



## RESEARCH ARTICLE

## DESIGN AND IMPLEMENTATION OF UNIVERSITY CLASSROOM QUALITY MONITORING PLATFORM BASED ON OPENPOSE

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## ARTICLE DETAILS

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## ABSTRACT

With the rapid development and popularization of the education industry, the number of all kinds of schools and educational institutions is increasing, and the problems in the teaching process are becoming increasingly prominent, especially the non-standard behaviors of students in the classroom and the proper teaching methods of teachers, which directly affect the teaching quality and learning effect. In this context, this paper designs a human bone key point monitoring technology and CNN algorithm based on OpenPose, which is specially used to realize intelligent monitoring of classroom teaching and provides objective and accurate data support by automatically identifying and recording key information in the teaching process, such as students' behaviors and teachers' teaching methods. Help education administrators and teachers to understand the teaching process more comprehensively, identify problems in time and take measures to correct them. At the same time, the platform can analyze students' learning behaviors and learning effects, provide teachers with targeted teaching suggestions, help them optimize teaching strategies and teaching methods, and improve teaching effects and students' learning efficiency.

## KEYWORDS

OpenPose; CNN; Computer vision; OpenCV; Deep learning

## 1. INTRODUCTION

With the continuous development of educational technology, monitoring and improving the quality of university classroom teaching has become an important topic in educational management. Traditional quality assessment methods often rely on subjective teacher evaluations or student feedback surveys, which may have problems such as high subjectivity and poor timeliness. In recent years, due to the rapid development and popularization of the use of computer vision and deep learning technologies, automated monitoring systems based on posture estimation are slowly becoming a new method to improve the quality of university classroom teaching (Shan, 2024).

The purpose of this paper is to explore and design a university classroom quality monitoring platform based on OpenPose technology. OpenPose, as an advanced multi-person posture estimation tool, can accurately and real-time capture the posture information of teachers and students in the classroom. By analyzing this posture data, we can quantify various movements and postures during teaching and learning, thus objectively assessing teaching effectiveness, identifying student engagement, and evaluating teachers' expression and communication skills, among other metrics.

This paper first introduces the principles and characteristics of OpenPose technology, and then describes in detail the design and implementation of the university classroom quality monitoring platform based on OpenPose (Liu, 2024). Finally, through experimental validation and case study, we verify the potential and advantages of the platform in improving the quality and efficiency of classroom teaching. Through the research and realization of this paper, we expect to provide a new way of thinking and

technical support for the assessment and management of modern university classroom teaching quality, and to promote the further development and application of educational technology in practical application.


## 2. OVERALL SYSTEM DESIGN

## 2.1 System Architecture Overview

With the continuous development of educational technology, monitoring and improving the quality of university classroom teaching has become an important topic in educational management. Traditional quality assessment methods often rely on teachers' subjective evaluation or students' feedback surveys, which may have problems such as high subjectivity and poor timeliness. In recent years look, with the rapid development and popularization of the use of computer vision and deep learning technology, the automated monitoring system based on posture estimation has gradually become a new way to improve the quality of university classroom teaching.

This university classroom quality monitoring platform is realized based on OpenPose technology, which aims to capture and analyze the posture data of teachers and students in the classroom in real time, so as to quantify various movements and postures in the process of classroom teaching, and to provide an objective data basis for the assessment of teaching quality level. The system consists of four main modules, namely, data acquisition module, posture analysis module, data storage and management module, and front-end display and analysis module.

As shown in Figure 1.

