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Learner's attention detection in connected smart classroom using internet of things and convolutional neural networks

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ABSTRACT

Detecting learner attention is an essential part of learning assessment. Consequently, it becomes an essential requirement for adaptive intelligent teaching systems, to identify specific needs and anticipate orientations. In this article, we propose a new model of a connected smart classroom, based on the internet of things, artificial intelligence and machine learning to detect in real time learners' attention and marking their presence during the execution of a teacher-assisted pedagogical activity, as well as to adapt the most suitable learning objects to these learners. The proposed model is based on head position, gaze direction, yawning and eye-state analysis as facial landmarks detected by cameras connected via the Bluetooth low energy network and transmitted to a developed convolutional neural network. In addition, a series of experiments have been conducted to evaluate the performance and efficiency of the model developed. The findings demonstrate that the model developed can be used to precisely capture the status of learners in the classroom in terms of attention and identification. In this way, these interesting findings can be used to adapt teaching activities to the individual needs of learners, and to identify areas where they have difficulties and needs extra help.

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1. INTRODUCTION

With the rapid evolution of information and communication technology (ICT), a new paradigm of the internet has been born, known as the internet of things (IoT). This concept has had an influence on numerous aspect of industrial and human life [1], [2]. It has led to the growth of "intelligent environments" utilized and operated in a variety of fields, including agriculture, healthcare, transport. It has significantly changed the way people and objects interact with each other, and teaching has not escaped this change, having established new modes of teacher-learner interaction to improve and enhance the learning process.

In this context, the learning/teaching process can be addressed in different ways, and two main approaches can be identified: i) "Self-learning" and ii) "Teacher-assisted learning". The former as its name indicates, self-learning, refers to the ability to learn autonomously without the direct intervention of a teacher. It is often seen as a flexible and autonomous module which enables learners to individualize their learning process according to their own needs and pace. Learners can build skills, attitudes and knowledge in the absence of a teacher [3]. Teachers consider prior self-learning to be an essential element and play a significant and an important role in aiding learners to memorizing and understanding basic knowledge. So, more time is available in class for fun and interactive activities that aim at helping learners to apply, analyze and evaluate knowledge [4]. Concerning teacher-assisted learning approach, it involves the presence and active guidance of a teacher in the learning process. This approach can take place in formal environments such as classrooms, workshops or individual tutorials. It offers the advantage of obtaining follow-up, immediate feedback and clarification of difficult concepts. Teachers can also provide the necessary learning objects (practical examples, exercises and videos) to reinforce learning based on learners' specific needs and characteristics. It is a traditional teaching approach that is usually teacher-led, teaching learners such a way as to encourages them to listen and sit [5].

Despite the flexibility of the self-learning approach, it should be noted that there are domains for which its use is not recommended such as medicine and engineering. Such domains require specific and specialized expertise, as professionally assisted learning is often necessary to ensure a thorough and accurate understanding of complex concepts. Similarly, finance and accounting require accreditation and may require specific certifications or licenses to operate legally. In these cases, professionally supervised training and formal follow-up are frequently required. Within the same pattern, surgery and airplane piloting require hands-on training under the guidance of experienced experts. A precise detection of learners' learning states can offer pertinent information to the teacher so that he or she can identify troubled learners in real time. In this way, a learner's degree of attention and engagement state can help and support intelligent tutoring systems to deliver customized learning resources. In this paper, the fundamental concept and purpose of this work is to propose a model for the connected smart classroom case: low-computing teacher-assisted learning based on internet of things (IoT), artificial intelligence (AI), Bluetooth low energy (BLE) and convolutional neural network (CNN) framework developed as a machine learning algorithms, so that they can be easily used in modern learning management systems (LMS). The aims of our work are i) to detect in real time the attention of learners in a teacher-assisted learning scenario by analyzing their facial expressions; ii) to detect in real time the presence of learners; and iii) to adapt in real time the content of the learning activity being executed by recommending the most appropriate learning path for the learner according to their level of attention.

This paper is organized into five main sections: The following section presents a literature review on the topic of modeling and systems development for IoT-based smart teaching classrooms, as well as the application areas of IoT. The second section describes the model proposed in our approach, while defining the various stages of operation of the model developed for real-time detection of attention and marking of learner presence during the class session. The third section presents an example of implementation of the developed model and the results obtained. Finally, the fourth section concludes the paper and offers suggestions and recommendations for future work.

