Dealing with Malnutrition: A Meal Planning System for Elderly

Johan Aberg
Department of Computer and Information Science
Linköpings universitet
581 83 Linköping, Sweden
{johab}@ida.liu.se

Abstract

Malnutrition is a serious problem among people of old age. To overcome malnutrition, a change of food consumption behaviour is necessary, which needs to be based on specialist advice from health-care professionals. Changing food-related behaviour, however, is known to be difficult. Our approach to this problem is to provide an intelligent meal planning system to be used by the elderly person in his or her home. The system provides recommendations of suitable food recipes, taking into account the advice of the care givers (e.g. in terms of dietary restrictions, suitable energy and fat levels, etc). We describe the requirements, design, algorithms, and user interface of the system, and discuss ongoing and future work.

Introduction

The world's population is ageing. Due to societal improvements in health-care, living standards, and socioeconomic status, more and more people are living to old age. The proportion of the world's population aged 65 or over is expected to increase from 11% in 1998, to 16% in 2025 (U.S. Bureau of the Census 1998). This causes a major public health issue, as with increased age there is an increased risk of developing a number of age-related diseases.

There is scientific evidence that many of the biological changes and risks for chronic disease which have traditionally been attributed to ageing are in fact caused by malnutrition (sub-optimal diets and nutrient intakes) (Beckman & Ames 1998; Blumberg 1994; Chandra *et al.* 1982; Mowé, Bøhmer, & Kindt 1994; Potter *et al.* 1995; Vellas *et al.* 1997). While some nutritional surveys of the elderly have shown relatively low prevalence of frank nutrient deficiencies, there is a clear increase in risk of malnutrition (Blumberg 1997; Sjögren, Österberg, & Steen 1994), and a high prevalence of malnutrition of elderly patients admitted to different clinical settings has been reported in the literature (Larsson *et al.* 1990; Mowé, Bøhmer, & Kindt 1994; Volkert *et al.* 1992). It has also been shown that hospitalisation as such has a negative influence on nutritional status of geriatric patients (Elmståhl *et al.* 1997; Larsson *et al.* 1990). Hence, to solve the challenges of improving quality of life and preventing or reducing disability and dependency of our ageing population, the problem of malnutrition must be dealt with.

There are several causes of malnutrition, see e.g. the discussion in (McCormack 1997). There can be specific age-related causes (e.g. optimal nutrient intake is affected by individual rates of change in physiologic function, or by diseases or drug therapies), economic causes (e.g. financial limitations lead to a down-prioritisation of nutritious food), social causes (e.g. loss of spouse, causing a loss of appetite due to depression, or simply not knowing how to cook, or what constitutes a nutritious meal), and limited dietary diversity (Kant *et al.* 1993). Hence, the role of health-care professionals is to educate and motivate the elderly patient to change his or her food consumption behaviour.

Changing habits of food consumption is known to be difficult, and may require continual supervision and education (Maciuszek, Aberg, & Shahmehri 2005). However, such support is not always available due to shortages in care resources. Thus, as an aid to changing food-consumption behaviour we propose an intelligent food support system, to be used by the elderly person in his or her home, capable of providing informed and individualised suggestions about what to eat. The system takes several important variables into account in the suggestions, such as taste, cost, preparation difficulty, dietary diversity, dietary restrictions, nutritional needs and properties, and available food items. Hence, a health-care provider's suggestions for the user can be incorporated into the system as individual constraints. Such a system, if used properly, has the potential of limiting the problem of malnutrition. For example, for elderly with economic constraints, low cost meals with good nutritional properties can be suggested, optimising the use of available food items, while still taking the taste of the user into account, and maintaining dietary diversity. Note that our system should not be regarded as a finished product, but rather as a tool for further investigations into the malnutrition problem of the elderly and how artificial intelligence can make a difference.

The rest of this paper is organised as follows. In the next section, we describe the problem of changing food consumption behaviour in more depth. After that we describe the meal planning system in terms of the requirements, the design, the algorithms, and the graphical user interface. We then discuss ongoing work and future directions. Finally, we conclude the paper.

