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A Multimodal Wireless System for Instant Quizzing and Feedback

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Abstract

This paper presents a wireless system for instant quizzing in the classroom and collecting students' feedback on teachers performance. This system is integrated with a student attendance management system to facilitate management of quizzing and quiz marking in addition to questionnaires about Quizzes. Such a system is very essential for following attendance and student learning progress in addition to formative assessment. The system uses two communication technologies: Wifi, and Radio Frequency Identification (RFID). Such a low-cost system assures attendance follow up to assure abiding by the university bylaws, avoid spoofing and cheating, and enhance both teaching and learning. A student recommendation system is also implemented to increase student retention and enhance students success rate..

Keywords: *Educational Platform, Student Attendance Management, Quiz Management System, Radio Frequency Identification (RFID), Face Verification, Students Alert System.*

1. Introduction

The advancement of higher education systems requires immediate implementation of effective teaching, learning, and assessment strategies. This paper focuses on the implantation of a formative assessment methodology that transforms formative assessment to assessment for learning.

Frequent assessment of student learning (formative assessment) by the end of each lecture is vital at all levels of education. It can significantly enhance the quality of learning process, improve student retention, and continuously inform the teaching process by identification of different learning needs and adaptively guiding the lecturer to adjust his teaching method accordingly. This leads to better student success. Instant quizzing and providing effective feedback helps in engaging all students in the learning process and helping them succeed. Supporting the culture of learning and building engagement is facilitated by providing students with tools to support them in owning their learning [1].

End of semester assessment (summative assessment) and end of semester student questionnaires fail to enhance learning and inform teaching. To simplify the process of formative assessment of large numbers of students, modern communication and educational technologies are presented in this paper.

The remainder of this paper is organized as follows. Section 2 reviews the current related work. Section 3 describes the proposed educational business intelligence system modules in more detail. In Section 4, the evaluation of the proposed system's performance is discussed. Finally, the conclusions and future work are given in Section 5.

2. Related Work

The development of student assessment and teacher evaluation systems is considered an active research topic in e-learning field. There are many trails to develop student assessment systems in order to improve the learning quality. For example, Vilas et al. [2] presented a mobile quizzing system for formative assessment during lectures using Bluetooth. Bluetooth is used together with a Raspberry Pi microcontroller to send quizzes to the students and collect their answers. Hosein [3] presented a system for wireless delivery of learning resources and messages to students.

Hosein and Bigram [4] presented a Bluetooth quizzing mobile client-server system to administer quizzes to students of a university. The quiz will be managed by a queue system to allow many mobile clients to connect simultaneously to the server. A registered mobile client can complete a quiz assigned by the lecturer. Results are automatically sent when the quiz is done on the client application. Analytics of received quiz answers were used to review students' progress.

There are many approaches in the literature for Student Attendance Management System (SAMS) [5], radio frequency identification (RFID) based SAMS [6], fingerprint system for SAM [7], a self-organizing map for attendance management based on face recognition [8], and SAM using clickers [9]. The SAM is one of the most challenging problems until the moment.

Also, it is noted that some of the previous literature used the RFID technology in the attendance system. The most challenging problems in this field are RFID data filtering, tag collision and handing some students their tags to their colleagues out. Many approaches solved the problem but not completely, such as a sliding window for de-noising and duplicate elimination [10-12], data redundancy reduction [13], Bloom approach for duplicate data elimination [14], and multiple RFID tag readers approach in [15]. In addition, many approaches are very complex and need much processing time [16]. There are no approaches specializing in RFID data filtering in the SAMS. The system presented in this paper combined the power of both the traditional RIFD approach with face verification to solve this problem and get student's attendance in real time. The matching is done dynamically. It starts to check the student EPC in the data warehouse and complete matching to make verification of the student's face depending on student EPC. The Quiz Management System (QMS) allows entering the students to quiz while avoid all the previous limitations.

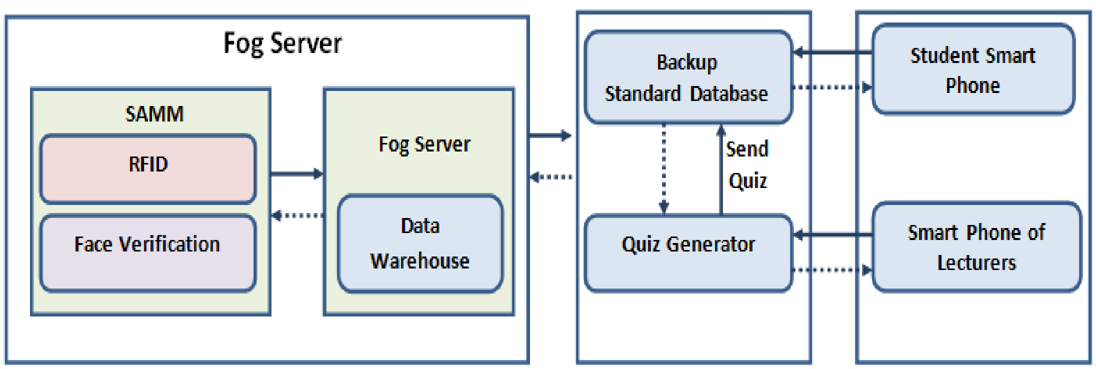
3. Educational Business Intelligence System (EBIS)

Figure 1 shows the architecture of the EBIS which consists of:

1- Student Attendance Management (SAM) module. It registers student attendance in a database using multiple modalities, such as RFID, and face verification.

2- Formative Assessment Module (FAM). It manages instant quizzing during lectures in order to focus student's attention during lecture time and give hints to the lecturer in case there are any misconceptions of difficulties in understanding some lecture parts. In the following subsection, the main building stages of our proposed system are discussed in detail.

