Random Interval Query and Face Recognition Attendance System for Virtual Classroom using Deep Learning

Karthikeyan S¹, Mohamadyousuf I² And Ramanan N³

¹,²,³ Department Of Computer Science And Engineering, Kongunadu College Of Engineering And Technology, Trichy, Tamil Nadu-621215 India.

Mrs.L.NIVETHA,M.E⁴
Assistant Professor, ⁴Department Of Computer Science and Engineering, Kongunadu College of Engineering and Technology, Trichy, Tamil Nadu-621215 India.

Abstract

The COVID-19 pandemic outbreak has resulted in an unprecedented crisis across the globe. The pandemic created an enormous demand for innovative technologies to solve crisis-specific problems in different sectors of society. In the case of the education sector and allied learning technologies, significant issues have emerged while substituting face-to-face learning with online virtual learning. Several countries have closed educational institutions temporarily to alleviate the COVID-19 spread. The closure of educational institutions compelled the teachers across the globe to use online meeting platforms extensively. In this regard, students' attendance management in virtual classes is a major challenge encountered by the teachers. Student attendance is a measure of their engagement in a course, which has a direct relationship with their active learning. However, during virtual learning, it is exceptionally challenging to keep track of the attendance of students. Calling students' names in virtual classrooms to take attendance is both trivial and time-consuming. Thus, in the backdrop of the COVID-19 pandemic and the extensive usage of virtual meeting platforms, there is a crisis-specific immediate necessity to develop a proper tracking system to monitor students' attendance and engagement during virtual learning. In this project, we are addressing the pandemic-induced crucial necessity by introducing a novel approach. In order to realize a highly efficient and robust attendance management system for virtual learning, we introduce the Random Interval Query and Face Recognition Attendance Management System (hereafter, AI Present). To the best of our knowledge no such automated system has been proposed so far for tracking students' attendance and ensuring their engagement during virtual learning.
1. Introduction

A virtual classroom is an online teaching and learning environment where teachers and students can present course materials, engage and interact with other members of the virtual class, and work in groups together. The key distinction of a virtual classroom is that it takes place in a live, synchronous setting. Online coursework can involve the viewing of pre-recorded, asynchronous material, but virtual classroom settings involve live interaction between instructors and participants. Virtual classrooms and distance learning, as alternate technology-driven learning methods, have been growing at a reasonable pace. Virtual classrooms have been specifically in use by all sectors, including primary and higher education as well as corporate learning.

The increasing popularity of social and microlearning strategies, fostered by general social media platforms like YouTube and Twitter, and major educational technology disruptions like edX, have added to the increasing acceptance of virtual modes of learning. It is expected that the predominant use of virtual classrooms would increase by a whopping 16.2% compounded annual growth rate by 2023. Nevertheless, virtual classrooms have not yet been considered as a serious alternative or substitute for the contemporary face-to-face (F2F) learning. Things have started to look different, however, in the wake of the current, novel coronavirus COVID-19 pandemic, since the entire world is under lockdown.

It is the time of the year when academic and teaching activities are in full swing in most parts of the world. The current pandemic situation has paved the way for a ground test of virtual classrooms as a prominent tool of learning in the current times. Schools, colleges, universities, corporates, and even world bodies and multilateral organizations like the UNO, WHO, and G20 have had to switch to the lesser-used virtual mode of learning and communications. These emergent circumstances stand as a conducive test for companies offering virtual classroom platforms and services like Blackboard, Desire2Learn, Cisco, Microsoft, etc. The test parameters are varied, some predominant ones being bandwidth management, network traffic, server response time, and a number of concurrent users.

2. A virtual classroom includes the following features

- **Video conferencing:** using the best web conferencing software to facilitate learner-teacher-learner communication
Digital whiteboards: offering real-time demonstrations and diagrams

Instant messaging: allowing typed conversations on lower bandwidths

Participation controls: enabling students to participate in discussions, mute their surroundings or virtually “raise” their hands

Sub-chats: breakout rooms to facilitate collaboration between learners

Video recording: to save live lectures as video-on-demand for later reference

End-to-end encryption: to ensure virtual classroom access is restricted to authorized learners

3. Types Of Virtual Classrooms That Are Learner-Friendly

Virtual classrooms can be tweaked depending on the use required of them. They may feature as an add-on in a course or form the backbone of an entire course; either way, virtual classrooms are highly customizable.

- Enriched virtual type

In this type, the majority of the course is carried out online, save for a few offline components to augment lessons and curricula. These components are most popularly in the form of face-to-face meetings with instructors or collaborative meetings with fellow learners over a critical assignment or thesis.

- Rotation type

Often used as part of the flipped classroom technique, rotation involves using both virtual and offline classrooms on rotation according to a schedule. In many cases, primary learning happens online, while in-person meetings happen for reinforcement and review.

- Fully online type

As the name suggests, a fully online classroom doesn’t require or allow for face-to-face offline interactions. These course types could be synchronous or asynchronous in that they use pre-recorded videos and minimal live interaction through online meeting software.

