

A Generic Conceptual Model Linking Wellness, Health Lifestyles, and User Assistance

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Abstract—The concept of the wellness mobile is one wherein wireless handheld devices such as cell phones are equipped with a set of biosensors, thereby enabling real-time, self-wellness monitoring by the cell phone user, and an incremental reduction in the healthcare costs. It is envisioned that this maturing technology will provide a safe and protective environment for an increasing cell phone user-population to help combat anti-wellness factors such as stress, fatigue, and illness. Because these factors manifest themselves in the form of detectable biometric fluctuations, they can be tracked using inexpensive biometric sensors embedded on smart phones. However, the monitoring solutions provided primarily cater to medical data collection from patients with specific diseases or health conditions and are unsuitable for day-to-day wellness monitoring. With this in mind, the purpose of this position paper is to motivate future research in this area, and to present a novel conceptual model for understanding (and implementation of) wellness assessment that links typical day-to-day user activities, wellness state recognition, and timely user assistance for a healthier lifestyle based on the multi-modality evidences.

Index Terms—Healthcare monitoring, health lifestyles, m-Health, wellness mobile, wireless wellness

I. GLOBAL WIRELESS HEALTH-CARE CONNECTIVITY

With the spread of wireless communications across the world, mobile phones are becoming an indispensable personal electronic gadget [1]. For this reason alone, using mobile phones can bring down personal healthcare and day-to-day healthcare costs by provisioning timely dissemination of information about new drugs, chronic disease management, early detection, and even presymptomatic testing [2]. Medical health practice supported

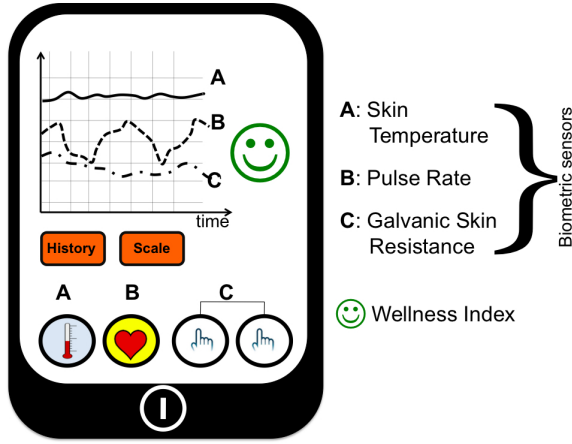
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by portable devices such as mobile phones and patient monitoring applications hold great potential to be the next paradigm shift in telemedicine [3].

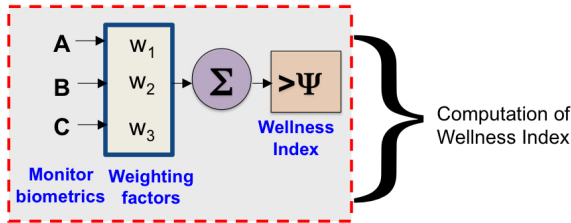
The paradigm of *wellness mobiles* is one wherein mobile phones are equipped with biometric sensors, thereby provisioning real-time self-wellness monitoring for users [4]. This maturing concept has great potential for innovation in the cellular world, and also to make personal healthcare cost-effective by limiting the use of emergency care benefitting both healthcare professionals and users. Based on this concept, healthcare professionals will have access to comprehensive real-time user data at the point-of-care and anywhere there is cellular network coverage. More importantly, users can continuously and frequently track their health on the go, and receive real-time user assistance when needed.

More recently, the wellness support platform by NTT DOCOMO is a new health screening and intervention program in Japan to reduce the number of people suffering from both metabolic syndrome and pre-metabolic syndrome by enabling collection and delivery of vital data such as weight, blood pressure and step-count to a healthcare provider or health adviser [5]. There has been growing interest in developing *proactive* wellness products and health-related smartphone applications, and although manufacturers of medical monitoring equipment have begun to adopt wireless technology, it will be a while before remote monitoring becomes standard procedure in healthcare [6]–[8].

The rest of the paper is organized as follows. Section II introduces the basic architecture for the wellness mobile. Section III introduces the main contribution of this short paper, a generic conceptual model for the wellness-state monitoring, and the concluding remarks are presented in Section IV.



(a) The wellness mobile.



(b) Wellness index computation.

Fig. 1. Basic wellness mobile platform using inexpensive sensors on the phone.

II. BASIC WELLNESS MOBILE PLATFORM

Fig. 1 illustrates the basic concept of the wellness mobile, which can be described as a real-time telemonitoring and diagnostic facility to command and control remote medical devices through mobile phones. The development of this new generation *health* device can be distinguished from the other non-intrusive body-worn wireless devices that can continuously monitor multiple vital signs in real-time, and feedback high-quality information to health professionals via mobile phones by the sensor array on the phone. Using inexpensive sensors, biometrics of the user such as temperature, heart rate, and galvanic skin resistance (GSR) (as shown in Fig. 1(a)) can be measured and recorded. The futuristic wellness mobile phone could enable the user to store and access different biometric data, change the resolution of the observation window, etc., all of which will empower the user to alter one's lifestyle as and when needed. For example, the prototype wellness mobile phone from NTT DOCOMO targets users with busy lives who want a hassle-free way of keeping track of their health using an inbuilt motion sensor that detects body movement and calculates how many calories you burn. The phone can

function as a breathalyzer, a mini body fat calculator, and has a sensor at the top of the phone that reads the pulse from the fingertip.

