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감성 웰빙 서비스 제공을 위한 웹 오브젝트 기반 감정 처리 기술

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Web Objects Based Emotion Technologies for Provisioning of Enhanced Affective Wellbeing Service

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ABSTRACT

The Internet of Things(IoT) has evolved from a futuristic thought to something that can actually be realized as a mainstream concept in coming years. Web objects based on emotion technologies has a goal to develop an IoT platform that determines context awareness with a focus on sentiment and emotion recognition and ambient adaptation. The main innovative aspect of this paper lies in considering emotion and sentiments as a context source for improving intelligent services in IoT. This paper proposes a functional architecture based on Web of Objects(WoO) platform to enhance human wellbeing using emotion based affective technologies in IoT environment. To realize the emotion technologies on WoO platform and to understand the wellbeing services, use cases have been studied and presented in this papers.

Key Words : EmoSpaces, emotion, WoO, WES, IoT, platform

Ⅰ. Introduction

As we move from www (static pages web), to web 2.0 (social networking web) and now to web 3.0 (ubiquitous computing web), there is a growing need for adapting sensor technologies to their users. For development of those human centric service technologies, one of the most relevant aspects is human's emotion. Affective computing[3] is very important aspect in order to realize the underpinning of human to machine relationship and interaction. Main objective of IoT platforms for developing affective services involve:

- Detect state of individual through smart sensors(sensor + data analytics)
- Detect and analyze current and relevant context, activities, behaviors and emotional states
- Adapt the environn mental situation and develop affective services
- Study the societal relevance and ethical issues

Nevertheless, there is still a lack of pervasive environments[16,17] that have been designed taking into account emotional behavior. The problems with current state of the art technologies is the lack of a holistic infrastructure to collect data from different

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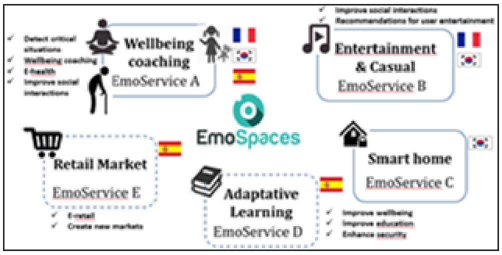
sources[16,18] (sensors, portals, wearable devices) and to translate data into meaningful information as universal meta-data[19], which can be processed to characterize the context and the activity of the users. Until today most of the product of the market and research and innovation projects have focused only on the recognition of some affects, location and some basic physical activities (motions) of users independently from their context. Unfortunately due to several technological issues[1] they put into background the recognition of complex activities and context and their relation to the cognitive abilities of users when they are using applications and services or interacting with other persons.

EmoSpaces aims to bridge this gap and proposes the development of an IoT Platform that recognizes emotions, fuses data[7,16] and user context and personalizes the user environment according to their context. A wide number of domains can benefit from the application of emotion aware technologies in IoT environments, such as ageing, healthcare, service provision for daily living, marketing, promotion of energy efficiency or leisure and entertainment.

The major targeted technical outcomes in EmoSpaces are: i) Technologies for Monitoring and Recommendation Service in Smart Environment[10,14]; ii) Data and Sensor virtualization[9] considering challenges of Big Data; iii) Tools and Techniques for Context-awareness [8,13,18] and Ubiquitous Environment; and iv) Social Simulation and Testing tool for developing cost-effective affective services. Figure 1 presents the overall scope of EmoSpaces. However, this paper is limited to proposition of system model and services provided with respect to smart home and wellbeing coaching services.

EmoSpaces is a project, initiated and supported by ITEA3, an inter-government consortium for research and development projects in the area of Software-intensive Systems and Services (SiSS). Currently EmoSpaces involves three countries namely, France, Korea and Spain. Figure 1 presents the overall scope of EmoSpaces, along with allocation to these countries. However, this paper is limited to proposition of system model and services provided with respect to smart home and wellbeing coaching services.



(a) Allocation to countries

(b) Organizations involvement in specified countries

Fig. 1. Scope wise allocation of EmoSpaces services

The work dissemination in EmoSpaces project defines different work packages which are further subdivided into many tasks. The overview of these work packages consists of: user driven requirement specification, sensing emotion in smart space environments, defining the model for user space, dynamic adaptation of spaces based on user needs and demonstration and testing based on the above defined work packages.

