet, smart watch, smart glasses, etc.) can implement the method to generate and deliver timely directives to the user. For example, Blocks of the method can be implemented within a native wellness platform application executing on a smartphone, the native wellness platform application supporting multiple internal wellness applications to guide and support the user in improving his wellness. Additionally or alternatively, one or more Blocks of the method can be implemented by an application server and/or within a user interface or user dashboard accessible through a web browser executing on a computer. Blocks of the method can also be implemented on one or more computer systems, such as a cloud-based computer system, a mainframe computer system, a grid-computer system, or any other suitable remote computer system. For example, the method can be implemented by a remote cloud-based computer system (e.g., a remote server) in communication with a smartphone carried by the user, wherein the remote computer system implements one or more Blocks of the method remotely to select or generate a prompt for the user, and wherein the remote computer system transmits the prompt back to the smartphone for presentation to the user. However, the method can be implemented by or in cooperation with any other one or more mobile computing devices, processors, computers, computer networks, etc.

Blocks of the method can therefore also interface with various hardware and/or software systems to collect user data and to present notifications to the user. For example, the method can interface with a "smart" wristband (or other wearable device) incorporating an accelerometer, a gyroscope, a temperature sensor, a magnetometer, and/or a display. For example, Block S110 can receive user motion, temperature, and/or other user-related data from the wearable device over time and extrapolate a user behavioral pattern and action triggers from these data. Blocks of the method can similarly interface with an external device--such as a bath scale or a digital environmental thermometer--to retrieve additional user or local environmental data. Blocks of the method can also interface with a mobile computing device (e.g., a smartphone) incorporating a GPS sensor, communication channels (e.g., email, SMS text messaging), and a display, etc. to retrieve relevant user data, location data, calendar data, communication data, etc. Block S160 of the method can further output notifications to the user through the mobile computing device, such as by displaying notifications on the display of the mobile computing device. One or more Blocks of the method can therefore aggregate various user and environment data from multiple sources and implement these data to generate and deliver notifications for the user.

3. Record of Activity Events

Block S102 of the method recites receiving a record of activity events of a particular activity type performed by the user over a period of time, the record specifying a start time and a duration of each activity event in the record of activity events. Generally, Block S102 functions to aggregate user and environmental data from multiple hardware devices, such as a wireless-enabled wearable wrist-borne device and a mobile computing device (e.g., smartphone) executing a native wellness platform, such as shown in FIG. 6.

In one implementation, Block S102 collects action data (e.g., a first set of action data) of the user from a wearable device worn by the user during the period of time, collects action data (e.g., a second set of action data) of the user from a mobile computing device associated with the user during the period of time, and fuses the action data from the wearable device and the mobile computing device into a register of discrete activity events performed by the user during the period of time. Block S102 can further filter the register of discrete activity events by activity type to assemble a record of activity events of a particular activity type; Block S102 can also apply multiple filters to the register of activity events to assemble multiple records, each containing documentation of activity events of a particular activity type. For example, Block S102 can generate a record of activity events containing documentation of walking, exercising, eating, driving, working, or sleeping events, the record further specifying a duration of each activity event in the record of activity events.

3.1 Wearable Device Data

Block S102 can interface with a wrist-borne device ("wristband") worn by the user both at night and during the day to collect user sleep- and activity-related data collected by the wristband. For example, the wireless-enabled wristband can incorporate an accelerometer, a gyroscope, a temperature sensor, and/or a display, such as a wearable device described in U.S. Provisional Application No. 61/710,867, filed on 8-Oct.-2012, which is incorporated in its entirety by this reference, and Block S102 can thus receive user motion, temperature, and/or other user-related data as the user wears the wristband during the day and/or at night. In one example implementation, Block S102 downloads raw acceleration data from the wristband. For example, Block S102 can execute on a smartphone carried by the user and store the raw acceleration data locally on the smartphone for manipulation in subsequent Blocks of the method. Block S102 can additionally or alternatively upload the raw acceleration data to a remote cloud-based computer system (e.g., a remote server) for analysis and extraction of relevant user action and user activity data from the raw acceleration data. These extracted data can then be communicated back to the smartphone for immediate implementation in subsequent Blocks of the method.