Figure 1
The EBIS Architecture



To solve the latency problems encountered by the cloud based systems, a Fog Computing system is implemented on a local server. The Fog server is responsible for students' attendance management using SAM through their identification of both students tag and verification of his face in addition to executing the tag filtering, and collision algorithms instantly. A local data warehouse is hosted on the fog server. Management of the quizzing process is also done locally. Students access the quiz and receive their marks through the Fog server.

3.1. Student Attendance Management Module (SAMM)

The primary aim of this module is to record the attendance of the students automatically by using a multimodal approach. Figure 2 shows the multimodal approach for student identification that combined the power of both the traditional RIFD approach with face verification module. Algorithm 1 shows the

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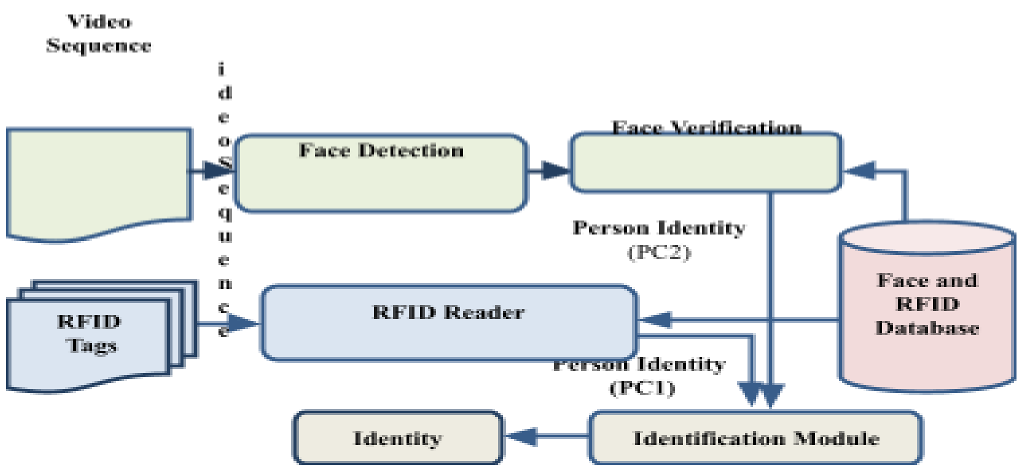
combination of the RFID technology and Face Verification technologies. The verification Algorithm works under three conditions, the first condition is making sure the tag ID is registered in students' RFID data warehouse, the second condition is matching the student's facial picture based on a similarity index with the pictured stored in the database for the identified tag ID.

Figure 2

The multimodal student identification system.



Algorithm 1: Multimodal approach for student identification

Input: Students' tag ID
Outputs: Student' identity
1. Do
2. Capture tag ID and detect reading time.
3. IF the tag ID is not registered in students' RFID data warehouse then
Ignore it.
Else
4. Matching the student's picture of tag ID with the facial frames that come from
the video camera.
5. IF the similarity index >= threshold then Register it in the attendance table and save the time of reading
6. End if;
7. End if;
8. While time <= end of attendance registration time.

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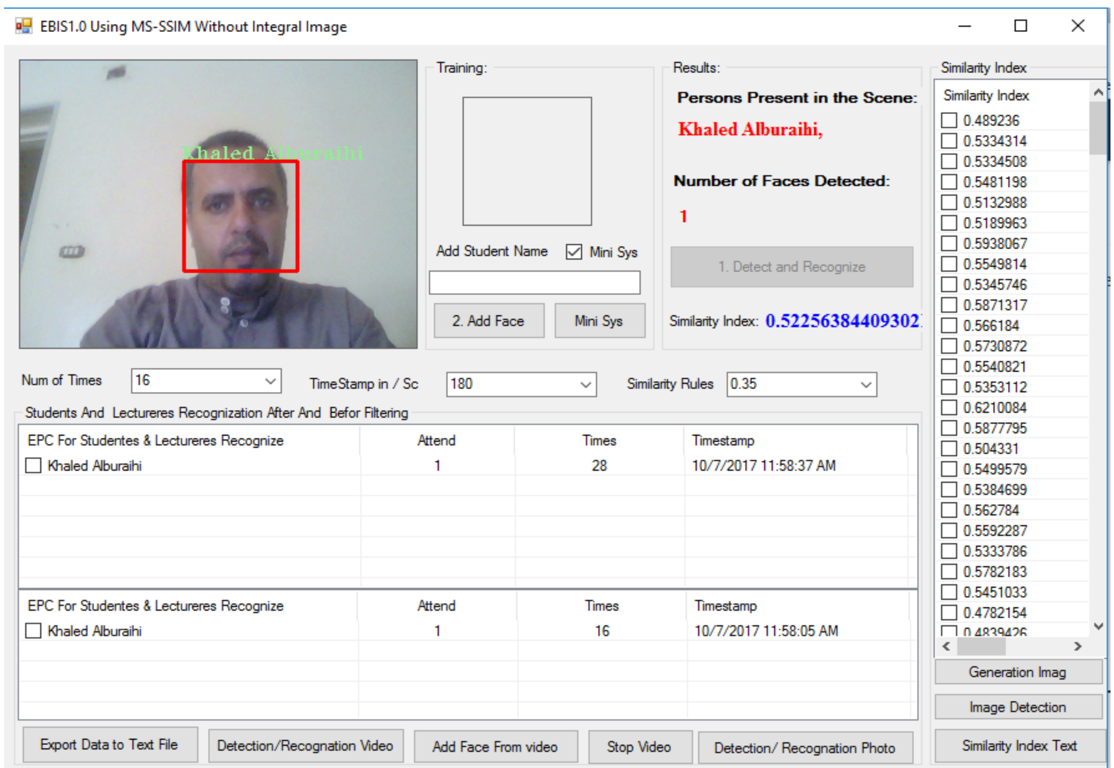
Figure 3 shows the real-time students' attendance using RFID with face detection and Verification (HaarCascade, PCA, and MS-SSIM) approaches depend on the structural similarity index, period of attendance, threshold counter, and threshold time.

Figure 3

A sample of real time implementation results for attendance management.