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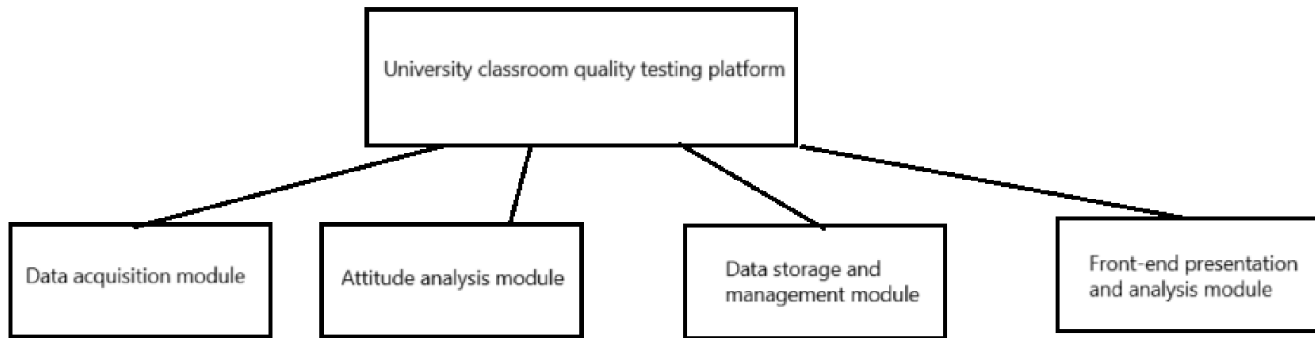


Figure 1: Design diagram of university classroom testing platform

## 2.2 Technology Options and Principles

### 2.2.1 CNN technology

Neural networks, also known as artificial neural networks, are at the heart of deep learning algorithms. It is inspired by neurons inside the human brain and mimics the way biological neurons transmit signals to each other in order to achieve the purpose of learning experiences. First proposed in 1943 by neurophysiologist Warren McCulloch and mathematician Walter Pitts, neural networks are relatively simple models that can only perform simple logical decisions. In 1958, psychologist Frank Rosenblatt proposed the Perceptron model, the first neural network that could automatically learn weights, allowing it to perform some simple image recognition tasks. However, perceptrons have only a single layer of neural networks, and their learning ability is very limited (Gao and Wang, 2024). In 1986, the backpropagation algorithm proposed by David Rumelhart and others can train multi-layer neural networks, greatly improve the learning ability of neural networks, and thus have been widely used.

Some variants of neural networks such as convolutional neural network and recurrent neural network have been proposed successively. Despite showing great potential, the development of neural network models stalled again due to the long training time and the lack of large data sets at the time, resulting in predictions that were often inferior to the then emerging Support Vector Machine algorithms. In 2006, Geoffrey Hinton et al. proposed a layer-by-layer pre-training method to solve the updating problem of the second-layer network, so that deeper neural networks can

be effectively trained, and proposed the concept of Deep Learning for the first time. Later, with the rapid development of computer hardware and the continuous improvement of data sets, deep neural networks have been widely used in new fields such as image recognition and automobile intelligent driving, and have also developed into the current mainstream artificial intelligence algorithm.

Neural network models are modeled after human brain neurons. There are about 86 billion neurons in the human brain, which are connected to each other and transmit information to complete the complex information processing in People's Daily life. Neurons are mainly composed of cell bodies, dendrites and axons, in which dendrites transmit incoming signals to neurons, cell bodies process incoming signals, and axons transmit signals, as shown in Figure 1. The neurons of the human brain are divided into two states, namely, the resting state (non-activated state) and the sending potential signal state (activated state), which is because the cell body of the neuron has a very important mechanism - threshold, that is, only when the input electrical signal reaches the threshold, the cell body will be activated and continue to forward the electrical signal.

OpenPose Technology: OpenPose is an open source library based on deep learning that can quickly and accurately detect the poses of multiple people simultaneously. It uses deep neural network models to analyze images or video streams and identify and label human key points, such as the position and posture of human head, limbs, and other key parts of the human body. The human key point location map is shown in Figure 2, Figure 3 and Table 1.