We examine briefly in this section. Related work in smart learning, modeling of smart classrooms, IoT approaches used to modeling of smart classrooms and IoT application areas. Thus, modeling of connected smart classrooms to which our study most directly contributes to detect in real time the attention of learners in a teacher-assisted learning scenario.

a. Smart learning

The current state of research into intelligent teaching focuses primarily on a variety of learning techniques. Saunders *et al*. [6] have used reverse classroom teaching to transform traditional teaching methods and integrate a variety of interactive processes. Based on concrete examples, the new intelligent teaching method is both reliable and capable of achieving its objectives. Alrikabi *et al.* [7] have utilized Moodle to design an open-source e-learning platform that supports both the learner and the teacher by delivering services that simplify teaching and administrative tasks linked to education and teaching efficiency. The application of this system, according to the authors, attracts learners who are unable to follow the traditional educational program, as it allows them to study according to their abilities and at the time they prefer. It also offers easy educational opportunities for those who have not been able to follow the current education system, and helps to bridge the teacher shortage. Biwer *et al.* [8] have validated the efficiency of the system by implementing an intelligent teaching process. Xu *et al.* [9] produced an intelligent network management model based on massive data mining for training and education optimization, and they demonstrated that this approach enables advantageous allocation of resources and a significant level of information fusion. Han and Xu [10] have developed an intelligent education system that efficiently recommends lessons and adapts the learning ecosystems based on the needs of learners, thus answering and addressing the individual learning demands of higher education learners.

b. Smart classroom

In the literature, different research and studies that have been carried out on the topic of "smart classroom" development and modeling show that the smart classroom paradigm has developed from a larger notion, namely the distance learning system that used the internet as a support medium to transform a "conventional" teaching classroom into a "smart" teaching classroom, the latter being equipped with a number of software and hardware tools [11]. Several studies have been done on the design and development of systems for the intelligent teaching classroom based on the IoT paradigm. Some of these systems are discussed in the following paragraph.

Mustapha *et al*. [12] introduced a generic architecture for the IoT-based smart teaching classroom environment in the context of the adaptive learning environment during the execution of a pedagogical activity among learners. This model illustrates, in the form of state-transition diagrams, the various adaptive and personalized learning scenarios proposed by the system during the execution of an adaptive pedagogical activity between teacher and learner, according to the learners' level and prior knowledge. To design this architecture, the authors have considered three poles: The learner, the teacher and the knowledge. Huang *et al*. [13] described the concept of the smart classroom and the smart model of the smart classroom at the system level, and proposed an architecture for the construction and operation of context-aware smart classrooms. The structure of the proposed system was able to build an intelligent teaching classroom considering the situation on an intelligent campus. Zhang *et al*. [14] have proposed a design for a "smart classroom" system based on internet of things technology, the findings of which are the ability to detect classroom temperature via the use of the DS18B20 chip, and light intensity using photo resistor Bai to collect light data. Banu *et al*. [15] have proposed a system design for a smart campus based on IoT and cloud computing technology. The approach suggested by the authors illustrates how IoT and cloud computing infrastructure successfully restructure traditional education and learning methods to enable interaction between instructors and students, as well as between various objects and connected devices. Xu *et al*. [16] have developed an IoT-based e-learning system named "Smart Campus" using the 5G network technology implementation model. This system uses a localization algorithm to obtain information about learner's location in the classroom. The authors' choice of 5G network technology in this model is to improve the speed of data transmission collected by the system. Similarly, Sutjarittham *et al*. [17] have developed an "intelligent campus" system for optimizing utilization of classrooms. This system describes the implementation of IoT and AI technologies, and includes detection techniques to measure the occupancy rate of lecture theaters across the entire campus. The system developed by these authors is characterized by live occupancy collection, identification of courses given, cancellation of course sessions. Kim [18] have suggested an environmental intelligence algorithm for intelligent classrooms that offers teachers with information by evaluating learner activity in the classroom in real time. Lin [19] have additionally created an advanced learning diagnostics system to aid in presenting courses. In this system, the researchers conducted experiments on a software engineering course at a Taiwanese institution to investigate the efficacy of the suggested approach. To supervise energy consumption in the teaching classroom Ani *et al*. [20] have presented an innovative technique for monitoring and managing electrical equipment such as light bulbs and fans that is based on the presence of humans. The aim of this system is to build a solution that could help reduce and save the overuse of resources in the classroom.

