Architecture of Automatic Training Data Gathering System - Training Assistant

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***Abstract*—The paper describes the core architecture of the Training Assistant system that allows users to automatically track their progress in using weighted training machines. It allows users to focus on correct execution of exercises during the training and not on the recording process. After the training one may see the progress and update the program for the next workout. Training Assistant system contains a special device that attaches to the training apparatus and gathers needed data: the weight that has been lifted by the user and how many times. This data is then collected through the special dispatcher on the web-server for later review and summarization.**

I. Introduction

For a fitness domain it is desirable to accumulate information about the trainings. A typical way to do this is to keep a diary. When a person performs an exercise set he/she records its description to the diary. Then the person or one's coach use this data to correct the training program to make it more productive [1].

Though being desirable the goal of keeping all correct data about performed exercises fails because of two serious obstacles. Firstly, the manual recording requires person time and attention, even if it is done with an electronic program. If a person takes too much time to make a record, he/she may break the exercise cycles and break out of schedule, failing to train properly. Secondly, the person can not correctly capture all the fine details of each action due to the complexity of training programs that may include dozens of exercises [2].

The solution for these problems lies in proper automation of training data recording. It allows people to spend all their training time in accordance with the formulated schedule. In this paper we present Training Assistant - a system to automatically collect data about exercises on weighted systems.

The paper structure is the following. Section II describes an existing approaches to record training progress. Section III presents core use cases of the proposed system. Section IV gives an overview of the system architecture. Section V discusses approaches to raw data collecting device development. Section VI provides implementation details of core components. Section VII concludes the paper.

II. Related work

First similar system is system for providing a portable diary and display of fitness information [3]. Each user should have a handheld device to input training data and view it later. All information about workout entered manually during the training process. Then collected data will send to server. The automation task is not resolved in the system because user oneself must input data. Also each person should buy its own special device.

Second similar system are applications that are created for smart phones and tablets and are published in the popular application stores. For example, one of the popular applications — "Fitness Point" [4]. It contains information about the exercises and allows users to manually record actions in the training process. But all training data is saved on the user mobile device unlike previous system that has a special server. Thus, this approach does not resolve automation task, but it does not require a specialized device.

III. System usage scenario

Main task of our system is to simplify training data accumulation. One of key points is to simplify and minimize the interaction between a user and the system during the training process. This section describes a training session supported by the Training Assistant system. The session consists out of three main parts: initialization, exercise selection and it execution.

In the beginning of the training the user must identify oneself in the system. We decided to use RFID technology, i.e. a RFID-tag in the form of the card or a strap is worn by the user. This tag is associated with the user during preceding registration procedure in the gym.

When user wants to train on the weighted system, he/she places a tag on the special pad on the training apparatus. The system identifies the user and greets him via a text message. If user was not previously registered, then a new account is automatically created. All the training data will be associated with the new account, but user must identify oneself in the gym in order to gain access to collected data.

Then the user picks an exercise that he wants to perform on the apparatus. Each training device is capable to support a number of activities, so the user's task is to select one item from the predefined list. He/she does so by moving back and forth in the list. This action is not mandatory, but it allows to add correctly identify the workout in the record. User may change the type of action he/she performed later directly in the web interface of the diary.

Lastly the user should perform desired exercise on the apparatus. During the exercise the system will capture block's movement, compose sets out of them and attach it to the user's records in the web application.

ISSN 2305-7254

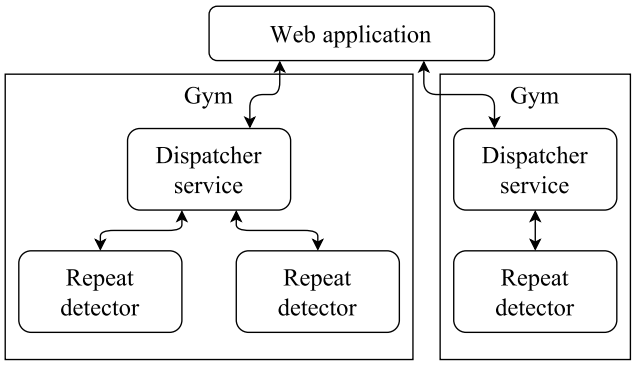

Fig. 1. Overall system architecture

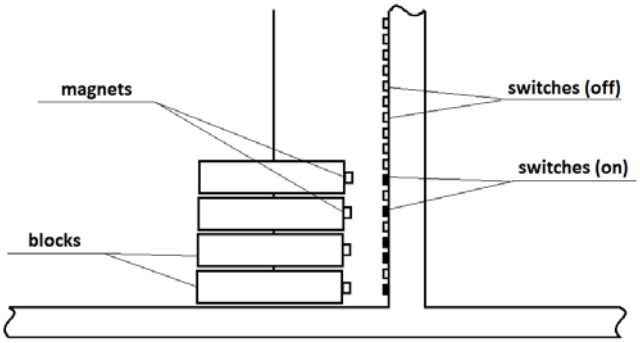

Fig. 2. Magnetically operated sealed switches on the training apparatus

After the training all collected data will be available to the user through the web-interface, where he/she can browse, modify it and update personal training program if needed.

IV. System architecture

The system consists out of three elements: a repeat detector on the training apparatus, a device dispatcher service and a web application. The principle interaction scheme between components is shown in Fig. 1.

