A Case Study Building a Web-Based Dietitian Expert System

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Abstract

This paper presents a method of using open source tools to create a TeleHealth system. The system works by providing recommendations to the patient on completion of a simple auto-reporting questionnaire. A comparison is given between this system and similar systems. Also, a description of how the system was built shows how a complex web based expert system can be easily constructed using Drools Execution Server. Finally screenshots of the final system in action were provided to show the final product.

Keywords

TeleHealth, Rule Based System, Expert System, Diet, Nutrition, Exercise, Health, Diet Assessment, Drools, Tohu,

1 Introduction

This paper presents an open source behavior monitoring and modification system in which patients can self-report their measurements and receive personalized diet and exercise feedback. TeleHealth systems are an emerging method of delivering health services to patients using telecommunications (e.g. chat, web based expert systems, video) and surprisingly, TeleHealth systems have been shown to perform quite well [1]. In the Journal of the American Medical Association, researchers at the Weight Control and Diabetes Research Center at Brown Medical School reported that a system in which patients submitted a weekly weight loss diary via email lost significantly more weight than those only given weight loss information [2]. Further results from studies published by Haugen HA, Tran ZV, Wyatt HR, Barry MJ, Hill JO [3] and Digenio AG, Mancuso JP, Gerber RA, Dvorak RV [1] validate that TeleHealth systems are valuable and effective tools for a population.

According to the Center for Disease Control, American society has become characterized by environments that promote increased food intake, non-healthy foods, and physical inactivity [5]. With alarming reports from the Journal of the American Medical Association (JAMA), 72% of American Men and 64% of American Women are Overweight or Obese [5]. Furthermore, for American Men, this figure is increasing as time goes on. These figures will have a huge economic impact as the population ages and starts to see the negative impact of this lifestyle. Research has shown that persons whose weight approaches levels classified as “overweight” and “obese,” the risks of diabetes, heart disease, cancer, and stroke also increase [6].

This system leverages the internet to bring quick dietitian consultations to a large population. The software performs a virtual consultation with the user by mimicking a consultation with a dietitian by asking the user a series of questions related to their lifestyle and habits. After the consultation, the user is given a customized list of practices they should try to incorporate into their lifestyle to achieve and maintain a healthy weight.

2 Related Works

2.1 Background Software and Tools

The eDietitian system in built using the Tohu [7] framework of classes for constructing the question-and-answer tree. Tohu is in turn built using Drools [8], a Java based Rules Engine.

2.2 Related Systems

One of the model systems that eDietitian was modeled after was WebMD's "Personal Diet Evaluator" [9]. The Personal Diet Evaluator's approach is a little different from eDietitian's but they share a similar questions-and-answer format.

Another system which bares a resemblance to eDietitian is the "Mozambican Diet Assessment Tool" [10]. The system was developed by the Mozambican Ministry of Health as a quick way to measure the diet of rural and urban communities. Donald Rose et al describes how the system works as follows:

> "The Mozambican Diet Assessment Tool (MDAT) is based on a simple, qualitative 24-hour recall of household food intake. The person in charge of food preparation in each household is asked to recall all foods eaten by household members at each meal and snack time in the previous 24 hours. Field personnel, usually the provincial nutritionists, then assign points to each food consumed, using a simple scoring system."

eDietitian is different from the Mozambican Diet Assessment Tool because it takes a different route during the evaluation by inquiring about exercise and BMI rather than strictly measuring the amount of nutrients consumed. The goal of MDAT is different from eDietitian's, which is mostly the reinforcement of a health lifestyle rather than nutrient assessment.

Denning et al developed BALANCE, a start phone application which measures caloric expenditure using sensor and activity sensing technology [11]. Their system can predict how much time a person has spent sitting, walking, jogging, or cycling each day and can recommend serving size to the patient to keep their caloric intake in balance with the expenditures.

