A Computer Game based Motivation System for Human Physiology Studies

T.Mathew [1] R.Herpers [1 3 4] J.Rittweger[2] J.Zange[2]
Bonn-Rhein-Sieg University of Applied Sciences, Grantham-Allee 20, 53757 Sankt Augustin
Aerospace Medicine Center, DLR, Cologne
York University, 4700 Keele Street, Toronto, Ontario, M3J 1P3, Canada
University of New Brunswick, Canada
tintu.mathew@smail.inf.h-brs.de

Introduction

In human physiology studies subjects are often asked to perform certain exercises, eg.knee extension or flexion,hip extension or flexion etc . Those experiments are split into several repetitions which might last just for few seconds. Therefore subjects need to motivated fast and reliably to perform a maximum extension or flexion. The standard procedure in those cases is however verbal motivation by the investigator (in fact, the investigator is just yelling at the subject "Push harder, harder..") . It has been shown that the performance of the subject is strongly correlated to verbal motivation by the investigator [3], [4], [5], [6], [7], [8]. Therefore, the experiments are not reproducible, and mainly biased by the invesigator. To overcome the problems associated with the standard verbal motivation procedure a game based motivation system has been designed for human physiology studies.

In the physiology laboratory at the Institute of Aerospace Medicine,DLR, the Biodex System3 Isokinetic Dynamometer [1] is used for force and power diagnostics in different human muscle groups [2]. The different force and power diagnostic experiments conducted requires the human subjects to exert maximum force voluntarily. The experiment heavily relies on the subject's voluntary effort as well as verbal motivation by investigator. Computer games are known to engage people in game play for long durations and make it an enjoyable experience.It is possible to create new and interesting tasks using gaming or virtual reality based systems. So computer games have been combined with exercising or rehabilitation equipments to provide motivation and customized training [9], [10], [11], [12], [13], [14], [15]. Taking a cue from this , a computer game based motivation system was developed for the isokinetic dynamometer. A tailor made game for the system can motivate the subject and also standardize the process. It will reduce the dependency on the investigator for encouragement as well as guide the subjects through the experiment.

The game based system is expected to replace verbal encouragement by

- Providing visual feedback to improve peak torque
- Providing continuous motivation
- Helping the user perform consistently over repetitions

Approach

The game was developed for one particular experiment on the dynamometer, the maximal isometric knee extension test.The test protocol for this experiment will specify the number of visits by the subject, number of times the test is repeated in a visit (repetition), time between repetitions(relax interval) and setup details of the dynamometer for the test. The game identified for implementation is 'Bruce- The Shark'. The shark chases a school of

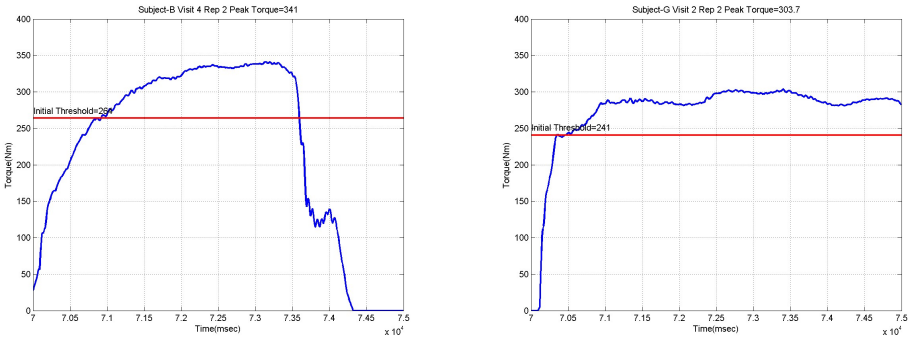

Figure 1: Torque response for one repetition for two different subjects. Each subject gets his individual initial threshold values based on previous tests.

fish in a deep sea environment. The shark has to move fast and get closer to the fish using torque applied on the dynamometer. The shark must aim to catch the maximum number of fish. The number of fish caught refects how well the player performed in the repetition and also in the complete visit. Torque data for isometric knee extension from a previous study was analysed to define control parameters for the game. The data set consisted of isometric knee extension tests which lasted five seconds. A baseline torque value, initial threshold, is established to compare different torque curves as well as to establish a reward system. A sample torque response is shown in Fig.1. The control parameters identified are mean torque(mean of torque samples within a sampling inerval), peak torque(maximum torque attained in a repetition) and threshold(intial threshold is adapted for every sampling interval).