c. IoT application areas

Based on the literature review, the "Internet of Things" paradigm plays a very interesting role in terms of technical support and promotion in the construction of information, energy, intelligent agriculture, the intelligent city, health, transport and other areas [21], [22]. The most useful application areas for IoT technology in human life are:

- Smart transportation: real-time traffic information extraction system (Bhatt and Bhatt 2017).
- Smart home: intrusion detection systems, water consumption, remote control applications and energy consumption.
- Retail and logistics: intelligent product management system, intelligent shopping applications, item tracking and fleet tracking.
- Health care: real-time patient health monitoring systems.
- Agriculture: soil humidity management system and irrigation management.

2. METHOD

The intelligent learning model developed in this paper is trained on videos recorded by cameras within the connected smart classroom, to capture learners' faces and analyze their behavior without disturbing or annoying them. The aim is to detect learners' attention in real time, to mark their presence in real time and to recommend and adapt the most appropriate learning path during the execution of the teacher-assisted pedagogical activity, by selecting suitable learning objects according to the attention detected. Our approach is based essentially on head position, gaze direction, yawning and eye-state analysis of learners' faces extracted by algorithms developed and passed on to a new CNN Framework developed using open-source computer vision library (OpenCV), Open-source online C^{++} library (Dlib) and python.

2.1. Overall process for the proposed model

We have outlined the general process that describes our contribution in Figure 1. The initial essential step in the pipeline is the extraction of images from video frames. Then, we used the network CNN Framework developed on the faces detected to detect in real time learners' attention and the presence of learners.

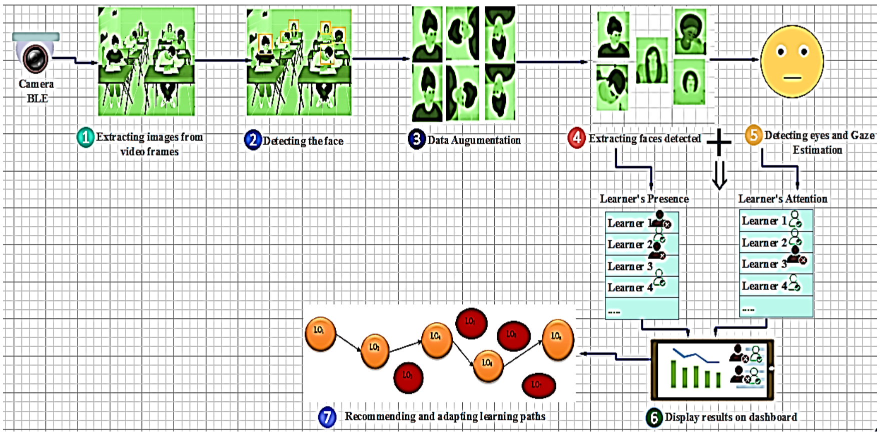

Figure 1. The general process of the proposed approach

Figure 1 illustrates the general process of the model proposed in this paper for the real-time detection of learners' attention and the marking of their presence, as well as the recommendation and adaptation of learning paths according to the attention detected. This process starts with the camera connected by BLE technology; it takes a video stream of learners during the execution of a teacher-assisted pedagogical activity inside the connected smart classroom. The stages of this process are:

Step 1. Extracting images from video frames: As video data cannot be used to train the neural network, images must be extracted and uploaded to the model.

Step 2. Detecting the face: We use facial landmarks to identify and represent the distinguishing features of the face, which might include the nose, mouth, eyes and jaw. These landmarks are essential for estimating head pose, detecting eye blinks and detecting yawning. open CV cascade is used [23], therefore an open-source online C++ library called Dlib [24], which has pre-written functions that are used to obtain facial landmarks. This library is programmed to find the x, y coordinates of 68 facial landmarks to map facial structure, as explained in the Figure 2.

