

# Smart Innovation, Systems and Technologies

Volume 25

*Series Editors*

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# Multimedia Services in Intelligent Environments

Recommendation Services

 Springer

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ISSN 2190-3018

ISBN 978-3-319-00374-0

DOI 10.1007/978-3-319-00375-7

Springer Cham Heidelberg New York Dordrecht London

ISSN 2190-3026 (electronic)

ISBN 978-3-319-00375-7 (eBook)

Library of Congress Control Number: 2013939051

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Printed on acid-free paper

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# Smart Recommendation Services in Support of Patient Empowerment and Personalized Medicine

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**Abstract** Medicine is undergoing a revolution that is transforming the nature of healthcare from reactive to preventive. The changes are catalyzed by a new systems approach to disease which focuses on integrated diagnosis, treatment and prevention of disease in individuals. This will replace our current mode of medicine over the coming years with a personalized predictive treatment. While the goal is clear, the path is fraught with challenges. The p-medicine EU project aspires to create an infrastructure that will facilitate this translation from current medical practice to personalized medicine. This Chapter focus on current research activities related to the design and implementation of an intelligent patient empowerment platform and its services. The focus of our work concerns the nature of the interaction between health institutions and individuals, particularly the communicative relation between physicians and patients, the ways of exchanging information, the nature of the information itself and the information assimilation capabilities of the patients. Our practical focus is the domain of cancer patients, whether in normal treatment or participating in clinical trials. The ultimate objective is to implement a smart environment (recommender system) able to act as a decision support infrastructure to support the communication, interaction and information delivery process from the doctor to the patient. A prerequisite of personalized delivery of information and intelligent guidance of the patient into

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his/her treatment plans is our ability to develop an appropriate and accurate profile of the user. In the p-medicine project we focus on modeling and profiling the psycho-cognitive capabilities of the patient based on questionnaires and other information features and behaviors extracted from a personal health record of the patient. In this chapter we will provide a systematic review of user profiling techniques and approaches and present our results in developing a psycho-cognitive profile of the user/patient. Subsequently we will describe the details and challenges of implementing the recommendation system and services using a combination of methods to counter-balance the intrinsic weaknesses in various algorithmic approaches. We will review solutions that have combined demographic user classes and content-based filters using implicit behavior and explicit preferences, collaborative filtering and demographic or collaborative filtering and knowledge-based filters. Finally, our approach will be fully described, which uses an adaptive user interface for the presentation of the e-consent, an ontology and a semantic web rule language to formally describe patient choices, and a reasoning engine to handle access and personalized delivery of pertinent disease related information.

## 1 Introduction

Personalized medicine refers to the tailoring of treatment to the individual characteristics of a patient [1]. It is mainly based on advances in the field of ‘Pharmacogenomics’, the study of genetic variation that uses genomic technology and the study of global properties of the human genome to gain insights about the mutual effects of relevant genes and a certain drug treatment. Advances in fundamentals of genomic medicine have facilitated the development of diagnostic tools and chemical agents targeting diseases such as cancer. By including genetic tests, one is nowadays able to predict the effectiveness of a certain drug treatment in an unique patient, thereby supporting the physician in the medical treatment decision-making process. The implementation of personalized medicine into clinical practice would lead to more cost-effective health care that is able to predict sooner, diagnose more accurately and treat more effectively, leading to a large number of lives saved.

The p-medicine EU project<sup>1</sup> aspires to create an infrastructure that will facilitate the translation from current medical practice to personalized medicine. Essential to the realization of personal medicine is the development of information systems capable of providing accurate and timely information about potentially complex relationships between individual patients, drugs, and tailored therapeutic options [2].

This Chapter focuses on current research activities related to the design and implementation of an intelligent patient empowerment platform and its services. The entry point for the patients is the p-medicine portal. After registering to the

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<sup>1</sup> <http://www.p-medicine.eu/>

portal the patients can access all patient empowerment services provided from the platform. The environment must not only represent data in a convenient format, but data must also be translated into language that is understandable to the patient. This is because the empowerment process implies that patients are able to understand medical statements, as well as legal and ethical considerations.

To achieve this, a collection of intelligent techniques is used to construct a patient profile. A profiling server collects information from different techniques and combines them to construct patient profiles. Central technique to our approach is the ALGA-C questionnaire which is used to collect psycho-cognitive information about patients.

The benefits of constructing patient profiles are many:

- Optimize information delivery from doctors to patients: Doctors, having a graphical summary of the patient profile, can rapidly adjust the content and the level of verbal information to the patient's perceived needs and their level of understanding.
- Optimize information delivery to patients in the patient empowerment environment: Information delivery is optimized according to each specific profile. Predefined rules use patient profile to personalize the contents of the information presented and to customize ways by which users complete their tasks in the patient empowerment environment. This makes it easier for the patient to decide what interest to him/her is at the moment.
- Identify relevant trials for enrollment: Besides using patient profiling to adapt the information provided, it can also enable the automatic identification of possible clinical trials that the patient could be enrolled. His/her clinical information is matched against the eligibility criteria of several trials and possible matches are identified. This matching uses advanced algorithms over a semantically-enriched clinical trial repository.

However, before any sharing of health information can take place, patients must give their consent. Our approach uses an adaptive user interface for the presentation of the e-consent, an ontology and a semantic web rule language to formally describe patient choices, and a reasoning engine to handle the access and the management of the personal health information.

The rest of this Chapter is structured as follows: [Sect. 2](#) provides a short review on the profiling techniques used for similar purposes. Then, [Sect. 3](#) describes the challenges in the area and the approach we selected to respond to these challenges using patient profiling. [Section 4](#), presents shortly the architecture of our platform and finally [Sect. 5](#) concludes this chapter and discusses future directions.

## 2 Review and Methods

The uniqueness of every individual patient is not only determined by his/her unique genetic material but also by his/her unique personal psychological profile

including psychological, psychosocial, cognitive and behavioral aspects. These dimensions mainly influence a patient's quality of life as well as patient satisfaction. Psychological aspects such as levels of anxiety, pain and depression as an example, substantially impact on a patient's quality of life and, in turn, influence the medical process and healing to a considerable degree.

Contemporary enhanced awareness of the strong correlation between quality of life aspects and the process of cure have led to recent attempts of finding reasonable and successful ways of including quality of life measures into the clinical process. In this section we examine in a more general sense what information constitutes a user profile, how the profile is represented, how it is acquired and built and finally how the profile information is used. Then, we focus on patient profiles and we show how these techniques are usually employed to assess the quality of life of a patient.

## *2.1 What Information Constitutes a User Profile?*

The most common user profile contents [3] are the following:

- **User interests:** They describe the concerns of the users. They can be short-term or long-term.
- **Knowledge, background and skills:** In intelligent tutoring systems and in adaptive environments it is essential to provide proper assistance to the user and to adapt the content of the information according to user's, knowledge and skill. Some systems try to categorize users as expert, intermediate or novice depending on how well they know the application domain. Finally the user's background refers to the user's characteristics that are not directly related to the application domain.
- **Goals:** Goals represent the user's objective or purpose with respect to the application he is working with, that is what the user wants to achieve [4]. Determining what a user wants to do is not a trivial task. Plan recognition is a well-known techniques used for this purpose [5].
- **Behavior:** User's behavior with a software application is an important part of the user profile. If a given user behavior is repetitive, then it represents a pattern that can be used by an adaptive system or an intelligent agent to adapt a web site or to assist the user according to the behavior learnt. The type of behavior modeled depends on the application domain.
- **Interaction preferences:** A relatively recent component of a user profile is interaction preferences, that is, information about the user's interaction habits and preferences when he interacts with an interface agent. For example, a user may prefer warnings, suggestions, or actions on the user's behalf. In addition, the agent can provide assistance by interrupting or not interrupting the user's work.
- **Individual characteristic:** This item includes mainly demographic information such as gender, age, marital status, city, country, number of children etc. Another characteristic that is included there is the user's learning style mainly

for tutoring systems. Finally, personality traits are also important features in a user profile. A trait is a temporally stable, cross-situational individual difference. One of the most famous personality models is OCEAN [6]. This model comprises five personality dimensions: Openness to Experience, Conscientiousness, Extraversion, Agreeableness, and Neuroticism. Personality models and the methods to determine personality are subjects widely studied in psychology [7, 8]. In the area of user profiling, various methods are used to detect user's personality. For example, in [9] facial actions are used as visual cues for detecting personality.