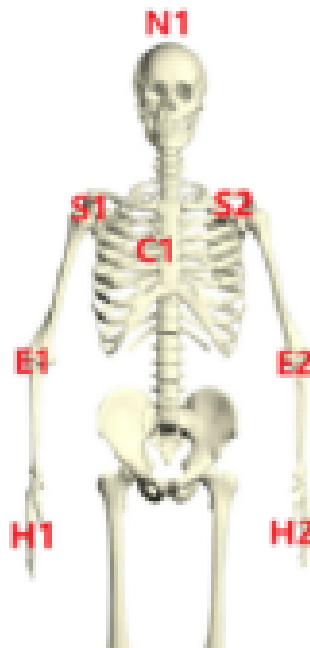


Figure 2: Diagram of key human body points

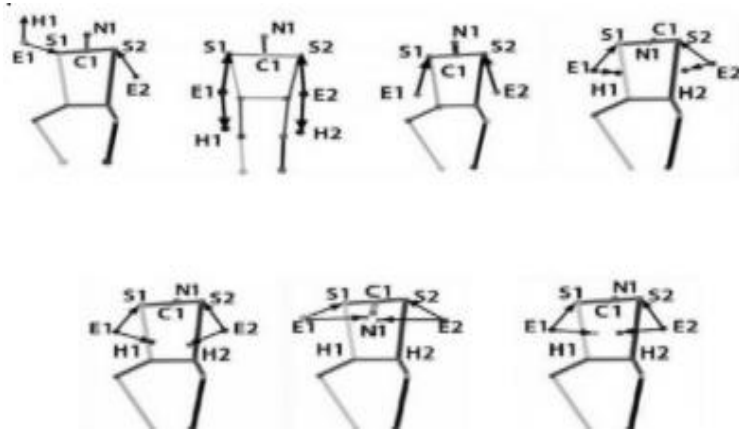


Figure 3: Mapping of key points in the human body

Table 1: Key points in the human body	
serial number	symbolize
N1	head
S1	right shoulder
S2	left shoulder
C1	chests
E1	right knee
E2	left knee
H1	right-hand side
H2	left hand

### 2.2.2 Algorithmic principles

After finding a lot of key points, how do we connect it is a difficult problem (Wang, 2024). Especially when it comes to multi-person pose estimation, there may be many possibilities for the relationship that exists between the key points in the above Figure 2.

In the  $img^{X_2,k}$  as well as  $X_3,k$  denote the positional information of the two limb parts 2 and 3 of the  $k$ th person, respectively, and if the position of point  $P$  is above these two body parts then  $L_{k,1,2}(P)$  then denotes the unit vector of the  $k$ th individual whose two components have the value 1 and point to 2. If the position of point  $p$  is not in this range, then point  $P$  becomes 0

$$L_{k,num_1,num_2} = \begin{cases} v & \text{if } p \text{ on limb } num_1 \rightarrow num_2, k \\ 0 & \text{otherwise} \end{cases} \quad (1)$$

Included among these  $L_{k,num_1,num_2}$  denote the unit vectors of the  $k$ th individual body parts 1 through 2.  $l_{num_1,num_2}$  Represents the length between body parts.

$$l_{num_1,num_2} = \|X_{num_1,k} - X_{num_2,k}\| \quad (2)$$

Average PAF:

$$L_{num_1,num_2}^{\Delta}(P) = \frac{\sum_{k=1}^K L_{k,num_1,num_2}(P)}{N_{num_1,num_2}(P)} \quad (3)$$

Which  $N_{num_1,num_2}(P)$  denotes the number of non-zero vectors

And in its prediction phase, for two candidate component points  $w_1$  and  $w_2$ , we sample along the line segment connecting them to predict the confidence of association between the two parts

$$E = \int_0^1 L_{num_1,num_2}(P(U)) \cdot \frac{W_2 - W_1}{\|W_2 - W_1\|_2} du \quad (4)$$

Association confidence where  $p(u)$  represents the position between two body parts:

$$p(u) = (1-u)w_1 + uw_2 \quad (5)$$

Practical predictions are made by summing uniformly spaced samples over the  $u$  interval to solve for the approximate integral values.