Yet alternatively, the wristband can process motion data locally, extrapolate specific user actions and/or activities from data collected locally, and output action and/or activity tags, such as described in U.S. patent application Ser. No. 14/315,195. In particular, the wearable device can locally compress raw motion data into one or more motion classifiers, such as compressed motion data (e.g., a compressed image of raw motion data), a user action (e.g., an instance extrapolated from compressed motion data), and a user activity (e.g., defined by a set of user actions). For example, the wearable device can generate action and/or activity tags (or timelines) and transmit these tags to the mobile computing device, and Block S102 can thus receive these tags substantially in real-time, such as substantially soon after generation on the wearable device, or asynchronously, such as every hour after a threshold number of user actions are identified, or every time a user activity (determined on the wearable device) changes with a suitable degree of confidence. However, Block S102 can collect user motion data from any other suitable type of wearable device worn in any other way by the user.

In one implementation, Block S102 collects user sleep data from the wristband while the user sleeps and/or after the user wakes from a period of sleep. For example, Block S102--executing on a smartphone--can sync (e.g., pair) with the wearable device (e.g., via Bluetooth), every morning once the user clears a silent alarm on the wearable device, the silent alarm indicating that the user is awake, that a period of user sleep has ended, and/or that the native wellness platform implementing the method should switch from a "user sleep" mode to a "user awake" mode. Block S102 can thus download user sleep data for the foregoing night and pass this data to subsequent Blocks of the method for analysis, such as to determine a quantity and a quality of the user's foregoing night of sleep. For example, the method can apply the user's sleep quality and/or quantity to predict a user energy level and/or energy level pattern throughout the forthcoming day, such as based on past user sleep and activity data. Subsequent Blocks of the method (e.g., Block S130) can also determine when the user went to bed (such as indicated by little to no movement after 9 pm), when the user woke (such as indicated by clearing an alarm through the wristband that also functions as a silent alarm), how long the user was in bed, how long it took the user to fall asleep, how many times the user woke during the night (such as indicated by certain movement patterns), the user's total time spent asleep, or the user's sleep quality (such as indicated by the total amount of user motion during sleep), etc. from sleep-related data collected from the wearable device in Block S102.

Block S102 can similarly receive user raw motion data or user activity and/or user action tags from the wearable device during the day, such as while the user eats, exercises, works, communes, etc. However, Block S102 can function in any other way to collect user action-related data over time from the wearable device, and subsequently Blocks of the method can analyze these data in any other suitable way.

3.2 Mobile Computing Device Data

Block S102 can similarly interface with a mobile computing device incorporating various sensors to collect relevant user data. For example, Block S102 can execute on a smartphone or tablet and collect raw sensor data from an accelerometer and/or a gyroscope incorporated within the mobile device. Like Block S102 and/or the wearable device described above, Block S102 can characterize local motion data from the mobile device into action or activity tags, timelines, etc. For example, Block S102 can identify a pattern in current acceleration data recorded through an onboard accelerometer and implement template matching to pair the behavioral pattern in the current acceleration data with a motion pattern of a known action, such as walking, running, biking, swinging (a tennis racket, a baseball bat), drinking, eating, watching television, sleeping, working at a computer, lifting weights, cooking, etc.

3.3 Additional Sensor Data

Block S102 can also interface with a sensor within the mobile computing device to determine a current location of the user. For example, Block S102 can interface with a Global Positioning System (GPS) sensor within the mobile computing device to retrieve a GPS coordinate position of the mobile computing device and then correlate this position with the current position of the user. Block S102 can additionally or alternatively interface with a cellular transceiver within the mobile computing device to triangulate the position of the mobile computing device relative to various local cellular towers. However, Block S102 can function in any other way to collect location data through the mobile computing device and to correlate these location data with the user's current (or previous) location.

