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A Web-Based Intelligent System for Personal Health Assistance

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Abstract. A web-based intelligent platform for personal health assistance is presented. It is based on the development of a personalized and ubiquitously accessible knowledge-based system that provides citizens with an intelligent tool for monitoring their health condition and lifestyle. Several innovative components are integrated to efficiently manage the storage, access, and retrieval of medical and personal data. Based on the latest technology of intelligent and communication systems, the proposed system aims at providing the user with personalized, certified lifestyle information and consultancy, tailored to individual needs.

1. Introduction

In a world characterized by an increasingly science-based and knowledge-intensive environment, the access to information and the capacity for converting information into useful knowledge for end-users is becoming of paramount importance. The healthcare industry is experiencing worldwide a substantial paradigm shift with regard to patient-centred homecare, due to the convergence of several technology areas. Increasingly-capable telehealth systems combined with Internet-based applications demonstrate great potential for delivering ubiquitous, highly automated and intelligent healthcare services [1]. The spread of the Internet and the appearance of web technology are factors helping to achieve this objective.

Current trends and continuously increasing developments in the area of health monitoring and decision support systems, promote the use of Internet technologies and web-based systems for customized advice and consultancy, tailored to the individual needs. Several patient communities related with illnesses such as cardiovascular diseases, diabetes, renal failure, asthma, and overweight people, as well as healthy individuals with low or high risk factors, turn to Internet to seek out the latest available information, advice, and support to monitor their lifestyle and health condition [2–5]. The increasing role of Information Technology (IT) in the delivery of patient-centred healthcare has led to the development of a wide range of applications and platforms, targeting the individual needs for health and lifestyle information and monitoring. Such examples are described in [6–9].

This paper describes an intelligent health environment that provides patients (diabetic and overweight) and citizens in general with a tool that can be used for monitoring and improvement of their health and lifestyle. By providing a technologically innovative platform for monitoring and interaction with the user, the proposed system integrates all actors (citizens, medical professionals, healthcare providers) involved in the healthy lifestyle industry. The design and the implementation of the intelligent system incorporate advances in different areas such as telecommunication technologies and services [10,11], knowledge engineering [12–14], and intelligent health monitoring systems [15,16]. The platform combines a wide range of functionalities from user profiling, customized plan selection and evaluation, and plan execution monitoring, to information retrieval and easy access through various terminal devices (mobile or fixed).

In the following, the overall system architecture is described together with the system modules and its functionalities.

2. Intelligent Personalized Health Assistant

The intelligent system constitutes a flexible and open architecture that can be easily extended to accommodate future needs. The architecture is displayed in Figure 1. It consists of two knowledge repositories: the user data repository and the medical data repository that constitutes the knowledge base of the system.

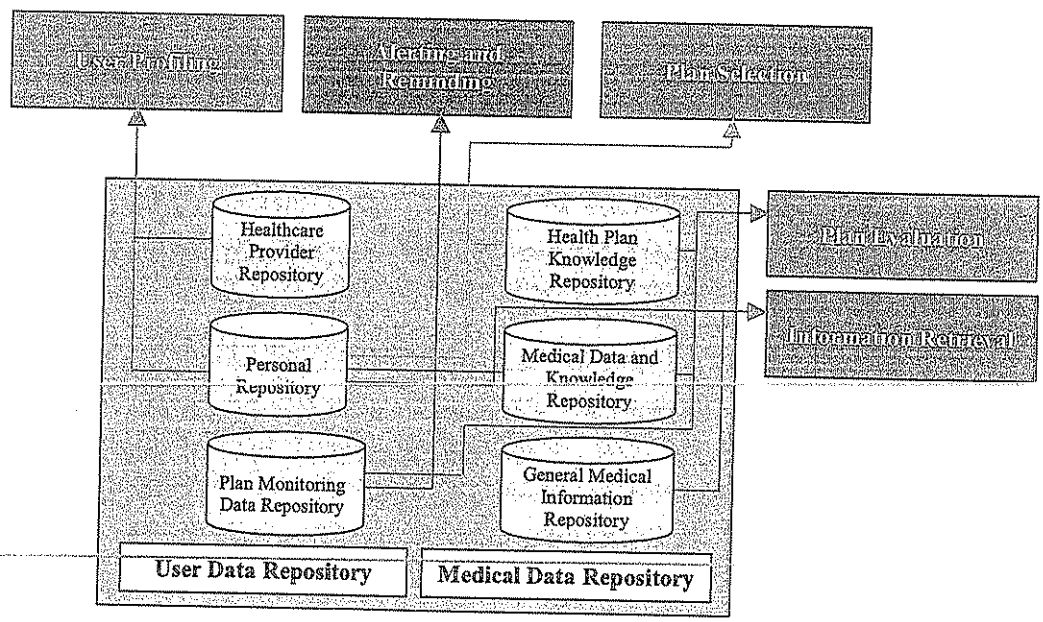

Figure 1: System architecture.