EmoSpaces innovations fall under two main categories. In the first one, EmoSpaces deals with the development of a smart environment upon an intelligent IoT platform where advance processing tools are integrated to collect and analyze heterogeneous sensor data (video, image, text, daily life and physiological data). These data is used to sense the surrounding space of users and characterize their behavior and emotional state. The second category of innovations involves building, upon the proposed platform, affective services responding established profiles of the inhabitants and in accordance with their expectations and desires.

Therefore, the Emospaces aims at gathering all available IoT and sensor data from various vertical sectors (security, health, family, disaster management, etc.) exploiting information coming from fixed home sensors with wearable quantified-self devices with the aim to determine the current relevant context, with emphasis on emotion detection, as means to improve the quality of many IoT vertical services (contextual well-being, caregiving, etc...).

This paper is organized as follows: Section II includes the overview of Web Objects enabled EmoSpaces Service (WES) and its components. Section III describes the system architecture exploiting the Web of Objects (WoO) reference model. Section IV elaborates the Use case scenario for the development of EmoSpaces well- being situation monitoring and recommending services. Finally Section V concludes the paper with results, discussions and future work.

Ⅱ. Related Works

Numerous applications are available regarding affective computing and wellbeing services. The diversity of researches, applications and innovation ideas in this domain reflects the high-level of expectations and innovation potentials. This section provides a relevant but not exhaustive enumeration of current R&D projects related to Affective computing to show the wide range of potential future applications related to emotion awareness. The use case examples include interactive gaming, security applications, devices to help autistics discern emotion, provide better learning experiences, better shopping experience and virtual psychology applications regarding on Human Interaction.

The current research mostly considers user centric applications for service provisioning. In this aspect different space domains and user characteristics have been considered. Affective Learning Companion[20], WASABI[21], Eyes of Things[22], Melomind[23] and the work of Keiran M. Rump et al[24] involve emotion related human interaction along with specific user considerations such as autisms, children, stressful environment etc. Other affective computing applications involve facial, textual and speech recognition, analysis and feature extraction fuctionalities which is current and fundamental solutions for emotion detection. Emotient[25] and affective[26] are example of such application domain. Aside from face emotion, textual analysis also provides promising results based on feature extraction from both keywords and sentences. Tone analyzer by IBM Watson[27], Receptiviti[28] and AlchemyAPI[29] provides good results regarding writer's styles and emotions. In speech analysis, Good Vibrations[30] and Vokaturi[31] are some of the examples with open source API to detect main primary emotions.

In the Wellbeing services, numerous programs dedicated to coaching, are already available on the internet and/or through smartphone applications. Each service has its own definition of wellbeing. But all definitions have a common trait which is finding the right balance between different life domains, such as physical health, social activities and relationships with family and friends, eat healthy, and develop brain activities and a healthy environment. Fabulous Motivate Me[32], Coach Me[33], Smylife[34], Hydro[35] and Med Helper[36] are some examples. Also, related applications in this domain are regarding diet control and other health related issues. Diabetes in Check[37], Glooko[38] and Weight Loss Coach by Fooducate[39] are some examples in this context.

All these applications are based on complex mechanisms, but lack detailed context and situation awareness mechanisms and also are based on non-scalable framework. Regarding scope definitions, and physical (device level) domain, EmoSpaces provides scalable architecture, considering distributed environment along with the knowledge elicitation mechanisms[4,5].

Ⅲ. Overview of Web Objects Based Emospaces Service Platform

The WES Platform include three main subsystems and some databases (Figure 2). The interface with

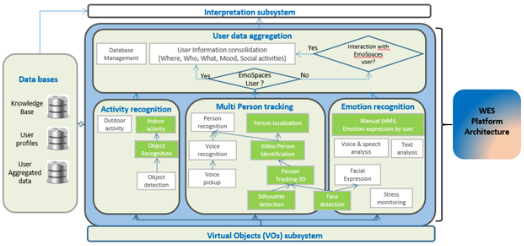


Fig. 2. WES Platform Overview.

sensors is done by Virtual Objects (VO)[2] Subsystem. In essence a Virtual Object is a representation of a real world object, such as sensors, actuators and other devices. Sensor, Actuator or any device. VOs provide a very basic set of functionalities analog to the actual functions of real world objects. The VO Subsystem provide environment data to other subsystems through VOs.

