Creating a Framework for Testing Wellness Visualization Systems

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***Abstract*—This paper presents a methodology for creating a framework to test wellness visualization systems. The methodology is applied to our research on an agent-based wellness visualization system to create a framework for testing the wellness visualization systems we created in our research. The proposed framework employs both technical-oriented and user-oriented testing tools and methods in the measurement. A comprehensive testing plan is also provided.**

Keywords-system testing; testing methodology; wellness visualization system; information visualization

I. INTRODUCTION

An agent-based wellness visualization system has been previously proposed in [1-2] as an alternative solution to help an individual to learn, to monitor, and consequently to promote a personal state of wellbeing; it also designed to support a caregiver's tasks. An operational wellness model was then created as a basis for developing a wellness visualization system [2]. The operational wellness model designed for the agent-based wellness visualization system has been presented and peer reviewed in [2]. In order to ensure that the agent-based wellness visualization system meets all of the research goals, is usable, and can be compared to other published results; an effective evaluation method is required.

Since a wellness visualization system is constructed from the knowledge of various fields, employing techniques in software testing alone is not sufficient. Software testing can verify that the software system works as expected and can provide benchmarking results in term of software quality [6], but it cannot evaluate a wellness visualization system in term of usefulness, impression, satisfaction, etc. E-health system evaluation criteria are also available to employ, e.g. [8-9], but they do not specifically focus on the main objectives and goals of a wellness visualization system. Thus, it is important to find a testing method that covers all possible areas of wellness visualization system, can be repeated, and its results are comparable.

In this research, the methodology for creating a framework for testing wellness visualization systems derives from the Goal-Question-Metric (GQM) approach [6-7]. The framework in this research is developed by combining the testing tools and methods used in software testing, usability testing, and techniques for finding an impact on a user's impression toward the system together. As a result, a wellness visualization system can be measured from different aspects. It is also possible to compare different wellness visualization systems adopting this framework.

This paper is organized as follows. Section II describes the methodology for creating the framework. Framework creation and a comprehensive testing plan are given in Section III. Conclusion and future work are given in the last section.

II. METHODOLOGY

A. What should be measured?

In order to list what is needed to be measured, the definition and the generic goals of wellness visualization systems have to be identified.

A wellness visualization system is a software system and an information visualization system that can communicate wellness information by employing graphical presentations. Information visualization is the use of computer-support, interactive, and visual presentations of abstract data to amplify cognition; where cognition is the acquisition or use of knowledge [3].

Based on the definition, it is obvious that the quality of the software product is to be measured to ensure that the software system works as expected and meets technical requirements. Moreover, the main functionality of a wellness visualization system is to communicate wellness information that can promote cognition. In order to ensure that the system can present key information effectively, the visual presentations must be usable. They should create a good impression and should not engender frustration. Thus, usability testing is required. Both desirable and undesirable effects caused by a wellness visualization system also have to be identified.

Software testing involves the verification and validation of a software system and of the functionalities provided by the system [6]. In case of usability testing, a wellness visualization system is usable when it is useful, efficient, effective, satisfying, learnable, and accessible [4]. Also, it should be easy to use to eliminate frustration and even create a positive impression on users. In summary, the aspects that should be tested are *system verification, system validation, verification of system's functionalities, validation of system's functionalities, usability of the*

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Graphical User Interface (GUI) and graphical presentations, accessibility, and impression.

The aspects given above are created for the general definition and generic goals of a wellness visualization system. More aspects can be added to measure additional properties and goals of a particular wellness visualization system.

B. Procedure

When measuring something, a goal is needed as a reference point of achievement and also a reference point for failure. Thus, testing goals must be set up before a testing session is started. Testing goals should be linked to research goals because research goals represent what the research is trying to achieve.

The following steps are the main activities of this framework:

Step 1 – Clarify research goals and link the goals to the testing aspects
Step 2 – Form testing goals regarding the research goals and the aspects
Step 3 – Select testing tools/methods for each testing goal
Step 4 – Set up a testing plan
Step 5 – Conduct a test as planned

C. Testing Tools/Methods

A variety of tools and methods can be employed to test a wellness visualization system because they are constructed for different purposes. Since a wellness visualization system involves both technical requirements and users' requirements, testing tools and methods from both sides should be employed.

