A Conceptual Framework for Augmented Smart Coach Based on Quantified Holistic Self

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Abstract. Augmented human (AH) refers to a research direction of enhancing or augmenting human abilities by human-computer-integration. At its core, AH attempts to monitor and interpret domains of knowledge about human nature to actuate appropriate augmentation. We envision AH as a human-centered approach and a major milestone to be accomplished for ubiquitous virtual reality (i.e., combining the real human with assets of virtual environments). As a concrete example of augmenting human with intellectual abilities, we present a conceptual framework for augmented smart coach. In the proposed framework, multi-dimensional life experiences of human, are systematically captured, assessed, refined, encoded, and quantified into basis patterns of digital holistic self (D-Personality). By doing so, quantified holistic self serves a purpose of a dynamic user profile, which is exploited and explored by anthropomorphic and adaptive augmented interfaces for coaching the needs of individual. We highlight and identify foreseeable technical challenges for future research direction revolving around the presented framework.

1 Introduction

Ubiquitous virtual reality (UVR) [1] and several research projects enriched visual and intellectual capability of users by combining real and virtual environments over the last decade. In the early stages of UVR, visionary interaction technology was developed and simulated using built-in displays, devices, and sensors of smart spaces with smart phones. Now we are entering the next stages of UVR as smart wearable devices and sensors (e.g., smart watch, smart glass, and smart accessories) incrementally encroach on the saturating smart phone market to take supremacy in the coming era of wearable augmented reality. The compulsory adjustments to the next stages of UVR include dealing with increased computation power of smart wearables and personal cloud, and computational sensemaking of increased volume and velocity of personal big data generated in variety of forms. An explosion of personal big data through smart wearables, attracts end-users to keep track of personal activities for self-tracking

N. Streitz and P. Markopoulos (Eds.): DAPI 2014, LNCS 8530, pp. 498–508, 2014.

and self-awareness by numbers [2] known as quantified-self movement[1] and paves the road to research and development of practical personalization through personal analytics[2] and personal informatics [3,4]. We believe that the next level of interactions for ubiquitous virtual reality requires interdisciplinary and concentrated research on augmented human [5] by promptly monitoring user activity, quantifying unique user patterns and delivering effective enhancements. In this paper we present a concrete example of augmenting human in intellectual abilities through a conceptual framework for augmented smart coach. The presented framework is consisted of components that systematically encode a disparate sources of heterogeneous personal big data into quantified holistic self and interpret quantified holistic self to be exploited and explored by augmented smart coach in wearable augmented reality. We review related works, present details of the framework and scenarios, and discuss technical challenges and issues followed by concluding remarks.

2 Related Work

In this section we briefly review relevant previous works on structural support for augmented agents and frameworks in the context of personal big data and quantified self.

Nagao and Rekimoto proposed agent augmented reality [6] where a special kind of software agent called a real world agent, augments the real world with information worlds via functions of situation awareness, user personalization, situated conversation, learning, adaptation, and collaboration. Nagao and Katsuno further expanded the concept to agent augmented community [7] which integrates cyberspace, the real world, and personal contexts for augmented communication via situation-aware and personalized agents. Rekimoto introduced research direction of augmented human [5] and his research group is active in augmented human research and applications [8,9].

Framework-level support for augmented agent is simulated mostly through mobile devices. AR puppet is a hierarchical animation framework for context-aware animated agents where the real world attributes can be used as input modalities and affect animated agents in appearance and behavior patterns [10]. Ubiquitous AR agent [11] overcame limitations of AR puppet by adding supports for migration of agents, ambient intelligence, multi-user interface adaptation, proactive behavior, and belief-desire-intention (BDI) model for self-contained reasoning engine. ARGarden is an augmented edutainment system where the user sees augmented scenes to learn the gardening while interacting with an augmented learning companion in a form of a bird [12]. The augmented bird perceives information according to BDI model and carries out causal interpretation based on its domain knowledge [13]. Ubiquitous Mobile Augmented Reality (UMAR) is a conceptual framework aiming to connect the digital and the real