- **Contextual Information:** The user's context is also relatively new feature in user profiling however, it is of great importance in medical area. According to Abowd et al. [10] context is any information that can be used to characterize the situation of an entity (person, place etc.). The environmental context captures the entities that surround the user whereas the personal context includes the physiological context (blood pressure, retinal pattern) and the mental context (mood, expertise, angeriness, stress). The social context describes the social aspects of the current user context (friends, relatives). The spacio-temporal context describes aspects of the user context relating to the time and spatial extent for the user context.

## *2.2 How Profiling Information is Represented?*

The most common representation of user interest is keyword-based models where interests are represented by weighted vectors or keywords [11]. Weights usually represent the relevance of the word for the user or within the topic. Another representation of user interest is through topic hierarchies [12], where each node in the hierarchy represents a topic of interest for a user, which is defined by a set of representative words. The most common representation of knowledge, background and skill is through models that keep a score on certain knowledge topics that a user might know [13] or does not know [14].

Goals or intentions can be represented in different ways such as Bayesian networks [15]. In this representation, nodes represent user tasks and arcs represent probabilistic dependencies between tasks. Given evidence of a task performed by the user, the system can infer the next most probable task and hence the user's goal.

## *2.3 How Profiling Information is Obtained?*

In order to build a user profile, the information can be provided explicitly by the user through implicitly observation of the user's actions.

The simplest way of obtaining information about users is through the data they submit via forms or other user interfaces provided for this purpose. Especially for patients their profile information commonly assessed by patient-reported outcome



measures (PROMs) including Health-Related Quality of Life (HRQL) information. PROMs can be defined as “reports coming directly from patients about how they function or feel in relation to a health condition and its therapy, without interpretation of the patients’ responses by physician or anyone else” [16]. Such measures can thus be described as instruments which provide patient-based information about health, illness and the effects of treatment. A large number of measures providing HRQL information are currently available. These instruments embrace a broad range of health dimensions such as physical, psychological and social functioning [17]. In addition to these aspects which are directly related to the quality of life of a patient, PROMs sometimes investigate broader constructs such as impairment, disability and handicap, also influencing quality of life to a substantial degree. The disadvantages of this method is that users most of the times are not willing to fill in long forms providing information about them. Moreover, users do not always write the truth when completing forms about themselves or they might not know how to express their interests or what they really want.

To cope with these disadvantages, long questionnaires are often replaced by rating specific pages, topics or sections (Facebook “Like” for example, or Google “+1”) using simple questions. Another way of providing explicit information is through the “Programming by Example/Demonstration” paradigm [11]. In this approach, the user demonstrates examples to the computer and a software agent records the interactions and writes a program that corresponds to the user’s actions.

On the other hand, in order to implicitly collect information about user’s actions, their actions should be logged and patterns should be discovered using *Data Mining*, *Information Retrieval* or *Machine Learning* techniques [18–20]. However, to be able to discover patterns the user behavior should be repetitive, and the behavior observed should be different on different users.

When no information about a user is available, Key [21] introduced another methodology which uses a stereotype as default information. Stereotypes enable the classification of users as belonging to one or more of a set of subgroups, and also the integration of the typical characteristics of these sub-groups into the individual user profile.

### **3 Profiling Mechanisms for Patient Empowerment**

#### ***3.1 Challenges and Opportunities***

In an epoch where shared decision making is gaining importance, patient’s commitment and knowledge about his/her health condition becomes more and more relevant. Nowadays patients spontaneously search for information on internet, as if they were thirsty of knowing what their future might prospect to them. Navigating around the web might provide valid information, but it can also make the patients get lost in the mess of websites, unknown sources, and inaccurate information.

With this background of possible biased information, patients interact with physicians to choose the best plan of action in order to reach the best possible outcome. As Geissler [22], Director of the European Cancer Patient Coalition and founder of Chronic Myeloid Leukemia Advocates Network, says “empowerment of patients is a pre-requisite for health, and access to high quality health information is fundamental to achieve this”.

In order to have “high quality” health information it is not sufficient that its content is accurate. It is also necessary that accurate content is comprehensible to the person who has to use that information. Health literacy has been defined as “the degree to which individuals have the capacity to obtain, process and understand basic health information and services needed to make basic health decisions” [23]. The capability to obtain, process, and understand basic health information, make patients able to look after themselves well or make good decisions on health [24]. Because health literacy is central to enhancing involvement of patients in their care, all strategies to strengthen patient’s engagement should aim to improve it. In view of that, several factors other than the mere medical jargon can impair patient processing and understanding of health information. Psychological aspects and cognitive style, for example, are two more elements that affect the way patient approach, select and retain information.

Assessment of the patient profile in the clinical context can benefit patient care in several occasions:

1. Increasing physicians’ and nurses’ awareness of patients.
2. Identifying and prioritizing problems such as physical or psychosocial problems that otherwise might have been overlooked and remain unrecognized.
3. Identifying patients’ preferences among outcome goals (that often differ substantially from the physicians’ preferences).
4. Enabling an anticipation of benefits regarding patients’ adherence to treatment.
5. Allowing for the monitoring of disease progression and treatment that may not be revealed via clinical testing.

As a result of including patient profiling into the treatment process, the patient might feel better cared for which positively influence his/her emotional functioning and the communication between the physician and the patient is facilitated and improved.

As a result, shared decision-making will be promoted. It is essential for the patient to be actively involved and to participate in the decision making process concerning treatment in order to assure that decisions are consistent with the patient’s values, preferences and general considerations. Shared decision making based on patient centered medicine involves a bi-directional information exchange between the physician and the patient [25]. For shared decision making to be effective, the content of communication in a medical consultation should include both factual data and patients’ considerations. While the former is derived from clinical tools providing information about genetics and supposed treatments, the latter is provided by patient profiling techniques providing HRQL information. Barnato et al. [26] noted that

in an ideal world [...] patients would come to a cancer consultation armed with sufficient knowledge, clarity about their personal value, and the ability to engage in a thoughtful discussion about the pros and cons of treatment options. Providers, in turn, would be prepared to support their patients, armed with an understanding of the patient's knowledge gaps, personal values about possible outcomes and treatment preferences (p. 627).

However, clinical consultations take place under conditions of limited time where physician talk sometimes overwhelms patient's preferences and considerations. This gap between an optimal and many actual encounters could be reduced by implementing smart patient profiling techniques that raise awareness of patient considerations, facilitate the discussion of these aspects and thereby actively involve the patient into the medical decision process. This shared decision making process empowers the patient because it provides him/her with the chance of making his/her own, well-discussed and well-informed, choice concerning the treatment.

Some governmental and professional organizations have advised routine screening for the presence of heightened psychological distress in cancer patients (NICE, Rebalance Action Focus Group). However, there are several barriers preventing the routine use of screening or PROMs in clinical practice. These barriers can be classified in practical, attitudinal and methodological barriers [17]. The practical barriers include a lack of IT support concerning storing and retrieval of data, a lack of time and money needed to collect, analyze and appropriately use data as well as physicians' lack of familiarity and knowledge in the field of HRQL measures. Additionally, the format and length of most existing tools is a barrier to the adoption in clinical practice because a considerable amount of time is required for administering, scoring and interpreting the self-report measures [27].

