Motivating to a regular diet – The FoodCoach

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ABSTRACT
In this paper we describe a software agent which motivates the user to pursue a healthy diet. Using a smart phone and bar codes for easy input of product information, the FoodCoach creates a profile of its users. The FoodCoach assists the user with their daily diet. It suggests a personal and healthy diet to its user. The suggestions are adaptive to the users feeding habits and the application uses motivation techniques to encourage the user.

Keywords
FoodCoach, consumption, diet, coaching, smart phone, agents

INTRODUCTION

The amount of people that suffer from an unhealthy diet continues to grow in western countries. This "western lifestyle" can cause various illnesses. For example Diabetes (type 2) which, when undiagnosed can result in life threatening or even fatal situations. In 2000, 16% of the deaths in the USA were caused by obesity [24]. Many of these deaths could be prevented by stimulating a healthier diet. Also, there are a lot of costs involved by the healthcare required in extreme obesity situations.

One of the major contributors to an unhealthy diet is the consumption of food that contains a lot of energy at irregular intervals (snacks). In this paper we propose an agent called the "FoodCoach" which goal is to ultimately motivate its users to attain a healthy diet at regular intervals.

HEATLHY FOOD

According to the Dutch Food Center there are five major points that are crucial for healthy food [31].

1. *Eat varied*

   People should eat a varied meal to profit from all kinds of nutrients. There should be variety in the usage of carbohydrates, vegetables, fruits, fats, dairies and proteins. The food guide pyramid (in Dutch: Schijf van Vijf) gives a good indication.

2. *Don't eat too much*

   To stay at a healthy weight, people shouldn't eat too much. Exercising helps to stay fit.

3. *Use less saturated fat.*

   Saturated fats increase the chance on cardiovascular diseases.

4. *Eat plenty vegetables, fruits and bread*

   Vegetables, fruits and bread contain lots of nutrients like vitamins, fibers and minerals.

5. *Use food safely*

   People should watch that their food isn't polluted and that their food is of high quality.

The FoodCoach implements these rules to compose a healthy diet, by creating a weekly menu that contains the ideal amount of nutrients.

FOODCOACH

The FoodCoach is designed to work on smartphones and also optionally on refrigerators where a small tablet display would be placed. This display would have two way interaction using the 3G or WIFI (two types of wireless networking) protocol to synchronize data.

When the user starts the application for the first time, they have to create a profile. This profile contains basic information like length, weight, age and gender. The user can also enter other profile information like hours of exercise per week, food specific preferences (e.g. vegetarian) and allergies. After completing this one time process, the user is ready to use the coach.

The coach offers the user a daily menu with suggestions for healthy food. The suggestions that the coach makes, are based upon the user profile, the time of day and the food that the user took earlier. Therefore the application needs to know what the user ate. It asks the user to submit the meals and products that they ate and drank.

The user registers the consumed products by scanning barcodes of products. This is done by taking a photo of the barcode using the camera of the smartphone. These barcodes are looked up in a database filled with products and the nutritional data. Another method of data input is by typing the first letters of the ingredient which are auto completed by the graphical user interface (GUI).

Using this data the coach determines the nutrients intake of the user and determines if this matches a healthy pattern.

When the coach makes suggestions for the user it takes the Body Mass Index (BMI) into account. A user's BMI is

based on the weight and the length of a user; it is calculated as the weight divided by the squared length. A healthy BMI lies between 18,5 and 25. In the case of a too high BMI (25+) the coach motivates the user to reduce their calorie intake by various ways:

- Informing the user to eat less often
- Eat less
- Eat food with fewer calories.

Users with a BMI higher than 30 or lower than 18,5 (seriously overweight or underweight) will be advised to see a doctor or dietitian.

To assist the user with their daily choices of proper food, the application has a large collection of ready to use recipes. These recipes don't use advanced cooking techniques and materials, so that it's feasible for everybody to prepare them. The user can specify their preference for the day, and the coach will search for a matching recipe. There is also an option available to add custom recipes by the user or choose for more advanced recipes.

It is also possible to receive a list for multiple days if the user desires so. These recipes are varied so that the options for a week will not become very repetitive.

