

## IMPLEMENTATION OF VIRTUAL REALITY ENHANCED CONTINUOUS PERFORMANCE TEST DESIGNED FOR ATTENTION DEFICIT HYPERACTIVITY DISORDER DIAGNOSIS

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### Abstract

The purpose of the study is to implement a virtual reality (VR) enhanced continuous performance test (CPT) specifically designed as an aid to attention deficit hyperactivity disorder (ADHD) diagnosis with the newest enabling technologies. To realize such an objective, firstly, the VR technology enabled ADHD diagnosis methodologies are investigated and required metrics are analyzed. Then, a new model is constructed in order to measure the required metrics and an assessment methodology is adopted to evaluate such metrics to cooperate with the created VR application. As the contribution, a new measurement model and procedure are presented and the effectiveness of the system is going to be examined in future studies.

**Keywords:** Virtual Reality, Continuous Performance Test, Attention Deficit Hyperactivity Disorder Diagnosis

## DİKKAT EKSİKLİĞİ HİPERAKTİVİTE BOZUKLUĞU TANISI İÇİN TASARLANMIŞ SANAL GERÇEKLİK DESTEKLİ SÜREKLİ PERFORMANS TESTİNİN GERÇEKLENMESİ

### Özet

Bu çalışmanın amacı en yeni teknolojileri kullanarak dikkat eksikliği hiperaktivite bozukluğu (ADHD) tanısına yardımcı olmak için özel olarak tasarlanan

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sanal gerçeklik (VR) destekli bir sürekli performans testinin (CPT) gerçekleşmesidir. Böyle bir hedefi gerçekleştirmek için ilk olarak VR teknolojisinin kullanıldığı ADHD teşhisi yöntemleri araştırılmış ve gerekli metrikler analiz edilmiştir. Ardından gerekli metrikleri ölçmek için yeni bir model oluşturulmuş ve oluşturulan VR uygulaması ile işbirliği yapacak metrikleri ölçmek için bir değerlendirme yöntemi kullanılmıştır. Katkı olarak yeni bir ölçüm modeli ve prosedürü sunulmuştur. Sistemin etkinliği gelecekteki araştırmalarda incelenecektir.

**Anahtar Kelimeler:** Sanal Gerçeklik, Sürekli Performans Testi, Dikkat Eksikliği Hiperaktivite Bozukluğu Tanısı

## **1. Introduction**

This study is intended to research and develop an application using virtual reality (VR) technology to provide aid and solution to people who lack attention for various reasons or who want to make their attention more intensive and specially to school-age children affected by modern technology. Attention is the power to concentrate thoughts on something. As can be seen in detail in literature, attention deficit is usually correlated with hyperactive disorder by scientists and referred to as attention deficit hyperactivity disorder (ADHD). Studies up to 15 years show that there is no evidence for attention deficit that practical drug treatment improves the long-term prognosis [1, 2].

According to these results, similar studies on this area are necessary for treating attention deficit. It is seen that there are lots of studies in various countries about ADHD. To the best of the authors' knowledge, however, there is no work in this context in Turkey. In this work, VR applications are investigated and put in practice to help in identifying problems of attention deficit using the Unity VR infrastructure. The developed applications are intended to be accessible by everyone. Therefore, the applications are developed for smartphones which are ubiquitous in everyday use.

The rest of the paper is organized as follows. In Section 2, related works are given. Section 3 introduces the proposed methodology. Section 4 investigates the results

of the methods used in this study. Finally, conclusions and future works are summarized in Section 5.

## **2. Related Works**

In literature, since attention deficit is usually correlated with hyperactivity disorder, they are investigated together. Attention can be divided into 5 basic parts to describe the lack of attention. These are focus, constant, selective, alternative, and dividing attention. Focus attention: reacting to certain stimuli, constant attention: permanent condensation in the work done, selective attention: not distracting by other factors while engaging in a topic, alternative attention: changing the focus to a different subject, and dividing attention: focus on more than one subject [3].

Children diagnosed with ADHD usually have problems in the public sphere. They are easily bored and behave without thinking. This is the most common childhood time behavior disorder. The disorder directly affects children's relationships with their teachers, families, friends, and siblings. Also, it causes difficulties in their learning life [4, 5]. The number of people with ADHD who are diagnosed with attention deficit is increasing. Besides, the number of people with ADHD is 3-7% without a complete measurement [6].

Many treatment techniques have been proposed and implemented for the treatment of ADHD in the past years. The tests done on paper used in the treatment cannot be employed on every patient. Attention deficit patients cannot pay enough attention on the long-term tests. Especially in children, these tests are not brittle and interesting, reducing the success rate of the test.

Drug treatment with adverse effects may affect children's future mental and physical development. Psychoactive drug treatment is a treatment that is avoided by parents at first because there is no proven effect on long-term ADHD symptoms. This is only recommended for severely sick children. In other cases, improvements are made using technology [7].

In literature, VR technologies have been demonstrated in various studies which they have shown promise for these patients [8]. It has been found that the patients using

VR technologies provide longer duration of concentration by removing image boundaries compared to other methods (paper test, drug, rehabilitation, etc.) [3, 9]. This is not only beneficial for children with attention deficit, but also for those who are physically handicapped. It has the potential to provide equal opportunity in education and avoid obstacles. In order to support curriculum training with VR, classes have been observed to be used in a variety of studies [10, 11].

VR systems also help to reduce the symptoms of illness without having to be diagnosed with a medical diagnosis and constantly monitored by a child psychologist [11-15].

