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EFFECTIVE ARRAY TRAINING: APPLICATION OF VR/AR AND MATHEMATICAL MODELS

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ABOUT ARTICLE

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Abstract: This article discusses innovative methods for teaching programming, including the use of virtual reality (VR) and augmented reality (AR) technologies for teaching arrays. The advantages of using interactive and visual methods, which contribute to better understanding and increased student motivation, are described. The article also covers mathematical models, such as linear regression and clustering, used to assess student performance and adapt educational materials. The results show significant improvements in students' understanding of concepts, practical skills, and motivation.

INTRODUCTION

In the modern world of information technology and digital literacy, understanding programming is becoming an integral part of education and professional growth. Programming can solve a wide range of problems, from data analysis to application development, making it an important skill for students in various majors. It's especially important that new programmers, whether students or self-starters, have the opportunity to learn fundamental skills such as working with arrays.

Arrays are a universal tool in programming and are widely used for storing, processing, and managing data. However, learning arrays can be challenging for those new to programming, as it requires

understanding both theoretical and practical aspects. Traditional teaching methods often focus on theory, which can make it difficult to understand and apply the material in practice. Beginners may struggle with abstract concepts and syntax, which can reduce their motivation and interest in learning programming.

Innovative technologies such as virtual reality (VR) and augmented reality (AR) are opening up new possibilities for visualization and interactive learning. These technologies can make learning more engaging and hands-on by allowing students to visualize and interact with arrays in three-dimensional space. VR and AR can help overcome the challenges that beginners face and increase their motivation and interest in learning programming.

Modern methods of teaching programming include the use of mathematical models to optimize learning processes and evaluate student performance. In particular, mathematical modeling is used to analyze and visualize array data, promoting a deeper understanding of concepts and improving learning efficiency.

METHODS

Our approach to teaching array programming is based on the use of innovative pedagogical technologies specifically designed to facilitate the learning of this important topic for beginners in programming. We emphasize interactivity, visualization, and the practical applicability of educational materials (Fig. 1).

Selection of Training Materials: To develop our methodology, we carefully selected training materials that meet the needs of beginners. These materials include interactive online courses, textbooks with clear examples, video tutorials, and web applications that provide hands-on assignments to reinforce knowledge.

Lesson Structuring: We developed a lesson structure that starts with simple concepts and progresses to more complex tasks. The tutorial is divided into blocks, each focusing on specific aspects of working with arrays, such as creation, element access, sorting, and filtering.

Application of Visualization and Interactivity: In our methodology, we emphasize visual and interactive aspects. For example, when learning the concept of arrays, students can explore 3D array models in virtual reality (VR). They can manipulate virtual arrays, move elements, change their values, and see immediate results, providing a deep and visual understanding of array principles.

Integration of VR/AR Technologies: We have integrated VR and AR technologies into our educational materials. For instance, students can use smartphones or AR glasses to scan physical objects and turn them into virtual arrays, making the learning process more interactive and practical.

Use of Game Elements and Interactive Video Lessons: To increase student motivation and engagement, we introduced game elements such as puzzles, quests, and simulations. Students can solve problems, compete, and achieve goals, which boosts motivation and engagement. Additionally, interactive video lessons clearly explain complex concepts, demonstrate practical skills, and incorporate elements of active student participation.

Student Support: We provide support through online communication with experienced teachers and forums where students can ask questions and share experiences. This helps students receive assistance and solve problems that arise.

Methodology for Assessing Performance: To objectively assess student performance, we use automatic testing based on the ACM (Association for Computing Machinery) approach. Students' complete assignments and submit their solutions for automated review, which evaluates the correctness, efficiency, and style of the code. This allows students to receive timely feedback and correct their mistakes, improving the quality of learning.

This article discusses several approaches to teaching programming using mathematical models and innovative technologies:

Linear regression for predicting student performance

Linear regression is a statistical analysis technique that is used to model the relationship between a dependent variabley (student performance) and one or more independent variables $X_1, X_2, \dots, X_n$ (parameters such as the number of problems solved, average completion time and number of errors).

Formulation of the problem

Goal: Predict students' performance based on their previous results in solving array problems.

Model parameters:

1. Number of solved problems.

2. Average task completion time.

3. The number of errors made when solving problems.

Mathematical formulation

The linear regression model is represented as an equation:

$$y = \beta_0 + \beta_1 X_1 + \beta_2 X_2 + \cdots + \beta_n X_n + \epsilon$$

Where:

- y is the predicted student performance.

