

1 AN RFID-INTEGRATED ATTENDANCE SYSTEM WITH
2 PHOTO VERIFICATION FOR CLASSROOM EFFICIENCY

3 A Special Problem Proposal
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Abstract

19 The UP System started deployment of RFID/NFC-enabled UP ID in 2019. 5 years
20 later, we have yet to see a system that fully utilizes the technology embedded in
21 the UP ID. In particular, we see a great potential in using it as an access key for
22 tracking the attendance of students in their classes. Professors currently either
23 use the traditional pen and paper or a spreadsheet in their laptops to check for
24 attendance. The mentioned practices are prone to forgery and takes precious time
25 away from the class period.

26 Our paper proposes a fully digital attendance tracking system that can be used
27 by professors to record the attendance of their students in real time. The system
28 uses UP ID and facial recognition for a two-layer validation process ensuring ac-
29 curacy of the records. Facial recognition uses a pretrained Facenet model that
30 surpasses human beings in multiple facial recognition tests for accuracy. The pro-
31 posed system allows the students to check in by tapping their ID to the RFID/NFC
32 reader, and aligning their face in the camera. The current prototype takes only
33 about 2-3 seconds per student to complete the whole validation and recording
34 process, with more room for optimizations down the line.

35 **Keywords:** UP System, RFID, attendance, machine learning, facial
recognition, Facenet model.

Contents

37	1 Introduction	1
38	1.1 Overview	1
39	1.2 Problem Statement	2
40	1.3 Research Objectives	3
41	1.3.1 General Objective	3
42	1.3.2 Specific Objectives	3
43	1.4 Scope and Limitations of the Research	3
44	1.5 Significance of the Research	4
45	2 Review of Related Literature	6
46	2.1 Importance of Attendance Tracking	6
47	2.2 Attendance Tracking Methods	6
48	2.2.1 Traditional Attendance Tracking Methods	7
49	2.2.2 Biometric-Based Attendance Systems	7
50	2.3 Chapter Summary	9
51	3 Research Methodology	10
52	3.1 Research Activities	10

53	3.2 Software Development Tools	11
54	4 Preliminary Results/System Prototype	13
55	4.1 System Architecture	13
56	4.2 Django Backend	14
57	4.2.1 Models	14
58	4.2.2 REST API by Django Ninja	14
59	4.2.3 Admin panel by Django	15
60	4.3 Nuxt Frontend	16
61	References	19
62	A Appendix Title	20
63	B Resource Persons	21

64 List of Figures

65	4.1	System Architecture	13
66	4.2	Student model	14
67	4.3	API Documentation	15
68	4.4	Django Administration	15
69	4.5	Time in and Time out Page	16
70	4.6	Successful Time In	17
71	4.7	Django saving the attendance time instance in 24-hr format . . .	17
72	4.8	Fake Delay	18

73 List of Tables

<small>74</small>	2.1 Comparison of Attendance Tracking Methods Using the CIA Triad	9
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Chapter 1

Introduction

1.1 Overview

Attendance plays an important role in improving the academic performance of students. There is evidence that students with lower attendance often have lower grades (Ancheta, Daniel, & Ahmad, 2021). Therefore, attendance is usually enforced and recorded at most higher education institutions. However, the systems in place for recording attendance are typically manual and time-consuming.

The traditional pen and paper attendance system has existed since the invention of paper itself. It is used for time keeping by manually writing or checking the 'present' status in a paper log book. Manually writing names takes an average of 17 seconds per student (Shoewu, Makanjuola, & Olatinwo, 2014), and for class size of 30 students that leads to approximately 8 minutes of class time wasted. While it is recognized that such system is time-consuming and wastes resources, it persisted because of its familiarity. Going to class means bringing pen and paper for most students and teachers alike, so using the same material for recording attendance seemed the most practical.