3.2. RFID Data Filtering Module (RFID-DFM)

Algorithm 2: Tag-based Student identification

Input: Students' tags
Outputs: Students' identities
1. Do
2. Capture tag ID and detect reading time.
3. IF the tag ID is not registered in students' RFID database then
4. Ignore it.
5. Else
6. IF RFID tag Reading within attendance period then
7. IF RFID tag is not registered before in attendance table then

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8. Register it in the attendance table and Save the time of reading
9. End if;
10. End if;
11. End if;
12. While time <= end of attendance registration time.

Figure 4
The RFID system layout [17].

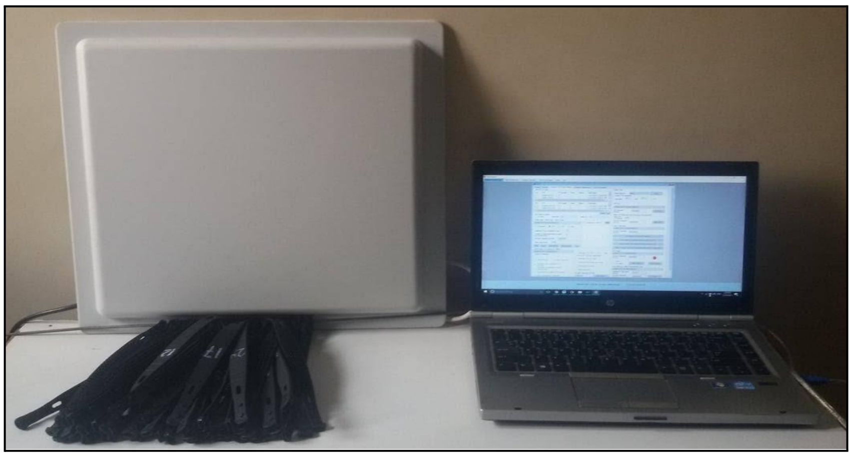

Figure 4 shows the RFID system layout. Figure 5 shows the real-time test results of the system. The output attendance sheet for a group of students shows the Electronic Product Code (EPC) for each attendant, his name, the date and time of lecture hall entry. The RFID system automatically gets the accuracy, error rate in real time.

Figure 5
The student's RFID based sample attendance sheet.

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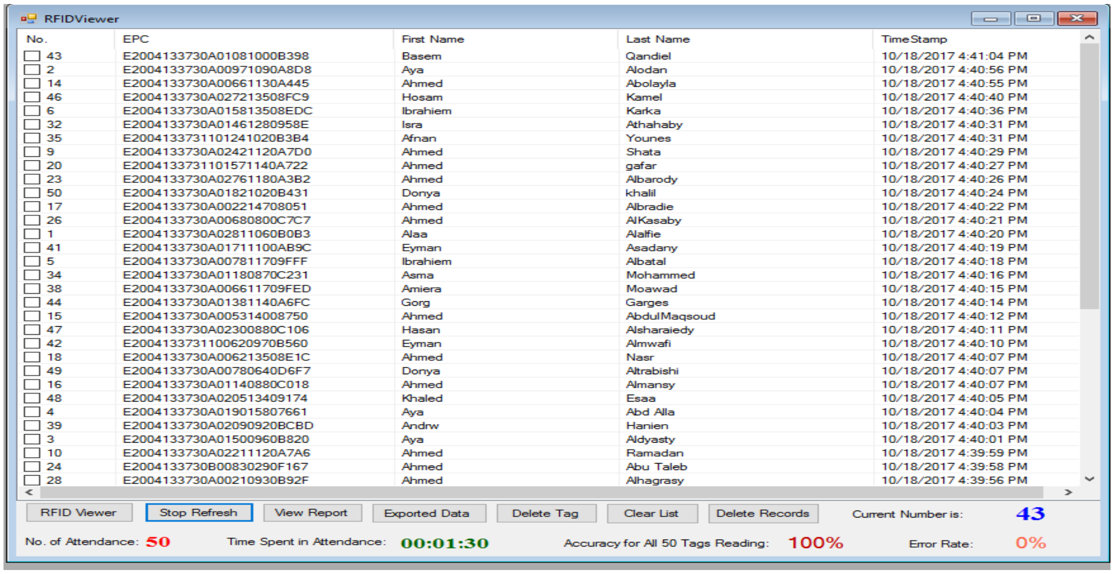
RFIDViewer