The important software segment on the wellness mobile is the *wellness inference algorithm* that weights the biometrics (weighting coefficients denoted in Fig. 1(b) as W_1 , W_2 , etc.) and combine them with other information, possibly also obtained using the mobile phone to compute a *wellness index* (denoted in Fig. 1(b) as Ψ) that could be customized to the mobile phone user's daily lifestyle. Many aging people have never used smart phones, let alone wearable sensors, etc. Many of them have reluctance to try something new. Some hold the false notion that they will not be able to use the advanced devices. As a result, in order to make this application a fruitful one, the wellness application on the mobile phone must be made simple in every sense. Representations of the data, suggestions, and all the user interfaces have to be extremely simple, self-explanatory and easy to use. In this way, the concept of wellness mobile envisioned can improve the quality-of-life for the cell phone user by facilitating timely and better quality measurements, instantaneous feedback, improving the quality of medical information and enhancing patient compliance. However, the issues in the design and implementation of a wellness application are manifold [4], [9].

III. FRAMEWORK FOR WELLNESS STATE MONITORING

In this section, we present a generic unified model for wellness state recognition, tracking, and user assistance for developing a robust wellness inference algorithm. Fig. 3 illustrates a four-layer conceptual model for affective state monitoring on a mobile wellness platform.

1) *Predictive Layer (Activities)*: The underlying idea for the proposed model is as follows. A typical day in the life of a working man comprises many activities that span the range from very enjoyable (or optional) to least enjoyable (or mandatory). It is hypothesized that the state of *wellness* undergoes variations during the different activities. For example, relaxing in the comfort of one's home after a busy day at work will have a salutary effect on the wellness, whereas a day at work filled with deadlines and important deliverables could impact the wellness negatively. The hope is that self-wellness monitoring on a regular basis will help mend one's lifestyle toward a healthy living.

User wellness states during different activities could be affected by a variety of factors. These factors may include importance of the goal, the user profile, the context, time of the activity, and prior wellness state

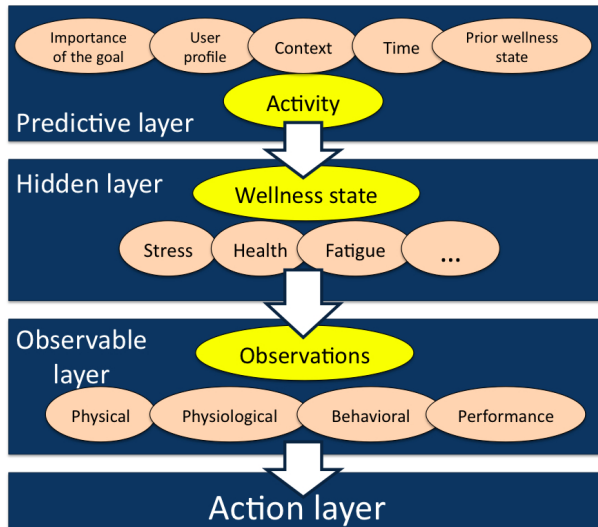


Fig. 2. A four-layer conceptual model for wellness state monitoring.

of the user as shown in the Predictive Layer in Fig. 2. The context of the activity is important because it helps in inferring about wellness based on the observations. For example, a physical activity such as running will bring out rapid fluctuations in heart beats and drop in skin temperature. However, knowing whether the user is running on a treadmill or running late for an important day at work is essential to make any conclusions about the stress level of the user. Moreover, context also reflects the exterior impact from the outside situation on user wellness states. The importance of the goal lead to interior influence on a user. The user profile information may include age, experience, sex, height, weight, health, etc., which play an important role in adapting the model to specific individual for the purposes of personalized solutions. Considering the time when the activity is being performed can help the user maintain a daily-life log and refer to it in the future to track personal wellness states better. The prior wellness state is important because for example, a stressed user might take more time and attempts to finish a task than if the stress level was lower. Thus, these factors are represent the Predictive Layer of the model.

2) *Hidden Layer (Wellness State)*: More recently, *wellness* has been defined as a state of well-coordinated goal-oriented functioning to maximize personal potential and to enhance the quality-of-life [10]. Some common wellness inhibitors are stress, fatigue, bad health, and confusion, which can cause various diseases or detectable conditions such as large deviations from normal processes and biometrics (e.g., body temperature,

heart rate, etc.). Further, they can also adversely alter users' productivity and negatively affect their decision-making and learning abilities. These inhibitors manifest themselves in ways that can be detected using biometric sensors. So the proposed model will recognize and track the anti-wellness (e.g., stress) state transitions using sensory measurements to infer about the wellness of the user. Each anti-wellness state can have a set of possible values. For instance, stress may vary from low to normal and to high. It is remarked that the anti-wellness states are not mutually exclusive. For example, a user can be both fatigued and stressed.