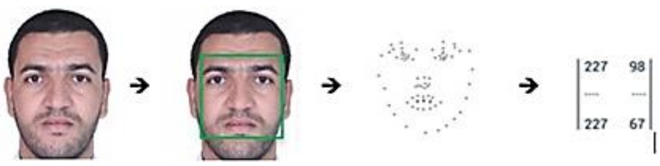

Figure 2. Detecting facial features process

Step 3. Data augmentation: It is very useful to have more data during the deep learning training phase, so that the model developed can identify all of the nuances and variations in the images. A popular technique of increasing the number of training points is to use "data augmentation" method. Codebox [25] was employed to create fresh images by applying a series of augmentation operations on the video frame images, such as random rotation, zooming, shearing and flipping. Figure 3 illustrates the data augmentation process.

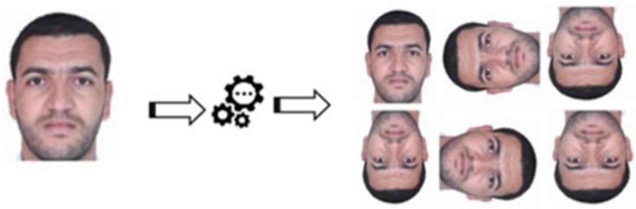

Figure 3. Data augmentation process

Step 4. Extracting faces detected: To extract the faces detected, while ignoring other objects in the image such as the table, chair and wall. the Dlib library uses the power of OpenCVs' Haar cascades to detect facial landmarks. Viola *et al*. [26] presented this technique, which has been refined over time as an Open Source initiative by contributors to the OpenCV library, based on machine learning. To detect the presence of an object, this technique makes use of multiple images that have been marked either positively or negatively. The learner's face would be this object in our scenario. From there, fresh facial image inputs to the algorithm will be recognized by the developed algorithm.

Step 5. Detecting eyes and gaze estimation: Once the learner's face extraction stage is complete, we move to eye detection in the detected learner's face to check eye position and estimate gaze.

Step 6. Displaying results on dashboard: Display the results of attention detection and learner presence marking in the teacher dashboard. i.e. display the faces of learners in "Attentive" and "Not Attentive" states, learners in "Present" and "Absent" states, as well as the rate of learner attention during execution of the pedagogical activity.

Step 7. Recommending and adapting learning paths: Recommend and adapt the most appropriate learning objects for learners according to the level of attention detected.

2.2. The proposed new classroom model

In this paper, a new model of connected classroom is proposed to automatically examine in real time the state of learners' attention, as well as their presence from facial expressions analyzed using cameras connected by BLE technology. Figure 4 illustrates the proposed model.

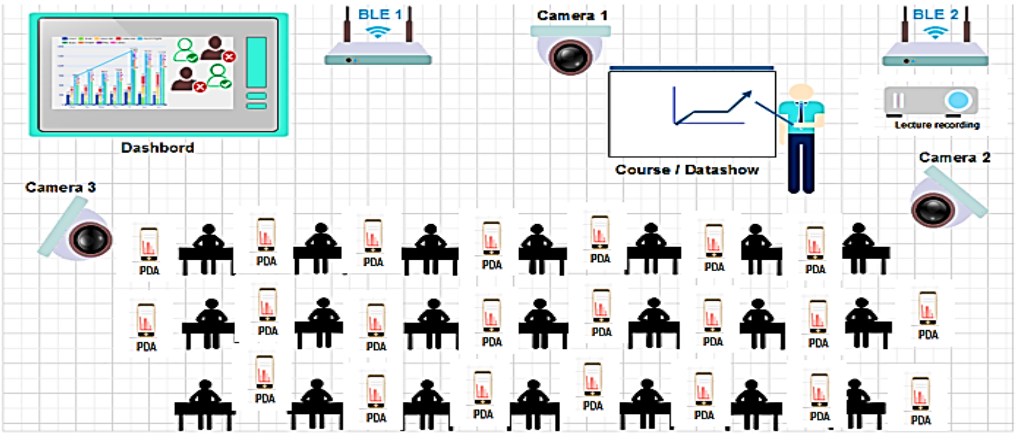

Figure 4. Architecture future of our smart classroom

Figure 4 illustrates the new model proposed for modeling a system to manage the connected smart classroom, by integrating the IoT approach, AI, machine learning algorithms and BLE technology in a "teacher-assisted learning" context. The aim of this model is to detect in real time learners' attention, mark their presence and adapt learning paths according to the level of attention detected in learners during the execution of the teacher-assisted pedagogical activity. This model constitutes of the following components:

- Connected smart cameras: For recording learners in the smart classroom.
- Environmental sensors: Personal digital assistants (PDAs) like smartphones, iPads and tablets.
- BLE communication network: All objects in the smart classroom and data collected by sensors and IoT devices are transmitted via BLE to the processing and analysis platform.
- Processing and analysis platform: Receiving real-time data from IoT cameras. This platform can be cloud-based, enabling scalable data storage and processing. It can also use data analysis and machine learning techniques to extract significant information from the collected data.
- Intelligent classroom management system: (Classroom management system software).
- Servers (lecture recording): To record teaching activities started by the teacher and keep track of them.
- Intelligent interactive whiteboard: For presenting lessons and giving explanations. It enables the teacher to supervise learners' progress, identify trends and patterns, and make informed decisions about teaching and pedagogical adaptation.
- Dashboard for displaying results: Display the rate of attention detected, learners in the attentive and non-attentive states, as well as the faces of learners in the present and absent states.

The objects (components) of the smart classroom for the proposed model are connected via the BLE communication network. It is a wireless personal area network technology and is used in many areas such as healthcare, industrial production, and indoor and outdoor location [27]. The main advantage of using BLE is its low energy consumption and cost compared with conventional Bluetooth technology. Consequently, BLE technology reduces the time needed to record the presence of learners in the smart teaching classroom [28]. In the following paragraph, we present the algorithms developed for the proposed approach.

2.3. Algorithms developed

Our contribution in this paper for the real-time detection of learners' attention and the marking of their presence, during the execution of the teacher-assisted pedagogical activity in the connected smart classroom, is essentially based on two algorithms developed below, that can be applied to a sequence of photos or a video stream. Algorithm 1 automatic face extraction to mark learner presence.

Algorithm 1. Real-time mark learner presence algorithm with CNN developed
```
Input: Video Frames or photos_Original’s;
Output: Nbr_Face_Detected; Nb_Learner_Identify;
Initialize: Nbr_Face_Detected=0; Nb_Learner_Identify=0;
Begin:
  If Face_Detected = false Then Start the video capture process;
     While Loop video sequence;
       Photo_Original = get an photo frame from the video sequence;
       Detect multiscale face image using cascade classifier
       "haarcascade_frontalface_default.xml";
       For Loop Rectangle Face_rect in Face_Detected;
         Draw rectangle around face photo;
         Extract photo_Original to Face_Only;
         Face_Detected = true
         Increment the number of Nbr_Face_Detected;
         Extract face encodings for each face detected;
         Compare face encodings according to datasets;
         If the number of reliable matches >=50 Then increment and Return
          Nb_Learner_Identify;
         Else keep the same value of Nb_Learner_Identify;
         End if
       End For Loop
       Crop and Copy face photo
  End if
End
```

Algorithm 1 shows the process of marking the presence of learners in the connected smart classroom. This marking is essentially based on face detection and similarity calculation, while Algorithm 2 presents the process of detecting learners' attention based on the estimation of their gaze, including the position of their head, during the execution of the pedagogical activity. Algorithm 2 automatic estimation of the learner's gaze to detect attention.

Algorithm 2. Real-time learner's gaze algorithm with CNN developed to detect attention
```
Input: Flux face photo extracted with the first algorithm;
Output: Nb_Attentive_Learners; Learner's_Gaze_Estimation; Teacher’s_Gaze_Estimation;
Initialize: Nb_Attentive_Learners=0; Learner's_Gaze_Estimation=0;
            Teacher’s_Gaze_Estimation=0;
Begin:
      Detect multiscale eye image using cascade classifier "haarcascade_eye.xml";
      Loop For Rectangle Eye_rect in Eye_ Detected;
              Draw rectangle around eye image;
              If (Face_Detected == true) Then check Learner's _Gaze_Estimation;
                 If Learner's _Gaze_Estimation = Teacher’s_Gaze_Estimation;
                    Then Increment and Return the Nb_ Attentive_Learners;
                    Else keep the same value of Nb_ Attentive_Learners;
                 End If
              End If
      End for loop
End
```

