Interfacing Sensors and Virtual World Health Avatar Application

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Abstract- In this paper, a new mobile application system that controls health avatars on mobile devices is proposed. The status of health avatars reflects personal physical state of a user, which is converted and estimated by data gathered from sensors attached to exercise equipment or from the time spent on a specific exercise routine on specific equipment installed in a U-Health park. Especially in this paper, we confine ourselves on introduction to a metadata application system that converts sensor signals to MPEG-V International Standard data format (ISO/IEC 23005-5). The proposed system utilizes the biometric metadata written in standard data formats from sensors to visualize virtual world health avatars, which make users recognize their health condition without difficulty. The health avatar system and its application scenario are presented in this paper.

I. INTRODUCTION

U-Wellness is gaining wide interest worldwide. U-Wellness opens up a wide variety of possibilities by proposing a brand new, unprecedented research area ranging from disease prevention to health management services, while conventional U-Healthcare only focuses on diagnosis and treatment of diseases. A well-known slogan of U-Wellness says it all – “Making healthy people stay healthier!” Drastic aging of overall society (especially in Korea) and increasing interests for healthier life and well-being trend have naturally led onto interests in U-Wellness as well.

Recently many wellness management systems and services have been developed and released in the market not only for elderly people but also for general public. USN-based Health park or U-Health park [1] in short, is one of them. Recent explosion of interests in steady health management and disease prevention gave birth to a U-Health park and it has proven to be effective and efficient for helping people stay healthy. U-Health park uses sensors attached onto exercise equipment to check the individual health status and measure impetuses.

Lately personal mobile communication has become very common. The U-Wellness area is no exception. Mobility became critical in U-Wellness area. Consequently vigorous researches on mobile healthcare systems based on USN technology have happened in lots of different forms. Mega vendors such as Intel, Palm, and Philips have released new products for integrated healthcare management systems specialized in services needed for healthcare environment by converting and upgrading existing healthcare management systems and equipment into a U-Health park. Especially in this paper, we confine ourselves on introduction to a metadata application system that converts sensor signals to MPEG-V International Standard data format (ISO/IEC 23005-5). The proposed system utilizes the biometric metadata written in standard data formats from sensors to visualize virtual world health avatars, which make users recognize their health condition without difficulty. The health avatar system and its application scenario are presented in this paper.

In particular, MPEG-V (ISO/IEC 23005) provides an architecture and specifies associated information representations to enable the interoperability between virtual worlds, e.g., digital content providers of a virtual world, (serious) gaming, simulation, DVD, and with the real world, e.g., sensors, actuators, vision and rendering, robotics (e.g. for revalidation), (support for) independent living, social and welfare systems, banking, insurance, travel, real estate, rights management and many others. This bridging will provide a lower entry level to (multiple) virtual worlds both for the provider of goods and services as well as the user [2].

In this paper, the health avatar mobile application and its system is introduced in order to bridge between exercise equipment in the U-Health Park and personal smart phones using the sensor data representations from MPEG-V Part 5. This application aims to the personal U-Wellness health care service, which can monitor both personal body condition and the amount of exercise in real time.

This paper is organized as follows. Section II describes the system architecture. Section III explains how to represent sensor data from exercise equipment with definitions of MPEG-V Part 5 (ISO/IEC 23005-5) which is referred to as Sensed Information. Furthermore, a detailed usage example is provided.
given. Section IV explains a mobile health avatar usage scenario. Finally, the paper is concluded in Section V.

II. System Architecture

The overall system architecture for the proposed health avatar application is depicted in Fig. 1. Sensors attached to the exercise equipment can measure human’s body temperature, weight, height, heart rate, blood pressure, and blood sugar rate in real time. The number of workout trials of exercise equipment (e.g. a bench press) can be provided by an accelerometer in real time as well.

The low level sensor data acquired from each sensor should be converted to the standardized data format. Since there are a variety of sensors manufactured in the world as well as there is no standard way to define the data format of those sensor outputs, some standard shall be utilized to maintain the system interoperability. For example, the motion sensing remote controller of “Wii” cannot be interchangeably used with the game contents of “Xbox” since they don’t share the same data format. Our health avatar application system aims to be facilitated to any u-Health parks in the world, it is important to apply some standard data format for the output of sensors.

In order to fulfill this purpose, syntax and semantics of the data formats for interaction devices defined in MPEG-V Part 5 (ISO/IEC 23005-5) [3][4] is adopted to represent data formats from real world sensors. The MPEG-V Part 5 aims to provide data formats for industry-ready interaction devices: sensors and actuators. As depicted in Fig. 1, this Sensed Information Metadata can be either directly delivered to the Health Avatar Application (i.e. Virtual world) or conveyed to RV Adaptation Engine for a further processing.

RV Adaptation Engine performs unidirectional communication from real world sensors to virtual world application (Health Avatar) as well as bi-directional communications to virtual world application (Health Avatar App) using data formats specified MPEG-V Part 5. The RV Adaptation Engine can produce a new set of virtual world data description in accordance with both the Sensed Information acquired and application scenarios. Although there might be some standard data format to describe the Virtual World Data Description for Health Avatar, this is saved for the future investigation.