Block S102 can similarly interface with other sensors within the mobile computing device to collect additional user and/or environmental data. For example, Block S102 can collect ambient light level data from a light sensor integrated into the mobile computing device, ambient noise level data from a microphone integrated into the mobile computing device, or ambient temperate data from a temperature sensor within the mobile computing device.

Block S102 can further interface with a local database on the mobile computing device or a remote databases in communication with the mobile computing device to collect additional user data. In various examples, Block S102 can interface with a local email client and/or an email server to collect user email information (e.g., email flux, timing, response types), a native phone call application or a voice-over-IP server to collect user phone call data, a device operating system or a media server to collect user media consumption data (e.g., music, video, images, consumption rate and trends), and/or a native calendar application or a personal data server to retrieve user calendar events and notes, etc. Block S102 can therefore interface with one or more data systems hosted internally on the mobile computing device or externally on a remote database, server, or computer system to access additional relevant user information.

Block S102 can similarly collect additional data from the wearable device, such as heart rate data collected through a heart rate sensor within the wearable device or user body temperate data collected through a temperature sensor within the wearable device. Block S102 can also interface with another standalone external device. For example, Block S102 can receive user weight data from a wireless-enabled digital bath scale or local ambient temperature or barometric pressure from a wireless-enabled thermometer or other environmental sensor. In these implementations, the mobile computing device hosting the native wellness platform can communicate with one or more external devices (e.g., the wearable device, a scale, an environmental sensor) over short-range communicate protocol, such as Bluetooth or Wi-Fi, or any other suitable communication protocol over any other suitable range.

3.1 Environmental Data

Block S102 can further function to retrieve environmental data from an external database and/or an external software system. For example, Block S102 can retrieve a local weather forecast for a location of the mobile computing device determined in Block S102, such as temperature, humidity, rainfall or chance of rain, and sunshine, fog, or cloud cover, etc.

3.5 Manual Data

Block S102 can also function to collect manual user entry of relevant user data, such as through a user interface within the native wellness platform executing on the mobile computing device.

In one implementation in which a wellness application within the native wellness platform is elected by the user, Block S102 selects a prompt defined by the wellness application, presents the prompt to the user, and collects the user's response to the prompt. In one example, a diet application--elected to the user's wellness account and executing within the native wellness platform on the user's mobile computing device--defines a prompt asking the user if and what he consumed for breakfast and a time window in which to present the prompt the user. In this example, Block S102 can select the prompt based on the time of day and communicate the prompt to the user, such as through a notification on the mobile computing device at the time specified by the diet application or based on a learned meal or dietary habit of the user (e.g., an average daily breakfast completion time for the user). In this example, once the user enters a response to the prompt, such as by selecting from a set of available responses or by inputting a custom textual response, Block S102 can pass the user's response to the corresponding diet application within the user's account. Block S102 can additionally or alternatively prompt the user to enter data through another device, such as by selecting an input region on a wearable device, by opening a web browser and completing a survey, etc. to collect a user response to a prompt defined within a wellness application.

In another implementation, Block S102 prompts the user to enter personal information. For example, Block S102 can present to the user a prompt reciting, "Hi Lily. What's the most important reason that you're dieting?" and subsequently collect a response from the user that includes, "I'm doing it for my kids." In this implementation, Block S102 can pass the user's response to Block S140 to select a subsequent directive for the user. As in the foregoing example, Block S140 can implement the user's response to generate a directive that includes, "Hi Lily. I know dieting is tough, but if you're having trouble, be sure to remember why you're doing it. You said that you were doing this for your kids." Block S102 can thus collect personal information from the user, and Block S140 can apply the user's personal information to generate custom, personal directives for the user.