In recent years, as laptops and portable computers became more accessible, some faculty of UP started transitioning to digital spreadsheets provided by services like Microsoft Excel. While it seemed to have moved the traditional pen and paper towards digitalization, another problem arises as this required manually roll calling students to say 'present'. It had the same problem of being a manual process. It is easily disrupted by a noisy class. Some time that was supposed to be utilized for immediate teaching was used for roll call.

Both systems mentioned are prone to errors and unnecessarily increases administrative burden for the faculty. Reduction in teaching time means frequently moving the lesson discussions by the faculty, with some topics being rushed or skip entirely by the end of semester. This reduces overall the quality of education students received and may negatively impact their readiness for subsequent courses they may take.

Therefore, we propose a fully automatic, digital attendance system that addresses these concerns. We utilize the already distributed UP ID and pretrained face recognition models that ensures an easy, accurate, attendance keeping. It aims to ease the burden of faculty and students from manual methods of attendance system, allowing them to focus on class discussions instead.

1.2 Problem Statement

The current methods of taking attendance today such as the manual call roll, biometrics, and online or remote attendance provides challenges in terms of efficiency, security, and authenticity. Manual roll calls are time consuming, according to (Mahato & Suman, 2013, p. 5875), it consumes an average of 5 to 15 minutes in order to complete an attendance using manual roll call attendance. It also provides a burden to some of the teachers through the disruptive behaviors of the students which lower the efficiency of manual roll call ("How Teachers Can Meet the Challenges," 2015). Biometrics attendance systems like fingerprint and facial scanning provide efficiency in taking an attendance but it is more costly and widely not accessible. The online or remote attendance system is only advisable in virtual class and not in face to face class as it is prone to attendance fraud.

Failure to resolve efficiency and a secured attendance system may lead to inaccurate attendance records and high risks of attendance fraud. These gaps may also affect the integrity in terms of attendance of the university. To fill those gaps, the solution should be the integration of RFID and facial recognition technology but there are uncertainties which are the efficient ways to integrate the real-time face capture while managing the privacy concerns and also finding an optimal way to gather sensitive information which are the student's biometric and their RFID serial number.

Given the gaps of the current attendance system method, there is a need to design an attendance system with the integration of RFID and facial recognition technology which are:

- 133 1. Efficiently captures the real-time data using the RFID and facial recognition
134 technology.
- 135 2. Ensure and maintain security and privacy of the student's sensitive data
136 such as their facial biometrics and unique serial number of their RFID.
- 137 3. Ensure compatibility with the university infrastructure which is the avail-
138 ability of RFID and the hardware for facial scanning.
- 139 4. Determine the effectiveness of the combination of the RFID and facial tech-
140 nology in the attendance system.

141 1.3 Research Objectives

142 1.3.1 General Objective

143 This project aims to develop a web application that effectively uses the current UP
144 RFID and face recognition for attendance checking and recording in the University
145 of the Philippines Visayas. Additionally, it also aims to assess the performance of
146 the application in terms of accuracy and efficiency.

147 1.3.2 Specific Objectives

- 148 1. To develop a full stack web application that uses an RFID scanner and facial
149 recognition models such as Facenet for an accurate and efficient tracking of
150 student attendance.
- 151 2. To enhance application security by implementing the CIA triad.
- 152 3. To analyze the application's performance based on metrics such as accuracy,
153 efficiency and security.

154 1.4 Scope and Limitations of the Research

155 The focus of this project is to create an attendance system that uses RFID together
156 with facial technology. This project will take real time attendance by scanning
157 the student's RFID and verify the student's identity using facial technology. The

158 project will also focus on the User Experience part where students can take their
159 attendance as quickly as possible by aligning their faces while they scan their
160 RFIDs. In that way it will enhance the overall efficiency and accuracy of taking
161 attendance in the university.

162 This project will not involve the training of face recognition models, as there
163 are high-performance, pretrained models readily available. The focus will be on
164 utilizing these existing face recognition models for the development of an effective
165 attendance tracking system. This project will only limit face to face classes, it
166 will not cover the virtual or online classes, it will also not cover the other forms
167 of biometric authentication such as fingerprint and eyes (iris scanning) because of
168 its expensive hardware and the privacy concerns of the students.