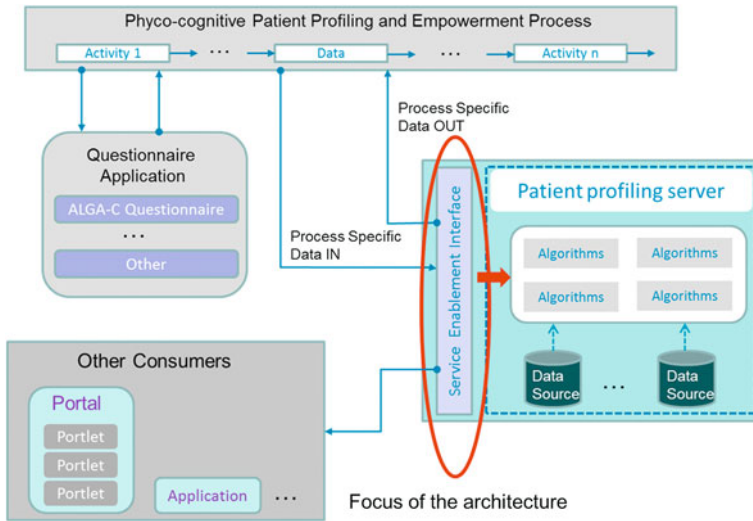
Addressing these challenges and trying to merge the two aspects of personalized medicine (genetic and psychological dimensions) we will develop a patient profiling server to capture the personal profile of the patient.

### ***3.2 Patient Profiling Server***

Patient profiling server is the central point for the patient's data analysis, and is currently in the analysis phase. Profiling questionnaire, PHR and EHR systems are the main data sources of the profiling server. These sources with specific application programming interfaces (APIs) will communicate and export the data for further analysis.

The patient profiling server will also provide the necessary services for combining the different sources. Information collected from the sources will be exploited in conjunction with the provided knowledge discovery tools, in order to form a platform for the patient empowerment.

In essence, the aim of the server is to provide the necessary methods and algorithms to collect, merge and analyze the patient's data. The server will be able to develop a patient profile and to operate as an integrated analysis environment for patient data analysis and knowledge discovery tools (Fig. 1).



**Fig. 1** Patient profiling server architecture

A variety of knowledge discovery tools exists in the public-domain (e.g., weka,<sup>2</sup> R-package/Bioconductor,<sup>3</sup> BioMoby<sup>4</sup>). We focus on a specific domain of data mining in order to discover patterns using Data Mining, Information Retrieval or Machine Learning techniques. Bayesian network, association rules mining and case-based reasoning are three well known techniques for solving such problems. These techniques will be evaluated and the best or all of them will be implemented within the patient profiling server.

1. A **Bayesian network** is a directed acyclic graph where nodes represent random variables and arcs represent probabilistic correlations between variables [18]. An important characteristic of BN is that Bayesian inference mechanisms can be easily applied to them. The goal of inference is typically to find the conditional distribution of a subset of the variables, conditioned on known values for some other subset (the evidence).
2. **Association Rules Mining** is a data mining technique widely used to discover patterns from data. An association rule is a rule which implies certain association relationships among a set of objects in a given domain, such as they occur together or one implies the other. Association rule mining algorithms tend to produce huge amounts of rules, most of them irrelevant or uninteresting. Therefore, post-processing steps, such as rule pruning [19] and grouping are needed to obtain valuable information to build a user profile.

<sup>2</sup> <http://www.cs.waikato.ac.nz/ml/weka/>

<sup>3</sup> <http://www.bioconductor.org/>

<sup>4</sup> <http://biomoby.open-bio.org/>

3. **Case-Based Reasoning** is a technique that solves new problems by remembering previous similar experiences [20]. A case-based reasoner represents problem-solving situations as cases. Given a new situation, it retrieves relevant cases (the ones matching the current problem) and it adapts their solutions to solve the problem.

Besides these three mainstream approaches, others are used as well such as genetic algorithms [28], neural networks [29], kNN-algorithms [30], clustering and classification techniques, fuzzy logic or combinations among them [31]. Thus the patient profiling server can be viewed as a data mining repository which will operate over patient's data sources. Algorithms and tools used within the system can evolve according to the end user's needs and the nature of the data sources.

Main instrument of collecting personal information is ALGA-C, a short, easy-to-use, and acceptable questionnaire that generates a personal profile of the patient. This personal profile questionnaire for cancer patients is aimed to produce data which support the physicians' decision making process by being merged with other data such as molecular information and imaging data, thanks to advances in IT technology. Furthermore, data generated by the instrument can also be used to monitor the patient's quality of life, thereby facilitating the patients' involvement in the clinical decision process, finally leading to patient empowerment.

### 3.3 ALGA-C

As previously mentioned, many approaches to personalized medicine include medical relevant data such as genetic and biomolecular information that are used to predict the best treatment choice including predictions about adverse effects. However, we claim that these approaches neglect the unique influence of psychological dimensions and cognitive style. Although a variety of biological and medical information have the power to predict the best treatment choice and thus lead to an increased life expectancy on the side of the patient, approaches that exclusively rely on biological and medical information miss a substantial part of the human being: psychology. By neglecting unique psychological information, these approaches limit their own effectiveness since psychological dimensions impact on treatment effectiveness to a considerable extent. Psychological influences limit the predictability of treatment effectiveness and thereby undermine the potential benefit of an approach that solely relies on biological and medical information. To illustrate the power of psychology regarding treatment effectiveness, we refer to the hypothesized example of a patient who is very anxious and possesses a moderate through high level of depression. A treatment that was predicted to yield good results because it was perfectly determined by analyzing biomolecular, genetic and imaging data, may turn out to be ineffective for the anxious and depressed patient. This patient might be unresponsive to the treatment due to noncompliance to the treatment caused by the patient's heightened psychological distress. Given these important psychological influences, we suppose

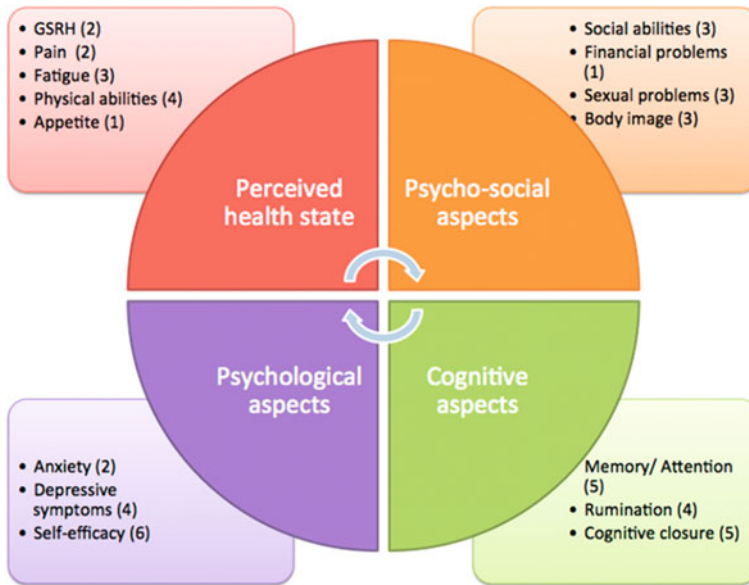
that current approaches to personalized medicine relying exclusively on biological and medical information, lack to consider the psychological component that contributes to human uniqueness in the same way genetic information does. A human being cannot be considered as unique by only referring to him/her as a biological and genetic entity. Instead, what makes a human being unique is also his/her specific needs and value, habits and behaviors, hopes and fears, beliefs and cognitive dispositions [32].