The recipes contain pictures of their ingredients, so that if a user is unfamiliar with them, they can still easily identify them in the store. A specification of the nutrients is also provided per recipe. In the situation that the user does not like the displayed recipes, he or she can ask for an alternative recipe.

The intelligence of our FoodCoach originates from the functionality that it tries to understand the consumption pattern of the user and tries to influence it by adapting to it (like what kind of 'taste' the user has) and to influence the user by supplying them with suggestions for dinner and to discourage the consumption of snacks.

Food and food intake

For home cooked meals, the majority of food choices are made in the grocery store [15]. Factors that influence what food we choose can be generalized to three categories: life course (i.e. past experiences), influences (i.e. ideals, personal factors based on psychological and physiological needs, resources both tangible and intangible, social framework and food context) and personal system (i.e. habits) [15]. Nutrition knowledge plays only a very small roll [32], although knowledge is the basis for beliefs that can cause behavioral changes [25]. One possibility suggested by [25] is to manipulate the energy density of the food, because people tend to eat the same weight of food rather than the amount of food needed to get the same amount of energy. Therefore one of the features of our coach is that it can propose meals to the user that can be eaten in the same quantities but with a lower sum of calories.

Part of a healthy diet is not only certain foodstuffs but also the amount of food that is consumed. Because people find it difficult to accurately keep track of this [33] our IUI assists them in doing so by giving the user the ability to register the consumed quantities of certain products. These quantities are defined by a standard list containing common quantity descriptions: weight (gram, kilogram), volume (liters, milliliters), portion, glass, bottle, etc. Alternatively, the user can choose one picture out of three pictures that resembles the amount they have eaten. This is particularly useful in situations where you eat a variable amount like crisps and snacks by using hands, as people will indicate that they ate less than they actually did [21].Therefore the coach has to auto-correct the amount that is indicated, by adding a standard margin.

Influencing the consumed quantities

One of the most influencing things on the perceived amount that is eaten is the number of people that enjoy the meal together. Compared to when eating alone, with two people one consumes 33% more and with seven or more people 96% more is consumed [8][10]. This boils down to the fact that the more someone is distracted, the harder it is to keep track of how much they have eaten and thus they need to eat more to get the feeling they have eaten enough. [33] For the surroundings this means that color should be cool [6] and meals should not be consumed in front of the television [33]. Because lighting conditions influence non-visual psychological conditions [22], dim lighting makes it difficult to judge the amount of food consumed. Harsh lighting on the other hand might also make it difficult to keep track of how much has been eaten. Under these conditions people eat very fast, which also hinders monitoring [33].

Psychological limits are mostly very much culture related. Western Europeans are unlikely to eat cat meat or soy sauce on bread, because it is not regarded as socially acceptable while the taste might be enjoyed [25].

Tangible resources can mean money for example [29].This would be a good way to influence behavior for governments [28], so taking pricing and promotions are also taken into account by our agent.

Perceived variety influences the amount consumed. The higher the perceived variety, the higher the expected satisfaction and the more people eat. E.g. one bowl with different colored candy is perceived as more varied than when the candy is sorted by color in different bowls [18][33]. This means our agent either suggests recipes that minimize perceived variety or reduce the amount of ingredients so that users can have some of everything but not eat too much.

Also the effort, both mental and physical, should be maximized to get more as the more effort is needed to get more, the less likely people are to try and get more. [33]

This means quantities are exactly what the user needs and nothing more.

Just as colors influence behavior subconsciously, they also influence the likelihood that consumers buy a product. However, they do not influence the enjoyment of the product once it has been bought [7].

REQUIREMENTS

Summarizing our FoodCoach's requirements, we come to the following list:

The coach must:

- accept both barcodes and manual product input, and find the nutritional data of this product in an online database;
- create a personal profile of the user based on the daily product inputs and his or her preferences, and the given tallness and weight of the user;
- display a user created avatar with text to speech support;
- motivate its users to input data and use the output (e.g. recipes);
- suggest recipes based on user preferences, previously consumed products and products that are already available.