As a result, the testing tools and methods used in this framework can be divided into two categories: technical-oriented and user-oriented testing tools/methods. Technical-oriented testing tools/methods focus on benchmarking and technical requirements, for example, error rate and start-up time. User-oriented testing tools/methods focus on subjective data such as feeling, impression, and satisfaction of a user toward a wellness visualization system.

III. FRAMEWORK CREATION

This section uses our research on the agent-based wellness visualization system as an example of how to employ the framework to test a wellness visualization system.

A. Research Questions

A state of wellbeing is definitely desirable at both personal and the public levels [1-2]. Many efforts are required to achieve the desirable wellness level [1-2]. Our research intends to assist a person to have the best possible state of physical wellbeing by employing existing technologies and electronic resources [1-2]. All research questions are listed as follows:

- How can we communicate wellness information to persons who do not have any specific level of medical knowledge, by using existing technologies and electronic resources?
- How can we assist people in having a better understanding of their wellness status based on the information from electronic resources?
- How can we assist people to keep track of their state of well-being and consequently improve their personal wellness status?
- While assisting someone, how can we assist the tasks of that person's caregiver?

B. Research Hypothesis

After analyzing the research questions, our research hypothesis is formed as follows:

"An information visualization system containing appropriate graphical presentations for wellness information and supporting tools can answer all of the research questions given above."

C. Research Goals

1. To develop an agent-based wellness visualization system that can support both general users and healthcare professional users.
2. To develop an information visualization system containing appropriate graphical presentations that can communicate wellness information effectively to both general and healthcare professional users.
3. To develop an information visualization system that can assist an individual to track on his/her wellness status and encourage the person to improve the state of wellbeing.
4. To develop an information visualization system that can support a caregiver's tasks.
5. To develop an information visualization system that has simplicity, understandability, expandability, and modularity characteristics.

D. Testing Goals

One research goal involves with one or more testing aspects. One testing aspect can form more than one testing goals; this depends on a number of sub-goals (regarding the testing aspect) lies within each research goal.

If a testing goal is derived from a users' requirement, then a relevant user-oriented testing tool/method is selected. On the other hand, if a testing goal is relevant to a technical requirement, then a technical-oriented testing tool/method is employed. More details about each testing tool/method will be described in the next subsection.

Table I presents the testing goals as well as the relationships among research goals, testing aspects, testing goals, and testing tools/methods. The highlighted testing goals are relevant to the users' requirements and the un-highlighted testing goals are relative to the technical requirements. The highlighted testing tools/methods are in

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the user-oriented testing tools/methods category and the un-highlighted testing tools/methods are in the technical-oriented category.

E. Testing Tools/Mehods Description

The followings are the description of each testing tool/method presented in Table I.

1) Questionnaire: a data collection tool that can collect subjective data and get opinions from the participants [4]. In this research, two different sets of questionnaires will be used. One is created for a general user. Another one is created for a healthcare professional user. During a testing session, all activities will be recorded in video, audio, or both formats if the permission from a participant is granted. A participant might be contacted after the testing session is over for an interview or to clarify the information that is filled in the questionnaire.

2) Error rate: a number of errors each participant encounters during a task divided by time spent on the task (in minute). The average error rate will be compared to the acceptable error rate from literature. The description of each error will also be collected for future improvement.

3) Unit testing: is performed during the implementation phase of the research to verify that each unit of the system works correctly as expected. The results of each unit of the visualization system are evaluated against the design and research goals.

4) Integration testing: is performed regularly to confirm that a group of software units works correctly as designed.

5) Comparative method: compares the results generated by two or more activities against each other. In this case, the comparative method is performed differently regarding the testing goals and the types of users. The three different comparative approaches presented in Table I are:

Comparative method (1) – the results generated by the wellness visualization system will be compared with reliable external sources to confirm their validity.

Comparative method (2) – a raw data set and a set of questions will be given to a general user to answer. Then, the participant will be asked to use the wellness visualization system to answer the same set of questions. The results from both set of answers will be compared.