169 1.5 Significance of the Research

170 Facial recognition has been in use mobile applications for validation of identity
171 and the performance has significantly improved over the years. This allowed us to
172 explore the possibility of using it in attendance tracking of students in UP Visayas
173 as there are currently no system like it in place. We also intend for this project to
174 be open-source. Some of the people that will benefit from our developed app are:

- 175 • Students - will benefit from the increased class time. This allow better
176 retention of topics and lesson discussions. This complements the goal of
177 recording attendance itself, which is to increase the quality of education the
178 students receive.
- 179 • Faculty - will also benefit from the increased class time. An automated
180 system will allow them to focus entirely on delivering the topics that need
181 to be covered. It will lessen the possibility of skipping modules or topics
182 needed by students to learn before taking their subsequent courses.
- 183 • UP System - Since the UP RFID are used across all constituent units of the
184 UP System, our project can be used by any faculty under the UP System.
185 They may also choose to create their own version as long as they also make
186 it open source, as stipulated in GNU GPLv3 license.
- 187 • Society benefits - this project is significant in our society. The project is
188 scalable and when it is improve more in the future, there is a high possibil-
189 ity that it can be applicable not only to tertiary, higher or in any education

190 but also it will be applicable to large organizations or corporations as it can
191 improve taking attendance plus it can reduce the fraud in taking attendance
192 because one of the gaps to be filled by this project is the integrity, the com-
193 bination of RFID and the real-time face capture can help the organizations
194 to have integrity in terms attendance.

195 We also hope that this project will bring focus on the growing accessibility
196 of facial recognition technologies and inspire the community to explore on how it
197 can be incorporated their own projects.

Chapter 2

Review of Related Literature

2.1 Importance of Attendance Tracking

Attendance has become increasingly important in every organization, institution, and workplace to ensure accountability, productivity, and engagement. For example, in schools, it ensures that students are present, participating, and fulfilling their responsibilities. Taking students' attendance is important for monitoring their performance in class. Good attendance is usually linked to good class performance, and vice versa (Zhi, Ibrahim, & Aris, 2014).

2.2 Attendance Tracking Methods

There are various methods to track classroom attendance, from traditional manual approaches, such as roll call or pen-and-paper methods, to modern technology-based systems, including biometric like fingerprint or facial recognition. The advantages and disadvantages of these systems will be discussed in the following subsections using the CIA Triad.

The Confidentiality, Integrity, and Availability (CIA) Triad is a commonly used information security model that helps organizations develop secure systems (Zhang, 2014). Confidentiality refers to the protection of information from unauthorized access to ensure that only authorized users can access or modify data. Integrity ensures that data remains complete, trustworthy, and unaltered by unauthorized users, whether accidentally or maliciously. Availability ensures that authorized users can access the data when needed. These three principles are often used to

220 identify vulnerabilities in a system.

221 **2.2.1 Traditional Attendance Tracking Methods**

222 The traditional method of taking attendance is through a manual roll call. Ac-
223 cording to Uniyal (2022), using manual attendance is cost-effective, simple to use,
224 and remains functional during power interruptions. However, despite these ad-
225 vantages, manual attendance has several flaws. For instance, the roll call method
226 is time-consuming as it can waste 5 to 15 minutes of class time which could other-
227 wise be spent on actual learning (Mahato & Suman, 2013, p. 5875). Additionally,
228 there is a problem in integrity when ledger sheets are used as it is easy for stu-
229 dents to fake another student's attendance by forging their name and signature
230 or erasing an already marked attendance.

231 CIA Triad Analysis:

- 232 • Confidentiality: Traditional attendance tracking methods may offer low con-
233 fidentiality as attendance can easily be accessed by unauthorized individuals,
234 especially with the pen-and-paper method.
- 235 • Integrity: Traditional attendance tracking methods have low integrity as it
236 is easy for students to forge another student's attendance or alter existing
237 records.
- 238 • Availability: Traditional attendance tracking methods have high availability
239 as attendance can always be taken during class, regardless of technological
240 failures.