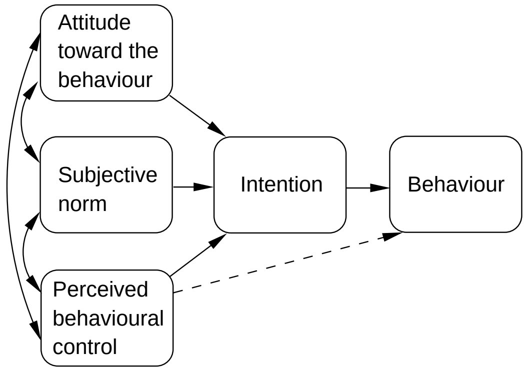

Figure 1: Theory of planned behaviour

Changing Food Consumption Behaviour

The problem of malnutrition is caused by sub-optimal eating. Hence, in order to come to terms with a malnutrition problem, a person must change the food consumption behaviour, and eat food that better fits his or her body's current needs. However, changing food-related behaviours is known to be difficult, and continual support is commonly needed.

According to one of the dominant theories in social psychology, the *theory of planned behaviour* (Ajzen 1991) (which is based on the *theory of reasoned action*), human behaviour is determined by specific considerations (see Figure 1). Behavioural beliefs refer to the outcome of a behaviour and the evaluation of the outcomes, and lead to an *attitude toward the behaviour*. Normative beliefs refer to the perceived expectations of others and the motivation to live up to these expectations, and lead to a *subjective norm*. Control beliefs refer to factors that can help or hinder performance of the behaviour and their relative importance, and lead to *perceived behavioural control*. Together, the attitude toward the behaviour, the subjective norm, and the perceived behavioural control lead to a behavioural *intention*. Finally, given an intention to perform a behaviour and the perceived behavioural control, a person is expected to succeed in performing the behaviour (assuming the perceived behavioural control is close to the actual behavioural control).

Our approach to help elderly people change their food consumption behaviour (and thus deal with malnutrition problems), is to provide them with a tool for meal planning to be used in their homes[1]. Connecting to the theory of planned behaviour, we expect this would raise the perceived behavioural control of the users[2], in the sense that they feel that they have all the knowledge and resources needed for actually changing their behaviour and prepare and consume meals suitable for them. This meal planning system is described next.

[1]This obviously raises questions of whether the users would be able and willing to use the system. See our discussion on user studies below.

[2]Our focus on increasing a user's perceived behavioural control does not mean that we neglect the other factors influencing intention and behaviour, it simply means that we must start somewhere.

A Meal Planning System

Our approach to helping users change their food consumption behaviour is a system that recommends meal plans. As such, our system is a recommender system, which is a class of decision aids, where the aim is to provide users with individualised recommendations on objects from some particular domain (Montaner, Lopez, & de la Rosa 2003). Recommender systems have so far been of great importance for e-commerce (Schafer, Konstan, & Riedl 2001), and also of value for other important tasks such as information search on the Internet (Montaner, Lopez, & de la Rosa 2003). However, to the best of our knowledge, our system is the first recommender system to be applied to a health care problem.

Requirements

The factors influencing a person's food choice have been studied to a fairly large extent in the science of food and nutrition. Shepherd (Shepherd 1989) described several attempts to identify factors influencing food choice, and went on to propose the use of the theory of reasoned action as a general model for food choice. However, this model is completely based on user's attitudes, and does not seem suitable as a *normative* framework. After all, we are not really interested in *predicting* a user's food choice, but to *persuade* the user of choosing optimal food, weighing in the relevant factors. Hence, we have taken the approach of gathering the most feasible[3] factors from all the models presented in (Shepherd 1989). This means that our system is required to represent and reason about the following information:

- Dietary restrictions, e.g. ingredients that the user is allergic to, or must not eat for other medical reasons.
- Nutritional values, e.g. amount of fat or protein contained in a recipe, or required by a user.
- Preparation time of a meal.
- Preparation difficulty of a meal.
- Cost of a meal, i.e. the cost of the needed ingredients.
- Availability of ingredients for a meal, e.g. to what extent does the needed ingredients match the ingredients available to the user at home.
- Variation with respect to other meals in the plan, in terms of used ingredients and the category of a meal.
- The user's food taste, i.e. how the user rates a recipe on a taste scale.

