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FIT4WORK

SELF-MANAGEMENT OF PHYSICAL AND MENTAL FITNESS OF OLDER WORKERS

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Recommendation System

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1. Introduction

The Fit4Wrok system utilizes the results of the data analysis presented in deliverable D3.2.1/3.2.2 and data stored into the data storage to provide the user with relevant recommendations (see Figure 1.1). There are four types of recommendations:

- According to the achieved daily and weekly activity requirements, the user is informed about the progress and the way how to achieve it successfully (see Section 2).
- The progress in functional fitness exercises is motivated by the functional fitness exercises recommendations (future work).
- According to the measured and accumulated stress level during the day, the user is recommended to perform stress relief exercises (Section 3).
- The recommendations about the environment rely on the results from the ambient conditions monitoring and aim at improving the environment quality in the office (Section 4).

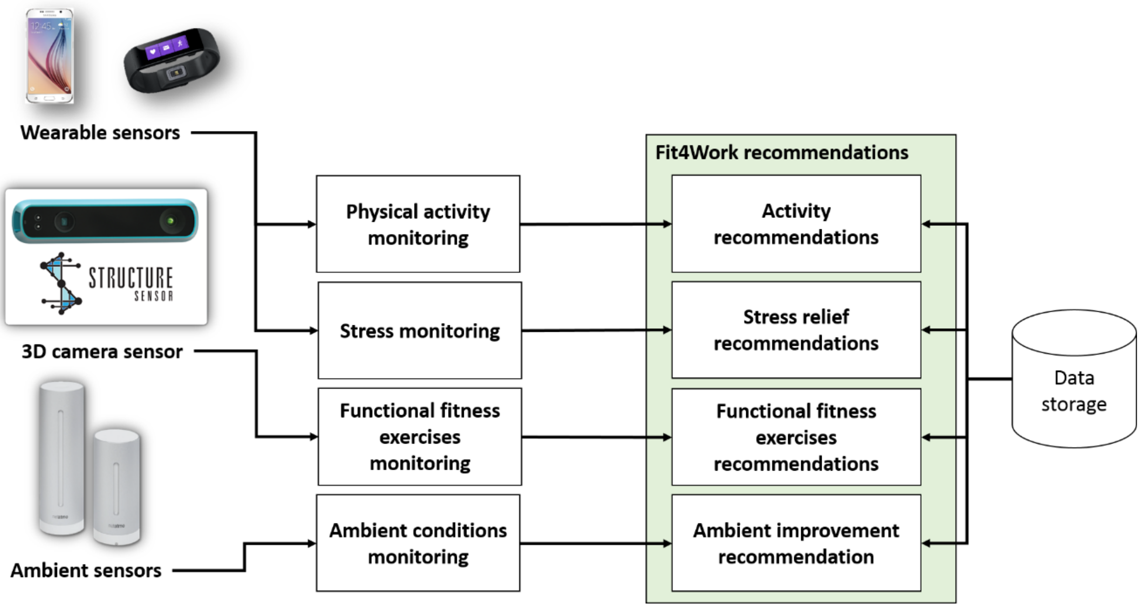

Figure 1.1 Inputs to the Fit4Work recommendations.

The current document contains contents related to the initial phase of the prototype development and to the final version of the component as developed within the project. The initial versions of the recommender modules prototypes (i.e. deliverable D3.3.1) were extended and updated to reflect the feedback of the end users on one side and provide better strategies to provide personalized recommendations (e.g. based on what works and what does not) on the other. That updated and extended version of the prototypes of recommender modules form the current version of the deliverable (D3.3.2).

2. Activity Monitoring Recommendations

The goal of activity monitoring recommendations is to introduce the current progress of the users' physical activity in regards to the daily and weekly requirements and to recommend the means to achieve them successfully. The recommendations receive an input from the physical activity monitoring module, which recognizes the users' activities and the estimated expended energy (in MET) while performing the activity. The physical activity monitoring keeps track of the history of the recognized activities and the estimated energy expenditure for the entire day. Daily activity achievements are stored into the database. The daily recommendations form the recommendations using the information about the daily progress and weekly recommendations are formed from the information retrieved from the data storage.

2.1. Daily requirements

The daily requirements are the predefined amount of burned active kilo calories (kcal), at least 10 minutes of continuous activity and one minute of standing movement per hour at least 12 times. The use case for daily requirements is presented in an Example 1.

