Context-based Lifelog Monitoring for Just-in-Time Wellness Intervention

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Abstract. These days adoption of healthy behavior can be quantified through Ubiquitous computing and smart gadgets. This digital technology has revolutionized the self-quantification to monitor activities for improving lifestyle. Context based lifelog monitoring is among the processes of tracking individual's lifestyle in an effective manner. We have proposed a methodology for context-based monitoring of an individual's prolonged sedentary physical activity and unhealthy dietary behavior in the domain of wellness and give just-in-time intervention to adapt healthy behavior. It detects multiple unhealthy activities of its users and verifies the context for intervention generation. The results depict that the average response of the context-based just-in-time interventions is about 75%.

Keywords: Lifelog, context-based, just-in-time, unhealthy behavior, wellness services, sedentary lifestyle, unbalanced diet.

1 Introduction

Innovative and smart gadgets have supported the wellness domain to enhance individual health and improve socio-economic situations by quantifying the human activities and daily routine. In 1990s, wellness was introduced as *Wheel of Wellness* [1], [2] with categorization of nutritional knowledge, physical fitness, stress management, environmental and social awareness [4]. Today, wellness domain requires innovative user centric platforms which should digitize wellness and health parameters to provide precise recommendations and wellness services [3]. The change in behavior requires a just-in-time (JIT) intervention which meets the constraints and conditions of the environment. The intervention should adapt according to the individual's dynamic status, the goals to target and the changes required for improvement [5].

1.1 Behavior's Concerns and Wellness Applications

Wellness literature shows that unhealthy behavior includes smoking, sedentary lifestyle, higher alcohol intake, and unhealthy diet. The unhealthy diet may increase the risk of chronic diseases like cardiovascular disease, hypertension, diabetes, and premature mortality [6]. The mortality rate is the indication of population's health status which is linked with the higher risk of lifestyle based diseases [13]. The unhealthy lifestyle is an influential cause of chronic diseases and premature death [9]. The regular interrupts in sedentary activities enhance metabolic profile of individual as compared to sedentary ones [8].

The design and development of wellness and health care applications are focusing to track the individual's activity log to identify lifestyle pattern [14]. The identified patterns support proactively to diagnose the cause of undesired fitness and health issues. There are multiple wellness applications are available [6] i.e. GoogleFit, Noom Coach, Apple Healthkit, Google Fit, and etc. These applications quantify user activities, step counts, calories consumption, and provide visualization of user status.

1.2 Context-based Adaptive Intervention

The design of intervention plays a vital role to adopt the changes in behavior. The retention or abandonment of intervention requires to consider the constraints, status and context of the user. The effectiveness of intervention needs to specify the extent and duration of engagement for targeted behavior. The JIT adaptive intervention is an emerging way to promote the healthy behavior adoption with the usage of powerful mobile and sensing technologies [5].

2 Context-based Just-in-Time Lifelog Monitor Architecture

Most of the wellness applications recognizes the user activities and provide interactive visualization to the users on demands [14]. Self-quantification and managing log provide foundation to take proactive action to avoid bad impact of unhealthy lifestyle pattern. The proactive demands in wellness domain lead us to propose context-based JIT lifelog monitor for appropriate intervention generation. According to the JIT philosophy "produce right item, at the right time, in right quantity" [7] supports us to monitor the right person, at right time, for right behavior.

The proposed context-based JIT lifelog monitor as shown in Fig. 1, consists of four components. These components manage the guidelines-based rules related to unhealthy patterns, monitor the lifelog, verify the context and constraints, and notify the wellness stakeholders instantly. The main components are *Monitor Event Configurator, Constraints Configurator, Situation Event Detector,* and *Intervention Manager.*

Monitor event manages the information of the monitor-able activities along with respective quantities in configuration database. The constraints define the situation of a specific monitor-able event and is responsible to manage the multiple constraint

conditions related to the monitor-able events. Constraints configurator verifies the situation by checking all constraint conditions related to that monitor-able event. Situation event detector continuously monitors the event to verify the state where it crosses the threshold quantity defined by expert. The information of micro-nutrients is extracted from the food database of United States Department of Agriculture [17] and consumption of micro-nutrients are obtained with the help of serving quantity [18]. The physical activity behavior is categorized into sedentary or active on the basis of Canadian Physical Activity guidelines [16]. If context supports the intervention, then Intervention Notifier is activated otherwise Intervention Adapter modifies the intervention time by delaying until the context become favorable for the intervention or otherwise ignores it.