Design

To be able to take these requirements into account, the system has a hybrid design in the sense that it makes use of both collaborative filtering and a content-based approach. The collaborative filtering is used for predicting a user's taste opinion of a certain recipe that he or she has not yet rated, based on the user's other ratings and the ratings of other users. For the content-based approach we make use of

[3]By feasible we mean that a factor should be feasible to make use of in the system, with respect to practical knowledge engineering and reasoning issues.

a specially designed XML-based mark-up language for food recipes, that allow us to represent the needed content information for the recipes in the database[4]. Our approach to construct optimal meal plans according to the factors presented above uses constraint satisfaction techniques. More details on the algorithms employed in our meal planning system are provided next.

Algorithms

We model the constraint-satisfaction problem with a mix of weighted soft constraints and traditional hard constraints, similar to the approach in (Torrens 2002). We have experimented with two different ways of modelling the problem. In our parameter-based approach, variables are used for the parameters of a recipe, such as *time*, *cost*, *energy*, *protein*, etc, and the variable domains are based on the existing values in the recipe database. There is also a special hard constraint requiring a complete variable assignment to match only existing recipes in the database. The other, recipe-based, model is simpler, and has only one variable per meal in the plan, with the set of recipes as value domain.

For both models, we employ a set of additional constraints to take the user's needs and preferences into account. Such constraints include hard constraints, e.g. for ingredients to avoid, and soft constraints, e.g. for variation between meals (a recipe with many ingredients in common with a recipe for a previous meal gets a penalty) and for taste (recipes with high rating or predicted rating get low penalty). A collaborative filtering approach is used to predict ratings for unrated recipes. We have implemented a version of the item-based algorithm (Sarwar *et al.* 2001), with adjusted cosine similarity, and weighted sum predictions.

For solving the constraint-satisfaction problem we base our approach on the well-known depth-first branch and bound algorithm. We have also been experimenting with a set of forward-checking approaches and variable ordering heuristics. Our current implementation uses depth-first branch and bound with partial forward checking.

User Interface

The user interface of the system has been designed particularly for elderly users. The current user interface design is the result of an in-depth exploration of the design space (by means of the QOC framework (MacLean *et al.* 1991)), taking existing literature on universal access and user interface design for elderly into account as evaluation criteria for the explored design options. Two separate prototype designs were created as paper prototypes and evaluated empirically with elderly users. Based on these user studies the current user interface was designed and implemented, in an attempt to use the best features from each of the two earlier prototypes. Figure 2[5] shows a part of the settings management, where a user can select the time period for which the system will recommend meals. Note that this is just a part of the settings that a user can perform. Among other things, a user can also select required intervals for energy, fat, cholesterol, etc. Such settings are absolutely crucial for our purpose of helping elderly people avoid malnutrition, and the actual settings should be done in collaboration with the user's care givers. The user can also select ingredients to avoid, select preference levels for cost, preparation time, etc, and mark ingredients as currently available.

Figure 3[6] shows an example of a recommended meal plan for a certain time period. Note that the user can switch between the top-5 meal plans, and give taste ratings on suggested recipes (on a scale from 1 to 5) and re-plan to take the new ratings into account, or create special settings for a certain meal, such as allowing a greater cost and preparation time for the Sunday meal.

Ongoing Work

Algorithms

In our ongoing work, we are investigating the trade-offs for the two constraint-satisfaction models we have implemented. The main aspect we are looking into is the computation time required for solving the constraint-satisfaction problem. Based on our two alternative constraint models of the meal planning problem, we are experimenting with the following parameters:

- Number of recipes in the database.
- Number of meals in the requested plan (e.g. the length of the time period).
- The number of users to plan for (e.g. the size of the family, or the number of persons in the assisted living facility).

Based on a set of 50 real food recipes and a much larger set of randomly generated recipes (the random generation is based on parameters from the real recipes) we have conducted several simulation experiments. So far, the results indicate that the two models have complementary characteristics. The parameter-based model performs very well with small recipe collections and can make plans for several meals with just a few seconds response time. However, this model only provides reasonable response times for data sets of a maximum of roughly 500 recipes. The recipe-based model on the other hand scales well with increasing

[4]We have also developed a semi-automatic tool to facilitate the extraction of information from food recipes in text format.