The assessment of psychological and personal variables serves the additional purpose of monitoring the patient's perceived health status and general quality of life. Different measures for the assessment of health-related quality of life of patients have been developed. However, most of them measure only one broad area, for example, psychological distress including depression and anxiety, psycho-social problems including dimensions such as social abilities, body image and financial problems, or health status in general including symptoms resembling pain, fatigue and physical problems. We claim that there is an urgent need for an instrument that measures all these different areas in order to represent a broad picture of the patient without missing essential information. Additionally, to our knowledge, there is no single measure including cognitive aspects of the patient such as memory and attention, rumination, or self-efficacy. One of the biggest problems in developing an instrument that measures all these broad areas is the fact that such an instrument needs to be very short and easy to fill out otherwise patients are not willing to comply. It is thus a major challenge to construct an instrument that measures all these areas and that is short and easy to fill out at the same time. The ALGA-C wants to be a short and easy to fill out instrument to measure four broad areas: perceived health state, psychological aspects, psycho-social as well as cognitive aspects, all investigated by different sub-dimensions. Below we describe in detail the areas that the aforementioned ALGA-C questionnaire focuses, shown also on Fig. 2.

### **3.3.1 Quality of Life and Perceived Health State**

The way a patient perceives his/her own health state is determining his/her quality of life to a large degree. Symptoms such as pain, sleep problems, fatigue, general physical problems and diminished appetite limit an individual's functioning, its perceived well-being and therefore its quality of life. Investigating these symptoms is essential as many cancer patients experience these problems to a heightened degree compared to healthy individuals.

Another symptom often related to impaired physical functioning is the loss of appetite in cancer patients as a result of chemotherapy or other treatments. In general, these illness- and treatment-related symptoms often interfere with the daily activities of a patient, lowering his/her general quality of life. Therefore, the assessment of these symptoms is of great importance in order to discover them, treat them where necessary and thereby improve patients' quality of life.



**Fig. 2** A schematic representation of ALGA-C. The *circle* represents the four main macro-areas, and the *four boxes* contain the different sub-dimensions with the relative number of questions in the brackets

### 3.3.2 Quality of Life and Psychological Aspects

The most important psychological dimension related to quality of life is psychological distress, which includes anxiety as well as depressive symptoms. A failure to detect and treat heightened levels of psychological distress limits the effectiveness of cancer treatments, decreases patients' quality of life, and negatively influences health care costs.

Arguments for including a measure of psychological distress in cancer patients are that it has been found to be a very common phenomenon in patients [33] and that heightened levels of anxiety and depression are associated with several negative outcomes containing patient noncompliance and non-adherence to treatment recommendations [34] and decreased patient satisfaction concerning care [35]. These negative outcomes, in turn, decrease a patient's quality of life.

Given the high prevalence rates of depression, anxiety, or both in cancer patients, and the increased chance for these symptoms to persist for years after diagnosis, their detection and treatment is essential. In order to optimize treatment, it is necessary to further investigate the main risk factors for continued psychological distress and clarify differences in results yielded by previously mentioned studies.

### 3.3.3 Quality of Life and Psychosocial Aspects

Cancer treatment often leads in major changes in patients' physical appearance. It may, for example, result in alterations of body image through the loss of a body part, disfigurement, scars and skin changes. Whereas the effects of chemotherapy, such as hair loss, weight loss or weight gain, are rather transient and reversible to a certain degree, effects of surgery are often permanent. Also radiotherapy may have considerable effects since it may cause tissue damage with insidious changes over many years. Although differences in methodology and measurement have led to a wide range of severity and frequency of body image outcomes reported by different studies, the vast majority of research indicates that body image is a key determinant of differences in quality of life.

In general, an extensive body of literature and studies regarding the effects of treatment on body image and other psycho-social aspects has mainly focused on breast cancer patients. However, a large number of patients across many disease groups and treatment types can be affected. Since body image and sexual problems were demonstrated to result from cancer treatment, especially chemotherapy, it is important to investigate these possible effects given their potential impact on mental health, partner relationships, social support and quality of life in general.

Social and interpersonal support was also found to be critical for cancer patients after completing treatment. A lack of social support is reasoned to be a risk factor for the development of depressive symptoms. However, patients often experience that their physical conditions or other effects resulting from treatment interfere with the family life, their social activities and their working abilities. Such impairments might result in social problems leading to a limited social and interpersonal support, which, in turn, negatively influence the patient's conditions and quality of life.

Next to social and interpersonal problems, financial problems might further impact on a patient's quality of life in a negative way. A study that examined differences in the quality of life of breast cancer survivors one year after diagnosis in comparison with women from the general population suggests that almost 40.0 % of breast cancer survivors reported to have financial problems [36].

### 3.3.4 Quality of Life and Cognitive Aspects

Potential health, psychological and psycho-social problems that result as side effects from cancer treatment might be most obvious and accordingly cared for in the first place. However, more subtle side effects, such as possible changes in cognitive functions, have received little attention, even though many patients report to suffer from subjective changes in memory and clear thinking during and after treatment [37]. Even small impairments in cognitive functioning are expected to influence a patient's ability to function, thereby negatively impacting his/her quality of life. The fact that subtle changes in cognitive abilities are sometimes difficult to detect might be a possible explanation for the lack of appropriate



measures investigating cognitive dimensions in cancer patients. However, we claim that it is crucial to measure these dimensions in order to improve patients' quality of life and additionally support the physician in the medical decision-making process by taking into account patient's cognitive characteristics.

Difficulties in the ability to remember, think and concentrate are often reported by breast cancer patients receiving chemotherapy. Evidence supporting this fact comes from a study that examined differences in cognitive functioning between breast cancer patients currently receiving chemotherapy and healthy control subjects [37]. In comparison to healthy women, breast cancer patients were found to have decreased cognitive functions, especially with regard to the memory domain. Furthermore, patients' cognitive functions were not only found to be impaired during the time of treatment but residual effects were detected even after completion of chemotherapy.

Next to the immediate impact of impairments in memory on the quality of life in patients, memory and concentration problems might also result in a patient's lowered chance of actively participating in the medical and treatment decision process when cognitive problems are not appropriately cared for. Impairments in memory and attention might account for the well-observed fact that patients do not fully understand and remember what was discussed in the encounter with the physician. By previously informing the physician about memory and attention problems, he/she might be able to adjust his/her way of communicating with the patient, thus ensuring shared decision making and patient empowerment.

Another cognitive dimension crucial of investigation is rumination which can be defined as the tendency respond to distressing situations in a maladaptive manner including repetitively and passively focusing on symptoms of distress [38]. The reason why the investigation of rumination is important in the context of cancer is the fact that it enhances the effects of depressed mood on thinking, it interferes with effective problem solving and it increases the chance of losing social support [38]. Furthermore, through these possible consequences, rumination possesses the potential to maintain and exacerbate initial depressive symptoms, possibly turning them into episodes of major depression. There is thus an increased chance for people who engage in rumination to experience prolonged periods of depression and develop clinically significant depressive disorders. Next to the correlation between rumination and depression, studies found rumination to be positively related to coping styles that include suppression or avoidance as reaction to distressing feelings and thoughts. It seems likely that the application of these coping styles as well as further impairment in concentration and memory, that is likely to result from rumination, influence treatment and cure of cancer in an undesired way. Given the fact that several treatments such as behavioral activation interventions, mindfulness and acceptance based approaches as well as interpersonal therapies were found to be effective in treating rumination, it is reasonable to investigate this dimension in cancer patients. Detecting and, where necessary, treating, patients who have the tendency to ruminate, is reasoned to positively influence depressive symptoms, treatment, cure and patients' quality of life.