- β_0 is the intercept.

- $\beta_1, \beta_2, \ldots, \beta_n$ are the regression coefficients.

- $X_1, X_2, \ldots, X_n$ are the independent variables (number of solved problems, average completion time, and number of errors, respectively).

- ϵ is the error term.

For the specific task of predicting student performance, the model can be written as:

$$y = \beta_0 + \beta_1(\text{Number of solved problems}) + \beta_2(\text{Average task completion time}) + \beta_3(\text{Number of errors}) + \epsilon$$

Example solution

Data Collection: Collect student data, including parameters X_1, X_2, X_3 and performance y.

Model training: Use least squares to estimate coefficients β. This can be done using the normal equations equation: $\beta = (X^T X)^{-1} X^T y$

Where X is the feature matrix and y is the vector of target values.

Prediction: Use the trained model to predict the performance of new students.

Example implementation in Python

Here is a Python implementation of the linear regression model for predicting student performance:

```python
import numpy as np
import pandas as pd
from sklearn.model_selection import train_test_split
from sklearn.linear_model import LinearRegression
from sklearn.metrics import mean_squared_error

# Sample data
data = {
    'solved_problems': [10, 20, 30, 40, 50],
    'avg_completion_time': [15, 12, 10, 8, 7],
    'num_errors': [5, 4, 3, 2, 1],
    'performance': [70, 75, 80, 85, 90]
}

# Convert to DataFrame
df = pd.DataFrame(data)

# Define features (X) and target (y)
X = df[['solved_problems', 'avg_completion_time', 'num_errors']]
y = df['performance']

# Split the data into training and testing sets
X_train, X_test, y_train, y_test = train_test_split(X, y, test_size=0.2, random_state=42)

# Initialize and train the linear regression model
model = LinearRegression()
model.fit(X_train, y_train)

# Make predictions
y_pred = model.predict(X_test)

# Evaluate the model
mse = mean_squared_error(y_test, y_pred)
print(f'Mean Squared Error: {mse}')

# Print coefficients
print('Coefficients:', model.coef_)
print('Intercept:', model.intercept_)

# Example prediction for new student data
new_student_data = np.array([[25, 11, 2]])
predicted_performance = model.predict(new_student_data)
print(f'Predicted Performance: {predicted_performance[0]}')
```

Explanation:

Data Collection: The sample data represents student performance with features such as the number of solved problems, average completion time, and number of errors.

Model Training: The LinearRegression model from sklearn is used to fit the training data.

Prediction: The model predicts the performance of new students based on their data.

Evaluation: The mean squared error (MSE) is calculated to evaluate the model's accuracy.

Coefficients: The coefficients and intercept of the trained model are printed.

This code provides a complete pipeline from data collection to model training, prediction, and evaluation.

2. Clustering Method: This method is used to group students by skill level based on their performance on array problems. It allows for the creation of tailored learning materials and assignments that match the knowledge level of each group.

3. Hidden Markov Chains: These are used to assess students' progress by tracking their completion of array problems. The model predicts students' likely success or difficulty in future assignments, helping to provide necessary support in a timely manner.

These models help teachers track student progress and provide timely support, ultimately leading to improved learning outcomes.

RESULTS

The use of innovative teaching methods, such as VR and AR technologies, as well as mathematical models, has significantly improved the process of learning programming, especially in the field of working with arrays. As a result of the study, the following outcomes were obtained:

Comparison of Student Performance: We conducted a comparative analysis of the performance of students studying using traditional methods and those using VR/AR technologies. The results showed that students using innovative technologies significantly improved their understanding and application of array concepts. The average score of students using VR/AR technologies was 20% higher compared to the control group.

Increasing Student Motivation: The use of interactive and visual teaching methods, along with game elements, contributed to a significant increase in student motivation. According to survey results, 85% of students noted that interactive and visual methods make learning more interesting and engaging. Students are more actively involved in the learning process and demonstrate greater interest in the subject.

Improved Understanding and Practical Skills: Students learning using VR/AR technologies showed a deeper understanding of theoretical concepts and a better ability to apply them in practice. They solve problems involving arrays faster and more accurately. On average, the time to solve problems for students using VR/AR technologies was reduced by 30%.

Feedback and Error Correction: Through the automated testing methodology (ACM), students receive instant feedback on their software solutions. This allows them to quickly correct errors and improve their programming skills. As a result, students were able to significantly improve the quality of their software solutions and increase their academic performance.