User Data Repository

The User Data Repository consists of the following three parts:

- the Healthcare Provider Repository: information related to the Content and Service Providers of the system (e.g., participating hospitals, diet clubs, insurance companies, etc.);
- the Personal Repository: end-user's demographics and personal preferences and characteristics;
- the Plan Monitoring Data Repository: personalized health plan information and health status indicators corresponding to each plan.

Medical Data Repository

The Medical Data Repository stores the knowledge that the overall system handles. Its purpose is to efficiently represent, store, and provide all the medical definitions and rules that describe the user input data. It consists of three major components, each of which carries distinct and concrete medical relative information, namely:

- the Medical Data and Knowledge Repository that holds all the medical definitions and user categories (e.g., laboratory quantities, normal values, measurement units);
- the Health Plan Knowledge Repository that holds all the plan-related information such as diets, duration, health status indicators for monitoring, etc;
- the General Medical Information Repository which contains links and additional data to facilitate directory service.

The above knowledge repositories are "active" and their functionalities are supported by two intelligent components: the *user profiling module* and the *intelligent advisor*. The intelligent user profiling [17] classifies the user according to his personal characteristics, preferences, and medical history. It constitutes a key component of the system since it provides the other modules with criteria for information filtering. Another important component is the intelligent advisor that provides advice to the user either upon request (plan selection, plan evaluation, information retrieval functionalities) or when specific updates have been performed either on the Personal Repository or the General Medical Information Repository (alerting and reminding mechanism). The development of the intelligent advisor component exploits advances in the areas of decision support systems [12–14], automated monitoring [16,18], and information retrieval approaches [19].

System Functionalities

The five major functionalities that the system (Figure 1) offers are described below:

User Profiling

The purpose of the user profiling is to create a set of attributes describing the user (subscriber). The construction of the user profile follows a dynamic process [17,20]. Any user entering the system for the first time is able to subscribe to the service by completing a subscription form. At the end of the subscription process the user profile is constructed in a *content-based* and *collaborative* form. The former type represents a profile as a vector of (possibly weighted) terms, while the latter corresponds to a list of similar users. In particular, profile attributes that will be more or less unique to a user may be represented as a content-based profile. Similarly, profile attributes that will be more or less shared by a number of users might be represented as a collaborative profile.

The dynamic feature of the profiling procedure allows for the user profile to be updated at any time the user changes his preferences. The updated profile may occur not only through direct modification of user's data, but also as a result of the user's interaction with the system interface. In the latter the web browsing operation updates the weighted profile vector. The constructed user profile will be used to filter the requested information provided by the knowledge retrieval module of the system.

Plan Selection

The plan selection mechanism is responsible for providing personalized plans to users according to their health condition and the user profile that the system has already built. This module selects a list of diet plans from the medical database of the system that matches the user's preferences by using a pattern-matching procedure [12,13]. Each selected plan is rated according to the weights of the user's feature vector and is displayed to the user interface. The final choice of the plan is made by the user. Furthermore, at a second level the user may select possible alternative components of the plan. In this way the system offers a fully customized diet plan that the user might follow.

Plan Evaluation

The system monitors personal health according to the plans that have been carried out by the users. The plan evaluation mechanism performs the evaluation of the effectiveness of the plans by defining indexes and measurable targets for each plan. Their values are compared to health indexes stored in the medical knowledge base to indicate degrees of success of a healthy lifestyle plan. The information that is presented by the system is combined with the personal user profile and user satisfaction so that certain decisions about the plan effectiveness can be made.

Alerting and Reminding

After the selection of a specific diet plan, the system starts monitoring user's health condition and processing with respect to the measurements received (the user is responsible to submit health status indicators continuously). During the plan execution period the intelligent platform generates reminders (e.g., for the end-user to submit health status indicators) and alerts (e.g., in cases where

unexpected results are displayed). In addition, the system may notify users of new-coming events that may be of their interest, based on their stored preferences. This constitutes the operation of a knowledge-based mechanism [12–14], the alerting and reminding module, that monitors all "active" plans on an individual basis. All these actions (reminders, alerts, and notifications) will be directed to the appropriate user device according to the settings specified to the user profile.