Self-efficacy which is one of the core aspects of Bandura's social-cognitive theory [39] refers to an individual's belief of being able to control and adapt to a wide range of challenging and demanding situations. It is referred to as "a broad and stable sense of personal competence to deal effectively with a variety of stressful situations" [40]. Individuals possessing high levels of self-efficacy are optimistic and self-confident of their own coping abilities when confronted with life stressors such as a diagnosis of cancer. A strong sense of self-efficacy was found to be generally correlated with better health [39, 40]. The additional fact that a rather low sense of self-efficacy is associated with depression and anxiety turn the dimension self-efficacy to be of crucial in the context of cancer.

Cognitive closure is a dispositional construct that is referred to as a latent variable manifested through several different aspects including the desire for predictability, the discomfort with ambiguity and close-mindedness. We reason that cognitive closure is related to a patient's preferences for the amount of information he/she wishes to receive from the physician and might therefore impact on the patient's level of involvement in the clinical decision making process. The assessment of cognitive closure might thus assist the physician in his/her decision how much information should be best provided to the patient in order for the patient to make an informed choice. If greater levels of informed choice are associated with greater levels of patient satisfaction and compliance to treatment, we should seek to better understand and measure patients' preferences. When talking about patients' preferences, it is critical to distinguish between preferences for specific health states and utilities and preferences for specific treatments. The investigation of the latter involves the assessment of risk.

In general, better understanding of patients' preferences concerning different treatment choices is central to the concept of informed choice and shared decision making of the physician and the patient [41]. Preference based decision making involves the assessment of risks and benefits of the alternative options for action. Therefore, the investigation of patients' perceptions of risk is essential given that informed treatment decisions must be made at the individual level after consideration of perceived risks as well as benefits. Another reason for the assessment of risk perception in patients considers that the attainment of improved health care relies on patients participating in clinical trials. Research evidence suggests that educating patients about clinical trials has a low impact on their willingness to participate. Instead, patients' choice of participating in clinical trials was rather influenced by their perception of risk [42].

In conclusion, considering that problems related to these four broad areas will limit the daily activities of cancer patients and thus influence their overall quality of life, an instrument that allows an early detection of these variables is crucial because timely interventions are likely to improve treatment outcomes. Furthermore, with respect to the aim of integrating psychological data with medical information, assessment of these dimensions at an early point in the health care process is necessary.

## 4 p-Medicine Interactive Empowerment Services

Addressing these challenges and trying to merge the two aspects of personalized medicine (genetic and psychological dimensions) we need an environment able to produce data which support the physicians' decision making process by being merged with other data such as molecular information and imaging data.

Obviously we are talking about an interactive environment. Thus, while the innovative aspect for the patient is the opportunity to have access to his/her own data, on the side of clinicians the ground-breaking element is the possibility to have access to data that is not just medical, but rather centered on values and needs of the specific patient, thorough the user's profile.

More specifically, as shown in Fig. 3, while waiting for the medical visit, the patient fills a questionnaire on an electronic device connected with the patient's personal health record. The outcome of the questionnaire is immediately stored in the PHR and re-coded in a patient's profile that is used by the physician to adjust content, level and modalities of verbal information to the patient's needs. The combined clinical and psycho-cognitive information becomes patient's and doctor's common knowledge, around which they can build together long term efficient decision-making plans (Fig. 4).

In order to cope with the previous challenges, p-medicine proposes the Interactive Empowerment Service (IEmS). The IEmS architecture is shown in Fig. 3 and combines the progress of technology and biomedical research with patients' personal needs. Patients and doctors can access the Interactive Empowerment Service through the p-medicine portal. Then, questionnaires and intelligent profiling mechanism are used in order to construct patient profiles. Thanks to collaboration among physicians, psychologists and ITs, the patient's profile can be combined with the Patient's Health Record System (PHR). PHR is one of the critical components of the IEmS, and where clinical information is patient-tagged and combined with his/her psychological, social and cognitive characteristics (patient's profile). Its importance is double: Firstly, it is a container of all the information related to the patient, such as information on diagnosis and biobank data as well as information on the possible clinical trials. Secondly, the patient his/herself has the opportunity to have access to such information. In the PHR, the patient can follow the journey of his/her data and based on it begin the decision process.

Furthermore, by having this information, the patient has the possibility to manage the consent for clinical trials and to track his biomaterials. Providing patients with "consent management" allows patients to control their own data and enhances the interaction between patients and doctors when a request for a new consent is needed, by increasing efficiency and again by involving the patient actively.

In the following we give a short description of these building blocks.

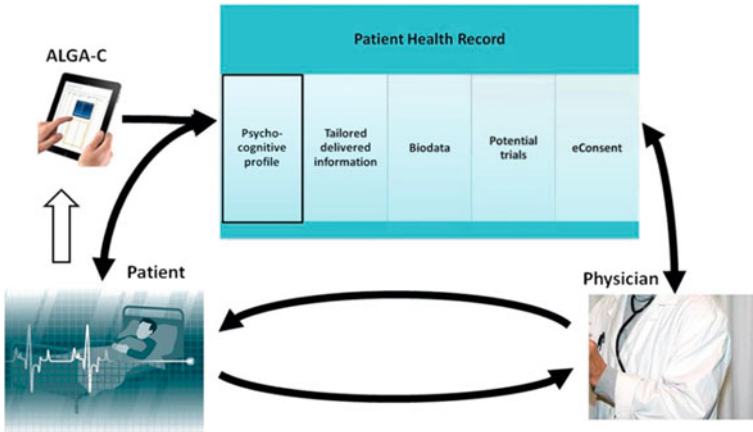


Fig. 3 Patient health record (PHR) and the information cycle in the doctor-patient interaction

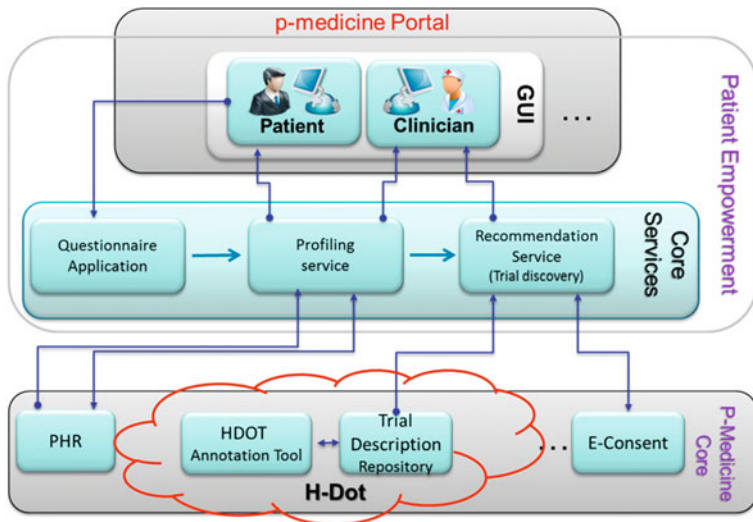


Fig. 4 High-level architecture of the p-medicine smart recommendation service

### 4.1 p-Medicine Portal

The p-medicine portal will be the common access point to all services provided. Through this gateway the end users will be able to search for specific tools, models, services and data based on their semantic annotations and user generated metadata.

## 4.2 PHR

The advancements in the health care field create a continuing demand for electronic health systems (EHS) everywhere. In the field of EHS, electronic health records (EHRs) are considered critical for improving the delivery of healthcare services. EHR systems improve accessibility to health records, support continuing treatment as repositories of information during and after the treatment, and can be used as a knowledge base for further medical research.