241 **2.2.2 Biometric-Based Attendance Systems**

242 According to (Truein, 2024), there is another one that is more reliable and has
243 a higher accuracy than the fingerprint biometric attendance system and that is
244 facial recognition. According to (Yang & Han, 2020), with the use of real time
245 video processing, it can result in a high accuracy for about 82% which is higher
246 compared to other attendance systems. It can also reduce the truancy rates in
247 school as the facial recognition system can easily identify who gets in and out in
248 real time, preventing the students from cutting classes or even skipping classes.
249 Biometric systems such as fingerprint recognition have addressed some of the
250 shortcomings of manual attendance methods. According to Walia & Jain (2016),

251 replacing traditional attendance methods with biometric fingerprint systems im-
252 proves confidentiality and integrity. However, while biometric fingerprint atten-
253 dance systems have high reliability, they still come with some limitations (Truein,
254 2024). For example, if a person’s finger is injured or dirty, the system may fail
255 to recognize the fingerprint which can affect the system’s effectiveness. Moreover,
256 the cost of deployment can be high due to the need for specialized hardware and
257 maintenance.

258 CIA Triad Analysis:

- 259 • Confidentiality: Biometric systems provide better confidentiality compared
260 to manual methods as biometric data is unique to each individual and stored
261 securely. However, if the data is compromised, the consequences can be
262 severe because biometric data cannot be changed, unlike passwords.
- 263 • Integrity: Biometric systems provide high integrity as it is almost impossible
264 to forge or alter fingerprint data.
- 265 • Availability: While biometric systems are generally available, they may face
266 limitations if the finger is injured or dirty or in areas with an unreliable
267 power supply.

268 Facial recognition technology has emerged as an even more accurate and con-
269 venient alternative to fingerprint systems (Truein, 2024). According to Yang &
270 Han (2020), real-time video processing in facial recognition systems has an accu-
271 racy rate of about 82%, which is higher than other attendance tracking methods.
272 Facial recognition can also help reduce truancy rates by identifying students in
273 real time in order to prevent them from skipping classes.

274 CIA Triad Analysis:

- 275 • Confidentiality: Facial recognition systems, like fingerprint systems, have
276 high confidentiality as biometric data is unique to each individual and stored
277 securely.
- 278 • Integrity: The integrity of facial recognition systems is typically high as it
279 is difficult for students to falsify their identity without being detected.
- 280 • Availability: Facial recognition systems are generally highly available, par-
281 ticularly in environments with stable lighting conditions.

2.3 Chapter Summary

This chapter discussed various classroom attendance tracking methods and analyzed their advantages and disadvantages using the CIA Triad. Traditional manual systems, while cost-effective, lack both confidentiality and integrity. Fingerprint systems offer better security but may suffer from availability issues when the finger is dirty or injured. Facial recognition systems, with higher accuracy and efficiency, provide significant improvements in terms of data confidentiality and integrity.

A table comparing these systems, based on the CIA Triad, is provided below:

Attendance Tracking Method	Confidentiality	Integrity	Availability
Traditional	Low	Low	High
Fingerprint Systems	High	High	Medium
Facial Recognition Systems	High	High	High

Table 2.1: Comparison of Attendance Tracking Methods Using the CIA Triad

Our proposed system aims to leverage the security advantages of Facial Recognition Systems by adding an extra layer of user authentication that requires students to use their UP RFID which is personal and unique to each student.

Chapter 3

Research Methodology

This chapter lists and discusses the specific steps and activities that will be performed to accomplish the project. The discussion covers the activities from pre-proposal to Final SP Writing.

3.1 Research Activities

This project aimed to create an automated attendance system with the help of RFID together with facial recognition technology. This attendance system will replace and reduce the usage of manual attendance such as the written and oral and enhance its lacking optimized features such as security, reliability, authenticity, and integrity using the student's RFID and facial biometric.