TARGET GROUP

Our target group is defined as: The people aged between 18 to 60 years with a BMI between 18,5 and 30. In our application we define three subsets in this range:

- families (one or two adults with one or more children)
- couples (two adults)
- individuals (a single adult)

There is also a group that we choose **not** to focus on, because their situation desires a specific diet:

- people with a chronic disease
- athletes
- people with an eating disorder
- people with a diet for medical reasons
- pregnant women
- women that give breastfeeding

In the case of multiple concurrent users (e.g. families or couples) the agent considers all user profiles. This way, an entire household can use the FoodCoach. If desired, the recipes that have been suggested for a multi person situation can be ignored and just a single recipe will be shown. The children in a family are assumed to be taken care of by the parents. Therefore they are not part of the agent and the input of products.

RELATED WORK

Other food coaching related software ('apps') have been developed for smartphones before, even including the scanning of barcodes to lookup products or 'calorie counting'. A good example of such an app is the "Calorie Tracker" [1] which displays the calorie consumption and burning, graphs of previous days and has many other features. However, these apps do not give any intelligent feedback based on the profile which is partially created by the user, and partially learned by our FoodCoach. Next to smartphone-applications there have been many books about diets in the past. The books are often about losing weight ('crash diet') and not necessarily about maintaining a healthy daily diet. We want to focus especially on the healthy diet.

THE SYSTEM

The components of our system and their relations are modeled in figure 1. We can see that the user interacts directly with the system by using either their smartphone or a tablet pc which can be attached to the fridge.

All information is stored in a central database in the cloud which is available through the internet. This database contains the different user profiles, recipes and information about ingredients and their nutritional value. Recipes and ingredient information are updated regularly, so that users always have access to the best data and will not get stuck with the same recipes every time.

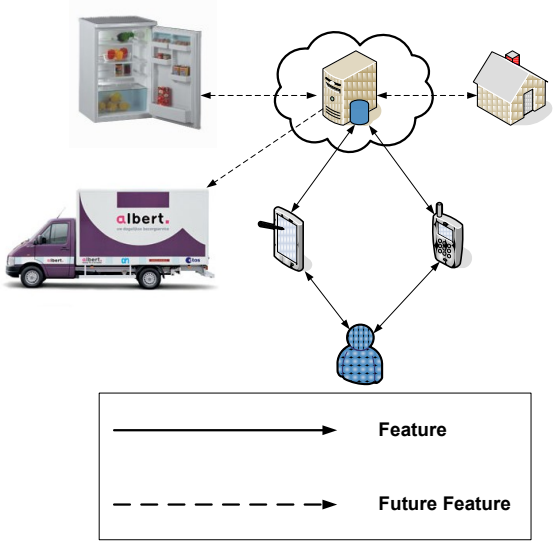

Figure 1: Architecture of the FoodCoach

A reduced version of the database is copied to the user's device, so that it remains accessible even when no internet connection is available. The reduction takes place based on user preferences. All products the user has said they prefer not to eat are extracted as are all recipes containing these products. Should a user not have set dislikes, the selection is made based on what they do like.

When an internet connection is available, the local and remote databases are synchronized. This way consistency between them is guaranteed.

HARDWARE SPECIFICATIONS

The device that would run our software agent can be any modern smartphone that has a camera of at least 1.3 megapixels (roughly a resolution of 1280 x 960) and the ability to connect to the internet (preferably through a data plan with 3G). This means that the user should have an internet subscription if he or she would like the ability of real-time information about products which have their barcode scanned. The operating system or brand of the phone is not relevant since each OS specific programming language has the ability to support the display of custom graphics, receiving and sending data over an internet connection and access to the build in camera. After starting and configuring the software once, it automatically starts (unless told not to do so) when the phone restarts. During normal operation the program will be an idle background service.

BARCODE

The barcode of products would be ideal to use in our agent. Nearly all products found in a supermarket are already tagged with a barcode, except for fresh fruit and vegetables. Nowadays these products are often weighed at the cash register, which makes it impossible to use barcodes to enter these products. Therefore there also is an option to easily enter a product by either name or by selecting from a list of categories accompanied by images.

Nearly all smartphones are equipped with a camera. There are already applications ('apps') available that can recognize barcodes and use an online database to look up further details. For example http://www.livaad.nl/ contains a database filled with products that can potentially be harmful to people who cannot consume gluten. This database can be combined with the "USDA National Nutrient Database for Standard Reference" [2]

Combining various databases (or region specific supermarket databases) provides a reasonable coverage of products. Other databases also need to be connected to get a clear view of the nutritional values of possible products and the ingredients of the recipes.