### **3. Proposed Methodology**

#### *3.1. Continuous Performance Test*

In order to improve the attention deficit, it has been pointed out that it is important to develop tasks such as working memory, auditory memory, and certain visual memory [16]. These tasks should be encouraged to listen, followed by verbal instructions to scan the environment, words of hidden treasures, letters, faces and objects, so that attention and organizational skills will be increased to trigger audible processes.

Continuous performance test (CPT) was first offered by [17] which demonstrated that brain damaged child and adults had difficulty in keeping attention and distinguishing if or if not a target letter in a randomized sequence of letters had followed a cue letter.

The fundamental nature of the CPT remained the same, although tests may vary in length and type of stimulus. They were all indicated as repetitive, boring task, and attendee must keep focus over a certain time period. Tests may use numbers, symbols or even sounds.

Test of variables of attention (TOVA) is a neuropsychological evaluation and it measures a person's attention while screening for ADHD [18]. The most common

metrics used in the CPT to measure the attention of the patient are listed and described below [19]:

Correct detection: this is a simple counter that counts the number of times the patient replied to the target stimulus. Better attention capacity is indicated with higher rates of correct detections.

Reaction times: this is a measurement for the amount of time between the presentation of the stimulus and the patient's response. This measure is generally calculated with standard deviation to understand the variability.

Omission errors: this is another counter that demonstrates the number of times the target was offered, but the patient did not respond/click the mouse. High omission rates show that the subject is either not paying attention to stimuli that the person may have distractibility or has a sluggish response.

Commission errors: this is a score that states the number of times the patient responded, but no target was presented. Difficulties with impulsivity are indicated with a fast reaction time and high commission error rate. A slow reaction time with high commission and omission errors generally points to inattention.

The other metrics not measured commonly are: hit reaction time (HRT), HRT standard deviation, variance, perseverance (random or anticipatory response i.e.  $HRT < 100ms$ ), and block measure to understand sustained attention.

### *3.2. Proposed Measuring Model and Application*

In order to measure the aforementioned metrics, an infrastructure establishment is needed. Therefore, proper object classes were designed and modelled which are utilized in the developed VR attention CPT games in Unity according to UML diagrams depicted in Figure 1. Furthermore, a new framework was developed for measuring timeline of the actions and reactions of the subject those are basically outputs with timestamp associated with each interaction and stimuli.

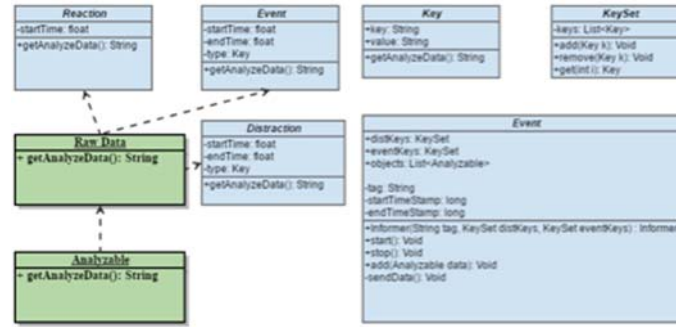


Figure 1. UML diagram of the proposed system to measure the metrics.

Since reviewed CPT tests are found as boring, our aim is to produce attention detection games that children may have fun while using. For this reason, entertainment situations of the games made within the scope of the project are taken into consideration. In this sense, the games have been gradually made more fun so that the correctness of the data can be checked. Within the scope of this process, four different games were developed. All games were designed to engage children in a school environment. Thus, they can feel as if they are at school. In this context, a virtual classroom was created with audio and visual distractions like sound of a motorcycle and a flying paper plane. These distractions are used while expecting an attention from a subject.

### 3.3. Experiment Setup

Mobile phone attachable VR glasses were utilized in the study. To get the reaction of the user, a Bluetooth joystick and a cable mouse were attached to the mobile phone. Unity was chosen as the development environment.

## 4. Results and Discussion

In this work, four different games are developed as shown in Figure 2. The developed attention measuring games are designed for school age children. It is planned that the games will be experimented on the two groups which are test and control. Test group will consist of children medically diagnosed with attention deficit and control group will compose of relatively normal reacting children. This phase of the study is not completed yet, however, the first impressions of adults for experiment are very

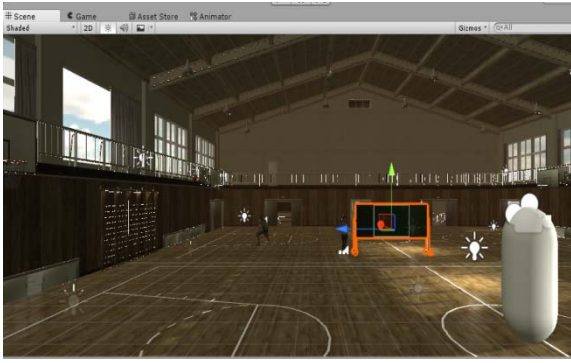
encouraging. The results of the experiments on children will be presented in the following studies.



(a) Virtual classroom



(b) Virtual auditorium hall



(c) Virtual gym



(d) Virtual pool

Figure 2. Plot locations of attendance game scenarios.

## 5. Conclusion and Future Works

In this study, experimental applications, namely, virtual classroom, auditorium hall, gym, and pool, designed for children suffering from ADHD are presented. The aim of the study is to ease the diagnoses process and if possible improve the attention of children. A new model and measurement procedure are presented. Suitable metrics are investigated and embedded in every developed game. The effectiveness of the system will be measured with the forthcoming experiments with aforementioned control and test groups. It is expected to obtain a meaningful and distinguishable correlation between test and control groups.

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