[5]The user interface is designed in Swedish, so some additional explanations may be needed for most readers of this paper. The menu to the left is used for reaching different settings pages. In this screen shot we are at the settings for the time period ("Tidsperiod"). The area to the right of the calendar shows the user's current calendar choices as additional feedback. The rightmost area of the screen contains a help text for this particular settings page. This help text can be toggled on and off, but is on by default.

[6]This screen shot illustrates the meal plan menu generated by the system. Currently the first, and best, alternative is displayed. The user can toggle between different alternatives with the topmost buttons. Note that the recipe names are shown in English in this example. To the right of each recipe name is a slider for changing the taste rating, and to the right of this slider is the current rating, written in text. In this example all recipes have previously been rated by the user, so no predicted ratings are displayed. Above the area for the recommended recipes are buttons for changing settings and for replanning based on new taste ratings.

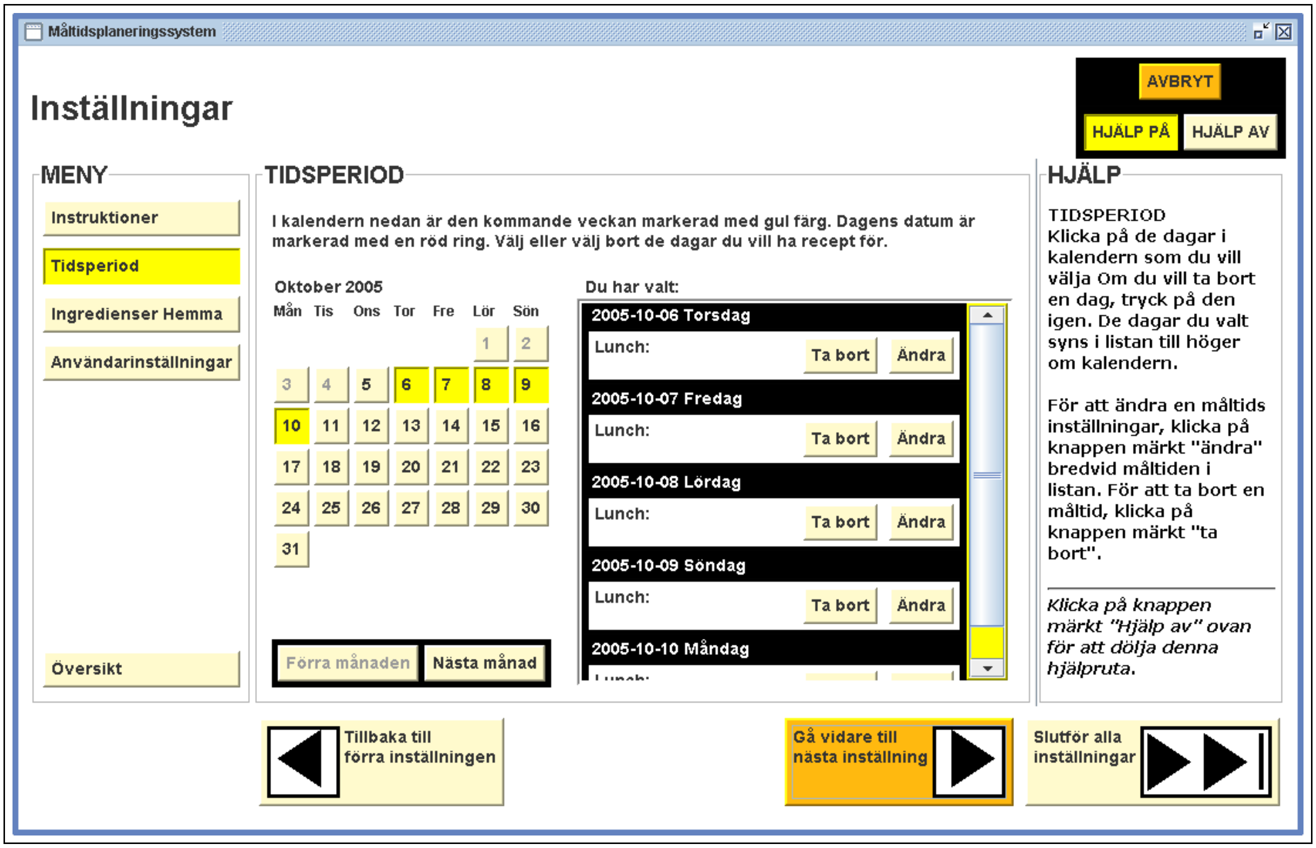

Figure 2: Meal planning system settings: selecting the time period for the meal plan

recipe collections, but is limited with respect to the number of meals to plan for.