Figure 2: The barcode scanner for a certain supermarket

Since our target group would be the USA and Europe, the barcode standards that are recognized are EAN13 (European Article Numbering) and the American UPC (Universal Product Code). Many algorithms have been proposed in the last decade concerning the usage of mobile devices and their camera [23]. The implementation of the algorithm would return the 12 (UPC) or 13 (EAN) digit code which is used to look up the product from a local (cached) data storage or from an online lookup service. Fortunately a large number of SDKs (Software Development Kits), including Open Source variants [3], exist including support for smartphones. To make our agent support the reading of product barcodes, it is a matter of choosing a proper SDK and feeding it the pictures taken by the user upon which the agent starts to retrieve the nutritional facts about the chosen product and registers it.

Without a barcode

It is very likely that the user does not have barcodes for each consumed product during the day. Products like bread, a slice of cheese, tea or coffee are likely not to have an easy to use barcode. To solve this problem our coach supports manual input. Since this manual input requires more manual labor, it needs to be as fast and easy as possible. Therefore we use the following methods:

In the case of a larger package containing smaller doses (like with presliced cheese), the user can scan the package. The first time the agent downloads the nutritional values from an (online) database. Next time, when the user consumes one slice of cheese, they can start typing the product and it is auto-completed using a list of suggestions. The user can then simply select the product and continue.

In the case of a product which has not been labeled with any type of barcode (like coffee or tea from a vending machine) the user can start to enter the product similar to the previous method. Again, the agent tries to auto-complete the product name. Products like 'coffee', 'tea' or 'soup' are very likely to be found. The user can then once again select the product. Next the user can disambiguate the product. For example, when choosing 'coffee' they should select 'coffee black', 'coffee with sugar', 'coffee with milk' or both 'sugar and milk'. Also a custom field is provided for individual ingredient lookup for further disambiguation of the consumed product 'coffee'.

After the product is successfully selected, the nutritional values are calculated and inserted in the daily consumed goods list. The product is also inserted in the database for easy and fast lookup later on (when the user consumes the same product with the same disambiguation).

In the case of products which are too complex to specify (like a special type of sandwich) and for which no disambiguation exists, the user can still choose a "generic sandwich". This might not be completely accurate, but still provides an estimate of what has been consumed.

RECIPE SELECTION

The agent comes with a default database of recipes. The recipes in the database are categorized using various tags. Tags could indicate the course (starter, main, dessert), difficulty (easy, medium, hard), vegetarian (yes, no) and calories per portion. The recipes contain a step by step procedure of the preparation, a list of required ingredients and optionally photos of the end product or the preparation steps. The recipes and the ingredients are linked to each other in the database. The recipe is made of smaller building blocks (the ingredients). The ingredients' data contains detailed information about the nutritional contents: calories, fat (saturated, trans), sodium, proteins and so on. Also the amount of minerals and vitamins is stored for each ingredient.

Using the tags, the agent can easily perform a selection of recipes based and display these. In this selection the agent takes into account the preferences (e.g.: vegetarianism or lactose intolerance) and the ingredients eaten during the previous day. The agent tries to vary the ingredients in such a way that it creates a healthy diet. So, it won't repeat the same meat or pasta products each day.

When the user asks the agent to specify a list of dinner suggestions, the same procedure is repeated. The agent gives a score for each recipe which indicates how well it would fit the current diet and taking account the dinners of the previous days again.

The agent can also create a total sum of calories based on the ingredients of earlier meals which the user consumed during the day. Taking this into account, and also the recommended daily allowance (RDA) for various minerals and vitamins, the agent can combine products to create a selection of ingredients, which can be looked up in the recipe database. The better the recipe/ingredient match, the higher the score.

The user can also input a number of ingredients and ask the agent to come up with suggestions that contain (most of) these ingredients. This function allows already available ingredients at home to be integrated in the advice of the agent.