In p-medicine we intend to adopt an open source, widely used EHR system, Tolven. It is a free, open source, web based, robust platform that complies with many technical and operational standards and provides numerous extendable and configurable services. The Tolven<sup>5</sup> software environment is composed of two basic UI components, an electronic Personal Health Record solution (ePHR) and an electronic Clinician Health Record solution (eCHR). The ePHR interface enables consumers to record and selectively share healthcare information about themselves and their loved ones in a secure manner and the eCHR interface enables physicians and other healthcare providers to securely access healthcare information (collated from any number of trusted sources) relating to an individual patient in a structured and easily accessible way. The healthcare data are stored in a healthcare informatics platform and are accessed via the ePHR and eCHR solutions.

From operational point of view Tolven complies with Meaningful Use criteria that have been established by the U.S. Office of the National Coordinator for Health IT<sup>6</sup> (ONC). Meaningful Use criteria define high level requirements for functionality, privacy and security. It's worth mentioning that security applies at many different layers and components in the system. Tolven uses LDAP<sup>7</sup> for authentication, SSL for protecting data at transit while it also applies encryption on data at rest (maintained in database) through symmetric and asymmetric key cryptography. Moreover, authorization is addressed in Tolven through Role Based Access Control (RBAC) [43].

From technical point of view Tolven utilizes state of the art, industry-standard technologies such as Java, EJB3, Faces, Facelets, AJAX and relational database and supports various data formats such as CDD, CCR, and CDA documents and standardized Health Level 7<sup>8</sup> (HL7) messages. Moreover, Tolven is built upon an architecture that is plugin-based down to the core module. This is an important advantage for maintenance, customizations and extensions that are often required from electronic health systems in order to meet specific healthcare environment needs.

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<sup>5</sup> <http://home.tolven.org/>

<sup>6</sup> [http://healthit.hhs.gov/portal/server.pt/community/healthit\\_hhs\\_gov\\_\\_home\\_/1204](http://healthit.hhs.gov/portal/server.pt/community/healthit_hhs_gov__home_/1204)

<sup>7</sup> <http://www.ietf.org/rfc/rfc2251.txt>

<sup>8</sup> <http://www.hl7.org/implement/standards/index.cfm?ref=nav>

### ***4.3 HDOT Components***

The p-medicine technological platform is a framework comprised by tools and services aimed at biomedical researchers and biostatisticians. The platform includes a federated Data Warehouse (DW) for storing heterogeneous data stemming from external repositories. These repositories range from private databases within hospitals and research institutions to public biomedical databases accessible through the Internet.

To achieve data transfer and semantic integration, a middle layer ontology, called HDOT, will act as global schema of the integrated data sources. Then, tools for harmonizing data sources with HDOT will be provided. The semantic layer will support the annotation of existing heterogeneous data sources with HDOT as well as the HDOT-compliant set up of new data sources for clinical trials. The Ontology Annotator Tool will be provided, which is aimed at external users (mainly database administrators) who wish to include their databases in the project framework. So Trial Description Repositories can be annotated using the HDOT annotation tool and their data will be extracted, transformed and loaded to the data warehouse.

### ***4.4 Recommendation Service***

Currently, registering patients into clinical trials and finding eligible trials for patients require manual search and clinicians may be overwhelmed by the number of clinical trials and the exclusion and eligibility criteria.

However, having both PHR data and Trial Descriptions in the data warehouse p-medicine will allow the efficient recruitment of eligible patients for clinical trials. Recommendation service will use semantic matching to identify and provide suggestions of potentially eligible patients according to the available eligibility and exclusion criteria. This service will be demonstrated in the context of concrete clinical trials, with realistic data set including longitudinal EHR and clinical trial data. By automatic matching, we expect to reduce the search space with respect to the number of patients, CTs and exclusion/inclusion criteria that need to be manually reviewed to approximately 20 % of the original search space.

### ***4.5 e-Consent***

The patient's written informed consent is mandatory for research use of human biomaterial. "Multi-layered" consent, which requests from patients to make different choices on research that might or must not be performed on their samples, is increasingly recommended by ethics experts as a participative tool for patients.

**Table 1** List of relevant resources

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<i>Related EU projects</i>	
p-medicine	<a href="http://www.p-medicine.eu/">http://www.p-medicine.eu/</a>
<i>PHR systems</i>	
Tolven	<a href="http://home.tolven.org/">http://home.tolven.org/</a>
<i>Representation of profiling information</i>	
Weighted vectors or keywords	[11]
Topic hierarchies	[12]
Scoring models	[13, 14]
Bayesian networks	[15]
<i>Obtaining profiling information</i>	
Questionnaires	[16, 17]
Programming by example	[11]
Simple questions	(Google “+1”, facebook “like”)
Data mining	[18]
Information retrieval	[19]
Machine learning	[20]
Stereotypes	[21]
<i>Knowledge discovery tools</i>	
WEKA	<a href="http://www.cs.waikato.ac.nz/ml/weka/">http://www.cs.waikato.ac.nz/ml/weka/</a>
R-package	<a href="http://www.r-project.org/">http://www.r-project.org/</a>
BioConductor	<a href="http://www.bioconductor.org/">http://www.bioconductor.org/</a>
BioMoby	<a href="http://biomoby.open-bio.org/">http://biomoby.open-bio.org/</a>
<i>Knowledge discovery methods</i>	
Bayesian networks	[18]
Association rules mining	[19]
Case-based reasoning	[20]
Genetic algorithms	[28]
Neural networks	[29]
kNN-algorithms	[30]
Clustering and classification	[31]
Fuzzy logic	[31]

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Management of multi-layered consent forms is to some extent already implemented in Biobanks Information Systems. Hence, tools for aggregating and integrating this ethical-legal data into meta biobanks and synchronizing patient’s consent with scientific information will be developed in p-medicine.

A key feature of the service proposed is interactivity. With this term we refer to the possibility given to a patient to view data organized according to her/his perception of the domain, to retrieve patient-understandable information and, finally, to state decisions. IEmS will entail the tool developed in p-medicine to put people in control over the use of their data (such as type text, state decisions, upload and consult video materials). Providing patients with “consent management” offers a dual benefit: first of all there is the direct empowerment aspect of controlling one’s own data; and secondly, it facilitates interaction with patients in order to ask for new consent (for new trials, secondary use of data) both increasing

efficiency and again involving the patient actively. All these features need a scientific evaluation and validation before an effective use. To reach this goal, a series of experimental tests will be performed on individuals classified by age, computer skills and specific expertise through empirical user-based tests.

## 5 Conclusion

In this Chapter we argue that the integration of psychological and personal variables into multi-scale data systems containing heterogeneous data from a patient will greatly improve the predictive power of decision support systems developed on the basis of these data systems. Besides this, the patient might feel better cared which positively influence his/her emotional functioning. Moreover, the communication between the physician and the patient is facilitated and improved.

As a proof of concept we designed a modular patient empowerment environment where intelligent profiling techniques capture patient profile. Then the profiling information along with smart information technology resources are used to provide personalized information to the patient, and to support decision support and trial enrollment.

The intelligent environment designed and presented in this Chapter, remains to be fully implemented and tested using real patients when all technology infrastructure will be ready to support it. Potential stakeholders will evaluate the environment and developed tools will be validated to be compliant with evaluation criteria. Hopefully our platform will act as a decision support infrastructure, supporting the communication, interaction and information delivery process between doctors and patients.

**Acknowledgments** The research leading to these results has received funding from the European Community's Seventh Framework Programme (FP7/2007-2013) under grant agreement N° 270089.

## A.1 6 Appendix

Table 1.