User Studies

As discussed previously, our main aim with the meal planning system is to put the elderly person in charge of changing his or her food consumption behaviour. By providing the user with recommendations of suitable recipes that take into account important parameters such as dietary restrictions, cost, and the preparation skills of the user, we hope to increase the user's behavioural control, which is critical for changing behaviour. However, it is of course a prerequisite that the user accepts the system and really uses it. Although the user interface has been designed based on user studies of paper prototypes involving potential future users, an important question is whether the *implemented* system is usable and acceptable for elderly users. To answer this question we are currently conducting a user study with several older adults. In the study, after a very brief oral description of the system, the users are assigned a set of tasks to be solved with the system. At the time of writing we have data from four users (with age ranging from 70 to 82, and with varying degrees of previous computer experience). Our observations and interviews have highlighted several problems with the current interface that will need to be adressed in the next version. However, and more importantly, after having gone through all the test tasks, all four users have been able to use all the main functions of the system, despite minor flaws and initial orientation problems. This is an important result, illustrating the potential of the system.

Future Directions

Faster Algorithms

Given the preliminary results reported on earlier, there is a clear need to further investigate means to speed up meal planning algorithms. Ideally we would like the system to be able to make plans for at least a week at the time, and with large databases containing up to 10,000 recipes. Even if our system is working well with our current small databases, we are not there yet, and we won't be there in a few years either if we extrapolate using Moore's law. Hence, we plan to continue our efforts to improve the algorithms and the constraint models. As a starting point we intend to examine how the complementing characteristics of the two present constraint models can be exploited. We will also explore the possibilities of terminating the search before the whole search tree has been explored. The rationale for this approach comes from our empirical results showing that the time spent searching for the last few complete assignments make up the great majority of the total time spent on the search, while the reduction in upper bound that these last as-

