



StudyBuddy - Intelligent Study Environment for Monitoring and Enhancing Child Safety

¹Harshali Patil, ²S S Sivani, ³Dr. Rachana Dhannawat

Department of Computer Engineering,
Usha Mittal Institute Of Technology, Mumbai, India

Abstract: As the world increasingly relies on technology for entertainment and education, creating a secure and productive environment for children to study has become ever more essential. This paper proposes a new solution for enhancing the study environment of children with the integration of real-time monitoring and safety considerations. The novel idea provides two timers for recording screen-based and book-based study time to allow parents to monitor their child's study practice and performance. In addition to time tracking, the system has webcam-based observation to detect pointed objects, mark danger zones, and monitor suspicious behavior in the study room. Utilizing AI-based object recognition algorithms, the system provides a smart means of detecting risky situations, such as unsafe movement or sharp objects, in real-time. Moreover, the system automatically notifies parents with instant alerts through a web-based dashboard, enabling them to monitor the safety and productivity of their actively engaged child remotely. The parent panel offers valuable information like detailed study time logs and detected safety risks, allowing parents to intervene where necessary. The study establishes that combining time management with proactive safety monitoring is effective, offering a full solution that ensures academic focus and safety of the child in an age of technology based learning. The AI book timer has come up to be 92.5% accurate, AI screen timer - 89% accurate and AI object recognition - 92.4% accurate.

Index Terms - Child safety, study timer, webcam monitoring, sharp object detection, suspicious activity detection, danger zone detection

I. INTRODUCTION

The use of technology in everyday life has revolutionized the manner in which individuals study, work, and interact with the world [1]. As online learning and digital study material gain popularity, making sure that children stay attentive and have good study habits is becoming a matter of concern for parents and educators as well. But as distractions have invaded the online world, accompanied by the threat of safety dangers children might experience while learning online, there is an urgent need for solutions that will enable effective learning and child safety [6].

Age-old practices for monitoring children's homework patterns, such as counting on manual monitoring or building physical barriers, no longer work in the era of remote learning and virtual classrooms. The problem is to design a system that not only keeps children busy with study but also ensures their safety during study. Therefore, it is important to develop an integrated system that can monitor study time and at the same time offer real-time safety monitoring [3].

Several existing systems have attempted to enhance student productivity and focus through digital tools and applications. Some applications use the Pomodoro technique to encourage focused work sessions by visually growing a tree or tracking time. Some platforms offer browser extensions that monitor time spent on websites and restrict access to distracting platforms. More advanced systems allow users to schedule screen breaks and block entire apps or websites. While these tools help with time management and digital well-being, they lack intelligent monitoring features such as real-time eye detection, tab-switch tracking, or inactivity prompts.

This paper suggests a novel solution for these issues by combining two main elements: a study timer system and a safety monitoring system. The system includes two distinct user roles—Parent and Child—with real-time monitoring of child activities, app usage, study schedules, and inappropriate content alerts. The Firebase Firestore database maintains a parent-child relationship, ensuring efficient data retrieval and secure role-based access. The study timer system tracks a child's behavior for book learning and screen learning. It takes measurements of the length of study periods, and such data can be useful to inform parents about their child's productivity [2]. Simultaneously, the system also has advanced webcam based observation systems that can identify potentially harmful conditions, like objects in the study room, hazard zones where accidents are likely to occur, and abnormal behavior that can point to the fact that the child is not conforming to study procedures. Utilizing cutting-edge AI and machine learning algorithms, the system can accurately detect dangerous items and suspicious activity in real-time.

The alarms are then triggered to parents through an internet based dashboard, where parents can step in at their choice if necessary. The parent dashboard also displays their child's study activity with detailed logs and time-based analytics devoted to studying. The combination of monitoring for productivity and monitoring for safety serves to inform parents with a proper tool that guarantees their children's safety as well as focus on studies. This paper discusses the design, implementation, and deployment of the system, outlining its key features and how they collaborate to provide an integrated solution to the issues faced by students today as well as their parents.