Information Retrieval

The system provides with search capabilities that allow users to search for specific subjects and produce information relevant to their interests. Information retrieval can be performed either by index searching or intelligent searching according to the type of the information browsing. During index searching information is structured in form of directories and web pages and therefore users can search for specific information within the user space. For example a user may find and contact a medical professional or find information on commercially available health and lifestyle products (e.g., nutrition supplements and health monitoring devices). On the other hand intelligent searching operates personalized search for information by using keywords including individual features described in the user profile. This way the system will provide more accurate results by filtering the retrieved information through the user profiling.

Communication and Security

Specialized modules are developed to facilitate the flexible and effective communication of messages and information between the system modules. Figure 2 shows the architecture of the communication subsystem. The system is accessible through wireless and wired means. Wireless access can be achieved with a laptop computer, a mobile phone, a Personal Digital Assistant (PDA) possible connected to a Global System for Mobile communication (GSM) or General Packet Radio Services capable (GPRS-capable) mobile phone or equipped with a GPRS-capable modem and other communication devices (Universal Mobile Telecommunications Service, UMTS-enabled).

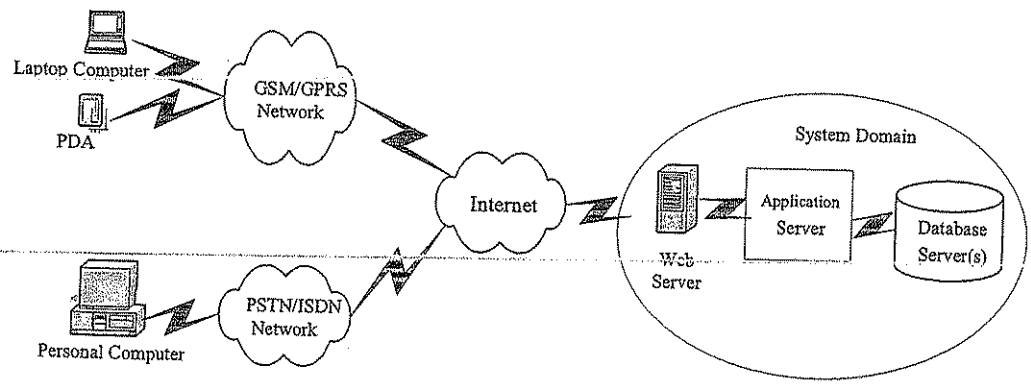

Figure 2: Communication subsystem.

Information is transmitted from and to the Internet-based server(s) via a local Internet Service Provider (ISP) General Packet Radio Services (GPRS) network. Wired access on the other hand concerns a desktop Personal Computer (PC) connected to a modem, which will provide access to a Public Switched Telephone Network / Integrated Services Digital Network (PSTN/ISDN) network operated (possibly) by a local Internet Service Provider (ISP). This network is connected to the Internet for accessing the system domain servers.

The proposed platform provides a secure environment covering all possible communication and data protection aspects. It incorporates access control models and public key infrastructure to guarantee the security for the transactions of the users. More specifically, the security mechanisms include:

- authentication mechanisms,
- management of users and their respective rights to accessing information,
- encryption mechanisms,
- methods for verifying the identity of the entity (digital signature).

Details on the architecture of the communication subsystem together with the security mechanisms are described elsewhere [21].

3. Conclusions

The proposed web-based intelligent system can be described as a platform for personalized delivery of health information to individuals. The embedded capabilities of 3rd generation mobile phones and intelligent user interaction protocols, such as alerting and reminding mechanism and user profiling, offer the opportunity for citizens to improve and monitor their lifestyle in a secure and safe way. On the other hand healthcare professionals and service providers will be provided with a unique tool for the re-organisation of customer monitoring methods, providing their customers with an added value service. The health and lifestyle industry will be able to promote services and products and to obtain significant feedback to improve the quality of their services and products.

In the near future the system will be integrated and expanded to provide increased functionalities. It has been engaged into an identification of a descriptive analysis of main and specific user needs and of specific constraints. Potential legal and ethical implication or constraints related to medical procedures have been addressed, so as to ensure that it can be provided and promoted through organized service providers (e.g., diet clubs, insurance companies, gym chains, hospitals). It can be considered as an added value supporting service which helps them to participate in the new market and to develop better products matching individual user preferences.

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