- Flexible type

In this type, the virtual classroom remains open and available for students to access at times convenient to them.
Otherwise, learning is encouraged through small groups, with the virtual classroom forming a place to return to in case of questions.

- **Mix-and-match type**

As the name suggests, this model allows students to select a method that works best for them, such that they gain maximum knowledge. It is a combination of digital teaching models and can either be student-led or institution-governed.

4. **Problems Identified**

The pandemic created an enormous demand for innovative technologies to solve crisis-specific problems in different sectors of society. In the case of the education sector and allied learning technologies, significant issues have emerged while substituting face-to-face learning with online virtual learning. The existing structures and processes of face-to-face learning have been disrupted because of the unforeseen situation that emerged out of COVID-19. Owing to the mandatory social distancing compelled by the pandemic, the standard operating mode of educational institutions around the world has changed into virtual mode significantly. Several countries have closed educational institutions temporarily to alleviate the COVID-19 spread.

The closure of educational institutions compelled the teachers across the globe to use online meeting platforms extensively. The virtual classrooms created by online meeting platforms are adopted as the only alternative for face-to-face interaction in physical classrooms. Subsequently, online meeting platforms like Zoom, Google Meet, Microsoft Teams, and Cisco Webex Meetings are used to create virtual classrooms. Educational institutions, teachers, and students are finding more advantages in using virtual learning that were not previously popular. On the other hand, researchers have identified several challenges associated with the widespread use of virtual learning, which is characterized by quite a lot of interrelated features pertaining to students, teachers, and the technologies involved.

In this regard, students' attendance management in virtual classes is a major challenge encountered by the teachers. Student attendance is a measure of their engagement in a course, which has a direct relationship with their active learning. Attendance in a course is a prerequisite as mandated
by various universities for the students to take their final examinations in every course. Further, the inclusion of attendance data on students' grade cards is a strategic decision of many universities across the globe to enhance students' attendance and engagement. However, during virtual learning, it is exceptionally challenging to keep track of the attendance of students.

Calling students' names in virtual classrooms to take attendance is both trivial and time-consuming. Due to the inherent characteristics of virtual learning, students may resort to unethical activities like not attending the class but still keeping their status as 'online'. Moreover, any student can go offline at any time without letting the teacher know. Further, it is not easy to find out whether the student is really attending the class or just being online without paying attention. In this case, teachers may not be able to check whether the student is actually present and paying attention to the class, as the student might have turned off the video camera.

5. Artificial Intelligence

Artificial Intelligence (AI) is the field of computer science dedicated to solving cognitive problems commonly associated with human intelligence, such as learning, problem solving, and pattern recognition. Artificial Intelligence, often abbreviated as "AI", may connote robotics or futuristic scenes, AI goes well beyond the automatons of science fiction, into the non-fiction of modern-day advanced computer science. Professor Pedro Domingo’s, a prominent researcher in this field, describes “five tribes” of machine learning, comprised of symbolists, with origins in logic and philosophy; connectionists, stemming from neuroscience; revolutionaries, relating to evolutionary biology; Bayesians, engaged with statistics and probability; and analogizes with origins in psychology. Recently, advances in the efficiency of statistical computation have led to Bayesians being successful at furthering the field in a number of areas, under the name “machine learning”.

Similarly, advances in network computation have led to connectionists furthering a subfield under the name “deep learning”. Machine learning (ML) and deep learning (DL) are both computer science fields derived from the discipline of Artificial Intelligence. Broadly, these techniques are separated into “supervised” and “unsupervised” learning techniques, where “supervised” uses training data that includes the desired output, and “unsupervised” uses training data without the desired output.

AI becomes “smarter” and learns faster with more data, and every day, businesses are generating this fuel for running machine learning and deep learning solutions, whether collected and
extracted from a data warehouse like Amazon Redshift, ground-trotted through the power of “the crowd” with Mechanical Turk, or dynamically mined through Kinesis Streams. Further, with the advent of IoT, sensor technology exponentially adds to the amount of data to be analyzed -- data from sources and places and objects and events that have previously been nearly untouched.

6. Scope of the project

In order to realize a highly efficient and robust attendance management system for virtual learning, this project introduce the Random Interval Attendance Management System (hereafter, AIPresent). To the best of our knowledge no such automated system has been proposed so far for tracking students' attendance and ensuring their engagement during virtual learning. The proposed method is the simplest and the best approach to automatically capture the attendance during virtual learning. The significance of the AIPresent model is that it precisely monitors attendance in virtual classrooms without hindering the learning process. Further, it can generate dedicated attendance reports, pinpointing students' attention during virtual learning at random time intervals. Moreover, the novel random attendance tracking approach can also prevent the dropping out of participants from the virtual classroom. Randomness ensures that students cannot predict at which instant of time the attendance is registered.

Another added advantage of the RIAMS approach is that it requires only nominal internet bandwidth in comparison with the existing face recognition-based attendance tracking systems. AIPresent is in such a way that it does not affect the learning process in any way. Neither the students nor the teachers will have to face any difficulties in virtual classrooms with the AIPresent design. As the random intervals required for executing AIPresent attendance tracking modalities are too short (30 seconds, or less), the teaching-learning process is not affected. The proposed model can be easily scaled and integrated into a wide variety of virtual meetings, including business meetings.