## References

1. Cawsey, A., Grasso, F., Paris, C.: Adaptive information for consumers of healthcare. In: Peter, B., Alfred, K., Wolfgang, N. (eds.) *The Adaptive Web*, pp. 465–484. Springer-Verlag (2007)
2. Luciano, J.S., Andersson, B., Batchelor, C., Bodenreider, O., Clark, T., Denney, C.K., Domarew, C., Gambet, T., Harland, L., Jentzsch, A., Kashyap, V., Kos, P., Kozlovsky, J.,



- Lebo, T., Marshall, S.M., McCusker, J.P., McGuinness, D.L., Ogbuji, C., Pichler, E., Powers, R.L., Prud'hommeaux, E., Samwald, M., Schriml, L., Tonellato, P.J., Whetzel, P.L., Zhao, J., Stephens, S., Dumontier, M.: The translational medicine ontology and knowledge base: Driving personalized medicine by bridging the gap between bench and bedside. *J. Biomed. Semant* **2**(Suppl 2), S1 (2011)
3. Schiaffino, S., Amandi, A.: Intelligent user profiling artificial intelligence an international perspective. In: Bramer, M. (ed.), vol. 5640, pp. 193–216. Springer Berlin (2009)
  4. Horvitz, E., Breese, J., Heckerman, D., Hovel, D., Rommelse, K.: The lumiere project: Bayesian user modeling for inferring the goals and needs of software users. In: Proceedings of the 14th Conference on Uncertainty in Artificial Intelligence, pp. 256–265 (1998)
  5. Greer, J., Koehn, G.: The peculiarities of plan recognition for intelligent tutoring systems (1995)
  6. Goldberg, L.R.: The structure of phenotypic personality traits. *Am. Psychol.* **48**, 26–34 (1993)
  7. McCrae, R., Costa Jr., P.T.: Toward a new generation of personality theories: Theoretical contexts for the five-factor model. In: Wiggins, J.S. (ed.) *The five-factor model of personality: Theoretical perspectives*, pp. 51–87. Guilford (1996)
  8. Eysenck, H.J.: Personality and prediction: Principles of personality assessment. In: Wiggins J.S. (ed.) *Personality and individual differences* 11, p. 97 (1990)
  9. Arya, A., Jefferies, L.N., Enns, J.T., DiPaola, S.: Facial actions as visual cues for personality. *Comput. Animation Virtual World* **17**, 371–382 (2006)
  10. Abowd, G.D., Dey, A.K., Brown, P.J., Davies, N., Smith, M., Steggle, P.: Towards a better understanding of context and context-awareness. In: Proceedings of the 1st International Symposium on Handheld and Ubiquitous Computing, pp. 304–307. Springer-Verlag, Karlsruhe, Germany (1999)
  11. Lieberman, H., Fry, C., Weitzman, L.: Exploring the web with reconnaissance agents. *Commun. ACM* **44**, 69–75 (2001)
  12. Godoy, D., Schiaffino, S., Amandi, A.: Interface agents personalizing web-based tasks. *Cogn. Syst. Res.* **5**, 207–222 (2004)
  13. Brusilovsky, P., Sosnovsky, S., Shcherbinina, O.: User modeling in a distributed e-learning architecture. In: Proceedings of the 10th International Conference on User Modeling, pp. 387–391. Springer-Verlag, Edinburgh, UK (2005)
  14. Chen, C.M., Hsieh, Y.L.: Mining learner profile utilizing association rule for common learning misconception diagnosis. In: Proceedings of the 5th IEEE International Conference on Advanced Learning Technologies, pp. 588–592. IEEE Computer Society (2005)
  15. Armentano, M., Amandi, A.: A bayesian networks approach to plan recognition for interface agents. *Argentine Symposium on Artificial Intelligence*, pp. 1–12 (2006)
  16. Valderas, J.M., Alonso, J., Guyatt, G.H.: Measuring patient-reported outcomes: Moving from clinical trials into clinical practice. *Med. J. Aust.* **189**, 93–94 (2008)
  17. Greenhalgh, J., Meadows, K.: The effectiveness of the use of patient-based measures of health in routine practice in improving the process and outcomes of patient care: A literature review. *J. Eval. Clin. Pract.* **5**, 401–416 (1999)
  18. Jensen, F.V., Nielsen, T.D.: *Bayesian Networks and Decision Graphs* (3 edn). Springer Verlag (2007)
  19. Shah, D., Lakshmanan, L.V.S., Ramamritham, K., Sudarshan, S.: Interestingness and pruning of mined patterns. In: *ACM SIGMOD Workshop on Research Issues in Data Mining* (1999)
  20. Kolodner, J.L.: Special issue on case-based reasoning: Introduction. *Mach. Learn.* **10**, 195–199 (1993)
  21. Kay, J.: Um: A user modeling toolkit. *User Modeling Workshop* (1990)
  22. Geissler, J.: Informations to patients debate: As if the internet was still a walled garden (2010)
  23. Ratzan, S., Parker, R.: National library of medicine current bibliographies in medicine: Health literacy. In: *Health, N.I.O.* (ed.), (2000)
  24. Nielsen-Bohman, L., Panzer, A.M.: *Health Literacy: A Prescription to End Confusion*. The National Academies Press, Washington, D.C. (2004)
  25. Neuman, H.B., Charlson, M.E., Temple, L.K.: Is there a role for decision aids in cancer-related decisions? *Crit. Rev. Oncol. Hematol.* **62**, 240–250 (2007)

26. Barnato, A.E., Llewellyn-Thomas, H.A., Peters, E.M., Siminoff, L., Collins, E.D., Barry, M.J.: Communication and decision making in cancer care: Setting research priorities for decision support/patients' decision aids. *Med. Decis. Mak.* **27**, 626–634 (2007)
27. Jacobsen, P.B.: Screening for psychological distress in cancer patients: Challenges and opportunities. *J. Clin. Oncol.* **25**, 4526–4527 (2007)
28. Yannibelli, V., Godoy, D., Amandi, A.: A genetic algorithm approach to recognise students' learning styles. *Interact. Learn. Environ.* **14**, 55–78 (2006)
29. Villaverde, J.E., Godoy, D., Amandi, A.: Learning styles' recognition in e-learning environments with feed-forward neural networks. *J. Comput. Assist. Learn.* **22**, 197–206 (2006)
30. Lathia, N., Hailes, S., Capra, L.: kNN CF: A temporal social network. In: *Proceedings of the 2008 ACM Conference on Recommender Systems*, pp. 227–234. ACM, Lausanne, Switzerland (2008)
31. Martin-Bautista, M.J., Vila, M.A., Larsen, H.L.: Building adaptive user profiles by a genetic fuzzy classifier with feature selection. In: *The 9th IEEE International Conference on Fuzzy Systems*, vol. 301, pp. 308–312 (2000)
32. Gorini, A., Pravettoni, G.: P5-medicine: A plus for a personalized approach to oncology. *Nat. Rev. Clin. Oncol.* **8**, 444 (2011)
33. Zabora, J., BrintzenhofeSzoc, K., Curbow, B., Hooker, C., Piantadosi, S.: The prevalence of psychosocial distress by cancer site. *Psychooncology* **10**, 19–28 (2001)
34. Kennard, B.D., Stewart, S.M., Olvera, R., Bawdon, R.E., hAilin, A.O., Lewis, C.P., Winick, N.J.: Nonadherence in adolescent oncology patients: Preliminary data on psychological risk factors and relationships to outcome. *J. Clin. Psychol. Med. Settings* **11**, 31–39 (2004)
35. von Essen, L., Larsson, G., Oberg, K., Sjoden, P.O.: 'Satisfaction with care': Associations with health-related quality of life and psychosocial function among Swedish patients with endocrine gastrointestinal tumours. *Eur. J. Cancer Care*. **11**, 91–99 (2002)
36. Arndt, V., Merx, H., Sturmer, T., Stegmaier, C., Ziegler, H., Brenner, H.: Age-specific detriments to quality of life among breast cancer patients one year after diagnosis. *Eur. J. Cancer* **40**, 673–680 (2004)
37. Brezden, C.B., Phillips, K.A., Abdolell, M., Bunston, T., Tannock, I.F.: Cognitive function in breast cancer patients receiving adjuvant chemotherapy. *J. Clin. Oncol.* **18**, 2695–2701 (2000)
38. Nolen-Hoeksema, S., Wisco, B.E., Lyubomirsky, S.: Rethinking rumination. *Perspect. Psychol. Sci.* **3**, 400–424 (2008)
39. Bandura, A.: Self-Efficacy: Toward a unifying theory of behavioral change. *Psychol. Rev.* **84**, 191–215 (1977)
40. Scholz, U., Dona, B.G., Sud, S., Schwarzer, R.: Is general self-efficacy a universal construct? psychometric findings from 25 countries. *Eur. J. Psychol. Assess.* **18**, 242–251 (2002)
41. Bowling, A., Ebrahim, S.: Measuring patients' preferences for treatment and perceptions of risk. *Quality in health care: QHC* **10**(Suppl 1):2–8 (2001)
42. Ellis, P.M., Butow, P.N., Tattersall, M.H.N.: Informing breast cancer patients about clinical trials: A randomized clinical trial of an educational booklet. *Ann. Oncol.* **13**, 1414–1423 (2002)
43. Sandhu, R., Coyne, E.J., Feinstein, H.L., Youman, C.E.: Role-based access control models. *IEEE Comput. (IEEE Press)* **29**, 38–47 (1996)