The predefined amount of kcal set as a daily goal is calculated from users weight (4*weight) and should not go below 200 active kcal per day. Active calories mean exclusion of basal burned kcal and inclusion of kcal while performing one of the activities, such as walking, running, cycling or active standing (e.g. cooking, cleaning, etc.). We track a history of the recognized activities and the estimated energy expenditure for the entire day and use these data to calculate the burned kcal.

The burned **kcal** can be calculated from the estimated energy expenditure in MET, which we estimate in the physical activity monitoring module. The transformation of MET to kcal is calculated with the following equation: $kCal = MET * weight\ (kg) * time\ (hours)$

The standing movement per hour is hourly and daily requirement. The motivation is to make the sedentary user stand up and walk around for at least one minute per hour. The daily requirement is to achieve at least 12 movement hours per day.

In the future work, the system will learn from the historic data of physical activity monitoring which set of activities this users' prefers. This knowledge will enable the system to form more personalized recommendations.

2.2. Weekly requirements

Weekly requirements are a more general and are based on the WHO recommendations. The requirements for people aged 18-64 years is to perform at least 150 minutes of moderate-intensity physical activity throughout the week or do at least 75 minutes of vigorous-intensity physical activity throughout the week or an equivalent combination of moderate- and vigorous-intensity activity [1].

The output of the physical activity module which corresponds to the estimated energy expenditure in MET can be easily transformed into intensity of the activity using the standardized thresholds as presented in Table 2.1.

Table 2.1 The intensity of activity corresponding to the estimated MET and example activties

Intensity of the activity	MET	Examples of physical activity
Light intensity	< 3	Sleeping, desk work, very slow walking, ...
Moderate intensity	3 to 6	Walking (> 4.8 km/h), cycling (>16km/h), …
Vigorous intensity	> 6	Jogging, Running, …

To calculate the weekly achievement we consider 75 minutes of vigorous intensity equal to 150 minutes of moderate physical activity, which enables us to calculate the equivalent combination of both. An example use case is presented in Example 2.

In the future work, the system will learn from the historic data of physical activity monitoring which set of activities this users' prefers. This knowledge will enable the system to form more personalized recommendations.

Example 1: Daily requirements

Let us take a 60 year old user with 75kg as an example. We monitored the user for the last hour and recognized 10 minutes of continuous walking with estimated 3.2 MET, 15 minutes of active standing (the user was cooking) with estimated 2.9 MET and 35 minutes of sitting with 1.3 MET.

The users daily goal is calculated from the users weight as follows:
$Dailygoal = 75 * 4 = 300$

1. Burned active calories

All together the user burned 151.7 kcal.

$$75kg * (3.2\ MET * 0.17\ hours + 2.9MET * 0.25\ hours + 1.3MET * 0.58\ hours) = 151.7\ kcal$$

Active kcal exclude the resting period and take into account the active activities. This sums up to 95.2 kcal.

$$75kg * (3.2\ MET * 0.17\ hours + 2.9MET * 0.25\ hours) = 95.2\ kcal$$

Recommendation: You have burned 95.2 kcal today. To reach the daily requirement you can:

- Walk for 30 minutes
- Jog for 12 minutes
- Cycle for 15 minutes

2. Standing movement per hour

The user was performing standing movement for 25 minutes in the last hour. Partial hourly goal was reached. To reach the daily requirement, he has to achieve standing movement per hour for 12 times.

Recommendation: You have moved in the last hour and you reached 1/12 standing streak. To reach your daily requirement try standing up and walking a bit each hour.

Example 2: Weekly requirements

Let us take a user who we monitored for the past three days. We estimated 15 minutes of vigorous activity and 60 minutes of moderate activity in the three days.

15 minutes of vigorous activity corresponds to 30 minutes of moderate activity.

Recommendation: You have reached 60% of your weakly requirement. To successfully fulfill the requirements you should:

- Fast walk for 60 minutes
- Jog for 30 minutes
- Cycle normally for 60 minutes
- Cycle vigorously for 30 minutes

3. Stress Monitoring Recommendations

The Fit4Work system aims to keep the user at the minimum stress level by recommending the user to perform one or more stress relief exercises if needed. The need for stress relief is reasoned from the results of the stress monitoring module, which accumulates the stress level in real time during the day. Once the stress level surpasses a predefined threshold the Fit4Work system notifies the user to think about performing the stress relief exercises. The user can choose from the set of prepared exercises explained in Deliverable 3.4.