The Perception Subsystem takes data from the VO System and process them into a high-level, aggregate representation of the context. Different modules in the Perception Subsystem extract information from VOs, which are subsequently fused to be delivered to the next Subsystem. These modules deal essentially with recognition of entities in the context, such as activity recognition, person tracking, and emotion recognition and so on. They are usually data-driven, in the sense that they employ signal processing and machine learning techniques. Info about recognized entities is then aggregated in a fusion module and delivered to the next module. Since the result is an aggregation of data provided by VOs, the output of the Perception Subsystem is organized in VOs called Composite VOs (CVOs)[2].

Finally, the Interpretation subsystem takes the perception information and interpret it in more high-level entities related to activity and behavior interpretation. The subsystem is mainly driven by symbolic techniques, such as ontologies and rule-based reasoning.

The information for all subsystems are kept in a series of databases that can be queried for domain knowledge, user profiles, etc. We expect that most of the system adaptation to new scenarios and contexts can be done by populating the knowledge base with new knowledge (i.e. as ontologies and rules).

Platform of Intelligent "Web objects based EmoSpaces Service" (WES) supports following service capabilities:

- Knowledge + Web Object based Open IoT Service Platform to Provide Intelligence for Ageing IoT Service Environments.
- Evolving Smart EmoSpaces via Knowledge based Service Capability
- Implementation of Personalized EmoSpaces Service
- Context Awareness service for the WES based Ageing Service Environment:
- SOA and Plug-in/Plug-out modular service model

3.1 Functional Components of WES

The Perception Subsystem recognizes and aggregates info in the environment. It includes four main modules: Activity Recognition, Multi-Person Tracking, Emotion Recognition and User Data Aggregation.

The Activity Recognition (AR) Module is responsible for detecting activities in raw sensor data. It takes mainly video-feed data and produce a stream of detected actions in the environment, which can be indoors or outdoors. For indoor environment, the module includes facilities for activity recognition itself, but also for object detection and recognition. The last two help in improving the quality of activity recognition.

The Multi-Person Tracking Module is responsible for detecting, identifying and tracking users and other persons in the house. It takes as input video and audio data, and outputs detected persons, with localization and identification data.

The Emotion Recognition Module is able to detect and recognize person's emotions. It takes as input video, sound, text (i.e. from messaging apps) and direct user commands to infer user current emotions. The objective is to detect the underlying feelings to these emotions, so that the services can act accordingly.

The aggregation module is responsible for fusing contextual information produced by the lower-level modules and produce an overall picture of the user context. The inputs are entities produced by the underlying level and the outputs are the same entities, but aggregated in a complete picture. This contextual object is the actual output of the Perception Subsystem.

The Interpretation Subsystem takes aggregated contextual data from the Perception Subsystem and try to recognize higher-level entities, such as behavior, activity and emotions. Essentially, the Interpretation Subsystem will try to infer information that could not be provided directly by perception. Thus, while action such as frying an egg and heating water can be recognized directly by perception, activities such as cooking require more high-level reasoning. This reasoning is done in the Interpretation Subsystem.

The output of the system is the input taken from the Perception Subsystem and output and enriched version of the input. The Interpretation Subsystem is composed by interpretation modules for relevant high-level entities. Also, it accesses a series of databases containing knowledge base necessary for reasoning, as well as user data.

The Activity Interpretation Module is able to infer high-level user activity from perceived actions. Different categories of activities require specific interpretation knowledge. As such, each category has its own sub module.

The Behavior Interpretation Module infers user behavior information mainly from activity information. It takes data from Perception and from the Activity Interpretation Module.

The main challenge in this platform, is to support many service features to fulfill the target requirements. This requires further reducing the component level dependencies so that the system can be easily adopted in different service scenarios and handle issue regarding scalability, fault tolerance etc. In order to meet with such requirements, plug and play service feature has been introduced, which involves light weight, single task oriented and loosely coupled service composition so that services become independent of other system functionalities and can be easily adopted based on the service

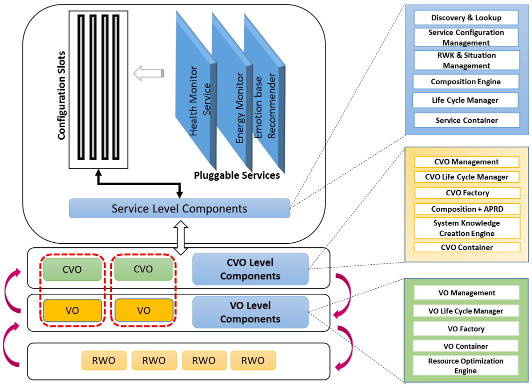


Fig. 3. SOA based WES plug and play feature

requirements. Figure 3 shows the pluggable service abstraction in terms of configuration slots, where easily a new service component can be plugged in order to meet the application level service requirement.