# Foreword

The explosive growth of data and information over the past decades, along with enabling technology to store and deliver data, has led to a descriptive term such as ‘Big Data’. ‘Big Data’ refers to datasets so extensive and complex that they are characterized by four features: volume, velocity, variety and veracity (Belanger 2012). Data *aggregate* from multiple sources such as Tweets and sensors, *change in real time* such as stock market trades, *take multiple forms* such as unstructured images and video, and *include noise and false signals* so that they may be untrustworthy (IBM 2013). IBM estimates that the world creates 2.5 quintillion bytes of data a day, with 90 % of the world’s data created in the last two years alone (IBM 2013). The problem of locating data of interest to a specific user in the face of such overwhelming obstacles provided the impetus for this book on *Multimedia Services in Intelligent Environments—Recommendation Services* as part of a series of edited volumes on multimedia services in intelligent environments.

Recommendation Systems, also referred to as recommender systems, attempt to help a user by identifying relevant and valuable data *in the eyes of a specific user* and presenting them in appropriate and useable forms. In general, these systems approach the task of recommendation through either collaborative filtering or content-based filtering (Rajaraman and Ullman 2011). Collaborative filtering develops a prediction of user preference based on the past behavior of the user and similarity with decisions of others. Content-based filtering bases the prediction on properties of the item recommended, while hybrid systems combine the two approaches. Intelligent systems that integrate artificial intelligence and advanced processing capabilities into the mix are essential to achieving the goals of more accurate and personalized user recommendations. The editors of this book have contributed to the literature by focusing attention on research that brings these areas together—advances in intelligent systems, enhanced recommendation

methods, and the challenging context of multimedia services. Their efforts, and those of the contributors, will provide the reader with a view of the current state of the field and serve as a roadmap for future research.

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## References

1. Belanger, D.: Senior Research Fellow, Stevens Institute of Technology. It's About the Data!! Lessons from a Decade+ Experiment in Big Data. Keynote Presentation to the BI Congress III, SIGDSS/TUN Pre-ICIS Workshop, Orlando (2012)
2. IBM: <http://www-01.ibm.com/software/data/bigdata/>. Accessed on 29 March 2013
3. Rajaraman, A., Ullman, J.: Mining of Massive Datasets. Chapter 9: Recommendation Systems. Cambridge University Press: New York, pp. 305–339 (2011)

# Preface

Multimedia services are now commonly used in various activities in the daily lives of humans. Related application areas include services that allow access to large depositories of information, digital libraries, e-learning and e-education, e-government and e-governance, e-commerce and e-auctions, e-entertainment, e-health and e-medicine, and e-legal services, as well as their mobile counterparts (i.e., *m-services*). Despite the tremendous growth of multimedia services over the recent years, there is an increasing demand for their further development. This demand is driven by the ever-increasing desire of society for easy accessibility to information in friendly, personalized, and adaptive environments. With this view in mind, we have been editing a series of books on *Multimedia Services in Intelligent Environments* [1–10].

Specifically, this book is a continuation of our previous books [1–4]. In this book, we examine recent *Recommendation Services*. Recommendation services appear in the mobile environment, medicine/biology, tourism, education, etc. The book includes 10 chapters, which present various recently developed recommendation services. Each chapter in the book was reviewed by two independent reviewers for novelty and clarity of the research presented in it. The reviewers' comments were incorporated in the final version of the chapters.

This research book is directed to professors, researchers, application engineers, and students of all disciplines. We hope that they all will find it useful in their works and researches.

We are grateful to the authors and the reviewers for their excellent contributions and visionary ideas. We are also thankful to Springer for agreeing to publish this book. Last, but not least, we are grateful to the Springer staff for their excellent work.

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## References

1. Tsihrintzis, G.A., Jain, L.C. (eds.): *Multimedia Services in Intelligent Environments—Advanced Tools and Methodologies*. Studies in Computational Intelligence Book Series, vol. 120. Springer, Berlin (2008)
2. Tsihrintzis, G.A., Virvou, M., Jain, L.C. (eds.): *Multimedia Services in Intelligent Environments—Software Development Challenges and Solutions, Smart Innovation, Systems, and Technologies Book Series, vol. 2*, Springer, (2010)
3. Tsihrintzis, G.A., Jain, L.C. (eds.): *Multimedia Services in Intelligent Environments—Integrated Systems, Smart Innovation, Systems, and Technologies Book Series, vol. 3*, Springer, (2010)
4. Tsihrintzis, G.A., Virvou, M., Jain, L.C. (eds.): *Multimedia Services in Intelligent Environments—Recommendation Services*. Studies in Computational Intelligence Book Series, Springer, (2013)
5. Tsihrintzis, G.A., Virvou, M., Howlett, R.J., Jain, L.C. (eds.): *New Directions in Intelligent Interactive Multimedia Systems and Services*, Studies in Computational Intelligence Book Series, vol. 142, Springer, (2008)
6. Tsihrintzis, G.A., Damiani, E., Virvou, M., Howlett, R.J., Jain, L.C. (eds.): *Intelligent Interactive Multimedia Systems and Services, Smart Innovation, Systems, and Technologies Book Series, vol. 6*, Springer, (2010)
7. Tsihrintzis, G.A., Virvou, M., Jain, L.C., Howlett, R.J. (eds.): *Intelligent Interactive Multimedia Systems and Services, Smart Innovation, Systems, and Technologies Book Series, vol. 11*, Springer, (2011)
8. Virvou, M., Jain, L.C. (eds.): *Intelligent Interactive Systems in Knowledge-Based Environments*, Studies in Computational Intelligence Book Series, vol 104, Springer, (2008)
9. Obaidat, M., Tsihrintzis, G.A., Filipe, J., (eds.): *e-Business and Telecommunications: 7th International Joint Conference, ICETE, Athens, Greece, July 26–28, 2010, Revised Selected Papers, Communications in Computer and Information Science Book Series, vol. 222*, Springer, (2012)
10. Tsihrintzis, G.A., Pan, J.-S., Huang, H.C., Virvou, M., and Jain, L.C. (eds.): *Intelligent Information Hiding and Multimedia Signal Processing (IIH-MSP 2012)*. In: *Proceedings of the Eighth International Conference*, IEEE Conference Publishing Services, (2012)

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