Exercise and Wellness Health Strategy Framework
Software Prototype for Rapid Collection and Storage of Heterogeneous Health Related Data

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Abstract: Unwillingness of many people to assume responsibilities for a personal health, fitness and wellness seems to be widespread. This can be partially remedied by individualized exercise and wellness program that integrates the basic knowledge domains: lifestyle, sports and fitness, and nutrition and personal/environmental health. However, collection, management and analysis of data and metadata related to these domains is demanding and time consuming task. Moreover, the appropriate annotation of raw data is crucial for their next processing. To promote such a program a software infrastructure for collection, storage, management, analysis and interpretation of health related data and metadata has been proposed and part of this infrastructure has been developed and tested outside laboratory conditions. This software prototype allows experimenters to collect various heterogeneous health related data in a highly organized and efficient way. Data are then evaluated and users can view relevant information related to their health and fitness.

1 INTRODUCTION

In the countries of the European Union (EU) deaths due to chronic diseases are projected to increase. It was estimated that out of the projected millions of people who would die by 2015, 64% of them die of a chronic disease – unless urgent action is taken (Tunstall-Pedoe, 2006). Given that both physical inactivity and obesity are strong independent causes and predictors of chronic illness and disability, it has been estimated that they impose a significant economic burden on the health-care system in EU. The most recent research in EU indicates that only 7.5% of children and 15% of adults are physically active for at least 150 minutes per week, while over 18% are obese and over 46% are overweight (Busse, 2010; Organization et al., 2010; Webber et al., 2014).

It is apparent that physical activity is essential in the prevention of chronic disease and premature death (Lee and Skerrett, 2001). Chronic diseases develop over ones lifetime, with clinical symptoms occurring many years after the underlying origins of the disease have occurred. As we move ahead in the 21st century, cardiovascular diseases, i.e. coronary artery disease (CAD) hypertension, stroke, and heart failure, type 2 diabetes, metabolic syndrome, and cancer are the leading killers in westernized society and are increasing dramatically in developing nations. Physical inactivity is a modifiable risk factor for cardiovascular disease and a widening variety of other chronic diseases, including diabetes mellitus, cancer (colon and breast), obesity, hypertension, bone and joint diseases (osteoporosis and osteoarthritis), and depression 1-14 (Taylor et al., 2004; Blair et al., 2001; Shephard, 2001).

The onset of progression of chronic diseases is mediated in the vast majority of cases by an interaction between genetic factors and their interaction with environmental factors. These environmental factors are largely lifestyle factors, namely physical activity and dietary patterns, but also include other influences, such as smoking, alcohol consumption, stress, and hazardous environmental compounds. These factors are modifiable, and, as such, disease manifestations from these factors are largely preventable.

To cope with these modifiable factors exercise and wellness intervention programs have been introduced, mainly in the United, States, Canada and Australia. This paper presents the first steps that have been done

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to introduce such exercise and wellness health strategy framework and related academic program within the European Union. Its attempt is to create professionals who are capable influence self-care practices positively, reinforce healthy habits and prepare responsible citizens for the future. This innovative, applied and unique initiative combines three traditionally exclusive disciplines (Etiology of Chronic Disease, Exercise Science and Behavioral Psychology) into one comprehensive curriculum that addresses two major front page challenges in Europe: chronic disease management and sedentary lifestyle. It is being applied through extensive clinical and fieldwork experiences, the degree will provide students with the theoretical knowledge, practical skills, and prerequisites that are necessary to provide a professional guidance during lifestyle changes.

Such exercise and wellness health strategy framework needs a supportive software infrastructure that besides others promotes collection of health related data and metadata followed by their further annotation, processing and visualization. This paper introduces the first version of such software infrastructure,a software prototype that focuses on definition and automation of the data collection process in order to capture a huge amount of heterogeneous health related data from many users in various environment in a short time. It is assumed that the procedure of data collection has to be as short and user friendly as possible to significantly promote the initial participants' motivation to cope with the most important step, a desired change of participants' behavior leading to their better physical, emotional and mental health.

The paper is organized in the following way. The next section discusses some questions related to chronic illnesses, personal physical, emotional and mental well-being and the necessity of exercise and wellness strategy framework to cope with these matters. The third section introduces a supportive software infrastructure for such a framework. The subsections then present the first version of this software infrastructure from architectural, implementation, deployment and testing points of view. The last section brings concluding remarks and introduces future steps and improvements.