No.	EPC	First Name	Last Name	TimeStamp
43	E2004133730A01081000B398	Basem	Qandiel	10/18/2017 4:41:04 PM
2	E2004133730A00971090A8D8	Aya	Alodan	10/18/2017 4:40:56 PM
14	E2004133730A00661130A445	Ahmed	Abolayla	10/18/2017 4:40:55 PM
46	E2004133730A027213508FC9	Hosam	Kamel	10/18/2017 4:40:40 PM
6	E2004133730A015813508EDC	Ibrahiem	Karka	10/18/2017 4:40:36 PM
32	E2004133730A01461280958E	Isra	Athahaby	10/18/2017 4:40:31 PM
35	E200413373110124102OB3B4	Afnan	Younes	10/18/2017 4:40:31 PM
9	E2004133730A02421120A7D0	Ahmed	Shata	10/18/2017 4:40:29 PM
20	E20041337311015711 40A722	Ahmed	gafar	10/18/2017 4:40:27 PM
23	E2004133730A02761180A3B2	Ahmed	Albarody	10/18/2017 4:40:26 PM
50	E2004133730A01821020B431	Donya	khalil	10/18/2017 4:40:24 PM
17	E2004133730A002214708051	Ahmed	Albradie	10/18/2017 4:40:22 PM
26	E2004133730A00680800C7C7	Ahmed	AlKasaby	10/18/2017 4:40:21 PM
1	E2004133730A02811060B0B3	Alaa	Alalfie	10/18/2017 4:40:20 PM
41	E2004133730A01711100AB9C	Eyman	Asadany	10/18/2017 4:40:19 PM
5	E2004133730A007811709FFF	Ibrahiem	Albatal	10/18/2017 4:40:18 PM
34	E2004133730A01180870C231	Asma	Mohammed	10/18/2017 4:40:16 PM
38	E2004133730A006611709FED	Amiera	Moawad	10/18/2017 4:40:15 PM
44	E2004133730A01381140A6FC	Gorg	Garges	10/18/2017 4:40:14 PM
15	E2004133730A005314008750	Ahmed	AbdulMaqsoud	10/18/2017 4:40:12 PM
47	E2004133730A02300880C106	Hasan	Alsharaiedy	10/18/2017 4:40:11 PM
42	E20041337311006209 70B560	Eyman	Almwafi	10/18/2017 4:40:10 PM
18	E2004133730A006213508E1C	Ahmed	Nasr	10/18/2017 4:40:07 PM
49	E2004133730A00780640D6F7	Donya	Altrabishi	10/18/2017 4:40:07 PM
16	E2004133730A01140880C018	Ahmed	Almansy	10/18/2017 4:40:07 PM
48	E2004133730A020513409174	Khaled	Esaa	10/18/2017 4:40:05 PM
4	E2004133730A019015807661	Aya	Abd Alla	10/18/2017 4:40:04 PM
39	E2004133730A02090920BCBD	Andrw	Hanien	10/18/2017 4:40:03 PM
3	E2004133730A01500960B820	Aya	Aldyasty	10/18/2017 4:40:01 PM
10	E2004133730A02211120A7A6	Ahmed	Ramadan	10/18/2017 4:39:59 PM
24	E2004133730B00830290F167	Ahmed	Abu Taleb	10/18/2017 4:39:58 PM
28	E2004133730A00210930B92F	Ahmed	Alhagrasy	10/18/2017 4:39:56 PM

3.3. RFID Tag Anti Collision (RTAC) Algorithm

The RTAC Algorithm works under several limitations, the first one is verification of Card Number Indexing (CNI) for every tag, if the CNI has the same length of student EPC then good capture. The second limitation is making sure that substring the student's EPCs to 24 bits for every tag and save them in the inventory list. A final limitation is acknowledging the student's EPCs and Save them in the Access list. The RTAC has applied Q algorithm [18] rules to solve the anti-collision problem, the different between RTAC and Q algorithm has been in the length of EPC and how to split the data and save it in inventory list depending on the new equation (m * 2 + 2, EPC length * 2) where m= 12 bit.

Algorithm 3: RFID Tag Anti Collision

Input: Students EPC, EPC Length=12 bit, m=0;Counter=0;
Outputs: Elimination of Tag Collision
1. Do
2. Capture tag ID and save the tag's EPC in new Select List
3. Check Card Number Indexing for every Tag
4. If Card Number Indexing!= EPC Length then
5. Ignore it
6. Else
7. For m=0:SelectList Length
8. Student EPC= Substring Access list using the Equation (m * 2 + 2,
9. EPClength * 2);
10. Save the Student EPC in Inventory list
11. m= m + EPC length + 1

```
 End For
  End If
For I= 0 to Inventory list length
      If the Student EPC has not been read before then
          Add the Student EPC in Access listwith Timestamp
          Increment the Counter by one
      Else
         I increment the Student EPC Counter by one
 End IF
End For
Until the reader get closed.
```

3.4. Students Notification Management Module (SNMM)

In Egypt, university regulations ensure that students attend at least 75% of lectures. The SNMM follows student's attendance during a complete semester and issues regular alerts to students before reaching the critical absence ratio of 25% to avoid course dropping out. Figure 6 shows the number of absence times for each student. The SNMM algorithm is given below:

Algorithm 4: Students Notification Management

Input: Students EPC, Lecturer ID, Subject ID, Period ID, Location ID, Department ID, Semester ID, Attendance ID.
Outputs: Students Alert.

```
Do
IF alerts table contains data then
Delete previous data in alert table.
Else
Select the data depend on input ID's to the List.
End if;
Counter Threshold = the number of Lecture / 4.
IF the number of Lecture <= counter Threshold then
The student is well attended and not send alert to student.
Else
Send student alert.
End if;
Add the data to the Alert Viewer Listen runtime.
Until close the system.
```

Figure 6
The SNM system sample sheet.

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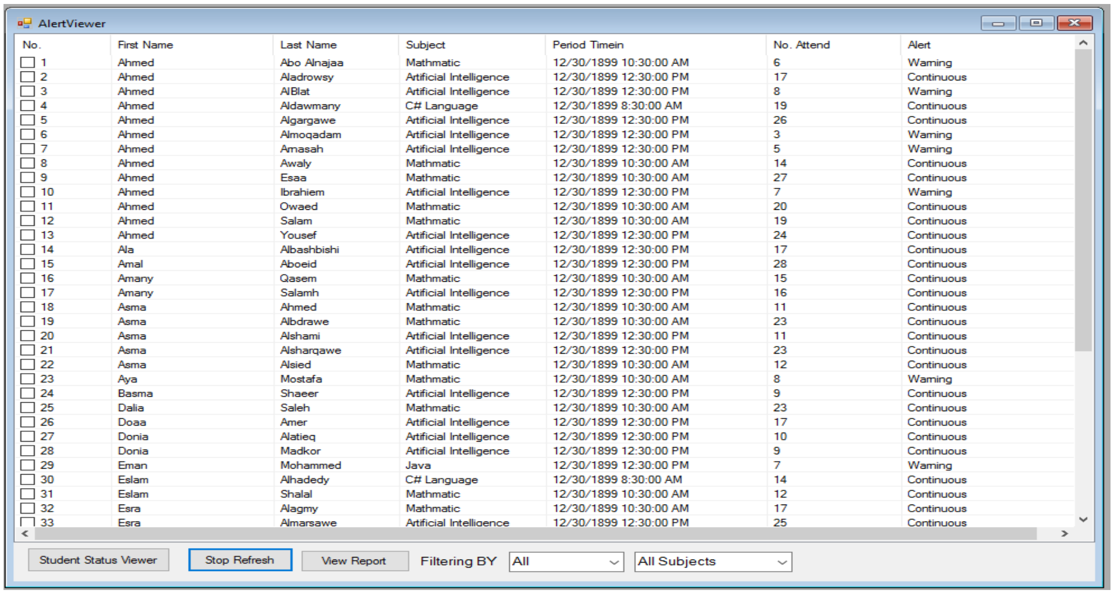