3 eDietitian Design and Architecture

3.1 Knowledge Base

The knowledge base for the system was built using a rules based approach. The final system contained approximately 80 rules. Rules came from numerous sources, but the main sources for rules are US Government websites such as PubMed Health from the U.S. National Library of Medicine [12], the "Dietary Guidelines for Americans" published by the US Department of Agriculture [13], and the Center for Disease Control Obesity and Overweight website [14].

3.2 Architecture

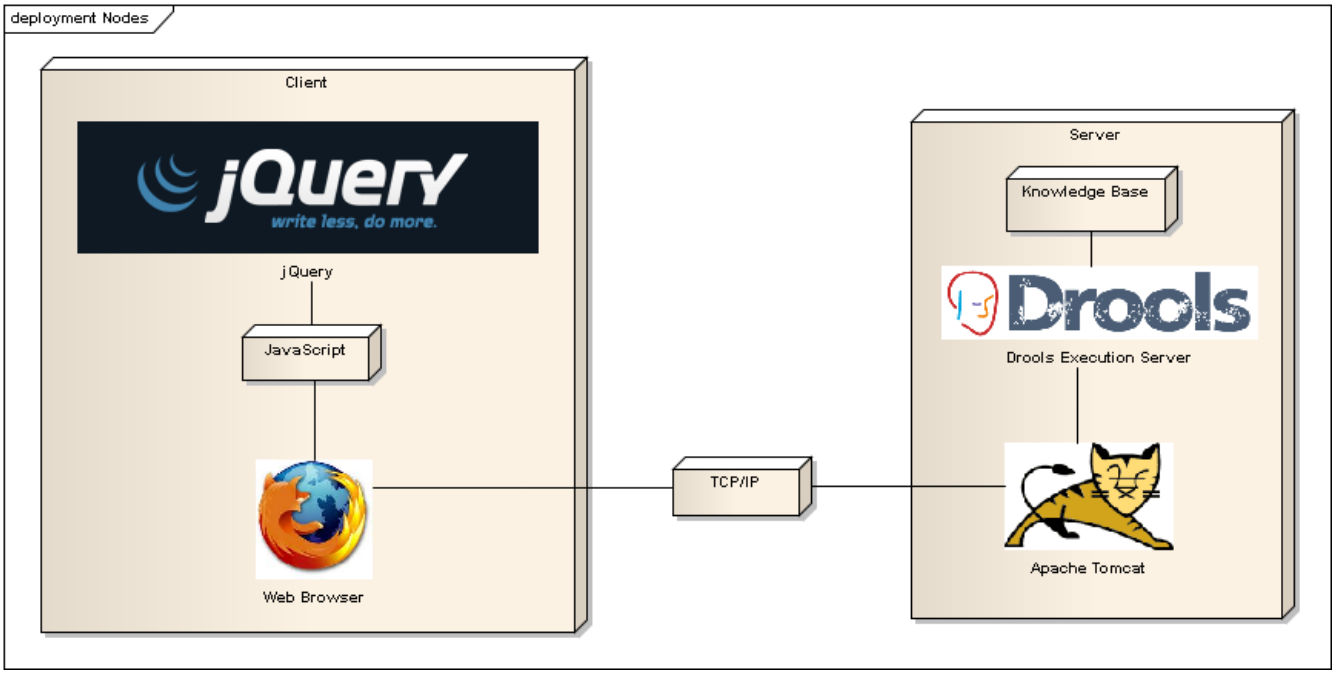


Illustration 1: The Client-Server setup used in the eDietitian system.

Server-Side

The server-side of the system runs a Java Virtual Machine instance. Inside the JVM a servlet container servers the normal web files (jsp, css, js), but also runs a RESTful web-service called Drools Execution Server, which provides an XML interface to Drools that accepts knowledge based commands from the outside world.

Client-Side

The client-side of the system could really be any program that knows the XML language used by Drools Execution Server. However, this project made use of the Tohu's jQuery library. The Tohu library provides a JavaScript framework which can dynamically create the HTML forms based on the responses given from the Server-Side. The JavaScript libraries use the popular jQuery library to create the forms.