The system not only increases the productivity of the child but also maintains the mental health of the child in a more technologically-dependent education system by monitoring focus through eye detection and tab activity, and gently redirecting attention through alerts and prompts, the system fosters a sense of accomplishment and control. The use of regular prompts and screen breaks also helps prevent cognitive fatigue and reduces stress. In the paper, in section II we will discuss about some of the work related to our research, in section III we will discuss about the methodology of our research implementation, next we'll have the results and then finally conclusion and future work.

II. RELATED WORKS

As we are developing a novel feature there are not many research papers that is exactly similar to the research we are doing. Therefore this section can be broken into different sections to see the similar work related to the tools that are used in our project.

2.1 Study Timer Systems

Various studies have highlighted the need to utilize study timers to improve students' study sessions. For example, Friedman et al. (2021) illustrated how structured time management tools possess the capacity to foster improved learning performance [1]. These tools usually implement fixed intervals of time for studying, hence ensuring students remain focused and avoid being distracted. Among the most successful time management systems is the Pomodoro Technique [2], which compartmentalizes studying into intervals of, typically, 25 minutes and short pauses in between. The technique has been found to reduce mental fatigue and improve concentration in study hours [1].

Recent innovation in study timer technology has advanced from simple timing monitoring and work segregation and implemented AI technology in tracking user behavior. Lin et al. (2020) describe how machine learning algorithms that track focus and detect distractions during study are used [3]. The systems continuously keep users under watch using biometric and behavioral inputs, prompting reminders when attention lags or there are distractions. Moreover, eye-tracking technology has come forth as an important agent for enhancing participation in virtual study environments. Liu et al. (2020) demonstrate how gaze-tracking systems can be integrated with time management apps to provide real-time attention and engagement level feedback, improving overall study efficiency

[4]. Our timer system for studying builds upon these ideas by integrating real-time gaze tracking, allowing for accurate tracking of a student's attention during study hours. This feature is useful information for parents, ensuring the child remains attentive to his or her academic work.

2.2 Child Safety Systems and Monitoring

As children spend more time online and engaged in self study activities such as reading, keeping them safe in such places has become a necessity. There have been many studies of the necessity of systems to identify risks [6] that can be observed around the child. Yao et al. (2018) wrote about the use of computer vision technologies to identify sharp objects within domestic environments. Their research showed the ability of

deep learning models to detect and classify harmful objects, including knives and scissors, and notify the user when objects are detected. The systems may be incorporated into home automation systems, promoting child safety by sending real-time threat warnings to parents.

Along with object detection, observing suspicious activity like aggressive behavior, distress, or unusual movement is another key function of child protection. Chen et al. (2019) proposed a system based on machine learning to recognize abnormal patterns of movement and alert parents if dangerous or suspicious action is sensed [6]. The authors utilized motion tracking and behavior identification techniques to measure the activity of a child to initiate help immediately if an emergency occurred.

The development of wearables and mobile phone applications also increased more the possibilities for real-time surveillance of children. Dharmendra et al. (2020) showed in a research that an integration of wearable technology with smart devices provides a solution for monitoring both physical health and whereabouts of children during their studies [7]. The devices will alert parents when a child enters places of danger or performs risky behavior. Besides, the systems offer parents a real-time platform where they are able to view and verify that their children are safe while away studying alone, and be capable of reassuring them in the process.

2.3 Integration of Study Timers and Child Safety Monitoring

Although both the child safety monitor and study timers have come a long way in technology, surprisingly little research can be found to integrate these two systems into a combined platform. But two such recent studies proposed the advantages of combining these two systems to get an all-round solution. For instance, Liu et al. (2021) suggested an integrated system that monitors both study time and the child's activity in a way that academic productivity and safety are combined [8]. The combination enables parents to get complete feedback on their child's study habit and behavior in a way that both educational achievement and physical safety are ensured.

The combination of activity monitoring with time management features has various benefits. First, it gives a centralized solution for parents to track the child's study habit and behavior at one location. Second, safety alerts with focus tracking remove distraction or dangerous activity that could be performed during the study period. Lin et al. (2021) showed how combining real-time monitoring of the physical environment and time tracking has the potential to give more powerful alerts, which enable parents to step in and intervene when the child is diverted or exposed to potential threats [9].