In order to simplify the selection of stress relief exercises, the Fit4Wotk system contains a recommender system, which aims to pick the exercises that are most useful for relieving the stress for each user. The recommended exercise is picked from a list of predefined breathing and muscle relaxation exercises using a probability-based algorithm. A recommendation probability is assigned to each exercise, which represent the probability for the specific exercise to be recommended to the user. The probability depends on the execution history of that exercise for the specific user. The exercises that are better in reducing the user's stress levels, have a higher probability to be picked. How much each exercise helps the user to reduce his/hers stress levels, it is automatically detected by monitoring his/hers physiological signs and the change in the stress level, while executing that exercise. In addition, there is always a small probability, for an exercises that has never been executed to be recommender, in order for the user to try some new exercises

4. Ambient Conditions Monitoring Recommendations

Ambient conditions monitoring recommendations aims to keep occupants in as optimal living space as possible. System firstly assess current conditions of ambiental parameters. We named assessment of the conditions Q-rating (quality rating). Then, using expert knowledge encoded in OWL ontology (as described in deliverable 3.4), we find possible recommendations (we refer to them actions), that could improve the conditions. Every possible combinations of actions are then presented to the simulator. Simulator is built from machine learning models. Every outcome is assessed with q-rating and according to the best q-rating score, we recommend to the user best possible subset of actions to take.

4.1. Simulator

The actions retrieved from the ontology can influence one or multiple monitored parameters. For example, turning up the humidifier influences only the humidity, whereas opening a window influences all the monitored parameters.

To predict the values of the monitored parameters for each suggested action, we change the value of the virtual sensor as the action suggest (windows = open, for example) and then run our prediction model on how is the ambiental parameter likely going to change. This is demonstrated in Figure 4.1. There was a decision point where window can be either opened or left closed; prediction shows that opening the window would result in fast decrease in temperature, so the action is not recommended. Actual past and future values of temperature are plotted for reference.

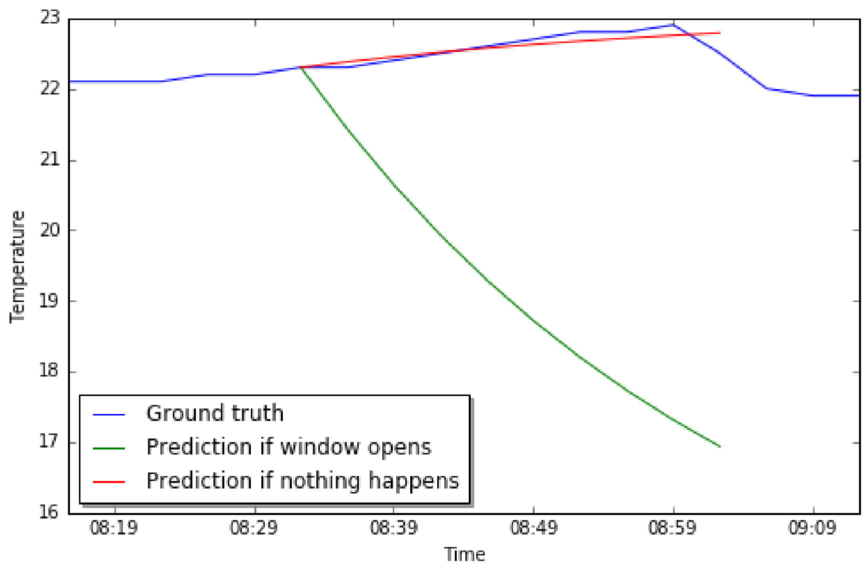

Figure 4.1 Temperature prediction for the system, given an action

Each set of predicted parameter values for each suggested action in the next four time steps is fed into the Q-rating module for the evaluation of the environmental quality.

4.2. Q-rating

The evaluation of the quality of the parameters is based on the intervals defined by workplace regulations. They define the value intervals in which individual parameters are considered good, medium, or bad. For example, humidity is considered good if the value is between 40 and 60 %, and bad if below 30 % or above 70 %. Otherwise, it is considered medium. CO2 is only considered good when below 500 ppm and bad when above 800 ppm, otherwise it is considered medium. Exhaustive list of parameters can be seen on Figure 4.2.