As a side effect of having this run as a web application is how easily the UI can be easily changed with CSS. The view can quite easily be modified using CSS with zero modifications to the rules or logic classes.

3.3 Rule Workflow

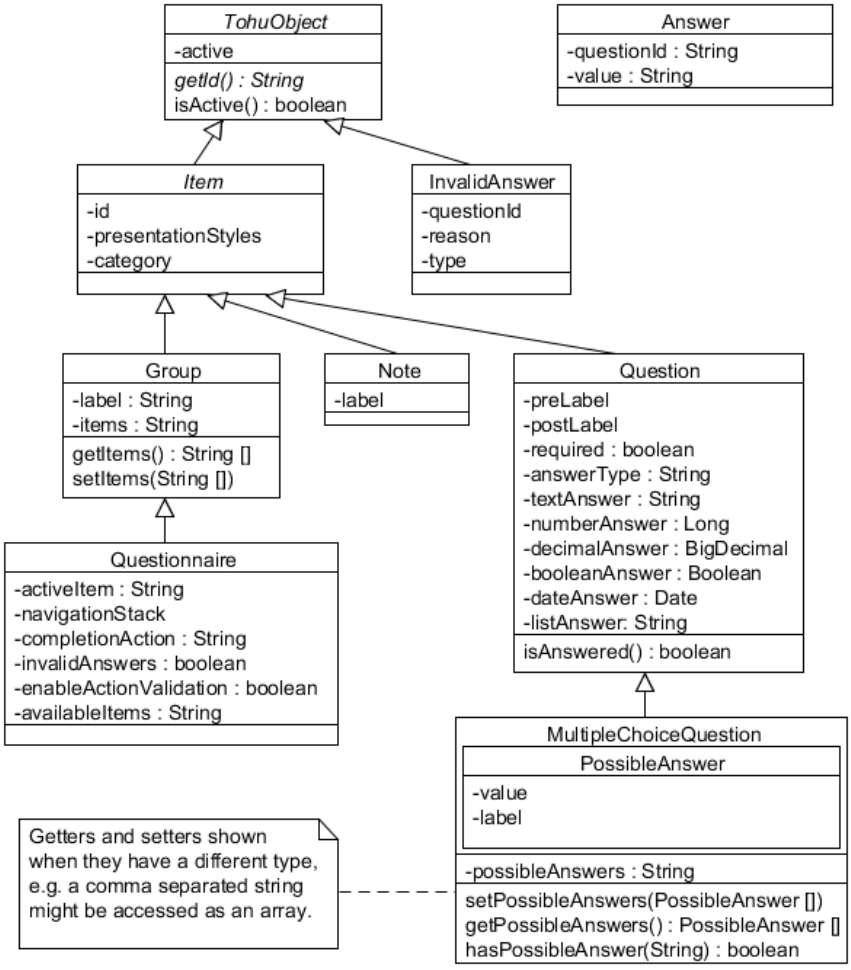


Illustration 2: Class Diagram of the Tohu classes used to write rules. Source: http://community.jboss.org/wiki/Tohu-HowItWorks

The Java classes from Illustration 2 are used to code the questionnaire workflow. An example is called for to demonstrate this. Suppose we want to ask the user whether they exercise or not and provide a recommendation if they answer "no" to the question. Using the Tohu classes to code the rule into the knowledge-base, we create a rule that inserts the Question object into the knowledge-base as follows:

```
rule "ask if user exercises"
dialect "mvel"
then
        Question question = new Question("exercise");
        question.setAnswerType(Question.TYPE_BOOLEAN);
        question.setPreLabel("Do you exercise?");
        question.setPresentationStyles({"radio"});
        insertLogical(question);
        . . .  // cut off
end
```

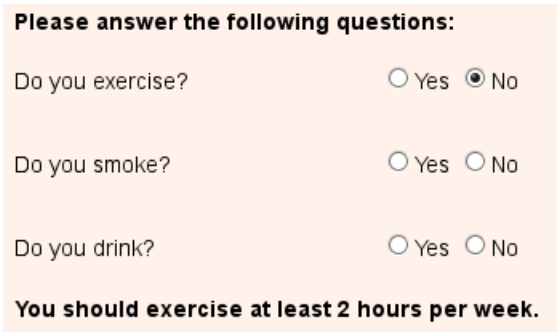


Illustration 3: How the final form looks in the web browser.