The proposed system is expected to function by tapping the RFID of the students with real time facial capture through face recognition technology. The identity of the students will be verified through the unique serial number of their RFID that will match from the system database while the face recognition will serve as the two-factor authentication. The face recognition is expected to work by capturing the students face then will be matched also through the system database. The attendance will only be valid once both student's unique serial number in their RFID and their face has been verified.

To make the system functional, several data from the students need to be collected. Those are the student's name, student number, student's unique serial number of their RFID, and their facial biometrics. Those data will be gathered either online or face to face. Students are encouraged to download any of the RFID

316 card readers to know their RFID's serial number but in case they are incapable of
317 doing that. Face to face to face will be an option where we can provide a physical
318 RFID card reader. The facial recognition data will be gathered through capturing
319 their image or video to be more accurate.

320 The hardware components will be using in this system are: RFID scanner:
321 Which will be used to read the RFID given to the students. This will also be
322 responsible for taking the students unique serial number on their RFID ensuring
323 the integrity of the students. USB connector: This will be used to connect the
324 RFID scanner and the Camera Module to the Laptop or Raspberry Pi. Laptop /
325 Raspberry Pi: This will serve as the main processing unit. The laptop or raspberry
326 pi will be used for running the required algorithm to make the face recognition
327 and read the RFID correctly. Overall, the laptop / raspberry pi will be in charge
328 of handling the data. Camera Module: In charge of capturing the student's facial
329 image while scanning the RFID to the RFID scanner. Software Python facial
330 recognition

331 3.2 Software Development Tools

332 Our current prototype include these frameworks and tools that are heavily used
333 in the industry for rapid development and deployment of web applications. All of
334 the tools used are open source. These include but are not limited to:

- 335 • Django - The web framework for perfectionists with deadlines. Django,
336 which serves as the backend server, allows us to interface with the database
337 server to do queries in the Python using Django's Object Relational Mapping
338 tool(ORM). We can easily integrate popular pretrained facial recognition
339 models as they are typically written in Python.
- 340 • deepface Python library - Provides the face verification tool and anti-spoofing
341 capabilities. It wraps the popular face recognition models into an easy to
342 use library. These include but is not limited to: Facenet, VGG-Face and
343 OpenFace.
- 344 • Django Ninja - Creates the REST API on top of our Django backend to
345 allow the frontend to consume the backend content.
- 346 • NuxtJS - The frontend JavaScript framework used to build our web interface.
347 Includes all the tools for routing, quering, and security. By default, it renders

348 our web interface in Server Side Rendering(SSR) mode. Most of the work
349 happens in the server and no authentication tokens are stored in the client
350 browser. This increases security since authentication tokens are only added
351 in the server side per request.

Chapter 4

Preliminary Results/System Prototype

4.1 System Architecture

Using the tools mentioned in Section 3.2, our system can be visualized as shown in Figure 4.1:

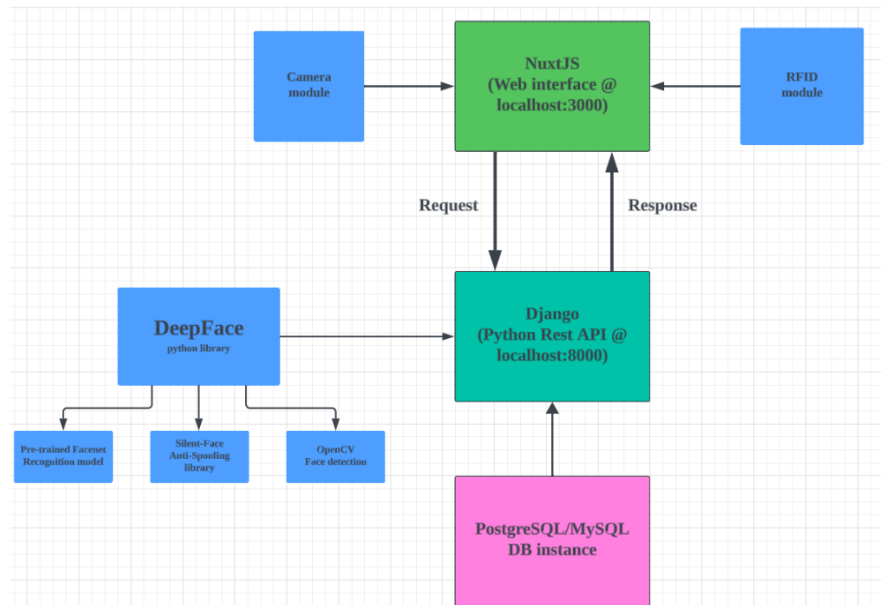


Figure 4.1: System Architecture

358 4.2 Django Backend

359 4.2.1 Models

360 Django Model class maps to SQL tables. For example, a Student table will have
361 the following columns which maps to Student Model class' attributes like in Figure
362 4.2:

```
class Student(models.Model):
    student_id = models.IntegerField(primary_key=True)
    first_name = models.CharField(max_length=100, default='')
    last_name = models.CharField(max_length=100, default='')
    email = models.EmailField(null=True)
    face_data = models.TextField(null=True)

    Codeium: Refactor | Explain | Generate Docstring | X
    def full_name(self):
        return f'{self.first_name} {self.last_name}'
    Codeium: Refactor | Explain | Generate Docstring | X
    def __str__(self):
        return self.full_name()
```

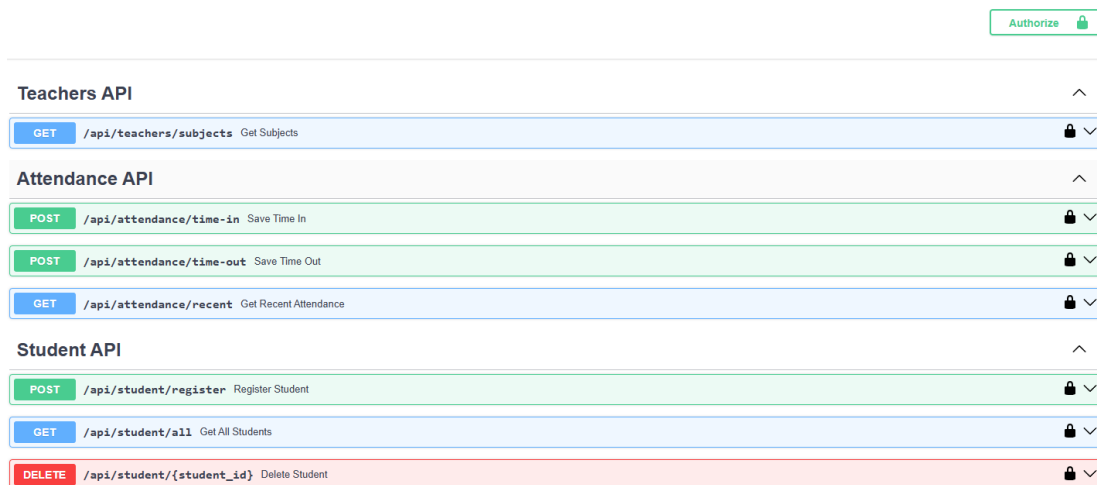
Figure 4.2: Student model

363 SQL equivalent would be:

```
364 CREATE TABLE Student (
365     student_id INTEGER PRIMARY KEY,
366     first_name VARCHAR(100) NOT NULL DEFAULT '',
367     last_name VARCHAR(100) NOT NULL DEFAULT '',
368     email VARCHAR(254),
369     face_data TEXT,
370     CONSTRAINT unique_email UNIQUE (email)
371 );
372
```