[1] www.quantifiedself.com

[2] www.technologyreview.com/news/514356/stephen-wolfram-on-personal-analytics/

domains with context-aware information [14]. UMAR retrieves and personalizes information from the Internet based on spatial relationship with GPS and cell ID of the real world. Lee et al. proposed a framework for context-aware visualization and interaction service with context-aware and adaptable service layer, interface layer and AR-based visualization and interaction layer [15]. This framework supports personalization using user preferences, device profiles, and security. AR-REHAB is an AR framework for patients in rehabilitation process to track and measure uses of tangible objects by patients [16]. In AR-REHAB framework, patient signs on to the patient subsystem and performs exercises where his hand movements are recorded. Afterwards patient's exercise records are reviewed and evaluated in therapist subsystem. Context-Aware Mobile Augmented Reality (CAMAR) integrated context-awareness and mobile augmented reality for personalized information augmentation, selective sharing and interaction of contents in smart spaces [17,18]. CAMAR 2.0 [19] and its unified application framework [20] further enriched the concept by including principles of ubiquitous augmentation, high-level of context-awareness and sustaining participatory ecosystem. Augmented Reality 2.0 (AR 2.0) is a hybrid of AR and Web 2.0 technologies for allowing AR applications to be deployed and used on a large scale [21]. AR 2.0 includes characteristics such as large-scale of users and working volume, no visual separation between local data and remote data, modular application modules, and user-generated AR content and mashups.

There are number of self-tracking tools and commercial devices for quantified-self including wearable arm band, activity trackers, fitness trackers and health trackers. Choe et al. studied extreme Quantified-Selfers' practices through video recordings of Quantified Self Meet Up talks and found that Quantified-Selfers (Q-Selfers) mainly self-track for the motivations of improving health, improving other aspects of life, and finding new life experiences [22]. Also the study found that Q-Selfers faced difficulties when tracking too many things, not tracking triggers and context, and current Q-Selfers' practices lack scientific rigor [22].

In comparison to related works, we attempt to polish current quantified-self practices to unobtrusive personal big data collection and analysis where an augmented smart coach with anthropomorphic appearance, better sympathizes, responses, and understands its user by forming, exploiting, and exploring an integrated multi-dimensions of self for interactive conversational coaching process.

3 Conceptual Framework for Augmented Smart Coach

Our goal is to build an augmented smart agent residing in UVR environment that invokes itself out on a need-to-know basis to guide, coach, and recommend its user by examining the individual's previous knowledge and experiences against the sensed context. The concept of augmented smart coach is depicted in Fig. 1. with three characteristics of personal big data as input, quantified holistic self as a dynamic user profile and augmented smart coach as an effective actuator.

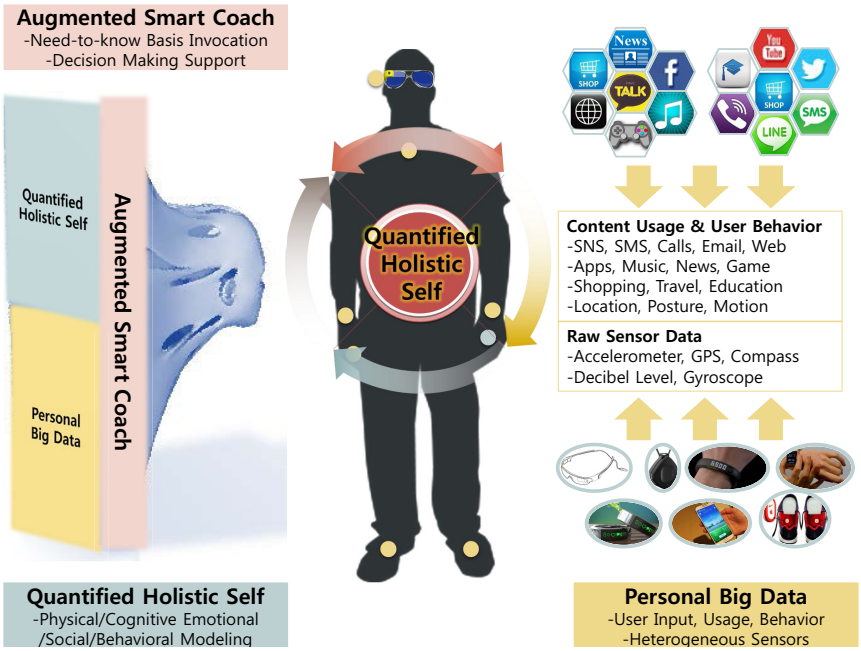

Fig. 1. Concept of augmented smart coach

3.1 Unobtrusive Life-Tracking of Personal Big Data

One of key elements to the framework is use of personal big data. Initiated from the mobile computing [23] and further accelerated by always-on wearable devices, an explosive volume of data is generated and consumed. By exploiting the increased volume of personal information known as personal big data, various episodic activities as well as continuous activities are tracked. Personal big data is generated from wearable sensors and devices such as smart glass and smart watch which include raw sensor data as well as application and content usages including user interaction. Specifically, personal big data contains various user-initiated and user-generated data from disparate and heterogeneous sources over the time for the user or by the user. Personal big data help predicting an individual's needs and store what one experiences computationally. There are many types of personal big data including photo, video, audio, calls, SMS, online/offline records, and activity records. These personal big data is used for numerous personalized applications and activity/trend prediction.