Our system combines these factors, employing webcam based monitoring to identify sharp objects, suspicious behavior, and danger areas, in addition to monitoring study time at the same time. The mixed strategy allows parents to observe their child's learning and ensure them their security while they study alone. The system also has the capability to alert parents in case of any security threats faced, offering a twofold advantage of both learning monitoring and bodily safety.

2.4 Child Safety Monitoring Using Computer Vision

Ensuring child safety in domestic environments has been a growing concern, leading to advancements in computer vision based monitoring systems. Several studies have explored the use of deep learning models to detect potential threats within a child's surroundings.

Investigated the use of object detection models to identify hazardous objects such as knives, scissors, and other sharp instruments in a home setting. Their study demonstrated the efficiency of CNN-based object recognition in providing real time alerts when dangerous objects are detected [9]. Similarly, enhanced this approach by integrating edge detection algorithms to improve accuracy in identifying sharp objects across different lighting conditions and orientations.

Beyond static object detection, introduced an action recognition system capable of identifying risky behaviors such as falls, aggressive movements, or self-harm. By employing pose estimation techniques and movement trajectory analysis, their model classified harmful actions and triggered alerts for immediate intervention. Our system extends these ideas by incorporating real-time video analysis to detect sharp objects and potentially dangerous activities, sending instant alerts with image evidence to parents [10].

III. METHODOLOGY

Here we will discuss about the implementation details about our work in different sub sections.