Once the Question objects are in the knowledge-base, and some event changes their state (such as an Answer object being inserted into the knowledge-base), other rules that have them as an antecedent will fire which we can use to add yet more questions, facts, or recommendations into the knowledge-base.

```
rule "everyone should get at least 2 hours of exercise per week"
dialect "mvel"
when
	Question(id == "exercise", answer == false);
then
	insertLogical(
		new Note(
			"exerciseNote",
			"You should exercise at least 2 hours per week."
		)
	);
	insertLogical(
		new ExerciseRecommendation(
			"needToStartExercising",                  // recommendation id
			Priority.HIGH,                            // priority
			"You should start an exercise regiment.", // text to show
			new Source(                               // link to source
				"http://www.cdc.gov/physicalactivity/everyone/guidelines/adults.html",
				"Physical Activity for Everyone: Guidelines: Adults"
			)
		)
	);
end
```

4 User Interface

The following section shows screen-shots of the eDietitian system through various stages of the questionnaire session.

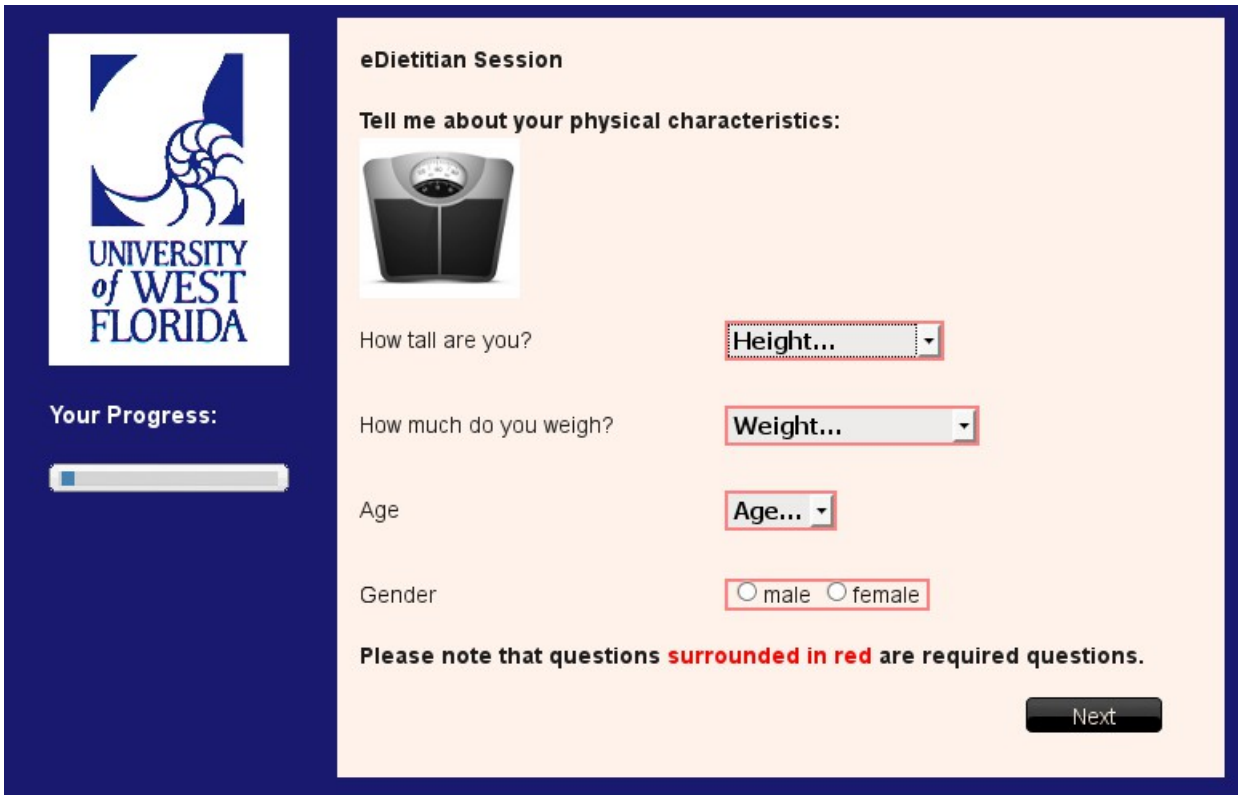
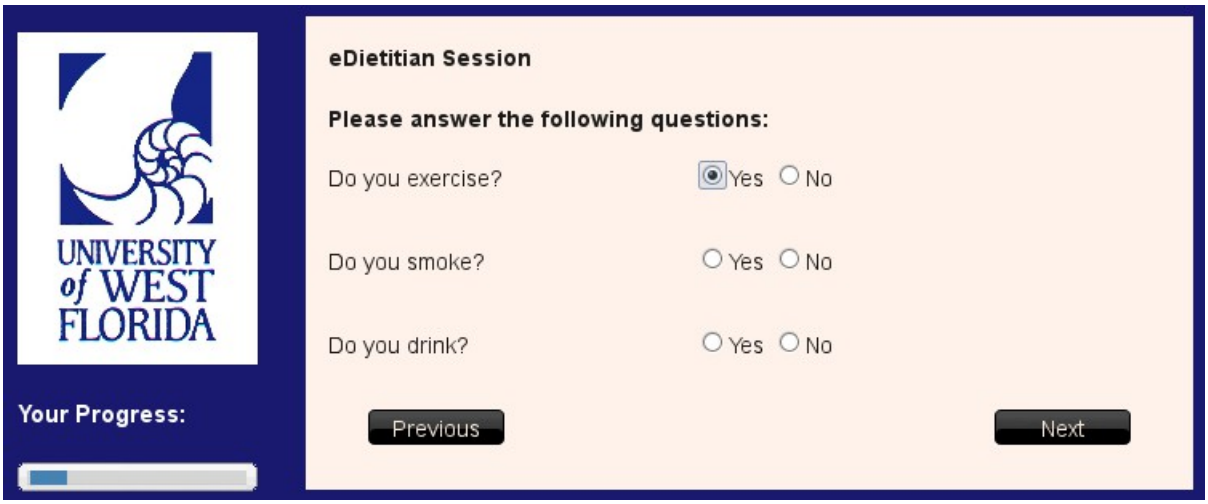


Illustration 4: The beginning screen of the system gathers some starting information from the user.

Once the user starts the questionnaire they are asked from basic starting information which is used to determine the user's BMI, BMR, and weight type (underweight, normal, overweight, obese).



Next the user is presented with questions which gather information on some high risk questions concerning exercise, tobacco use, and alcohol use.