AVATAR

Using a virtual graphical character in a virtual environment is a common way to represent a user. A recent example is the "Mii" from Nintendo's Wii video game console (figure 2). An avatar is often considered a representation of the user but they are also closely related to believable agents, chat bots and intelligent virtual agents [12]. In our situation the coach is represented by a virtual character that is customizable by the user. Some factors of the avatar are handled automatically by the profile of the user like height and weight. Using these variables the BMI of the user can easily be calculated. Since our avatar needs to be able to convince the user to change the personal lifestyle as advised the avatar needs to be able to express levels as trust, as defined by Gabarro [16]:

- Trust of Character: This base includes the character traits that an individual may have and display to the outside world.
- Trust of Competence: This base includes functional skills and interpersonal and business sense.
- Trust of Judgment: Trust in the ability of the other to make good judgments in work and behavior.

The visual aspect of avatars has also been studied in various studies. According to Kang [19] and Garau [17] more realistic avatars are considered to increase the quality of communication and the perceived effects between appearance and behavior.

Gender difference does not really matter for the quality of communication and perceived behavior of the communication partner [19], yet we will allow the user to choose an avatar with a specific gender. [19] indicates that communication with photo realistic avatars is more suitable for social communication when it comes to communication between two human beings.

Figure 3: Nintendo Wii character [2]

It is very common for games to contain non photo realistic avatars and therefore we use a non-photo realistic avatar and use a more cartoonlike representation of the avatar, to ease the customization of the avatar. In non-real-time two-way communication (like human-computer) the difference between the realistic and non-realistic is smaller than in two way communication [13].

Our avatar would support communication by just text, but also by speech (using text to speech software) which means that the user does not necessarily need to pay attention to the mobile device while doing something else. Audio could also increase the experienced social functionality of the avatar [19]. Our avatar looks similar to a Nintendo Wii character (cartoon like, but clearly recognizable as a human character). Our customization system allows the user to change the following properties of the avatar to be altered: hair type and color, eyebrow size and color, eye color and type, nose, mouth, skin color, and clothing color and the size of the body.

What is shown of the avatar depends on the chosen menu. Menu's that have to display a lot of information have just the head of the avatar visible. In other menu's (like the preferences menu) a complete avatar is visible and explains to the user what each option means. Although the display resolutions of mobile devices continues to increase, the common smartphone resolutions are around the 640x480 or 800x600 range which is still limited.

The avatar's function is to be a friendly personal interface to the FoodCoach, instead of an application which is only a large collection of various screens filled text and numbers. It is the embodiment of the agent, as it mediates between the computer and the human user [5]. This avatar presents the generated suggestions and advice as his' or hers' by using speech bubbles and optionally a text to speech interface. This text to speech interface is particularly useful during the preparation of a meal: The avatar can speak the instructions, and the user can meanwhile perform these instructions. The user has the ability to start, pause, stop and continue at will at each step.

Figure 4: Recipe selection menu

FOOD DIARY

The FoodCoach wants to know the diet of the user. Therefore, the user has to input every day all the food and drinks that they have consumed; i.e. fill in a food diary using the FoodCoach. With the information that the coach gains it can create an adaptive menu.

A food diary gives a clear overview over the user's feeding habits [9]. But the need to fill in a food diary has a high feeling of intrusion on the user. Only highly motivated users will fill in the diary every day.

People with low motivation will not easily change health beliefs [21]. Therefore they most likely won't fill in the food diary. For this group of users there's the possibility to turn off the interaction with the coach. The coach then only gives healthy menus without adapting these to the user. The results of this functionality are expected to be less positive, but the system is less intrusive this way.

To make sure the motivation of highly motivated users remains high, the coach uses motivation techniques.

MOTIVATIONAL CUES

It's important that people want to use the FoodCoach and keep using the FoodCoach. Therefore users need to be motivated to eat healthy. To increase motivation with its users, the application needs to use motivational techniques.

To define these techniques we use the ARCS model [20]. This model states that motivation is defined by four dimensions; Attention, Relevance, Confidence and Satisfaction. For every dimension there are a couple of measures that the coach manages to keep the user's spirit high.

Attention:
The FoodCoach analyzes the frequency of use. In general, the coach should be used at least once a day. If the user hasn't used the application for a day, the application gives a message with a reminder to give in their consumption. Furthermore the application contacts the user every week with an overview of their eating behavior.