2 EXERCISE AND WELLNESS HEALTH STRATEGY FRAMEWORK

Chronic illness has profound effects on a persons physical, emotional, and mental well-being, which often make it difficult to carry on with daily routines and relationships. Over the past decades, considerable knowledge has accumulated concerning the significance of exercise in the treatment of a number of diseases, including diseases that do not primarily manifest as disorders of the locomotive apparatus. Today, exercise is indicated in the treatment of a large number of additional medical disorders. In the medical world, it is traditional to prescribe the evidence-based treatment known to be the most effective and entailing the fewest side effects or risks. The evidence suggests that an exercise therapy is just as effective as medical treatment in selected cases and even more effective or improving the final effect in special situations. In this context, exercise therapy does not represent a paradigm change, it is rather that the accumulated knowledge is now so extensive that it has to be implemented.

There is a growing interest in the use of exercise for clients with chronic diseases and disabilities. It is thus suitable to provide a framework for determining functional capacity and developing exercise strategy in persons with chronic diseases and/or disabilities. The basic principles for exercise testing and training stated provides the foundation for program design. However, some special situations created by a disease pathology, disability, or treatment alter these basic principles. For example, exercise testing is an important aspect of the approach used, but some people will not have completed an exercise test before starting an exercise program. Participation in regular physical activity can enhance functional capacity, and a primary goal is to get more individuals physically active. Thus, for many people, exercise testing may not be absolutely necessary before starting a low-level physical activity program.

Many people who have chronic disease or disability enter a downward spiral toward exercise intolerance, so exercise intervention programs should be designed to resist this spiral and optimize functional capacity. Within any given population, there is a wide range of abilities determined by several factors; progression of the disease, response to treatment, and presence of other concomitant illnesses. Expected outcomes of exercise training are not always known. Realistically, optimal exercise and medical programming may yield improvements or merely prevent further deterioration. There may be recommended tests or programs that have not been validated, but that experience has shown to be successful. It is hoped that optimal management will bring the individual greater independence and improved quality of life.

In general, our society has a bias toward curative rather than palliative medicine, toward making the disease go away rather than finding ways to cope with disease. An unfortunate consequence of this perspective is that for persons with chronic disease or disability, we devalue the palliative benefits of preserving functionality and well-being. Since the 1960s, exercise has been promoted as a method of extending life, largely through prevention and moderation of cardiovascular disease. In recent years we discovered, however, that perhaps the greatest potential benefit of exercise is its ability to strengthen musculoskeletal system structure and function, enhance functioning of cardiovascular, digestive and endocrine system and to augment mental capacity through changes in body chemistry. Its side effects unlike other pharmacological interventions are positive (improvement and preservation in functional capacity, freedom, and independence).

The frameworks and applications that cope with the questions of health and wellness and that are available to the broad public audience are described e.g. in (Banos et al., 2015; Joo et al., 2012; Laakko et al., 2008).

3 SUPPORTIVE SOFTWARE INFRASTRUCTURE

3.1 Software Requirements Specification

This section introduces a supportive software infrastructure for the exercise and wellness health strategy framework. This infrastructure will provide means for definition of the data collection procedure and data collection itself, repository for storing and long term management of health related data and metadata in a standardized way, data processing and interpretation methods and/or defined interfaces for the application of data processing and interpretation methods. Last but not least visualization tools providing views on collected/analyzed data and their interpretations will be included.

An important aspect of this supportive software infrastructure is its wide range that includes collecting data from classic measurements such as blood pressure to relatively rare kinds of measurements such as acquisition of brain frequencies or brain event related potentials. It means that also experience of experimenters from the neuroinformatics lab (reference omitted for a review process) in measuring brain waves highly contributed to the definition of the first set of collected health related human body parameters.

Since big health related data (from at least thousands of people) are planned to be stored in the repository of this software infrastructure, the future analysis of interdependence between brain parameter values, other physiological and body proportion values and personal lifestyle records would bring valuable results for the targeted application of exercise and wellness health framework strategies.

Thus the whole infrastructure will enable to find out complex information related to health conditions of each participant and derive statistical results when defining various cohorts. With long-term and repeated measurements appropriate software modules will be able to detect and depict personal trends and changes in measured values.

However, the preliminary version of the software infrastructure presented in this article (hereafter called a software prototype) is required to help experimenters to efficiently collect all health related data and metadata outside the laboratory environment in one session according to the procedure that could be defined even on site. The schema of such experimental procedure (that contains a limited set of measurements) is depicted in Figure 1.