3) *Observable Layer (Evidence)*: An evidence is an observable feature that is capable of providing clues about the users internal wellness state that is hidden. Four classes of measurable evidence have been considered in this paper: the user's physical appearance features, physiological measures, behavioral traits, and performance measures. Physical appearance evidence includes the visual features that characterize users eye-lid movement, pupil movement (eye gaze movement, pupillary response, etc.), gestures, change in pressure at finger tips, and head movement. The importance of these features may vary with different affective states. For example, head tilting frequency is a useful feature for identifying fatigue, while it may not be effective for recognizing stress. Physical evidences can be recorded and tracked using specialized biosensors for eye and gaze tracking or motion-detecting cameras that can be fitted on a mobile phone. Lastly, by using accelerometers or gyroscopes on mobile phones it is possible to detect or identify gestures and changes in pressure at fingertips.

The physiological evidence can be electrocardiograph (ECG) measures that assess the electrical pulse of the heart, electromyography (EMG) measures that assess the electrical signal generated by muscles when they are being contracted, GSR measures that assess the electrical properties of the skin in response to different kinds of stimuli, and many others such respiration period and blood pressure. Physiological evidences can be measured, recorded, and tracked by biosensors, some of which are available in most advanced smart phones today. Alternatively, these signals can be measured by external medical devices such as ECG, heart rate, and glucose monitors, which can then be transferred wirelessly via Bluetooth to a Bluetooth enabled-phone.

User behavior may be influenced by user wellness states. For example, a highly stressed user fighting deadlines user might press the keyboard heavily and make more mistakes, thereby requiring many more key strokes. The key strokes from an emotional user might

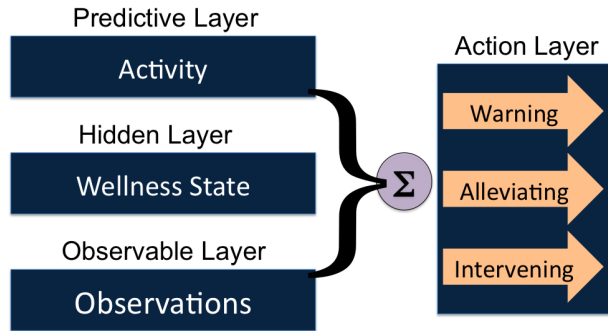


Fig. 3. A model for devising appropriate assistance to the user.

be more erratic and with a lot of pressure that can be detected using pressure sensitive sensors, accelerometers or gyroscopes on mobile phones. Performance can vary with user wellness states and therefore may indicate user wellness. In a task specific environment, the performance may be accuracy rate, user response time, time required for completion, or other measures.

4) *Action Layer (Timely User Assistance)*: Assistance actions may have different degrees of intrusiveness to a user. For example, in one extreme, the assistance can be null if the user is at positive wellness states; in the other extreme, the user may be interrupted and forced to quit if he is in a dangerous level of negative wellness states. Some typical assistance could be *Alerting* (warning the user about a dip in the wellness states and prompt for subsequent immediate tracking), *Alleviating* (simplify user interface, use a less-demanding activity for diversion, decrease task difficulty, etc.), *Active Intervention* (completely stop user the current activity), and etc. as illustrated in the Action Layer of Fig. 2. How to design appropriate assistance should depend on a number of factors such as the activity, context, and should be personalized to the user. The range of applications and assistive services offered to the user could range from advice/tips from medical on-line professionals to entertainment (e.g., on-demand video, music, etc.) to online games. The wellness mobile could offer these different alternatives to the user and provide an *updated* personal wellness score enabling the user to make a well-informed decision, i.e. whether to resume the activity immediately or after some time, punctuate the activity with periodic brakes, etc. Hence, the optimum user assistance should be a function of the activity, the current wellness state, and the observations as illustrated in Fig. 3.

IV. CONCLUDING REMARKS

A novel hierarchical model for activity-based wellness monitoring for an mHealth device called the wellness

mobile, which is a cell phone with a “sensor array” is proposed in this paper. The proposed model achieves two objectives, namely context-aware stress recognition based on the multi-modality evidences, and timely user assistance by balancing the benefits of improving user productivity and the costs of performing possible user assistances. Further, the paper emphasizes the need for a context-aware algorithm that is coupled with the knowledge of various wellness inhibitors, the causes and the symptoms for designing an effective wellness monitoring system. We envision that such a model will aid in the design of a real-time human stress monitoring and assistant system. Future research directions include validating the effectiveness of such a system in recognizing human stress and offering automated assistances.

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