Block S102 can also interface with the wearable device to collect user responses to an explicit or implicit prompt. For example, when the user consumes something, such as a glass of water, a snack, or a full meal, the user can record consumption by engaging an input region on the wearable device, such as by pressing and holding a button on the wearable device or double-tapping a surface of the wearable device. The wearable device can record the input as a consumption indicator and tag the input with a timestamp, such as according to an internal clock maintained by the wearable device. When the mobile computing device syncs with the wristband (e.g., every hour), Block S102 can download consumption indicators and associated time tags stored on the wearable device and add these consumption data to a timeline of user actions or activities. Block S102 can thus interface with the wearable device to log activity data, such as the time, type, size, etc. of a meal, by engaging a readily-accessible input region on a wearable device. Block S102 can further prompt and/or enable the user to add additional consumption details (e.g., a meal size, category, quality, content, etc.) to the consumption data received from the wearable device indicators, such as in real-time or asynchronously. By recording such additional user consumption data, Block S102 can enable subsequent Blocks of the method to further identify a relationship between user activity level, sleep patterns, etc. and user consumption.

3.6 Data Fusion

With any of the foregoing user data thus collected through one or more sensors integrated into one or more devices, Block S102 can extrapolate a user activity (or user action) from these data. Generally, Block S102 can implement machine learning, activity characterization algorithms, pattern extraction and recognition, statistical methods, template matching, lookup tables, or any other suitable analytic technique to determine a user action or activity from raw or compressed motion data thus collected. For example, Block S102 can implement pattern recognition to analyze accelerometer and/or gyroscope data collected from over a period of time from the wearable device and the mobile computing device associated with the user and to automatically group identified user actions (or activities) based on classifications of recognized motion patterns. In this example, Block S102 can analyze raw three-dimensional accelerometer data to count the user's steps. Block S102 can similarly classify motion data as any of biking, walking, driving, raking the grass, playing tennis or basketball, swimming (and the user's type of stroke), etc. Block S102 can also determine if the user is sedentary, such as based on a period of composite accelerometer (e.g., three-axis) amplitudes falling below a threshold acceleration. Block S102 can also characterize user motion data to determine if the user is sleeping and/or the user's current sleep cycle. For example, for acceleration data recorded through the wristband worn on the user's wrist, Block S102 can correlate small, high amplitude, oscillatory accelerations accompanied by little or no gradual, low amplitude acceleration with typing and little to no overall acceleration with sleeping or resting. Block S102 also can correlate smaller amplitude, more gradual, and oscillatory accelerations with walking and similar, higher-amplitude accelerations with jogging or running, through Block S102 can correlate raw user motion data with any other action or activity.

Block S102 can therefore identify a user activity (or action, combination of actions) from motion data collected through the mobile computing device, the wearable device, etc. substantially in real-time, such as within one minute of user initiation of an action or activity. Block S102 can alternatively correlate motion data from a user activity asynchronously, such as by analyzing motion data within predefined time periods or blocks (e.g., in thirty-minute time blocks).

3.7 Record

As activity events are thus identified over time, Block S102 can aggregate these activity data in a record of activity events based on activity type. Block S102 can also incorporate additional data--such as start time, duration, location, intensity, distance (e.g., for running or walking activities), quality (e.g., for sleep periods), etc. --for one or more activity events noted in the record. In one example, Block S102 generates a record of walking events performed by the user over a sequence of days, the record specifying a start time and a duration of each walking event in the record of walking events. In this example, the method can then select a time-based filter specifying a minimum duration of a walking event and a particular subset of weekdays on which such walking events are performed by the user, and the method can subsequently discard walking events--in the record of walking events--of duration less than the minimum duration and occurring on days outside the particular subset of weekdays to identify a cluster of activity events--in the record of activity--indicative of a behavioral pattern, as described below.

Alternatively, Block S102 can retrieve such a record of activity events previously assembled, such as a record generated by a remote application server executing methods and techniques similar to those described above.

4. Behavioral Pattern Detection

Block S110 of the method recites detecting a behavioral pattern of a user from a record of activity events--of a particular activity type--performed by the user during a first time period. Generally, Block S110 implements a pattern engine to extrapolate a behavioral pattern (e.g., a "macro habit") from user motion, location, and/or related event data collected over a relatively long period of time (e.g., one or two weeks) from a wearable device worn by the user and/or from a mobile computing device carried by the user. Block S110 can extrapolate from these data a behavioral pattern pertaining to a particular type of behavior elected by the user for adoption or reinforcement. For example, Block S110 can match a behavioral pattern extrapolated from these user data with a walking-, exercising-, sleeping-, or working-related behavior elected for adoption by the user. Block S110 can also identify various behavioral patterns of the same, similar, or dissimilar types, such as three most-likely or most-valuable user behavioral patterns, as described below, and then pass any one or more of these three behavioral patterns to subsequent Blocks of the method to trigger recommendations for building and/or maintaining related habits.