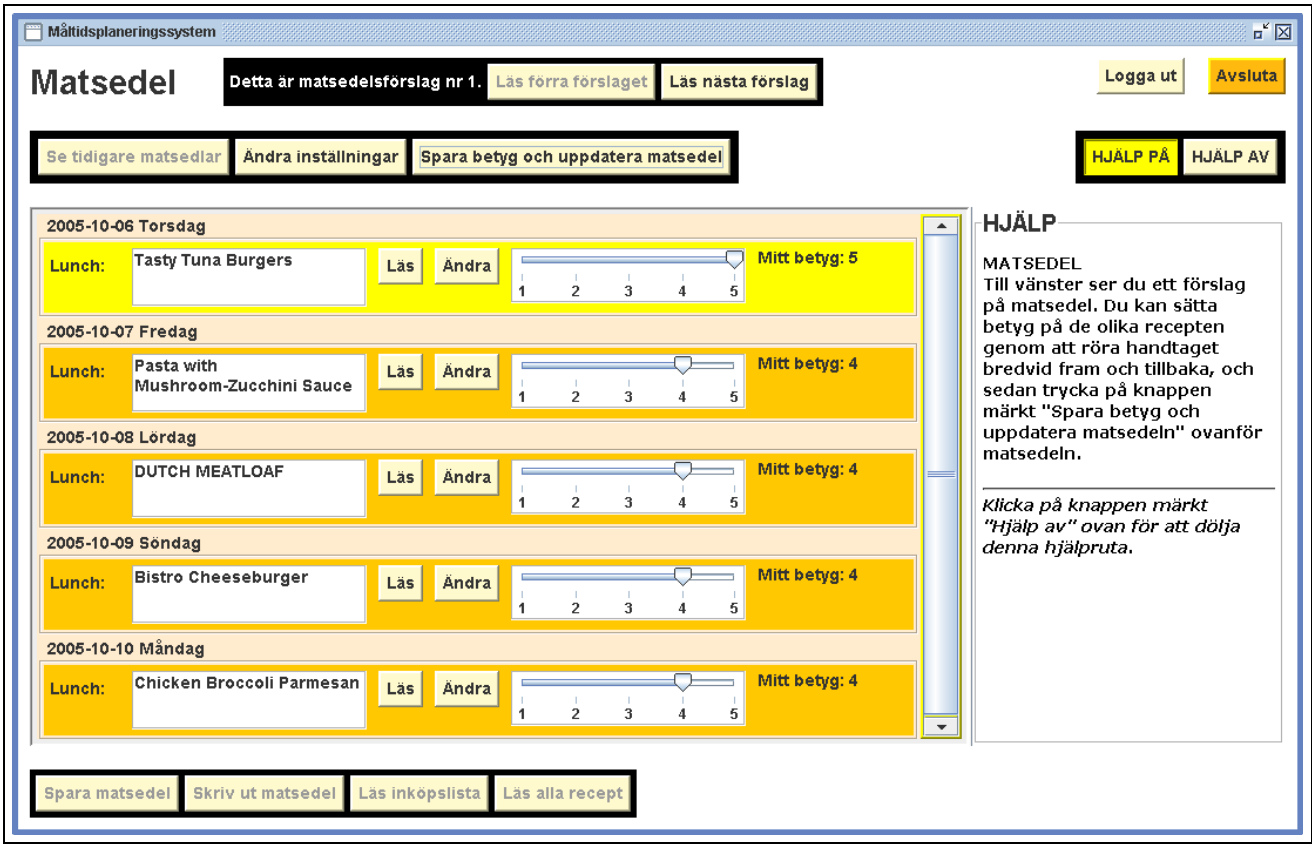

Figure 3: Meal planning system output: a recommended meal plan

signments bring is fairly small. The important question to be answered is of course whether such pre-termination, and the resulting non-optimal plan, would have a negative effect on users' acceptance of the system.

Explanation Facilities

We are looking into explanation facilities as a means of improving the system's acceptability. One of the main features of explanation facilities is to make the performance of the system transparent to the users. System explanations can provide information about the knowledge that the system has, and how it reasons. Explanations can also serve as justifications for advice provided by the system. In the context of advice-giving systems, explanations are of most importance for users when they perceive an anomaly (such as a recommendation that they disagree with), or when they want to learn about the system (Gregor & Benbasat 1999).

Explanations can be categorised according to three dimensions (Gregor & Benbasat 1999): 1) the content of the explanations, 2) the provision mechanism, and 3) the presentation format. The content of explanations can in turn be divided into four types. The first type is called *trace* (or *line of reasoning*). Trace explanations explain why decisions were made by describing the steps taken to reach the decision. The second type is called *justification* (or *support*). Justification explanations attempt to justify each step in the system's reasoning, by connecting it to "deep" knowledge from which the reasoning was derived. The third type of explanation is called *control* (or *strategic*). Control explanations aim at explaining the system's control behaviour and problem solving strategy. Finally, the fourth explanation type is called *terminological*. The aim is to provide terminological information, such as definitions of terms used by the system. There is empirical support indicating that justification and terminological explanations are particularly useful (Gregor & Benbasat 1999; Ye & Johnson 1995).

As for the provision mechanism, explanations can be user-invoked (provided at the request of the user), automatic (always presented to the user, possibly with extensions within reach with a hypertext click), or intelligent (explanations provided only when the system considers they are needed). Existing theory suggests that the less cognitive effort required to access and absorb an explanation, the more used and effective they will be (Gregor & Benbasat 1999). This clearly speaks for automatic or intelligent provision mechanisms. The advantage of automatic explanations over user-invoked ones has also been demonstrated empirically (Moffitt 1994). It has also been shown that case-specific explanations are more effective than generic explanations (Berry & Broadbent 1987).

Explanations can be presented in different text-based formats, such as rules of the system in some kind of pseudo code, "canned text" versions of such rules, or in generated natural language. There are also possibilities for using multimedia, with graphics, animation, or voice. There is currently little evidence as for what kind of presentation format should be preferred. However, general usability principles must be adhered to.

To summarise, we can conclude that for explanations to be used and useful they have to be provided automatically (or intelligently), be of justification type, and be case specific. Also, the existing terminology in the system should be explained. Finally, we note the importance of tailoring the presentation to the user's preferences (Carenini & Moore 2001; Grasso, Cawsey, & Jones 2000). This will be the starting point for our work on exploring different kinds of explanation facilities for the meal planning system, and their relation to users' acceptance of the system, as well as their potential for educating the user about healthy eating.