3. RESULTS AND DISCUSSION

Based on the analysis of the previously cited studies, not all the models proposed by researchers address the problem of detecting learners' attention and marking their presence within the smart classroom, as well as adapting learning paths according to the level of attention detected. It is therefore necessary to find effective mechanisms and techniques to overcome the shortcomings of existing systems. Our contribution in this article, aims to propose a new model of connected smart classroom, to detect in real time learners' attention, mark their presence, and recommend and adapt the most appropriate learning path for learners. The model presented is based on the IoT approach, AI, machine learning algorithms and BLE technology in a teacher-assisted learning context. The experiments were carried out on a Lenovo machine equipped with an Intel Core i5. The process of assessment and experimentation unequivocally demonstrate that the eyes play a critical role in learners' ability to detect attention. In this section, we present an example implementation for real-time detection of learners' attention, marking of their presence and different ways for recommendation and adaptation of the teacher-assisted pedagogical activity in the connected smart classroom at the moment of execution of the pedagogical activity by the teacher.

3.1. Marking the learner's presence

To detect learner attention, we first mark the presence of the learner in question within the smart classroom, by detecting and extracting faces , then using face recognition cameras. [29]. In comparative studies, cameras will produce better results than detectors (sensors) because they are specifically designed to detect human presence more precisely, while sensors have to be customized to different user needs and their use can vary from weather forecasting to disease prediction [30] and healthcare systems [31]. Face recognition has received increasing attention due to its great potential in many applications (security, criminal justice systems, surveillance, man-machine interactions, image database investigation, smart card application, multimedia environments with adaptive man-machine interface, video indexing and civil applications) [32], [33]. The facial recognition system can be used in two ways: Verification and identification. Face verification (one-to-one matching) involves confirming or denying the identity claimed by a specific individual. The face identification system (many-to-many matching) attempts to find the identity of a given individual against all the image templates in the face database [34].

Various face detection methods are used and tested, including: i) Haar Cascade, an object detection algorithm used to identify faces [35]; ii) Histogram of oriented gradients (HOG) is a feature used for object detection [36]; 3) Convolutional neural networks (CNN). DLIB creator Davis King, has trained a CNN face detector based on maximum-margin object detection [37]. In this paper, learners' presences marking can be done by implementing the algorithm developed in CNN (Algorithm 1), using a cascade classifier which is an object detection algorithm based on 3 feature extraction techniques. These comprise modules such as: i) border characteristics, ii) line characteristics and iii) characteristics of the four rectangles [38]. This cascading classifier can be used to detect the aforementioned facial landmarks. Figure 5 illustrates the process of face detection by the algorithm developed. Equation (1) expresses mathematically the number of faces detected.

$$Face(f) = \begin{cases} 0, & if\ no\ face \\ \sum_{i=1}^{n} f_i & on\ each\ face \end{cases} \tag{1}$$

where f is a single photo captured by the BLE-connected camera in the smart classroom.

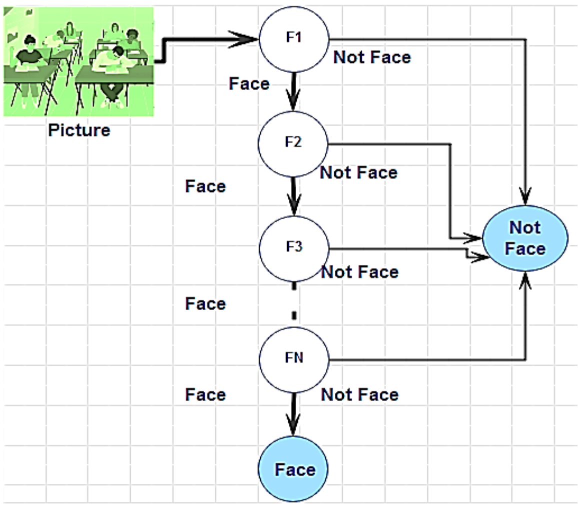

Figure 5. Face detection process

Once the face detection process is done, marking the presence of learners in the smart classroom is based on matching the faces detected by the developed Algorithm 1 with the faces in our dataset containing all the faces of the learners in the classroom. This correspondence can be performed using Euclidean distance [38]. Figure 6 shows the results of the execution of Algorithm 1. Figure 6 illustrates the number of faces detected in the video recorded by the BLE camera, *i.e.* one male student's face, marked inside a rectangular box in green. Figure 7 shows the individual face extracted and saved as a PNG image using the algorithm developed (Algorithm 1).