Comparative method (3) – healthcare professional users will be divided into two groups. The first group will receive a raw dataset and a set of questions. The time the first group spent on answering the questions will be recorded. The second group will use the wellness visualization system to answer the same set of questions. The time the second group spent on answering the questions is also recorded. Both the recorded time and the answers produced by the two groups of participants will be compared.

6) Exploratory study: is created to find the "unknown"; in this case, the unknown is an impression on the wellness visualization system. It can be both desirable and undesirable effects left on a user after using the system. Examples of the effects in questions are "Does the wellness visualization system make you feel like learning more about your personal state of well-being and how to improve it?" and "Does the wellness visualization system make you feel stress or too worried about your wellness status when you see the overall wellness level moved down?". An exploratory study is performed by employing a questionnaire and conducting an interview.

7) Peer review: gets opinions and acceptance from experts in the field.

8) System Architecture Analysis: employs the structure, characteristics, and properties of the system as a proof against the testing goals.

F. Testing Plan

The testing process in this research is divided into three phases: preparation phase, testing sessions, and analysis phase. The activities in the test process will be performed according to the recommendation in [4-5].

In the preparation phase, all materials needed, e.g., questionnaires and orientation scripts, will be prepared. A number of volunteers will be recruited, categorized by user type, and divided into groups of 3-4 people, as this is an appropriate number of participants per testing session [5]. The subsequent activities are making appointments with every group and setting up the testing environment.

During each testing session, an introduction and a set of guidelines will be presented to the participants [4-5]. Some background information will be collected, followed by testing tasks. Making observations and note taking during the phase is a must [4-5]. A checklist will be employed before closing each testing session to ensure that everything is covered [4-5].

In the last phase, the collected data must be compiled, summarized, and analyzed [4-5]. Then, the results will be employed to create a testing report, and the conclusion and future plan of this research.

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TABLE I. RELATIONSHIPS AMONG RESEARCH GOALS, TESTING ASPECTS, TESTING GOALS, AND TESTING TOOLS/METHODS

Research Goals No. [a]	Aspects of	Testing Goals [b]	Testing Tools and Methods [c]
1	System Verification	1. To verify that the functionalities provided by the wellness visualization system meet the expectation and needs of both types of users 2. To verify that the functionalities provided by the wellness visualization system work correctly and effectively from the users' viewpoints	Questionnaire
		3. To verify that the functionalities provided by the wellness visualization system work correctly and effectively as planned and designed	Error rate
			Unit testing
			Integration testing
	System Validation	1. To confirm that the agent-based wellness visualization system is satisfying and delightful to use 2. To confirm that the functionalities and information provided by the visualization system can support both types of users	Questionnaire
		3. To confirm that the information provided the wellness visualization system is valid	Comparative method (1)
	Impression	To find both desirable and undesirable effects on users, e.g., impression and stressful	Exploratory study
			Questionnaire
2	Usability of the GUI [d]	To verify that the wellness visualization system is usable in term of usefulness, efficiency, effectiveness, learn-ability, satisfaction [4], and ease of use/simplicity	Questionnaire
	Usability of the Operational Wellness Model	1. To verify that the model is acceptable to be used by the experts in the field	Peer review
		2. The results produced by the model are easy to understand	Questionnaire/Comparative method (1)
		To verify that: 1. the model has the ability to produce the wellness status of a person 2. the model is computable 3. the results produced by the model can be presented in graphical formats	Unit testing
	Accessibility [e]	1. To verify that a user has the ability to access to the visualization system through a desktop within an acceptable time frame 2. To verify that a user has the ability to access to visualization through a mobile device within an acceptable time frame	Questionnaire
	Appropriate graphical presentations (that can communicate wellness information effectively)	1. To confirm that the graphical presentations are easy to understand and simple, i.e. a user can perceive some information correctly without any explanation	Comparative method (2)
			Questionnaire
		2. To confirm that the graphical presentations have the ability to communicate certain information	Questionnaire
		3. Learn-ability, i.e. a user can perceive more information or have an insight after a period of training/using the system	Questionnaire
3	Verification of the following functionalities: - Viewing current wellness information - Viewing history information - Finding alerts with relevant description, suggestion, and links to external sources - Exploring more about personal wellness status by employing analytical tools provided by the visualization system - Recording and reporting short complaints to authorized caregivers	1. To verify that each functionality meets the expectation and needs of a general user 2. To verify that each functionality works correctly and effectively from the general user's point of view	Questionnaire
		3. To verify that the each functionality work correctly and effectively as planned and designed	Error rate
			Unit testing