In one implementation, Block S110 assembles action and/or activity data collected through the user's mobile computing device and/or wearable device--as described in U.S. patent application Ser. No. 14/315,195--into a timeline of user behaviors. Block S110 then compares similar actions across the timeline according to various timescales and with varying tolerances to identify repeated user actions or activities indicative of a behavioral pattern. In one example, as shown in FIG. 1, Block S110 can identify walking events completed by the user during a running period of two-weeks timeline and group the walking events by start times and durations, such as according to preset or user-specific start time ranges and duration ranges. In this example, Block S110 can compare start times of walking periods of similar duration occurring every day within the two-week period, occurring every weekday during the two-week period, occurring every Sunday, Monday, and Thursday during the two-week period, occurring every Friday during the two-week period, occurring every four-hour period of daylight on weekends during the two-week period, occurring every hour of daylight during the weekdays of the two weeks period, and/or occurring on any other time basis.

Block S110 can thus identify--from user data collected over a period of time--a set of possible behavioral patterns, each possible behavioral pattern defining a type of activity (e.g., walking) with a range of start times within a corresponding timescale. For example, Block S110 can extrapolate a first potential behavioral pattern indicating that the user "walks 3.+-.1 minutes starting between 8:30 AM and 10:15 AM on Mondays and Tuesdays," a second potential behavioral pattern indicating that the user "walks 8.+-.3 minutes starting between 12 PM and 1 PM on Wednesdays," and a third potential behavioral pattern indicating that the user "walks 22.+-.3 minutes starting between 7:30 AM and 7:45 AM on weekdays."

In this implementation, Block S110 can then calculate a probability that the user would substantially randomly perform a similar activity within a corresponding indicated range of start times and of corresponding durations on a date fulfilling the corresponding time basis. In particular, Block S110 can estimate a higher probability of random repetition of an activity by the user for a possible behavioral pattern characterized by larger variations in duration and/or start times of the activity on days (or within other periods) fulfilling the selected time basis (and vice versa), and the method can thus correlate a lower probability--calculated in Block S110--with a stronger likelihood that the repeated action corresponds to a behavioral pattern. For example, Block S110 can assign a first potential behavioral pattern (indicating that the user "walks 3.+-.1 minutes starting between 8:30 AM and 10:15 AM on Mondays and Tuesdays") with a highest probability of including substantially random walking events and therefore a lowest likelihood of being a pattern, can assign a second potential behavioral pattern (indicating that the user "walks 8.+-.3 minutes starting between 12 PM and 1 PM on Wednesdays") with a moderate probability of including substantially random walking events and therefore a moderate likelihood of being a pattern, and can assign the third potential behavioral pattern (indicating that the user "walks 22.+-.3 minutes starting between 7:30 AM and 7:45 AM on weekdays") with a lowest probability of including substantially random events and therefore a highest likelihood of being a pattern. Block S110 can then prioritize and/or filter possible behavioral patterns according to corresponding probabilities that repetitions of activity associated therewith--on the selected time basis--are substantially random. For example, Block S110 can select a particular behavioral pattern--from a set of identified possible behavioral patterns potentially related to a current habit program engaged by the user--corresponding to a lowest probably of containing records of random activity events. Subsequent Blocks of the method can thus identify deviation from this particular behavioral pattern and deliver notifications related to the particular behavioral pattern to the user.

