METHODOLOGY AND ARCHITECTURE OF A COMPUTER-BASED INTERACTIVE TIMING SYSTEM FOR APPLICATIONS IN MEDICINE

Maria Angelova

Technical University – Sofia
1000, 8 Kl. Ohridski Blvd, Sofia
maria@tu-sofia.bg

Kalin Dimitrov

Technical University – Sofia
1000, 8 Kl. Ohridski Blvd, Sofia
kld@tu-sofia.bg

Stefan Valyukov

Therapist
1000, 39 Vladimir Vazov Blvd, Sofia
svalyukov@gmail.com

Abstract

This article describes the design and realization of an Interactive Timing System. Such systems are used in the therapy of children who have learning and attention issues. The concept is that people can "retrain their brain" to focus and work more efficiently. The matching of different beats can help the brain work more efficiently and become more organized.

A similar existing system is observed and a methodology and architecture of a computer program which performs interactive timing is proposed. Open-source software environment is used for the practical realization of the program. Some results of the program functioning are shown.

1. INTRODUCTION

Interactive timing is a computer-based therapy that trains people to match various beats. Concentrating and keeping a beat eventually stimulate the growth of important connections in the brain. This would help children improve their skills. Those skills might include focus, making sense of information, reading, movement and controlling impulsive or aggressive behaviour. Children listen to a beat while wearing headphones. They are asked to clap their hands or tap their feet to the beat. The computer then tells them how well they are doing. The goal is for children to get better at matching various beats over repeated sessions.

Conditions such as ADHD (Attention-Deficit Hyperactivity Disorder), dyslexia, autism, Parkinson's disease, auditory processing disorders, and other issues are often the result of problems that occur within the brain [9, 10, 11, 12, 14]. Some researchers believe these problems in the brain also impact the brain's internal clock. Interactive Timing Systems work by addressing these issues in timing [1, 2, 3, 5, 13].

In our observation of existing Interactive Systems we discovered one major product. Interactive Metronome® [4, 6, 7, 8] is an assessment and training tool that measures and improves the synchronization of neural impulses within key brain networks. It helps to improve the cognitive, communicative, sensory and motor performance. As the individual activates a trigger in time with a steady auditory beat, IM technology provides real-time visual feedback for millisecond timing. Knowing whether he is hitting before, after, or exactly in sync with the beat to the millisecond allows the individual to make immediate, online corrections to improve timing over the course of training. It is a well known timing system which requires payment for regular usage.

2. SYSTEM ARCHITECTURE

Figure 1 depicts all components of the system. Before the system starts its operation, it is necessary to set the basic characteristics of the regular beats. This is the time interval in which these beats will be generated and the number of beats per minute. This is usually done by the therapist. The next step is to start the computer program and to ana-

lyze the beats generated by the user. The process of time matching between the two beats (t_i and $t_{click,\ i}$) is made by the computer program algorithm. The obtained result R_i is recorded for each beat. The user is able to see his/her current results and the general evaluation after the end of the set time period. The final result is given as an average estimate of the gap between the beats in milliseconds and the percentage of delays and early clicks of the user. Based on this assessment, a change in the user achievements can be traced over time.

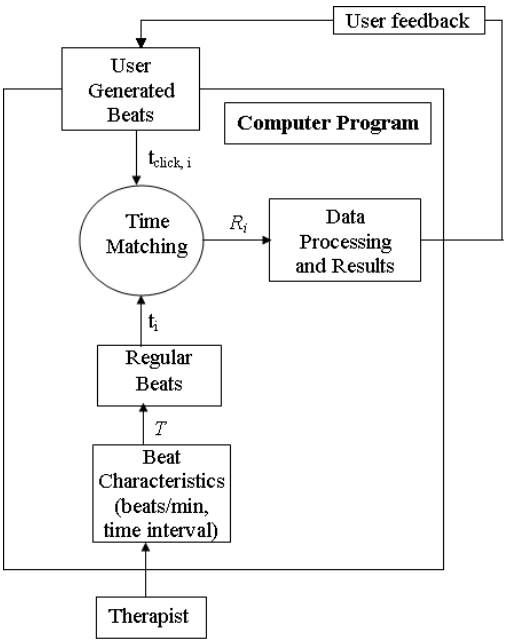

Figure 1. Interactive Time Matching System Architecture

The computer program is meant to be used for children but it is possible to use it for all kinds of patients who want to train their brain timing.