No.	First Name	Last Name	Subject	Period Timein	No. Attend	Alert
1	Ahmed	Abo Alnajaa	Mathmatic	12/30/1899 10:30:00 AM	6	Warning
2	Ahmed	Aladrowsy	Artificial Intelligence	12/30/1899 12:30:00 PM	17	Continuous
3	Ahmed	AlBlat	Artificial Intelligence	12/30/1899 12:30:00 PM	8	Warning
4	Ahmed	Aldawmany	C# Language	12/30/1899 8:30:00 AM	19	Continuous
5	Ahmed	Algargawe	Artificial Intelligence	12/30/1899 12:30:00 PM	26	Continuous
6	Ahmed	Almoqadam	Artificial Intelligence	12/30/1899 12:30:00 PM	3	Warning
7	Ahmed	Amasah	Artificial Intelligence	12/30/1899 12:30:00 PM	5	Warning
8	Ahmed	Awaly	Mathmatic	12/30/1899 10:30:00 AM	14	Continuous
9	Ahmed	Esaa	Mathmatic	12/30/1899 10:30:00 AM	27	Continuous
10	Ahmed	Ibrahiem	Artificial Intelligence	12/30/1899 12:30:00 PM	7	Warning
11	Ahmed	Owaed	Mathmatic	12/30/1899 10:30:00 AM	20	Continuous
12	Ahmed	Salam	Mathmatic	12/30/1899 10:30:00 AM	19	Continuous
13	Ahmed	Yousef	Artificial Intelligence	12/30/1899 12:30:00 PM	24	Continuous
14	Ala	Albashbishi	Artificial Intelligence	12/30/1899 12:30:00 PM	17	Continuous
15	Amal	Aboeid	Artificial Intelligence	12/30/1899 12:30:00 PM	28	Continuous
16	Amany	Qasem	Mathmatic	12/30/1899 10:30:00 AM	15	Continuous
17	Amany	Salamh	Artificial Intelligence	12/30/1899 12:30:00 PM	16	Continuous
18	Asma	Ahmed	Mathmatic	12/30/1899 10:30:00 AM	11	Continuous
19	Asma	Albdrawe	Mathmatic	12/30/1899 10:30:00 AM	23	Continuous
20	Asma	Alshami	Artificial Intelligence	12/30/1899 12:30:00 PM	11	Continuous
21	Asma	Alsharqawe	Artificial Intelligence	12/30/1899 12:30:00 PM	23	Continuous
22	Asma	Alsied	Mathmatic	12/30/1899 10:30:00 AM	12	Continuous
23	Aya	Mostafa	Mathmatic	12/30/1899 10:30:00 AM	8	Warning
24	Basma	Shaeer	Artificial Intelligence	12/30/1899 12:30:00 PM	9	Continuous
25	Dalia	Saleh	Mathmatic	12/30/1899 10:30:00 AM	23	Continuous
26	Doaa	Amer	Artificial Intelligence	12/30/1899 12:30:00 PM	17	Continuous
27	Donia	Alatieq	Artificial Intelligence	12/30/1899 12:30:00 PM	10	Continuous
28	Donia	Madkor	Artificial Intelligence	12/30/1899 12:30:00 PM	9	Continuous
29	Eman	Mohammed	Java	12/30/1899 12:30:00 PM	7	Warning
30	Eslam	Alhadedy	C# Language	12/30/1899 8:30:00 AM	14	Continuous
31	Eslam	Shalal	Mathmatic	12/30/1899 10:30:00 AM	12	Continuous
32	Esra	Alagmy	Mathmatic	12/30/1899 10:30:00 AM	17	Continuous
33	Esra	Almarsawe	Artificial Intelligence	12/30/1899 12:30:00 PM	25	Continuous

3.5. Instant Quizzing Module (IQM)

Figure 7

Instant quizzing module.

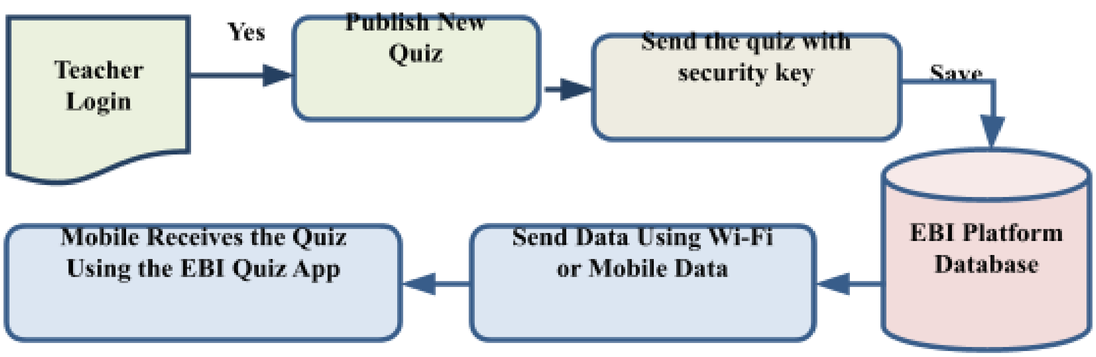

Figure 7 shows the instant quizzing module. The students access the quiz through their smartphone, and their answers are received, evaluated, and results are stored in the Formative Assessment Database (FAD). A dashboard presents a summarized report about student's results, and answers will also be sent to students after the quiz. Pointers are also given to the teacher about the difficulties facing the students such that he can emphasize on difficult concepts and enhance his teaching approach.