Various wearable sensors can track life activities where raw data are collected from *wearable sensor communicator* and application usages are tracked by recording logs in *application log aggregator*. Personal big data from disparate sources are integrated in a signal-level through seeking, filtering, reading, and extracting information in *personal big data integrator*. The result is stored in a schematic *compact context* which is stored on the internal storage of wearable

devices. Since storage capacity is limited in wearable devices, the essence of personal big data is kept on the device and the rest of raw data are anonymized in *personal big data anonymizer* and stored on a *personal cloud* which can be later retrieved when needed. Even though much of the data may found be useless and easily discarded, raw data can be stored on a cloud for characterization, investigation, and validation in modeling processes. In the lower level of the framework, raw information is turned into intermediate representations and then prepared to be turned into reportable results in the upper level of framework.

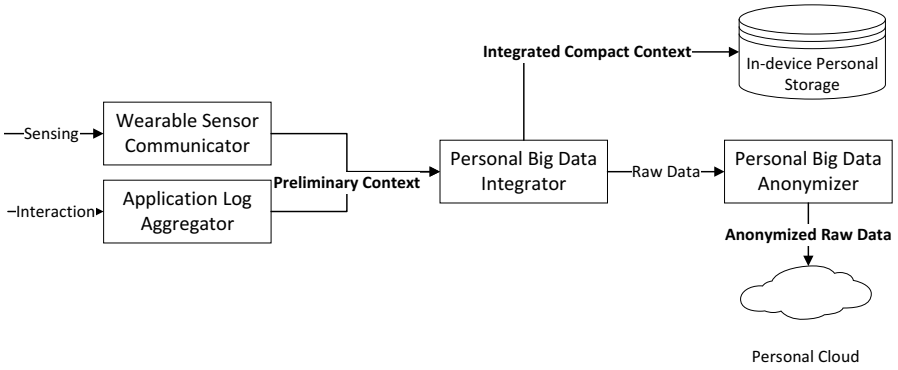

Fig. 2. Tracking of personal big data

3.2 Sensemaking of Quantified Holistic Self

Quantified self is known as using self-tracking tools and sensors to measure one's various activities of life for self-awareness [2]. Quantified self help the user to track activities with the technology and alter behavior to self-improve. A multitude of personal big data requires multiple perspectives to make sense. Therefore we propose quantified holistic self as a user model and sensemaking logic. We include multiple measurable paradigms related to time, frequency, activities, phenomenons and other variables that can be measured and uniquely characterized as personal yet salient patterns called Digital-Personality (D-Personality). Extending this concept further we define quantified holistic self as "a digital form of self that systematically integrates the reciprocal relationships across physical condition, cognitive emotional state, social relationship, and value-based Digital-consumer (D-consumer) behavior in a continuous time domain." Figure 3. and Figure 4. depicts how personal big data is first encoded into D-Personality, then combined to quantified holistic self.

QHS integrator and profiler find meanings in personal big data by analyzing compact context against various inter-related dimensions in *physical condition mapper* to quantify one's body, *cognitive emotional state mapper* to measure one's mind, *social relationship mapper* to track one's interacting targets, and *value-based consumer behavior mapper* to produce D-Personality and gauge one's culture in reference with specific domain knowledge base in *Knowledge Base*.