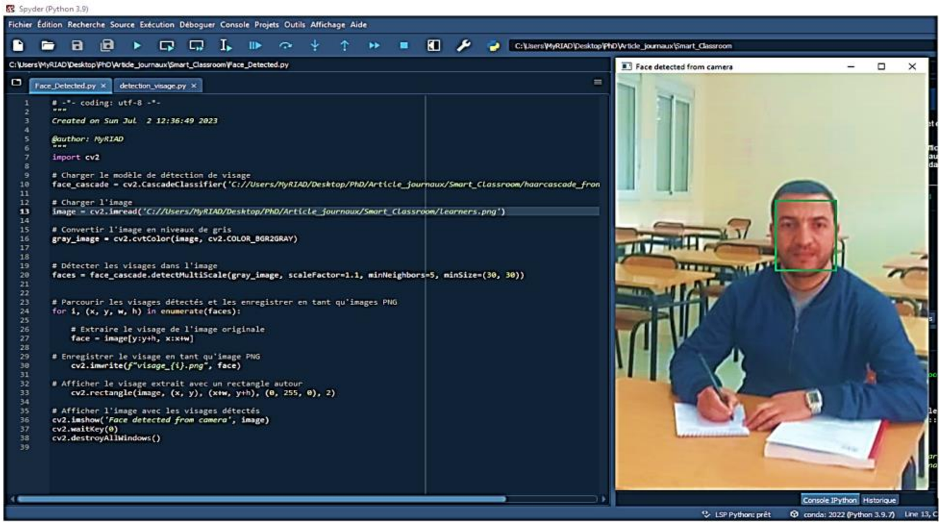

Figure 6. Example of face detection using Algorithm 1

Figure 7. Face extracted by using Algorithm 1

Once the face detection and extraction stage are done, we start calculating the similarity between each detected face and those in our dataset, using scale-invariant feature transform (SIFT) descriptors to detect key points in the photo and their associated descriptors. The result is used to determine the state of the learners: If the number of reliable matches is greater than or equal to 50, the developed script displays a message indicating that the extracted face is similar to an image in our dataset, so the learner is in the "Present" state. If it is not, the script displays a message indicating that the extracted face is not similar to any image in our dataset, so the learner is in the "Absent" state. Figure 8 shows the result of running the algorithm.

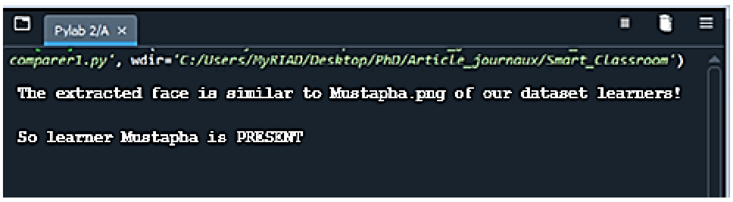

Figure 8. Comparison of extracted faces with the faces of all learners using Algorithm 1

The Figure 8 shows the result of the comparison. We found that the extracted face named Face_0.png is similar to the learner's photo named Mustapha.png from our datasets. This means that the Face_0.png corresponds to the face of the learner Mustapha, *i.e.* the learner is present in the teaching classroom.

3.2. Detection of learners' attention

Once the learner presence marking stage within the connected smart classroom is achieved, by running the algorithm developed in CNN (Algorithm 1). We start to estimate the learners' gaze in relation to the teacher's gaze, by detecting the eyes using the algorithm developed (Algorithm 2). Figure 9 illustrates a real example of attention detection for the learner named Mustapha Riad. Figure 10 shows the result of running the algorithm developed (Algorithm 2) to detect learners' eyes. It concerns the eyes on a learner's face; these eyes are marked inside a rectangular box in blue. Figure 10 shows the eyes of individual faces extracted by Algorithm 2.

Based on the achieved results, we initiate a comparison between the learner's gaze estimation and the teacher's gaze estimation to detect the learner's attention. If the learner's gaze aligns with the teacher's gaze, the learner is classified as "Attentive"; otherwise, the learner is categorized as either "Non-Attentive" or "Distracted". This process allows us to discern and classify the attentional states of the learners within the intelligent teaching environment, providing valuable insights into their engagement levels during the instructional session.