Conclusions

We have presented a new approach to meal planning, aiming at helping elderly people deal with malnutrition problems by increasing their behavioural control. This work is part of the Virtual Companion project at Linköping university (Shahmehri *et al.* 2004). The approach should be regarded as a novel AI-based approach to the problem, and represents the first steps in a larger project. Hence, the implementation described in this paper should be regarded as a tool for future research and studies, and not as a finished product.

The meal planner in its current form mainly attempts to help the users change their food consumption behaviours by influencing their perceived behavioural control. However, by also including persuasive features in the system we could influence the users' attitudes toward their behaviour as well. The explanation facilities we have discussed could be regarded as persuasive features, but other approaches should also be explored. Such approaches could range from the simple (e.g. having a traffic light symbol indicating healthy settings with a green light and unhealthy settings with a red light), to the complex (e.g. transforming a scanned photo of the user into a relaxed smile when the settings are good, and into an angry and tired look when the settings are bad).

Although the system presented here has been focused on individual users, the underlying techniques could very well be used for different purposes, for example supporting the meal planning of a hospital or a retirement home. In fact, the system already has support for dealing with multiple user profiles, e.g. several members of a family or dinner guests.

Finally, even if our proposed system is targeted at the elderly population where the problem of malnutrition is of greatest concern, it could as well be of use for the younger population. In stressed situations, it is easy to resort to well remembered meals that have been frequently cooked in the recent past, and thus sacrificing dietary diversity. Having access (possibly mobile) to suggestions provided by our system could thus make the life easier for many people, not necessarily of old age.

Acknowledgements

This research has been partly supported by the Swedish Council for Working Life and Social Research. Thanks to Kajsa Lindén for her work on the implementation of the user interface, and to Niclas Sundmark for his work on the implementation of the meal planning algorithms. The ongoing user study is done in collaboration with Birgitta Lorefält at the Department of Medicine and Care, Division of Nursing Science, Faculty of Health Sciences, Linköping University.

References

Ajzen, I. 1991. The Theory of Planned Behavior. *Organizational Behavior and Human Decision Processes* 50:179–211.

Beckman, K. B., and Ames, B. N. 1998. The Free Radical Theory of Ageing Matures. *Physiological Reviews* 78(2):547–581.

Berry, D. C., and Broadbent, D. E. 1987. Explanation and Verbalization in a Computer-assisted Search Task. *The Quarterly Journal of Experimental Psychology* 39A:585–609.

Blumberg, J. B. 1994. Nutrient Requirements of the Healthy Elderly – Should There Be Specific RDAs? *Nutrition Reviews* 52(8):515–518.

Blumberg, J. 1997. Nutritional Needs of Seniors. *Journal of the American College of Nutrition* 16(6):517–523.

Carenini, G., and Moore, J. D. 2001. An Empirical Study of the Influence of User Tailoring on Evaluative Argument Effectiveness. In *Proceedings of the 17th International Joint Conference on Artificial Intelligence (IJCAI 2001),* 1307–1314.

Chandra, R.; Joshi, P.; Au, B.; Woodford, G.; and Chandra, S. 1982. Nutrition and immunocompetence of the elderly: effect of short-term nutritional supplementation on cellmediated immunity and lymphocyte subsets. *Nutrition Reseach* 2:223–232.

Elmståhl, S.; Persson, M.; Andren, M.; and Blabolil, V. 1997. Malnutrition in geriatric patients: a neglected problem? *Journal of Advanced Nursing* 26:851–855.

Grasso, F.; Cawsey, A.; and Jones, R. 2000. Dialectical argumentation to solve conflicts in advice giving: a case study in the promotion of healthy nutrition. *International Journal of Human-Computer Studies* 53:1077–1115.

Gregor, S., and Benbasat, I. 1999. Explanations From Intelligent Systems: Theoretical Foundations and Implications for Practice. *MIS Quarterly* 23(4):497–530.