III. Interfacing Sensed Information for Health Avatar Application

A. Sensed Information from exercise equipment

To correctly measure the body condition and amount of personal workout, the sensor inputs acquired from exercise equipment can be described in Sensed Information Metadata specified in [3][4].

The current syntax and semantics of Sensed Information Metadata from sensors are based on XML Schema. However, in this paper an EBNF (Extended Backus–Naur Form)-like overview of standardized sensed information is provided due to the lack of space and the verbosity of XML [5]. In the following the EBNF will be described.

```
SensedInfoBaseType ::= [TimeSamp] sensedInfoBaseAttributes

The SensedInfoBaseType provides the topmost type of the base type hierarchy which each individual sensed information can inherit. The TimeStamp provides the time information at which the sensed information is acquired. As defined in MPEG-V Part 6 (ISO/IEC 23005-6) [6], there is a choice of selection among three timing schemes, which are absolute time, clocktick time, and delta of clock tick time. The sensedInfoBaseAttributes describes a group of attributes for the sensed information as follows.

sensedInfoBaseAttributes ::= [id] [sensorIdRef][linkedlist] [groupId] [activate] [priority]

The id is a unique identifier for identifying individual sensed information. The sensorIdRef references a sensor device that has generated the information included in this specific sensed information. The linkedlist describes the multi-sensor structure that consists of a group of sensors in a way that each record contains a reference to the ID of the next sensor. The groupId is an identifier for a group multi-sensor structure to which this specific sensor belongs. The activate describes whether the sensor shall be activated. A value of ‘true’ means the sensor shall be activated and ‘false’ means the sensor shall be deactivated. The priority describes a priority for sensed information with respect to other sensed information sharing the same point in time when the sensed information becomes adapted. A value of ‘one’ indicates the highest priority and larger values indicate lower priorities. The default value of the priority is ‘one’. If there are more than one
```
sensed information with the same priority, the order of process can be determined by the Adaptation engine itself.

### BodyHeightSensorType

<table>
<thead>
<tr>
<th>BodyHeightSensorType ::=</th>
</tr>
</thead>
<tbody>
<tr>
<td>SensedInfoBaseType [unit] value</td>
</tr>
</tbody>
</table>

The `BodyHeightSensorType` is a tool for describing sensed information with respect to a body height sensor. The `unit` specifies the unit of the sensed value, if a unit other than the default unit is used, as a reference to a classification scheme term provided by UnitCS defined in A.2.1 of MPEG-V Part 6 (ISO/IEC 23005-6) [6]. The `unit` attributes from this point on in this paper will share the same meaning. The `value` describes the sensed value of the body height with respect to the centimeter (cm) scale.

### BodyWeightSensorType

<table>
<thead>
<tr>
<th>BodyWeightSensorType ::=</th>
</tr>
</thead>
<tbody>
<tr>
<td>SensedInfoBaseType [unit] value</td>
</tr>
</tbody>
</table>

The `BodyWeightSensorType` is a tool for describing sensed information with respect to a body weight sensor. The `value` describes the sensed value of the body weight with respect to the kilogram (kg) scale.

### BodyTemperatureSensorType

<table>
<thead>
<tr>
<th>BodyTemperatureSensorType ::=</th>
</tr>
</thead>
<tbody>
<tr>
<td>SensedInfoBaseType [unit] [location]value</td>
</tr>
</tbody>
</table>

The `BodyTemperatureSensorType` is a tool for describing sensed information with respect to a body temperature sensor. The `location` describes the position information where the sensor is sensed. The `value` describes the sensed value of the body temperature sensor.

### BodyFatSensorType

<table>
<thead>
<tr>
<th>BodyFatSensorType ::=</th>
</tr>
</thead>
<tbody>
<tr>
<td>SensedInfoBaseType [unit] value</td>
</tr>
</tbody>
</table>

The `BodyFatSensorType` is a tool for describing sensed information with respect to a body fat sensor. The `value` describes the sensed value of the body fat with respect to the percentage (%).

### BloodPressureSensorType

<table>
<thead>
<tr>
<th>BloodPressureSensorType ::=</th>
</tr>
</thead>
<tbody>
<tr>
<td>SensedInfoBaseType [systolicBP] [diastolicBP] [MAP] [unit]</td>
</tr>
</tbody>
</table>

The `BloodPressureSensorType` is a tool for describing sensed information with respect to a blood pressure sensor. The `systolicBP` describes the sensed value of the systolic blood pressure with respect to the millimeters of mercury (mmHg). The `MAP` describes the sensed value of the mean arterial pressure with respect to the millimeters of mercury (mmHg).

### BloodSugarSensorType

<table>
<thead>
<tr>
<th>BloodSugarSensorType ::=</th>
</tr>
</thead>
<tbody>
<tr>
<td>SensedInfoBaseType [unit] value</td>
</tr>
</tbody>
</table>

The `BloodSugarSensorType` is a tool for describing sensed information with respect to a blood sugar sensor. The `value` describes the sensed value of the blood sugar with respect to the milligrams per deciliter (mg/dL).