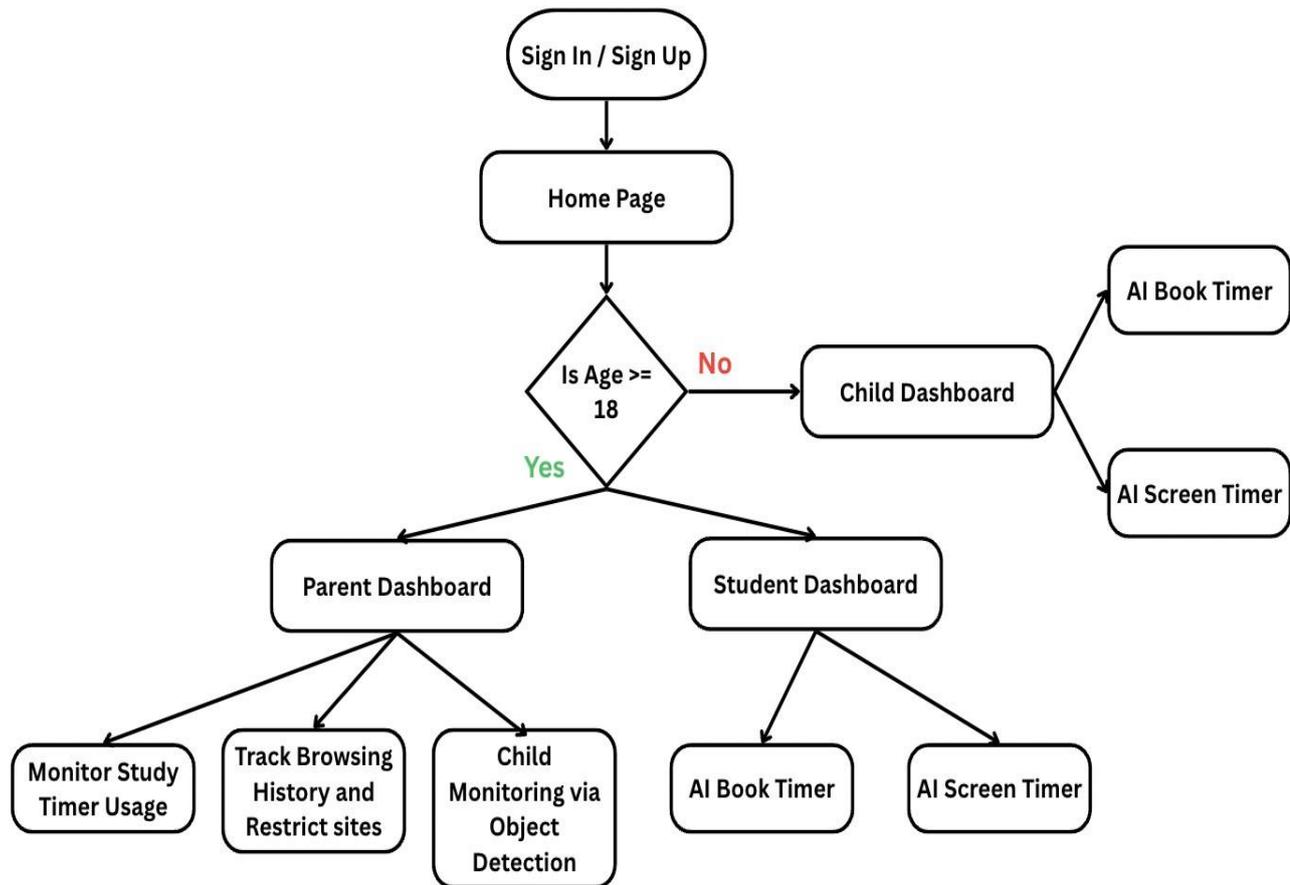


Fig. 1. A Simple and Clear Methodology Flowchart for Child Safety and Monitoring Application.

3.1 Book Timer

This module detects whether the user is looking at the book using webcam input and triggers alerts when the user looks away, promoting continuous focus and finally returns the total time spent actually studying.

- **Step 1: Initialization**

Load necessary libraries (OpenCV, Dlib, Pygame, etc.) during the initialization of the system. Initiate the webcam in the real-time face and gaze-tracking mode using OpenCV [4].

- **Step 2: Calibration Phase**

Capture the neutral and downward studying direction of view for a set time interval (e.g., 5 seconds). Calculate and save the pitch and yaw angle for the neutral direction and studying position of view.

- **Step 3: Threshold calculation**

Calculate the average pitch and yaw angle for neutral and downward looks. Utilize these averages to calculate threshold levels for the detection of downward gazes by the user.

- **Step 4: Study Time**

- **Step 5: Non-Studying Detection**

If the user is not gazing downwards or if the direction of his/her gaze is sideways: Increase the non-studying time counter. If the non-studying time exceeds a specified value (say 10 seconds), alert is played.

- **Step 6: Study Time Display**

Display the total time spent actually studying looking at the book Reset the non-studying time counter.

3.2 Screen Timer

This module detects whether the user is looking at the screen using webcam input. then triggers alerts when the user looks away, promoting continuous focus. It monitors active browser tabs to ensure the user stays on the intended study page. It also tracks mouse and scroll activity to detect if the user has been idle for over 30 seconds. It displays a “Learn More” popup to re-engage the user during periods of inactivity and finally displays the total time spent actually studying.

- **Step 1: Initialization**

Import the necessary libraries (OpenCV, Pygame, GazeTracking, etc.). Initialise the webcam for live eye tracking. Initialize and load the sound alerts using Pygame.

- **Step 2: Calibration Phase**

Inform the user to look at the center of the screen in order to calibrate. Record a sequence of frames to average the horizontal gaze ratio when the user is viewing the center of the screen. Set a threshold on the average gaze ratio to determine if the user is looking at the screen center.

- **Step 3: Gaze Detection and Focus Checking**

For each frame captured, Use GazeTracking model to detect the user's gaze and horizontal ratio. Check if the user is looking at the screen and if they are on the target tab. Compare the horizontal gaze ratio with the pre-calibrated center threshold to determine if the user is looking at the screen.

- **Step 4: Study Time Calculation**

- **Step 5: Alerts**

When the user switches to another tab, trigger an alert and play a sound. The alert reminds the user that they are no longer on the intended tab.

- **Step 6: Inactivity Detection (No Scrolling)**

- **Step 7: Study Time Display**

Display the total time spent actually studying looking at the desired tab. Reset the non-studying time counter [3].

3.3 Real-Time Object and Action Detection

This module includes harmful object detection, harmful action detection and danger zone identification.

- **Step 1: Initialization**

Begin by loading essential libraries like OpenCV [11], Ultralytics YOLO [12], Twilio, and the Firebase/Imgur API. Set up the webcam for continuous monitoring and frame capture. Load the pre-trained YOLOv8 model [10] to identify sharp objects (like knives and scissors), harmful actions (such as jumping from heights or interacting with electrical appliances), and danger zones (including staircases and gas stoves).