Ⅳ. WoO Reference Model

In the technical architecture, we add implementation details to the global functional architecture. We call it Web of Object (WoO) Reference Model[2]. System Architecture is distributed into two levels that are Service Level and Virtual Level (Figure 4). Whereas Virtual Level is further partitioned into Composite Virtual Object sublevel and Virtual Object sublevel. Service level constitutes all the necessary components to support applications. Service layer is supported with

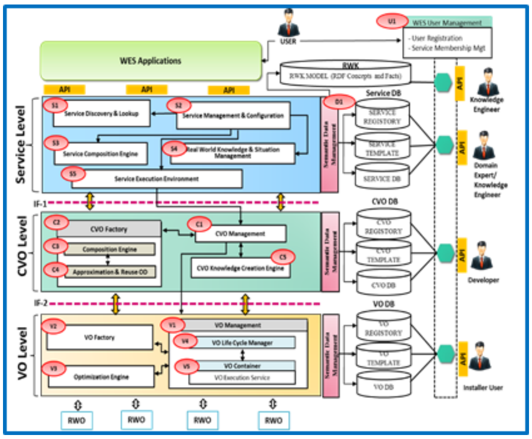


Fig. 4. WoO Reference Model

databases to semantically represent service related data. Composite Virtual Object provides functions to support composition of virtual objects. CVO sublevel makes use of CVO repositories to store and manage CVO data. Virtual Object sublevel provides necessary component to digitally represent physical objects in the form of virtual objects. VOs are semantically represented in repositories at this level.

4.1 Service Level Components

In top down fashion service level is one of the first interaction point for WoO applications. Service level[15] incorporates service management, configuration and execution function along with real world knowledge management sub component.

The service request initiated from the application layer is received at Service Request Handler, which includes mechanisms to parse and evaluate the service request, and its suitable service function is selected. Then the extracted specifications are passed to Service Management and Configuration component which consists of tasks from request inception to service configuration, registration, template management and controlling service execution. It assigns task to Service Discovery and Lookup component which checks the current status of the required service in the system and notifies the Management and Configuration unit. If it is required to compose the service based on request, then this task is assigned to Composition Engine. It includes, service selection, workflow management, binding function to achieve composition of services. After the service is successfully composed, its execution is initiated and managed in Service Execution Environment which includes Service Container to provide mechanisms for service execution. In addition, it contains Life Cycle Manager Component, to handle service switching among different states from active to release.

An important part in the service layer and distinctive aspect of WoO is Real World Knowledge and Situation Manager, constitutes the functions to manage, situational information, represent the current and past situations and user data in the form of real world knowledge. It manages a RWK database which includes a knowledge and situational facts related to real world objects. User Situation Model is handled here to get user situation information. It also includes Situation Managements function, such as detection, classification and recognition.

All the data gathering and management in the service layer is performed at Service databases enable the system to store and retrieve RDF triples about description of available services, along with the data accumulation. Semantic Data Handling Services includes the mechanisms to handle Sparql end point towards these databases.

4.2 Virtual Level Components

Composite Virtual Object (CVO) is a conglomeration of one or multiple VOs. CVOs are self-managed, self-configurable

components. The objective of CVO is to make the effective link between service level and virtual object level. The execution environment of CVO is implemented with multiple microservices[15]. CVO is a mash-up of semantically interoperable VOs. CVO offers enhanced and complex services according to the service execution request. The CVO sublevel must permanently and actively monitor and react changes in service level and VO sunlevel.

A Virtual Object (VO) is a virtual representation of a real world object (e.g sensor, device, task, process and information). VO sub-level provides the functional capabilities responsible for the control and management of Virtual Objects. In the context of WoO, Virtual Object is any entity that represents a Real World Object (Sensor, Actuator, IoT device, etc.) or any Data and Information. A single Virtual Objects can be seen as providing a very basic set of functionalities, representing the actual functions of Real World Objects.