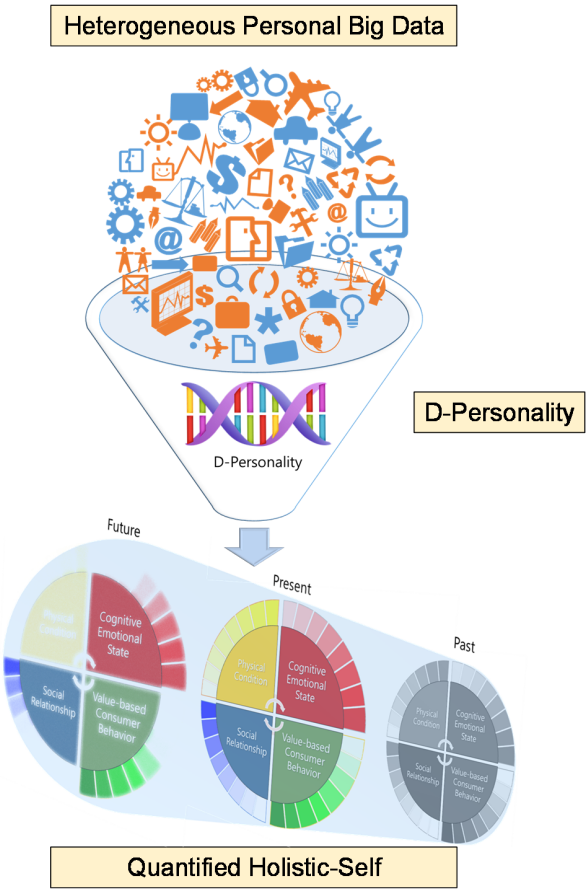

Fig. 3. Quantified holistic self generation concept

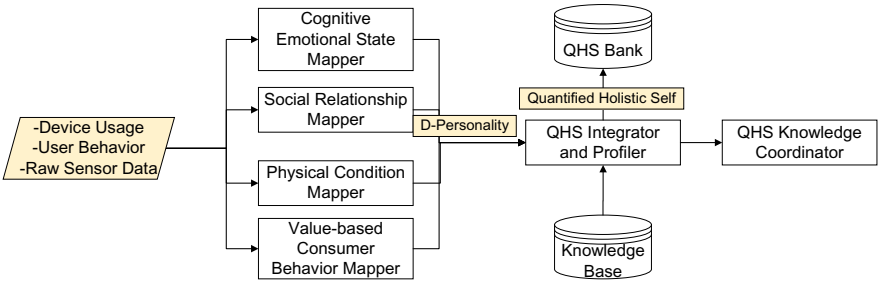

Fig. 4. Quantified holistic self generation procedures

The mapping result as quantified holistic self is stored in *QHS bank* with respect to time which is coordinated by *QHS knowledge coordinator* for continuous learnings and updates.

3.3 Invocation of Augmented Smart Coach

Augmented smart coach is transparent and natural user interface. More specifically, augmented smart coach is personalized and user-friendly agent residing in a wearable augmented reality environment which is enacted and invoked on a need-to-know basis by the sensed context. It is smart since it knows and understands the user from quantified holistic self. As a user-friendly augmented smart coach, it guides, helps, supports and motivates the user in achieving goals. Augmented smart coach is augmented on a user's wearable display such as glass-type display or head mounted display (HMD) to guide, coach, and recommend users in making decisions to achieve immediate tasks as well as long time goals. Figure 5. depicts augmented smart coaching process.

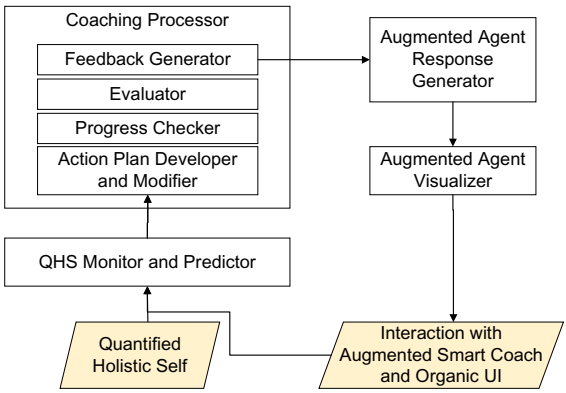

Fig. 5. Augmented smart coaching process

When a user sets goals via augmented user interface, the user's quantified holistic self at the moment is compared against the goals in *QHS monitor and predictor* by calculating the distance between the user and his goals. In *coaching processor*, it follows procedures of coaching such as recommendation, giving instructions and guidelines, decision-making support, progress checking and feedback. Especially, feedback is presented to user via the augmented agent by selecting appropriate responses exploiting and exploring the quantified holistic self in *augmented agent response generator* and the augmented agent is visualized for gestural, behavioral, emotional responses in *augmented agent visualizer*. The coaching process repeats until the goal is achieved.

3.4 Overall Procedures

Figure 6. shows the overall conceptual framework for augmented smart coach based on quantified holistic self.