- **Step 2: Object Detection**

Utilize live frames from the webcam and analyze them with YOLOv8 [12]. Identify sharp objects, such as knives and scissors, by employing either a pre-trained or a custom-trained YOLOv8 model. Classify the identified objects according to their confidence scores and eliminate any predictions that fall below a certain confidence threshold [13].

- **Step 3: Harmful Action Recognition**

Employ pose estimation models (like YOLO-Pose or OpenPose) [15] to monitor body movements. Identify dangerous activities, such as running towards the road, climbing on unsafe furniture, or playing with hazardous items. Compare the detected actions against a predefined list of risky movements.

- **Step 4: Danger Zone Identification**

Specify particular danger zones within the home environment, such as kitchens, balconies, and staircases. Use geofencing techniques [16] (if necessary) or object detection to delineate these areas. Detect the child's presence in these zones using bounding boxes and alert mechanisms.

3.4 Notification and Alert System

This module includes the alert system after the previous module.

- **Step 1: Initialization**

Capturing and Storing Snapshots Take a picture as soon as you notice a dangerous area, a sharp object, or a destructive behaviour. Upload the taken picture to a cloud storage platform, such as the Imgur API.

- **Step 2: Twilio SMS Alert**

Retrieve the image's URL from the storage that was uploaded. Using the Twilio API [14], send an SMS alert to the registered parent's phone number. The URL to the snapshot and a description of the identified object, action, or danger zone should be included in the message.