## 3. SYSTEM IMPLEMENTATION

### 3.1 General Design of System Functional Modules

The system consists of the student side and the teacher side as well as the faculty side. Its overall design scheme is shown in Figure 4.

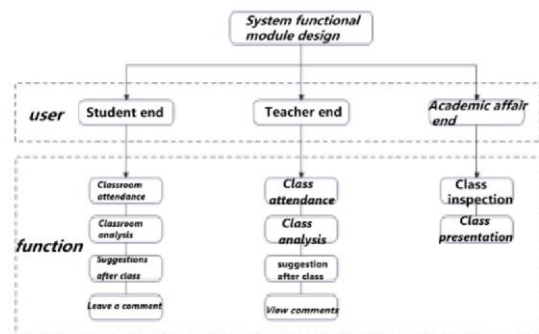


Figure 4: System function module design table

#### 3.1.1 Student side

The student side has the following main features:

##### 3.1.1.1 Class Attendance.

Students can view the overall attendance of a course and also view the specific attendance of the class corresponding to that course;

##### 3.1.1.2 Classroom Analysis.

Students can view the recent learning concentration of a course, and then view the detailed attendance of the corresponding class, including sign-in time, sign-in location and sign-in status, etc.; at the same time, they can also view the details of the classroom behavior, including the number of times of various classroom behaviors, the degree of commitment, interaction, and disengagement;

### 3.1.1.3 Suggestions after class

The platform analyzes students' classroom behavior data and the concentration level in the comprehensive evaluation, and gives specific feedback and reasonable suggestions for students' reference after class, so as to facilitate students' checking of deficiencies and adjustment of their learning status;

### 3.1.1.4 Post a comment.

Students can post comments about a specific class or delete them.

## 3.1.2 Teacher's side

The teacher's end has the following main features:

### 3.1.2.1 Class Attendance

Teachers can view the recent student attendance rate of a course after selecting the course, and select the class corresponding to the course to view the specific attendance list of students in the class, and can modify the attendance status of each student;

### 3.1.2.2 Classroom Analysis

After selecting a class, teachers can view the detailed learning situation of students in that class, including the number of students in each classroom behavior, the number of times students show various classroom behaviors, concentration and classroom quality ranking;

### 3.1.2.3 Post-lesson advice: The platform utilizes an existing database of student behavior.

The platform uses the existing student behavior database to analyze and calculate the data reasonably and predict the trend of students' future learning status, so as to give teachers reasonable teaching suggestions (Li and Jia, 2024);

### 3.1.2.4 View Comments

Teachers can view and respond to all the comments made by students in each class.

## 3.1.3 Academic Affairs

The main functions of the teaching side are as follows:

### 3.1.3.1 Classroom Supervision

Teaching supervisors select the course taught by the designated teacher to view the real-time monitoring video of the corresponding classroom of the course and the specific list of students' attendance, attendance and absence, the number of students for each classroom behavior, the number of times each student appears for various classroom behaviors in this class, the situation of concentration, and so on;

### 3.1.3.2 Classroom Reporting.

Faculty supervisors can view the learning quality ranking of the classroom, and the ranking is based on the same course taught by the same teacher.

## 3.2 Data Acquisition Module Implementation

### 3.2.1 Video Stream Acquisition

Read and process live or recorded classroom video streams using the OpenCV library (Li et al., 2024). The video frame data is acquired continuously by calling the camera or processing pre-recorded video files (Pi et al., 2019).

### 3.2.2 Video Frame Processing

The acquired video frame data is passed to the OpenPose library for analysis, which recognizes the multiple human poses in each frame as a set of keypoint coordinates (Li, 2023; Jian et al., 2024).