3.6. Students Quiz Management Algorithm (SQMA)

The SQMA is listed in Algorithm 5. Algorithm 5 works under two limitations, the first one is depended on authenticating students log in using RFID tag attendance. The second limitation, if the student's attendance in lecture is in the same period

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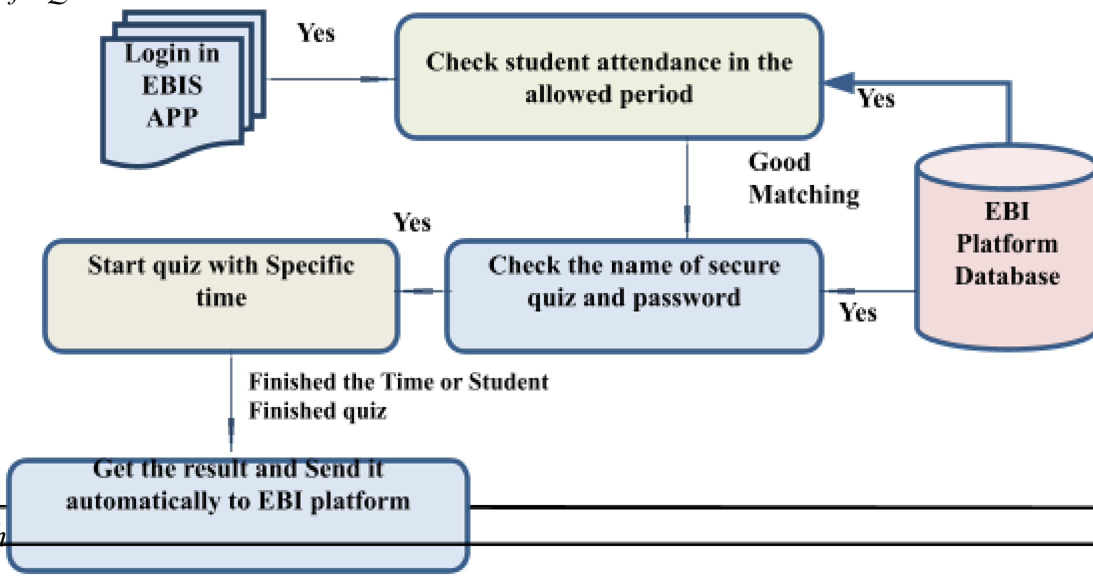
and gets correct authentication through his name and password. Start the quiz at the specified time and send the results automatically to FAD. Figure 8 shows the Layout of SQMA.

Figure 8

Layout of SQMA.



Algorith

Input: Students' NFC tags, RFID Tags, EBIS App
Outputs: Quiz Results, Feedback to Students and Lecturer Indicators
1. Do
2. Authenticate students' login in.
3. If the student attends lecture in the allowed period then
4. Check the Quiz name and password then
5. IF the matching is correct then
6. Start Quiz at the specified time
7. IF the Time is finished or Student finished the Quiz then
8. Send results automatically to EBI Platform
9. End if;
10. End if;
11. Else
12. Ignore it.
13. End if;
14. While time <= end of attendance registration time.

4. System Performance Evaluation

To assess the system performance, attendance registration and instant quizzing have been conducted in the lecture halls of the Faculty of Computers and Information Sciences, Mansoura University, Egypt. Fifty RFID tags have been handed out to 50 students each time. The system has been tested in real time to evaluate its performance. It has been found that the system successively identified 100% of the attending students. The major problem, which faced the system, was that the range of the RFID antenna was limited to up to 8 meters. Therefore, the antenna has been placed at the entrance of the lecture hall and students were asked to pass by the system.

4.1. Frequency of Tag Reading (FOTR)

The RBSMS sensitivity to operating parameters has been thoroughly tested. Table 1 shows the system accuracy for four cases which specify the frequency of tag reading (FOTR) by the RFID reader. It is clearly shown that the system accuracy has not been changed with FOTR but increasing the FOTR leads to increased attendance registration time. Table 1 and Figure 9 show the relation between the change of the FOTR with the increase in attendance registration time.

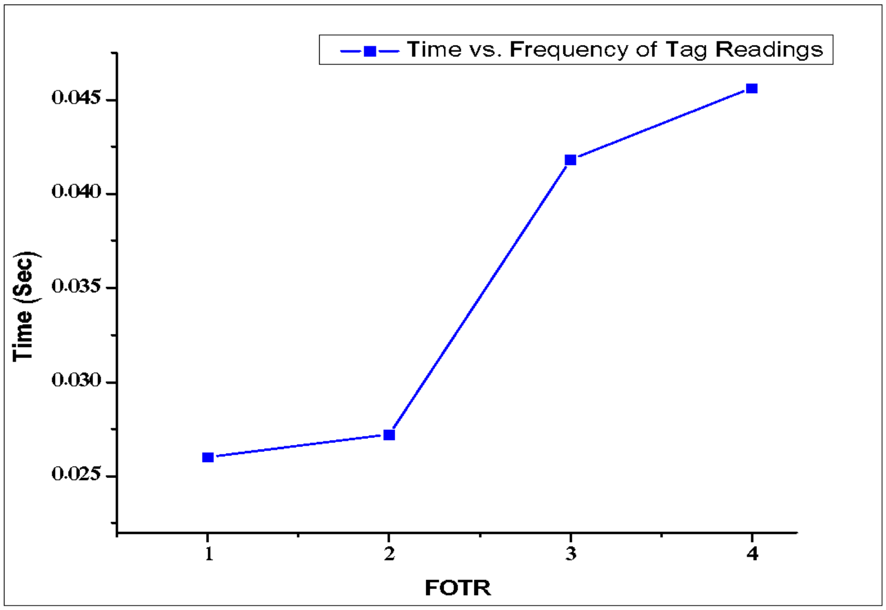
Table 1

Student at a time during attendance checking.