Kant, A. K.; Schatzkin, A.; Harris, T. B.; Ziegler, R. G.; and Block, G. 1993. Dietary diversity and subsequent mortality in the First National Health and Nutrition Examination Survey Epidemological Follow-up Study. *American Journal of Clinical Nutrition* 57:434–440.

Larsson, J.; Unosson, M.; Ek, A.-C.; Nilsson, S.; Thorslund, S.; and Bjurulf, P. 1990. Effect of Dietary Supplement on Nutritional Status and Clinical Outcome in 501 Geriatric Patients – a Randomised Study. *Clinical Nutrition* 9:179–184.

MacLean, A.; Young, R. M.; Bellotti, V. M. E.; and Moran, T. P. 1991. Questions, Options, and Criteria: Elements of Design Space Analysis. *Human-Computer Interaction* 6(3&4):201–250.

Maciuszek, D.; Aberg, J.; and Shahmehri, N. 2005. What Help Do Older People Need? Constructing a Functional Design Space of Electronic Assistive Technology Applications. In *Proceedings of the Seventh International ACM SIGACCESS Conference on Computers and Accessibility (ASSETS'2005)*, 4–11.

McCormack, P. 1997. Undernutrition in the elderly population living at home in the community: a review of the literature. *Journal of Advanced Nursing* 26:856–863.

Moffitt, K. 1994. An Analysis of the Pedagogical Effects of Expert System Use in the Classroom. *Decision Sciences* 25(3):445–460.

Montaner, M.; Lopez, B.; and de la Rosa, J. L. 2003. A taxonomy of recommender agents on the internet. *Artificial Intelligence Review* 19:285–330.

Mowé, M.; Bøhmer, T.; and Kindt, E. 1994. Reduced nutritional status in an elderly population ($>$ 70 y) is probable before disease and possibly contributes to the development of disease. *American Journal of Clinical Nutrition* 59:317–324.

Potter, J.; Klipstein, K.; Reilly, J. J.; and Roberts, M. 1995. The Nutritional Status and Clinical Course of Acute Admissions to a Geriatric Unit. *Age and Ageing* 24:131–136.

Sarwar, B.; Karypis, G.; Konstan, J.; and Riedl, J. 2001. Item-Based Collaborative Filtering Recommendation Algorithms. In *Proceedings of the 10th International World Wide Web Conference (WWW10)*, 285–295.

Schafer, J. B.; Konstan, J. A.; and Riedl, J. 2001. E-Commerce Recommendation Applications. *Journal of Data Mining and Knowledge Discovery* 5(1/2):115–152.

Shahmehri, N.; Aberg, J.; Maciuszek, D.; and Chisalita, I. 2004. Linköping University's Virtual Companion Project. *IEEE Pervasive Computing* 3(2):50.

Shepherd, R. 1989. Factors Influencing Food Preferences and Choice. In Shepherd, R., ed., *Handbook of the Psychophysiology of Human Eating*. John Wiley and Sons. chapter 1, 3–24.

Sjögren, A.; Österberg, T.; and Steen, B. 1994. Intake of Energy, Nutrients and Food Items in a Ten-year Cohort Comparison and in a Six-year Longitudinal Perspective: A Population Study of 70- and 76-year-old Swedish People. *Age and Ageing* 23:108–112.

Torrens, M. 2002. *Scalable Intelligent Electronic Catalogs*. Phd. thesis no. 2690, Swiss Federal Institute of Technology (EPFL), Lausanne, Switzerland.

U.S. Bureau of the Census. 1998. World population profile: 1998. Technical Report WP/98, US Government Printing Office, Washington DC.

Vellas, B. J.; Hunt, W. C.; Romero, L. J.; Koehler, K. M.; Baumgartner, R. N.; and Garry, P. J. 1997. Changes in Nutritional Status and Patterns of Morbidity Among Free-Living Elderly Persons: A 10-Year Longitudinal Study. *Nutrition* 13(6):515–519.

Volkert, D.; Kruse, W.; Oster, P.; and Schlierf, G. 1992. Malnutrition in geriatric patients: diagnostic and prognostic significance of nutritional parameters. *Annals of Nutrition Metabolism* 36:97–112.

Ye, L. R., and Johnson, P. E. 1995. The Impact of Explanation Facilities on User Acceptance of Expert System Advice. *MIS Quarterly* 19(2):157–172.