3. TIME MATCHING ALGORITHM

Each result obtained should measure the time gap between the regular and the user beats. It is important to determine when the gap will be considered a delay and when it will be considered as an early click. Figure 2 shows how the Interactive Time Matching System solves this problem.

It applies the following rules:

If the user click occurs before the middle of the period between the regular beats, the result is considered to be a delay for the current beat and is calculated by formula (1):

$$R_i = t_{click,\ i} - t_i \qquad (1)$$

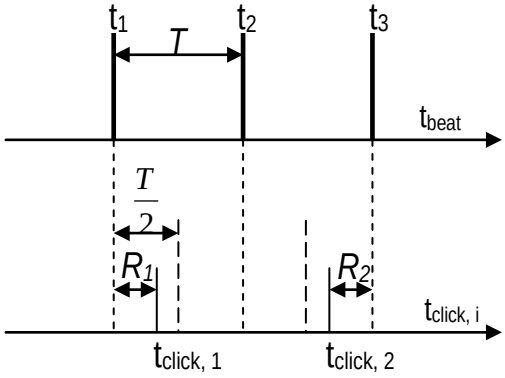

Figure 2. Distribution of user clicks

If the user click occurs after the middle of the period between the regular beats, the result is considered to be an early click for the next regular beat and is calculated by formula (2):

$$R_{i+1} = t_{click,\ i} - t_i - T \qquad (2)$$

4. COMPUTER PROGRAM INTERFACE

The computer program was created with the free visual object-oriented Lazarus platform. The interface includes all the tools needed to set the initial settings and to track the results (Figure 3). It is possible to use it free of charge and to document the patients' results.Figure 3. Computer Program Interface

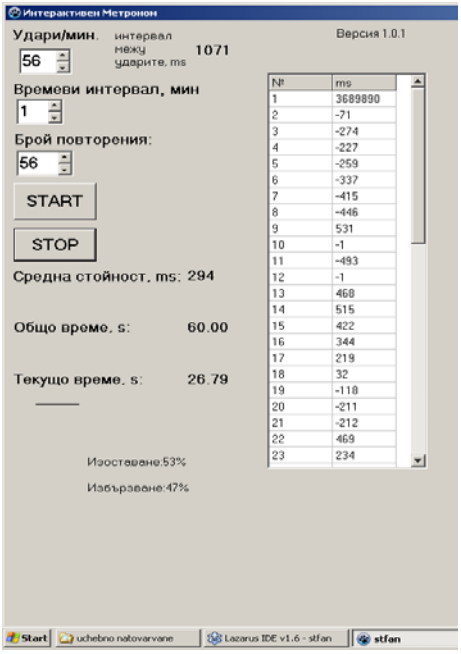

Figure 3. Computer Program Interface

A timer is used to create the regular beats in the program. For the introduction of user beats, a sen-

sor generating OnClick() event is needed. The timing is done by taking ticks from the Operating System Clock.

After the end of the training process a therapist can evaluate the user results and give directions how to improve the brain timing process.

5. CONCLUSION

Some children and adults experience problems related to malfunction of the internal brain clock. Interactive timing therapy is a good starting point in the effort to help these people. The repetitive training sessions are supervised by therapists who give directions to the patients how to properly conduct their treatment. In order to do so they need reliable tools. The Interactive Timing System described in this article is such a tool. It can assess the user results and trace their achievements over time. The system has a user-friendly and intuitive interface and is developed in an open-source programming environment. It is free of charge and it can reduce the cost of otherwise expensive treatment.

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