### HeartRateSensorType

<table>
<thead>
<tr>
<th>HeartRateSensorType ::=</th>
</tr>
</thead>
<tbody>
<tr>
<td>SensedInfoBaseType [unit] value</td>
</tr>
</tbody>
</table>

The `HeartRateSensorType` is a tool for sensed information with respect to a heart rate sensor. The `value` describes the sensed value of the heart rate with respect to the beats per minute (BPM).

### AccelerationSensorType

<table>
<thead>
<tr>
<th>AccelerationSensorType ::=</th>
</tr>
</thead>
<tbody>
<tr>
<td>SensedInfoBaseType [Acceleration][unit]</td>
</tr>
</tbody>
</table>

The `AccelerationSensorType` is a tool for sensed information with respect to an acceleration sensor. The `Acceleration` describes the value of the acceleration sensor in three dimensional vectors with respect to m/s². The input from the acceleration sensor is gathered and analyzed in the RV Adaptation Engine to calculate the number of workout trials.

#### B. Usage Example

In this section an example of Sensed Information Metadata with an in-depth description is provided to explain how it shall be used to control the virtual world Health Avatar.

**Listing 1. Example for a Body Height Sensor.**

```xml
<idl:SensedInfo xsi:type="siv:BodyHeightSensorType"
   id="BH01" sensorIdRef="BHID_01" value="175"
   unit="urn:mpeg:mpeg-v:01-C1-UnitTypeCS-NS:cm"/>
<idl:TimeStamp
   xsi:type="mpegvct:ClockTickTimeType"
   timeScale="100" pts="60000"/>
</idl:SensedInfo>
```

This example shows the description of a body height sensing with the following semantics. The description has an identifier of “BH01” and the sensor references an actual sensor with ID of “BHID_01”. The `id` and the `sensorIdRef` are hereinafter used in accordance with the current definition. The sensor returns the value 175 with the unit of cm. The sensor shall be sensed at timestamp="60000" where there are 100 clock ticks per second.

**Listing 2. Example for a Body Weight Sensor.**
This example shows the description of a body weight sensing with the following semantics. The sensor returns the value 68 with the unit of kg.

Listing 3. Example for a Body Temperature Sensor.

This example shows the description of a body temperature sensing with the following semantics. The sensor returns the value 36.5 with the unit of Celsius (°C). The location “4” means sensor position is finger.

Listing 4. Example for a Body Fat Sensor.

This example shows the description of a body fat sensing with the following semantics. The sensor returns the value 25 with the unit of percentage (%).

Listing 5. Example for a Blood Pressure Sensor.

This example shows the description of a blood pressure sensing with the following semantics. The sensor returns the systolicBP 120, the diastolicBP 70, and the MAP 100 with the unit of millimeters of mercury (mmHg).


This example shows the description of a blood sugar sensing with the following semantics. The sensor returns the value 55 with the unit of mg.

Listing 7. Example for a Heart Rate Sensor.

This example shows the description of a heart rate sensing with the following semantics. The sensor returns the value 60 with the unit of beats per minute (BPM).

Listing 8. Example for an Acceleration Sensor.

This example shows the description of an acceleration sensing with the following semantics. The sensor returns the value Ax="9.8" (m/s²), Ay="4.9" (m/s²), and Az="-4.9" (m/s²).

IV. Usage Scenario
Fig. 2 shows an example of exercise equipment installed in a U-Health park. Users can execute mobile health avatar applications, which enable them review the status of their body conditions based on the data gathered from biometric sensors attached on the exercise equipment.

As illustrated in Fig. 3, users can receive their personal biometric data in real-time, such as body weight, body fat, blood pressure, blood sugar, heart rate, etc. The App offers users a convenient way to check how long and how many times they exercise. The mobile health avatar App can also provide an assessment on the status of the body and a recommendation of an appropriate exercise plan for each user. Avatars in the App change their appearance and behavior according to their owners’ health condition. From these avatars, users can visually recognize their status of health.

V. Conclusion
This paper presents a new health avatar system and its application scenario to obtain personal health data from biometric sensors attached to exercise equipment and convert the data into the standard metadata format of sensors based on MPEG-V (ISO/IEC 23005-5) to interface sensors and virtual world health avatar applications. The proposed system utilizes the biometric metadata from sensors to visualize virtual world health avatars, which make users recognize their health condition without difficulty.

As the future work, we plan to develop techniques for converting low-level data from various sensors attached to exercise equipment, such as accelerometers, to high-level information such as the number of exercises or health conditions for users. We will also develop a RV adaptation engine to analyze health conditions of users and generate personalized exercise plans. In addition, we plan to study the standard method to define virtual world data description for health avatars.

ACKNOWLEDGMENT
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Fig. 3. Example of a mobile health avatar App.

REFERENCES