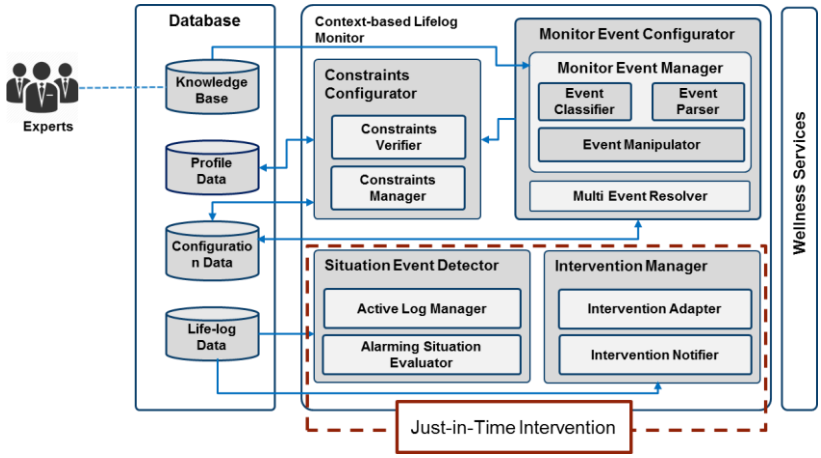


Fig. 1. Architecture of context-based JIT lifelog monitor

3 Integration of context-based lifelog monitor with wellness platform

We have integrated the proposed lifelog monitor with an open source Mining Minds (MM) platform [14], [11]. The individual's context is identified through key attributes location, time, physiological factors, preferences, and activity to generate personalized wellness recommendations [10]. The complexity of the platform is managed through *Supporting Layer (SL)*, *Knowledge Curation Layer (KCL)*, *Information Curation Layer (ICL)*, *Service Curation Layer (SCL)*, and *Data Curation Layer (DCL)* respectively as shown in Fig. 2.

The *SL* provides multidimensional view of the activities' pattern and analytical reports. It classifies the stakeholders on the basis of access rights and demands [12]. The *SCL* manages personalized recommendation services to provide support either in push or pull mode on the basis of the user requirements [15]. The *KCL* helps an expert to express the knowledge into rules to define the unhealthy behavior using knowledge authoring environment [12].

The *ICL* recognizes individual's activities and context through sensory data of emotion, movement, and location. The lifestyle patterns are recognized through the

low and high level contexts [11]. The *DCL* continuously gathers and manages the raw multimodal sensory data into lifelog and big data storage [3].

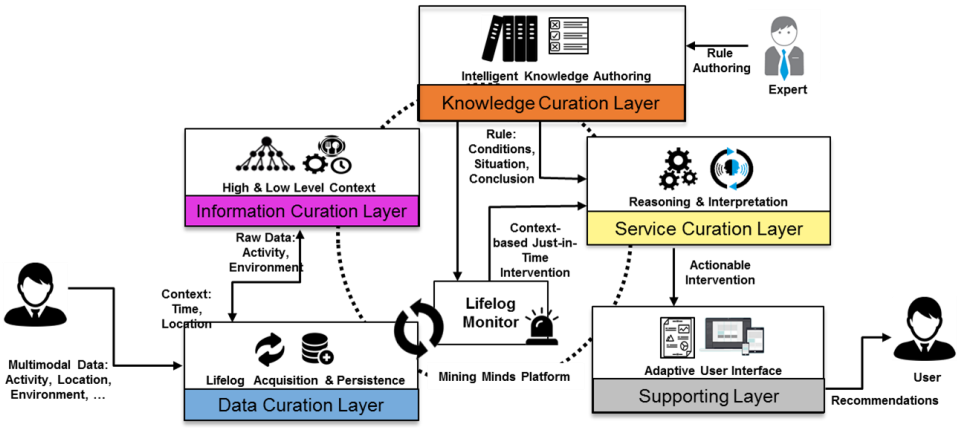


Fig. 2. Integration of lifelog monitor with wellness platform.

