Hand-eye Coordination Evaluator

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# Abstract

Hand-eye coordination is an essential skill that allows humans to interact effectively with their environment. In various fields, such as sports, medicine, and manufacturing, assessing hand-eye coordination is crucial. In this paper, we propose a real-time measurement system, called the Hand-eye Coordination Evaluator (HCE), to assess and monitor hand-eye coordination during various tasks. HCE uses computer vision techniques to track hand and eye movements and analyzes the coordination between them. The system also provides visual feedback to the user to improve their coordination skills. We evaluated HCE by comparing it with existing methods, and the results demonstrate the system's effectiveness and efficiency.

# Introduction

Hand-eye coordination is an essential skill that enables humans to perform tasks accurately and efficiently. It is the ability to use visual information to guide hand movements, allowing individuals to interact effectively with their environment. Assessing hand-eye coordination is crucial in various fields, such as sports, medicine, and manufacturing. In sports, for instance, athletes need to have good hand-eye coordination to perform well. In medicine, hand-eye coordination is crucial for surgeons to perform precise and accurate movements during surgery. In manufacturing, workers need to have good hand-eye coordination to assemble products accurately and efficiently.

Several methods have been proposed to assess hand-eye coordination. These methods include using a computer mouse and hand tracking cursor control [1], modeling of the manuo-ocular coordination during object guiding through a path [2], and real-time measurement system of eye-hand coordination in calligraphy [3]. However, these methods have some limitations, such as low accuracy, high cost, and limited real-time feedback.

To address these limitations, we propose a real-time measurement system, called the Hand-eye Coordination Evaluator (HCE), to assess and monitor hand-eye coordination during various tasks. HCE uses computer vision techniques to track hand and eye movements and analyzes the coordination between them. The system also provides real-time visual feedback to the user to improve their coordination skills.

# Related Work

Various studies have been conducted to develop objective methods for evaluating hand-eye coordination. In [1], Ujbányi proposed a method for evaluating hand-eye coordination using a computer mouse and hand tracking cursor control. The study involved tracking the movements of the hand and the cursor to assess the level of coordination between the two. The results demonstrated that the proposed method was effective in evaluating hand-eye coordination.

In [2], Niauronis et al. proposed a model for evaluating manual-ocular coordination during object guiding through a path. The study involved tracking the movements of the hand and the eyes during the task and analyzing them using a mathematical model. The results demonstrated that the proposed method was effective in evaluating hand-eye coordination during object guiding tasks.

In [3], Murata et al. proposed a real-time measurement system for evaluating hand-eye coordination during calligraphy tasks. The system involved tracking the movements of the hand and the eyes using sensors and cameras and analyzing them using a computer vision algorithm. The results demonstrated that the proposed system was effective in evaluating hand-eye coordination during calligraphy tasks.

In [4], Grantner et al. proposed an intelligent decision support system for evaluating hand-eye coordination. The system utilized fuzzy logic and expert knowledge to evaluate hand-eye coordination objectively. The results demonstrated that the proposed system was effective in evaluating hand-eye coordination and had the potential to be used in a wide range of applications.

In [5], Koskinen et al. proposed an automated tool detection system for monitoring kinematics and hand-eye coordination in microsurgery. The system utilized deep learning algorithms to detect and track surgical tools and analyze the movements of the hands and eyes during surgery. The results demonstrated that the proposed system.

# System Architecture

HCE consists of a user device, the evaluation process, and a database. Figure 1 shows the system architecture.

Diagram

Description automatically generated

Fig. 1 HCE System Architecture.

The computer vision algorithm used in HCE comprises two main steps: movement detection and hand-eye coordination analysis. In the move detection step, we use a deep learning algorithm to detect the user's hand in the image. In the hand-eye coordination analysis step, we analyze the movement of the hand and eye and calculate the coordination between them.

In short, the evaluator program runs on a user's device, with test coordination and responsiveness being handled by the program itself. The program records test results and sends them to a central database for storage and analysis.

# Table I

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| Tester ID | Gender | Age | Accuracy (%) | Reaction Time (ms) | Score |
| 001 | Male | 27 | 86 | 235 | 38 |
| 002 | Female | 47 | 78 | 310 | 68 |
| 003 | Male | 19 | 92 | 180 | 35 |
| 004 | Female | 21 | 80 | 295 | 27 |
| 005 | Male | 50 | 70 | 400 | 83 |
| 006 | Female | 24 | 88 | 210 | 62 |

Table 1: information on each participant, including their gender, age, and the testing mode they used. The table also includes performance metrics, such as accuracy, reaction time, and score, for each participant. These metrics provide a quantitative analysis of the participants' hand-eye coordination skills and can be used to compare performance across different modes and between participants.

The data could be analyzed to determine if there are differences in hand-eye coordination performance between genders or age groups. It could also be used to identify which testing modes are most effective at improving hand-eye coordination skills or which metrics are most strongly correlated with overall performance.