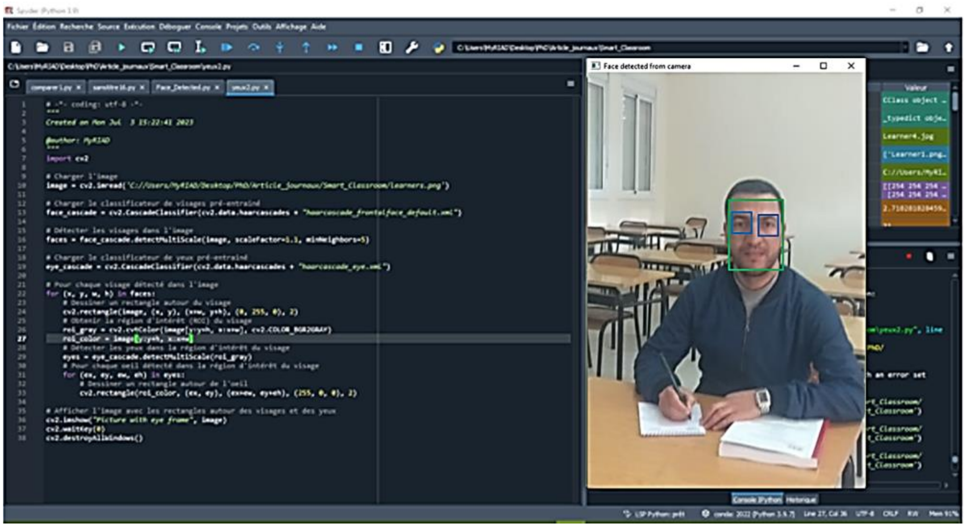

Figure 9. Example of eyes detection using algorithm 2

Figure 10. Eyes detected using algorithm 2

3.3. Recommended and adapt of learning path

By examining the results obtained by the two algorithms developed, the teacher can identify learners who might need extra help or support and distinguish the areas in which they are having difficulty in order to make learners more attentive. It can adapt teaching activities to the individual needs of learners using a variety of interactive tools. Executing a teacher-assisted learning activity in the connected smart classroom is an example in this regard. If the proposed system detects that some learners are distracted or disinterested, the pedagogical activity can be adapted in real time on the basis of the learners' learning needs in terms of knowledge, skills and attitudes, to help them focus more on the content using:

- An interactive whiteboard can be connected to the IoT to display graphs, equations or images that can help capture learners' attention.
- An intelligent audio system can be used to adjust the volume of the teacher's voice based on the noise level in the classroom. If the system detects that some learners are distracted and talking amongst themselves, the audio system can automatically adjust the voice volume to attract their attention.
- Gamification tools can be used to encourage learner participation and engagement. For example, a reward points system can be used to reward learners who answer questions correctly or those who actively participate in the class.

Based on the results obtained by implementing the two algorithms developed, learning environments can become more intelligent, interactive and adaptive by integrating the IoT into teacher-assisted learning. This integration can provide teachers with valuable information for assessing learner performance, identifying shortcomings and adapting learning. They can also provide additional learning objects, such as videos, images, targeted exercises or specific activities to support differentiated learning and promote the success of each learner. It provides continuous feedback to learners, guiding them in their learning and assessing their progress. This can be done using automated reports, personalized feedback or real-time evaluations.

4. CONCLUSION

This research describes an improved model for real-time attention detection and presence marking of learners via the integration of IoT, AI and machine learning. This system is based on a CNN Framework developed from machine learning. The primary goal is to develop a connected, lightweight, cost-effective and environmentally sustainable ecosystem that can be implemented in modern learning management systems while maintaining and achieving high performance. The system was capable of detecting learners' facial landmarks from images captured by cameras connected via BLE technology and transmit them to a CNN-based learning model developed to detect learners' attention and presence marking in real time, adapting learning activities to individual learner needs based on detected learner attention rates. As a result, a learning model with a small size but relatively high in efficiency. This system can be easily integrated into the teacher's dashboards in the smart classroom to intervene when learners are asleep or distracted. Teachers can focus more time on teaching and learning than on managing and controlling classroom workflow.

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