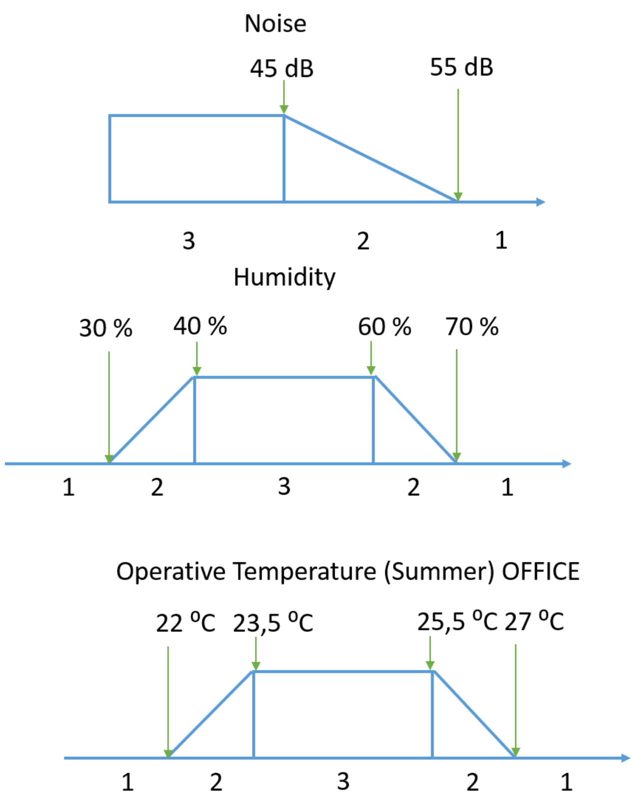

Figure 4.2 Figure 9 Figure is showing bounds of the parameters noise, CO2, humidity, illuminance and temperature in winter and summer time. Intervals marked as number 3 are presenting zones, where single parameter have good value. Sections marked with 2 are representing medium value while bad zone is represented with 1.

The overall quality rating is composed of the ratings of the individual parameters. Several different approaches to evaluate such quality exist in the literature, typically using different weights on parameters deemed more or less important in a particular study. Here, we treat three parameters (temperature, humidity, co2) more important and noise and luminosity as inferior ones. We propose next scoring system:

Every parameter contributes to overall score. We can see scores In Table 4.1. If parameter is more important, it is referred as 1, inferiors are referred as 2.

Table 4.1 Score table for more important and less important parameters

Type of parameter	Score
Good1	1000
Good2	100
Medium1	10
Medium2	1

Bad1	-100000
Bad2	-10000

Scores were designed with following in mind: If any parameter is bad, then we have bad condition. If any important parameter is not good, then we do not have good condition. If we calculate all possible outcomes, we can see, that scoring system corresponds to these statements and it also creates ladder to compare possible outcomes.

As first score is calculated, we perform deduction for every parameter that is not in good state. This means that we deduct distance from current value of parameter to the nearest good value. Then we perform "normalization" in next manner: we divide that distance with the middle value of the good interval. Normalization is introduced because various ranges of parameters. If we not perform normalization, CO_2 has much more influence on score, since it has higher values than for instance temperature. Example of scoring for temperature is as follows (Table 4.2): if it is 26.9°C we evaluate it with Medium1 value, which is 10. It is 1.4°C away from 25.5°C, which is bound for good interval. Middle value of temperature's good interval is 24.5°C, which means that we get deduction of 1.5/24.5. Temperature's contribution to score is then 10 – 1.4/24.5 = 9.94.

Table 4.2 Example of conditions in room in summer and their contribution to score. Overall score is equal to -9880.67896104

Parameter	Value	Score calculation
Temperature	26.9	10 – 1.4/24.5
Humidity	38	10 - 2/50
Co2	900	-10000 – 700/500
Noise	43	100
Luminosity	400	1 – 100/550

Let us say, that we want to simulate action open the window.

Table 4.3 Simulation of parameters after we open window. Overall score is -9880.09447124.

Parameter	Value	Score calculation
Temperature	26.3	10 – 0.8/24.5
Humidity	36	10 - 4/50
Co2	900	-10000 – 400/500
Noise	43	100
Luminosity	400	1 – 100/550

After simulation, we get total score of -9880.09447124. We can see that all parameters were still in same comfort zone as before action, but temperature and CO_2 were starting to move towards good zone, while humidity was a little bit worsened (Table 4.3). Reason for introduce deduction to score can be seen in example above, while CO_2 did not change in comfort zone, we are still able to see progress towards good zone, what is expressed in total score. So we can conduct in example, that opening the window will improve overall well-being in the room, even if we worsened humidity for a small amount.

5. Discussion

In this deliverable we present the mechanism for utilizing the results of the modules presented in Deliverable 3.2.1/3.2.2 to form appropriate recommendations on daily or weekly bases. Recommendations about physical activity and stress relief are currently based on rules which take into account the users daily “progress” and the recommendations about the ambient conditions are more complex. The system simulates and evaluates all possible actions which improve the environment quality and the one with the best score is selected as a recommendations.

6. Bibliography

[1] WHO, http://www.who.int/dietphysicalactivity/factsheet_recommendations/en/