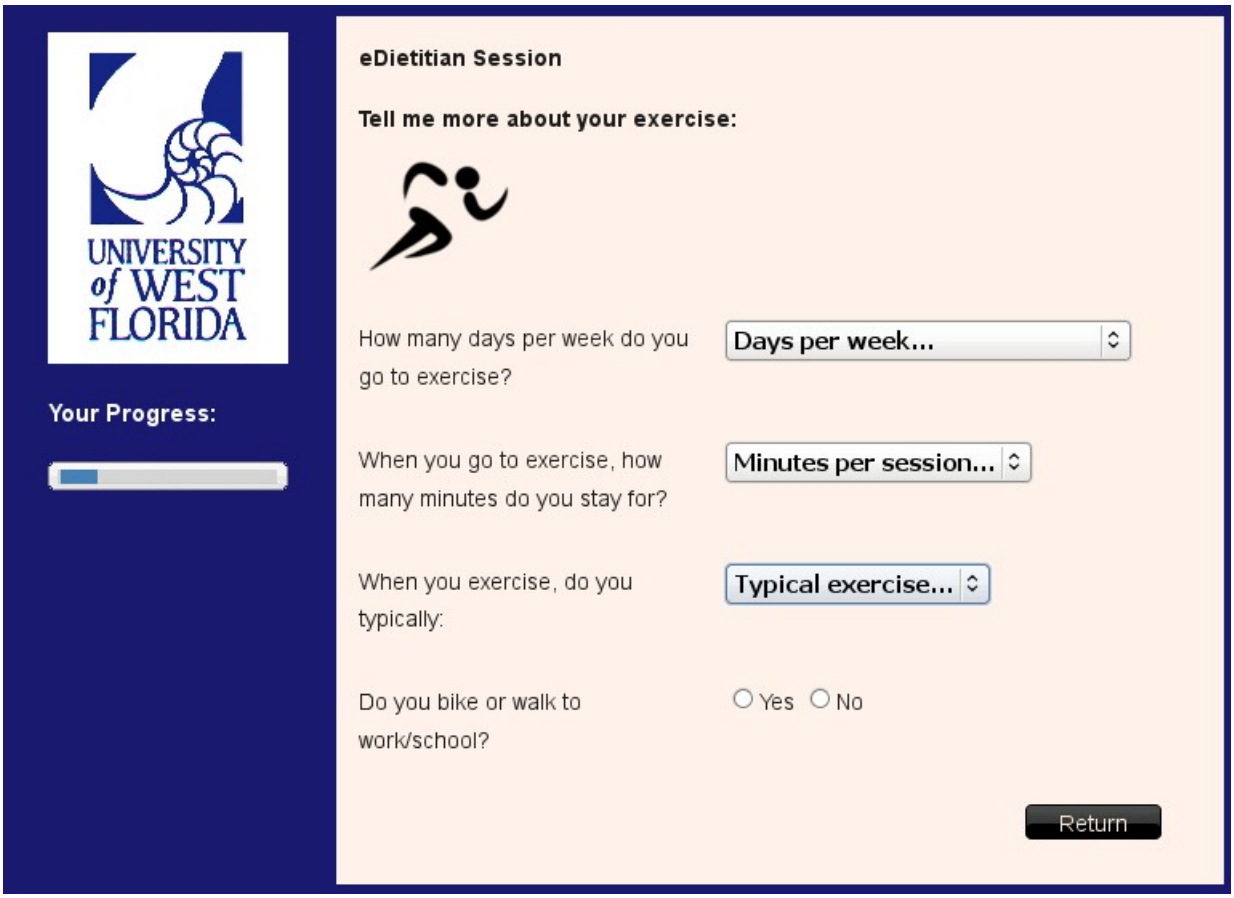


Illustration 5: Gathering information about the user's exercise output.

From here the screens diverge depending on whether they answered “yes” or “no” to the previous questions.