The game is implemented using the control parameters identified from the data analysis. The user details are gathered through the menu at the beginning of the game. The investigator has to enter the subject's name and the study name. Using this information it is determined whether it is a new user or whether the user is already in the database. In case of a new user, details regarding the test protocol such as number of visits, number of repetitions, duration of a repetition and duration of a rest interval are gathered. For a new user a familiarization repetition is conducted to find the initial threshold to be used in the study. For an existing user, the initial threshold is calculated from the history available in the database. The initial threshold will not be updated within a visit.

The game works as follows. The torque values from the dynamometer are read by the game. The school of fish starts moving and the shark follows the school. The mean of every twenty torque samples is calculated.The threshold is compared against this mean torque.Once the subject crosses initial threshold, the threshold value is updated. If the mean torque is greater than the current threshold the threshold is updated and a catch flag is set to indicate that the user deserves a reward. Once the catch flag is set the reward algorithm is initiated. The reward algorithm compares the speed of the fish and shark and gives the shark a speed boost to catch a fish. The catch flag is reset after the shark gets a fish. These steps are continued until the repetition time is over. Once the repetition time is over, the user can relax over a rest interval. A countdown is displayed during the rest interval. After the rest interval the threshold is re-initialized and the repetition continues as above until all the repetitions for the current visit are over.

Evaluation and Results

Two approaches were used for evaluation. The system was analysed existing data and also was tested on subjects in real time.

Retrospective Analysis

The behavior of the reward system on an existing data set was analyzed.The data set contained isometric knee extension tests for eight subjects across four visits. Each vist had

three, five second long, knee extension repetitions. Different parameters in the reward system are explored. The evaluation of the game shows that the game encourages the user to improve his torque output by continuously rewarding him for any increase in torque exerted. The game also encourages a user to cross the initial threshold faster to gain more rewards. The analysis of game events for the torque curves shows that the game provides appropriate motivation for different kinds of torque curves, although the latency in rewards(0 to 700ms) delayed the encouragement. The subject was rewarded more when he crossed initial threshold early in the repetition and reached peak torque towards the end. The rewards were not directly proportional to peak torque but to time time taken to reach peak torque.

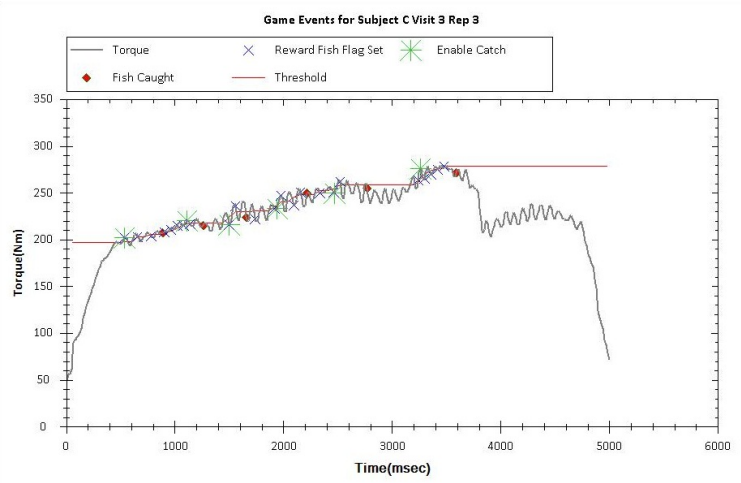

Figure 2: Retrospective Analysis on existing data. Here the torque response increases and correspondingly the threshold is also increased. The user is rewarded at every point.

Online Analysis

The game was tested on real time data with subjects. The subjects performend three consecutive five second lon isomtric knee extension tests. The subjects were rewarded for any increase in torque data. The subjects were more enthusiastic to participate in the tests. The peak torque attained remained consistent over repetitions. The game based motivation provided tandardized and reproducible motivation to the subject. The subject was motivated by rewarding any increase in torque. There was no visible increase in torque generated by game based motivation so far.