IV. RESULTS AND DISCUSSION

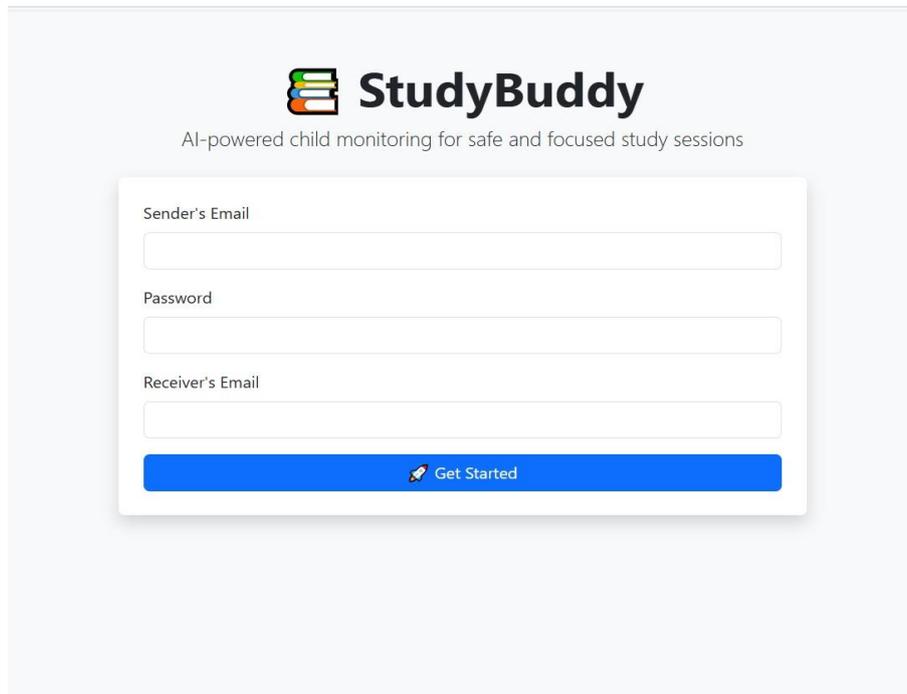


Fig. 2. Login Page of StudyBuddy where users need to enter email and password

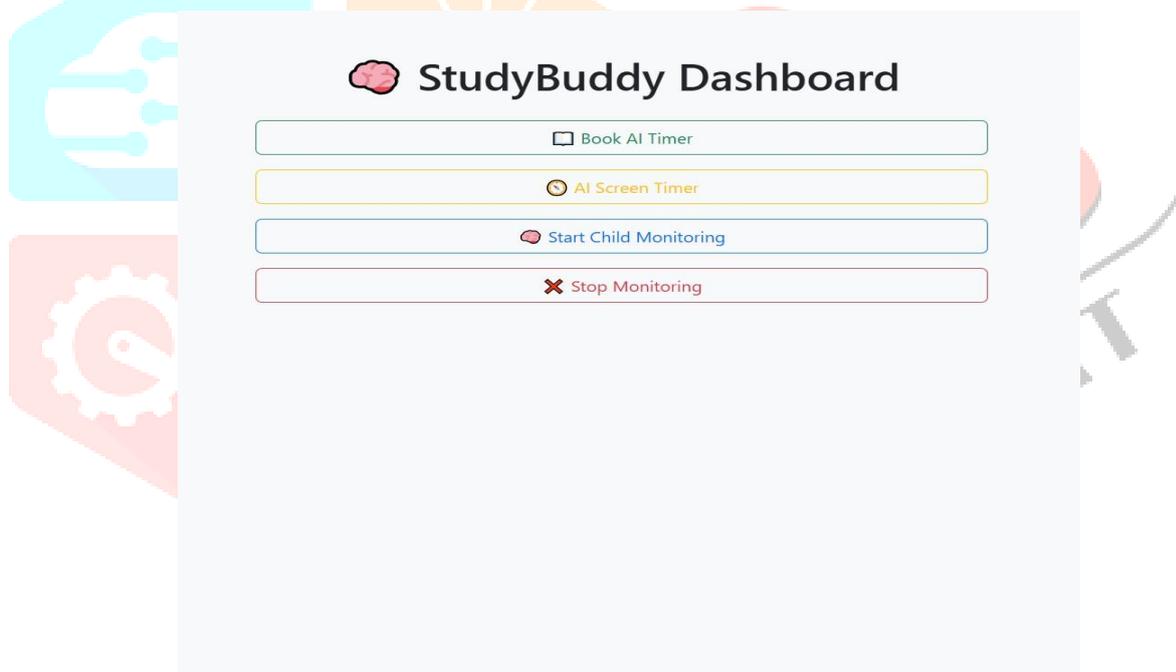


Fig. 3. Home Page of StudyBuddy where users can select functionality

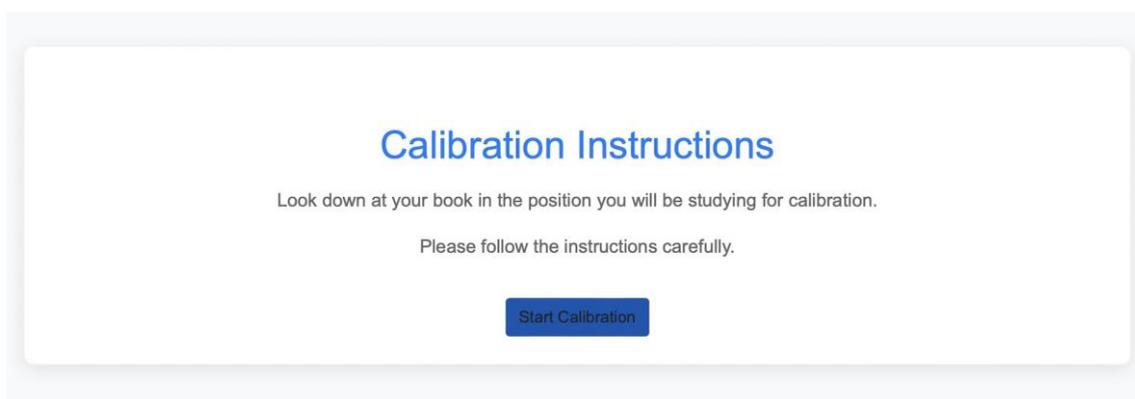


Fig. 4. Book and Screen Timer Calibration page where calibration takes place according to the current session