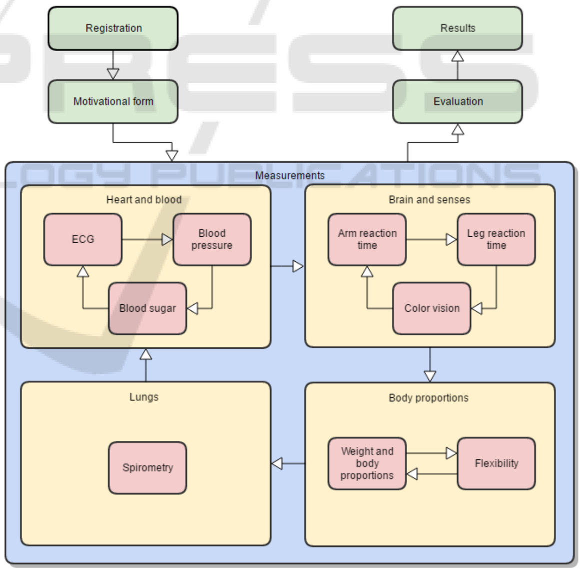

Figure 1: Experimental procedure.

The measured person starts with his/her registration, where he/she agrees with the collection and processing of his/her personal and health related data (informed consent) and provides basic information about himself/herself (name, sex, age, etc.). After the registration he/she proceeds to fill in a motivational questionnaire containing a set of 10-15 single choice questions related to his/her lifestyle. Then the measurement cycle starts (as shown in Figure 1). Individual measurements are grouped into sections depending on measured parameters of human body. Every section includes one or more physical sites where the experimenter takes the measurement. When a single measurement is completed, the acquired data are inserted via a user interface into the system and sent to the server. When the whole set of measurements is completed, the data are evaluated, sent back to the client application and the participant can see his/her results extended with additional information. The whole procedure shown in Figure 1 takes approximately 10–15 minutes.

The following list contains the current set of defined physical sites and health related data acquired at these sites:

1. Brain
   - P300 latency [ms]
   - Fundamental frequency during concentration [Hz]
   - Fundamental frequency during meditation [Hz]
2. Body proportions
   - Height [cm]
   - Weight [kg]
   - Muscle mass [kg] or [%]
   - Body fat [kg] or [%]
   - Body water [kg] or [%]
   - Body Mass Index (BMI)
3. Electrocardiography (ECG)
   - Heart rate [BPM]
   - ST segment [ms]
   - QRS complex [ms]
4. Blood pressure
   - Heart rate [BPM]
   - Systolic pressure [mm Hg]
   - Diastolic pressure [mm Hg]
5. Blood sugar
   - Concentration of glucose [mmol/l]
6. Spirometry
   - FVC (Forced Vital Capacity) [l]
   - FEV1 (Forced Expiratory Volume in 1st second) [l]
   - PEF (Peak Expiratory Flow) [l/s]
7. Hand reaction time
   - Average reaction time [ms]
   - Number of falsely pressed buttons
   - Number of missed buttons
8. Leg reaction time
   - Average reaction time [ms]
   - Best reaction time [ms]
   - Worst reaction time [ms]
   - Standard deviation [ms]
9. Flexibility
   - Difference between fingers and foot during deep forward bend [cm]
10. Color vision
    - Number of wrongly recognized pseudoisochromatic tables

The whole software infrastructure as well as the current software prototype is designed in a way that allows easy enrollment of any future health related data category, it means with any new collection of health related data and metadata that could be defined even on site (just before the measurement). This put further requirements on the flexibility of the data model itself and the technologies used for its representation.

The software prototype can work in the online (default) or offline mode. When it is connected to the Internet, it sends all input data directly to the main server and receives back results and additional data. When the Internet connection is not available, the prototype switches to the offline mode. In this mode all data are stored to a local repository and sent to the server immediately when the Internet connection is again available.

The parametric requirements on the prototype application include its performance (input of health related data does not produce any visible delay), mobility (application can be used outside laboratory conditions when several hundreds people are measured during a day), simplicity and user friendliness (experimenters are able to work with the application after five minutes of training in the worst case).

3.2 Architecture and Design

The architecture of the software prototype is shown in Figure 2. It follows the MVC architectural pattern and client server architectural style.

The functionalities are encapsulated in modules that can be added as plugins.