Ⅴ. Emospaces Usecase Scenarios

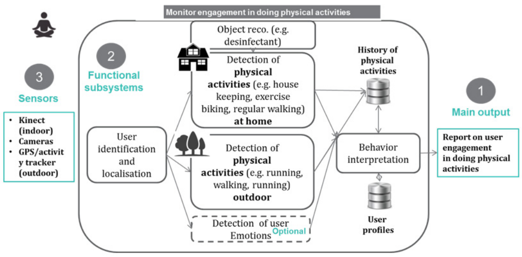
The EmoSpaces solution provides support to typical use case scenario, involving user's routine life activities. Due to heavy workload and competent life style, a person is often diagnosed with depressive disordered symptoms[11]. Therefore this system provides monitoring services[12] to track user's situation. The vicinity of monitoring activities is home or his connected car while travelling to or from office. The activities are monitored through the automation of real world objects, to which he interact with them. The methodology caters three fundamental queries: (1) what are the "platform output" to fulfil the EmoSpaces service requirement? (2) What are the "subsystems" required to provide these outputs? (3) What "sensors" shall be selected to provide input data? Considering this criteria, three use cases have been presented in the following sub-sections to realize the EmoSpaces services. Furthermore, a use case for services regarding user's depressive disorder situations have been presented.

5.1 Use case 1- Lifestyle coaching to control weight

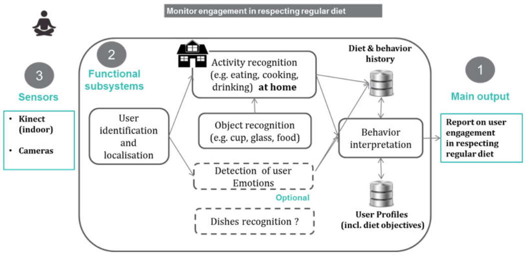
In this scenario, the system offers analyzed result in the form of report regarding physical activities and regular diet which are non-trivial aspects of weight control schemes. This analysis is performed based on monitoring user's physical indoor and outdoor activities through Kinect, GPS and other cameras and sensors. Since user emotional situations do not have any sound impact on user weight control, therefore this functional part is kept as optional. The data is then feed to WoO system where the data is processed into meaningful ontologies and finally the result is forwarded to the application layer. Figure 5 shows the two aspects of life style coaching to control weight.

5.2 Use case 2- Coaching by detection of abnormal behavior

The analysis in this case is complex as compared to use case 1 as the detection and analysis of abnormality becomes very critical when the system has to distinguish it from normal behaviors. In order to avoid any ambiguity, different sensors and readings are taken into account for behavior detection. In this case system is targeted to detect two abnormal situations: (1) prolonged time spent at home which can lead to isolation and social withdrawal, (2) monitoring user mood and behavior through his medium of communication in the network such as; social media and email content analysis, detecting user tone in phone call conversations, facial expressions etc.). Figure 6 depicts these two aspects considering the three

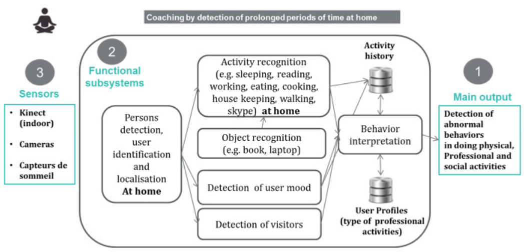


(a) monitoring engagement in doing physical activities

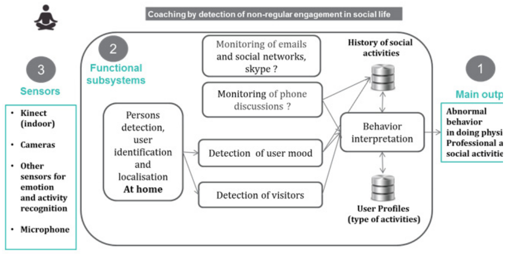


(b) monitoring engagement in respecting regular diet.

Fig. 5. Use case for life style coaching to control weight



(a) prolonged time period in staying at home



(b) non regular engagement in social life

Fig. 6. Use case for life style coaching by detection of abnormal behavior

fundamental queries.

5.3 Use case 3- Coaching in critical situation

Fall detection is mainly performed through position, movement and posture detection (Figure 7). It also requires the identification of user as if the system is monitoring specified user in case of multiple person detected in the house. In case of anomalies, it is also required to differentiate user's situation as person is lying intentionally or is fallen by any cause. This makes the detection process complex due to which different parameters are considered such as heart reading, location of user (floor, bed etc.), body movement etc.