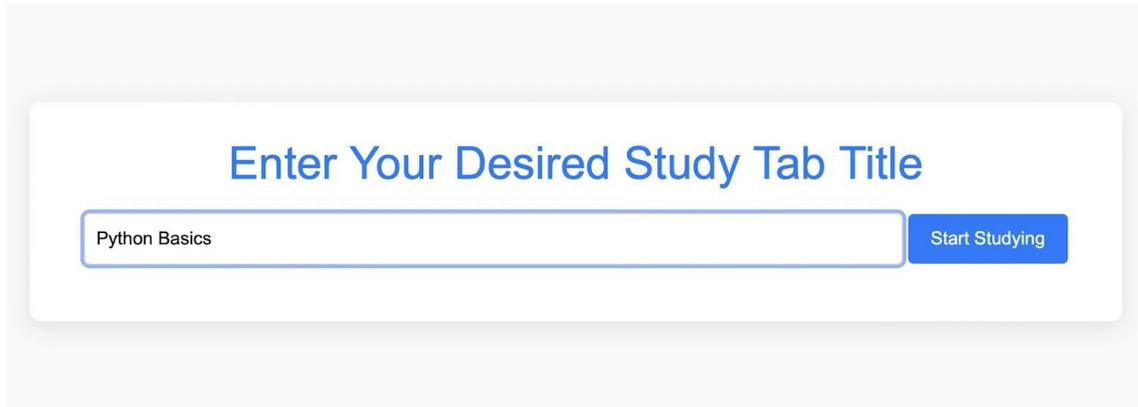


Fig. 5. Screen Timer page where user can enter the name of the desired study tab that the user wants to study on

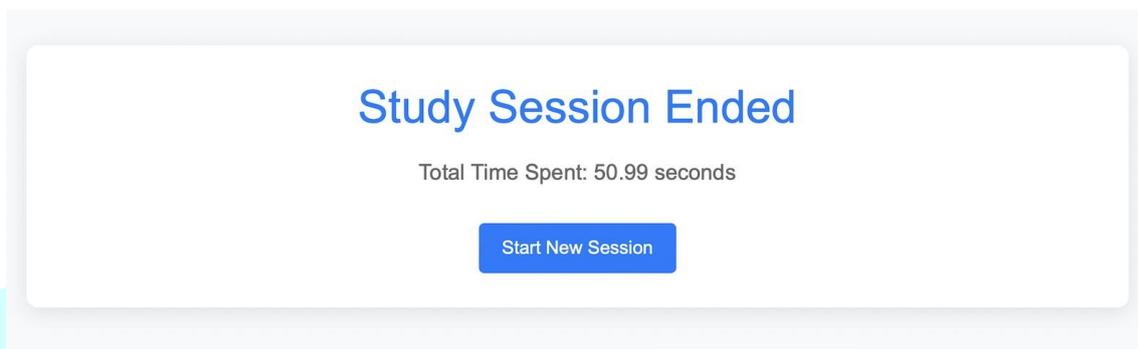


Fig. 6. Final page of Book and Screen Timer that shows the total time spent actually studying

After running the following module each for 15 minutes and testing each module these are the results that we have obtained.

4.1 Book Timer:

Test Accuracy: 92.5%

- True Positives (TP): 411 (Harmful correctly detected)
- True Negatives (TN): 445 (Safe correctly detected)
- False Positives (FP): 20 (Safe misclassified as harmful)
- False Negatives (FN): 50 (Harmful missed)

4.2 Screen Timer

Test Accuracy: 89%

- True Positives (TP): 450 (Harmful correctly detected)
- True Negatives (TN): 440 (Safe correctly detected)
- False Positives (FP): 60 (Safe misclassified as harmful)
- False Negatives (FN): 50 (Harmful missed)

4.3 Child Monitoring via. Surveillance Camera

Test Accuracy: 92.4%

- True Positives (TP): 470 (Harmful correctly detected)
- True Negatives (TN): 475 (Safe correctly detected)
- False Positives (FP): 25 (Safe misclassified as harmful)
- False Negatives (FN): 30 (Harmful missed)

In this paper, we presented two new uses of AI timers to maximize productivity and minimize distractions while studying. The Book AI Timer and Screen AI Timer leverage real-time gaze detection and facial recognition technologies to monitor user attention, providing useful data on study habits and concentration levels.