The repeat detector on the training machine interacts with the user and records ones exercise progress. It may be divided into two logical parts: the controller and the sensors. Controller allows user to identify oneself using an RFID-sensor and select an exercise. In order to choose an exercise user should use buttons located on the sides of the controller. Current prototype contains a LCD display to communicate short simple notices to the user. Sensors allow to determine weight of the blocks and the height that they were lifted. Collected data is send to the dispatcher service.

The main purpose of the device dispatcher service is to orchestrate work of the devices in a particular gym and to convert and accumulate requests from devices to the web-server. The addition of dispatcher allowed us to simplify the logic of apparatus devices, so cheaper equipment could be used to satisfy the specification. The dispatcher also performs an initial configuration of devices: setups a communication channel and provides a list of exercises that can be done on a particular apparatus.

The web application is a focal point of user's interaction with the system. It contains data about all exercised performed by the users and statistics about apparatus usage. Users may see details of their trainings and review statistics, for example general, body or exercises statistic. The web application is capable to serve several gyms with all training machines in them.

V. Device development

A. Magnetically operated sealed switches

Initially, we decided to use magnetically operated sealed switches to detect training machine blocks state. As you can see in Fig. 2 the switches are places near-by blocks on the whole length of the block movement. Switches are turned on when the magnetic field is getting stronger (the block is near-by the switch) and turned off when the magnetic field becomes weaker. The blocks are usually made out of iron, so they provide quite strong magnetic field. If they don't, small magnets can be attached to the blocks.

When blocks change their position, the states of the switches also changes. When a state of the switch is changed, the repeat detector sends current state of switch array to the device dispatcher. It processes the state and detects when a user started a movement, the height that blocks were lifted, when the movement ended. Based on this data, the dispatcher derives an exercise set description and passes it to the web application.

This approach has a couple of disadvantages. First of all such switches are fragile and may be broken after a single unintentional hit or drop of weights. If a switch is broken, it limits the quality of positioning detection and may lead to wrong position recognition. The broken switch must be manually replaced therefore introducing unnecessary downtime.

Secondly every block of the training machine should have a magnet in order to make detection possible. The powerful magnets change the weight of the block or may disable the functioning of the training machine.

And thirdly, the switches must be placed on the whole length of the weight movement length, so this movement could be detected.

In accordance with this disadvantages we decided to use distance sensor with the photo switches.

B. Photo sensors and distance sensor

The photo switches are places in the initial position of all blocks in the system. Usually there are up to 20 blocks available. The distance sensor is placed on top of blocks and detects the height of their movement.

When the user moves blocks, the photo sensors detect the amount of block that are being used. The distance sensor allows to detect the moment when blocks begin to move downwards. The amount of blocks and the height is sent to the dispatcher service.

These sensors are more reliable than magnetically operated switches and allow to get more accurate readings on the block

position during exercises. With this setup it becomes feasible to support many apparatus that differ in block count and height with the standardized repeat detectors.

VI. Interaction protocols

System has two protocols for elements interaction. The detector and the dispatcher communicate with each other with the use of TCP messages. Every message is a simple string describing a status of the detector or the authorization request.

There are three messages that detector can send to the dispatcher service. They are:

1) NFC_READ:tag_id - detector have read tag identification and requests authorization from the dispatcher.
2) SENSORS_STATUS:state - indicate the state of the sensors to the dispatcher. The message is send when the detector indicates that the user begin to lower weights.
3) SELECTED:exercise number - indicate that the user have selected appropriate exercise from the list of loaded exercises.

Device dispatcher can send two types of messages to the repeat detector. They are:

1) DISPLAY:text - request detector to display corresponding text on the screen of the controller. Usually this text contains the name of the user.
2) SET_ARRAY:exercise1, exercise2, e.t.c. - initialize a detector with the set of exercises.

The interaction between dispatcher and the web application is done via REST-like interface. The dispatcher acts an http-client: it generates requests and acts on receiving the response from the web application. There three type of requests available to the dispatcher:

1) Request for configuration of repeat detectors. The dispatcher sends the request without any parameters and receives a set of configurations for each detector. The configuration initially include the list of available exercises and block weights.
2) User identification request. The dispatcher sends this request when user places the RFID tag onto the controller. The web application responds with the name of the user if one was identified or with the greeting to the new user.
3) Store exercise set request. The dispatcher registers a series of actions made by the user and composes an exercise set out of them. When user finishes his/her set, the dispatcher sends description of the set to the web application, so it will be added to the personal record of the user.

VII. Web application functionality

The web application is intended to act as a personal tool to monitor training progress and later as a training management center where trainers could provide assistance in making training safe and more efficient. Currently the application is in the beginning of the development and provides only visualization of data gathers from the repeat detectors.

The application allows users to authenticate themselves using the user name and the password, and to register new account if it is desirable. All other information is available to the user if he/she proceeded with the authentication procedure. The provided information include: statistics on each performed exercise, general workout statistics, and muscle load levels.

VIII. Conclusion and future work

The paper presented the current status of the Training Assistant - the system to automatically collect information about performed exercises using the weighted apparatus. The system consists out of three modules: the repeat detector, the dispatcher service and the central web application. First element provides raw data and interacts with the user, the second orchestrates the work of several detectors inside the gym, the web application consolidates configuration and data gathering functions.

In order to implement the system we have chosen an appropriate sensors. In the latest installation they are photo sensors and distance sensors. These sensors do not directly interact with the moving parts of the training apparatus and allow to work for a several years without substantial repairs.

In the future the prototype of the system will be tested in a local university gym to identify core weakness of the system on the physical level. Also the web application features will be broaden up to support operations of trainers and gym owners.

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