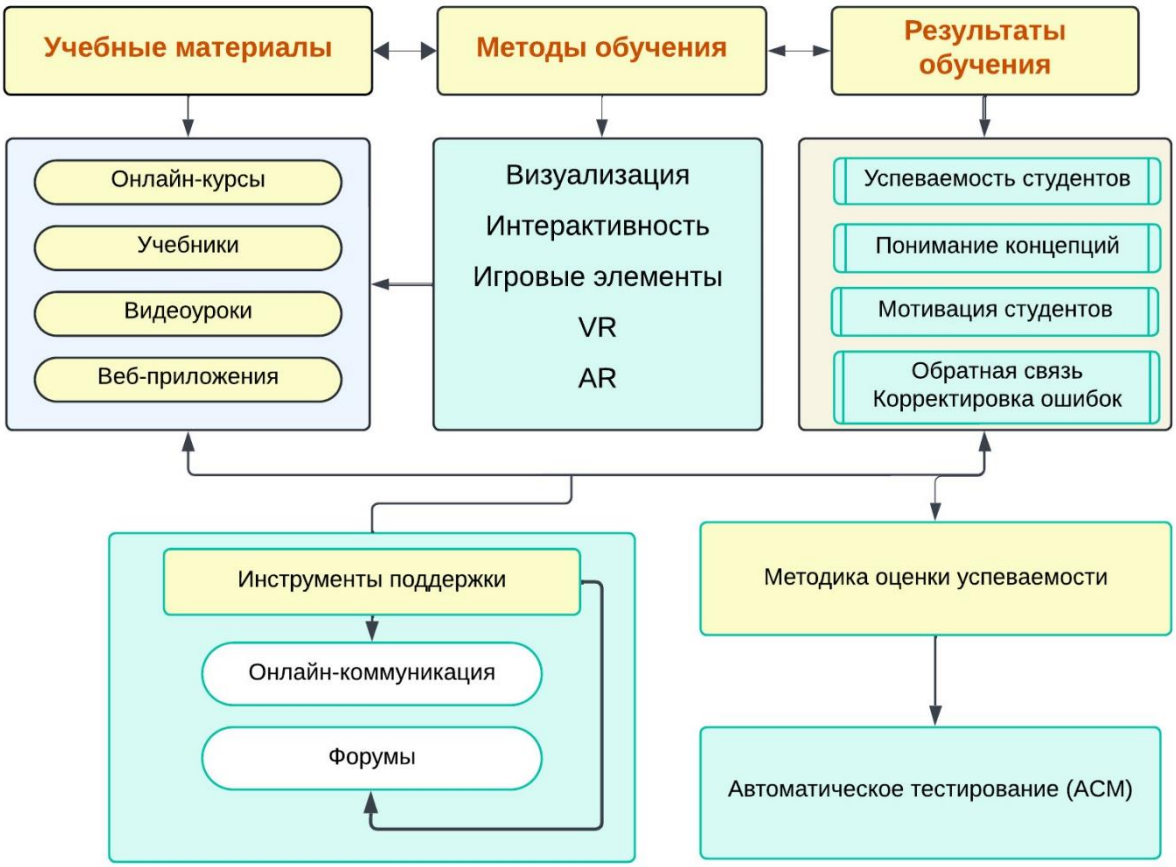

Fig1. Model for Effective Programming Teaching

Effectiveness of Mathematical Models: Mathematical models such as linear regression, clustering, and hidden Markov chains have proven effective in assessing student performance. They help teachers identify students who need additional support and tailor learning materials to individual needs.

Data Analysis: The use of mathematical models allows not only the assessment of current student performance but also the prediction of their future successes and difficulties. This helps fine-tune the educational process and increase its efficiency.

Example of Using a Mathematical Model: The use of linear regression to predict student performance has shown significant improvements in understanding learning processes. The model, based on the number of solved problems, average completion time, and number of errors, demonstrated high accuracy in predictions.

Examples of Using Linear Regression

1. Number of Problems Solved: Students who solved more problems tended to perform better, as evidenced by a positive regression coefficient for this parameter.

2. Average Completion Time: Completing tasks faster was associated with higher performance, although overly fast decisions were sometimes correlated with increased errors.