FOTR	Accuracy	Time (Sec)
1	100%	0.026
2	100%	0.0272
3	100%	0.0418
4	100%	0.0456

Figure 9

Time vs. frequency of tag readings



4.2. Number of Students Approaching RBSMS at a Time and Tag Collision

We conducted another experiment to show the reliability of the proposed system. It shows the effect of the student's grouping (Tag Collision) on the accuracy of the system, as listed in Table 2. In the first group (Group 1), the system captures the attendance of the students one by one. The accuracy of this system is 100% for four different times of reading an RFID tag. In the second group (Group 2), the system captures the attendance of the students two by two. The average accuracy of this group is 98.25% for four different times of reading an RFID tag. The attendance of the third group (Group 3) is captured for three by three students, which achieved average accuracy of 95.75%. The attendance of the fourth group (Group 4) is captured for four by four students, which achieved average accuracy of 95.13%. Finally, the attendance of the fifth group (Group 50) is captured for all students at the same time, which achieved average accuracy of 78.75%. All the aforementioned results show that the system is very reliable even if for a large number of students at the same time. Figure 10 shows the system performance with increasing the number of students approaching the tag reader at the same

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time. It has been dearly concluded that increasing the number of students' tags presented to the system results in RBSMS performance deteriorations as a result of tag collision and in an increase of registration time.

Table 2

Effect of tag collision on system performance

Times of reading in RFID reader	One Student (Group 1)			Two Students (Group 2)			Three Students (Group 3)			Four Students (Group4)			Fifty Students (Group 50)	
	Accuracy (%)	Time (Sec)	Error Rate (%)	Accuracy (%)	Time (Sec)	Error Rate (%)	Accuracy (%)	Time (Sec)	Error Rate (%)	Accuracy (%)	Time (Sec)	Error Rate (%)	Accuracy (%)	Time (Sec)
1	100	**0.026**	0	99.5	0.0094	0.5	97.5	0.0104	2.5	94.5	0.009	5.5	84.5	0.029
2	100	**0.027**	0	99.5	0.0282	0.5	96.5	0.0252	3.5	95.5	0.0106	4.5	78	0.0292
4	100	0.041	0	97.5	0.0302	2.5	95.5	0.029	4.5	96	0.029	4	77	0.0298
6	100	0.045	0	96.5	0.047	3.5	93.5	0.0502	6.5	94.5	0.0446	5.5	75.5	0.0406

Figure 10

System performance with increasing number of students approaching the tag read.

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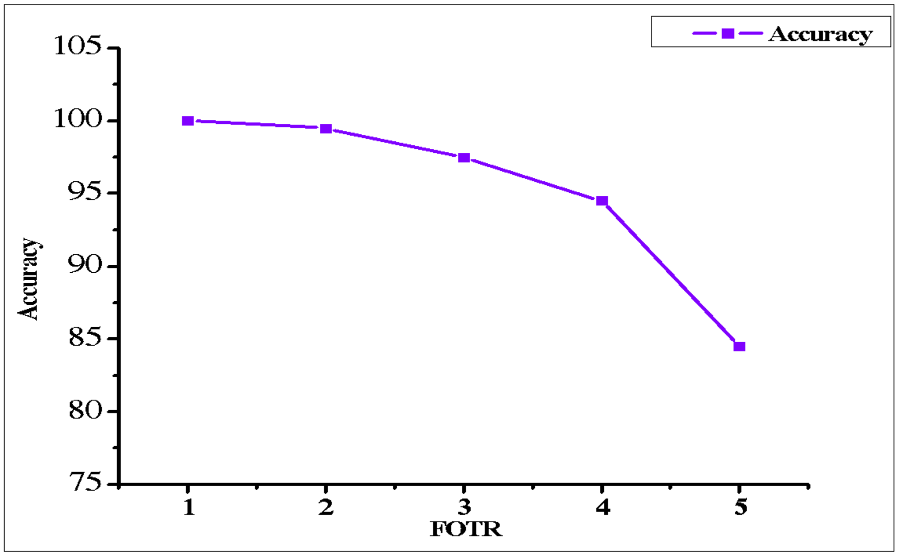

4.3. RFID Tag Anti-Collision

Table 3 shows the system accuracy by using RTAC. It is clearly shown that the system accuracy has been changed to hundred percent compared to table 2. There is no error rate, but the time has been increased slightly if compared to previous results.

Table 3

Times of reading in RFID reader	One Student (Group 1)			Two Students (Group 2)			Three Students (Group 3)			Four Students (Group4)			Fifty Students (Group 50)		
	Accuracy (%)	Time (Sec)	Error Rate (%)	Accuracy (%)	Time (Sec)	Error Rate (%)	Accuracy (%)	Time (Sec)	Error Rate (%)	Accuracy (%)	Time (Sec)	Error Rate (%)	Accuracy (%)	Time (Sec)	[illegible]
1	100	**0.026**	0.0	100	0.01	0.0	100	0.0116	0.0	100	0.02	0.0	100	0.04	[illegible]
2	100	**0.027**	0.0	100	0.029	0.0	100	0.028	0.0	100	0.0276	0.0	100	0.0434	[illegible]
4	100	0.041	0.0	100	0.0312	0.0	100	0.031	0.0	100	0.0404	0.0	100	0.0522	[illegible]
6	100	0.045	0.0	100	0.0482	0.0	100	0.0514	0.0	100	0.054	0.0	100	0.054	[illegible]