Block S110 can further assign a time-based trigger to a selected (e.g., identified) behavioral pattern. In particular, Block S110 can correlate a time-related variable with a trigger for user performance of the activity of the behavioral pattern. For example, for the third potential behavioral pattern described above, Block S110 can identify "7:30 AM and 7:45 AM on weekdays" as a time-based trigger for "walking 22.+-.3 minutes" on a weekday (e.g., Monday through Friday) time basis. Thus, in this example, Block S110 can group repeated walking activities starting approximately between 7:30 AM and 7:45 AM on weekdays and of durations approximately between 19 and 25 minutes into a behavioral pattern, set 7:30 AM as an early bound on beginning a walking event on a weekday, and set 7:45 AM as a late bound on beginning a walking event on a weekday; subsequent Blocks of the method can thus deliver a walking-related prompt of a first type to the user in response to approach of the 7:30 AM early bound on a weekday, and subsequent Blocks of the method can similarly deliver a walking-related prompt of a second type to the user in response to passage of the 7:45 AM late bound on a weekday and a detected absence of the expected walking event.

Block S110 can further combine location, calendar, and/or other related event data collected through the user's mobile computing device and/or wearable device with a record or activity events collected over a period of time to form a (virtual) map of user behaviors over time and/or over various locations and then filter these activity events according one or more selected time bases (e.g., weekdays, weekends, Mondays and Tuesdays, or the first week of every month). Block S110 can then identify groups of activity events of similar types, occurring in the same or similar locations (e.g., with a threshold ground distance), occurring within a threshold period of time after the user's presence in the same or similar location, occurring (e.g., starting, ending) within a (static or dynamic) threshold time, and or corresponding to the same or similar durations within a (static or threshold) time range. Block S110 can thus correlate each groups or "clusters" containing more than a minimum or threshold of number activity events with a behavioral pattern. Block S110 can also set or adjust location tolerances, start times tolerances, duration tolerances, etc. to achieve a target number of activity events in a group and then implement methods or techniques described above to calculate a probably that future repetition of the activity type of the group by the user and fulfilling parameters of the group may be substantially random.

Block S110 can also manipulate location tolerances, start times tolerances, duration tolerances, weather-related parameters, leading event detection, etc. to set location, weather, calendar, and/or other related triggers for delivery prompts related to the behavioral pattern to the user. For example, Block S110 can determine that the user walks 9.+-.3 minutes between 2 PM and 2:15 PM on weekdays on which the user enters his workspace by 10 AM but does not complete this walking event on weekdays on which he arrives at work after 10 AM, and Block S110 can thus tag this walking-based behavioral pattern with a location and an event (e.g., arrival at a particular location on or before a particular time) that must be satisfied to trigger delivery of a related notification to the user. In another example, Block S110 can determine that the user walks 15.+-.4 minutes when the user nears a particular location, such as a grocery store, and Block S110 can thus tag this behavioral pattern with a particular location and a threshold range from the particular location that must be occupied by the user (e.g., the user's mobile computing device) in order to trigger delivery of a related notification to the user.

However, Block S110 can function in any other way to extrapolate a user behavioral pattern from user data over any other suitable period of time and to associate an identified behavioral pattern with any other suitable type of trigger. As described above, Block S110 can elect a single behavioral pattern as exhibiting a greatest correlation with and/or probability of being an established user habit, and Block S110 can thus pass this pattern to subsequent Blocks of the method. Block S110 can also elect and pass any other number and type of behavioral patterns to subsequent Blocks of the method. Block S110 can additionally or alternatively cooperate with Block S130 to implement machine learning to determine whether a series of user actions indicate a pattern and to then apply classifiers of the behavioral pattern to individual user actions to determine if a singular event qualifies as a deviation from that pattern.

5. Filters

Block S110 can therefore also function to select a time-based filter--from a set of time-based filters--for application to the record of activity events to enable detection of one or more behavioral patterns from the record. In particular, for a record containing documentation of activity events of a particular activity type, days (e.g., dates) on which the user performed the activity events, and start times and durations of the activity events, Block S110 can select a time-based filter defining a cycle time and/or a cycle trigger for repetition of the activity type by the user. Block S110 can then test the selected time-based filter to group arrange documentation of activity events occurring serially over time into a spatial distribution of activity events. As described above, Block S110 can then identify activity events in the spatial distribution of activity events as either an outlier or belonging to a cluster of like activity events and correlate a cluster of activity events with a (possible) behavioral pattern (e.g., habit), such as if a number of activity events contained within a cluster exceeds a threshold number.