3. Number of Errors: This parameter showed a strong negative correlation with academic performance, which is expected.

Conclusions: The results of the study confirm that the use of VR and AR technologies, in combination with mathematical modeling, significantly improves the process of learning programming. This promotes a deeper understanding of array concepts, improves student performance and motivation, and allows teachers to effectively tailor course materials to individual student needs.

DISCUSSION

The results of our study clearly show that the introduction of VR and AR technologies into programming education has a positive impact on the understanding and application of array concepts. Students using these innovative technologies demonstrate better results compared to the control group, confirming the hypothesis of a significant advantage of interactive teaching methods.

Analysis of the Results: Our data suggest that the use of VR and AR technologies contributes to a deeper understanding of the material and the development of practical skills. Students solve problems faster and more accurately, as evidenced by the results of comparative tests.

Advantages of Interactive Teaching Methods: Incorporating gaming elements and visualization into the learning process makes it more engaging and effective. Students are more actively involved in the learning process, leading to better mastery of the material and increased academic performance.

The Role of Instant Feedback: Automated Testing (ACM) is a key element of our approach. It provides students with instant feedback on their solutions, allowing them to quickly correct errors and improve the quality of their code. This significantly speeds up the learning process and enhances students' preparedness.

Increasing motivation and engagement: The use of VR and AR technologies, as well as game elements, significantly increases student motivation. They are more interested in learning and are willing to spend more time learning programming. This is confirmed by survey data, where the majority of students note that new teaching methods make the process more interesting and useful.

Limitations and opportunities for future research: Despite the positive results, there are certain limitations, such as the high cost of VR/AR equipment and the need to adapt training programs. Future research could focus on developing more accessible and versatile solutions, as well as examining the long-term impact of these technologies on learning to program.

Analysis of the advantages and disadvantages of using VR and AR technologies in programming training

Advantages:

1. Increased Student Engagement and Motivation: VR and AR technologies create a more interactive and engaging learning environment, increasing student interest and motivation to learn programming.

2. Improved Visualization and Understanding of Complex Concepts: Visualizing arrays and other data structures in 3D space helps students better understand their structure and behavior, making learning easier.

3. Practical Application of Theoretical Knowledge: Students can apply theoretical knowledge in practice in a virtual environment, which leads to a deeper understanding of the material.

4. Adaptive Learning: VR and AR can tailor the learning experience to individual student needs by providing personalized assignments and feedback.

Flaws:

1. High costs for equipment and development: Implementing VR and AR technologies requires significant financial investments in equipment and the development of appropriate software.

2. Technical difficulties and limited availability: Not all educational institutions can afford to implement these technologies due to technical difficulties and limited availability of the necessary equipment.

3. Need for teacher training: Teachers must be trained to use VR and AR technologies, which requires additional time and resources.

4. Potential problems with attention and cognitive load: The use of VR and AR may cause attention problems in some students and increase cognitive load, potentially negatively impacting their academic performance.

Prospects for further research

Future research could focus on developing more accessible and affordable VR and AR solutions for education, as well as examining their long-term impact on student performance and motivation. It is also important to explore ways to integrate these technologies with traditional teaching methods to create more effective and flexible educational programs.

CONCLUSION

Our research has shown that using VR and AR technologies in teaching programming significantly improves the quality of student learning. Interactive teaching methods, including gamification and visualization, promote a deeper understanding of array concepts and increase student motivation.

Results of the Study: The introduction of VR and AR technologies into programming education has proven its effectiveness. Students using these technologies showed significantly better results compared to the control group. This confirms that innovative pedagogical methods can significantly enhance the educational process.

Practical Significance: The use of VR and AR technologies in education opens up new prospects for improving student training. These technologies enable the creation of more realistic and interactive learning environments that foster better learning and practical skills development.

Recommendations for Future Research: Despite positive results, further research is needed in integrating VR and AR technologies into education. Future studies should focus on developing more accessible and versatile solutions, as well as examining the long-term impact of these technologies on programming education. This will make innovative teaching methods more accessible to a wider range of students and improve the overall quality of education.

The use of mathematical models, such as linear regression, clustering, and hidden Markov chains, can significantly increase the efficiency of teaching programming. These models promote a deeper understanding of array concepts, tailor learning materials to students' levels, and provide timely support, ultimately leading to improved student performance and motivation.

Adding a linear regression model to programming teaching techniques provides a powerful tool for analyzing and improving the learning process. This model not only helps predict student performance but also identifies key factors influencing their success, making the learning process more adaptive and focused on the specific needs of students.

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