4 Experimental Setup

This work is focusing the unhealthy dietary habits and prolonged sedentary bouts. The context-based JIT intervention is provided to avoid the unhealthy habits of physical activities and dietary pattern. For this particular evaluation we have considered 12 volunteers with different gender and age. In order to assess the effectiveness of the JIT intervention, we have drawn the 12 scenarios on the basis of the profile information of our volunteers as shown in Table 1.

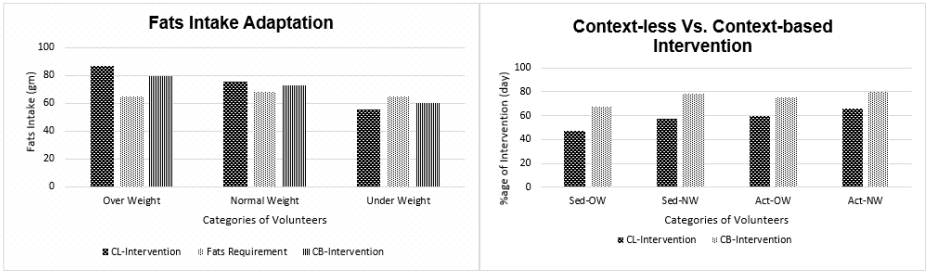
Table 1. Situations for Monitoring the Activities

Situation	Gender	Height (cm)	Weight (kg)	BMI	Activity Level	Calories Requirement	Recommended Fat (gm)
S1	Male	178	92	30.9	Sedentary	2075	57
S2	Male	173	73	24.4	Active	2312	51
S3	Female	168	72	25.5	Sedentary	2020	45
S4	Female	164	56	20.8	Active	1982	40
S5	Male	179	69	21.5	Sedentary	2033	52
S6	Male	176	78	25.2	Active	2112	54
S7	Male	165	48	17.5	Sedentary	1676	43
S8	Female	164	68	25.3	Active	1931	43
S9	Male	165	78	28.7	Active	2042	52
S10	Male	180	98	30.2	Active	2298	59
S11	Female	164	58	21.6	Sedentary	1793	40
S12	Male	168	90	31.9	Sedentary	2100	53

The wellness platform has recorded the volunteers' activities for 21 days with at-least 4 consecutive days for a user. The intimation is generated just-in-time on the basis of detected prolonged activities, location, and the food that they logged.

4.1 Experimental Result Analysis

The context-based just-in-time lifelog monitor has monitored the activities of the user and generated interventions of the unhealthy lifestyle. The response of the volunteers increases when it considers the context of the volunteers while generating the intervention. After analysis of the lifelog, it is observed that the intimation for fats has improved the intake and consumption effectively as shown in Fig. 3(a). The analysis of the log represents that about 42% of interventions are unattended in case of context-less intervention. The result shown in Fig. 3(b) represents the impact of context-based intervention as compare to context-less intervention. The context-based intervention is about 17.5% more effective than context-less intervention.



Abbreviation:

CL: Context Less	OW: Over Weight
CB: Context Based	NW: Normal Weight
Sed: Sedentary	Cal: Calories
Act: Active	

Fig 3. Evaluation of intervention effectiveness on the basis of context

5 Conclusion and Future Work

The designed context-based just-in-time lifelog monitor, monitors the activities and generates the interventions about the alarming situation on the basis of the context. The push based indication to right person, at right time for alarming event helps the individual to change unhealthy behavior proactively. The novel approach of context-based monitoring and just-in-time intervention generation has not only improved the dietary habits but also reduced the number of prolonged sedentary bouts. This precautionary approach can support to avoid chronic diseases by reducing weight and adopting active lifestyle. In future we want to use behavior theory to adopt healthy behavior by identifying the behavior status of the user and generate behavior based intervention.

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