References

[1] Biodex,http://www.biodex.com,April 2012

[2] Physiology Laboratory at the Institute of Aerospace Medicine, German Aerospace Center, http://www.dlr.de/me, April 2012

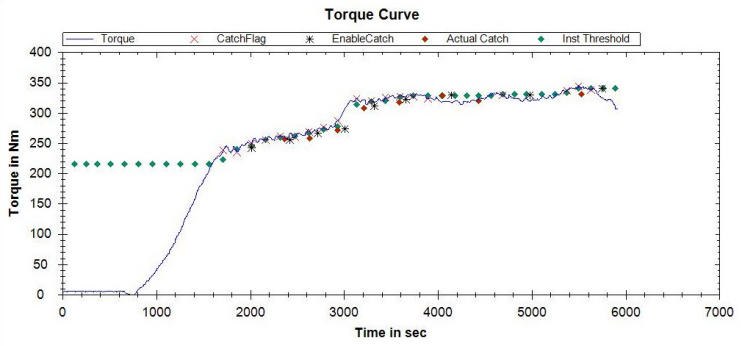

Figure 3: Analysis of real time data

[3] ,Campenella, B., Mattacola, C.G., Kimura, I.F., Effect of visual feedback and verbal encouragement on concentric quadriceps and hamstrings peak torque of males and females, Isokinetics and exercise science, 8, 1-6, 2000, IOS Press

[4] , Jung, M.C., Hallbeck, M.S., Quantification of the effects of instruction type, verbal encouragement,and visual feedback on static and peak handgrip strength,International Journal of Industrial Ergonomics, 2004, 34, 367–374, Elsevier

[5] Hald, R.D., Bottjen, E.J.,Effect of Visual Feedback on Maximal and Submaximal lsokinetic Test Measurements of Normal Quadriceps and Hamstrings, The Journal of orthopaedic and sports physical therapy,1987

[6] ,Andreacci, J.L., Lemura, L.M., Cohen, S.L., Urbansky, E.A., Chelland, S.A., von Duvillard, S.P., The effects of frequency of encouragement on performance during maximal exercise testing, Journal of sports sciences, 2002, 20, 345–352

[7] McNair, P.J., Depledge, J., Brettkelly, M., Stanley, S.N., Verbal encouragement: effects on maximum effort voluntary muscle: action, British journal of sports medicine, 30, 243–245, 1996, BMJ Publishing Group Ltd and British Association of Sport and Exercise Medicine

[8] Figoni, S.F., Morris, A.F., Effects of Knowledge of Results on Reciprocal, lsokinefk Strength and Fatigue., The Journal of orthopaedic and sports physical therapy,6,190,1984

[9] Bogost, I.,The rhetoric of exergaming, Digital Arts and Cultures (DAC) Conference (December 2005), IT University Copenhagen,2005

[10] Goebel, S. ,Hardy, S. ,Wendel, V., Mehm, F. ,Steinmetz,R., Serious games for health: personalized exergames, Proceedings of the international conference on Multimedia 2010,1663–1666,ACM

[11] Lin, J.,Mamykina, L., Lindtner, S., Delajoux, G., Strub,H., Fish n Steps: Encouraging physical activity with an interactive computer game, UbiComp 2006: Ubiquitous Computing,2006,261–278,Springer

[12] Merians, A.S., Jack, D., Boian, R., Tremaine, M., Burdea, G.C., Adamovich, S.V., Recce, M., Poizner, H., Virtual reality–augmented rehabilitation for patients following stroke,Physical therapy, 2002,82,898–915, American Physical Therapy Association

[13] Heidi, S., Motor rehabilitation using virtual reality, Journal of NeuroEngineering and Rehabilitation

[14] Yannakakis, G.N., Togelius, J., Experience-driven procedural content generation, IEEE Transactions on Affective Computing, 2, 147–161, 2011

[15] Burke, J.W., McNeill, M.D.J., Charles,D.K., Morrow,P.J., Crosbie,J.H., McDonough, S.M., Serious games for upper limb rehabilitation following stroke,IEEE Conference on Games and Virtual Worlds for Serious Applications, 2009. VS-GAMES'09., 103–110, 2009