In one example, Block S110 selects a filter specifying a test for a weekly cycle of repetition of the activity type, and Block S110 populates the filter with cycle triggers corresponding to days of the week on which repetition of the activity type may indicate a behavioral pattern. In this example, Block S110 can select a first filter specifying a weekly cycle and repetition of the activity type on all weekdays within a week, and Block S110 can aggregate all activity events, in the record, occurring on weekdays (within the first period of time) into a spatial distribution based on a time of the day that each activity event was initiated and the duration of each activity event based on the filter. In this example, if the first filter fails to yield a cluster of activity events of sufficient number or density, Block S110 can select a second filter to test on the record of activity events, such as a second filter specifying a test for a weekly cycle of repetition of the activity type and populated with cycle triggers corresponding to Mondays, Tuesdays, and Thursdays on which repetition of the activity type may indicate a behavioral pattern. Block S110 can thus apply the second filter to the record of activity events to generate a spatial distribution of a subset of activity events performed by the user on Mondays, Tuesdays, and Thursdays--according to the second filter--based on a time of the day that each activity event was initiated and the duration of each activity event. Block S110 can continue to test alternative filters on the record of activity events until one (or a minimum number of) cluster of activity events of sufficient number or density to indicate a behavioral pattern is identified. For example, Block S110 can sequentially test the record of activity events against a filter specifying a single weekday, a filter specifying a combination of two weekdays, a filter specifying a combination of three weekdays, a filter specifying a combination of four weekdays, a filter specifying a combination of five weekdays, a filter specifying a single weekend day, and a filter specifying a combination of weekend days, etc. and/or select a particular filter from a set of filters containing the foregoing filters.

Block S110 can additionally or alternatively select filters specifying bi-weekly, monthly, quarterly, semi-annually, annually, or any other cycle duration or combination of cycle durations, such as based on a period of time over which activity events in the record were collected. For example, Block S110 can select a bi-weekly cycle specifying repetition of an activity type on the first Monday and Wednesday of the bi-weekly cycle. In another example, Block S110 can select a monthly cycle specifying repetition of an activity type on the first Friday of the monthly cycle. In yet another example, Block S110 can select an annual cycle specifying repetition of an activity type on weekends of the month of June in the annual cycle.

Block S110 can similarly select a filter (or populate a time-based filter with a parameter) specifying one or more of a minimum duration of an activity event, a maximum duration of an activity event, a location or range of locations coincident an activity event, an intensity of an activity event, distance traversed during an activity event, quality an activity event, etc. Block S110 can thus apply such a filter to the record of activity events to filter the activity events in the record by an additional dimension (e.g., duration, location, intensity, quality, etc.). Block S110 can further aggregate activity events into a spatial distribution representative of the multiple dimensions of the activity events and identify (presence of absence of) clusters in the spatial distribution, as described above.

6. Behavioral Pattern Strength

One variation of the method includes Block S120, which recites classifying a strength of the behavioral pattern. Generally, Block S120 functions to estimate a confidence in subsequent repetition of the action or activity by the user in response to one or more triggers and to classify the behavioral pattern on a short time scale (i.e., shorter than the first period) accordingly, as shown in FIG. 1. In one implementation, Block S120 classifies the behavioral pattern identified in Block S110 as one of a strong pattern (CASE 1), a medium or growing pattern (CASE 2), and a weak pattern (CASE 3) based on a range of start times and/or a durations, etc. of an action or activity specific to the behavioral pattern. For example, Block S110 can identify a behavioral pattern specifying that the user completes one continuous ten-minute walk every weekday but at widely varying times ranging between 7 AM and 9 PM, and Block S120 can classify this pattern as weak (CASE 3). In this example, though Block S110 determines that the user is substantially likely to walk everyday, and Block S120 can classify this pattern as weak bec