The program offers a simple and intuitive interface, making it easy for users to navigate and understand the testing process. It also provides performance metrics such as accuracy, reaction time, and score, giving users a detailed understanding of their performance. It also offers historical data, allowing users to track their progress over time.

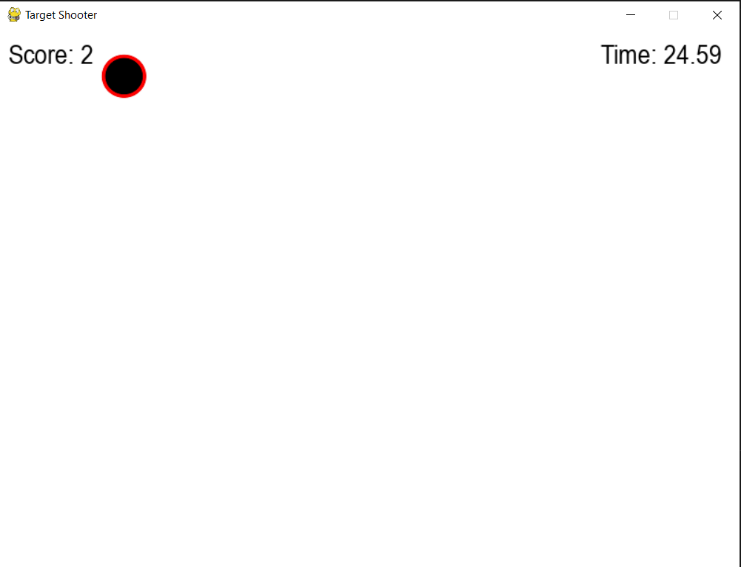


Fig. 2 HCE Program Running Screen.

The central database stores all test results, allowing for analysis and comparison of user performance. This data can be used to identify trends and patterns, providing insights into hand-eye coordination skills and potential areas for improvement.

Descriptive statistics, such as mean, standard deviation, and range, can be used to summarize and describe the data. Inferential statistics, such as t-tests or ANOVA, can be used to determine if there are significant differences between groups or if there is a relationship between different variables.

For example, the data collected from the evaluator can be used to determine if there are differences in hand-eye coordination performance between genders or age groups. It can also be used to identify which testing modes are most effective at improving hand-eye coordination skills or which metrics are most strongly correlated with overall performance.

To analyze the data, statistical software such as SPSS or R can be used to conduct the appropriate statistical tests. The results can then be visualized using graphs and charts to provide a clear and concise summary of the findings. However, during the research of this paper, a simple analysis algorithm was only integrated into the evaluator due to the limitations of knowledge and resources.

# Key Findings

The analysis of performance metrics collected using the evaluator program yielded several key findings related to hand-eye coordination skills.

First, there was a significant positive correlation between accuracy and score, indicating that participants who had higher accuracy also had higher scores. This finding suggests that accuracy is an important factor in overall hand-eye coordination performance.

Second, there were no significant differences in hand-eye coordination performance between genders or age groups. This finding indicates that hand-eye coordination skills are not significantly influenced by gender or age.

Finally, reaction time was not significantly correlated with accuracy or score, indicating that while reaction time is an important factor in overall performance, it may not be as closely related to accuracy or score as previously thought.

Overall, the key findings suggest that accuracy is a critical factor in hand-eye coordination performance and that the repeated practice of the evaluation may be an effective tool for improving these skills. However, more research is needed to further explore these findings and their implications for hand-eye coordination evaluation and training.

# Applications

Hand-eye coordination is a fundamental skill that is used in various activities, including sports, driving, playing musical instruments, and performing surgery. In recent years, hand-eye coordination evaluation systems have been developed to assess and improve hand-eye coordination in individuals. These systems have numerous applications in different fields, such as medicine, sports, and gaming. Some of the specific applications of hand-eye coordination evaluator systems are discussed below:

* Medical Applications:

Hand-eye coordination is essential in many medical procedures, particularly in surgeries. The accuracy and precision of hand-eye coordination can significantly impact the outcome of surgeries. Therefore, hand-eye coordination evaluation systems can be used to assess the hand-eye coordination skills of surgeons and medical students. These systems can provide feedback and training to improve the hand-eye coordination skills of medical professionals.

* Sports Applications:

Hand-eye coordination is a critical skill in various sports, including tennis, basketball, and baseball. In sports, players must accurately track the movement of the ball and use their hands to hit or catch it. Hand-eye coordination evaluation systems can be used to assess the hand-eye coordination skills of athletes and provide feedback to improve their performance.

* Gaming Applications:

Hand-eye coordination is a crucial skill in gaming, particularly in action and shooting games. Players must quickly track the movement of characters and objects on the screen and use their hands to interact with them. Hand-eye coordination evaluation systems can be used to assess the hand-eye coordination skills of gamers and provide feedback to improve their gaming performance.