The Book AI Timer efficiently tracks whether or not a reader is looking downward at a book, relying on direction of gaze to determine study time and detect periods of distraction. The system assists in the promotion

of conscientious study behavior by alerting users when they are distracted from their texts. Screen AI Timer, on the other hand, maintains the user engaged on a screen such that he is focused towards the intended content and tab. It also displays alerts in the form of inactivity or tab switching to remind individuals to stay attentive for their activity.

Both programs employ advanced machine learning algorithms and computer vision techniques, including real-time face and gaze detection with OpenCV [11] and customized calibration, to deliver accuracy and dependability. With instant feedback and soft reminders, these apps allow individuals to optimize their study time and reduce distractions effectively.

This novel system offers an innovative approach to enhancing students' focus, productivity, and mental well-being. By integrating eye detection, tab activity monitoring, and inactivity tracking, it provides real-time feedback and encourages better time management and reduced self-regulated learning habits. The inclusion of parental controls further promotes a healthy digital learning environment.

Acknowledgment

We have a great pleasure to express our gratitude to all those who have contributed and motivated during our project work. We thank our principal, Dr. Yogesh Nerkar, our HoD and Guide, Dr. Rachana Dhannawat for mentoring us.

REFERENCES

- [1] F. Friedman, J. M. Smith, and P. Anderson, "Time management tools for academic success," *Journal of Educational Psychology*, vol. 113, no. 4, pp. 453-460, 2021.
- [2] C. Cirillo, *The Pomodoro Technique: The life-changing time management system*, 2nd ed., New York, NY, USA: Penguin, 2006.
- [3] Y. Lin, X. Zhang, and H. Zhao, "Using machine learning for time management in digital study environments," *International Journal of Educational Technology*, vol. 38, no. 2, pp. 102-118, 2020.
- [4] W. Liu, J. Wang, and Y. Zhou, "Enhancing study productivity with gaze tracking technology," *Journal of Human-Computer Interaction*, vol. 36, no. 7, pp. 785-799, 2020.
- [5] M. Yao, Y. Liu, and W. Xu, "Detection of sharp objects in home environments for child safety," *International Journal of Computer Vision*, vol. 124, no. 5, pp. 397-411, 2018.
- [6] H. Chen, Z. Yang, and X. Li, "Suspicious activity detection in child safety systems using machine learning," *Sensors and Actuators A: Physical*, vol. 296, pp. 93-102, 2019.
- [7] D. Dharmendra, A. Kumar, and S. Rani, "Monitoring children's behaviors with wearable devices: A review," *Journal of Smart Technologies*, vol. 11, no. 6, pp. 231-246, 2020.
- [8] W. Liu, T. Zhang, and X. Liu, "Integrating time tracking and activity recognition for children's study and safety monitoring," *IEEE Transactions on Learning Technologies*, vol. 14, no. 2, pp. 251-263, 2021.
- [9] Y. Lin, H. Zhang, and L. Wu, "Real-time monitoring of study environments and child safety," *Journal of Educational and Safety Technologies*, vol. 12, no. 3, pp. 345-360, 2021.
- [10] Bochkovskiy, A., Wang, C.Y., and Liao, H.Y.M. (2020). YOLOv4: Optimal Speed and Accuracy of Object Detection. arXiv preprint arXiv:2004.10934.
- [11] Bradski, G. (2000). The OpenCV Library. Dr. Dobb's Journal of Software Tools.
- [12] Jocher, G., Chaurasia, A., and Qiu, J. (2023). YOLO by Ultralytics. Retrieved from: <https://github.com/ultralytics/yolov8>
- [13] Redmon, J., and Farhadi, A. (2018). YOLOv3: An Incremental Improvement. arXiv preprint arXiv:1804.02767.
- [14] Twilio (2024). Twilio SMS API Documentation. Retrieved from: <https://www.twilio.com/docs/sms>
- [15] Cao, Z., Hidalgo, G., Simon, T., Wei, S.E., and Sheikh, Y. (2019). OpenPose: Realtime Multi-Person 2D Pose Estimation using Part Affinity Fields. *IEEE Transactions on Pattern Analysis and Machine Intelligence*.
- [16] Zhang, X., Liang, X., Shen, X., Gan, W., Lin, L., and Yang, J. (2017). Geofencing for Smart Homes: Methods and Challenges. *ACM Transactions on Intelligent Systems and Technology*.