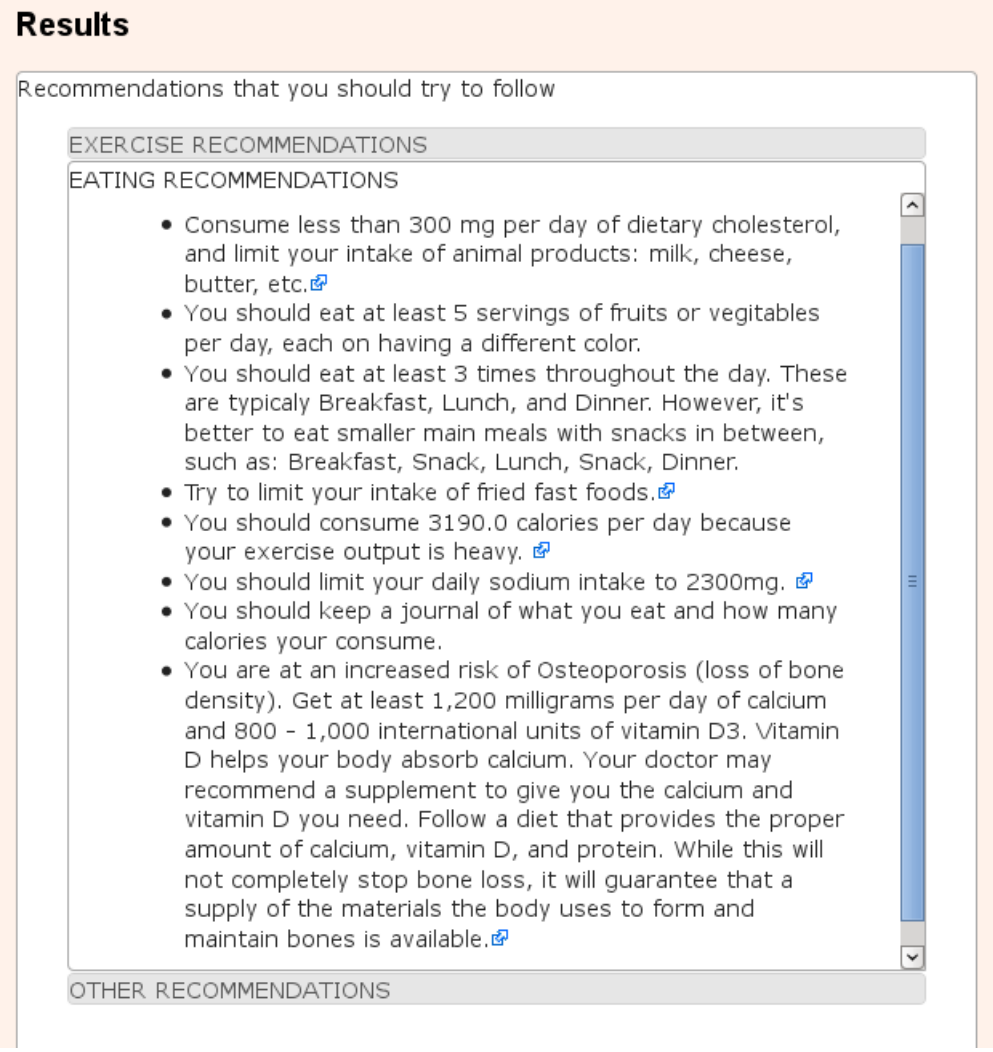


Illustration 6: Results screen of the eDietitian system. Recommendations are placed in to three categories: Exercise, Eating, and Other.

The final screen of the system shows the results of the questionnaire, the user's exercise, eating and any other recommendations are displayed in a jQuery “accordion” widget.

5 Review and Quality Assurance (review given by nutritionist)

Like most expert systems, opinions can differ on what should be encoded in the rules. Whoever reviews the system will most likely have a criticism of some aspect of it. For the review and quality assurance of the system, a licensed dietitian was contracted to review the system. The review sessions were held as sit-down sessions every couple of weeks in which the developer and expert would go through the system screen-by-screen and inspect the wording, flow, and correctness of the system.

During these sessions, the developer would make a deficiency list, in which items where added to the list that needed to be corrected. After the review the deficiency list was worked through and the bugs were fixed. Reviews were performed four times.

6 Conclusion and Future Work

This paper presented a method using open source tools to create a TeleHealth system. The system works by providing recommendations to the patient on completion of a simple auto-reporting questionnaire. A comparison was given between this system and similar previous systems. A description of how the system was built shows how complex web based expert system can be easily constructed using Drools Execution Server. Finally screenshots of the final system in action were provided to show off the final product.

In the future, it would be nice to extend the Tohu project to be able to display video and selections based on pictures. By making these upgrades, it would make the questionnaire more entertaining to the user. More work could be put into refining the user interface by adding useful pictures and video content that explains conditions clearly.

This software is by no means finished and could still be worked on to go into more depth on other areas. It is this author's hope that others can extend this system to include more rules or incorporate this system into another system.

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