- The General module covers functionalities affordable also for non-logged users.
- The Admin module serves for the administration of users and application setting.
- The Auth module is responsible for user registration and login.

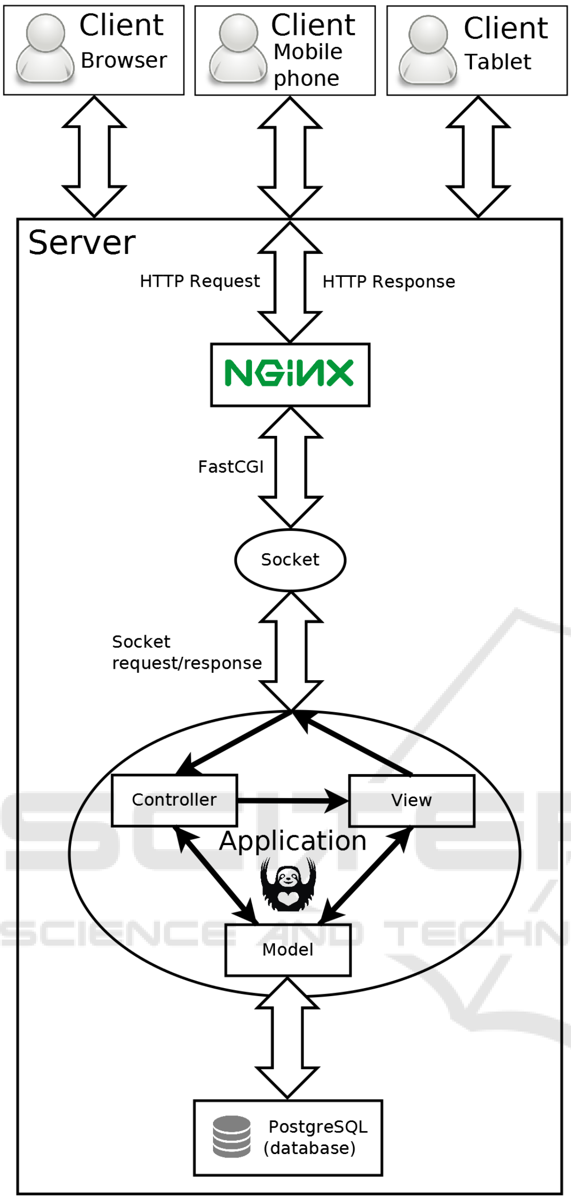

Figure 2: Software prototype architecture.

- The Measurement module includes definition of measurement procedure and overall data management.
- The Experiment module provides features for adding, editing and deleting experiments.
- Every experiment needs own equipment for measuring devices. The Equipment module stores them in the database and provides tools for their management.
- The QR generator module generates QR codes into a PDF document given to the participant. Each person has his/her number identifier included in his/her QR code.
- The Statistics module currently includes a function for simple statistics of reaction time.

Rest API is defined for collecting data from client devices.

3.3 Implementation and Deployment

The software prototype has been written in Python 3 language and uses the Flask micro framework that is based on the Werkzeug toolkit and Jinja2 template engine. The used languages and technologies include Python, HTML5, CSS3, Flask, Sqlalchemy, and Postgre SQL.

The Postgre SQL database is used for storing data. As a representative of open source object-relational database system it offers significant support for storing and retrieving JSON documents. Object relational mapping is provided by the SqlAlchemy framework. The current ERA model of the software prototype is shown in Figure 3.

The application is hosted by a virtualized server having the technical parameters provided in Table 1. The web server NGINX listens on two ports (the first port is used for the release version and the second one for the development version). NGNIX extends HTTP requests for non-standard headers CORS (cross-origin resource sharing) technology which is important for communication with mobile devices. NGINX passes requests to the python application with FastCGI protocol by a socket. Both development and release versions run five instances. The process describing how the requests are handled by the server is shown in Figure 2.

Table 1: Server hardware and software specifications.