## 3.3 Attitude Analysis Module Implementation

### 3.3.1 OpenPose Integration and Calling

Integrate the OpenPose model into the system and call its API interface to analyze the pose of each image frame. Obtain the coordinate information

of each key point, such as the position of head, limb, hand and other key parts.

### 3.3.2 Data Processing and Filtering

Process and filter the posture data output from OpenPose to filter out the key actions and postures related to teaching quality (Wang and Qiu, 2024). For example, standing, sitting, and hand gestures can be recognized and recorded.

## 3.4 Data Storage and Management Module Implementation

### 3.4.1 Database Selection and Design

Select mybaits database to store posture data, timestamps, course information according to requirements. etc. metadata.

### 3.4.2 Data Storage Interface

Utilizes Python's database connectivity libraries (e.g., SQLAlchemy or using the database's native connectivity method) to efficiently store processed pose data in a database and ensure data integrity.

## 3.5 Front-end display and analysis module implementation

### 3.5.1 Visualization Interface Design

Web development technologies (including HTML, CSS and JavaScript) are used for the design of the user interface. The interface should include visual display of real-time and historical attitude data, report generation and data analysis functions. The JSON fields are automatically pushed to the web address of the configured web page through the JSON fields, and the JSON fields table is shown in Table 2.

Table 2: Table of JSON fields	
field name	clarification
data	Identification results
dataType	Data type PeopleDomain
actionList	Action Recognition by List
deviceId	equipment identification
imageName	Image Name
imageUrl	Recognition result image download address
peopleList	Screen Task List
points	Coordinates of each character bone node
x	Bone node x-coordinate
y	Bone node y-coordinate

### 3.5.2 Data display and analysis

Read posture data from the database and utilize JavaScript charting libraries (e.g. Chart.js or D3.js) to achieve dynamic data chart display. Users can view the results of posture data analysis for different time periods or specific courses through the interactive interface.

## 3.6 System Integration and Testing

### 3.6.1 Module Integration

Integration of the above individual modules into a holistic system to ensure that they work effectively together.

### 3.6.2 Functional Testing and Performance Optimization

Perform comprehensive functional validation and performance tuning of the system, including unit testing, inter-module integration testing, and end-to-end testing of the entire process, to ensure that the system meets the expected standards in terms of stability and accuracy.

### 3.6.3 User Feedback and Iterative Optimization

Based on the results of initial validation and user feedback, make necessary adjustments and improvements to enhance the user experience and functional completeness of the system.

### 3.6.4 Security testing

Checks the security of the system, including data protection, permission control, and vulnerability scanning, to prevent potential security threats.

### 3.6.5 Compatibility testing

Ensure that the system works properly on different environments, devices, and operating systems.

### 3.6.6 Regression testing

After the system changes, the system is retested to ensure that the previous functionality is not affected.

### 3.6.7 User acceptance testing

End users test the system to confirm that it meets their business needs and can be put into use.

## 4. SUMMARY

The design and function of this student posture monitoring and analysis system reflects the innovative application of technology in the field of education. Through posture detection technology, the system can monitor students' posture in real time, and help teachers better understand students' learning status and participation degree. This personalized monitoring and data analysis provides teachers with more information about students' learning habits and needs, enabling more targeted adjustments to teaching methods and content to improve teaching outcomes and student learning experiences.

In addition to improving teaching efficiency and student engagement, this system has important implications for the development of educational technology. It shows the application potential of digital technology in the learning process to the education field and points out the direction for the development of educational technology in the future. By continuously optimizing the algorithm and function of the system, the system can better adapt to the diversified and rapidly changing needs of the education field, and further improve the teaching quality and education effect.

In general, the design and function of this system is not only to improve traditional teaching methods, but more importantly to promote innovation and progress in the field of education. By combining technology and education, the system demonstrates the positive role of technology in education reform, providing educators and policy makers with a new way of thinking and tools to promote student learning and development, and achieve overall improvement in education.

## ACKNOWLEDGEMENT

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