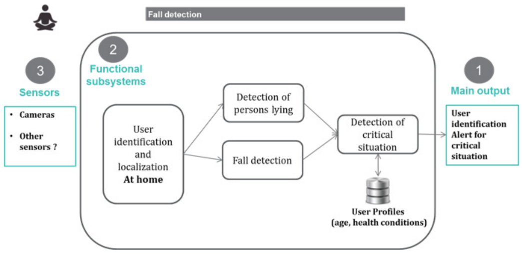


Fig. 7. Use case for fall detection

5.4 Use case 4- Services and object definitions for depressive disorder situation

In order to provide wellbeing services to a person having depressive disorder symptoms, we have sub divided the case into two sub scenarios: Monitoring user depression state, context awareness for the situation and recommending services based on the detected depressive disorder state.

Figure 8 describes the scenario for monitoring services, where the defined sensors will provide different information in the specified house domain. This detection will involve methods described in the functional subsystems. Facial expression will provide face scanning through camera to extract features regarding the emotional states. With the same requirement, user voice and his detected state will be captured audio sensors. Body sensors, such as wrist band, will detect state through skin and nerve response. Finally, to collect more information about

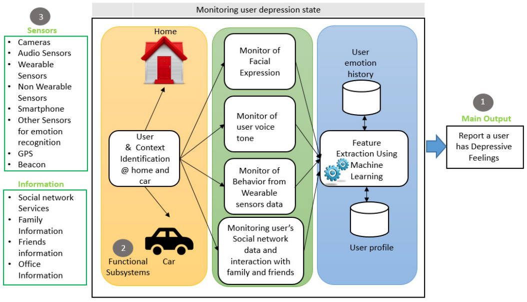


Fig. 8. Service scenario for monitoring depressive disorder state

user state, user's social data is accessed and monitored (with user consent) which will involve text analysis for state detection. In such manner, gather data through various sources will add more support for decision making capabilities.

These detected situations are further analyzed in the service level by the Real World Knowledge [4,5] and Situation Manager[6] in order to identify desired recommending service to be offered to the user. This recommendation will direct the user to handle the depressive disorder situation effectively. Figure 9 shows the scenario for recommendation services based on the detected situation. For monitoring services some smart devices have been selected for the virtualization (to be represented as VO) and data fusion, and further their provided information is collaborated under specified Composite Virtual Objects (CVOs) to perform content centric functionalities.

In order to detect the particular depressive disorder symptom, data gathered from different sources with result in large number of ontology triples[19], interlinked with each other. Creation of

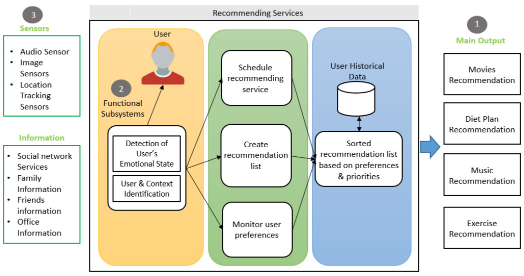


Fig. 9. Scenatrio for Recommending Service Provisioning

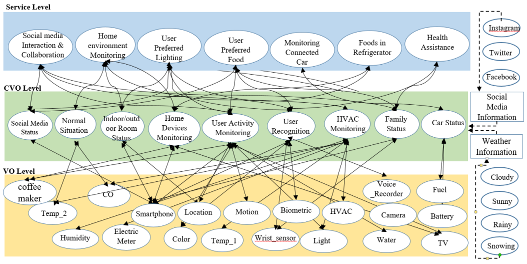


Fig. 10. Conceptual Semantic Ontology Model

such ontology model is possible through the definition of ontology model at the service, CVO and VO layer, in terms of content and the situation to be detected. Conceptual semantic ontology model for Smart Space, to monitor user's depressive disorder based on user's activities & emotions, in Smart home, is shown in Figure 10.

Ⅵ. Conclusion

This paper has discussed the key issues in Smart IoT environment and has proposed the system along with its detailed technical aspects to handle issues related to data and sensor fusion, context awareness, situation detection, semantic annotation and adaptation of the system in user centric environment.

EmoSpaces is still under development for above mentioned domains which is the future aim of this work. It is targeted to innovate and acquire maturity in a variety of discipline including multimedia computing, multimodal data analysis oriented information extraction, sensing based affect recognition, Big Data handling and semantic fusion of co-operating sensor data. Work on new technologies for capturing/recognizing social and emotional symptoms and their associate models for characterizing the behavior patterns of users in smart spaces as well as their cognitive(Social environment, Personal space, work environment, emergency situation etc.) and physical (home, connected car, office etc.) context. IoT services considering emotions are still an unexplored innovation and EmoSpaces aim at going a step further and advance in IoT automation based on affective and persuasive technology.

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