7. Objective

The key objective of AIPresent is to develop a robust system that monitor students' attendance and engagement in a virtual classroom, at random intervals of time.
It encompasses a novel design using the AI Deep CNN (Convolution Neural Network) model to capture face biometric randomly from students' video stream and record their attendance automatically.

Thus, the main component of the proposed model is a face recognition module built using the AI-DL tools.

RIAMS also incorporates ancillary submodules for assessing students' responses to CAPTCHAs and UIN queries, to ensure active engagement in virtual classrooms.

8. Algorithm:

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Algorithm 1  Training algorithm of CNN

Input:
train_x, train_y: features and labels of Training Set 

Output:
\( w_{ij}, b_{ij} \): weights and bias of Convolution and Pooling Neural Network (CPNN). 
\( w_{jk}, b_{jk} \): weights and bias of Full Connection Neural Network (FCNN, FCNN have 2 layers) 

Required parameters:

\( \text{max\_time} \): maximum value \( n \) of nACs in every ISP 
\( \text{target\_error} \): when the current training error is less than target error, the training is finished 
\( \eta, \text{CPNN} \): the learning rate of CPNN 

Initialization work:
\( w_{ij}, b_{ij}, w_{jk}, b_{jk} \): weights and scaling parameters of CNN (CPNN+FCNN) are set as random numbers. 
\( t \): \( t \) is the current simulation time, which is initialized as \( t = 1 \) before the training loop. 
\( L(t): L(t) \) is the mean square error at simulation time \( t \). \( L(t) \) is initialized as \( L(1) = 1 > \text{target\_error} \).

Begin:
1: Set the required parameters and complete the initialization work
2: while \( t < \text{max\_time} \) and \( L(t) > \text{target\_error} \)
3:   for all trainingSet:
4:       train_p (prediction of label) is calculated according to train_x and forward calculation formula 1-9
5:   end for
6:   L(t) is re-calculated as \( L(t) = \frac{1}{2} \sum_{n=1}^{N} (\text{train}_p(n) - \text{train}_y(n))^2 \), \( N \) is the total number of trainingSet.
7:   \( \Delta w_i, \Delta b_i, \Delta w_{ij}^{-1}, \Delta b_{ij}^{-1} \) are updated according to the formula 20-23
8:   \( w_i(t), b_i(t), w_{ij}^{-1}(t), b_{ij}^{-1}(t) \) are adjusted according to the formula 24-27
9:   \( t++ \)
10: end while
End
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9. Overall System Architecture

Student Management

AIPresent

Learning Management

College Server

Staff Management

Auto Notification

- View Notification
- View Marks
- View Exam Info
- View Fees Details
- Up/Download Assignments
- View Attendance
- Attend Live Class
- View Time Table
- View Profile
- Login

- View Notification
- View Marks
- View Exam Info
- Payroll
- Up/down Assignments
- View Attendance
- Initiate Live Class
- Boot QA for Learning Pre.
- View Profile
- Login

- Generate Notification
- Add Marks
- Add Exam Info
- Add Fees Details/Payroll
- Add/Update Query
- Attendance Report
- Live Class Report
- Generate Time Table
- Add Student & Staff
- Login

Students

Staffs

Admin
10. AIPresent Architecture

11. Literature Survey Findings

However, the face detection and recognition processes in a virtual classroom environment are complex tasks because the processing of faces with the poor image quality from captured video frames is highly challenging. Further, real-time image processing with varied camera positions, image blur issues, students' poster changes, background structures, and other occlusions adds to the existing challenges of Video-based Face Recognition (VFR).

A few of these issues had addressed by Ding C by proposing a CNN-based framework for VFR. To develop a more effective solution, we designed a novel, customized face recognition module specifically suited for virtual learning requirements. Nevertheless, if we go for an attendance

12. Modules

1. Virtual Meet Dashboard Web API
2. AI Present Module
2.1. Face Enrolment Phase
2.2. Face Verification Phase
2.3. Attendance System
3. Learning Attentive Prediction
4. User Control Panel
5. Notification Module
6. Performance Analysis

13. Conclusions

Random Interval Attendance Management System (AIPresent) is an innovation based on Artificial Intelligence – Deep Learning, specially designed to help the teachers/instructors across the globe for effective management of attendance during virtual learning. AIPresent facilitates precise and automatic tracking of students' attendance in virtual classrooms. It incorporates a customized face recognition module along with specially designed ancillary submodules. Both the face recognition and the sub modalities are for students' attendance monitoring in virtual classrooms. The submodules check students' responses to CAPTCHAs, ConceptQA and UIN queries. The system captures face biometric from the video stream of participants and gathers the timely responses of students to ConceptQA and UIN queries, at random intervals of time. An intelligible and adaptive weighting strategy is employed for finalizing the decisions from the three modalities. AIPresent could be integrated with any existing virtual meeting platform through an application interface like a web page or a specific App.

14. References