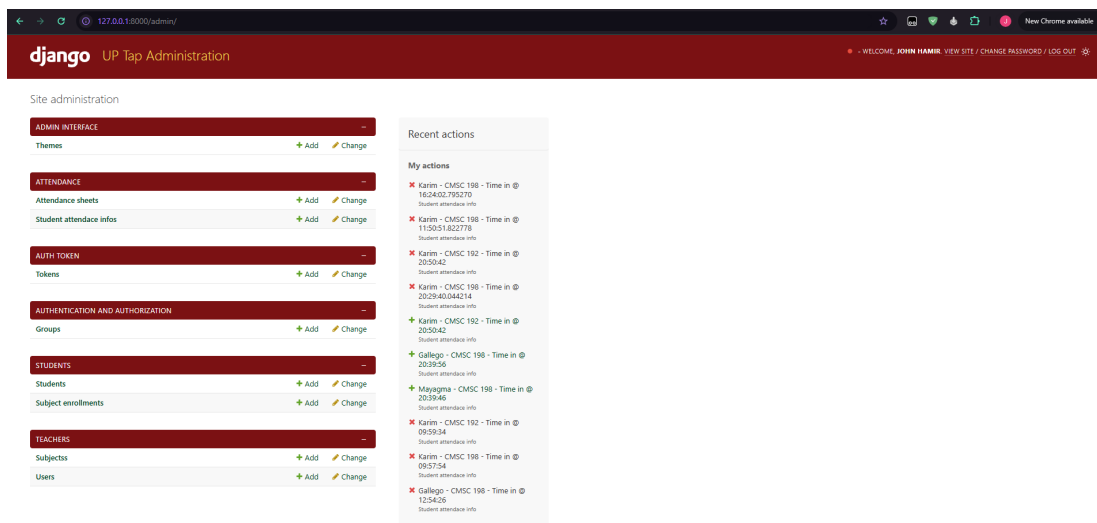
373 4.2.2 REST API by Django Ninja

374 Figure 4.3 is the automatic OpenAPI compliant documentation provided by Django
375 Ninja. It contains all endpoints we can use to query data from the database. All
376 endpoints are protected using HTTP Bearer token authentication.



377 4.2.3 Admin panel by Django

Figure 4.4 is the Django administration page only accessible to a superuser account. This is where most of the backend maintenance work happens. It contains all the data inside the database allow full control over them. It also contains every authentication tokens used by each teacher account.



4.3 Nuxt Frontend


With the backend handling most of the heavy work, the frontend only needs to capture images from the camera and sending them to the backend to verify student identity. The localhost:3000/dashboard/time-in-out page handles the time in and time out process. The RFID input is automatically highlighted upon opening

UP Tap Attendance System


CMSC 198

1. Time in

2. Time out

Step 1: Face Recognition

Align your face with the camera, please.

Step 2: RFID Scan

Scan your RFID card...

Figure 4.5: Time in and Time out Page

the page so it will be immediately ready to take in input from the RFID scanner. When the proper number length is inputted, it will immediately start to verify the identity. It will then notify the student for the time in/time out time and status. It will also notify for any errors like spoof image or no face detected. From our testing, the response time is currently at most 2.3 seconds, most of the delay comes from the fake delay we used to allow the student to read the notification after verification.