Processor	Intel(R) Xeon(R) CPU E5-4620 v2 @ 2.60GHz
Memory	8036MB
Hard disk capacity	100GB
Operating system	Debian 8.4 with kernel 2.6
Web server	NGINX 1.6.2
Database	Postgres 9.4
Language and technologies	Python 3 using framework Flask

3.4 Testing

The software prototype has been tested on 346 people in real environment (e.g. Days of science and technologies that were held in large tents on the square)

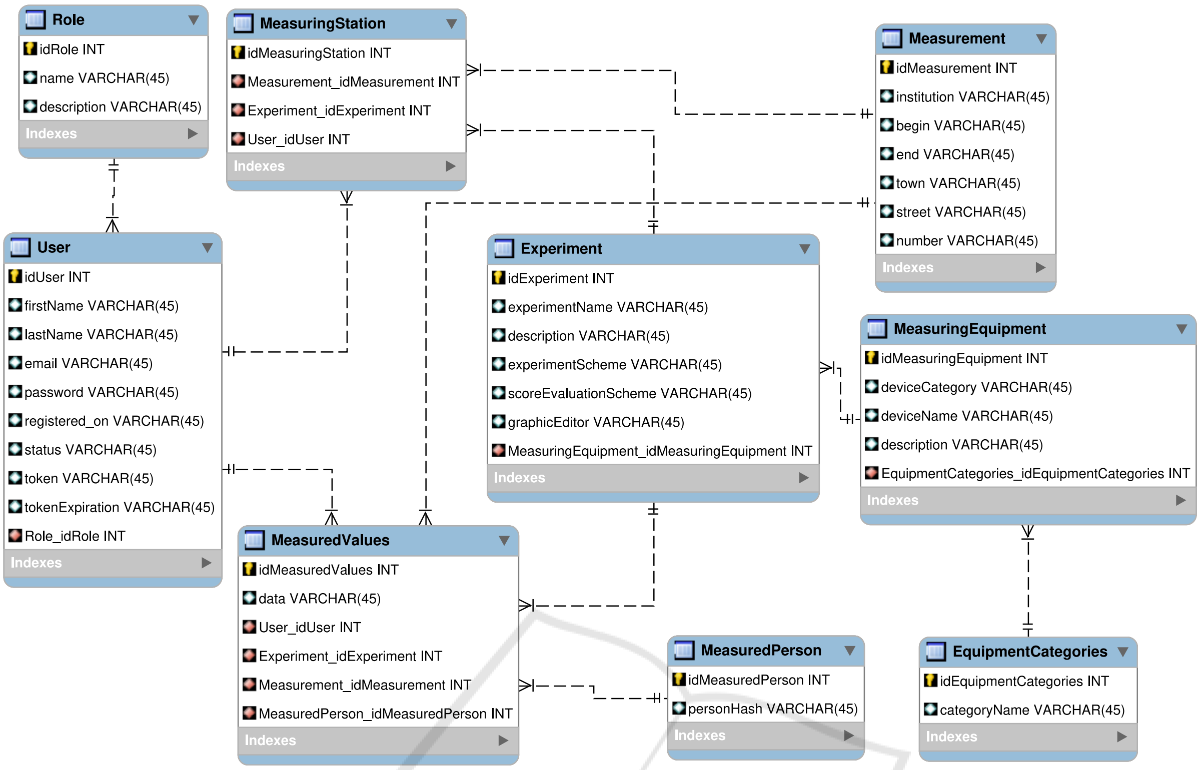

Figure 3: ERA model.

and has been continuously improved according to operation difficulties.

The list of devices which were used during the testing is shown in Table 2. The control software for impact dance is described in (omitted for the review process).

Table 2: Used devices.

Site	Device name
Body proportions	Medisana BS 440 Connect
Electrocardiography	ReadMyHeart Handheld ECG
Blood pressure	Omron M6 Comfort IT
Blood sugar	FORA Diamond Mini
Spirometry	SP10W
Hand reaction time	Device for cognitive research
Leg reaction time	Impact Dance Pad
Flexibility	Podium and ruler
Color vision	Pseudoisochromatic tables

4 CONCLUSIONS

In this paper we presented an idea of the exercise and wellness health strategy framework and the first steps that were done to support this framework by an appropriate software architecture. The proposed and developed software prototype covering a part of the whole infrastructure, namely rapid collection, storage and visualization of heterogeneous health related data, was successfully tested on more than three hundreds participants outside laboratory conditions.

The presented software prototype enables its users to quickly set the health related data to be collected and the whole data collection procedure. Then the data are collected, stored and visualized in an efficient way. Currently the prototype enables not only collection of classical data, but also non-traditional data (such as brain data) gathering. The software prototype design follows proven architectural patterns and styles, its modular structure facilitates its further extension.

In the future work we will focus on continuous extension of the software prototype to cover other parts of the intended software infrastructure for exercise and wellness health strategy framework. This include e.g. the modules for food and exercises recommendations, overall data evaluation or improved data visualization.

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