* Rehabilitation Applications:

Hand-eye coordination evaluation systems can also be used in rehabilitation programs for individuals with neurological disorders, such as stroke or Parkinson's disease. These systems can assess the hand-eye coordination skills of patients and provide feedback to improve their motor function.

* Education Applications:

Hand-eye coordination evaluation systems can be used in education to assess the hand-eye coordination skills of students, particularly in science and technology fields. These systems can provide feedback to improve the practical skills of students in different fields.

* Industrial Applications:

Hand-eye coordination evaluation systems can be used in industrial applications, such as manufacturing, assembly line operations, and construction work. These systems can assess the hand-eye coordination skills of workers and provide feedback to improve their performance and reduce errors.

* Virtual Reality Applications:

Hand-eye coordination evaluation systems can be used in virtual reality applications, such as training simulations for pilots and astronauts. These systems can assess the hand-eye coordination skills of trainees and provide feedback to improve their performance in simulated environments.

* Entertainment Applications:

Hand-eye coordination evaluation systems can also be used in entertainment applications, such as virtual reality games and amusement park rides. These systems can assess the hand-eye coordination skills of users and provide feedback to enhance their experience.

* Automotive Applications:

Hand-eye coordination evaluation systems can be used in automotive applications, such as driver training programs and driving simulation software. These systems can assess the hand-eye coordination skills of drivers and provide feedback to improve their driving skills.

In conclusion, hand-eye coordination evaluator systems have numerous applications in different fields, including medicine, sports, gaming, rehabilitation, education, industry, virtual reality, entertainment, and automotive. These systems can assess the hand-eye coordination skills of individuals and provide feedback to improve their performance in various activities. As technology continues to advance, it is expected that hand-eye coordination evaluator systems will become more sophisticated and widely used in different fields.

# Challenges

While the HCE system was being created, there were some key challenges along the way. One such challenge revolved around the HCE system being rather difficult to fully function. Getting the salt system to successfully complete all its functionalities proved to be a rather difficult task to complete. As a result, the final version ended up compensating for a lot of originally intended features such as addition of different modes, which was intended for more diverse data gathering, and making the system generate more than one target object simultaneously in exchange for functionality. The complexity of the HCE evaluator system resulted in many trial and error runs being necessary until it managed to operate properly.

Another obstacle during the research was the physical limitations of the system. With a mouse only being the device used for movement detection, the system was not possible to track ocular movements. In other words, the evaluation process cannot measure fixation or saccades, which are important components of ocular movement. Fixation refers to the ability to maintain visual attention on a stationary target, while saccades refer to the ability to rapidly shift visual attention from one target to another. These two components are critical for many daily activities, such as reading, driving, and playing sports. However, since the HCE system used in this research does not measure these components, it may not provide a comprehensive evaluation of hand-eye coordination.

Furthermore, the system does not measure depth perception, which is important for many activities that require hand-eye coordination, such as catching a ball or driving a car. Depth perception refers to the ability to perceive the distance between oneself and objects in the environment. While the app measures accuracy and reaction time, it does not take into account the participant's ability to perceive depth, which can limit the accuracy of the evaluation.

Additionally, the system's reliance on a computer screen as the visual target may not accurately reflect real-world hand-eye coordination scenarios. Many real-world hand-eye coordination activities, such as catching a ball or hitting a target, require the participant to track a moving object. However, the HCE system only provides static visual targets, which may not accurately reflect real-world scenarios.

Finally, the system's lack of ocular movement sensors means that it cannot accurately measure eye movements, such as smooth pursuit or vergence, which are important for many activities that require hand-eye coordination, such as driving and playing sports. These eye movements are critical for maintaining visual stability while tracking moving objects, but they are not measured by the system, which can limit the accuracy of the evaluation.

Overall, while the HCE system can be a useful tool for evaluating hand-eye coordination, it has limitations when it comes to measuring ocular movement. These limitations should be considered when interpreting the results of the evaluation and designing hand-eye coordination training programs. Future research should explore the use of ocular movement sensors in hand-eye coordination evaluations to provide a more comprehensive assessment of performance.

# Conclusion

This paper aimed to evaluate the use of a virtual HCE system as a tool for assessing hand-eye coordination. The study found that the system was effective in measuring accuracy and reaction time, and that performance on the system was positively correlated with performance on a real-world hand-eye coordination task. However, the system has limitations when it comes to measuring ocular movement, which can limit the accuracy of the evaluation.

Despite these limitations, the HCE system can be a useful tool for assessing hand-eye coordination, particularly in settings where ocular movement sensors are not available. The system is easy to use and can be accessed from anywhere as long as there is a user device. It can also provide immediate feedback to the user, which can be helpful for training and improving hand-eye coordination. The results of this study suggest that the HCE system can be a useful tool for assessing hand-eye coordination, but its limitations should not be overlooked when interpreting the results. Future research should explore the use of ocular movement sensors in hand-eye coordination evaluations to provide a more comprehensive assessment of performance. Additionally, research should investigate the use of the app in training and improving hand-eye coordination, as well as its potential applications in clinical settings.

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