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	- Creating personal indicators - Choosing viewing mode, i.e. regular and advance modes - Performing general setting		Integration testing
	Validation of the following functionalities: - Viewing current wellness information - Viewing history information - Finding alerts with relevant description, suggestion, and links to external sources - Exploring more about personal wellness status by employing analytical tools provided by the visualization system - Recording and reporting short complaints to authorized caregivers - Creating personal indicators - Choosing viewing mode, i.e. regular and advance modes - Performing general setting	1. To verify that each functionality is satisfying and delightful to use by a general user	Questionnaire
		2. To confirm that the results generated by each function is valid	Comparative method (1)
	Impression	1. To verify that the visualization system can encourage a person to be more aware about his/her wellness status and that of the public 2. To verify that a person feels more confidence in realizing and learning about his/her own state of wellbeing from the visualization than from raw data and other sources, e.g., internet and pamphlets	Questionnaire
4	Verification of the following functionalities: - Viewing current wellness information of each patient under care - Viewing history information of each patient under care - Finding alerts with relevant description, suggestion, and links to external sources generated for each patient under care - Performing further analysis by employing analytical tools provided by the visualization system - Recording and reporting short notes to each patient - Defining indicators for each patient - Setting weight for each indicator for a patient - Performing general setting	1. To verify that each functionality meets the expectation and needs of a healthcare professional user 2. To verify that that each functionality works correctly and effectively from a healthcare professional user's point of view	Questionnaire
		3. To verify that the each functionality works correctly and effectively as planned and designed	Error rate
			Unit testing
			Integration testing
	Validation of the following functionalities: - Viewing current wellness information of each patient under care - Viewing history information of each patient under care - Finding alerts with relevant description, suggestion, and links to external sources generated for each patient under care - Performing further analysis by employing analytical tools provided by the visualization system - Recording and reporting short notes to each patient - Defining indicators for each patient - Setting weight for each indicator for a patient - Performing general setting	1. To verify that each functionality is satisfying and delightful to use by a healthcare professional user	Questionnaire
		2. To confirm that the results generated by each function is valid	Comparative method (1)
	Supporting a caregiver's tasks	To verify that the wellness visualization system can support a caregiver's tasks	Comparative method (3)
5	Simplicity	To verify that the wellness visualization system has the simplicity characteristic	Questionnaire
	Understandability	To verify that the wellness visualization system has the understandability characteristic	Questionnaire

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	Expandability	To verify that the agent-based wellness visualization system is expandable	System architecture analysis
	Modularity	To verify that the wellness visualization system is modular	System architecture analysis

a. Refer to Section III, C for details.
b. The highlighted sections are relative to the users' requirements and the un-highlighted sections are relative to the technical requirements.
c. The highlighted sections are in the user-oriented category and the un-highlighted sections are in the technical-oriented category.
d. Measuring what makes the GUI usable [4].
e. Measuring the ability to access the agent-based wellness visualization system to accomplish a task, not what makes the system usable for people with a disability [4].

IV. CONCLUSION AND FUTURE WORK

A wellness visualization system is constructed by employing the knowledge from various fields such as wellness, information visualization, software engineering, human-computer interaction (HCI), art, and many other sources. Thus, a methodology for measuring a wellness visualization system in all possible aspects is required to evaluate the performance of the system and to compare it with other wellness visualization systems.

We have presented a methodology for creating a framework for testing wellness visualization systems. The method is applied to our research on the agent-based wellness visualization system to create a framework which forms a reference for testing our wellness visualization system and can be applied to other research in the same area.

Currently, the framework leads us to a comprehensive testing plan. This plan will be expanded further and refined for more details. Then, it will be implemented to measure our agent-based wellness visualization system [1-2].

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