System Performance after application of the anti-collision algorithm

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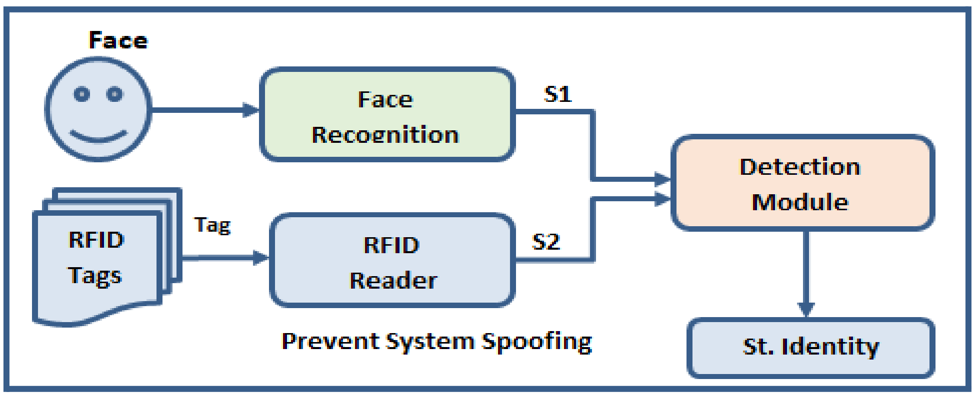
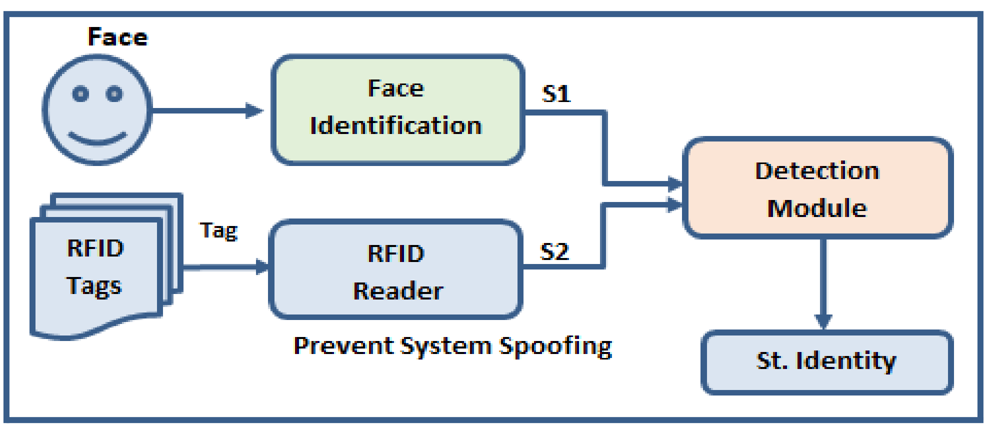
4.4. Multimodal Identification using both RFID and Face Verification

Figures 11-A, 11-B shows two multimodal identification systems which have been implemented in EBIS: (A) RFID integrated with face recognition and (B) RFID integrated with face identification. Figure 12 shows the comparison between the response-times of both cases.

Figure 11
Multimodal System.



(A)



(B)

Figure 12

Comparison between the Response-times of both Face Recognition and Face Identification.

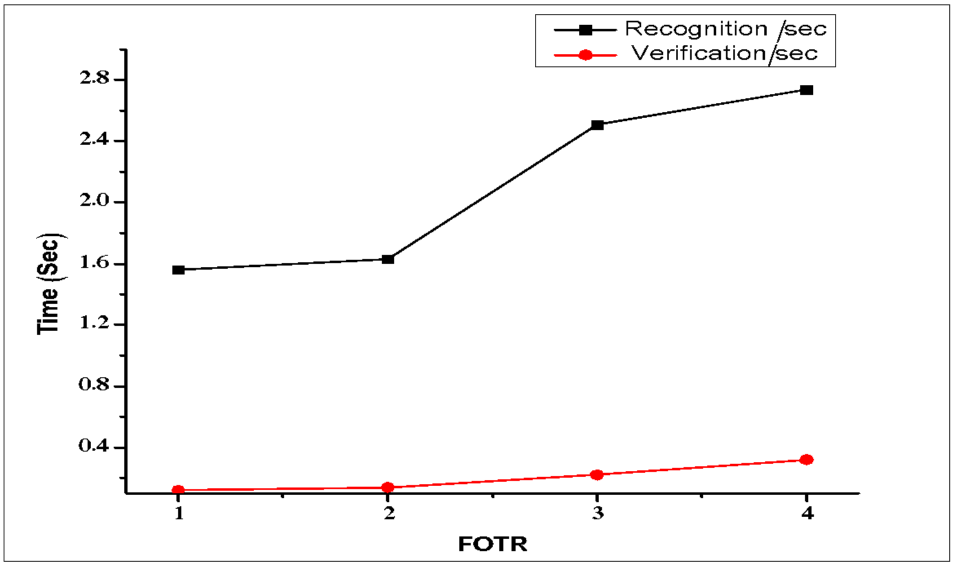


Table 4

Comparison of response times of our approach and other approaches.

Performance Indicators	PCA	MS-SSIM	Eigen face with MS-SSIM
Recognition Time	0.075625 S/ Frame	21.9725 S/Frame	**0.18 S/ Frame**
Verification Time	0.009375 S/ Frame	0.0425 S/ frame	**0.0525 S/ Frame**

Although, face recognition has resulted in promising results, face verification has been implemented and its results are compared with these of face recognition and it has been found that the time required for face verification is only 29% of the time needed for face recognition. Table 4 shows the comparison of response times of our approach and other approaches.

5. Conclusions and Future Work

It has been concluded that a multimodal system combining face verification, with RFID technology resulted in a near perfect performance. Face verification based on the multi structural similarity index has speeded up the system by a factor of 3.5 times compared to the traditional PCA approach. The RFID challenges of data filtering and tag collision has been effectively resolved. A dynamic fog based quiz generator sends quizzes to the attending students and their answers are saved to both the fog and the cloud. A student alert system sends a notification in case of violating university attendance bylaws. Feedback is also sent to the students and grades analytic report is sent to the lecture. Our future work will focus on solving the problems related to the range of RFID antenna, the size of the face database and securing the Quiz and the student grades.

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