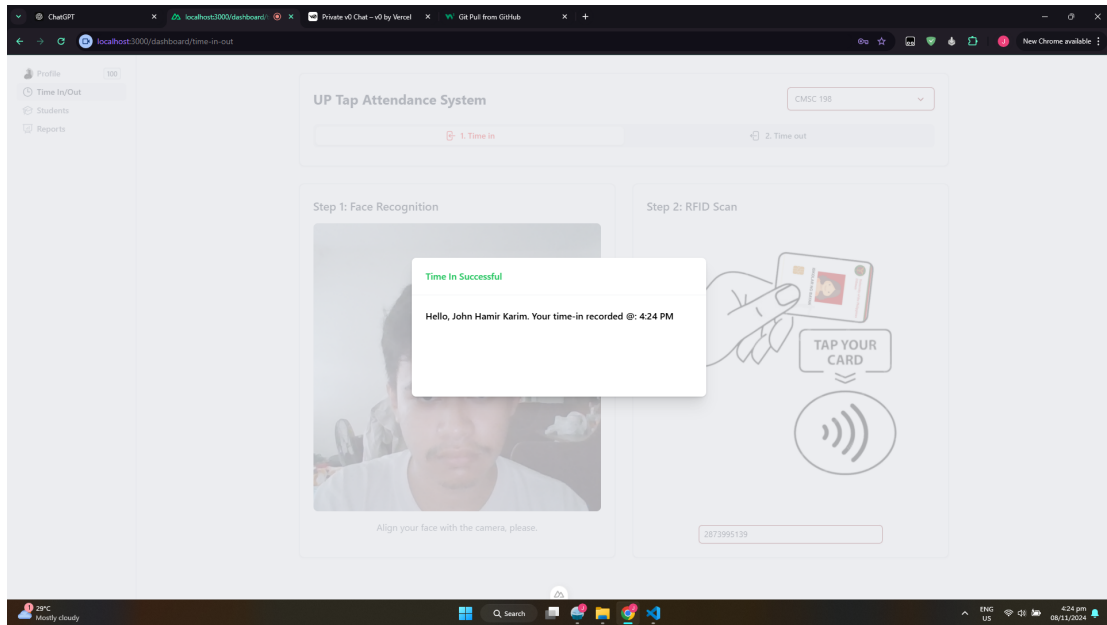


Figure 4.6: Successful Time In

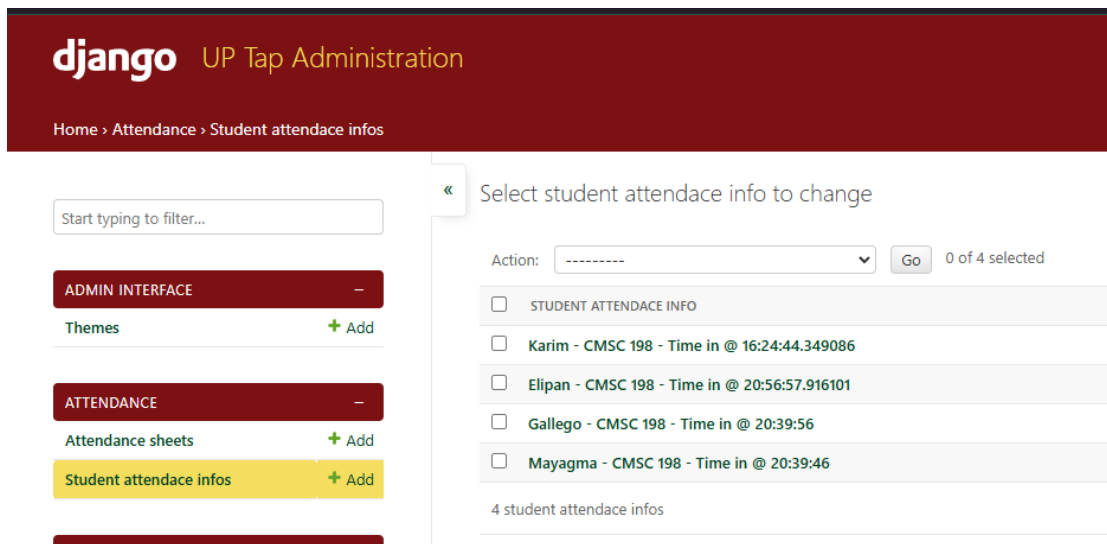


Figure 4.7: Django saving the attendance time instance in 24-hr format

```
if(time_in){  
  openModal(time_in)  
  // 2 second countdown  
  setTimeout(() => {  
    closeModal()  
  }, 2000);  
  setTimeout(() => {  
    rfidRef.value.$refs.input.focus()  
  }, 2300)  
}
```

Figure 4.8: Fake Delay

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⁴¹⁴ **Appendix A**

⁴¹⁵ **Appendix Title**

⁴¹⁶ **Appendix B**

⁴¹⁷ **Resource Persons**