Relevance:
To make sure that users see the relevance of eating healthy, the FoodCoach confronts them with the consequences their feeding habits. If a user eats unhealthy for two days in a row, the FoodCoach confronts them with a message with the consequences of eating unhealthy. If the user manages to eat healthy the coach gives them a compliment and lets them see the importance of healthy food.

Confidence:
When users start the application for the first time, their confidence will be low. Therefore, the application guides the user through the first instructions. By this approach, the user should gain some confidence.

Satisfaction:
People will only use the application if they are satisfied with the process and the results. An important factor in food is taste. People won't be motivated by the application if they only get suggestions for unappetizing dishes. To make sure that users get suggestions for tasty dishes, the system composes a personal profile of taste for every user and adapts the advices to these profiles.

Autonomy, Mastery and Purpose
According the ideas of Pink [28] people will be more motivated when they have the chance to profile themselves in terms of autonomy, mastery and purpose. The FoodCoach gives the user the opportunity to achieve this, by allowing them to add their own recipes to the database.

TYPICAL DAY WITH THE COACH

Assuming that our user would have already configured the coach with their preferences, we describe a typical scenario with our coach.

When our user wakes up, they would eat breakfast. The coach suggests a low-carb cereal breakfast, but the user decides to fry an egg. The user inputs the data of his breakfast into the coach after the coach asked for it. The coach determines the nutrition value using the database. Then the coach cancels the cookie that the user would have gotten at 10 A.M. because they got too many calories at breakfast.

As the day progresses, the coach starts to give feedback at common times for eating. It gives advice about the amount of calories eaten and how often the user has eaten something. At the end of the day the user is wondering what he or she should have for dinner. The user would like to get a few recipe suggestions and enters some ingredients upon which the coach finds recipes for, of course matching the amount of calories which the user can still take during the day. The user chooses the tastiest dinner and cooks it. The following days the user gets different recipes.

Daily data is stored while using the FoodCoach. Using this data the FoodCoach can try to continue to improve its daily advice based upon historic data.

POSSIBLE EVALUATION METHODS

To confirm whether or not the FoodCoach actually works, we would suggest performing an experimental study. In this study there would be four groups of participants:

- A group which has a healthy lifestyle and does not use the FoodCoach nor a traditional method
- A group which has a healthy lifestyle and uses the FoodCoach
- A group which has a healthy lifestyle and uses a traditional method
- A group which has an unhealthy lifestyle and does not use the FoodCoach nor a traditional method
- A group which has an unhealthy lifestyle and uses the FoodCoach
- A group which has an unhealthy lifestyle and uses a traditional method

These groups would use the FoodCoach for a given period. Before and after this period their diet should be measured with a survey. During the experiment, variables like weight, fat percentage and user experience. After the specified experimentation period the acquired data can be used to determine whether the FoodCoach does have a positive effect or not in comparison to both the control groups (not using the FoodCoach) and between the two lifestyles (healthy, unhealthy).

DISCUSSION & FUTURE WORK

In this paper we have presented the basics for an intelligent user interface that assists its user in attaining and maintaining a healthy diet. Although we fully believe that our FoodCoach will work, we have not done any research yet to support this believe. In order to be able to do that research properly a fully functional prototype will first have to be constructed.

The main challenge for the FoodCoach is to keep the motivation of its users high enough, so that they will keep using it. In an ideal world, the user's behavior would be changed to stick to the healthy diet by themselves without the need for the FoodCoach to motivate them. In this case the FoodCoach could still be used as a cookbook, supplying the user with new recipes once in a while.

Should this be turned into a marketable product, then the challenge for the company running it will be to keep their databases of recipes, ingredients and products up to date. After a strong position in the market is acquired, this could be done for example in cooperation with the producers of foodstuffs, the publishers of regular cookbooks or the "Voedsel en Waren Autoriteit". A different option would to create an active and involved userbase, which contributes by keeping the databases up to date.

To improve results the FoodCoach could be integrated with a smarthome once these become more main stream. When that happens, the system will interact with sensors in the smarthome to ascertain if you are preparing a meal [26][27], so that appropriate actions can be taken. This could for example consist of changing the lighting conditions to less distracting, cooler colors at normal brightness.

Another possibility would be that the system monitors your food stocks and either orders new ingredients that are needed for the upcoming recipes directly online or gives you a shopping list, depending on user preferences.

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