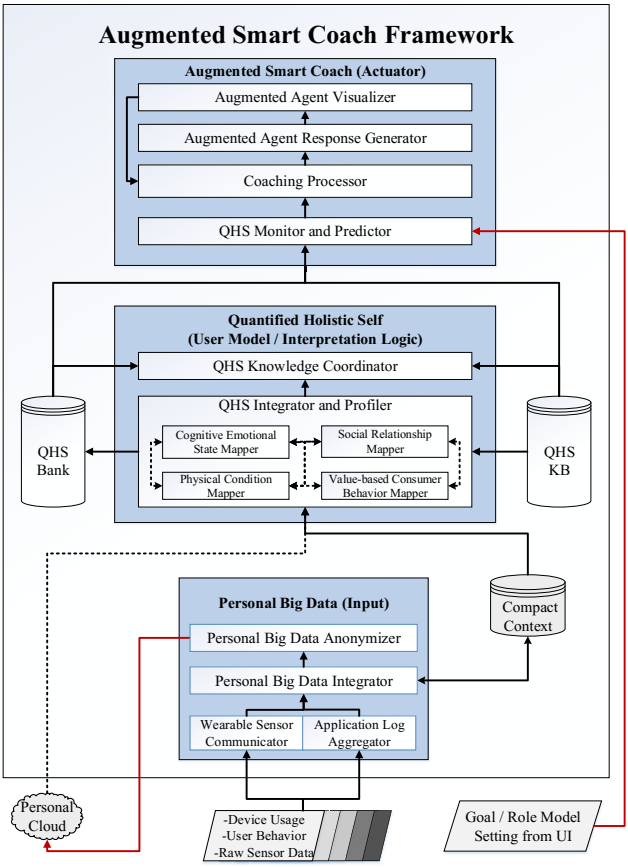

Fig. 6. Conceptual framework for augmented smart coach

3.5 Technical Challenges

Encoding Personal Big Data into Components of D-Personality: Heterogeneous wearable sensor data and wearable device usage (email, SMS, SNS, news, music, shopping, travel, game, education, etc.) are collected in real time. Personal big data is then represented with 5W1H (Who, When, Where, What, Why, How) according to many-to-many relations and encoded into corresponding D-Personality components. Modeling and analysis of personal big data are either processed in real-time on-device, offline batch processing, computation

offloading to the cloud, or mixed/hybrid approach depending on the characteristics of personal big data (volume and frequency of data) and heuristics and rules determined by experiments.

Formation of Quantified Holistic Self from D-Personalities: By examining existing theories and models about components of self, such as physical conditions, cognitive emotional state, social relationship, value-based D-consumer behavior, we identify, model and test measurable characteristics and features as D-Personality. If two models or theories conflict with each other, further experiments are conducted to verify and update the model for practicality. On the other hand, multi-dimensional characteristics of self can be holistically considered to classify and make patterns out of D-Personalities.

Interpretation of Quantified Holistic Self: Basic action plan is prepared by referencing domain-specific knowledge base that covers topics of the goal or role-model. Then quantified holistic self is personally interpreted by referencing user's previous history relating to the goal or role-model and modifies the action plan. Then the action plan is transferred to augmented smart coach where it translates action plan to natural persuasive responses (speech, gesture, emotion) and adaptively changes organic user interface according to the required action. Augmented smart coach checks progress of the user and gives feedback. Also if the user's progress is technically or computationally difficult to check or indecisive, then unobtrusive intervention by augmented smart coach which incorporates digitized survey and experience sampling method questioning and answering, can come to play.

4 Application Scenarios

Augmented smart coach is applicable in various applications that needs personalized guidance and assistance. The coach presents viable solutions for many societal problems.

Addiction Prevention. Augmented smart coach keeps track of user's personal big data and warns the user if addiction-related behaviors are expected. The coach then recommends other activities to user or help the user to be aware of his current situation.

Role Model Follower/Virtual Life Coaching. Augmented smart coach helps the user to follow his role model or achieve certain goals. Quantified holistic self of user and role model is first compared to find difference between the two. Then the coach gives instructions to become like the model or necessary steps to achieve the goal.

Happiness Pursuer. Augmented smart coach measures user's activities and values to see when the user is happy and unhappy. With these characteristics captured in quantified holistic self, the coach can motivate users toward activities that yield to happiness.

5 Conclusions

In this paper, we presented a conceptual framework for smart augmented coach based on quantified holistic self. To assess a user as a whole, we used various sources for personal big data and defined D-Personality and quantified holistic self in terms of physical condition, cognitive emotional state, social relationship, value-based consumer behavior over the time domain. We presented detailed procedures in the conceptual framework and three revolving key ideas of personal big data, quantified holistic self, and augmented smart coach along with technical challenges and possible applications.

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